

# Perennial ice and snow masses



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A contribution  
to the International  
Hydrological  
Decade



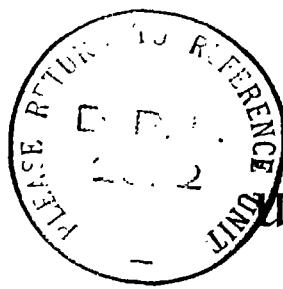
In this series:

- 1 Perennial Ice and Snow Masses. A Guide for Compilation and Assemblage of Data for a World Inventory.
- 2 Seasonal Snow Cover. A Guide for Measurement, Compilation and Assemblage of Data.
- 3 Variations of Existing Glaciers. A Guide to International Practices for their Measurement.
- 4 Antarctic Glaciology in the International Hydrological Decade.
- 5 Combined Heat, Ice and Water Balances at Selected Glacier Basins. A Guide for Compilation and Assemblage of Data for Glacier Mass Balance Measurements.

A contribution to the  
*International Hydrological  
Decade*

# Perennial ice and snow masses

A guide for  
compilation and assemblage of  
data for a world inventory



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# Preface

The International Hydrological Decade (IHD) 1965-1974 was launched by the General Conference of Unesco at its thirteenth session to promote international co-operation in research and studies and the training of specialists and technicians in scientific hydrology. Its purpose is to enable all countries to make a fuller assessment of their water resources and a more rational use of them as man's demands for water constantly increase in face of developments in population, industry and agriculture. In 1968 national committees for the Decade had been formed in 100 of Unesco's 122 Member States to carry out national activities and to contribute to regional and international activities within the programme of the Decade. The implementation of the programme is supervised by a co-ordinating council, composed of twenty-one Member States selected by the General Conference of Unesco, which studies proposals for developments of the programme, recommends projects of interest to all or a large number of countries, assists in the development of national and regional projects and co-ordinates international co-operation.

Promotion of collaboration in developing hydrological research techniques, diffusing hydrological data and planning hydrological installations is a major feature of the programme of the IHD which encompasses all aspects of hydrological studies and research. Hydrological investigations are encouraged at the national, regional and international level to strengthen and to improve the use of natural resources from a local and a global perspective. The programme provides a means for countries well advanced in hydrological research to exchange scientific views and for developing countries to benefit from this exchange of information in elaborating research projects and in implementing recent developments in the planning of hydrological installations.

As part of Unesco's contribution to the achievement of the objectives of the IHD the General Conference authorized the Director-General to collect, exchange and disseminate information concerning research on scientific hydrology and to facilitate contacts between research workers in this field. To this end Unesco has initiated two collections of publications 'Studies and Reports in Hydrology' and 'Technical Papers in Hydrology'.

The collection 'Technical Papers in Hydrology' is intended to provide a means for the exchange of information on hydrological techniques and for the co-ordination of research and data collection.

The acquisition, transmission and processing of data in a manner permitting the intercomparison of results is a prerequisite to efforts to co-ordinate scientific projects within the framework of the IHD. The exchange of information on data collected throughout the world requires standard instruments, techniques, units of measure and terminology in order that data from all areas will be comparable. Much work has been done already toward international standardization, but much remains to be done even for simple measurements of basic factors such as precipitation, snow cover, soil moisture, streamflow, sediment transport and ground-water phenomena.

It is hoped that the guides on data collection and compilation in specific areas of hydrology to be published in this collection will provide means whereby hydrologists may standardize their records of observations and thus facilitate the study of hydrology on a world-wide basis.

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# Foreword

Since about 80 per cent of all fresh water exists in solid form, an accurate assessment of the amount, distribution and variation of all snow and ice masses, both near to and far from areas at present inhabited is of importance for the understanding of man's environment. To comply with the need for more complete and detailed information on ice and snow, the Co-ordinating Council of the IHD at its first session passed a resolution recommending to Member States the mapping of permanent snow and ice masses and the compilation and assemblage of data for publication in order to obtain the elements necessary for the establishment of the regional distribution of permanent snow and ice various territories and the degree of accuracy in each area.

The International Commission of Snow and Ice (ICSI) of the International Association of Scientific Hydrology (IASH) was asked to prepare guidance material for the compilation of a world inventory of perennial ice and snow masses as a contribution to the estimation of the world water balance. This technical paper was prepared by a Working Group of ICSI under the chairmanship of Professor F. Müller.

The guide takes into account the recent manual *Guide to Making a Catalogue of Glaciers of the U.S.S.R.* published in 1966 in the U.S.S.R.

Unesco gratefully acknowledges the efforts of the working group and the aid of the officers of ICSI in the preparation of this manual.

# 1 Ice and snow on the surface (glacier inventory)

Almost 99 per cent of all ice on the earth is contained in glaciers, and most of it is stored in the two continental ice sheets of Antarctica and Greenland (97 per cent of the total glacier area of the earth). Some of the remaining 3 per cent of the glacierized area is, however, of direct importance to mankind, providing water for irrigation, industry, hydro-power, recreation and domestic supplies.

A pilot study for a glacier inventory was carried out by C. S. L. Ommeney, in close co-operation with the ICSI Working Group, on the ice masses of Axel Heiberg Island (Canadian High Arctic). It will appear as a separate publication (Ommeney, 1969).

## *Different levels of sophistication in the glacier inventory*

Owing to differences in availability and quality of maps, photographs and personnel, and in the nature of the glacierized areas, it will be easier for some countries to produce a glacier inventory than for others. On the following pages standard requirements are presented for data collection and accuracy; it is hoped that they can be fulfilled by everyone. For certain areas, however, it might prove impossible—for a variety of reasons—to meet these requirements. In such cases it is suggested that statistically valid sampling techniques be used for selected areas, and that models be developed, such as are frequently applied in the earth sciences (Krumbein and Graybill, 1965), to calculate the best possible over-all values for large areas. On the other hand, all countries capable of providing information additional to the standard requirements should do so.

## *The Standard Data Sheet*

The objective of the Standard Data Sheet (Fig. 1) is to permit useful and rapid processing of the data for hydrological needs as well as for further use by the various environmental sciences. It is suggested that the information on each glacier or ice mass should be entered on a separate data sheet, from which punch cards of standard format are easily prepared.

## *Source material*

The primary sources of information are maps, photographs and published accounts.

## *Maps*

In general, standard topographical maps will have to be the basis from which most data are extracted. The minimum suitable scale is probably 1 : 250,000, but wherever available larger scales should be used. Unfortunately many topographical maps pay scant heed to the exact shape and precise extent of glaciers and perennial snowfields; consequently it is frequently necessary to check the glaciological information depicted on the map. Anomalies must be corrected with the aid of photographs, etc., and a note to this effect must be made on the Standard Data Sheet together with the other required map information,

In addition to the largest scale maps available, a regional map on a smaller scale—perhaps at 1 : 500,000 or less, depending on the size and nature of the glacierized area—will be required in order to work out the identification and coding system.

## *Photographs*

Aerial and terrestrial photographs must be used to substantiate and where necessary to improve the

Perennial ice and snow masses

State, Province or Region:	Regional and basin identification																														
Mountain area:	Glacier number																														
Hydrological basin:-	Longitude																														
Ist order:	Latitude																														
IIInd order:	U.T.M.																														
IIIrd order:	Orientation: Accumulation area (8 pt. compass)																														
IVth order:	Ablation area (8 pt. compass)																														
Glacier name:	Highest glacier elevation (m/a.s.l.)																														
Sources:-	Lowest glacier elevation: Exposed (m/a.s.l.)																														
Map, title & No:	Total (m/a.s.l.)																														
Compiled by:	Elevation of snow line (m/a.s.l.)																														
Date:	Date of snow line																														
Scale:	Mean accumulation area elevation, weighted, (m/a.s.l.)																														
Contour interval:	*Accuracy rating (1-5)																														
Reliability:	Mean ablation area elevation, weighted, (m/a.s.l.)																														
Photographs:-	*Accuracy rating (1-5)																														
Type:	Maximum length:Ablation area (km) incl.debris covered																														
Serial No:	Exposed (km)																														
Date:	Total (km)																														
Remarks:	Mean width of main ice body (km)																														
Literature:	Surface area: Exposed (km <sup>2</sup> )																														
Data compiled by:	Total (km <sup>2</sup> )																														
Date & organisation:	*Accuracy rating (1-5)																														
Supervisor:	Area of ablation (km <sup>2</sup> )																														
REMARKS (special geomorphological features, abnormal characteristics, if international boundary, source information on mean depth estimate, observations regarding snow line or equilibrium line from other years)	*Accuracy rating (1-5)																														
	Accumulation area ratio (per cent)																														
	Mean depth (m)																														
	Volume (km <sup>3</sup> ) of ice																														
	*Estimated accuracy rating (1-5)																														
	Classification and description (see Table 1)																														
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FIG. 1. Glacier inventory data sheet

glaciological information on the map. In particular, photographs are needed to assess the snow line, which is rarely shown on ordinary maps. Again it is essential to record the full information regarding the photos (date, etc.) on the Standard Data Sheet.

#### *Literature*

Much useful information, e.g. regarding the snow line position or tongue activity can be found in various publications. It should be incorporated in the inventory and reference given under 'Literature'.

#### *Identification system*

Each glacier must have an 'address', which gives in the first place the name of a sizable political unit—a state of the United States of America such as Alaska, or a small country such as Nepal—or a geographical unit; for this the first two digits should follow an international code obtainable from the world data centres. The study area must then be divided and subdivided into drainage basins of I<sup>st</sup> (A-Z), II<sup>nd</sup> (0-9), III<sup>rd</sup> (0-9) and, if necessary, IV<sup>th</sup> (a-z), etc., order. The lettering and numbering should start from the mouth of the major stream and proceed clockwise round the basin. A key map (or a sequence of them) must be drawn up showing the assigned letters and numbers. Finally, each glacier in the III<sup>rd</sup> (or IV<sup>th</sup>) order basin is given a number, again starting with '1' at the outlet of the drainage basin, proceeding clockwise to '999'. Index maps with the glacier numbers are required. In addition the identification of individual glaciers should be given in geographical co-ordinates, as well as—wherever available—in UTM (Universal Transverse Mercator) co-ordinates. The point on the glacier chosen for the co-ordinates should be in the upper part of the ablation area, in the main stream, and high enough not to be lost if the glacier retreats.

#### *Delineation*

##### *Catchment*

Measurement of glacier dimensions should be made within the carefully delineated drainage area of the individual ice stream.

#### *Tributaries*

Where tributaries join into and cannot be differentiated from the main stream, they should be included with it. However, where former tributaries can be clearly distinguished from the main glacier, they should be measured separately. Their régime is frequently quite different.

#### *Snow and ice boundaries*

Delineation of visible ice, firn and snow versus rock and debris surfaces as well as delineation of active glacier versus inactive ice (dead ice), as diagrammatically shown in Figure 2, can affect various inventory measurements, particularly for subtropical glaciers. Inactive ice must be included in the inventory for hydrologic purposes. Many marginal and terminal moraines of arctic glaciers should be included because the ice content usually amounts to 80 per cent and more. The distinction between 'exposed' and 'total' glacier area, as made in the Russian inventory of Franz Josef Land (Vinogradov and Psareva, 1965), is supported. Rock glaciers must be included if evidence of large ice content has been or can be established. Glacierets and snow patches of large enough size, as well as aufeis (nayled)—if perennial—should also be included in the inventory, but must be clearly marked as such (see 'Glacier classification and description', page 16).

#### *International boundaries*

Many glaciers cross international boundaries—this should be noted.

#### *Exposure*

There is frequently a marked difference in exposure between the accumulation and ablation areas, which may be of great significance for the régime of the glacier. It is therefore necessary to establish the main direction of exposure for both parts.

#### *Area and linear measurements*

##### *Ice aprons in accumulation area*

The 'inactive' ice aprons, frequent above the bergschrund, are part of the glacierized area. There is a serious danger, however, that seasonal snow-fields may be included that do not belong to the

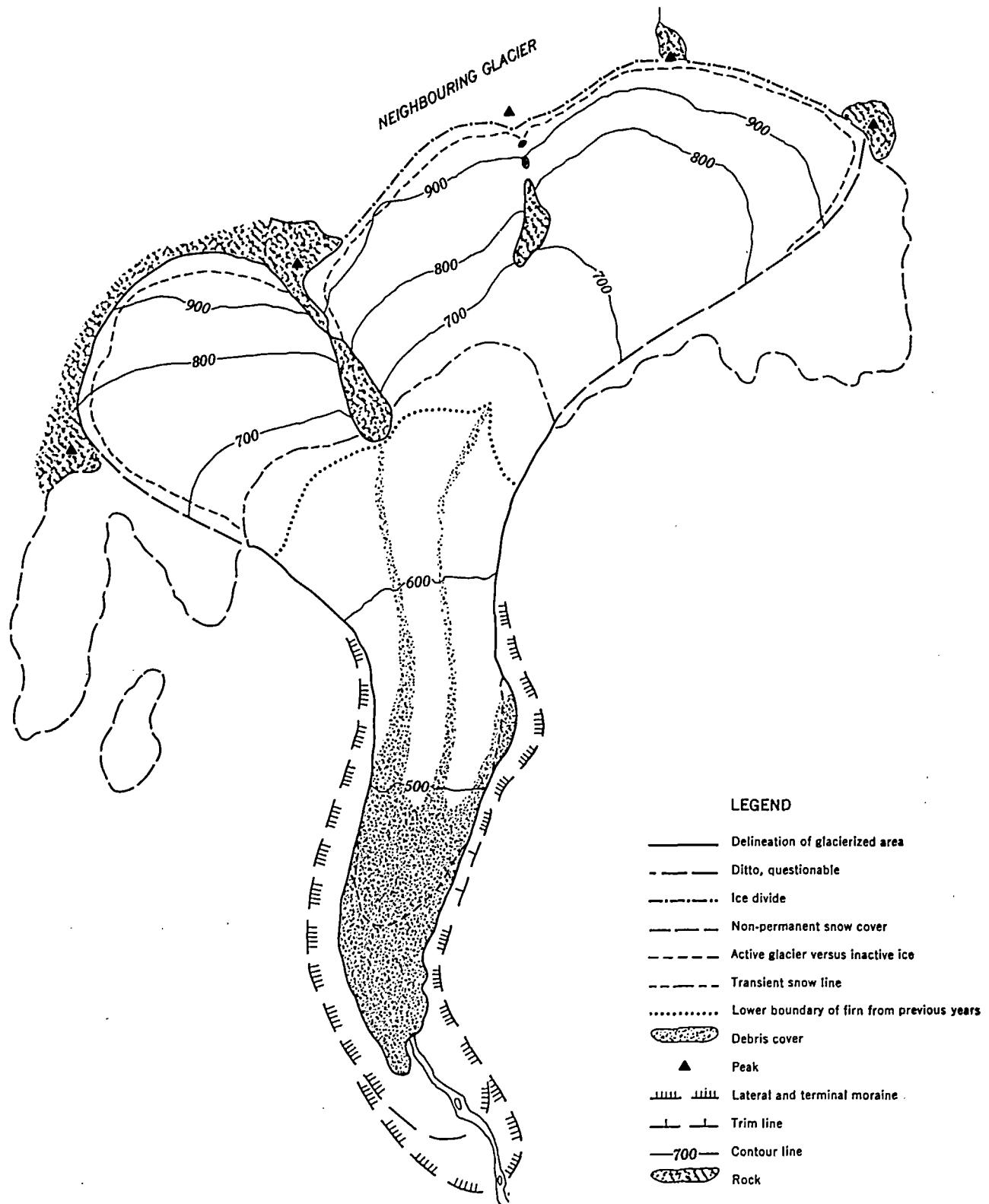


FIG. 2. Diagrammatic delineation of glacierized area

accumulation area. Analysis of photos from different years might help to prevent this error.

#### *'Exposed' versus 'total' ablation area*

There is frequently a considerable difference between the 'exposed' and the 'total' ablation area, when the lower reaches are covered by a debris layer of varying thickness. It is suggested that for the purpose of this inventory a distinction be made between the two values because of their importance for hydrology and for the albedo of the glacier. The total area and length measurements include the debris-covered parts of a glacier and the ice-cored moraines, if they are close to the terminus.

#### *Mean width*

When a glacier has a uniform width, as with a valley glacier, its mean width in the ablation area should be measured.

#### *Measuring techniques*

Up-to-date measuring techniques and equipment (for example electronic dot planimeter, etc.) should be used when available. The instrument error must be established.

#### *Transient snow line, firn line and equilibrium line, and AAR value*

The *transient snow line*, usually simply called the snow line, is defined as the continuously shifting line separating areas with a closed snow cover from areas free of snow.

The *firn line* on a glacier is defined as the lower boundary of those recent snow deposits which are carried over as firn into the next balance year.

The *equilibrium line* separates areas of equal accumulation and ablation for a given balance year, as observed at the end of the ablation season. On some glaciers, particularly in polar regions, the firn line may be separated from the equilibrium line by an area of superimposed ice.

The firn line and the equilibrium line will only be available for a relatively small number of glaciers, i.e. for those on which detailed field-work was carried out. For the practical purpose of the glacier inventory it will be necessary to quote the (transient) snow line, as recognized on aerial or terrestrial photographs taken near the end of the ablation season. This is not a reliable dividing line

between the areas of accumulation and ablation. Nevertheless, if the photographs are taken close to the end of the ablation season it is possible to calculate an approximate *accumulation area ratio* value (AAR):

$$\text{AAR (\%)} = \left( \frac{\text{accu. area}}{\text{total area}} \right) \times 100 = \left( 1 - \frac{\text{abla. area}}{\text{total area}} \right) \times 100$$

The elevation of the snow line should always be quoted together with the appropriate date. Any information on elevations of snow lines (or firn line, or equilibrium line) and on AAR values for earlier years should be given.

Where no snow-line assessment is possible an approximate elevation of the mean equilibrium line over several years can be established in lieu—at least for glaciers in near balance—by using either one or a combination of the following:

1. Change in the shape of the contour lines from convex (in the ablation area) to concave (in the accumulation area).
2. Beginning of moraines.
3. Höfer's or similar method (von Wissmann, 1959). The Höfer method, for example, calculates the approximate elevation of the 'mean equilibrium line over several years' from the arithmetic mean of the elevation of the glacier terminus and the average elevation of the ridge which surrounds the accumulation basin. This method can only be applied to small simple basin glaciers.
4. 'Summit' method (Ostem, 1966).

#### *Mean elevations of accumulation and ablation areas*

Because of their importance as climatic indicators, the mean elevations of the areas of accumulation and ablation should be assessed. This is achieved by choosing that contour line which halves the areas of accumulation and ablation respectively.

#### *Volume*

The mean depth of the glacier from which the volume of ice (not w.e.) is calculated, is extremely difficult to assess. It is, however, of such significance to the world water balance that every effort should be made by qualified people to obtain 'intelligent estimates'. Based on the experience gained from glaciers on which detailed depth measurements were carried out, estimates of the mean ice depth can be made using a combination of

surface area and glacier type as shown in the examples given in Chapter 3 of this guide and estimates of depth values must be reassessed for each climatic area (Meier, 1961). To date there are far too few glaciers with known depths. Wherever possible, further depth probes on glaciers of the various types should be carried out with modern geophysical techniques such as radio echo and seismic sounding, etc.

#### Error estimates

All quantitative data are to be accompanied by an estimate of the error involved. A 5-point accuracy rating is proposed at the bottom of Figure 1.

#### Glacier classification and description

A morphological matrix-type classification and description is proposed (Table 1). Each glacier may be coded as a 6-digit number, the 6 digits being the vertical columns of the table; the individual numbers for each digit (horizontal row numbers) must be read on the left-hand side.

In addition to the guidance given on the next pages for the use of Table 1, consultation of the *Illustrated Glossary of Ice and Snow* (Armstrong, Roberts and Swithinbank, 1966) could prove helpful.

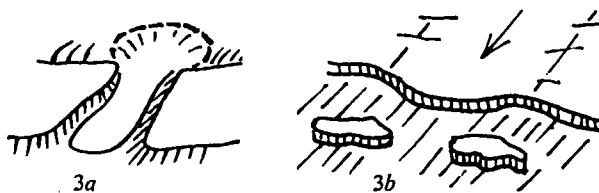
Table 1. Glacier classification and description

	<b>Digit 1 Primary classification</b>	<b>Digit 2 Form</b>	<b>Digit 3 Frontal characteristic</b>	<b>Digit 4 Longitudinal profile</b>	<b>Digit 5 Major source of nourishment</b>	<b>Digit 6 Activity of tongue</b>
0	Uncertain or misc.	Uncertain or misc.	Normal or misc.	Uncertain or misc.	Uncertain or misc.	Uncertain
1	Continental ice sheet	Compound basins	Piedmont	Even; regular	Snow and/or drift snow	Marked retreat
2	Ice-field	Compound basin	Expanded foot	Hanging	Avalanche ice and/or avalanche snow	Slight retreat or avalanche
3	Ice cap	Simple basin	Lobed	Cascading	Superimposed ice	Stationary
4	Outlet glacier	Cirque	Calving	Ice-fall		Slight advance
5	Valley glacier	Niche	Coalescing, non-contributing	Interrupted		Marked advance
6	Mountain glacier	Crater				Possible surge
7	Glacieret	Ice aprons				Known surge
8	Ice shelf	Groups of small units				Oscillating.
9	Rock glacier	Remnant				

#### Digit 1 Primary classification

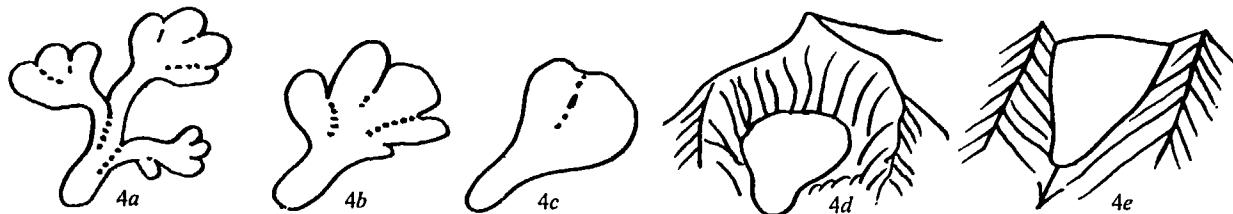
0	<i>Miscellaneous</i>	Any not listed.
1	<i>Continental ice sheet</i>	Inundates areas of continental size.
2	<i>Ice-field</i>	Ice masses of sheet or blanket type of a thickness not sufficient to obscure the subsurface topography.
3	<i>Ice cap</i>	Dome-shaped ice mass with radial flow.
4	<i>Outlet glacier</i>	Drains an ice sheet or ice cap, usually of valley glacier form; the catchment area may not be clearly delineated (Fig. 3a).
5	<i>Valley glacier</i>	Flows down a valley; the catchment area is well defined.
6	<i>Mountain glacier</i>	Cirque, niche or crater type; includes ice aprons and groups of small units.

- 7 *Glacieret and snowfield* A glacieret is a small ice mass of indefinite shape in hollows, river beds and on protected slopes developed from snow drifting, avalanching and/or especially heavy accumulation in certain years; usually no marked flow pattern is visible and therefore no clear distinction from snow-field is possible. Exists for at least two consecutive summers.
- 8 *Ice shelf* A floating ice sheet of considerable thickness attached to a coast, nourished by glacier(s); snow accumulation on its surface or bottom freezing (Fig. 3b).
- 9 *Rock glacier* A glacier-shaped mass of angular rock in a cirque or valley either with interstitial ice, firn and snow or covering the remnants of a glacier, moving slowly downslope.



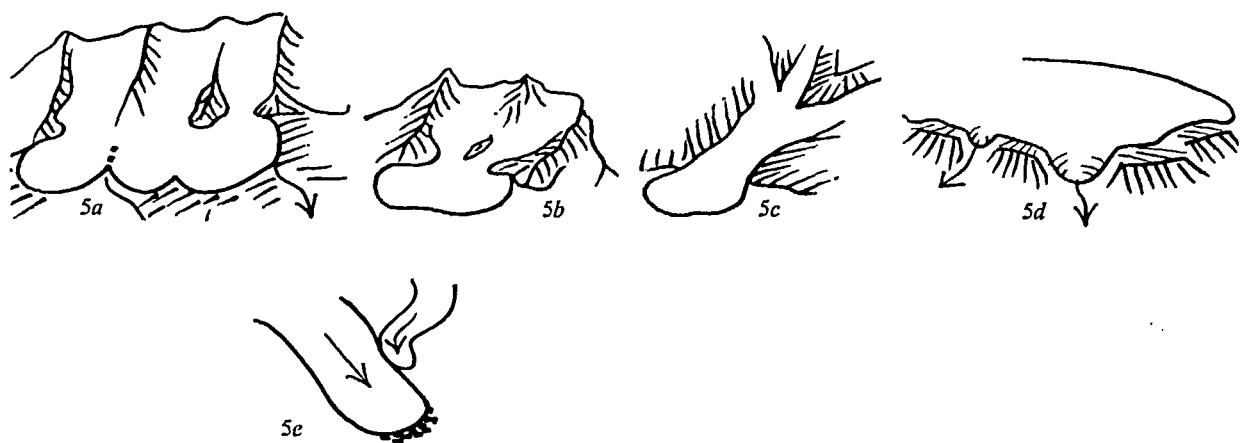
#### Digit 2 Form

- 1 *Compound basins* Two or more individual valley glaciers issuing from tributary valleys and coalescing (Fig. 4a).
- 2 *Compound basin* Two or more individual accumulation basins feeding one glacier system (Fig. 4b).
- 3 *Simple basin* Single accumulation area (Fig. 4c).
- 4 *Cirque* Occupies a separate, rounded, steep walled recess which it has formed on a mountain-side (Fig. 4d).
- 5 *Niche* Small glacier formed in initially V-shaped gully or depression on mountain slope; generally more common than the genetically further developed cirque glacier (Fig. 4e).
- 6 *Crater* Occurring in extinct or dormant volcanic craters which rise above the regional snow line.
- 7 *Ice apron* An irregular, usually thin, ice mass plastered along a mountain slope or ridge.
- 8 *Group* A number of similar small ice masses occurring in close proximity and too small to be assessed individually.
- 9 *Remnant* An inactive, usually small ice mass left by a receding glacier.



**Digit 3 Frontal characteristics**

- 1 *Piedmont (glacier)* Ice-field formed on a lowland by the lateral expansion of one or the coalescence of several glaciers (Fig. 5a, 5b).
- 2 *Expanded foot* Lobe or fan of ice formed where the lower portion of the glacier leaves the confining wall of a valley and extends on to a less restricted and more level surface (Fig. 5c).
- 3 *Lobed* Part of an ice sheet or ice cap, disqualified as outlet or valley glacier (Fig. 5d).
- 4 *Calving* Terminus of glacier sufficiently extending into sea or occasionally lake water to produce icebergs; includes—for this inventory—dry land calving, which would be recognizable from the ‘lowest glacier elevation’.
- 5 *Coalescing, non contributing* (see Fig. 5e).



**Digit 4 Longitudinal profile**

- 1 *Even* Includes the regular or slightly irregular and stepped longitudinal profile.
- 2 *Hanging (glacier)* Perched on a steep mountain-side or issuing from a hanging valley.
- 3 *Cascading* Descending in a series of marked steps with some crevasses and séracs.
- 4 *Ice-fall* Break above a cliff, with reconstitution to a cohering ice mass below.

**Digit 5 Nourishment**

Self-explanatory.

**Digit 6 Tongue activity**

A simple-point qualitative statement regarding advance or retreat of the glacier tongue in recent years, if made for all the glaciers on earth, would provide most useful information. The assessment for an individual glacier (strongly or slightly advancing or retreating, etc.) should be made in terms of the world picture and not just that of the local area; however, it seems very difficult to establish an objective, i.e. quantitative basis for the assessment of the tongue activity. A change of frontal position of up to 20 m per year might be classed as a ‘slight’ advance or retreat. If the frontal change takes place at a greater rate it would be called ‘marked’. Very strong advances or surges might shift the glacier front by more than 500 m per year. It is important to specify whether the information on the tongue activity is documented or estimated.

*Data presentation and submission*

Inventory data should be stored on computer cards or tapes and summarized on print-out sheets for submission to data centres. Each country's data collection should be accompanied by a general physiographic and climatic description of the glacierized region(s), together with index and general reference maps, selected photographs, and reference lists of pertinent literature, e.g. on earlier observations and related current work. Each national submission should also include summaries of the information collected on the left side of

the Standard Data Sheet (Fig. 1), that is: the scale, accuracy and data of the maps used; the height, focal length, picture scale and data of the aerial and/or terrestrial photographs; the equipment used (planimeter type, etc.) with accuracy information. The inventory data sheets for the individual glaciers should remain in the custody of national archives to be available on request, together with the corresponding computer cards or tapes.

The three pilot studies reported in Chapter 3 below may, in part, serve as examples of data submissions.

## 2 Ice beneath the surface

Ice occurring beneath the land surface is called underground ice. The total of underground ice is estimated by Shumskiy and Vtyurin (Shumskiy and Vityurin, 1963, p. 108) as 0.2 to 0.5 million km<sup>3</sup>, or less than 1 per cent of the ice volume of the earth; nevertheless, in some northern regions of Asia and America ice constitutes as much as 50 to 80 per cent of the uppermost 20 to 30 metres of the lithosphere. It is realized that to draw up an inventory of underground ice will be exceedingly difficult and that it will necessarily be of very limited accuracy. However, because of the rapidly increasing importance of this ice to human activity a serious effort should be made to obtain improved information on the underground ice in polar and subpolar regions and in high mountain areas. Only in recent years has serious attention been given to the occurrence of perennially frozen ground in the high mountains. Brown's permafrost map of Canada (Brown, 1967) attempts to delineate the areas of permafrost in the Western Cordillera.

Much of the information on underground ice, particularly the more massive forms, will only be available from indirect evidence, i.e. its surface manifestations. Pingos, ice-wedge polygons, palsas, thermokarst mounds and pits lend themselves to aerial photograph recognition and on low-level aerial photographs even smaller permafrost features may be distinguished. However, the lack of permafrost surface features does not indicate the absence of ground ice. In the northern portion of the discontinuous permafrost zone there is undoubtedly a considerable volume of ground ice which has no surface expression.

### *Classification*

For the purpose of a ground-ice inventory a descriptive as well as a simple genetic classification

is needed. A detailed description of the physiographic, lithologic and geologic units is required to permit an assessment of the genetic situation, which provides the key to volume estimates.

After a survey of the pertinent literature (Linell and Kaplar, 1963; Mackay, 1966; Péwé, 1966; Pihlainen and Johnston, 1963; Shumskiy and Vtyurin, 1963) the following simple descriptive classification is suggested for use by non-specialists:

Non-visible ground ice: pore ice.  
Visible ground ice:  $\leq 2.5$  cm: segregated ice.  
 $> 2.5$  cm: layers } stratified or random.  
Massive ground ice:  $\geq 10$  cm: horizontal (as in pingos and massive ice beds).  
vertical (as in ice wedges).  
buried ice.  
cave ice.

### *Procedure*

It is suggested that the inventory of ground ice be carried out in four stages:

1. *Search of the literature.* Previous studies should be utilized. The search for published and unpublished information is particularly important for all those ground-ice masses that have little or no surface expression.
2. *Mapping* on a scale of 1: 250,000 or better for the representative areas and on the scale of 1 : 1,000,000 for other permafrost areas : (a) all the information contained in the literature (including boundaries of continuous and discontinuous permafrost); (b) all the ground-ice indicators which can be recognized on aerial photographs—pingos, ice wedges, palsas, ice associated with thermokarst features.
3. *Recording* of the individual features compiled on the maps by numbering them for each drainage basin and—where practical—filling in on a form

the quantitative information, including error estimates.

A small pilot study for stages 2 and 3 was carried out for an area in the Canadian Arctic by G. Falconer, Department of Energy, Mines and Resources. It is estimated that for Canada the compilation of information on to about 440 maps at the scale of 1 : 250,000 (stage 2) would take about 700 work days; an additional 200 work days would be required for numbering, measuring, recording and summarizing of the mapped information (stage 3).

4. *Estimate of ice volume*, based on the quantitative information and the geological and physiographic situation, and carried out by an expert. The relative accuracy (probable error) of the volume data must be indicated.

Brown (1967) has made a first approximation for the volume of ground ice contained beneath the Coastal Plain of northern Alaska. The estimates are based on surface and subsurface data obtained in the Barrow area and a number of assumptions concerning: size and shape of ice wedges and pingo ice; occurrence of wedges with depth and below lakes; the area and depth of lakes; and the saturated water content of both near-surface and deeper sediments and rocks. The total perennial ice volume in the upper 7.5 metres of permafrost is estimated at 175 km<sup>3</sup> (total area of 50,000 km<sup>2</sup>). If pore ice is eliminated from this calculation, the volume is reduced to 49 km<sup>3</sup>. A rough estimate for the total quantity of underground ice in the permafrost of the Coastal Plain sediments and underlying strata is 1,500 km<sup>3</sup>.

This and similar investigations clearly demonstrate the great contribution to the underground ice volume made by the pore ice. The assessment of pore-ice quantities, however, is dependent on geologic, geomorphic and climatic data.

#### *Delineation of permafrost*

The boundaries between continuous and discontinuous permafrost and permafrost-free areas are determined from mapped ground-temperature data, well-log data, the distribution of thermokarst features in cleared fields and changes in plant cover. In the southern fringe of the discontinuous zone the occurrences of permafrost are mostly confined

to peat bogs and much of the ground ice is found in palsas.

Mapping the surface indicators—ice wedge polygons, thermokarst mounds or pits, palsas and pingos—will establish the minimum extent of massive ground ice.

#### *Some suggestions for an inventory of perennial ice beneath the land surface*

##### *Quaternary deposits*

Mapping of those Quaternary deposits in permafrost areas which have a potentiality for considerable quantities of pore and segregation ice.

1. Geographic identification: latitude, longitude and/or UTM co-ordinates for centre of feature; name of geographical region; regional index map number; hydrological basin; height above sea level.
2. Area and linear measurements, with probable error.
3. Geologic and lithological description.
4. Physical setting: main slope angle; orientation of main slope; surrounding topography.
5. Climatic setting: any climatic data, particularly radiation and temperature.
6. Depth estimate: of deposit; of permafrost.
7. Ice volume estimate (km<sup>3</sup>): technique used and probable error.
8. Source material: aerial and ground photographs (flight line number, date, scale of photographs, quality, etc.); map (official reference, year, scale, reliability, etc.).

##### *Polygon fields (ice wedges)*

1. Geographic identification: as above.
2. Area and linear measurements with probable error.
3. Physical setting: orientation in 8-point compass; regional slope angle; lithology and physiography.
4. Ice volume estimate (km<sup>3</sup>): technique used (measured or estimated) and probable error.
5. Source material: same as above.

##### *Pingos, thermokarst mounds and pits, and palsas*

1. Geographic identification: as above.
2. Measurements of height and diameter (or length and width).

3. Classification: open system pingo, code 1; closed system pingo, code 2; other pingos, code 3; thermokarst mound, code 4; thermokarst pit with lake, code 5; thermokarst pit, dry, code 6.
4. State of degradation: undisturbed, code 1; cracked, code 2; ponded, code 3; remnant, code 4.
5. Physical setting: orientation; slope angle; height above valley bottom; height below surrounding mountains; lithology and physiography; for pingos indicate if surrounded by lake or not.
6. Source material: as above.

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## Permafrost ice in high mountains

Climatic data (annual mean and seasonal fluctuation of temperature, etc.) and geological information (surface geology maps and their tectonic interpretation) may permit mapping of approximate permafrost boundaries in high mountains.

As the surface layers of the upper reaches of high mountains are mainly bed-rock, the underground ice in these areas consists predominantly of some pore ice (in the rock itself) and 'fissure' and cave ice.

### 3 Three pilot studies for the IHD world inventory of glaciers

#### Introduction

To test the feasibility of the recommended instructions for a glacier inventory, inventories of three areas of markedly different nature have been compiled and presented here as first examples of implementations of the guide.

The three test areas are:

1. The south-west part of Axel Heiberg Island ( $79^{\circ}$  N.,  $90^{\circ}$  W.) in the Canadian High Arctic. This region has moderate mountain relief (ranging from sea level to an elevation of 1,750 m) with many different types of cold glaciers: minor ice sheets, outlet glaciers, valley glaciers, piedmont glaciers, etc. Some 200 glaciers from this area were included.
2. The region of the Waputik Range in the Canadian Rocky Mountains ( $52^{\circ}$  N.,  $116^{\circ}$  W.). A number of valley glaciers descend from three small ice-fields at about 2,600 m with numerous cirque glaciers and glacierets on the surrounding ridges; about 100 glaciers were surveyed.
3. The Mount Everest region in eastern Nepal ( $28^{\circ}$  N.,  $87^{\circ}$  E.) where many valley glaciers are avalanche-fed from the precipitous (up to 3,000-m-high) slopes, the ablation areas often being thickly covered with debris. Some 160 glaciers were included in this pilot study.

Some critical problems are assessed in each area and the experience gained from the actual implementation of the guide is presented. It was found that the identification system, i.e. the numbering and coding of the individual glaciers, needs careful

attention at the outset of the work. An international agreement on identification and coding is required. Difficulties of delineation in the accumulation as well as in the ablation area are mentioned. These appear to be more pronounced in low-latitude high-mountain areas, such as the Himalayas, than in the Arctic. The assessment of an annual or climatic snow line, or even better of the firn and equilibrium lines, and subsequently an AAR value, is discussed. The glacier classification suggested in the guide proved to be a useful aid in the problematic ice-volume assessment. The difficulties of error estimation for area, elevation and volume data are discussed. Maps, photos and measuring equipment of differing quality were used in the three test cases. Two examples of completed standard data sheets and computer print-outs of all the glacier inventory data are appended to each pilot study.

Though some data summaries of general interest are given in table form, no analysis was attempted. In each case it was felt to be premature to draw conclusions from such a limited amount of data. A study of the more interesting elements in the inventory (changes in elevation of snow line, mean accumulation and ablation areas, etc.) necessitates (a) statistical validity tests of the data itself and (b) proper consideration of the environmental parameters (climatic, topographic, etc.) in an elaborate multiple-factor analysis.

A. A pilot study for an inventory of  
the glaciers of the High Arctic

Glacier inventory of Steacie Ice Cap area ( $79^{\circ}$  N.,  $90^{\circ}$  W.),  
Axel Heiberg Island, N.W.T.

*Physiography*

The area selected for this study (Fig. 6) is the triangular-shaped south-western corner of Axel Heiberg Island bordered to the north by Strand Fiord, to the west and south by the sea, and to the east by Wolf Fiord and the mountain trough separating the Steacie Ice Cap from the major ice mass on the island, the McGill Ice Cap. The moderately mountainous relief ranges from sea level to an elevation of 1,750 m. Within this region the ice cover constitutes 37.5 per cent of the total land area of 8,100 km<sup>2</sup>. In physical appearance the Steacie Ice Cap rather resembles an ice-field. The surface ice movement is strongly controlled by the topography, which divides this ice mass into individual units: minor ice sheets, outlet, valley and piedmont glaciers, etc. Three large mountain troughs run north to south through the region terminating in Surprise, Glacier and Wolf fiords. The ridges on either side form the major drainage divides. The western trough which ends in Surprise Fiord contains the largest glacier (641 km<sup>2</sup>) in the region, the second largest glacier (383 km<sup>2</sup>) flows in the neighbouring trough to the east. Many glaciers flow to the coast, especially in Glacier Fiord, none of which are, at the present time, tidal.

*Climate and meteorological data*

A recent analysis of the climate of Axel Heiberg Island (Müller and Roskin-Sharlin, 1967) has shown that all the major precipitation comes from the south-west. This is of great significance for the nourishment of glaciers in the area as the low lands

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to the west, Amund and Ellef Rignes islands, seem to have little influence on the air masses coming from the Arctic Basin. The Norwegian Sea is free of ice for a considerable period every summer. To the east and north-east the ice-free lowlands of Axel Heiberg Island and the land mass of Ellesmere Island have a more continental climate.

At present long-term weather records for this region are only available from the joint Canadian-United States weather stations at Isachsen (Ellef Rignes), Eureka (Ellesmere), and Resolute Bay (Cornwallis). In 1961 an automatic weather station was installed at Sherwood Head but removed after operating intermittently for three years. The data are available from the Canadian Department of Transport, Meteorological Branch, Toronto.

*Source material*

Recent (1958 and 1959) stereo aerial photograph coverage was available for the whole area. An RC5 aerial camera was used with a focal length of 152 mm. The flying height was 9,100 m providing photographs with an approximate scale of 1 : 60,000. None of the area was obscured by cloud at the time of photography so that the only real problems experienced with the photo-interpretation were due to lack of contrast in the more extensive areas of snow.

Advance prints of a new map at a scale of 1 : 125,000 were obtained and used for all the measurements (Table 2).

<sup>1</sup>. Formerly of McGill University, Montreal (Canada).

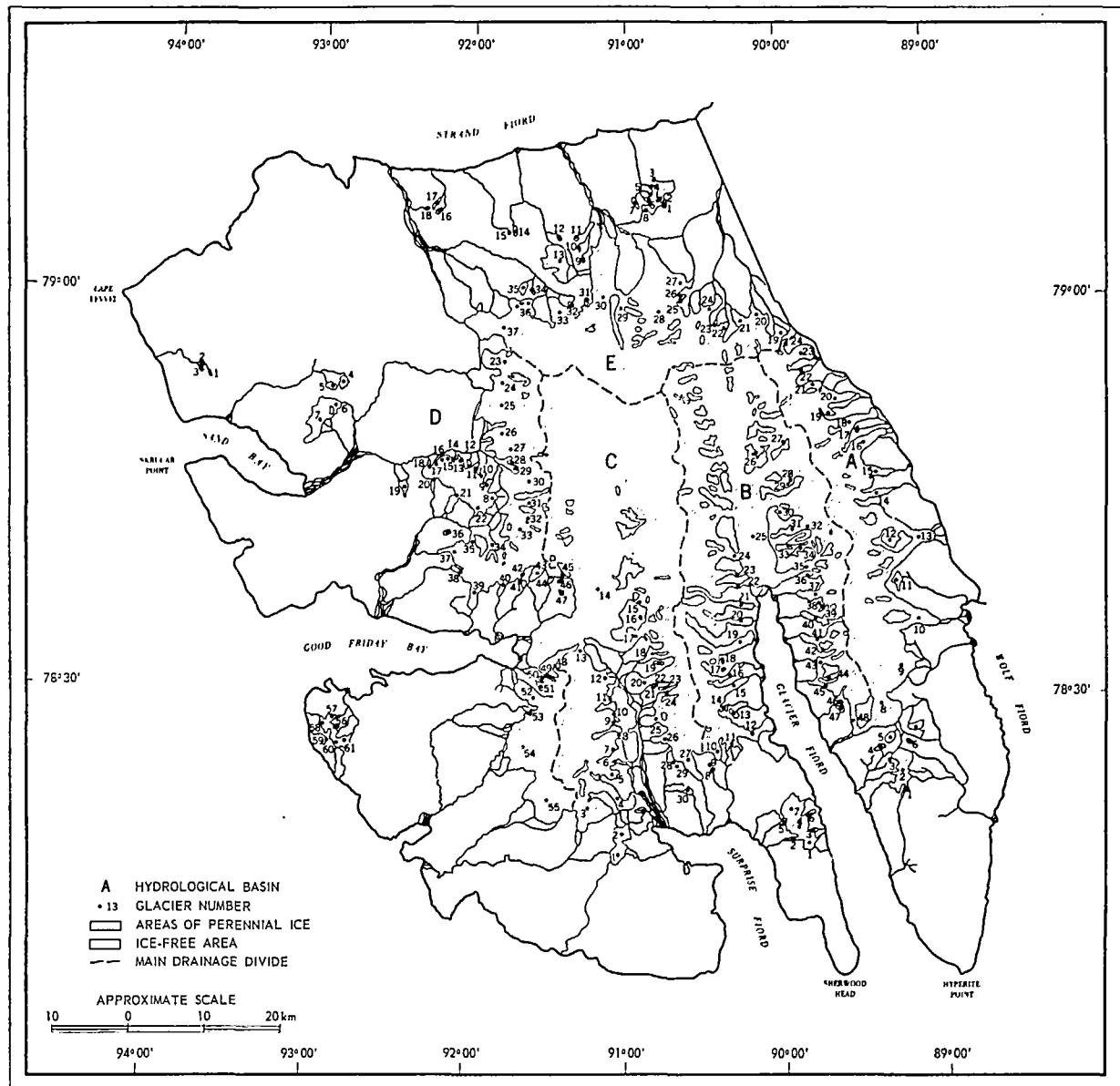


FIG. 6. Steacie Ice Cap, Axel Heiberg Island, N.W.T. (Canada).

Table 2

Map	Date	Scale	Contour interval (ft)	Accuracy (ft)	
				Vertical	Horizontal
59E	1959	1 : 125 000	500	± 200	± 200
59F	1958/9	1 : 125 000	500	± 150	± 200
59G	1959	1 : 125 000	500	± 150	± 200
59H	1959	1 : 125 000	500	± 200	± 200

Just to the north of the Steacie Ice Cap is one of the most intensively investigated glaciated areas in the Arctic. For eight years McGill University has carried out detailed field-work on the White Glacier ( $79^{\circ}25' N.$ ,  $90^{\circ}40' W.$ ) and on several neighbouring glaciers. The results of this work have been published as a continuing series of reports (*Axel Heiberg Island Research Reports, 1961-67*). Two regional studies of the Queen Elizabeth Islands were completed in 1956, one by the Canadian Defence Research Board (Dunbar and Greenaway, 1956), and the other by Taylor (1956) for the American Geographical Society.

#### Problems and procedure

##### Snow line

The transient snow line was determined from aerial photographs and then transferred to the maps. For 187 glaciers the 1959 photographs were used, for the remaining 13 glaciers only 1958 photographs were available. Field-work on three

glaciers 60 km to the north of this region in 1959 showed that in the lower half of the ablation area some 75 cm of ablation occurred after the aerial photographs were taken (unpublished expedition data). No such information is available for 1958. In this region a considerable amount of superimposed ice and slush is usually found below the transient snow line. Therefore it is felt that the snow line determined for 1959 corresponds quite closely to the equilibrium line. A difference of some 400 m was observed in the snow lines of 1958 and 1959 and an analysis of the climatic data will be necessary before it can be established whether this is the result of a snowfall prior to taking the photos or an indication of the more positive nature of the 1958 mass balance. The mean snow line in Table 3 was determined only from the 1959 values. This shows how premature it would be to draw conclusions from such a small amount of data and without proper consideration of the climatic parameters. Therefore Table 3 should be considered only as a factual summary and not in any way an analysis.

Table 3

Location	No. of glaciers	Mean Elevations			Length (max.)	Area (max.)	Mean AAR	Vol. (max.)
		Snow line	Accum.	Abla.				
Wolf Fiord	24	950	1 100	760	15.9	88.00	28	17.60
Glacier Fiord	48	800	930	600	33.3	382.94	33	95.53
Surprise Fiord	30	740	860	540	45.0	641.09	24	160.27
Good Friday Bay and Sand Bay	61	820	920	650	10.2	53.22	38	10.65
Strand Fiord	37	1 010	1 130	879	25.8	149.28	30	37.32

##### Area

Area measurements were made using a Bruning areagraph random dot overlay with 100 dots per square inch, in conjunction with a dot counter developed by the Engineering Research Service of the Canada Department of Agriculture. Precision for large areas better than 97 per cent was found

in tests against standard planimeters, and by counting squares the accuracy for areas less than one square kilometre was almost as good. The use of a dot planimeter provides a considerable saving in time without any corresponding reduction in accuracy.

*Volume*

Considerable problems were encountered in attempts to estimate depths for the volume estimates. For the previously mentioned region to the north, depth values are available for an outlet and a medium-sized valley glacier from seismic and gravity investigation (Redpath, 1965). In addition all available information on glacier depths from similar regions was used to construct a table of estimated depth values according to glacier type and area (Table 4). These estimates should only be applied to this particular climatic region. They

Table 4

Type	Area ( $\text{km}^2$ )	Depth (m)
Ice-field	0-5	20
	5-20	30
	20-100	50
	100-300	100
	300-1 000	150
	1 000 +	200-500
Ice cap	0-1	15
	1-5	25
	5-20	75
	20-100	150
	100-300	250
	300 +	> 250
Outlet and valley glaciers	0-5	50
	5-20	125
	20-100	200
	100 +	250-500
Mountain glacier	0-1	15
	1-2	20
	2-5	35
	5-20	50
	20 +	> 50

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are considered minimum values and will be adjusted as soon as additional information becomes available.

Some 69 valleys, 58 mountains and 32 outlet glaciers were distinguished. The depth estimates in Table 4 were adhered to in all but two cases where small valley glaciers were found with areas just over  $5 \text{ km}^2$ , for which a depth value of 75 m was assigned.

*Activity*

Time has not permitted detailed analysis of the photographs to determine whether the estimated tongue activity for each glacier is correct or not. However, there seems to be a fairly general, though slight retreat of ice in all areas that were studied apart from the Good Friday Glacier No. C14 which may be surging at the present time.

*Conclusion*

Within the area selected for this study it was found possible to apply the guide without any great difficulty. Some trouble was experienced with determining ice divides where the contrast on the aerial photographs was poor. Careful study of the photographs was also necessary to determine whether terminal moraines were recessional, and in this region, therefore, probably ice-cored, or push features with a very small ice content.

The accuracy of the data collected in this inventory of the Steacie Ice Cap area is felt to fall well within those recommended limits that are considered acceptable.

Approximately three months' work was involved in the completion of the pilot study but much of this time was spent in producing proposals for the improvement of the guide, which then necessitated revision of already completed data sheets.

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## WOLF FIORD

IDENT	NO.	LONGITUDE	LATITUDE	U.T.M.	ORIENT	AC	AB	HIGH	ELEVATIONS	L.E.X	L.T.L	SNOW	DATE	MEAN ELEVATION	ACCU	ABLA
A	1	W 89 11.0	N 78 22.2	16XDC509005	S S	640	427	427	945	28	7 59			549	3	
A	2	W 89 11.0	N 78 24.0	16XDC510040	NW NW	640	290	290	945	28	7 59			686	3	
A	3	W 89 16.0	N 78 24.8	16XDC492053	W W	686	655	655	823	28	7 59			667	3	
A	4	W 89 19.0	N 78 25.8	16XDC483072	NW NW	686	457	457	823	28	7 59			625	3	
A	5	W 89 15.0	N 78 26.5	16XDC496084	NW NW	769	625	625	823	28	7 59			686	3	
A	6	W 89 18.0	N 78 26.2	16XDC522079	NW NW	762	670	670	823	28	7 59			701	3	
A	7	W 89 5.0	N 78 27.2	16XDC532099	NW NW	792	610	610	823	28	7 59			838	3	
A	8	W 89 19.0	N 78 25.3	16XDC494137	SE S	280	396	396	823	28	7 59	945	4	594	3	
A	9	W 89 11.0	N 78 32.3	16XDC516191	E E	180	259	259	869	28	7 59	960	4	610	3	
A	10	W 89 3.0	N 78 35.5	16XDC547250	E E	1234	137	137	884	28	7 59	991	4	625	3	
A	11	W 89 13.0	N 78 36.3	16XDC513303	NE NE	1097	610	610	1067	28	7 59	1082	4	823	3	
A	12	W 89 14.0	N 78 41.5	16XDC512365	NE NE	1052	549	549	945	28	7 59	991	4	808	3	
A	13	W 89 3.0	N 78 41.5	16XDC554364	E E	1378	137	137	975	28	7 59	1128	4	655	3	
A	14	W 89 17.0	N 78 45.0	16XDC505428	E E	1341	250	250	1006	28	7 59	1128	4	823	3	
A	15	W 89 18.0	N 78 44.5	16XDC502456	NE NE	1341	274	274	975	28	7 59	1112	4	823	3	
A	16	W 89 21.0	N 78 45.0	16XDC490593	NE NE	1402	244	244	884	28	7 59	1052	4	762	3	
A	17	W 89 26.5	N 78 45.4	16XDC472515	SE SE	1021	914	914	1967	28	7 59			960	3	
A	18	W 89 26.0	N 78 50.5	16XDC474933	E E	1524	259	259	975	28	7 59	1128	4	762	3	
A	19	W 89 36.5	N 78 51.1	16XDC438584	SE SE	1097	762	762	975	28	7 59	1036	4	884	3	
A	20	W 89 34.0	N 78 52.2	16XDC447655	E E	1686	335	335	1006	28	7 59	1189	4	823	3	
A	21	W 89 43.0	N 78 53.1	16XDC441458	E E	1554	442	442	1067	28	7 59	1234	4	853	3	
A	22	W 89 48.0	N 78 54.2	16XDC398002	NE NE	1524	564	564	1067	28	7 59	1250	4	869	3	
A	23	W 89 46.0	N 78 55.7	16XDC410630	NE NE	1387	442	442	1128	28	7 59	1295	4	808	3	
A	24	W 89 52.0	N 78 56.2	16XDC384043	NE NE	1067	732	732	1067	28	7 59	899	3			

## GLACIER FIORD

IDENT	NO.	LONGITUDE	LATITUDE	U.T.M.	ORIENT	AC	AB	HIGH	ELEVATIONS	L.E.X	L.T.L	SNOW	DATE	MEAN ELEVATION	ACCU	ABLA
B	1	W 89 48.0	N 78 18.5	16XDB368942	S S	759	305	305	800	28	7 59			660	3	
B	2	W 89 53.0	N 78 15.0	16XDB350949	W S	732	274	274	800	28	7 59			550	3	
B	3	W 89 45.0	N 78 19.2	16XDB380956	E E	732	122	122	800	28	7 59			460	3	
B	4	W 89 52.0	N 78 15.8	16XDB358964	E E	792	442	442	800	28	7 59			640	3	
B	5	W 89 55.0	N 78 20.0	16XDB340972	W W	777	320	320	800	28	7 59			600	3	
B	6	W 89 47.0	N 78 20.5	16XDB374980	E E	777	91	91	800	28	7 59			460	3	
B	7	W 89 53.0	N 78 21.5	16XDB350949	N N	777	213	213	800	28	7 59			610	3	
B	8	W 90 22.5	N 78 24.2	15XKT590044	NE NE	651	579	579	655	13	8 59			600	3	
B	9	W 90 26.0	N 78 24.5	15XKT587050	S S	549	488	488	640	13	8 59			515	3	
B	10	W 90 22.0	N 78 25.5	15XKT592068	SE SE	686	290	290	655	13	8 59			670	4	
B	11	W 90 15.0	N 78 26.0	15XKT614080	S S	732	488	488	640	13	8 59			686	4	
B	12	W 90 50.0	N 78 26.2	15XKT636096	SE SE	930	15	15	579	13	8 59			747	4	
B	13	W 90 14.0	N 78 26.2	15XKT616124	E E	610	427	427	640	13	8 59			411	3	
B	14	W 90 14.0	N 78 26.8	15XKT616132	E E	792	427	427	579	13	8 59			490	3	
B	15	W 90 15.0	N 78 30.5	15XKT612162	NE NE	1173	137	137	564	13	8 59			732	4	
B	16	W 90 16.0	N 78 31.2	15XKT601676	E E	1173	137	137	579	13	8 59			732	4	
B	17	W 90 19.0	N 78 31.8	15XKT596183	NE NE	696	594	594	590	13	8 59			640	3	
B	18	W 90 16.5	N 78 32.5	15XKT597197	N N	640	427	427	533	13	8 59			610	4	
B	19	W 90 16.0	N 78 33.5	15XKT606216	E E	1410	30	30	579	13	8 59			823	4	
B	20	W 90 16.0	N 78 35.2	15XKT610252	E E	1410	76	76	533	13	8 59			762	4	
B	21	W 90 13.5	N 78 36.8	15XKT612278	E F	1410	91	91	618	13	8 59			777	4	
B	22	W 90 12.0	N 78 38.2	15XKT616206	E E	1387	122	122	533	13	8 59			800	4	
B	23	W 90 12.0	N 78 39.2	15XKT613322	E E	1387	137	137	518	13	8 59			866	3	
B	24	W 90 13.0	N 78 40.0	15XKT610345	E E	1387	152	152	488	13	8 59			792	4	
B	25	W 90 8.0	N 78 41.5	15XKT628368	S S	1685	91	91	640	13	8 59			920	4	
B	26	W 90 5.0	N 78 46.0	15XKT63249C	W W	884	579	579	792	13	8 59			820	4	
B	27	W 89 56.0	N 78 46.7	16XDC365501	E E	1250	1052	1052	1052	13	8 59			1158	4	
B	28	W 89 52.0	N 78 46.2	16XDC376455	SE SE	1494	914	914	1067	13	8 59			1250	4	
B	29	W 89 53.0	N 78 45.8	16XDC375448	SE SE	1494	884	884	1097	13	8 59			991	3	
B	30	W 89 58.0	N 78 43.5	16XDC354410	NH NH	1067	610	610	792	13	8 59			823	4	
B	31	W 89 55.0	N 78 42.2	16XDC367386	W W	1245	244	244	694	13	8 59			1082	4	
B	32	W 89 47.0	N 78 42.2	16XDC391304	NW SW	1250	1189	1189	1189	28	7 59			1200	4	
B	33	W 89 55.0	N 78 41.2	16XDC363366	H H	1219	274	274	914	13	8 59			1067	4	
B	34	W 89 52.0	N 78 41.8	16XDC372354	H W	1219	305	305	914	28	7 59			1036	4	
B	35	W 89 48.0	N 78 35.2	16XDC387328	H W	1378	76	76	945	28	7 59			1128	4	
B	36	W 89 44.5	N 78 38.8	16XDC398316	W N	975	427	427	914	28	7 59			930	4	
B	37	W 89 43.0	N 78 37.5	16XDC403292	W H	1341	168	168	945	28	7 59			1067	4	
B	38	W 89 41.0	N 78 37.0	16XDC408202	W NH	914	564	564	945	28	7 59			747	3	
B	39	W 89 40.0	N 78 36.5	16XDC412271	SH SH	975	457	457	945	28	7 59			955	4	
B	40	W 89 41.0	N 78 35.5	16XDC408254	W H	1219	198	198	945	28	7 59			1036	4	
B	41	W 89 40.0	N 78 33.2	16XDC410214	H NH	1097	427	427	1090	28	7 59			1093	4	
B	42	W 89 40.0	N 78 34.0	16XDC409228	W H	1234	137	137	914	28	7 59			1040	4	
B	43	W 89 45.0	N 78 32.4	16XDC407197	H S	1280	137	137	1006	28	7 59			1128	4	
B	44	W 89 38.0	N 78 31.2	16XDC414175	H SW	1097	381	381	975	28	7 59			1037	4	
B	45	W 89 39.0	N 78 30.6	16XDC412166	H W	1097	122	122	975	28	7 59			1006	4	
B	46	W 89 24.5	N 78 25.6	16XDC426148	H SH	762	564	564	975	28	7 59			686	3	
B	47	W 89 35.0	N 78 25.0	16XDC425137	H W	975	610	610	975	28	7 59			838	3	
B	48	W 89 30.5	N 78 26.3	16XDC442122	S S	1143	137	137	884	28	7 59			995	4	

## SURPRISE FIORD

IDENT	NO.	LONGITUDE	LATITUDE	U.T.M.	ORIENT	AC	AB	HIGH	ELEVATIONS	L.E.X	L.T.L	SNOW	DATE	MEAN ELEVATION	ACCU	ABLA
C	1	W 90 59.0	N 78 17.0	15XKT545916	SE SE	640	411	411	670	28	7 59			533	3	
C	2	W 90 58.0	N 78 19.1	15XKT546094	NW NH	640	259	259	670	28	7 59			442	3	
C	3	W 90 10.0	N 78 2													

## WULF FIORD

IDENT NO.	TOTAL LENGTH			WIDTH	SURFACE AREA			AAR	DEPTH	VOLUME	TYPE		
	ABA	EXP	TOTAL		EXP	TOTAL	ABALATION						
A 1	2.2	2.2	2.2	.3	.91	.91	.91	0	15	.01	4 650132		
A 2	6.1	6.1	6.1	11.39	11.39	3	11.39	0	75	.85	4 300132		
A 3	.2	.2	.2	.10	.10	3	.10	0	15	.00	4 300132		
A 4	1.4	1.4	1.4	.50	.50	3	.50	0	15	.01	4 300132		
A 5	1.7	1.7	1.7	1.71	1.71	3	1.71	0	25	.04	4 300132		
A 6	.9	.9	.9	.40	.40	3	.40	0	15	.01	4 300132		
A 7	2.0	2.0	2.0	1.51	1.51	3	1.51	0	25	.04	4 300132		
A 8	9.2	14.5	14.5	2.4	48.28	48.28	3	25.70	47	200	9.66	4 532114	
A 9	4.0	7.1	7.1	.88	.88	3	1.72	3	80	.30	.26	4 200112	
A 10	10.0	13.9	13.9	1.9	64.21	64.21	3	34.88	3	46	12.84	4 510114	
A 11	1.5	2.0	2.0	2.62	2.62	3	2.32	3	11	.25	.58	4 300112	
A 12	1.2	2.4	2.4	4.03	4.03	3	2.82	3	30	.25	.10	4 300112	
A 13	11.0	15.4	15.9	1.8	88.00	88.00	3	44.76	3	49	17.60	4 510114	
A 14	6.2	7.9	7.9	.9	10.59	10.59	3	7.26	3	32	1.33	4 530112	
A 15	6.2	8.6	8.6	1.0	16.54	16.54	3	12.00	3	27	2.07	4 520112	
A 16	7.0	10.4	10.5	1.0	24.19	24.59	3	11.99	3	51	200	4.92	4 530112
A 17	.9	.9	.9	.40	.40	3	.40	0	15	.01	4 300112		
A 18	6.6	11.4	11.6	.8	34.27	35.38	3	18.75	3	47	200	7.08	4 512112
A 19	1.2	1.8	1.8	1.11	1.11	3	1.01	3	9	.20	.02	4 650112	
A 20	6.4	10.2	10.2	1.1	23.28	23.50	3	10.28	3	56	200	4.72	4 536112
A 21	4.2	6.1	6.1	.8	9.17	9.17	3	4.13	3	55	125	1.15	4 505112
A 22	3.2	4.2	4.2	.6	5.64	5.64	3	1.51	3	73	125	.71	4 522112
A 23	6.2	8.8	8.8	1.1	19.05	19.05	3	9.57	3	51	125	2.38	4 532112
A 24	1.4	1.4	1.4	.2	1.41	1.41	3	1.41	3	0	50	.07	4 520112

## GLACIER FIORD

IDENT NO.	TOTAL LENGTH			WIDTH	SURFACE AREA			AAR	DEPTH	VOLUME	TYPE		
	ABA	EXP	TOTAL		EXP	TOTAL	ABALATION						
B 1	2.8	2.8	2.8	3.33	3.33	3	3.33	3	0	25	.08	4 300132	
B 2	2.6	2.6	2.6	1.71	1.91	3	1.91	3	0	50	.01	4 400132	
B 3	2.7	2.7	2.7	1.51	1.51	3	1.51	3	0	50	.01	4 400132	
B 4	3.6	3.6	3.6	5.04	5.04	3	5.04	3	0	75	.37	4 300132	
B 5	2.0	2.0	2.0	.4	1.41	1.41	3	1.41	3	0	50	.01	4 400132
B 6	3.5	3.5	3.5	2.92	3.12	3	3.12	3	0	50	.16	4 400132	
B 7	3.0	3.0	3.0	5.94	5.94	3	5.94	3	0	75	.45	4 300132	
B 8	.8	.8	.8	.30	.30	3	.30	3	0	15	.00	4 300132	
B 9	.2	.2	.2	.15	.15	3	.15	3	0	15	.00	4 650112	
B 10	4.0	4.4	4.4	1.0	7.87	7.87	3	7.06	3	10	125	.98	4 530110
B 11	.5	1.5	1.5	2.01	2.01	3	1.31	3	35	20	.04	4 200112	
B 12	8.5	13.1	13.2	.8	30.44	31.65	3	14.62	3	54	200	5.31	4 520112
B 13	.9	.9	.9	.50	.50	3	.50	3	0	20	.01	4 220102	
B 14	.4	1.4	1.4	.70	.70	3	.70	3	30	57	15	.01	4 65C110
B 15	4.6	9.0	9.0	.8	14.02	14.52	3	4.94	3	66	125	1.82	4 520114
B 16	4.6	8.4	8.4	.8	9.98	10.68	3	4.33	3	59	125	1.33	4 530112
B 17	.4	.4	.4	.20	.20	3	.20	3	0	15	.00	4 650112	
B 18	.6	1.0	1.0	.25	.25	3	.15	3	30	15	.00	4 650112	
B 19	7.8	13.6	13.7	1.4	34.27	35.08	3	13.61	3	61	200	7.02	4 510112
B 20	4.5	11.0	11.2	.8	15.42	15.92	3	4.53	3	72	125	2.00	4 520112
B 21	5.0	10.6	10.8	.9	15.42	16.12	3	5.03	3	69	125	2.01	4 520112
B 22	3.8	8.6	8.8	.6	11.49	11.89	3	3.12	3	74	125	1.49	4 535112
B 23	3.2	5.1	5.1	.6	10.69	10.69	3	2.12	3	80	125	1.34	4 535112
B 24	5.0	8.2	8.2	1.0	32.36	32.36	3	7.06	3	88	200	6.47	4 512110
B 25	23.2	33.2	33.3	4.6	382.13	382.94	3	135.88	3	65	250	93.53	4 410114
B 26	.9	1.2	1.2	.2	.60	.60	3	.40	3	33	15	.01	4 620112
B 27	.4	.4	.4	.11	.11	3	.10	3	10	15	.00	4 650112	
B 28	.2	1.2	1.2	.1	.50	.50	3	.10	3	80	15	.01	4 650112
B 29	.7	1.4	1.4	.2	.60	.60	3	.30	3	50	15	.01	4 620112
B 30	.5	.8	.8	.70	.70	3	.30	3	57	15	.01	4 650112	
B 31	3.6	5.8	5.8	.5	5.35	5.35	3	3.33	3	38	75	.40	4 520112
B 32	.2	.2	.2	.20	.20	3	.20	3	100	20	.00	4 093112	
B 33	3.5	4.8	5.1	.5	4.38	4.43	3	3.73	3	100	50	.22	4 520112
B 34	1.6	2.5	2.5	.2	1.31	1.31	3	.91	3	31	20	.03	4 62C112
B 35	11.9	15.6	15.7	1.6	49.39	50.80	3	24.59	3	52	200	10.16	4 512114
B 36	1.4	1.4	1.4	.2	.23	.23	3	.28	3	0	15	.00	4 650112
B 37	6.2	7.2	7.4	.9	14.51	14.91	3	9.77	3	34	125	1.87	4 513112
B 38	.8	.8	.8	.19	.19	3	.19	3	.19	3	15	.00	4 65C102
B 39	1.4	1.6	1.6	.1	.54	.54	3	.38	3	30	15	.01	4 65C112
B 40	5.6	6.5	7.0	1.1	8.16	8.46	3	6.04	3	79	125	1.00	4 530112
B 41	5.5	7.0	7.0	1.1	11.89	12.19	3	8.26	3	32	125	1.52	4 510110
B 42	2.5	2.9	2.9	.5	1.81	1.91	3	1.71	3	10	20	.04	4 655112
B 43	6.2	7.4	7.4	.5	7.86	7.86	3	6.65	3	15	125	.98	4 525112
B 44	2.8	3.4	3.4	.4	2.42	2.42	3	1.41	3	42	50	.11	4 535112
B 45	5.0	5.0	5.1	.6	4.33	4.53	3	4.33	3	4	50	.23	4 535112
B 46	.6	.6	.6	.40	.40	3	.40	3	0	15	.01	4 650102	
B 47	1.0	1.0	1.0	.60	.60	3	.60	3	0	18	.01	4 300102	
B 48	7.1	10.6	10.6	1.1	17.74	17.74	3	12.80	3	28	125	2.22	4 535112

## SURPRISE FIORD

IDENT NO.	TOTAL LENGTH			WIDTH	SURFACE AREA			AAR	DEPTH	VOLUME	TYPE		
	ABA	EXP	TOTAL		EXP	TOTAL	ABALATION						
C 1	3.4	3.4	3.4	10.48	10.48	3	5.44	3	0	30	.31	4 200102	
C 2	2.8	2.8	2.8	5.04	5.04	3	5.04	3	0	30	.15	4 200102	
C 3	3.8	5.5	5.5	2.0	18.44	18.59	3	15.67	3	16	125	2.32	4 403112
C 4	8.1	10.6	10.8	1.3	18.45	20.77	3	15.73	3	24	200	4.15	4 522112
C 5	2.6	2.6	2.6	2.87	2.92	3	2.92	3	0	20	.06	4 200112	
C 6	4.0	4.4	4.6	.6	3.75	3.83	3	2.72	3	29	50	.19	4 530112
C 7	1.5	1.9	1.9	1.41	1.41	3	1.11	3	21	20	.03	4 655112	
C 8	4.5	11.6	11.7	1.0	43.14	45.06	3	23.79	3	47	200	9.11	4 422112
C 9	4.6	7.2	7.6	.2	10.28	10.58	3	7.46	3	29	30	.32	4 205112
C 10	7.8	12.1	12.1	1.1	34.67	34.67	3	15.52	3	55	200	6.94	4 402114
C 11	5.5	10.2	10.2	.9	27.72	27.72	3	14.01	3	49	200	5.54	4 402114
C 12	4.3	5.8	5.8	1.0	9.98	9.98	3	8.37	3	16	125	1.25	4 402114
C 13	3.8	6.8	6.8	.9	17.34	17.34	3	10.89	3	37	125	2.17	4 405114
C 14	28.2	45.0	45.0	6.3	641.09	641.09	3	214.10	3	67	250	160.27	4 411114
C 15	1.4	1.9	1.9	.2	1.51	1.51	3	.81	3	46	50	.08	4 535110
C 16	.6	.6	.										

## GOOD FRIDAY BAY AND SAND BAY

IDENT	NO.	LONGITUDE	LATITUDE	U.T.M.	ORIENT	AC	AB	HIGH	ELEVATIONS	L.E.X	L.T.L	SNOW	DATE	MEAN ELEVATION
														ACCU
D	1	W 93 42.0	N 78 53.3	15XWT050574	NE NE	549	290	290	305	22	7 58	442 4	295 3	
D	2	W 93 46.0	N 78 53.5	15XWT036578	NE NE	427	274	274	305	22	7 58	366 4	290 3	
D	3	W 92 47.0	N 78 53.5	15XWT032578	NE NE	442	229	229	305	22	7 58	381 4	274 3	
D	4	W 92 48.5	N 78 53.0	15XWT042568	NE NE	935	427	427	823	22	7 58	884 4	610 3	
D	5	W 92 53.5	N 78 52.7	15XWT024561	NE NW	853	411	411	750	22	7 58	650 4	610 3	
D	6	W 92 52.0	N 78 51.2	15XWT030535	NE E	732	305	305	300	22	7 58	686 4	472 3	
D	7	W 92 57.5	N 78 50.0	15XWT010513	NW NW	972	305	305	777	22	7 58	853 4	670 3	
C	8	W 91 49.0	N 78 44.7	15XWT25716	E E	1106	564	564	823	25	7 59	1006 4	732 3	
C	9	W 91 51.5	N 78 45.0	15XWT250436	NE NE	1067	549	549	853	25	7 59	914 4	716 3	
D	10	W 91 53.0	N 78 46.5	15XWT242466	NE NE	1028	518	518	869	25	7 59	914 4	716 3	
C	11	W 91 56.0	N 78 47.0	15XWT233457	NE NE	1028	549	549	1030	25	7 59	930 4	762 3	
D	12	W 91 58.5	N 78 47.0	15XWT233457	N N	1028	442	442	930	25	7 59	960 4	732 3	
D	13	W 92 3.0	N 78 47.5	15XWT206666	N N	1006	244	183	930	25	7 59	975 4	762 3	
D	14	W 92 5.0	N 78 47.5	15XWT198465	N N	991	305	305	945	25	7 59	975 4	762 3	
C	15	W 92 7.0	N 78 47.5	15XWT192466	N N	991	427	427	945	25	7 59	975 4	792 3	
D	16	W 92 10.0	N 78 47.5	15XWT182646	N N	945	366	366	884	25	7 59	930 4	762 3	
D	17	W 92 12.0	N 78 47.0	15XWT174456	NE NE	884	244	244	853	25	7 59	869 4	640 3	
D	18	W 92 14.5	N 78 46.0	15XWT165652	NE NE	914	229	229	723	25	7 59	869 4	625 3	
D	19	W 92 24.5	N 78 45.3	15XWT129624	N N	747	411	411	610	22	7 58	686 4	533 3	
D	20	W 92 11.0	N 78 45.8	15XWT179432	S S	1057	366	366	869	25	7 59	914 4	655 3	
D	21	W 92 4.5	N 78 44.0	15XWT202411	SW SW	1057	283	183	914	25	7 59	1006 4	576 3	
D	22	W 91 55.0	N 78 43.7	15XWT239397	S SW	1106	457	457	823	25	7 59	960 4	670 3	
D	23	W 91 47.5	N 78 55.0	15XWT260607	NW NW	1485	564	564	823	28	7 59	960 4	747 3	
D	24	W 91 45.0	N 78 52.5	15XWT268575	NW NW	1372	579	579	823	28	7 59	975 4	762 3	
D	25	W 91 48.0	N 78 51.2	15XWT258539	NW NW	1372	427	427	838	28	7 59	1173 4	732 3	
D	26	W 91 47.0	N 78 45.5	15XWT263505	NW NW	1372	305	305	838	28	7 59	1082 4	686 3	
D	27	W 91 45.0	N 78 48.2	15XWT272582	NW NW	1250	290	290	777	28	7 59	930 4	610 3	
D	28	W 91 42.0	N 78 47.3	15XWT282644	NW NW	823	579	579	777	28	7 59	808 4	686 3	
D	29	W 91 41.5	N 78 46.0	15XWT285455	NW NW	823	594	594	747	28	7 59	808 4	686 3	
D	30	W 91 38.0	N 78 45.5	15XWT297438	NW NW	1204	427	427	777	28	7 59	1006 4	670 3	
D	31	W 91 38.0	N 78 44.2	15XWT299408	NW NW	1204	320	320	792	28	7 59	975 4	625 3	
D	32	W 91 39.0	N 78 43.5	15XWT295395	NW NW	1072	320	320	732	28	7 59	869 4	625 3	
D	33	W 91 41.0	N 78 42.8	15XWT288382	NW NW	1072	274	274	701	28	7 59	838 4	655 3	
D	34	W 91 50.0	N 78 41.4	15XWT256354	NW NW	1250	274	274	747	25	7 59	884 4	549 3	
D	35	W 91 57.0	N 78 41.4	15XWT230352	NE N	960	290	290	762	25	7 59	899 4	550 3	
D	36	W 92 7.5	N 78 41.8	15XWT192461	NW NW	755	610	610	762	25	7 59	670 3		
D	37	W 92 5.0	N 78 46.0	15XWT202339	NW NW	975	229	229	762	25	7 59	838 4	594 3	
D	38	W 92 2.0	N 78 35.2	15XWT214310	N W	945	427	427	914	25	7 59	925 4	640 3	
D	39	W 91 56.0	N 78 27.7	15XWT1237283	S S	1006	274	274	777	25	7 59	884 4	594 3	
D	40	W 91 44.5	N 78 38.0	15XWT278292	S S	1250	290	290	777	25	7 59	960 4	564 3	
D	41	W 91 38.0	N 78 38.3	15XWT302298	SE SE	1250	427	427	777	28	7 59	1036 4	564 3	
D	42	W 91 37.0	N 78 39.0	15XWT304310	SE SE	945	747	747	838	28	7 59	880 4	780 3	
D	43	W 91 32.0	N 78 38.0	15XWT323306	S S	1067	457	457	823	28	7 59	960 4	701 3	
D	44	W 91 25.5	N 78 38.7	15XWT348306	S S	1067	549	549	823	28	7 59	884 4	470 3	
D	45	W 91 21.0	N 78 38.8	15XWT364308	S SE	869	427	427	823	28	7 59	840 4	655 3	
D	46	W 91 22.5	N 78 38.2	15XWT358298	NE NE	655	579	579	823	28	7 59	610 3		
D	47	W 91 22.5	N 78 37.3	15XWT359280	NE NE	670	579	579	823	28	7 59	615 3		
D	48	W 91 27.5	N 78 31.7	15XWT345174	NW NW	762	366	366	823	28	7 59	579 3		
D	49	W 91 26.0	N 78 3C.0	15XWT349199	NW NW	1072	137	137	823	28	7 59	975 4	457 3	
D	50	W 91 29.5	N 78 3C.0	15XWT335159	NW NW	853	533	533	853	28	7 59	835 4	670 3	
D	51	W 91 31.0	N 78 3C.0	15XWT331151	NW NW	853	533	533	853	28	7 59	835 4	670 3	
D	52	W 91 31.5	N 78 25.2	15XWT329129	NW NW	1072	152	152	823	28	7 59	960 4	564 3	
D	53	W 91 31.5	N 78 2E.2	15XWT328114	N W	1072	427	427	823	28	7 59	960 4	670 3	
D	54	W 91 34.0	N 78 25.8	15XWT320064	NW SW	1072	274	274	686	28	7 59	884 4	564 3	
D	55	W 91 24.0	N 78 22.1	15XWT361799	SW SW	967	274	274	747	28	7 59	808 4	579 3	
D	56	W 92 46.0	N 78 26.8	15XWT051079	E E	865	244	244	411	22	7 58	610 4	335 3	
D	57	W 92 48.0	N 78 27.5	15XWT045793	NE E	701	213	213	457	22	7 58	594 4	391 3	
D	58	W 92 51.0	N 78 25.8	15XWT034063	N W	792	488	488	457	22	7 58	670 4		
D	59	W 92 51.0	N 78 25.8	15XWT034063	NW NW	823	335	335	457	22	7 58	655 4	427 3	
D	60	W 92 46.0	N 78 25.5	15XWT052056	S S	549	366	366	457	22	7 58	518 4	427 3	
D	61	W 92 42.0	N 78 25.0	15XWT068062	NE NE	610	183	183	396	22	7 58	503 4	290 3	

## STRAND FJORD

IDENT	NO.	LONGITUDE	LATITUDE	U.T.M.	ORIENT	AC	AB	HIGH	ELEVATIONS	L.E.X	L.T.L	SNOW	DATE	MEAN ELEVATION
														ABLA
E	1	W 90 41.0	N 75 6.8	15XWT487834	N N	975	808	808	1067	13	8 59	945 3		
E	2	W 90 44.0	N 75 7.0	15XWT476837	E E	1250	762	762	1067	13	8 59	1220 4	960 3	
E	3	W 90 45.0	N 75 9.0	15XWT472880	N N	716	676	676	1158	13	8 59	690 3		
E	4	W 90 47.0	N 75 8.2	15XWT466860	NW NW	1250	762	762	1158	13	8 59	1204 4	1052 3	
E	5	W 90 47.0	N 75 7.0	15XWT466864	NW NW	1250	884	884	1158	13	8 59	1204 4	1052 3	
E	6	W 90 47.0	N 75 7.0	15XWT465836	NW NW	1250	732	732	1158	13	8 59	1204 4	1036 3	
E	7	W 90 49.0	N 75 6.2	15XWT460823	N N	1250	914	914	1158	13	8 59	1204 4	1006 3	
E	8	W 90 54.0	N 75 6.9	15XWT463834	NE NE	1006	914	914	1067	13	8 59	960 3		
E	9	W 91 16.0	N 75 2.8	15XWT367753	N N	1021	495	495	1067	13	8 59	1006 3		
E	10	W 91 17.0	N 75 3.5	15XWT363788	N N	1021	495	495	1067	13	8 59	975 3		
E	11	W 91 18.0	N 75 4.2	15XWT359783	N N	1067	844	844	1067	13	8 59	975 3		
E	12	W 91 24.0	N 75 4.8	15XWT337778	NW NW	960	823	823	1067	13	8 59	930 3		
E	13	W 91 24.0	N 75 2.4	15XWT340745	N W	1128	754	754	1067	13	8 59	1097 4	991 3	
E	14	W 91 42.0	N 75 4.0	15XWT275782	N N	914	640	640	1006	28	7 59	945 3		
E	15	W 91 45.0	N 75 4.3	15XWT284782	NW NW	975	869	869	1006	28	7 59	945 3		
E	16	W 92 10.0	N 75 6.6	15XWT175313	NE NE	900	762	762	1006	25	7 59	914 3		
E	17	W 92 12.0	N 75 6.8	15XWT170024	NE NE	945	564	564	1006	25	7 59	762 3		
E</th														

## GOOD FRIDAY BAY AND SAND BAY

IDENT NO.	TOTAL LENGTH	WIDTH	SURFACE AREA	AAR	DEPTH	VOLUME	TYPE				
	ABLA EXP TOTAL		EXP TOTAL	ABALATION							
D 1	.4	1.6	1.6	.40	.40 3	.30 3	25	15	.01 4	700112	
D 2	.2	.5	.5	.10	.10 3	.05 3	50	15	.00 4	700112	
D 3	.3	.8	.8	.20	.20 3	.10 3	50	15	.00 4	700112	
D 4	1.1	1.9	1.9	2.01	2.01 3	1.51 3	25	20	.04 4	200112	
D 5	.4	1.4	1.4	1.31	1.31 3	.50 3	62	20	.03 4	650112	
D 6	1.2	1.2	1.2	1.71	1.71 3	3	100	20	.03 4	640112	
D 7	2.5	3.9	3.9	9.97	10.07 3	2.72 3	73	30	.30 4	200112	
D 8	1.4	2.5	2.5	3.73	3.73 3	1.51 3	60	50	.19 4	520112	
D 9	1.5	2.2	2.2	.6	2.32	2.32 3	1.51 3	38	.50	.12 4	530112
D 10	1.8	2.5	2.5	.9	1.41	1.41 3	1.11 3	21	50	.07 4	530112
D 11	1.9	1.9	1.9	.4	1.71	1.71 3	1.71 3	0	20	.03 4	650112
D 12	1.9	2.5	2.5	.5	1.61	1.61 3	1.21 3	25	50	.08 4	520112
D 13	2.8	3.2	3.5	.8	3.32	3.72 3	3.12 3	16	50	.19 4	400212
D 14	1.8	2.1	2.1	.1	.80	.80 3	.70 3	12	25	.02 4	400212
D 15	2.1	2.4	2.4	2.27	2.27 3	2.12 3	7	50	.11 4	403112	
D 16	1.7	2.0	2.0	2.12	2.12 3	2.02 3	5	50	.11 4	403112	
D 17	1.6	1.8	1.8	.2	1.01	1.01 3	.91 3	10	50	.05 4	530112
D 18	2.3	2.5	2.6	.5	2.41	2.56 3	1.86 3	27	50	.13 4	530112
D 19	.8	1.6	1.6	1.41	1.41 3	.49 3	72	20	.03 4	700112	
D 20	2.5	3.8	3.8	.6	4.63	4.63 3	1.51 3	67	50	.23 4	533112
D 21	5.1	6.5	6.5	.9	19.56	19.56 3	8.57 3	56	125	2.44 4	522112
D 22	1.9	2.8	2.9	.5	3.63	3.83 3	1.21 3	68	50	.19 4	530112
D 23	3.1	5.2	5.2	2.1	25.60	25.60 3	7.26 3	72	200	5.12 4	504112
D 24	1.8	6.6	6.8	8.87	8.87 3	2.45 3	72	125	1.11 4	403112	
D 25	4.1	16.2	16.2	32.06	32.06 3	13.51 3	58	200	6.41 4	435112	
D 26	4.6	10.2	10.2	32.76	32.76 3	9.27 3	72	200	6.55 4	525112	
D 27	3.5	5.6	5.6	18.85	18.85 3	6.96 3	63	125	2.36 4	535112	
D 28	1.1	1.4	1.4	1.10	1.10 3	.70 3	36	20	.02 4	650112	
D 29	.6	1.0	1.0	.40	.40 3	.20 3	50	15	.01 4	65C112	
D 30	2.4	8.0	8.0	2.5	28.23	28.23 3	9.48 3	66	200	5.65 4	421112
D 31	2.5	7.2	6.2	.9	8.46	8.56 3	2.92 3	66	125	1.07 4	535112
D 32	4.1	7.1	7.1	.8	10.99	10.99 3	3.23 3	71	125	1.38 4	405112
D 33	3.1	5.5	5.5	.9	23.88	23.88 3	5.74 3	76	200	4.78 4	402112
D 34	6.2	5.5	5.5	1.2	22.93	22.98 3	11.39 3	50	200	4.60 4	512112
D 35	2.6	3.9	3.9	.5	4.13	4.13 3	3.02 3	27	50	.21 4	520112
D 36	.9	.9	.9	.81	.81	.81 3	0	15	.01 4	300132	
D 37	4.1	5.6	5.6	.8	9.07	9.07 3	4.84 3	47	125	1.13 4	533113
D 38	2.1	2.4	2.4	.5	1.71	1.71 3	1.61 3	6	20	.03 4	650112
D 39	4.5	7.5	7.5	1.2	18.35	18.35 3	8.57 3	53	125	2.30 4	532114
D 40	2.3	5.0	5.0	.8	6.75	6.95 3	2.92 3	58	125	.87 4	530112
D 41	2.1	4.0	4.1	.5	3.53	3.83 3	1.81 3	53	50	.19 4	532112
D 42	.5	.6	.6	.30	.30 3	.20 3	33	15	.00 4	650112	
D 43	2.5	4.0	4.0	1.4	7.45	7.45 3	3.12 3	58	125	.93 4	530114
D 44	2.1	3.6	3.6	1.0	3.83	3.83 3	2.12 3	45	50	.19 4	530110
D 45	2.6	3.0	3.0	.5	2.32	2.32 3	2.22 3	4	50	.12 4	535112
D 46	.5	.5	.5	.50	.50	.50 3	0	15	.01 4	650112	
D 47	.8	.8	.8	.60	.60	.60 3	0	15	.01 4	300112	
D 48	1.0	1.0	1.0	.40	.40	.40 3	0	15	.01 4	730212	
D 49	4.4	5.6	5.6	.2	5.54	5.66 3	2.52 3	55	75	.42 4	402312
D 50	1.0	1.0	1.0	.40	.40	.60 3	.60 3	0	15	.01 4	650112
D 51	.5	.5	.5	.60	.60	.60 3	.60 3	0	15	.01 4	650112
D 52	4.8	7.8	7.8	1.5	16.33	17.03 3	8.66 3	49	125	2.13 4	400112
D 53	1.9	4.4	4.4	.6	3.02	3.02 3	1.31 3	57	50	.15 4	400112
D 54	5.4	6.5	6.5	3.02	53.22	53.22 3	31.55 3	41	200	10.65 4	403112
D 55	5.4	6.0	6.0	3.02	39.61	39.61 3	29.33 3	26	200	7.93 4	403112
D 56	.6	2.5	2.5	.4	3.02	3.02 3	.20 3	93	50	.15 4	526112
D 57	1.0	2.6	2.6	.2	2.16	2.16 3	.35 3	84	35	.08 4	650112
D 58	.8	.8	.8	1.11	1.11 3	3	100	20	.02 4	730112	
D 59	.6	1.8	1.8	1.36	1.36 3	.35 3	74	20	.03 4	650112	
D 60	.2	1.5	1.5	1.26	1.26 3	.15 3	88	20	.02 4	730112	
D 61	1.2	3.0	3.0	.5	2.82	2.82 3	.30 3	89	35	.10 4	650112

## STRAND FJORD

IDENT NO.	TOTAL LENGTH	WIDTH	SURFACE AREA	AAR	DEPTH	VOLUME	TYPE				
	ABLA EXP TOTAL		EXP TOTAL	ABALATION							
E 1	1.0	1.0	.40	.40 3	.40 3	0	15	.01 4	650102		
E 2	.6	1.2	1.2	1.91	1.91 3	.52	20	.06 4	203112		
E 3	.2	.3	.15	.15 3	.15 3	0	15	.00 4	650112		
E 4	1.0	1.4	.30	.90 3	.70 3	22	15	.01 4	650112		
E 5	.7	1.2	1.2	1.00	1.00 3	.50 3	50	.02 4	650112		
E 6	1.6	2.1	2.1	1.21	1.21 3	.81 3	33	20	.02 4	650112	
E 7	1.6	2.2	2.2	1.91	1.91 3	1.81 3	5	20	.04 4	620112	
E 8	2.2	2.2	2.2	.81	.81 3	.81 3	0	15	.01 4	700112	
E 9	.6	.6	.20	.20 3	.20 3	0	15	.00 4	650112		
E 10	.6	.6	.20	.20 3	.20 3	0	15	.00 4	650112		
E 11	.9	.9	.25	.25 3	.25 3	0	15	.00 4	650112		
E 12	.8	.8	.30	.30 3	.30 3	0	15	.00 4	650112		
E 13	1.8	6.0	6.0	13.91	13.91 3	7.16 3	48	75	1.04 4	300112	
E 14	2.2	2.2	2.2	2.02	2.02 3	2.02 3	0	35	.07 4	650112	
E 15	.6	.6	.15	.15 3	.15 3	0	15	.00 4	650112		
E 16	.9	.9	.60	.60 3	.60 3	0	15	.01 4	650112		
E 17	1.4	1.4	.70	.70 3	.70 3	0	15	.01 4	620112		
E 18	.8	.8	.30	.30 3	.30 3	0	15	.00 4	900100		
E 19	3.0	4.7	.7	7.89	8.06 3	4.84 3	39	125	1.01 4	532112	
E 20	4.6	9.1	9.1	21.57	21.77 3	12.80 3	41	200	4.35 4	426112	
E 21	4.8	8.0	8.0	16.83	17.13 3	7.76 3	55	125	2.14 4	420112	
E 22	2.8	6.5	6.5	13.21	13.21 3	3.43 3	74	125	1.64 4	430112	
E 23	1.4	1.5	1.5	1.31	1.46 3	1.01 3	31	20	.03 4	650112	
E 24	5.2	21.2	21.2	.8	43.04	43.19 3	10.23 3	76	200	8.64 4	510112
E 25	1.0	1.2	1.2	.70	.70 3	.40 3	43	15	.01 4	625112	
E 26	.6	.9	.30	.30 3	.20 3	33	15	.00 4	655112		
E 27	3.1	4.2	4.2	.5	8.77	8.77 3	3.03 3	56	50	.44 4	640113
E 28	6.5	15.8	15.8	1.5	53.93	53.93 3	17.04 3	68	200	10.79 4	432112
E 29	4.2	9.3	9.3	21.88	21.08 3	7.36 3	66	200	4.38 4	525410	
E 30	13.5	25.8	25.8	3.6	149.28	149.28 3	44.55 3	71	250	37.32 4	423110
E 31	1.0	1.2	1.2	.81	.81 3	.71 3	12	15	.01 4	650112	
E 32	.6	1.5	1.5	1.20	1.20 3	.60 3	50	20	.02 4	650112	
E 33	2.2	4.5	6.5	14.92	15.02 3	3.63 3	76	125	1.88 4	510113	
E 34	1.2	1.2	1.2	.40	.40 3	.40 3	0	15	.01 4	650112	
E 35	1.9	1.9	1.9	1.21	1.21 3	1.21 3	0	20	.02 4	650112	
E 36	2.8	3.1	3.1	.7	7.56	7.56 3	6.35 3	16	50	.38 4	620112
E 37	6.0	16.2	16.2	2.0	70.06	70.06 3	17.34 3	75	200	14.01 4	424112

FIG. 10.  
Computer print-out, Axel Heiberg Island, Good Friday Bay and Sand Bay, and Strand Fjord. (Note. For volume accuracy rating '4' read '3'.)

State, Province or Region: CANADA																													
Mountain area: AXEL HEIBERG ISLAND																													
Hydrological basin:- Ist order: WOLF FIORD																													
IIInd order:																													
IIIInd order:																													
IVth order:																													
Glacier name:																													
Sources:- ADVANCE PRINT Map, title & No: GLACIER FIORD																													
Compiled by: DEPARTMENT OF ENERGY, MINES AND RESOURCES S9E																													
Date: 1965																													
Scale: 1: 125,000																													
Contour interval: 500 ft.																													
Reliability: ± 200 ft.																													
Photographs:-																													
Type: VERTICAL 30,000 ASL																													
Serial No: A 16859 - 132																													
Date: 28/7/59																													
Remarks: NO CLOUDS																													
Literature:																													
Data compiled by: C.S.L. OMMANNEY																													
Date & organisation: 1967																													
Supervisor: F. MÜLLER, MCGILL UNIVERSITY																													
REMARKS (special geomorphological features, abnormal characteristics, if international boundary, source information on mean depth estimate, observations regarding snow line or equilibrium line from other years)																													
DRAINS ICE CAP; BRANCH ICE STREAM FLOWS OUT FROM EXPANDED FOOT INTO VALLEY TO SOUTHWEST, FORMING A SMALL OUTLET GLACIER; MAIN SNOUT STEEPLY CLIFFED WITH GLACIER DAMMED LAKE IN FRONT																													
Regional and basin identification																													
Glacier number																													
Longitude																													
Latitude																													
U.T.M.																													
Orientation: Accumulation area (8 pt. compass)																													
Ablation area (8 pt. compass)																													
Highest glacier elevation (m/a.s.l.)																													
Lowest glacier elevation: Exposed (m/a.s.l.)																													
Total (m/a.s.l.)																													
Elevation of snow line (m/a.s.l.)																													
Date of snow line																													
Mean accumulation area elevation, weighted, (m/a.s.l.)																													
*Accuracy rating (1-5)																													
Mean ablation area elevation, weighted, (m/a.s.l.)																													
*Accuracy rating (1-5)																													
Maximum length: Ablation area (km) incl. debris covered																													
Exposed (km)																													
Total (km)																													
Mean width of main ice body (km)																													
Surface area: Exposed (km²)																													
Total (km²)																													
*Accuracy rating (1-5)																													
Area of ablation (km²)																													
*Accuracy rating (1-5)																													
Accumulation area ratio (per cent)																													
Mean depth (m)																													
Volume (km³) of ice																													
*Estimated accuracy rating (1-5)																													
Classification and description (see Table 1)																													
<table border="1"> <thead> <tr> <th colspan="4">*Accuracy ratings</th> </tr> <tr> <th></th> <th>Area</th> <th>Elevations</th> <th>Volume</th> </tr> </thead> <tbody> <tr> <td>1 Excellent</td> <td>0-5%</td> <td>0-25 m</td> <td>0 - 10%</td> </tr> <tr> <td>2 Good</td> <td>5-10%</td> <td>25-50 m</td> <td>10 - 25%</td> </tr> <tr> <td>3 Fair</td> <td>10-15%</td> <td>50-100 m</td> <td>25 - 50%</td> </tr> <tr> <td>4 Acceptable</td> <td>15-25%</td> <td>100-200 m</td> <td>50 - 100%</td> </tr> <tr> <td>5 Unreliable</td> <td>&gt; 25%</td> <td>&gt; 200 m</td> <td>&gt; 100%</td> </tr> </tbody> </table>		*Accuracy ratings					Area	Elevations	Volume	1 Excellent	0-5%	0-25 m	0 - 10%	2 Good	5-10%	25-50 m	10 - 25%	3 Fair	10-15%	50-100 m	25 - 50%	4 Acceptable	15-25%	100-200 m	50 - 100%	5 Unreliable	> 25%	> 200 m	> 100%
*Accuracy ratings																													
	Area	Elevations	Volume																										
1 Excellent	0-5%	0-25 m	0 - 10%																										
2 Good	5-10%	25-50 m	10 - 25%																										
3 Fair	10-15%	50-100 m	25 - 50%																										
4 Acceptable	15-25%	100-200 m	50 - 100%																										
5 Unreliable	> 25%	> 200 m	> 100%																										

FIG. 11. Glacier inventory data sheet for Axel Heiberg Island, Wolf Fiord.

State, Province or Region: CANADA	Regional and basin identification	B																												
Mountain area: AXEL HEIBERG ISLAND	Glacier number	21																												
Hydrological basin:- GLACIER FIORD	Longitude	N 90°13.5'																												
Ist order:	Latitude	N 78°36.8'																												
IIInd order:	U.T.M.	115, X.W. T.6, 1, 2, 2, 7, 8																												
IIIrd order:	Orientation: Accumulation area (8 pt. compass)	E																												
IVth order:	Ablation area (8 pt. compass)	E																												
Glacier name:	Highest glacier elevation (m/a.s.l.)	1,410																												
Sources:- ADVANCE PRINT Map, title & No: GLACIER FIORD SFE	Lowest glacier elevation: Exposed (m/a.s.l.)	91																												
Compiled by: DEPARTMENT OF ENERGY, MINES & RESOURCES	Total (m/a.s.l.)	91																												
Date: 1965	Elevation of snow line (m/a.s.l.)	518																												
Scale: 1 : 125,000	Date of snow line	day 13 mo 8 yr 59																												
Contour interval: 500 ft.	Mean accumulation area elevation, weighted, (m/a.s.l.)	777																												
Reliability: ± 200 ft.	*Accuracy rating (1-5)	4																												
Photographs:-	Mean ablation area elevation, weighted, (m/a.s.l.)	3.35																												
Type: VERTICAL	*Accuracy rating (1-5)	3																												
Serial No: A 16840-II	Maximum length: Ablation area (km) incl. debris covered	5.0																												
Date: 13/8/59	Exposed (km)	1.05																												
Remarks: NO CLOUDS	Total (km)	1.08																												
Literature:	Mean width of main ice body (km)	9																												
Data compiled by: C.S.L. OMMANNEY	Surface area: Exposed (km <sup>2</sup> )	1.542																												
Date & organisation: 1967	Total (km <sup>2</sup> )	1.612																												
Supervisor: F. MÜLLER, MCGILL UNIVERSITY	*Accuracy rating (1-5)	3																												
REMARKS (special geomorphological features, abnormal characteristics, if international boundary, source information on mean depth estimate, observations regarding snow line or equilibrium line from other years)	Area of ablation (km <sup>2</sup> )	5.03																												
TWO MAIN STREAMS; SEVERAL DAMMED LAKES; ONE DEEP DRAINAGE CHANNEL FOLLOWING MEDIAL MORaine; LATERAL AND WELL-DEVELOPED TERMINAL MORaine, WHICH COULD BE A PUSH-MORaine	*Accuracy rating (1-5)	3																												
	Accumulation area ratio (per cent)	69																												
	Mean depth (m)	1.25																												
	Volume (km <sup>3</sup> ) of ice	20.1																												
	*Estimated accuracy rating (1-5)	3																												
	Classification and description (see Table 1)	5.2.0.1.1.2																												
<table border="1"> <thead> <tr> <th colspan="4">*Accuracy ratings</th> </tr> <tr> <th></th> <th>Area</th> <th>Elevations</th> <th>Volume</th> </tr> </thead> <tbody> <tr> <td>1 Excellent</td> <td>0-5%</td> <td>0-25 m</td> <td>0 - 10%</td> </tr> <tr> <td>2 Good</td> <td>5-10%</td> <td>25-50 m</td> <td>10 - 25%</td> </tr> <tr> <td>3 Fair</td> <td>10-15%</td> <td>50-100 m</td> <td>25 - 50%</td> </tr> <tr> <td>4 Acceptable</td> <td>15-25%</td> <td>100-200 m</td> <td>50 - 100%</td> </tr> <tr> <td>5 Unreliable</td> <td>&gt; 25%</td> <td>&gt; 200 m</td> <td>&gt; 100%</td> </tr> </tbody> </table>			*Accuracy ratings					Area	Elevations	Volume	1 Excellent	0-5%	0-25 m	0 - 10%	2 Good	5-10%	25-50 m	10 - 25%	3 Fair	10-15%	50-100 m	25 - 50%	4 Acceptable	15-25%	100-200 m	50 - 100%	5 Unreliable	> 25%	> 200 m	> 100%
*Accuracy ratings																														
	Area	Elevations	Volume																											
1 Excellent	0-5%	0-25 m	0 - 10%																											
2 Good	5-10%	25-50 m	10 - 25%																											
3 Fair	10-15%	50-100 m	25 - 50%																											
4 Acceptable	15-25%	100-200 m	50 - 100%																											
5 Unreliable	> 25%	> 200 m	> 100%																											

FIG. 12. Glacier inventory data sheet for Axel Heiberg Island, Glacier Fiord.

## B. A pilot study for an inventory of the glaciers in the Rocky Mountains

### Inventory of glaciers in the Waputik Mountains

by A. D. Stanley, Glaciology  
Sub-Division, Inland Waters Branch,  
Ottawa (Canada)

Glacier ice once covered a considerable portion of North America but is now restricted to two main areas: the Arctic Islands and the Western Cordillera. Partial inventories have been compiled for some regions by Field (1958) and Meier (1961). In preparation for a complete inventory a pilot study has been carried out for the Waputik Mountains ( $116^{\circ}30' W.$ ,  $51^{\circ}30' N.$ ), part of the Rocky Mountains.

One of the initial problems was applying a numerical system to identify the drainage basin in which a glacier is located. The guide suggests subdividing river basins into first, second and third order parts progressively upstream. However, in Canada a code system already exists for the drainage areas, established by the Water Survey of Canada. The main ocean basins are defined by a number (e.g. Pacific, 8; Arctic, 7) and smaller units within them by letters (Fig. 13). The division of basins is not uniform but in general the first letter refers to all or part of a major river basin. Further subdivisions, designated by a second letter, are not necessarily separate drainage areas of lower order. For some of the main river systems the subdivision A covers the head waters and successive areas downstream are lettered consecutively.

For the purpose of the glacier inventory the existing system of drainage area identification is adequate but it was necessary to divide the areas into smaller units (Fig. 14). Where possible the smaller units were lettered clockwise from the downstream end of the subdivision. For many

basins it was not possible to remain consistent and the first unit may not be a single drainage area. Difficulties in basin identification were accentuated in the area of the pilot study as the Waputik Mountains form part of the divide between two main river systems: the Columbia flowing westward to the Pacific and the Nelson flowing eastward.

#### *Geographic location*

In Canada the Rocky Mountains extend in a north-westerly direction from the 49th parallel for a distance of over 1,300 km to the Liard River. Much of their length forms the political boundary between the provinces of British Columbia and Alberta and the Continental Divide between main drainage basins. Part of the divide is formed by the Waputik Mountains that extend north-westward for a distance of 63 km from Lake Louise, Alberta. They cover a roughly triangular area of nearly  $900 \text{ km}^2$  with the widest section, 25 km, at the southern end. The mountains are defined by the rivers Bow and Mistaya on the east and the Blaeberry, Kicking Horse and Howser on the west. Valley floors are at an elevation of 1,500 m and steep slopes lead to ridges of 2,700 m that culminate in a number of peaks, one over 3,300 m.

Most of the higher ridges have small areas of permanent ice and snow but few valleys contain large glaciers. Wapta Icefield in the centre of the mountains is the largest ice mass and forms the accumulation for the Yoho and Daly rivers and

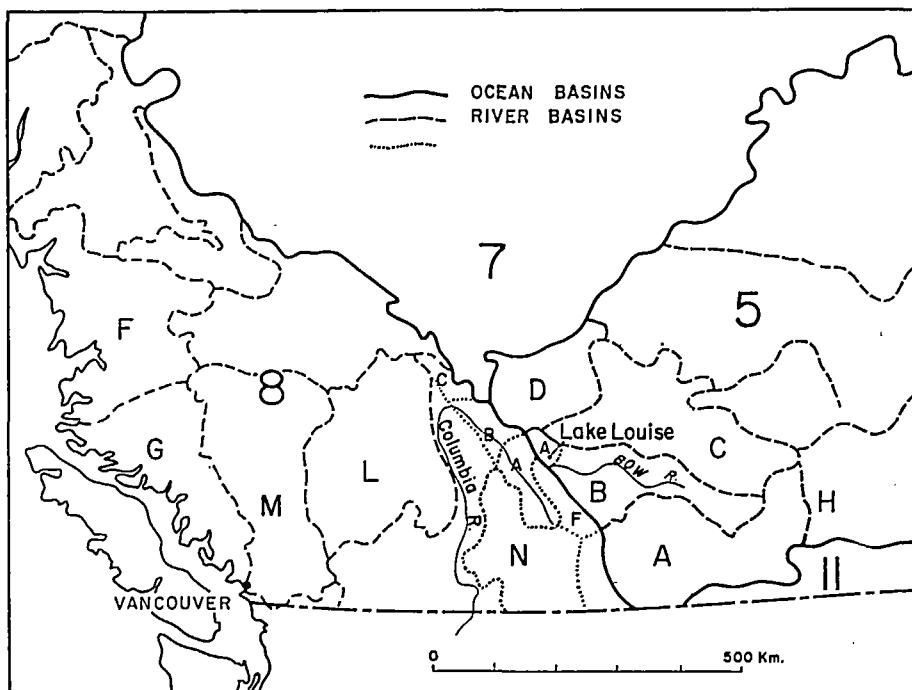


FIG. 13.  
Drainage basins in  
Canada.

for the Peyto Glacier. Peyto Glacier is now being investigated as an IHD project and detailed information is available which can be correlated with data gathered for the inventory.

#### *Climate*

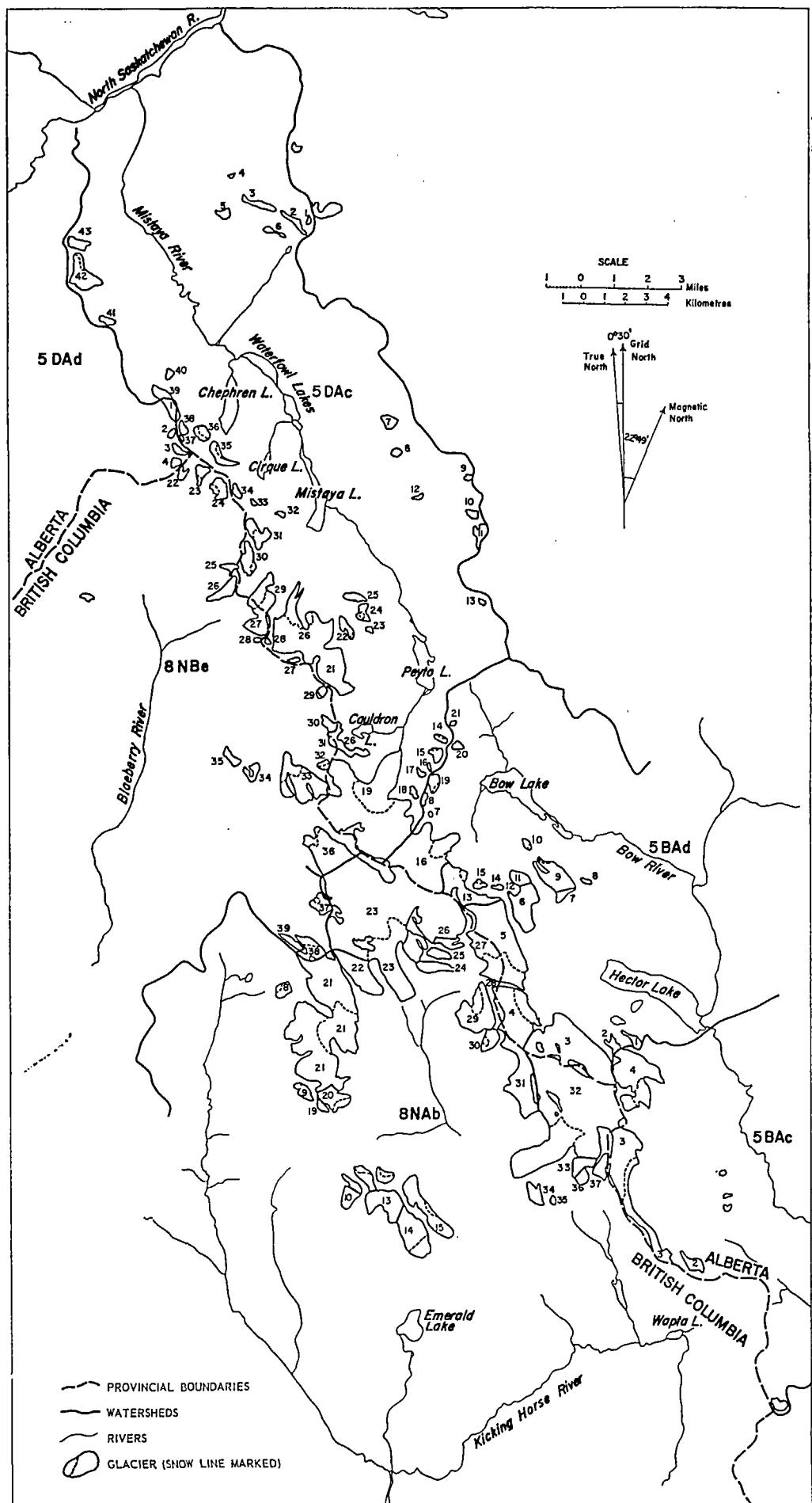
Within the general area there are no extensive bodies of open water and any moisture from the Pacific Ocean to the west must pass over 700 km of land including more than one range of high mountains. From the Pacific Ocean along a west-to-east profile to the Rocky Mountains there are a number of meteorological stations but climatic information is limited for the Waputik Mountains. There are no meteorological data for high elevations. The nearest station is in the valley at Lake Louise at an elevation of 1536 m; observations of the daily precipitation and temperature have been recorded there since 1915. For the period of record the annual precipitation averaged just under 70 cm with nearly two-thirds of it falling during the winter months from October to April. During the winter the average temperature is  $-5^{\circ}\text{C}$  and in the summer months, from May until September, the temperature is well over  $9^{\circ}\text{C}$ .

#### *Maps and aerial photographs*

Glaciers are portrayed on all maps of the Waputik Mountains. These include special maps of national parks and regular editions of the National Topographic series produced by the Surveys and Mapping Branch, Department of Energy, Mines and Resources. These maps have been published at a variety of scales including: 1 : 1,000,000; 1 : 500,000; and 1 : 250,000, but only the larger areas of ice and snow are portrayed and their outlines have been generalized. The most detailed glaciological information is given on the regular National Topographic series, printed at a scale of 1 : 50,000 with contours every 100 feet. These sheets are: Golden, 82, N/7 E; Lake Louise, 82, N/8 W; Hector Lake, 82, N/9 W; Blaeberry River, 82, N/10 E; Mistaya Lake, 82, N/15 E & W; Siffleur River, 82, N/16 W.

All these maps give excellent detail but they have been compiled from aerial photographs taken in 1949 and 1951. On some maps small glaciers have been omitted and on others areas shown as snow and ice were probably patches of snow that had not melted at the time the photographs were taken. For the glacier inventory, areas of snow

FIG. 14.  
Glacier inventory of the  
Waputik  
Mountains,  
Alberta, B.C.  
(Canada).



and ice on all maps were compared with high-level aerial photographs taken in 1966. A good coverage was obtained for glaciers along a transect from the Pacific Ocean to the Rocky Mountains including a number of IHD project glacier basins in southern British Columbia and Alberta. All photographs were taken at a height of 30,000 feet above sea level between 21 to 23 August 1966 using a Wild RC/5a camera with a focal length of 153 mm.

The photographs are very suitable for the inventory as glacier margins and termini are readily identifiable, but some of the larger glaciers have ice-cored moraines and their exact boundaries are difficult to determine. For most glaciers there is good contrast between white areas of snow and darker areas of ice and firn.

#### *Method*

For the inventory the location of glaciers on each map was compared with the distribution of snow and ice on aerial photographs. Where necessary glacier boundaries were adjusted to agree with the photographs, and small glaciers that had been omitted were sketched on the map. Geographic co-ordinates and the UTM grid are clearly shown on each map and there was no difficulty in determining the glacier location. Elevations were obtained directly from the map to the nearest 50 feet and the values converted to the metric system. Each of the initial readings is accurate to within  $\pm 75$  feet, but the metric value is a direct conversion and does not imply precision to the nearest metre. Areas were measured with a dot planimeter and a random-grid overlay; for most glaciers the error is just more than 5 per cent. The location of the snow line for each glacier was determined from inspection of aerial photographs, and that of the Peyto Glacier found to be at 2,500 m. Detailed field observations show that the transient snow line was at an average elevation of 2,500 m in late August but it rose to 2,600 m by the end of the ablation season. Thus it may be assumed that for many glaciers the highest position of the snow line in 1966 would be 100 m above the elevation given in the computer print-out.

Glacier thickness was not measured directly but estimated by comparison with depths obtained for alpine glaciers elsewhere in the world. From a general survey of published data the depths for

Table 5

Type	Area ( $\text{km}^2$ )	Average depth (m)
Valley glaciers	0-2.5	50
	2.5-5	70
	5-10	100
	10-25	150
Mountain glaciers	0-0.5	10
	0.5-2.5	25
	2.5-5	50

each of two glacier classifications has been estimated (Table 5).

During the last period of glaciation the Waputik Mountains had extensive valley glaciers. These have retreated and now all that remains are small valley glaciers and a large number of remnants. For the pilot study these have been listed as mountain glaciers for they are not glacierets and they do not conveniently fit any other description given in the guide.

These small glaciers are less than  $1 \text{ km}^2$  and occupy walls of cirques and basins or mantle the eastern slopes of the ridges. They tend to be irregular or elongate bodies parallel with the hill-side and structurally controlled by the general strike of the layered rocks that form these mountains. There are all gradations from a single basin to a cirque and it was not possible to clearly distinguish between the extremes for some glaciers.

#### *Summary*

All information compiled for the glacier inventory is given on the computer print-outs (Figs. 15 and 16), and the main data are summarized in Table 6. Within the Waputik Mountains there are 109 glaciers with a total volume of  $12 \text{ km}^3$  covering an area of  $150 \text{ km}^2$ . The glaciers range in elevation from 2,100 m to well over 3,200 m, with transient snow lines from 2,050 m to 2,650 m. AAR values are commonly 70 to 80 per cent. There appears to be no relation between the transient snow line and the size of the glacier, and many of the smaller glaciers occur on slopes at high elevations well above the transient snow line.

Table 6. Summary of glacier inventory of Waputik Mountains

Location	No.	Volume (km <sup>3</sup> )	Area (km <sup>2</sup> )	Max. size (km <sup>3</sup> )	Elevation (m)		
					Highest	Terminus	Transient snow line From      To
<b>Bow River headwaters</b>							
5 B Ac	6	.366	7.33	4.3	2 800	2 100	2 450
5 B Ad	21	1.560	26.67	5.9	2 900	2 100	2 350      2 600
<b>North Saskatchewan</b>							
5 D Ac	30	2.690	28.19	12.6	3 100	1 920	2 050
5 D Ad	4	.008	.95	.45	3 250	2 450	—
<b>Columbia River</b>							
8 N Ab	30	7.067	70.74	13.7	3 150	2 100	2 300
Columbia River							
8 N Bc	18	.495	11.93	3.2	2 750	2 200	2 250
<b>Total</b>	<b>109</b>	<b>12.186</b>	<b>145.81</b>				

### Conclusion

The directives set down in the guide of the Commission of Snow and Ice were followed in the compilation of the glacier inventory for the Waputik Mountains. This region was selected for a pilot study because it is covered by large-scale maps and recent aerial photography, which brought out more clearly difficulties inherent in the guide. The three main problems were glacier identification, classification and thickness determination.

The identification system was modified to follow the existing index of drainage basins used by the

Water Survey of Canada. The proposed classification does allow for some irregular ice masses; consequently all those that are not definitely valley glaciers have been designated mountain glaciers irrespective of their shape, size, or location. The actual term seriously influences any volume determinations, for the estimated thickness values are considerably greater for valley glaciers. Estimates used in this pilot study are considered reasonable and as the most unreliable figures are for the smaller ice masses the total value of 12 km<sup>3</sup> appears acceptable.

### References

FIELD, W. O. 1958. Geographical study of mountain glaciation in the northern hemisphere, parts 2a and 2b, New York, American Geographical Society (Mimeographed report.), p. 274, p. 108.

MEIER, M. F. 1961. Distribution and variations of glaciers in the United States, exclusive of Alaska. *General Assembly of Helsinki, IUGG* (IASH publication no. 54.), p. 420-429.

Three pilot studies: the Rocky Mountains

WAPUTIK MOUNTAINS ROCKY MOUNTAINS WESTERN CANADA

A.O. STANLEY INLAND WATERS BRANCH OTTAWA 1967

BOW RIVER HEADWATERS

IDENT NO.	LONGITUDE	LATITUDE	U.T.M.	ORIENT	ELEVATIONS			DATE	MEAN ELEVATION
					AC	AB	HIGH		
SEAC 2	W 116 20.0	N 51 24.0	11UNH546257021	N N	2347	2134	2134	22 08 66	2225 2
SEAC 3	W 116 23.0	N 51 30.5	11UNH543157063	S SE	2774	2347	2347	22 08 66	2652 2
SEAC 4	W 116 22.5	N 51 33.0	11UNH543357126	SE SE	2713	2225	2225	22 08 66	2530 2
SEAC 5	W 116 18.5	N 51 26.5	11UNH547857047	N N	2605	2499	2499	22 08 66	2591 2
SEAC 6	W 116 18.5	N 51 30.0	11UNH547857053	E E	2377	2195	2195	22 08 66	2347 2
SBAC 7	W 116 19.0	N 51 30.5	11UNH547770700	NE E	2225	2103	2103	22 08 66	2195 2
SEAC 1	W 116 22.5	N 51 34.0	11UNH543357126	N NW	2804	2225	2225	22 08 66	2682 2
SBAC 2	W 116 22.5	N 51 34.0	11UNH542357123	N NW	2774	2347	2347	22 08 66	2652 2
SEAC 3	W 116 25.0	N 51 34.0	11UNH540257126	N NW	3044	2134	2134	22 08 66	2286 2
SEAC 4	W 116 27.5	N 51 34.5	11UNH53787141	NE E	3044	2288	2288	22 08 66	2896 2
SEAC 5	W 116 27.5	N 51 35.5	11UNH537457160	SE SE	2034	2330	2330	22 08 66	2713 2
SEAC 6	W 116 27.5	N 51 37.0	11UNH537957171	SE SE	2865	2445	2445	22 08 66	2743 2
SEAC 7	W 116 25.5	N 51 37.5	11UNH539757193	S S	2743	2575	2575	22 08 66	2698 2
SBAC 8	W 116 26.0	N 51 36.0	11UNH539457202	NE NE	2377	2316	2316	22 08 66	2347 2
SEAC 9	W 116 27.0	N 51 36.5	11UNH538057217	SE E	2438	2286	2286	22 08 66	2316 2
SBAC 10	W 116 27.0	N 51 36.5	11UNH538057217	SE E	2438	2286	2286	22 08 66	2408 2
SEAC 11	W 116 27.5	N 51 36.0	11UNH537757202	NW NW	2894	2575	2575	22 08 66	2790 2
SBAC 12	W 116 27.5	N 51 37.5	11UNH537257194	NW NW	2743	2682	2682	22 08 66	2713 2
SEAC 13	W 116 30.0	N 51 31.0	11UNH534657203	N E	2924	2469	2469	22 08 66	2665 2
SEAC 14	W 116 28.0	N 51 37.5	11UNH535757198	NW NW	2591	2452	2452	22 08 66	2499 2
SEAC 15	W 116 29.0	N 51 36.0	11UNH535857198	N E	2433	2256	2256	22 08 66	2377 2
SEAC 16	W 116 20.5	N 51 35.0	11UNH533957216	N E	2774	2317	2317	22 08 66	2652 2
SBAC 17	W 116 21.0	N 51 35.5	11UNH534557233	E E	2804	2652	2652	22 08 66	2743 2
SEAC 18	W 116 21.5	N 51 40.0	11UNH532557240	E E	2896	2713	2713	22 08 66	2758 2
SEAC 19	W 116 31.0	N 51 41.5	11UNH533657246	SE E	2743	2576	2576	22 08 66	2652 2
SEAC 20	W 116 20.0	N 51 41.5	11UNH535657264	NE NE	2591	2469	2469	22 08 66	2560 2
SEAC 21	W 116 30.0	N 51 42.0	11UNH534557276	N N	2499	2377	2377	22 08 66	2438 2

NORTH SASKATCHEWAN RIVER

IDENT NO.	LONGITUDE	LATITUDE	U.T.M.	ORIENT	ELEVATIONS			DATE	MEAN ELEVATION
					AC	AB	HIGH		
SEAC 14	W 116 20.5	N 51 41.5	11UNH534057268	N N	2591	2438	2438	22 08 66	2530 2
SEAC 15	W 116 20.5	N 51 41.5	11UNH533757261	N N	2774	2545	2545	22 08 66	2652 2
SEAC 16	W 116 31.0	N 51 41.0	11UNH533457254	N N	2743	2621	2621	22 08 66	2682 2
SEAC 17	W 116 31.5	N 51 41.5	11UNH532957252	NW NW	2743	2530	2530	22 08 66	2591 2
SEAC 18	W 116 21.5	N 51 41.0	11UNH532657242	N N	2865	2469	2469	22 08 66	2652 2
SEAC 19	W 116 23.0	N 51 41.5	11UNH531257249	NE NE	3078	2042	2042	22 08 66	2621 2
SEAC 20	W 116 25.0	N 51 41.5	11UNH528957266	NE NE	2804	2560	2560	22 08 66	2652 2
SEAC 21	W 116 25.0	N 51 43.5	11UNH528857298	E E	2713	2438	2438	22 08 66	2576 2
SEAC 22	W 116 24.5	N 51 44.5	11UNH529557217	SE SE	2957	2515	2515	22 08 66	2743 2
SEAC 23	W 116 23.5	N 51 44.5	11UNH534557217	E E	2560	2484	2484	22 08 66	2530 2
SEAC 24	W 116 24.0	N 51 44.5	11UNH530157237	E E	2652	2438	2438	22 08 66	2560 2
SEAC 25	W 116 24.5	N 51 45.0	11UNH525657334	N N	2804	2438	2438	22 08 66	2652 2
SEAC 26	W 116 27.0	N 51 45.0	11UNH526657334	N N	2894	2042	2042	22 08 66	2560 2
SEAC 27	W 116 26.5	N 51 43.5	11UNH5265757303	NW NW	2957	2094	2094	22 08 66	2526 2
SEAC 28	W 116 28.0	N 51 44.0	11UNH526557313	SE E	2924	2682	2682	22 08 66	2865 2
SEAC 29	W 116 28.0	N 51 45.0	11UNH525357333	N N	2652	2256	2256	22 08 66	2530 2
SEAC 30	W 116 28.5	N 51 46.0	11UNH524657348	E E	2835	2530	2530	22 08 66	2682 2
SEAC 31	W 116 28.5	N 51 44.5	11UNH524857364	SE S	2926	2408	2408	22 08 66	2713 2
SEAC 32	W 116 27.5	N 51 47.0	11UNH526257373	NE NE	2286	2208	2208	22 08 66	2256 2
SEAC 33	W 116 20.5	N 51 47.5	11UNH524857377	NE NE	2256	2134	2134	22 08 66	2164 2
SEAC 34	W 116 29.0	N 51 46.0	11UNH524057383	SE E	2743	2469	2469	22 08 66	2652 2
SEAC 35	W 116 40.0	N 51 48.5	11UNH523357399	NW NW	2225	1920	1920	22 08 66	2085 2
SEAC 36	W 116 40.5	N 51 45.5	11UNH522557411	NE NE	2134	1981	1981	22 08 66	2103 2
SEAC 37	W 116 41.0	N 51 49.0	11UNH521557407	E E	2987	2804	2804	22 08 66	2880 2
SEAC 38	W 116 41.0	N 51 49.5	11UNH521657411	SE E	2865	2530	2530	22 08 66	2804 2
SEAC 39	W 116 42.0	N 51 51.0	11UNH520457429	NW NW	3200	2591	2591	22 08 66	2591 2
SEAC 40	W 116 42.0	N 51 51.0	11UNH525574348	NE NE	2256	2134	2134	22 08 66	2195 2
SEAC 41	W 116 44.5	N 51 52.0	11UNH517857464	NW NW	2987	2743	2743	22 08 66	2804 2
SEAC 42	W 116 45.5	N 51 53.5	11UNH516757485	N E	2804	2499	2499	22 08 66	2713 2
SEAC 43	W 116 45.5	N 51 54.0	11UNH516557499	NE NE	2743	2530	2530	22 08 66	2606 2
SEAC 44	W 116 42.0	N 51 45.5	11UNH521057422	SW SW	3261	2865	2865	22 08 66	3139 2
SEAC 45	W 116 42.0	N 51 45.5	11UNH521157410	NW NW	2896	2713	2713	22 08 66	2789 2
SEAC 46	W 116 41.5	N 51 49.0	11UNH521157403	N S	3200	2713	2713	22 08 66	2957 2
SEAC 47	W 116 41.5	N 51 46.5	11UNH521257397	N N	2743	2469	2469	22 08 66	2621 2

COLUMBIA RIVER

IDENT NO.	LONGITUDE	LATITUDE	U.T.M.	ORIENT	ELEVATIONS			DATE	MEAN ELEVATION
					AC	AB	HIGH		
SBAB 8	W 116 37.0	N 51 35.0	11UNH526357150	N N	2591	2377	2377	22 08 66	2499 2
SBAB 9	W 116 26.0	N 51 32.5	11UNH527357103	NW NW	2896	247C	247Q	22 08 66	2682 2
SBAB 10	W 116 24.5	N 51 30.0	11UNH5265657053	N E	2835	2530	2530	22 08 66	2713 2
SBAB 11	W 116 24.5	N 51 25.0	11UNH529557039	S S	2814	2438	2438	22 08 66	2591 2
SBAB 12	W 116 34.0	N 51 25.5	11UNH5303157043	N N	3048	2804	2804	22 08 66	2957 2
SBAB 13	W 116 24.0	N 51 30.0	11UNH531357048	SE SE	3109	2591	2591	22 08 66	2896 2
SBAB 14	W 116 21.5	N 51 30.5	11UNH532957031	SE SE	2957	2103	2103	22 08 66	2667 2
SBAB 15	W 116 31.5	N 51 25.5	11UNH533357046	NE NE	2621	2240	2240	22 08 66	2608 2
SBAB 16	W 116 23.0	N 51 32.5	11UNH531457062	N N	2743	2377	2377	22 08 66	2621 2
SBAB 17	W 116 24.0	N 51 31.5	11UNH530357065	NW NW	2957	2301	2301	22 08 66	2499 2
SBAB 18	W 116 34.5	N 51 32.0	11UNH5207567060	NW NW	2835	2225	2225	22 08 66	2510 2
SBAB 19	W 116 25.5	N 51 32.0	11UNH528257095	S S	3018	2835	2835	22 08 66	2926 2
SBAB 20	W 116 25.0	N 51 32.5	11UNH529057097	E E	3018	2480	2480	22 08 66	2743 2
SBAB 21	W 116 25.0	N 51 34.0	11UNH528957128	E E	2987	2240	2240	22 08 66	2591 2
SBAB 22	W 116 23.0	N 51 35.0	11UNH530757149	SE SE	2972	2498	2498	22 08 66	2728 2
SBAB 23	W 116 22.5	N 51 35.5	11UNH531757174	SE SE	3125	2149	2149	22 08 66	2652 2
SBAB 24	W 116 20.5	N 51 35.5	11UNH53257159	E E	2896	2469	2469	22 08 66	2621 2
SBAB 25	W 116 30.5	N 51 36.0	11UNH532571615	SE SE	2850	2408	2408	22 08 66	2789 2
SBAB 26	W 116 20.0	N 51 36.5	11UNH534457171	SE SF	3170	2865	2865	22 08 66	2957 2
SBAB 27	W 116 28.5	N 51 36.0	11UNH536357166	SE SF	2890	2361	2361	22 08 66	2743 2
SBAB 28	W 116 28.5	N 51 35.0	11UNH536557150	N N	2891	2377	2377	22 08 66	2530 2
SBAB 29	W 116 29.0	N 51 34.5	11UNH536571741	N N</					

Perennial ice and snow masses

COLUMBIA RIVER HEADWATERS

IDENT NO.	LONGITUDE	LATITUDE	L.T.M.	ORIENT	ELEVATIONS			DATE	MEAN ELEVATION	
					AC	AB	HIGH		L.EX	L.TL
8NBE	22	W 116 41.5	N 51 46.0	11UNH521557391	SW SW	2743	2408	2408	22 08 66	2530 2
8NBE	23	W 116 40.5	N 51 46.0	11UNH522357389	SW SW	2835	2515	2515	22 08 66	2713 2 2530 2
8NBE	24	W 116 40.0	N 51 46.0	11UNH523257384	W W	2743	2560	2560	22 08 66	2868 2 2591 2
8NBE	25	W 116 39.5	N 51 46.0	11UNH523857340	W W	2957	2591	2591	22 08 66	2835 2
8NBE	26	W 116 39.5	N 51 46.5	11UNH523457347	NW NW	2972	2591	2591	22 08 66	2743 2
8NBE	27	W 116 38.0	N 51 45.0	11UNH525157327	NW N	2987	2377	2377	22 08 66	2835 2 2418 2
8NBE	28	W 116 38.0	N 51 44.0	11UNH525157314	SW SW	2896	2743	2743	22 08 66	2819 2
8NBE	29	W 116 35.5	N 51 42.5	11UNH528157289	SW SW	2697	2545	2545	22 08 66	2621 2 2245 2
8NBE	30	W 116 35.0	N 51 42.0	11UNH528657273	NW NW	2835	2637	2637	22 08 66	2774 2 2667 2
8NBE	31	W 116 35.0	N 51 41.5	11UNH528657286	W W	2835	2698	2698	22 08 66	2774 2
8NBE	32	W 116 35.5	N 51 41.0	11UNH528257255	NW NW	2743	2591	2591	22 08 66	2713 2 2469 2
8NBE	33	W 116 26.5	N 51 46.5	11UNH527057251	NW N	3044	2179	2179	22 08 66	2652 2 2347 2
8NBE	34	W 116 28.5	N 51 46.5	11UNH524957252	N N	2774	2438	2438	22 08 66	2591 2
8NBE	35	W 116 39.0	N 51 41.0	11UNH523857258	NW NW	2839	2566	2560	22 08 66	2713 2
8NBE	36	W 116 25.5	N 51 46.0	11UNH528157217	NW NW	2835	2347	2347	22 08 66	2621 2 2438 2
8NBE	37	W 116 35.5	N 51 37.5	11UNH528157189	NW NW	3139	2637	2637	22 08 66	2819 2 2667 2
8NBE	38	W 116 26.0	N 51 36.5	11UNH527057170	N N	2713	2316	2316	22 08 66	2652 2 2408 2
8NBE	39	W 116 27.0	N 51 36.5	11UNH526757172	NE NE	2621	2438	2438	22 08 66	2530 ?

Three pilot studies: the Rocky Mountains

WAPUTIK MOUNTAINS ROCKY MOUNTAINS WESTERN CANADA

A.D. STANLEY INLAND WATERS BRANCH OTTAWA 1967

BOW RIVER HEADWATERS

IDENT NO.	TOTAL LENGTH		WIDTH	SURFACE AREA			AAR	DEPTH	VOLUME	TYPE
	ABLA	EXP TOTAL		EXP	TOTAL	ABLATION				
SBAC 2	.2	.4	.4	.34	.34	2	100	10	.003 3	600010
SBAC 3	.2	2.1	3.1	1.5	4.30	4.30	2	92	.50	.215 3
SBAC 4	1.2	3.2	3.2	.8	2.50	2.90	2	79	.50	.145 4
SBAC 5	.3	.3	.3	.06	.06	2	100	10	.001 4	600010
SBAC 6	.4	.4	.4	.2	.08	.08	2	100	10	.001 4
SBAC 7	.4	.4	.4	.2	.05	.05	2	100	10	.001 4
SBAC 8	.6	.6	.6	.27	.27	2	100	10	.003 4	644010
SBAC 9	.8	.8	.8	.31	.31	2	100	10	.003 4	603312
SUAD 3	1.5	2.5	3.9	1.2	5.90	5.20	2	71	.70	.413 3
SBAC 4	.5	2.7	2.7	.2	2.90	2.90	2	74	.70	.203 3
SBAC 5	1.3	3.2	3.2	1.0	4.90	4.90	2	79	.70	.343 4
SBAC 6	1.1	1.6	1.6	.8	1.50	1.50	2	71	.50	.008 4
SBAC 7	.5	.5	.5	.2	.25	.25	2	100	10	.002 4
SBAC 8	.4	.4	.4	.12	.12	2	100	10	.001 4	
SBAC 9	.1	1.6	1.6	.7	1.50	1.50	2	66	.25	.004 4
SBAC 10	.1	.6	.6	.2	.14	.14	2	100	10	.001 4
SBAC 11	1.0	1.6	1.6	.7	.45	.45	2	100	10	.004 4
SBAD 12	.3	.3	.3	.2	.06	.06	2	100	10	.001 4
SBAC 13	.3	2.6	2.6	.1	2.00	2.00	2	95	.25	.050 4
SBAC 14	.1	.4	.4	.11	.11	2	80	10	.001 4	640012
SBAC 15	.2	.5	.5	.27	.27	2	78	10	.003 4	640012
SBAC 16	1.6	3.1	3.1	.5	5.10	5.10	2	90	.10	.510 3
SBAC 17	.2	.2	.2	.06	.06	2	100	10	.001 4	640000
SBAC 18	.2	.2	.2	.20	.20	2	100	10	.002 4	630010
SBAD 19	.1	.7	.7	.38	.38	2	79	10	.004 4	630002
SBAD 20	.5	.5	.5	.19	.19	2	100	10	.002 4	640000
SBAD 21	.3	.3	.3	.06	.06	2	100	10	.001 4	600012

NORTH SASKATCHEWAN RIVER

IDENT NO.	TOTAL LENGTH		WIDTH	SURFACE AREA			AAR	DEPTH	VOLUME	TYPE
	ABLA	EXP TOTAL		EXP	TOTAL	ABLATION				
SDAC 14	.1	.3	.3	.12	.12	2	.03	2	75	.001 4
SDAC 15	.7	.7	.31	.31	2	.05	2	84	10	.003 4
SDAC 16	.2	.2	.06	.06	2	100	10	.001 4	600012	
SDAC 17	.6	.6	.12	.12	2	100	10	.001 4	600012	
SDAC 18	.7	.7	.16	.16	2	100	10	.002 4	630212	
SDAC 19	3.3	5.0	1.0	12.60	12.60	2	3.40	2	73	150
SDAC 20	.3	.3	.62	.62	2	100	25	.015 4	600010	
SDAC 21	1.3	1.3	2.20	2.20	2	100	25	.055 4	640011	
SDAC 22	.1	1.0	1.0	.42	.42	2	.06	2	86	10
SDAC 23	.4	.4	.12	.12	2	100	10	.001 4	640092	
SDAC 24	.5	.5	.39	.39	2	.05	2	87	10	.004 4
SDAC 25	.9	.9	.34	.34	2	100	10	.003 4	600290	
SDAC 26	2.0	4.3	.45	.45	2	.98	2	22	.70	.315 3
SDAC 27	.3	.3	.14	.14	2	100	10	.001 4	630210	
SDAC 28	.3	.3	.09	.09	2	100	10	.001 4	630010	
SDAC 29	1.5	1.7	1.15	1.15	2	.72	2	65	.50	.058 4
SDAC 30	.2	1.5	.66	.66	2	.08	2	88	.25	.016 4
SDAC 31	.8	1.4	.55	.55	2	.27	2	61	.25	.018 4
SDAC 32	.3	.3	.06	.06	2	100	10	.001 4	600000	
SDAC 33	.3	.3	.08	.08	2	100	10	.001 4	600000	
SDAC 34	.8	.8	.17	.17	2	100	10	.002 4	630000	
SDAC 35	.1	.5	.36	.36	2	.11	2	70	10	.004 4
SDAC 36	.5	.5	.34	.34	2	.19	2	44	10	.003 4
SDAC 37	.3	.3	.08	.08	2	100	10	.001 4	630000	
SDAC 38	.8	.8	.17	.17	2	100	10	.002 4	630000	
SDAC 39	1.1	1.1	.39	.39	2	100	10	.004 4	600010	
SDAC 40	.3	.3	.12	.12	2	100	10	.001 4	630000	
SDAC 41	.7	.7	.23	.23	2	100	10	.002 4	630010	
SDAC 42	.3	1.6	1.10	1.10	1	.14	2	77	.25	.275 4
SDAC 43	.5	.5	.39	.39	2	100	10	.004 4	600210	
SDAC 1	.6	.6	.45	.45	2	100	10	.004 4	600010	
SDAC 2	.2	.2	.14	.14	2	100	10	.001 4	600010	
SDAC 3	.8	.8	.22	.22	2	100	10	.002 4	600010	
SDAC 4	.5	.5	.14	.14	2	100	10	.001 4	600010	

COLUMBIA RIVER

IDENT NO.	TOTAL LENGTH		WIDTH	SURFACE AREA			AAR	DEPTH	VOLUME	TYPE
	ABLA	EXP TOTAL		EXP	TOTAL	ABLATION				
BNAB 8	.2	.8	.8	.33	.33	2	.06	2	81	.003 4
BNAB 9	.3	1.2	1.2	.30	.30	2	.08	2	74	.003 4
BNAB 10	.8	.8	.49	.49	2	100	10	.005 4	630010	
BNAB 11	1.5	1.5	.86	.86	2	100	25	.022 4	600010	
BNAB 12	.3	.3	.30	.30	2	100	10	.003 4	600010	
BNAB 13	.3	1.0	1.80	1.80	2	.09	2	95	.25	.045 4
BNAB 14	.7	2.5	2.20	2.20	2	.61	2	73	.25	.055 4
BNAB 15	.1	1.0	1.90	1.90	2	.28	2	85	.25	.048 4
BNAB 16	.2	.6	.45	.45	2	.16	2	66	10	.004 4
BNAB 17	1.5	1.5	.75	.75	2	.20	2	73	.25	.019 4
BNAB 18	1.3	1.3	.36	.36	2	.13	2	100	10	.001 4
BNAB 19	.6	.6	.14	.14	2	100	10	.001 4	600010	
BNAB 20	.3	1.7	1.19	1.19	2	.20	2	82	.25	.003 4
BNAB 21	1.5	4.6	12.10	12.80	2	3.68	2	72	100	1.280 5
BNAB 22	.3	2.2	3.2	1	70	1	.09	2	94	.25
BNAB 23	3.9	7.0	1.0	20.90	20.90	2	.440	2	79	150
BNAB 24	.4	2.1	.78	.78	2	.09	2	88	.25	.020 4
BNAB 25	2.0	2.0	.42	.42	2	.42	2	100	10	.004 4
BNAB 26	.6	.6	.33	.33	2	100	10	.003 4	600200	
BNAB 27	1.1	2.5	1.50	1.90	2	.94	2	50	.25	.048 4
BNAB 28	.3	.3	.05	.05	2	100	10	.001 4	600010	
BNAB 29	.6	2.4	2.00	2.00	2	.44	2	78	.25	.011 4
BNAB 30	.2	1.1	.59	.59	2	.06	2	90	.25	.015 4
BNAB 31	1.4	1.4	.250	.250	2	100	10	.250 4	620210	
BNAB 32	3.7	7.0	.9	13.70	13.70	2	3.50	2	74	150
BNAB 33	1.3	1.3	.59	.59	2	100	25	.015 4	600010	
BNAB 34	1.3	1.3	.36	.36	2	100	10	.004 4	630010	
BNAB 35	.4	.4	.16	.16	2	100	10	.002 4	600110	
BNAB 36	1.0	1.0	.42	.42	2	100	10	.004 4	630010	
BNAB 37	1.0	1.0	.47	.47	2	100	10	.005 4	600000	

FIG. 16.

Computer card,

Waputik Mts., Bow

River headwaters,

North Saskatchewan

River, Columbia

River headwaters.

(Note. For volume

accuracy rating '4'

read '3' and for '3'

read '2'.)

## Perennial ice and snow masses

## COLUMBIA RIVER HEADWATERS

IDENT NO.	TOTAL LENGTH	WIDTH	SURFACE AREA			AAR	DEPTH	VOLUME	TYPE	
			ABL	EXP	TOTAL					EXP
BNBE 22	.5	.5	.4	.16	.16	2	100	10	.002 4	630011
BNBE 23	.4	1.0	.5	.41	.41	2	77	10	.004 4	630012
BNBE 24	.2	.7	.7	.44	.44	2	71	10	.004 4	630012
BNBE 25	.5	.5	.4	.20	.20	2	100	10	.002 4	600310
BNBE 26	.4	.6	.8	.59	.59	2	100	25	.015 4	630310
BNBE 27	.3	1.9	.6	1.07	1.07	2	112	90	.053 4	630310
BNBE 28	.4	.4	.1	.06	.06	2	100	10	.001 4	600000
BNBE 29	.2	.5	.5	.17	.17	2	64	10	.002 4	63C110
BNBE 30	.2	1.0	.6	.33	.33	2	87	10	.003 4	600010
BNBE 31	.3	.3	.3	.09	.09	2	100	10	.001 4	600010
BNBE 32	.2	.4	.4	.17	.17	2	55	10	.002 4	650000
BNBE 33	1.2	2.5	2.5	2.70	2.70	2	84	50	.135 4	620212
BNBE 34	.7	.7	.7	.33	.33	2	100	10	.003 4	630410
BNBE 35	1.0	1.0	.2	.22	.22	2	100	10	.002 4	6CC310
BNBE 36	.5	2.3	2.3	3.21	3.21	2	90	70	.225 4	533010
BNBE 37	.3	1.2	1.2	.69	.69	2	82	25	.017 4	630310
BNBE 38	.5	1.6	1.6	.84	.84	2	67	25	.021 4	630410
BNBE 39			.2	.25	.25	2	100	10	.003 4	600000

State, Province or Region: ALBERTA Mountain area: CANADA	Regional and basin identification Glacier number Longitude Latitude U.T.M.	1.5.8.1.8 1.5. N. 111°29.0' N. 51°38.0' 1.1.1.0.1.5.3.5.8.5.7.1.9.8.																												
Hydrological basin:- Ist order: NELSON RIVER IIInd order: SOUTH SASKATCHEWAN RIVER IIIrd order: BOW RIVER IVth order: BOW LAKE	Orientation: Accumulation area (8 pt. compass) Ablation area (8 pt. compass)	N																												
Glacier name:	Highest glacier elevation (m/a.s.l.)	2,438																												
Sources:- Map, title & No: HECTOR LAKE 80N/9W Compiled by: DEPARTMENT OF ENERGY MINES AND RESOURCES Date: 1961 Scale: 1:50,000	Lowest glacier elevation: Exposed (m/a.s.l.) Total (m/a.s.l.)	2,256 2,256																												
Contour interval: 100 ft. Reliability: ± 50 ft.	Elevation of snow line (m/a.s.l.) Date of snow line	2,316 day 32 mo. 8 yr. 6.6																												
Photographs:- Type: VERTICAL 30,000 ASL Serial No: A 19685-152 Date: 22/8/66	Mean accumulation area elevation, weighted, (m/a.s.l.) *Accuracy rating (1-5)	2,377 2																												
Remarks:	Mean ablation area elevation, weighted, (m/a.s.l.) *Accuracy rating (1-5)	2,286 2																												
Literature:	Maximum length: Ablation area (km) incl. debris covered Exposed (km) Total (km)	2 2 2																												
Data compiled by: K. SEDGWICK Date & organisation: AUGUST 1967	Mean width of main ice body (km)	2																												
Supervisor: A. STANLEY, INLAND WATERS BRANCH REMARKS (special geomorphological features, abnormal characteristics, if international boundary, source information on mean depth estimate, observations regarding snow line or equilibrium line from other years)	Surface area: Exposed (km²) Total (km²)	2.7 2.7																												
GLACIER LIES IN A SMALL BASIN ON NORTH FACE OF ST. NICHOLAS PEAK	*Accuracy rating (1-5)	2																												
	Area of ablation (km²) *Accuracy rating (1-5)	0.6 2																												
	Accumulation area ratio (per cent)	7.8																												
	Mean depth (m)	1.0																												
	Volume (km³) of ice *Estimated accuracy rating (1-5)	0.003 4																												
	Classification and description (see Table 1)	6.4.0.0.0.2																												
<table border="1"> <thead> <tr> <th colspan="4">*Accuracy ratings</th> </tr> <tr> <th></th> <th>Area</th> <th>Elevations</th> <th>Volume</th> </tr> </thead> <tbody> <tr> <td>1 Excellent</td> <td>0-5%</td> <td>0-25 m</td> <td>0 - 10%</td> </tr> <tr> <td>2 Good</td> <td>5-10%</td> <td>25-50 m</td> <td>10 - 25%</td> </tr> <tr> <td>3 Fair</td> <td>10-15%</td> <td>50-100 m</td> <td>25 - 50%</td> </tr> <tr> <td>4 Acceptable</td> <td>15-25%</td> <td>100-200 m</td> <td>50 - 100%</td> </tr> <tr> <td>5 Unreliable</td> <td>&gt; 25%</td> <td>&gt; 200 m</td> <td>&gt; 100%</td> </tr> </tbody> </table>			*Accuracy ratings					Area	Elevations	Volume	1 Excellent	0-5%	0-25 m	0 - 10%	2 Good	5-10%	25-50 m	10 - 25%	3 Fair	10-15%	50-100 m	25 - 50%	4 Acceptable	15-25%	100-200 m	50 - 100%	5 Unreliable	> 25%	> 200 m	> 100%
*Accuracy ratings																														
	Area	Elevations	Volume																											
1 Excellent	0-5%	0-25 m	0 - 10%																											
2 Good	5-10%	25-50 m	10 - 25%																											
3 Fair	10-15%	50-100 m	25 - 50%																											
4 Acceptable	15-25%	100-200 m	50 - 100%																											
5 Unreliable	> 25%	> 200 m	> 100%																											

FIG. 17. Glacier inventory data sheet for Waputik Mts., Nelson River, South Saskatchewan River, Bow River, Bow Lake.

Perennial ice and snow masses

State, Province or Region: CANADA  
 Mountain area: BRITISH COLUMBIA  
 Hydrological basin:-  
     Ist order: COLUMBIA RIVER  
     IIInd order: BLAEBERRY RIVER  
     IIIrd order: EBON CREEK  
     IVth order:  
 Glacier name:  
 Sources:-  
     Map, title & No: MISTAYA LAKE  
     82 N/ISE  
     Compiled by: DEPARTMENT OF  
     ENERGY, MINES AND RESOURCES  
     Date: 1962  
     Scale: 1:50,000  
     Contour interval: 100 ft.  
     Reliability: ± 50 ft  
 Photographs:-  
     Type: VERTKAL 39 000 ASL  
     Serial No: A 1968S-158  
     Date: 22/8/66  
 Remarks:  
 Literature:  
 Data compiled by: K. SEDGWICK  
 Date & organisation: 1967  
 Supervisor: A. STANLEY  
                   INLAND WATERS BRANCH  
 REMARKS (special geomorphological features, abnormal characteristics, if international boundary, source information on mean depth estimate, observations regarding snow line or equilibrium line from other years)

This GLACIER IS A WELL-  
DEFINED CIRQUE ON WEST  
 FACE OF MIDWAY PEAK

Regional and basin identification	8 N/ISE
Glacier number	124
Longitude	W 116° 40.0'
Latitude	N 51° 48.9'
U.T.M.	1110N H 523257384
Orientation: Accumulation area (8 pt. compass)	W
Ablation area (8 pt. compass)	W
Highest glacier elevation (m/a.s.l.)	2743
Lowest glacier elevation: Exposed (m/a.s.l.)	2560
Total (m/a.s.l.)	2560
Elevation of snow line (m/a.s.l.)	2621
Date of snow line	22/8/66
Mean accumulation area elevation, weighted, (m/a.s.l.)	2868
*Accuracy rating (1-5)	2
Mean ablation area elevation, weighted, (m/a.s.l.)	2591
*Accuracy rating (1-5)	2
Maximum length: Ablation area (km) incl. debris covered	3
Exposed (km)	1.7
Total (km)	1.7
Mean width of main ice body (km)	1.1
Surface area: Exposed (km <sup>2</sup> )	4.4
Total (km <sup>2</sup> )	4.4
*Accuracy rating (1-5)	2
Area of ablation (km <sup>2</sup> )	1.2
*Accuracy rating (1-5)	2
Accumulation area ratio (per cent)	71
Mean depth (m)	1.0
Volume (km <sup>3</sup> ) of ice	0.4
*Estimated accuracy rating (1-5)	4
Classification and description (see Table 1)	6.3.0.0.1.2

\*Accuracy ratings

	Area	Elevations	Volume
1 Excellent	0-5%	0-25 m	0 - 10%
2 Good	5-10%	25-50 m	10 - 25%
3 Fair	10-15%	50-100 m	25 - 50%
4 Acceptable	15-25%	100-200 m	50 - 100%
5 Unreliable	> 25%	> 200 m	> 100%

FIG. 18. Glacier inventory data sheet for Waputik Mts., Columbia River, Blaeberry River, Ebon Creek.

## C. A pilot study for an inventory of the glaciers in the Eastern Himalayas

### Inventory of glaciers in the Mount Everest region

by Fritz Müller, McGill  
University, Montreal  
(Canada)

The Mount Everest region in eastern Nepal ( $28^{\circ}$  N.,  $87^{\circ}$  E.) (Figs. 19 and 20) was chosen as a test area for the glacier inventory for several reasons: (a) it contains a multitude of glacier types, some common and some unusual; (b) maps of different scale and quality are available; (c) the author's field observations and familiarity with some of the glaciers in the area (Müller, 1959) permitted an evaluation of the inventory data; and (d) there is a practical importance in glaciated mountains near heavily populated areas for hydrological, climatological and other reasons.

#### *Physiography*

This test area (Fig. 21) covers the highest mountain group in the eastern Himalayas and, for that matter, in the world. It contains three mountains with an elevation of more than 8,000 m, including Mt. Everest (8,848 m), and some 75 peaks of more than 6,500 m. The lowest point lies at 3,500 m but the main valley bottoms are at an elevation of 4 to 5,000 m.

There are only two S.-N. gaps in this part of the mountain chain, the Nangpa La (5,716 m) and the Lho La (6,006 m); the former serves occasionally as a trade route between India and China. The neighbouring hills to the north, edging the Tibetan Plateau (mean height about 5,000 m), are of markedly different nature, whereas to the south of the area, though elevations are somewhat lower,

the character is essentially the same, with, however, many more, and deeper, S.-N. gaps, produced by the south-oriented drainage system.

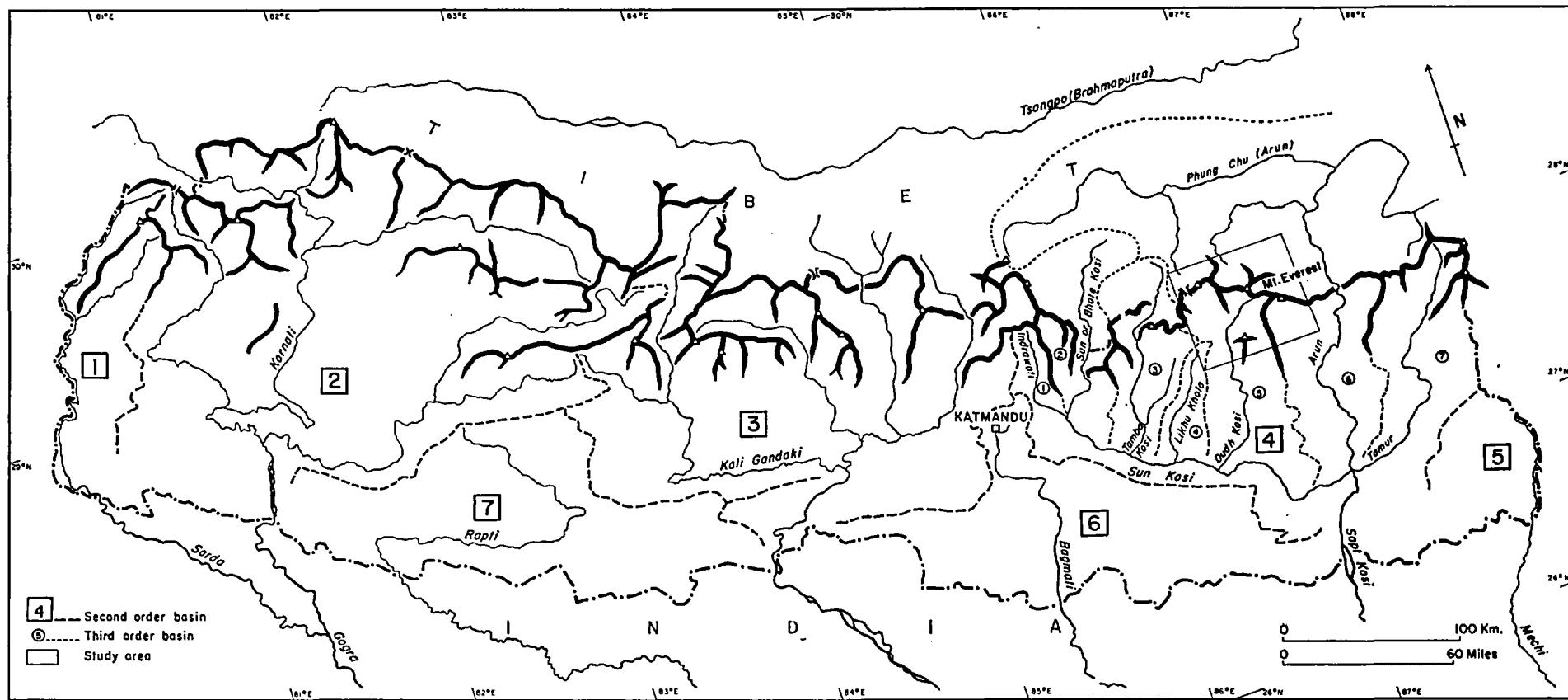
Comprehensive accounts of the geology of eastern Nepal have been given attention by Lombard (1958), Hagen (1959) and others.

There is little climatic data for the area. The only weather station, operating continuously since 1957 and intermittently before that, is located at Namche Bazar at 3,440 m, too low to be representative for the main valleys and the glaciated heights. For these there are only some sporadic weather data collections from expedition stations which operated for short periods. At a station established in 1956 at 5,300 m above sea level near the Khumbu Glacier the precipitation total for an 8 months' period (including the whole of the monsoon season) was found to amount to only 39 cm of water, testifying to an unexpectedly great aridity in the Everest region. This finding is in good agreement with (a) the small size and low surface velocity of the glaciers and (b) the vast quantities of debris covering most of the ablation areas, forming huge lateral and terminal moraines and blanketing the lower slopes and valley floors.

Three former glacier positions are evidenced in the area:

1. A well-developed, sub-recent stage in which the valley glacier termini were very close to the present positions. The mass loss of the recent decades led mainly to a thinning of the larger glaciers and only the smaller, usually steeper

FIG. 19.  
Drainage basins in Nepal.



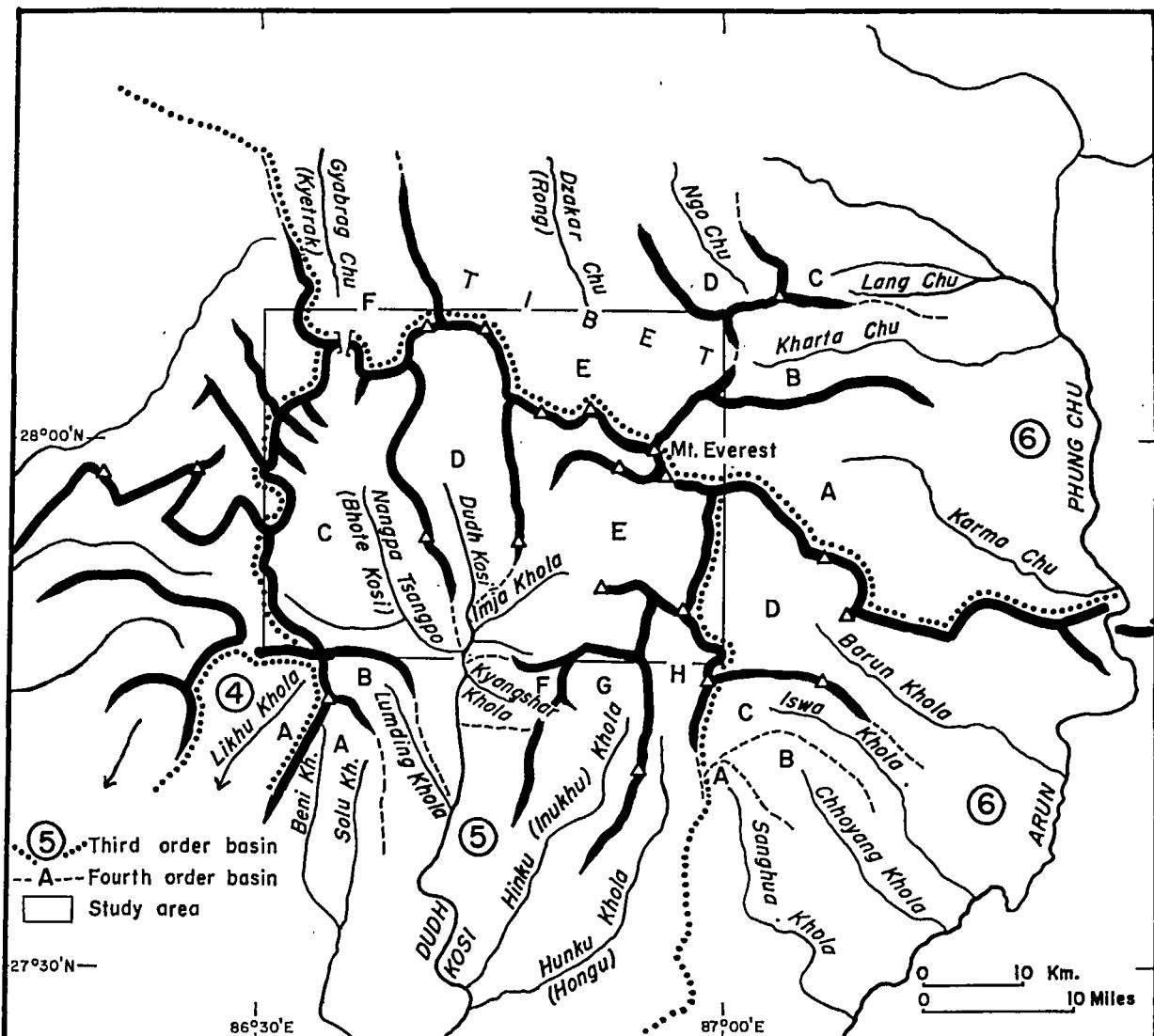


FIG. 20. Drainage basins in the Mt. Everest region.

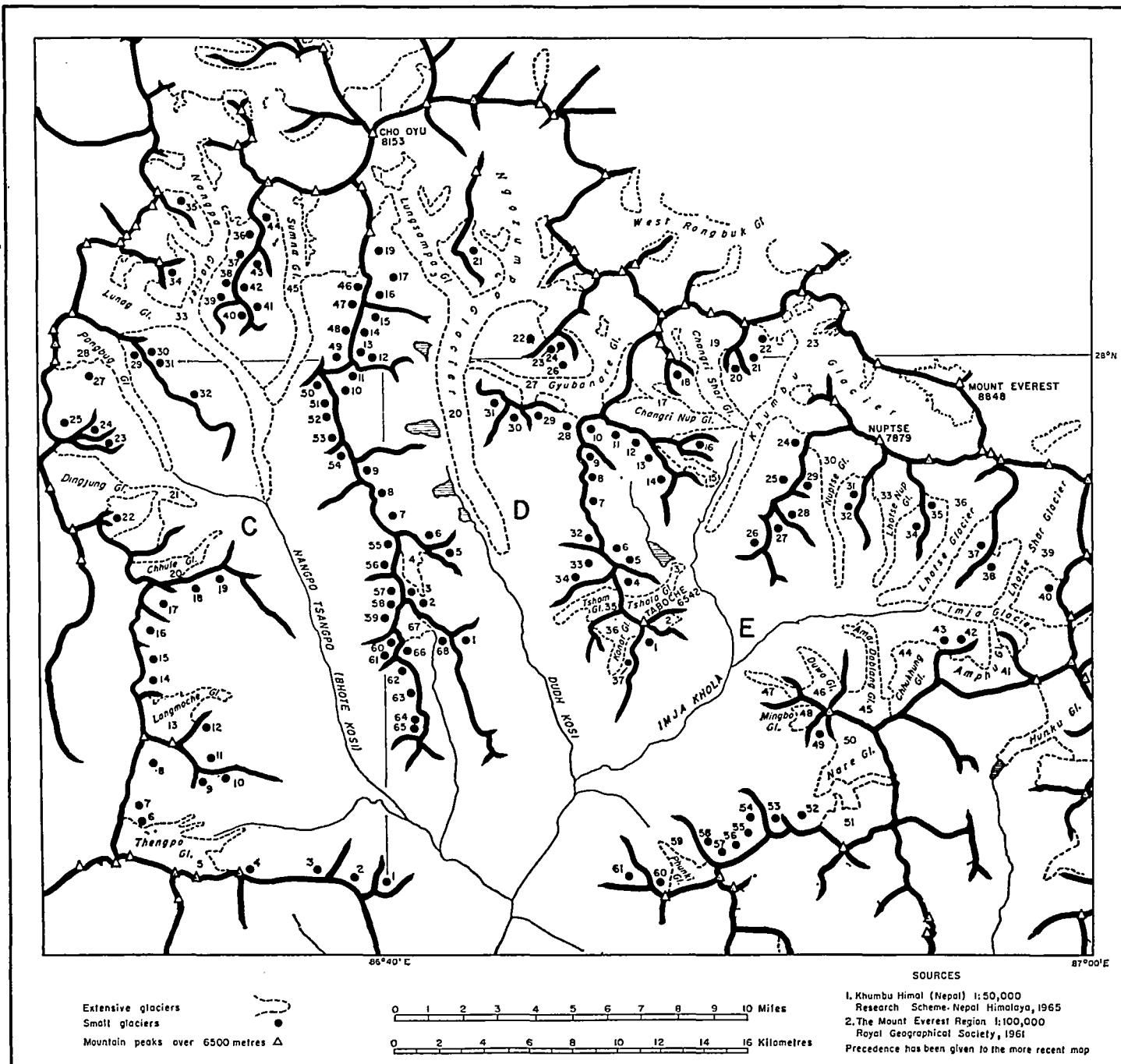


FIG. 21. The glaciers of the Mount Everest region.

Table 7. Drainage basins with glaciers on 1 : 100,000 map (RGS) of the Mount Everest region

Basin	Political division	Order of drainage basins				No. of glaciers per basin
		1st	2nd	3rd	4th	
Likhu Khola	NE <sup>1</sup>	A <sup>2</sup>	4	4	A	5
Beni-Solu Khola	NE	A	4	5	A	3
Lumding Khola	NE	A	4	5	B	12
Nangpa (Bhote Kosi) <sup>3</sup>	NE	A	4	5	C	68
Dudh Kosi <sup>3</sup>	NE	A	4	5	D	35
Imja Khola <sup>3</sup>	NE	A	4	5	E	61
Kyangshar Khola	NE	A	4	5	F	5
Hinku (Inukhu) Khola	NE	A	4	5	G	20
Hunku (Hongu) Khola	NE	A	4	5	H	40
Sangkhuwa Khola	NE	A	4	6	A	2
Chhoyang Khola	NE	A	4	6	B	3
Iswa Khola	NE	A	4	6	C	5
Barun Khola	NE	A	4	6	D	37
Karma Chu	TB <sup>4</sup>	A	4	6	A	29
Kharta Chu	TB	A	4	6	B	20
Lang Chu	TB	A	4	6	C	1
Ngo Chu	TB	A	4	6	D	29
Dzakar (Rong) Chu	TB	A	4	6	E	61
Gyabrag (Kyetrak) Chu	TB	A	4	6	F	13

1. NE = Nepal.

2. A = Ganges.

3. Basins included in study.

4. TB = Tibet.

Table 8. Some statistics for the glaciers in the three basins of the pilot study

Subject	Nangpo (Bhote Kosi)	Dudh Kosi	Imja Khola
Total area of basin (km <sup>2</sup> )	452	279	440
Number of glaciers, total	68	35	61
Number of glaciers > 5 km in length	5	2	8
Number of glaciers < 1 km in length	29	13	15
Glacierized area (km <sup>2</sup> )	106	100	154
Glacierized area in % of basin area	23	36	35
Number of glaciers > 1.0 km <sup>2</sup>	20	9	23
Largest glacier:			
length (km)	19.2	21.0	18.2
area (km <sup>2</sup> )	30.5	65.3	33.8
volume (km <sup>3</sup> )	3.0	10.5	3.4
Total ice volume (km <sup>3</sup> )	6.0	12.1	9.8
Mean elevation of:			
accu. area (m)	5 740	5 690	5 860
snow line (m)	5 540	5 530	5 580
abla. area (m)	5 350	5 380	5 320

ones have detached themselves noticeably from the '1850' moraines.

2. A prehistoric glacier position (Daun ?) left well-preserved large-size moraines some few kilometres downstream from the present termini.
3. Isolated remnants show an even older, somewhat more extensive, glacier position but even this does not alter the impression that the Mt. Everest region has not supported large glaciers during at least the latter part of the Pleistocene.

#### The present glacier in the test area

Before it was possible to label the 164 glaciers in the three drainage basins to the south-west of Mt. Everest it was found necessary first to apply the guide's identification system to the whole of Nepal (Fig. 19), then to subdivide the second-order basins further into third- and fourth-order units as shown in Figure 20 and Table 7. The glaciers of the three basins, numbered clockwise, are presented in Figure 21, the 'index map'. Table 8 gives some statistics on these basins and glaciers.

The majority of the glaciers are very small: only 7 have a surface area of more than 10 km<sup>2</sup>, while 68 per cent of them measure less than 1 km<sup>2</sup>. Only one glacier, the Ngozumpa, occupies any considerable length of a main valley. Some 30 glaciers could be called valley glaciers, but most of them lie in small side valleys and only 6 reach the floor of a main valley. A large number of the medium and smaller sized ice masses occupy either cirques or form ice aprons and hanging glaciers on the steep and expansive mountain flanks.

The full inventory data for the 167 glaciers are included with this paper in the form of computer print-out sheets reduced to page size (Figs. 22 to 27). For each glacier an individual data sheet was compiled, two of which (C20 and E23) are shown in Figures 25 and 26.

#### Source material

Four different sets of maps and photographs were used for this inventory. They are:

1. Schneider (1957): Mahalangur Himal (1 : 25,000), contour interval 20 m. Covering almost all of the Khumbu-Imja basin; particulars of this map are described by E. Schneider (1959). Schneider very kindly provided original-size copies of his high-quality 1955 terrestrial photogrammetry photographs for the entire area of this map.
2. Schneider (1965): Khumbu Himal (1 : 50,000), contour interval 40 m. Based on 1955 to 1963 terrestrial photogrammetry; excellent quality; covers all three test basins. The measurements for most data sheets were extracted from this map.
3. Royal Geographical Society (1961): the Mount Everest Region (1 : 100,000), contour interval 100 m. Compiled from various published and unpublished sources; strongly varying quality. The Royal Geographical Society made available unpublished photographs and original large-scale maps from many expeditions.
4. Survey of India (1930): Nepal-Tibet (1 in. to 4 miles), contour interval 1,000 ft. Indicates only the major glaciers in approximate form lines.

In addition a large number of unpublished expedition photographs, both single and panoramic, were provided by the Swiss Foundation for Alpine Research, Zürich.

#### *Problems of obtaining the data*

##### *Area delineation*

A comparison of the photographs and the map of a glacier frequently illustrated the arbitrary decisions forced on both the cartographer and the inventory maker when delineating the perennial ice mass. The difficulties are numerous in both the accumulation and the ablation areas: separating seasonal snow from perennial ice; connecting hanging glaciers (feeding ice avalanches) to a glacier body lower separated by a large rock wall; distinguishing between debris-covered ice and morainic deposits, etc. The area measurements were carried out with a dot planimeter and a random grid overlay; the measuring error is less than 5 per cent for the glaciers larger than 0.5 km<sup>2</sup>, but increases considerably for the smaller ones.

#### *Snow-line assessment*

For only a few glaciers were field observations of the snow line available. It was found impossible to extract reliable snow-line data from the photographs except in a few cases. Therefore, it was decided to follow the suggestions made by von Wissman (1959, p. 48-55) for establishing an approximate elevation of the climatic firn line. Usually a combination was used of the value gained with the Höfer method and those obtained by studying the changes in configuration of the contour lines and by establishing the highest elevation of morainic material on the surface. It is self-evident that many individual values for the firn-line elevation and subsequently the mean elevations for the accumulation and ablation areas are in considerable error.

#### *Mean ice-depth estimates*

There are no measurements of ice thickness for any of the glaciers in the area. Table 9, listing estimated depth values for different types and sizes of glaciers,

Table 9. Mean glacier-depth estimates

Type	Area (km <sup>2</sup> )	Depth (m)
Valley glacier	Compound basins	1-10
		10-20
		20-50
		50-100
	Compound basins	1-5
		5-10
		10-20
		20-50
		50-100
	Simple basins	1-5
		5-10
		10-20
Mountain glacier, cirque	0-1	20
	1-2	30
	2-5	50
	5-10	90
	10-20	120
Glacieret and snow-fields	0-0.5	10
	0.5-1	15
	1-2	25

1. Individual adjustments needed.

was inferred from a critical analysis of all glacier-depth measurements known to the author for the Karakoram Mts. and the Alps. Table 9 was not rigidly adhered to; for about half of the cases individual adjustments were made.

The assessments of the firn line and the estimates of the mean ice-depth values, as well as some of the area delineations, were carried out by the author.

### Conclusion

The difficulties encountered in making a glacier inventory of a selected area near Mount Everest are: (a) those inherent in the mapping of glacierized areas; (b) those generally met in the assessment of the firn line; and (c) those due to the lack or scarcity of glacier-depth data. The suggestions made by the guide were easily followed and led to results for an acceptable accuracy, and thus of practical and scientific meaning.

### References

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## NANGPO TSANGPO (BHOTE KOSI)

**FIG. 22.**  
**Computer card,**  
**Mount Everest**  
**region, Nangpa**  
**(Bhote Kosi), Dudh**  
**Kosi.**

IDENT NO.	LONGITUDE	LATITUDE	U.T.M.	ORIENT	AC	AB	HIGH	ELEVATIONS	DATE	MEAN ELEVATION
					L.E.X	L.T.L	SNOW	ACCU	ABLA	
NEA45C 0	E 86 39.3	N 27 47.5		E E	6093	5010	5010	5350		5650 3 5200 2
NEA45C 1	E 86 39.7	N 27 47.0		NE NE	5400	4640	4640	5040		5200 3 4800 2
NEA45C 2	E 86 38.5	N 27 47.8		N N	6187	4700	4700	5400		5720 3 5100 3
NEA45C 3	E 86 28.0	N 27 46.9		NE NE	6120	4620	4620	5250		5600 3 4920 3
NEA45C 4	E 86 36.0	N 27 46.3		NE NE	6500	5460	5460	5460		6000 3 4800 3
NEA45C 5	E 86 34.0	N 27 45.0		NE E	6718	4470	4300	5450		5920 3 4960 3
NEA45C 6	E 86 33.9	N 27 45.8		NE E	5673	4960	4900	5450		5560 2 5160 3
NEA45C 7	E 86 33.2	N 27 45.9		E E	6215	4970	4920	5550		5800 3 5240 2
NEA45C 8	E 86 33.6	N 27 51.0		SE SE	6940	5160	5160	5750		6300 3 5470 3
NEA45C 9	E 86 34.9	N 27 50.5		S S	6180	5120	5120	5600		5990 2 5320 2
NEA45C 10	E 86 35.5	N 27 51.5		E SE	6060	5040	5040	5550		5840 2 5240 3
NEA45C 11	E 86 35.1	N 27 51.1		NE NE	6650	4900	4900	5500		5920 3 5190 3
NEA45C 12	E 86 34.9	N 27 51.7		E E	6010	5400	5400	5500		5620 3 5450 2
NEA45C 13	E 86 34.0	N 27 52.0		NE E	6940	4490	4410	5500		6200 3 4850 2
NEA45C 14	E 86 33.2	N 27 52.3		NE E	6640	4960	4960	5500		6000 3 5120 2
NEA45C 15	E 86 33.7	N 27 52.3		E E	6940	5100	5100	5560		5700 3 5360 2
NEA45C 16	E 86 33.6	N 27 54.0		SE SE	6293	5910	5910	5640		5940 3 5470 2
NEA45C 17	E 86 34.0	N 27 54.5		SE SE	6263	5260	5260	5680		5760 4 5520 3
NEA45C 18	E 86 34.9	N 27 55.0		E S	6000	5160	5160	5620		5690 3 5490 3
NEA45C 19	E 86 35.9	N 27 55.1		SE SE	5700	5280	5280	5610		5680 3 5440 3
NEA45C 20	E 86 33.5	N 27 55.5		E NE	5880	5040	4850	5560		5760 3 5150 3
NEA45C 21	E 86 32.6	N 27 51.3		E E	6801	5130	4850	5400		5800 3 5200 3
NEA45C 22	E 86 32.2	N 27 56.5		NE NE	6200	5200	5200	5500		5840 3 5360 2
NEA45C 23	E 86 32.0	N 27 56.4		E E	5680	5410	5410	5580		5630 2 5495 2
NEA45C 24	E 86 32.1	N 27 56.7		E E	5620	5390	5390	5520		5570 2 5455 2
NEA45C 25	E 86 31.1	N 27 55.0		E E	6320	5240	5160	5530		6000 3 5560 3
NEA45C 26										
NEA45C 27	E 86 32.1	N 28 CC.G		S S	5990	5390	5370	5600		5660 3 5440 3
NEA45C 28	E 86 32.5	N 28 CC.6		SE SE	6716	5280	5020	5600		6160 3 5110 3
NEA45C 29	E 86 33.3	N 28 CC.4		SE S	5580	5340	5340	5560		5570 3 5450 2
NEA45C 30	E 86 33.7	N 28 CC.4		N N	5720	5270	5270	5640		5560 2 5335 2
NEA45C 31	E 86 33.9	N 28 CC.2		NE N	5777	5240	5240	5550		5660 2 5490 2
NEA45C 32	E 86 34.8	N 27 55.5		N N	5530	5300	5300	5450		5490 2 5380 2
NEA45C 33	E 86 35.0	N 27 CC.0		S S	7352	5120	4500	5800		6200 4 5160 3
NEA45C 34	E 86 24.2	N 26 CC.5		SE SE	6777	5330	5330	6100		6200 3 5800 3
NEA45C 35	E 86 24.5	N 26 CC.1		SE E	6590	5310	5310	5850		6060 3 5560 2
NEA45C 36	E 86 36.5	N 28 CC.3		SK SW	5700	5260	5260	5500		5500 3 5310 2
NEA45C 37	E 86 36.4	N 26 CC.8		SK W	6296	5350	5350	5700		5940 3 5490 2
NEA45C 38	E 86 35.8	N 26 CC.1		W W	5640	5310	5310	5500		5570 3 5390 2
NEA45C 39	E 86 35.6	N 26 CC.8		W W	5410	5220	5220	5400		5405 3 5280 2
NEA45C 40	E 86 36.3	N 26 CC.4		E E	5480	5310	5310	5450		5465 2 5395 2
NEA45C 41	E 86 35.5	N 26 CC.9		N N	5560	5330	5330	5480		5500 2 5610 2
NEA45C 42	E 86 36.2	N 26 CC.5		NE NE	5650	5450	5450	5520		5585 3 5490 2
NEA45C 43	E 86 36.1	N 26 CC.5		S S	6296	5380	5380	5100		6080 3 5520 3
NEA45C 44	E 86 36.8	N 28 CC.6		SE SE	6040	5480	5480	5800		5860 3 5570 2
NEA45C 45	E 86 37.7	N 28 CC.0		S S	7352	5210	4840	5750		6320 4 5240 3
NEA45C 46	E 86 39.4	N 28 CC.2		SK SK	5580	5230	5230	5500		5540 3 5360 2
NEA45C 47	E 86 39.3	N 23 CC.6		W W	5420	5120	5120	5500		5220 3 5220 3
NEA45C 48	E 86 39.1	N 23 CC.9		N N	5927	5390	5390	5640		5730 2 5520 2
NEA45C 49	E 86 39.7	N 22 CC.4		N N	5977	5240	5240	5440		5600 3 5360 2
NEA45C 50	E 86 36.3	N 27 55.9		S S	5977	5600	5600	5400		5880 2 5710 2
NEA45C 51	E 86 38.5	N 27 55.2		NW NW	5660	5320	5320	5500		5590 2 5600 2
NEA45C 52	E 86 38.5	N 27 55.0		W W	5740	5240	5240	5600		5600 2 5610 2
NEA45C 53	E 86 38.2	N 27 56.5		NW NW	5855	5190	5190	5400		5800 2 5320 2
NEA45C 54	E 86 28.4	N 27 56.1		S SK	5355	5440	5440	5600		5670 2 5520 2
NEA45C 55	E 86 40.0	N 27 55.8		W W	5906	5240	5240	5400		5649 3 5240 2
NEA45C 56	E 86 40.0	N 27 55.5		SH SH	5800	5340	5340	5550		5660 2 5460 2
NEA45C 57	E 86 40.1	N 27 54.8		SH SH	6186	5020	5020	5300		5700 3 5240 2
NEA45C 58	E 86 40.1	N 27 54.4		W W	6186	5360	5360	5600		5780 3 5430 2
NEA45C 59	E 86 39.9	N 27 55.1		W W	5700	5100	5100	5450		5220 2 5220 2
NEA45C 60	E 86 40.0	N 27 53.7		W W	5880	5210	5210	5560		5760 3 5150 2
NEA45C 61	E 86 40.0	N 27 53.3		W W	5845	5200	5200	5520		5670 2 5300 2
NEA45C 62	E 86 40.5	N 27 52.8		W W	5843	5350	5350	5500		5640 2 5430 2
NEA45C 63	E 86 40.7	N 27 52.4		W W	5560	5340	5340	5400		5480 2 5370 2
NEA45C 64	E 86 40.8	N 27 51.8		W W	5590	5120	5100	5380		5520 2 5240 2
NEA45C 65	E 86 40.7	N 27 51.5		W W	5673	5270	5270	5380		5530 2 5340 2
NEA45C 66	E 86 40.2	N 27 53.3		SE E	5800	5380	5380	5640		5690 2 5560 2
NEA45C 67	E 86 35.4	N 27 54.0		E E	6186	5350	5350	5640		5700 3 5520 2
NEA45C 68	E 86 41.5	N 27 53.7		W W	5593	5280	5280	5440		5470 1 5400 1

## CHUH KOSI

IDENT NO.	LONGITUDE	LATITUDE	U.T.M.	ORIENT	AC	AB	HIGH	ELEVATIONS	DATE	MEAN ELEVATION
					L.E.X	L.T.L	SNOW	ACCU	ABLA	
NEA45D 1	E 86 41.7	N 27 53.7		SE E	5593	5080	5080	5360		5420 2 5240 2
NEA45C 2	E 86 40.8	N 27 54.3		N N	5620	5240	5100	5360		5480 3 5310 2
NEA45C 3	E 86 40.5	N 27 54.8		E F	5760	5280	5280	5600		5680 2 5440 2
NEA45D 4	E 86 40.5	N 27 55.7		S S	6073	5180	5140	5600		5760 2 5370 2
NEA45C 5	E 86 41.4	N 27 55.2		E E	5980	5120	5060	5530		5800 3 5260 2
NEA45C 6	E 86 41.1	N 27 56.1		NE NE	5660	4940	4940	5440		5500 3 5160 3
NEA45D 7	E 86 40.2	N 27 56.5		N N	5900	5140	5140	5280		5520 3 5270 2
NEA45D 8	E 86 39.2	N 27 57.1		S SE	5560	5300	5300	5430		5500 2 5390 1
NEA45U 9	E 86 39.3	N 27 57.6		S E	5620	5180	5180	5500		5550 3 5360 2
NEA45C 10	E 86 39.0	N 27 55.5		E E	5977	5300	5300	5530		5600 3 5350 2
NEA45D 11	E 86 39.1	N 27 56.9		SE E	5780	5340	5340	5560		5610 3 5480 2
NEA45C 12	E 86 39.5	N 26 CC.1		E E	5740	5420	5420	5560		5600 2 5520 2
NEA45D 13	E 86 39.2	N 28 CC.3		NE NE	5509	5300	5300	5400		5620 3 5350 2
NEA45D 14	E 86 39.4	N 28 CC.9		S S	5820	5540	5540	5660		5740 3 5600 3
NEA45C 15	E 86 39.8	N 28 CC.2		S S	5480	5360	5360	5560		5560 2 5560 2
NEA45D 16	E 86 39.9	N 26 CC.1		E E	5560	5310	5310	5500		5520 3 5450 2
NEA45D 17	E 86 40.2	N 26 CC.2		N N	5530	5350	5350	5470		5490 2 5410 2
NEA45C 18										
NEA45C 19	E 86 39.7	N 28 CC.6		SE SE	6500	5320	5320	5730		5850 3 5600 2
NEA45D 20	E 86 42.2	N 28 CC.0		S S	8153	5010	4690	5580		6400 3 5130 3
NEA45D 21	E 86 42.4	N 28 02.5		SE NE	6060	5330	5330	5670		5920 2 5390 2
NEA45C 22	E 86 44.0	N 28 CC.5		NW NW	5913	5240	5240	5480		5600 2 5380 2
NEA45L 23	E 86 44.6	N 28 CC.6		S S	5913	5590	5590	5750		5840 2 5650 2
NEA45D 24	E 86 44.7	N 28 CC.3		SH SW	5880	5480	5480	5650		5720 3 5550 3
NEA45C 25										
NEA45C 26	E 86 44.8	N 28 CC.1		W SW	5760	5380	5380	5660		5700 3 5430 2
NEA45C 27	E 86 45.0	N 27 55.5		S W	7020	5260	5000	5670	</td	

## NANGPA TSANGPO (BHOTE KOSI)

IDENT	NO.	TOTAL	LENGTH	WIDTH	SURFACE AREA			AAR	DEPTH	VOLUME	TYPE
		ABL	EXP	TOTAL	ABL	EXP	TOTAL				
NEA45C	0	0.3	1.3	1.3	1.57	1.57	3	0.37	3	76	25
NEA45C	1	0.4	0.7	0.7	0.31	0.31	4	0.19	3	39	15
NEA45C	2	0.5	0.9	0.9	1.28	1.28	3	0.58	4	55	25
NEA45C	3	0.9	1.3	1.3	0.53	0.53	4	0.34	4	36	17
NEA45C	4	0.4	0.7	0.7	0.44	0.44	4			100	13
NEA45C	5	4.1	4.5	5.9	5.74	6.37	3	4.54	3	29	60
NEA45C	6	1.1	1.3	1.4	0.2	0.37	4	0.23	4	38	15
NEA45C	7	1.7	2.2	2.4	0.4	1.10	1.35	3	0.61	3	55
NEA45C	8	1.6	2.6	2.6		3.77	4.01	3	2.14	3	47
NEA45C	9	0.5	1.2	1.2		0.74	0.74	3	0.37	3	50
NEA45C	10	0.7	1.5	1.5		0.81	0.81	3	0.55	3	32
NEA45C	11	1.1	1.7	1.7		2.30	2.30	3	1.34	3	42
NEA45C	12	0.2	0.4	0.4		0.08	0.08	5	0.05	4	38
NEA45C	13	3.3	3.6	4.7	0.5	3.20	3.86	3	2.12	3	45
NEA45C	14	0.5	2.0	2.0		1.07	1.07	3	0.32	3	70
NEA45C	15	0.9	1.4	1.4		1.16	1.16	3	0.56	3	52
NEA45C	16	0.6	2.2	2.2		1.18	1.18	3	0.85	3	27
NEA45C	17	1.6	2.4	2.4		1.65	1.65	3	1.33	3	19
NEA45C	18	2.2	3.1	3.1		1.05	1.05	3	0.68	4	35
NEA45C	19	1.2	1.6	1.6		0.97	0.97	3	0.87	3	10
NEA45C	20	2.8	3.6	4.8	0.4	1.26	1.92	3	1.39	3	32
NEA45C	21	6.2	3.1	6.6	0.4	5.25	7.23	3	5.35	3	26
NEA45C	22	1.0	1.8	1.8		1.10	1.10	3	0.53	3	52
NEA45C	23	0.6	1.3	1.3	0.3	0.42	0.42	3	0.23	3	45
NEA45C	24	0.4	0.7	0.7		0.16	0.18	4	0.10	4	44
NEA45C	25	4.0	2.8	4.3	0.4	1.96	2.98	3	2.20	3	26
NEA45C	26										30
NEA45C	27	0.5	1.0	1.2		0.45	0.45	4	0.34	3	24
NEA45C	28	7.5	2.8	8.1	0.5	1.91	4.92	3	4.67	3	5
NEA45C	29	0.6	1.1	1.1	0.2	0.15	0.15	5	0.13	4	13
NEA45C	30	0.5	0.8	0.8	0.2	0.18	0.18	4	0.06	4	67
NEA45C	31	0.2	0.5	0.5		0.11	0.11	5	0.05	5	55
NEA45C	32	0.3	0.8	0.8		0.45	0.45	4	0.16	4	32
NEA45C	33	18.1	6.5	19.2	0.6	17.24	30.49	2	19.28	2	37
NEA45C	34	2.7	1.3	1.3		0.44	0.44	4	0.21	3	52
NEA45C	35	1.5	2.0	2.1	0.3	0.61	0.61	4	0.47	3	23
NEA45C	36	0.4	1.4	1.6	0.4	0.50	0.53	4	0.42	3	21
NEA45C	37	0.5	1.0	1.0		0.31	0.31	3	0.18	3	42
NEA45C	38	0.4	0.5	0.5		0.10	0.10	4	0.08	4	20
NEA45C	39	0.6	0.6	0.6	0.2	0.13	0.13	4	0.12	4	8
NEA45C	40	0.4	0.5	0.5	0.1	0.06	0.06	4	0.05	4	17
NEA45C	41	0.4	0.5	0.5	0.2	0.11	0.11	4	0.10	4	9
NEA45C	42	0.3	0.5	0.5	0.2	0.13	0.13	4	0.06	4	54
NEA45C	43	0.6	0.9	0.9		0.26	0.26	4	0.11	4	58
NEA45C	44	1.9	2.0	2.0	0.3	0.73	0.73	3	0.61	3	16
NEA45C	45	9.1	5.4	11.0	0.6	9.83	15.35	3	9.88	2	36
NEA45C	46	1.1	1.2	1.2	0.3	0.32	0.32	3	0.31	4	3
NEA45C	47	0.4	0.4	0.4	0.3	0.40	0.40	3	0.40	4	0
NEA45C	48	0.3	0.5	0.5	0.2	0.10	0.10	4	0.06	4	40
NEA45C	49	0.7	1.7	1.7		0.63	0.63	3	0.32	3	49
NEA45C	50	0.2	0.5	0.5		0.06	0.06	4	0.03	4	50
NEA45C	51	0.2	0.6	0.6		0.18	0.18	3	0.11	3	39
NEA45C	52	0.3	0.6	0.6		0.10	0.10	4	0.06	4	40
NEA45C	53	0.2	0.5	0.5		0.11	0.11	3	0.08	4	27
NEA45C	54	0.3	0.7	0.7	0.3	0.23	0.23	3	0.08	3	65
NEA45C	55	0.5	1.0	1.0	0.2	0.29	0.29	3	0.08	3	72
NEA45C	56	0.4	1.1	1.1		0.36	0.36	3	0.11	3	69
NEA45C	57	0.8	1.4	1.4		0.52	0.52	3	0.34	3	35
NEA45C	58	0.1	0.8	0.8	0.1	0.06	0.06	4	0.05	4	17
NEA45C	59	0.4	0.4	0.4		0.05	0.05	4	0.05	3	0
NEA45C	60	0.6	1.0	1.0		0.24	0.24	4	0.19	3	21
NEA45C	61	0.6	0.9	0.9		0.11	0.11	4	0.05	4	55
NEA45C	62	0.2	0.5	0.5		0.13	0.13	4	0.06	4	54
NEA45C	63	0.1	0.2	0.2		0.06	0.06	4	0.02	4	67
NEA45C	64	0.6	1.0	1.1		0.06	0.06	4	0.03	4	50
NEA45C	65	0.1	0.4	0.4		0.15	0.15	3	0.06	3	69
NEA45C	66	0.4	0.4	0.4		0.45	0.45	3	0.10	4	78
NEA45C	67	1.5	1.8	1.8		1.29	1.29	3	0.82	3	36
NEA45C	68	0.2	0.5	0.5		0.05	0.05	4	0.02	4	60

FIG. 23.  
Computer card,  
Mount Everest  
region, Nangpa  
(Bhote Kosi), Dudh  
Kosi.

## DUDH KOSI

IDENT	NO.	TOTAL	LENGTH	WIDTH	SURFACE AREA			AAR	DEPTH	VOLUME	TYPE	
		ABL	EXP	TOTAL	ABL	EXP	TOTAL					
NEA45D	1	0.5	0.8	0.3	0.25	0.25	3	0.16	3	36	15	
NEA45D	2	0.4	0.8	0.3	0.22	0.25	3	0.11	3	56	15	
NEA45D	3	0.4	0.6	0.1	0.11	0.11	3	0.06	3	46	10	
NEA45D	4	2.2	2.7	2.8	0.6	1.64	1.81	2	1.05	2	42	
NEA45D	5	0.7	0.8	1.0	0.08	0.11	4	0.08	3	27	10	
NEA45D	6	1.0	1.1	1.1	0.41	0.47	4	0.34	4	28	15	
NEA45D	7	1.2	1.6	1.6	1.14	1.22	2	1.03	2	16	30	
NEA45D	8	0.4	0.6	0.6	0.06	0.06	4	0.06	4	0	10	
NEA45D	9	0.8	1.6	1.6	0.42	0.45	3	0.27	2	40	15	
NEA45D	10	1.7	1.9	1.9	1.08	1.08	4	0.73	3	32	25	
NEA45D	11	1.1	1.6	1.6	0.63	0.63	3	0.39	3	38	15	
NEA45D	12	0.6	1.0	1.0	0.33	0.33	4	0.17	3	49	13	
NEA45D	13	0.3	0.4	0.4	0.16	0.16	3	0.11	3	31	10	
NEA45D	14	0.1	0.6	0.6	0.09	0.09	4	0.02	4	88	8	
NEA45D	15	0.5	0.5	0.1	0.11	0.11	4	0.11	4	0	10	
NEA45D	16	1.7	1.9	1.9	0.94	0.94	3	0.72	2	23	20	
NEA45D	17	0.3	0.4	0.4	0.06	0.06	3	0.03	3	50	10	
NEA45D	18										0.0001	
NEA45D	19	1.4	2.0	2.0	1.25	1.25	3	0.87	3	30	20	
NEA45D	20	17.4	2.5	21.0	1.0	46.50	45.35	2	28.67	2	57	160
NEA45D	21	1.1	1.7	1.7	0.70	0.70	3	0.36	3	51	20	
NEA45D	22	0.7	1.5	1.5	0.88	0.88	3	0.47	3	47	20	
NEA45D	23	0.4	0.7	0.7	0.14	0.14	4	0.09	3	36	12	
NEA45D	24	0.6	1.1	0.1	0.20	0.20	4	0.12	4	40	12	
NEA45D	25										0.0024	
NEA45D	26	0.5	0.6	0.6	0.14	0.14	4	0.11	4	21	12	
NEA45D	27	9.9	8.6	10.7	0.5	9.81	14.17	2	9.10	2	36	80
NEA45D	28	1.4	1.8	0.4	0.81	0.88	3	0.48	2	45	20	
NEA45D	29	0.7	1.2	1.2	0.3	0.65	0.65	2	0.30	3	57	15
NEA45D	30	0.3	1.0	1.0	0.28	0.28	3	0.12	3	57	12	
NEA45D	31	0.4	0.6	0.6	0.22	0.22	3	0.06	3	73	12	
NEA45D	32	1.0	1.1	1.3	0.45	0.50	3	0.34	2	32	16	
NEA45D	33	1.0	1.6	1.6	1.12	1.12	2	0.45	2	60	23	
NEA45D	34	0.3	0.3	0.3	0.12	0.12	3	0.05	3	58	10	
NEA45D	35	3.0	1.6	3.5	0.4	1.14	2.37	3	1.64	2	31	35
NEA45D	36	2.1	1.2	2.8	0.5	1.12	2.34	3	1.61	2	31	35
NEA45D	37	0.7	0.7	0.7	0.1	0.18	0.18	3	0.12	3	33	12

Perennial ice and snow masses

**FIG. 24.**  
**Computer card,**  
**Mount Everest**  
**region, Imja Khola.**

IMJA KHOLA										DATE	MEAN ELEVATION	
IDENT	NO.	LONGITUDE	LATITUDE	U.T.M.	ORIENT	AC	AB	HIGH	ELEVATIONS		ACCU	ABLA
NEA45E	1	E 86 47.0	N 27 53.6		SE SE	6542	5380	5280	5850	6200	3	5400 3
NEA45E	2	E 86 47.5	N 27 53.6		SE E	6542	5096	5096	5950	6200	3	5300 3
NEA45E	3	E 86 47.0	N 27 54.7		NE NE	6440	4860	4580	5450	5900	4	4840 2
NEA45E	4	E 86 46.5	N 27 54.7		NE E	6440	5020	5020	5480	6000	3	5260 3
NEA45E	5	E 86 46.5	N 27 55.3		NE NE	6440	5040	5040	5600	6080	4	5240 3
NEA45E	6	E 86 46.3	N 27 55.7		NE SE	6020	4840	4740	5400	5700	3	4920 2
NEA45E	7	E 86 45.4	N 27 56.7		E E	5580	5160	5160	5540	5620	3	5420 2
NEA45E	8	E 86 45.4	N 27 56.3		SW SE	5580	5280	5280	5500	5460	2	5320 2
NEA45E	9	E 86 45.5	N 27 57.7		S S	5690	5180	5180	5550	5560	3	5380 2
NEA45E	10	E 86 45.6	N 27 58.2		SE SE	6080	5300	5300	5650	5680	3	5460 2
NEA45E	11	E 86 46.3	N 27 56.2		SW SM	6145	5160	5160	5680	5900	3	5500 3
NEA45E	12	E 86 46.7	N 27 56.1		SW SW	6145	5140	5140	5600	5880	3	5460 3
NEA45E	13	E 86 47.2	N 27 57.6		SW SW	6119	5140	5140	5600	5720	3	5320 3
NEA45E	14	E 86 47.5	N 27 57.1		SE SE	6145	5120	4980	5570	5740	2	5080 2
NEA45E	15	E 86 48.1	N 27 57.6		N N	5980	5540	5540	5720	5820	2	5650 2
NEA45E	16	E 86 48.0	N 27 58.0		S E	6853	5280	5220	5620	5740	3	5420 2
NEA45E	17	E 86 47.3	N 27 56.8		S SE	6549	5440	5300	5780	6000	3	5420 3
NEA45E	18	E 86 48.1	N 27 55.6		S S	7145	5290	5120	5700	5600	3	5380 3
NEA45E	19	E 86 48.0	N 27 55.2		S S	6080	5440	5440	5730	5840	3	5600 2
NEA45E	20	E 86 49.4	N 28 CC.0		SE SE	7145	5440	5320	5900	6200	3	5490 3
NEA45E	21	E 86 50.0	N 26 CC.0		SE SE	7145	5520	5520	6000	6360	3	5680 2
NEA45E	22	E 86 50.2	N 28 CC.5		NW SW	6848	5220	4920	5720	6360	3	5280 3
NEA45E	23	E 86 50.5	N 27 56.5		NW NW	5969	5270	5270	5630	5760	2	5460 2
NEA45E	24	E 86 51.0	N 27 56.4		NW NW	5965	5100	5100	5500	5590	3	5180 3
NEA45E	25	E 86 50.5	N 27 56.2		N N	5806	5360	5360	5520	5620	2	5500 2
NEA45E	26	E 86 50.0	N 27 55.7		S S	5760	5540	5540	5670	5700	2	5600 1
NEA45E	27	E 86 50.5	N 27 56.3		NE NE	5640	5380	5380	5540	5600	3	5480 2
NEA45E	28	E 86 50.8	N 27 56.2		NE NE	5880	5580	5580	5700	5760	2	5640 1
NEA45E	29	E 86 51.1	N 27 56.5		SH S	7879	5480	4970	5700	6340	4	5340 3
NEA45E	30	E 86 51.5	N 27 57.0		NW N	5640	5420	5420	5570	5580	2	5450 2
NEA45E	31	E 86 52.2	N 27 56.7		NW N	5800	5380	5380	5580	5660	2	5440 2
NEA45E	32	E 86 52.5	N 27 56.5		S S	7680	5180	4980	5700	6200	4	5280 3
NEA45E	33	E 86 53.6	N 27 56.2		W W	9775	5250	5250	5680	5560	3	5320 2
NEA45E	34	E 86 54.3	N 27 56.0		SE SE	6220	5400	5400	5800	5900	3	5680 3
NEA45E	35	E 86 54.7	N 27 56.6		SH SW	8380	5200	4920	5750	6700	4	5220 2
NEA45E	36	E 86 55.3	N 27 55.5		NW NW	6189	5260	5260	5720	5880	3	5500 3
NEA45E	37	E 86 56.0	N 27 55.5		S S	6189	5560	5560	5820	5960	3	5720 3
NEA45E	38	E 86 56.1	N 27 55.0		SW SW	6383	5280	5020	5730	6600	3	5300 2
NEA45E	39	E 86 56.5	N 27 54.0		W W	6677	5260	5260	5750	6080	2	5600 2
NEA45E	40	E 86 58.0	C 27 54.5		E E	6840	5260	5100	5550	5900	3	5340 3
NEA45E	41	E 86 56.0	N 27 52.4		NE NE	6265	5380	5380	5670	5840	2	5522 2
NEA45E	42	E 86 55.5	N 27 53.2		N N	6230	5020	5020	5600	5900	3	5480 2
NEA45E	43	E 86 55.0	N 27 53.3		NW NW	6430	5020	5020	5570	5860	3	5320 2
NEA45E	44	E 86 54.0	N 27 52.5		N N	6856	5100	4820	5400	5800	3	5080 3
NEA45E	45	E 86 53.0	N 27 52.2		NE NW	6856	4920	4780	5300	5640	4	4960 3
NEA45E	46	E 86 51.7	N 27 52.5		NW NW	5600	4740	4220	5300	5500	3	4780 3
NEA45E	47	E 86 50.7	N 27 52.2		W W	6856	5100	5100	5800	6080	3	5440 3
NEA45E	48	E 86 51.2	N 27 51.7		S S	6856	5460	5300	5840	6320	3	5480 3
NEA45E	49	E 86 51.6	N 27 51.2		SH SW	6856	5340	5020	5640	5930	3	5360 3
NEA45E	50	E 86 52.6	N 27 50.8		N N	6571	5140	5020	5600	5800	3	5420 3
NEA45E	51	E 86 52.9	N 27 45.1		N N	5993	4960	4620	5310	5500	3	4960 3
NEA45E	52	E 86 51.1	N 27 45.2		N N	5680	5000	4580	5240	5500	3	4880 3
NEA45E	53	E 86 50.4	N 27 45.3		N N	5960	4820	4780	5370	5500	3	5000 2
NEA45E	54	E 86 49.6	N 27 45.2		N N	6077	4780	4740	5370	5850	3	5020 2
NEA45E	55	E 86 49.6	N 27 46.8		N N	6080	5000	4620	5290	5650	3	5000 2
NEA45E	56	E 86 49.2	N 27 46.7		N N	6420	4840	4840	5400	5800	3	5100 2
NEA45E	57	E 86 48.8	N 27 46.3		N N	6420	4860	4860	5390	5680	3	5080 2
NEA45E	58	E 86 48.4	N 27 46.5		N N	6420	4820	4220	5270	5720	3	4880 2
NEA45E	59	E 86 47.6	N 27 46.1		N N	6608	5200	5320	5270	5840	3	4880 2
NEA45E	60	E 86 47.1	N 27 47.7		N N	6346	4820	4820	5300	5720	3	5140 2
NEA45E	61	E 86 45.5	N 27 47.2									

## IMJA KHULA

IDENT NO.	TOTAL LENGTH	WIDTH	SURFACE AREA			AAR	DEPTH	VOLUME	TYPE		
			ABLA	EXP	TOTAL						
NEA45E 1	0.6	1.1	1.1		0.27	0.27 3	0.08 4	70	15	0.004 3	600421
NEA45E 2	1.1	1.7	1.7		0.58	0.58 2	0.19 2	67	20	0.012 3	640421
NEA45E 3	2.7	1.5	3.3	0.4	0.81	1.54 2	1.31 2	15	40	0.062 2	532322
NEA45E 4	1.0	1.5	1.5		0.55	0.55 3	0.34 3	38	18	0.010 3	600421
NEA45E 5	0.4	0.8	0.8	0.1	0.16	0.16 4	0.04 4	75	15	0.002 4	600020
NEA45E 6	1.2	0.6	1.5	0.3	0.28	0.48 3	0.37 3	30	20	0.010 3	600022
NEA45E 7	0.5	0.8	0.8		0.19	0.19 3	0.11 2	42	18	0.003 3	600022
NEA45E 8	0.5	0.6	0.6	0.1	0.11	0.11 3	0.06 3	46	18	0.002 3	600010
NEA45E 9	1.1	1.2	1.2	0.4	0.44	0.44 2	0.39 2	11	20	0.009 2	640021
NEA45E 10	1.7	2.2	2.2	0.4	1.37	1.37 3	0.89 2	35	40	0.055 2	530111
NEA45E 11	0.5	1.1	1.1		0.37	0.37 3	0.17 3	54	16	0.006 4	600021
NEA45E 12	0.7	1.0	1.0		0.42	0.42 3	0.25 3	40	16	0.007 4	600221
NEA45E 13	0.5	0.8	0.8		0.62	0.62 3	0.33 3	47	18	0.011 4	600221
NEA45E 14	0.7	1.2	1.2		0.58	0.58 3	0.30 3	48	18	0.010 4	600011
NEA45E 15	2.3	2.2	3.5	0.4	0.66	1.69 3	0.99 2	42	40	0.068 2	532312
NEA45E 16	0.2	0.6	0.6		0.14	0.14 4	0.03 4	79	15	0.002 4	640022
NEA45E 17	4.9	4.6	6.7	1.1	5.06	8.20 2	5.45 2	34	50	0.410 3	515112
NEA45E 18	1.5	1.1	2.2		0.39	0.92 4	0.73 3	21	18	0.017 3	645322
NEA45E 19	5.5	3.5	6.0	0.9	3.85	8.98 2	5.45 2	39	70	0.629 3	535112
NEA45E 20	0.6	1.0	1.0	0.3	0.48	0.48 2	0.19 2	60	18	0.009 3	600211
NEA45E 21	2.1	1.7	3.0	0.5	0.67	1.31 3	1.11 2	20	35	0.049 3	530121
NEA45E 22	0.8	1.8	1.8		0.62	0.62 3	0.33 2	47	15	0.009 3	603211
NEA45E 23	11.1	10.7	18.2	0.7	25.41	33.79 2	12.25 2	64	100	3.379 3	510312
NEA45E 24	0.7	1.1	1.1		0.63	0.63 3	0.31 2	51	18	0.011 3	600011
NEA45E 25	1.6	2.2	2.2	0.3	1.11	1.11 2	0.66 3	42	25	0.028 3	522312
NEA45E 26	0.2	0.6	0.6		0.31	0.31 3	0.19 2	39	16	0.005 3	600011
NEA45E 27	0.6	0.6	0.8	0.3	0.22	0.22 3	0.16 2	27	15	0.003 3	640121
NEA45E 28	0.2	0.3	0.3		0.17	0.17 3	0.12 2	29	15	0.003 3	600020
NEA45E 29	0.1	0.4	0.6		0.19	0.19 3	0.04 3	80	15	0.003 3	600010
NEA45E 30	4.2	2.4	7.8	0.4	2.53	5.95 2	4.37 2	25	55	0.327 2	520122
NEA45E 31	0.4	0.5	0.5		0.11	0.11 3	0.09 2	18	12	0.001 3	600021
NEA45E 32	0.4	0.7	0.7		0.17	0.17 3	0.11 2	35	12	0.002 3	600112
NEA45E 33	4.4	2.6	6.1	0.4	2.61	5.09 2	3.12 2	39	60	0.305 2	520122
NEA45E 34	0.6	0.6	0.6		0.22	0.27 3	0.19 3	30	15	0.003 3	600021
NEA45C 35	0.5	0.7	0.7		0.36	0.36 3	0.19 3	47	15	0.005 3	600211
NEA45E 36	4.2	3.5	8.5	1.0	6.93	11.61 2	7.36 2	37	90	1.045 3	530122
NEA45E 37	0.7	1.1	1.1		1.17	1.17 2	0.55 2	53	20	0.023 3	603011
NEA45E 38	0.3	1.1	1.1		0.43	0.43 2	0.14 2	67	17	0.007 3	600311
NEA45E 39	8.2	5.2	11.2	0.6	11.61	19.87 2	10.99 2	45	70	1.391 2	515112
NEA45E 40	0.8	1.4	1.4		1.29	1.29 2	0.37 2	71	27	0.035 3	600011
NEA45E 41	4.0	2.1	4.6	0.3	2.44	4.62 3	3.04 2	34	30	0.139 3	525122
NEA45E 42	0.4	0.8	0.8	0.2	0.16	0.16 3	0.08 3	50	15	0.002 3	530021
NEA45E 43	0.6	1.0	1.0		0.48	0.48 3	0.28 2	42	17	0.003 3	600211
NEA45E 44	1.6	2.5	2.5		3.17	3.17 2	2.66 2	16	45	0.143 2	600011
NEA45E 45	4.8	1.0	5.6	0.6	5.39	7.11 2	3.15 2	56	70	0.498 3	530112
NEA45E 46	2.2	1.4	3.3	0.8	1.12	2.33 3	1.56 2	33	40	0.096 3	530021
NEA45E 47	2.7	1.5	2.5	0.3	0.44	0.92 3	0.78 2	15	20	0.018 3	530322
NEA45L 48	1.1	1.5	1.9		1.12	1.12 3	0.75 2	33	28	0.031 3	600321
NEA45E 49	1.7	1.1	2.3	0.3	0.41	0.72 3	0.52 2	23	18	0.013 3	532322
NEA45E 50	3.4	2.3	4.6	0.5	3.25	5.73 3	3.73 2	35	60	0.347 3	520112
NEA45E 51	2.4	1.9	2.6		5.18	5.18 3	2.76 2	47	60	0.311 3	600011
NEA45E 52	2.3	1.3	2.6		0.66	1.66 3	1.30 3	22	30	0.050 3	605021
NEA45E 53	1.7	0.8	2.2	0.4	0.39	0.84 3	0.59 2	30	18	0.015 3	530322
NEA45E 54	0.8	1.1	1.3	0.2	0.28	0.33 3	0.27 2	18	18	0.006 3	600021
NEA45E 55	1.1	1.2	1.8	0.2	0.75	0.78 3	0.48 2	39	20	0.016 3	600221
NEA45E 56	1.1	0.5	1.6	0.3	0.39	0.73 3	0.55 2	25	20	0.015 3	530021
NEA45E 57	0.7	1.3	1.3	0.2	0.53	0.53 2	0.16 3	70	18	0.016 3	530011
NEA45E 58	0.8	1.7	1.7	0.3	0.52	0.52 3	0.25 2	52	18	0.009 3	530021
NEA45C 59	2.3	2.5	3.1	0.4	2.26	2.53 3	1.42 2	44	28	0.071 3	520021
NEA45E 60	0.6	0.9	0.9		0.52	0.52 4	0.100	15	15	0.008 4	600210
NEA45E 61	0.9	1.6	1.6		0.78	0.81 3	0.41 3	49	15	0.012 3	600011

State, Province or Region: NEPAL Mountain area: MT. EVEREST Hydrological basin:- Ist order: GANGES (A) IIInd order: SUN KOSI (4) IIIrd order: DUDH KOSI (5) IVth order: NANGPO (BHOTE KOSI) C. Glacier name: CHHULE Sources:- Map, title & No: KHUMBU, HIMAL. Compiled by: ERWIN SCHNEIDER Date: 1965 Scale: 1 : 50,000 Contour interval: 40 METRES Reliability: BETTER THAN ONE CONTOUR Photographs:- TERRESTRIAL PHOTO - Type: GRAMMETER AND HAND CAMERA Serial No: RESEARCH SCHEME Date: NEPAL, HIMALAYA 1955 AND END OCTOBER 1966 Remarks: Literature:  Data compiled by: J. H. WOLFE Date & organisation: JULY 1967 Supervisor: F. MÜLLER, MCGILL UNIVERSITY REMARKS (special geomorphological features, abnormal characteristics, if international boundary, source information on mean depth estimate, observations regarding snow line or equilibrium line from other years) THIS GLACIER SHARES A LARGE ACCUMULATION BASIN WITH THE LARGER DROLUM BAU GLACIER, TO THE WEST, DELINEATION VERY DIFFICULT. THE PRESENT CHHULE RECEIVES LARGE AVALANCHE SUPPLY FROM SOUTH, WHERE GREATER THAN 1000- METRE ROCK FACES EXIST. LARGE LATERAL AND TERMINAL MORAINES LIE NEAR PRESENT GLACIER AND ABOVE CHHULE VILLAGE	Regional and basin identification N.E.A. & S.C. Glacier number 2.0 Longitude 86° 33'.5" Latitude 27° 55'.5" U.T.M. Orientation: Accumulation area (8 pt. compass) E Ablation area (8 pt. compass) N.E. Highest glacier elevation (m/a.s.l.) 5,880 Lowest glacier elevation: Exposed (m/a.s.l.) 5,040 Total (m/a.s.l.) 4,850 Elevation of snow line (m/a.s.l.) 5,560 Date of snow line day mo. yr. Mean accumulation area elevation, weighted, (m/a.s.l.) 5,760 *Accuracy rating (1-5) 3 Mean ablation area elevation, weighted, (m/a.s.l.) 5,150 *Accuracy rating (1-5) 3 Maximum length: Ablation area (km) incl. debris covered 3.8 Exposed (km) 3.6 Total (km) 4.8 Mean width of main ice body (km) 4 Surface area: Exposed (km <sup>2</sup> ) 1.26 Total (km <sup>2</sup> ) 1.92 *Accuracy rating (1-5) 3 Area of ablation (km <sup>2</sup> ) 1.39 *Accuracy rating (1-5) 3 Accumulation area ratio (per cent) 3.2 Mean depth (m) 3.5 Volume (km <sup>3</sup> ) of ice 0.67 *Estimated accuracy rating (1-5) 3 Classification and description. (see Table 1) 53.03.2.2																								
<p><b>*Accuracy ratings</b></p> <table border="1"> <thead> <tr> <th></th> <th>Area</th> <th>Elevations</th> <th>Volume</th> </tr> </thead> <tbody> <tr> <td>1 Excellent</td> <td>0-5%</td> <td>0-25 m</td> <td>0 - 10%</td> </tr> <tr> <td>2 Good</td> <td>5-10%</td> <td>25-50 m</td> <td>10 - 25%</td> </tr> <tr> <td>3 Fair</td> <td>10-15%</td> <td>50-100 m</td> <td>25 - 50%</td> </tr> <tr> <td>4 Acceptable</td> <td>15-25%</td> <td>100-200 m</td> <td>50 - 100%</td> </tr> <tr> <td>5 Unreliable</td> <td>&gt; 25%</td> <td>&gt; 200 m</td> <td>&gt; 100%</td> </tr> </tbody> </table>			Area	Elevations	Volume	1 Excellent	0-5%	0-25 m	0 - 10%	2 Good	5-10%	25-50 m	10 - 25%	3 Fair	10-15%	50-100 m	25 - 50%	4 Acceptable	15-25%	100-200 m	50 - 100%	5 Unreliable	> 25%	> 200 m	> 100%
	Area	Elevations	Volume																						
1 Excellent	0-5%	0-25 m	0 - 10%																						
2 Good	5-10%	25-50 m	10 - 25%																						
3 Fair	10-15%	50-100 m	25 - 50%																						
4 Acceptable	15-25%	100-200 m	50 - 100%																						
5 Unreliable	> 25%	> 200 m	> 100%																						

FIG. 25. Glacier inventory data sheet for Mount Everest region, Ganges (A), Sun Kosi (4), Dudh Kosi (5), Nangpa (Bhote Kosi), Chhule glacier.

State, Province or Region: NEPAL (N.E.)  
 Mountain area: MOUNT EVEREST  
 Hydrological basin:-  
     1st order: GANGES (A)  
     2nd order: SUN KOSI (4)  
     3rd order: DUDH KOSI (5)  
     4th order: IMJA KHOLA (E)  
 Glacier name: KHUMBU  
 Sources:-  
     Map, title & No: MAHALANGUR HIMAL.  
     Compiled by: ERWIN SCHNEIDER  
     Date: 1957  
     Scale: 1 : 25,000  
     Contour interval: 20 METRES  
     Reliability: BETTER THAN ONE CONTOUR  
 Photographs:-  
     Type: TERRESTRIAL PHOTOGRAPHOMETRY  
     Serial No:  
     Date: MAY 1955  
     Remarks: EXCELLENT QUALITY;  
                 UPPER REACHES LESS DETAIL  
 Literature:  
  
     Data compiled by: J. J. WOLFE  
     Date & organisation: JUNE 1967  
     Supervisor: F. NÜLLER, MCGILL UNIVERSITY  
     REMARKS (special geomorphological features, abnormal characteristics, if international boundary, source information on mean depth estimate, observations regarding snow line or equilibrium line from other years)  
  
     VARYING THICKNESS OF DEBRIS COVER FOR MOST OF ABLATION AREA; LOWEST THIRD MOST HEAVY. LARGE PENITENTS.  
     THERE IS A 400-METRE ELEVATION DIFFERENCE BETWEEN HIGHEST AND LOWEST PART OF FIRN LINE, WHICH WAS ESTABLISHED BY FIELD-WORK AND WAS PARTICULARLY DIFFICULT TO ASSESS, ESPECIALLY IN THE 1600 METRE-HIGH KHUMBU ICE-FALL.

Regional and basin identification		<u>N.E.A.4,5,E</u>
Glacier number		<u>2,3</u>
Longitude	E	<u>86°50'.5'</u>
Latitude	N	<u>27°58.9'</u>
U.T.M.		
Orientation: Accumulation area (8 pt. compass)		<u>N.W.</u>
Ablation area (8 pt. compass)		<u>S.W.</u>
Highest glacier elevation (m/a.s.l.)		<u>8,848</u>
Lowest glacier elevation: Exposed (m/a.s.l.)		<u>5,220</u>
Total (m/a.s.l.)		<u>4,930</u>
Elevation of snow line (m/a.s.l.)	day	<u>5,720</u>
Date of snow line	mo.	<u>9:56</u>
Mean accumulation area elevation, weighted, (m/a.s.l.)		<u>6,360</u>
*Accuracy rating (1-5)		<u>3</u>
Mean ablation area elevation, weighted, (m/a.s.l.)		<u>5,280</u>
*Accuracy rating (1-5)		<u>3</u>
Maximum length: Ablation area (km) incl. debris covered		<u>11.1</u>
Exposed (km)		<u>10.7</u>
Total (km)		<u>11.2</u>
Mean width of main ice body (km)		<u>1.7</u>
Surface area: Exposed (km <sup>2</sup> )		<u>2.5,41</u>
Total (km <sup>2</sup> )		<u>3.3,7.9</u>
*Accuracy rating (1-5)		<u>2</u>
Area of ablation (km <sup>2</sup> )		<u>1.2,2.5</u>
*Accuracy rating (1-5)		<u>2</u>
Accumulation area ratio (per cent)		<u>64</u>
Mean depth (m)		<u>1.00</u>
Volume (km <sup>3</sup> ) of ice		<u>3,3,7.9</u>
*Estimated accuracy rating (1-5)		<u>3</u>
Classification and description (see Table 1)		<u>5,1,0,3,1,2</u>
*Accuracy ratings		
	Area	Elevations
1 Excellent	0-5%	0-25 m
2 Good	5-10%	25-50 m
3 Fair	10-15%	50-100 m
4 Acceptable	15-25%	100-200 m
5 Unreliable	> 25%	> 200 m
		Volume
		0 - 10%
		10 - 25%
		25 - 50%
		50 - 100%
		> 100%

FIG. 26. Glacier inventory data sheet for Mount Everest region, Ganges (A), Sun Kosi (4), Dudh Kosi (5), Nangpa (Bhote Kosi), Khumbu glacier.

