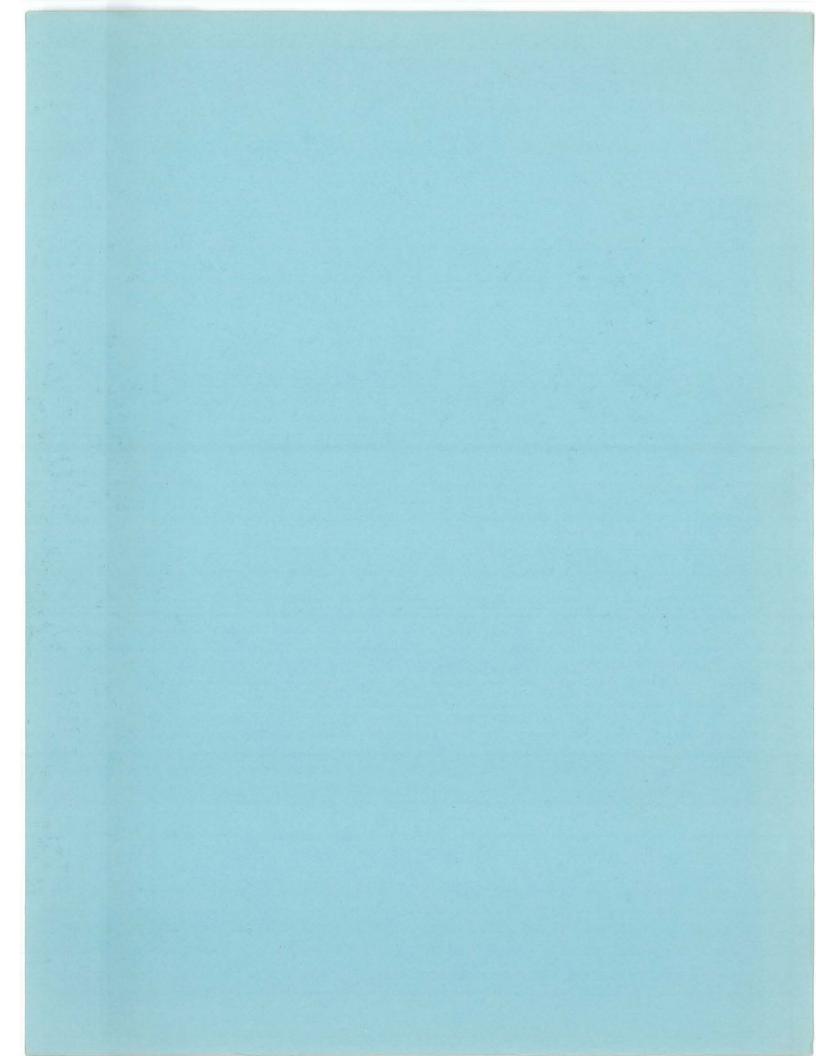
Western Snow Conference

FINAL REPORT -

Metrication of Manual Snow Sampling Equipment



WESTERN SNOW CONFERENCE METRICATION COMMITTEE



Svediso

FINAL REPORT

METRICATION OF MANUAL SNOW SAMPLING EQUIPMENT

by WESTERN SNOW CONFERENCE METRICATION COMMITTEE:

Phillip E. Farnes, Soil Conservation Service, Bozeman, Montana Barry E. Goodison, Atmospheric Environment Service, Downsview, Ontario Ned R. Peterson, Department of Water Resources, Sacramento, California Robert P. Richards, Ministry of the Environment, Victoria, British Columbia

March 1983

Approved for printing at 50th Annual Meeting, Reno, Nevada, April 23, 1982.

AVAILABLE FROM
Western Snow Conference
c/o Robert T. Davis, Secretary
P. O. Box 14884
Spokane, WA 99214
USA

Cost \$10.00 U.S. currency

	Pa	ge
		0
PREFACE .	***********	i
LIST OF A	BBREVIATIONS	i
1.	INTRODUCTION	1
1.1.	Canadian conversion to metric units	1
1.2.	v v	2
1.3		2
1.3.1		2
1.3.2.		2
1.3.3.		3
1.3.4.	Sampler tests in shallow snowpacks	3
1.3.5.		4
1.4.	Lead time needed for conversion to metric	4
1.5.	Standardization	4
_		,
2.	WSC METRICATION COMMITTEE ACTIVITIES	6
0.1		,
2.1.	0 0 1	6
2.2.		6
2.2.1.	0 1 1	6
2.2.2.		6
2.2.3.	11020000 12 1212 100 10 10010 1 1 1 1 1	7 7
2.3.		7
2.3.1.		7
2.3.2 2.3.3.		8
2.3.4		8
	- ''해면진제, '' 전에 가장하면 가장하면 가장하면 주가는 ''라겠다. ''하겠다. ''하겠다. '' 내가 내려를 하라고 있는 것도 하는 것도 하는 것도 하는 것도 하는 것도 되는 것도 하는 것	8
2.3.5.		8
2.3.5.1.		8
2.4.	0 11	8
2.4.1.	, and the second	8
2.4.2.		9
2.4.3.	-market and an employed the state of the sta	9
2.4.3.1.		9
2.4.3.2.		9
2.5.	Analysis of all snow sampler data	
2.5.1.	Effect of snow density on overmeasurement	
2.5.2.	Small-diameter samplers	
2.5.3.	Large-diameter samplers	
2.5.4.	Volumetric samplers	6
2.6.	Collection of auxiliary data and other tests	6
2.6.1.	Profiles	6
2.6.2	Pits	6
2.6.3	Comparisons between snow sampler scales and gram-balance scales 10	6
2.6.4.	Driving tests in deep, dense snowpacks	8
2.6.5.	Agricultural Research Service tests	8
2.6.6.	Colorado State University tests	8
2.6.7.	McMaster University tests	9
2.7.	Special or unusual conditions	
2.7.1.	Ice and shallow snow conditions	
2.7.2.	Ice layers	
2.7.3.	Depth hoar	
2.7.4.	Isothermal snowpack	
2.7.5.	New snow	
2 8	Further testing	0

TABLE OF CONTENTS (continued)

																								Page
3.	DESI	GN RECOMME	ENDATION	NS, SPE	ECIF	ICA	TI	ONS	S, A	AND	DI	RAW	/IN	GS										21
3.1.	Prop	sed WSC m	netric s	snow sa	amp1	er																		21
3.1.1.		ifications																						21
3.1.2.		ifications																						24
3.1.3.		ifications																						26
3.2.		osed ESC 3																						28
3.2.1.		ifications																						28
3.2.2.		ifications																						30
4.	PROP	SAL FOR C	CONVERT	ING TO	MET	RIC																		32
4.1.	Exis	ting equip	ment .																					32
4.1.1.		l-diameter																						32
4.1.2.		e-diameter																						32
4.1.3.		sition sta																						32
4.1.4.		sed conve																						32
4.2.		oric data																						33
4.3.		ce data co																						33
5.	ACKNO	OWLEDGMENT	S																					35
REFERENCE	ES .																							36
APPENDIX	I.	Data summ	nary and	l regre	essi	on	an	aly	ysis	S .												٠		37
APPENDIX	II.	Snow prof	files of	f snow	sam	pli	ng	pi	its	by	me	etr	ic	at	io	1 (om	mi	tte	ee.				
		1979-1982	2				٠				٠					. ;		٠		٠	٠	٠		53
APPENDIX	III.	Forms and	proced	dures .																			•	85
APPENDIX	IV.	Photograp	hs of s	snow sa	ampl	ing	p	ro	cedi	ıre	S	and	l e	qu	ipı	nei	ıt							93

PREFACE

The Western Snow Conference (WSC) established a metrication committee in July 1978 to review, test, and recommend equipment and procedures for the metrication of snow surveys.

In April 1982, the metrication committee summarized its findings in a technical session at the 50th Annual Meeting of the WSC which was held jointly with the 39th Annual Meeting of the Eastern Snow Conference (ESC) in Reno, Nevada.

At the business meeting, the WSC authorized the metrication committee to complete and print their final report, Metrication of Manual Snow Sampling Equipment. The WSC suggested that the ESC concur with the findings and recommendations of the WSC Metrication Committee and advise ESC members of the availability of the final report.

The final report includes data collected before the formation of the metrication committee as well as data obtained by the committee.

Inquiries or requests for additional copies or enlarged drawings of snow sampling equipment presented in this report should be directed to:

Western Snow Conference c/o Robert T. Davis, Secretary P. O. Box 14884 Spokane, WA 99214 USA

LIST OF ABBREVIATIONS

AES Atmospheric Environment Service
ARS Agricultural Research Service

CRREL Cold Regions Research and Engineering Laboratory

CSU Colorado State University

DWR California Department of Water Resources

ESC Eastern Snow Conference

MSC Meteorological Service of Canada

NWS National Weather Service SCS Soil Conservation Service

SI The International System of Units (Metric)

USGS U.S. Geological Survey

WMO World Meteorological Organization

WSC Western Snow Conference

1. INTRODUCTION

A variety of snow samplers are in use in North America. The most widely used is the standard Federal snow sampler, sometimes erroneously referred to as the Mt. Rose sampler. It is used primarily in the deeper snowpacks of western North America, and it has been well documented that this sampler overmeasures the actual water equivalent of the snowpack (e.g., Farnes, 1964; Work et al., 1965; Freeman, 1965; Peterson and Brown, 1975). For shallower snowpacks, both large-diameter (30- to 50-cm² cutter area) and small-diameter (10- to 11.5-cm² cutter area) samplers are used. Each provides various degrees of accuracy (Goodison, 1978). Virtually all of the samplers used measure in English units, even though most of the world is using the International System of Units (SI) or metric system. Recognizing the need to coordinate the design and modification of snow sampling equipment, the Western Snow Conference (WSC) established a four-member working committee* in 1978 to prepare designs and specifications of metric snow sampling equipment, to evaluate the accuracy of existing and new metric equipment, and to develop procedures for converting snow measurement data from English to metric.

1.1. Canadian conversion to metric units

In 1970 the Canadian Parliament endorsed a White Paper on Metric Conversion, with the most up-to-date International System of Units, or SI. The White Paper stated that the Federal government "accepts eventual conversion as a definite objective of Canadian policy. . ." To this end, a Metric Commission was appointed to prepare, coordinate, and provide leadership for this conversion. As far as snow survey practice was concerned, British Columbia, with the most extensive network and inventory in Canada, moved decisively in this direction after enabling legislation entitled "Metric Conversion Act" was passed in June 1974. Various government departments within British Columbia set up metrication committees to prepare for implementation. The conversion from "Canadian Units" to "Metric Units" was based on the Metric Practice Guide, (Canadian Standards Association, 1973) and conforms to meteorological standards established by the World Meteorological Organization (WMO).

During 1975, planning within the British Columbia Water Resources Service called for publication of the 1976 British Columbia Snow Survey Bulletin in SI units and for the soft conversion of equipment during the summer of 1977 as described by Letvak (1978). The Atmospheric Environment Service (AES) adopted nationwide standards in 1977 for most meteorological data and for hydrometric data in 1979. All other provinces in Canada are presently working in metric units, although many observations are still made in imperial units.

Initially, snow surveyors in British Columbia used equipment calibrated in imperial units. After submission, the data were mathematically converted to metric units for filing and publication. The equipment in use in western Canada is the standard Federal sampler, which includes snow coring tubes with a cutter, and a spring scale. The imperial markings and numerals on the coring tubes and the water equivalent markings and numerals on the inner cylinder of the spring scale were converted to metric in the summer of 1977. This was accomplished by canceling the imperial units on the tubes and adding metric markings and numerals and replacing the inner cylinder of the spring scale. All other equipment, designs, and dimensions were preserved.

All new tubing is being marked in centimeters. In British Columbia the "call-in" of equipment for conversion to metric provided an opportunity to check inventory and to repair and calibrate all kit components as required. A serial number was scribed on each scale so that future calibrations can be compared with earlier ones.

Since 1977, all observations in British Columbia have been taken in metric units. Elsewhere in Canada, a "soft" conversion of data rather than changing of the equipment was the method used by agencies for the metrication of snow survey data. Use of the metric system has not created any confusion even though sampling is performed by individuals with various degrees of experience--from unpaid cooperators to government staff.

No attempt has been made in Canada to eliminate the overmeasurement, and all equipment conforms to existing standard Federal sampler specifications.

^{*}Phillip E. Farnes, Soil Conservation Service, Bozeman, Montana Barry E. Goodison, Atmospheric Environment Service, Downsview, Ontario Ned R. Peterson, Department of Water Resources, Sacramento, California Robert P. Richards, Ministry of the Environment, Victoria, British Columbia

1.2. United States conversion to metric units

In the Western United States, the Soil Conservation Service (SCS) and in California, the California Department of Water Resources (DWR) are principally responsible for coordinating the snow survey programs. SCS was scheduled to convert to metric units by 1983, but this date has been delayed. The DWR reports snow and related data in dual (metric/English) units. Both agencies still plan to convert historic data files and existing equipment to metric some time in the future.

In the Eastern United States the National Weather Service (NWS), U.S. Geological Survey (USGS), and their cooperators are the primary agencies that make snow surveys. Conversion to metric has been delayed, but is being considered for the future.

1.3. Previous tests

Several evaluations of sample tube errors have been conducted since the pressure snow pillow (automatic snow sensor) was developed in the early 1960s. Snow tube measurement error became a critical concern because manual data were used to check the accuracy of automatic snow sensing devices. Differences in snow water equivalent readings between the snow sensor and manually obtained control samples taken adjacent to the sensor's surface had to be defined either as tube (cutter) error or snow sensor error.

The following list identifies and references some of the more detailed tests that are particularly related to the standard Federal snow sampler. It is not intended to be all-inclusive. Most of the data from these earlier tests are presented in Appendix I, table IV. Photographs of many of the cutters used in various tests are shown in Appendix IV.

1.3.1. Mt. Hood

In 1963 and 1964, SCS conducted numerous field and laboratory tests to determine the accuracy of field snow surveys (Work $\underline{\text{et}}$ $\underline{\text{al}}$., 1965). The snow sampler scales were tested to evaluate differences associated with $\underline{\text{temperature}}$, reading errors, and calibration.

Snow samplers tested were the standard Federal, Adirondack, Bowman, Rosen, and High Plains. Snow water equivalent measurements obtained using these different snow tubes were compared with values determined by weighing snow from pits having an area of $2.8~\rm m^2$. Most data were obtained in the Mt. Hood, Oregon, area, but measurements were also taken in Alaska and Montana.

The report concluded that the standard Federal snow sampler overmeasured the snow water equivalent from 7 percent in shallow snow to as much as 10 to 12 percent in deep, dense snow. The report suggested that the cutter design was partly responsible for the errors and that the cutter should be redesigned to reduce or eliminate these errors. The standard Federal snow sampler scales had no appreciable error, nor did the slots in the standard Federal snow tube contribute to overmeasurement of water equivalent.

The Rosen snow sampler demonstrated the least overmeasurement; this was attributed to the shape and sharpness of its cutter. The Adirondack sampler was found to be very accurate, but not practical for snow depths of more than 150 cm. The Bowman sampler was reported to be accurate and reasonably practical for depths of less than 250 cm.

In general, the authors concluded that the present standard Federal snow sampling equipment is as utilitarian as can be found for deep, dense western snows and even for shallow sub-Arctic snow. However, they recommended that design modifications and further test work be performed on the cutter to reduce the overmeasurement error of this equipment.

1.3.2. California

The DWR tested various cutters, using the volumetric pit method, at the Alpha test site between 1966 and 1974 (Peterson and Brown, 1975). Snow depths ranged from 75 to 265 cm, snow densities from 23 to 53 percent, and snow water equivalents from 300 to 1,200 mm. These tests substantiated that the standard Federal cutter overmeasured snow water equivalent by as much as 12 percent. This test also led to the theory that the overmeasurement may be a function of snow density, with overmeasurement increasing as density increased. Based on this theory of snow density influence, DWR devised a "Control

Sample Correction Curve" from the test data and applied this correction to 64 control sample observations taken adjacent to a 3.7 m diameter pressure snow pillow. The results showed that apparent pillow measurement error was diminished once the control sample error was adjusted for snow density. Similar results were obtained when DWR used 1963-67 unpublished data supplied by SCS from the Mt. Hood test site.

Determining what correction should be used and how good it was when comparing snow tube data with snow sensor data continued to be a problem. Farnes (1964) noted errors of 7 to 10 percent in 1964; a correction of minus 9 percent was stipulated by the SCS Technical Service Center in 1966 based on the Mt. Hood tests; a correction of minus 10 percent was recommended for Alaska (Freeman, 1965); and a variable correction based on snow density was indicated by the California tests. Although much additional work was undertaken in California to define snow sensor accuracy (California Department of Water Resources, 1976), no correction procedure was found that was considered consistently reliable. Additional evaluation (Farnes, 1980) confirmed lack of a consistency for determining true snow water equivalent.

1.3.3. Short and long metric cutters 1977-1978

As the result of an informal meeting of snow surveyors at the Lake Tahoe West Wide Snow Survey Training School in January 1977, Bob Shillinglaw of Carpenter Machine Works, Seattle, Washington, manufactured two metric cutters. The short metric cutter was similar to the standard Federal cutter, and the length of the cutter was approximately 25 mm from teeth to shoulder. The teeth were sharpened to the inside, and the cutter area was 10 cm² (see Appendix IV for photograph). The long metric cutter was similar to the McCall and Bowman cutters with sharp teeth and 10 cm² cutter area. The cutter was approximately 50 mm from teeth to shoulder (see Appendix IV).

Field tests were conducted in British Columbia, California, Montana, and Ontario to compare those cutters with standard Federal cutters having an area of 11.17 cm². The standard Federal cutter used in Montana had a tooth thickness of 17.78 mm. The tooth thicknesses of the other standard Federal cutters are not known, but differences could account for 2 to 3 percent variation between standard Federal samplers. In British Columbia, measurements were also obtained with the Glacier sampler. In Ontario, volume samples also were obtained by weighing the snow from pits.

In general, the short and long metric cutters yielded nearly identical water equivalent measurements, but their water equivalent was less than that obtained with the standard Federal snow sampler (see Appendix I, table IV). The long metric cutter was the hardest to drive in dense snowpacks. The short metric cutter was a little harder to drive than the standard Federal cutter, but not enough to prevent penetration of the snowpacks that were sampled. The short metric, with its steeper cutting slope, was difficult to use in cutting through ice lenses and ground ice layers encountered in Ontario (Goodison and Metcalfe, 1978).

In February 1978 the AES conducted tests to assess cutter performance in cutting ice. Tests were conducted on ice blocks in a cold chamber kept at constant temperature. A constant turning rate and axial load was applied during each test. The Bowman cutter had the deepest penetration into the ice blocks, followed by the long metric. The short metric had less penetration and was only slightly better than the standard Federal. Tests were rerun in July 1978 with similar results. The application of silicone oil to the cutter before cutting the ice provided only a marginal change in the depth of penetration. An increase in axial load, however, did increase depth of penetration. It was also found that for the small-diameter cutters under a given axial load, the diameter of the cutter at the point of maximum penetration was the same. Consequently, it was logical to expect the long, gently tapered cutters to penetrate the ice deeper than the short, steeper sloped cutters.

1.3.4. Sampler tests in shallow snowpacks

In shallow snowpacks, those of 1 m or less, large-diameter (cutter area of 30 to 35 cm²) samplers are commonly used. In the Eastern United States, the Adirondack sampler has been used by the USGS and the NWS. In Canada, the Meteorological Service of Canada (MSC) sampler has been in general use by the AES and other agencies since the mid-1960s. Large-diameter samplers are not used exclusively in shallow snowpack regions; many operators still prefer the standard Federal sampler.

Bindon (1964) presented initial results for a variety of snow samplers tested by the AES in Southern Ontario. Goodison (1978) presented a more complete analysis on the accuracy and general performance of various snow samplers based on tests in a variety of shallow, variable, ice-layered snowpacks, mostly in Ontario, between 1974 and 1977. These tests showed that, where complete snow cores are taken, the standard Federal. Leupold & Stevens 8-tooth cutter, and MSC samplers overmeasured snow water equivalent by an average of 5 to 10 percent. The Adirondack sampler consistently measured within 4 percent of the true snow water equivalent. Although the Adirondack sampler was the most accurate of those tested, it has difficulty penetrating thick ice lenses.

The Bowman and McCall samplers were also tested. The Bowman gave results similar to those obtained with the standard Federal, although it penetrated ice lenses more easily. The McCall sampler, with drop hammer, repeatedly provided the most accurate mean snow water equivalent. It averaged within 1 percent of true actual snow water equivalent and showed no consistent measurement bias. This was the best sampler for penetrating ice layers and for ensuring that a solid soil plug was obtained. Comments on the performance of each sampler are included in Goodison (1978).

Analysis of the data from these tests failed to confirm that the overmeasurement may be a function of snow density, specifically with overmeasurement increasing as density increased. The test data showed that one should expect considerable scatter in the measurement error in snowpacks that have significant ice layers or ice lenses in them. The small-diameter samplers may encounter cutter blocking or snow collapse when ice layers are present in the snowpack.

1.3.5. Alaska - Bowman vs CRREL

From 1964 through 1978, the Alaska SCS Snow Survey staff compared the Bowman snow sampler and the 500-cm³ CRREL snow sampler. This work was supported by CRREL. Ten snow courses were sampled twice each season near the first of March and April. Snowpacks were typically shallow, cold, and with well-defined depth hoar on the bottom of the snowpack. Snow depths in over 200 comparative samples ranged from 24 to 132 cm and averaged about 50 cm. The correlation coefficient of the snow water equivalent measured by these two samplers was 0.987. This analysis indicates that the CRREL sampler overmeasured the snow water equivalent of the Bowman sampler by 2.5 percent in cold, shallow snow. This is comparable with the findings for the first portion of the study as reported at the 1973 WSC by Crook and Freeman (1973) where the overmeasurement of the Bowman sampler was 4.1 percent and the CRREL procedure was 7.1 percent overmeasurement.

1.4 Lead time needed for conversion to metric

Lead time is a critical factor in major equipment conversion involving measuring devices and data units, particularly because of the large numbers of snow samplers now in use in North America. Some of the factors that affect lead time are formal adoption of SI standard units, a decision to convert to metric on a specific date, and time needed to manufacture the equipment.

Metric equipment must be designed and adopted before a conversion date is selected. Also, lead time is needed for manufacturing both new and retrofit equipment. In addition, the following items should be completed: revision of instruction manuals and maps, conversion and adjustment of historic data, training of staff and cooperators, revision of field markers (if required), and conversion of recorders, sensors, and other measuring devices.

1.5. Standardization

Before the series of cutter tests discussed here, many independent efforts had been made to design new cutters and to check the accuracy of existing equipment. The proposed conversion to metric provided additional stimulus to design a metric snow sampler and particularly a cutter that does not overmeasure.

Concurrent with the cutter redesign efforts, the WSC realized that widespread testing using uniform procedures would ensure a large volume of reliable test data for comparison of old and new equipment under a variety of snow conditions. Such testing would also help speed selecting and evaluating a final design. The goal was to develop a standard cutter that was either consistently accurate under all snow conditions or had a

measurement bias that could be proved to be consistent in all types of snow. Such a cutter, when adopted universally, would be of great benefit in alleviating the problems of future data analysis and exchange among all snow data users who may now be using a variety of equipment. Such a standard cutter would also provide more reliable comparisons of control sample data obtained manually at snow sensor sites with the onsite manometer or telemetered data. And finally, a cutter adopted as standard would cost less because manufacturers would have to tool-up only once for ongoing repetitive production for all customers.

WSC METRICATION COMMITTEE ACTIVITIES

2.1. Recommendations from first working group meeting

Member agencies of the WSC have been active in metrication planning for many years, but many decisions were made unilaterally through 1977 because there had been no agreement on the development of universally acceptable metric equipment. The WSC, under the direction of General Chairman Manes Barton, named a metric work group which met July 17-21, 1978 in Portland, Oregon, to prepare such a plan. The working group outlined their objectives (Metrication Committee, 1978). In essence, the committee expected to review past test data, to recommend design specifications for metric equipment, to unify the test programs of various contributing agencies in both the WSC and ESC, and to recommend interim and final equipment designs.

The metric work group agreed that the design of the cutter was fundamental and involved two principal elements—the cutting area and the shape of the teeth. The group proposed that there be a snow sampler primarily for use in deep snowpacks in the western mountainous region. This sampler was designated WSC 10 (Western Snow Conference 10-cm² area cutter). In other regions, where snowpacks are relatively shallow, the work group proposed another cutter which they named ESC 50 (Eastern Snow Conference 50-cm² area cutter). The work group thought that the shape of the teeth was partly responsible for the overmeasurement bias associated with the standard Federal sampler. The teeth on the standard Federal cutter have a flat surface so at least part of the snow displaced by the teeth is diverted into the core. The group proposed that the teeth on both samplers be sharpened to the inner surface.

The working group also recommended that field tests be made to verify the feasibility of using 10-cm^2 or 50-cm^2 cutting areas and to determine the effect of sharpening the teeth as described. Because different agencies would be testing the equipment independently, the group decided to use standard forms and test procedures. It was known that the larger diameter cutters tend to be the most accurate. Working from this premise, a 10-cm-diameter stainless steel toothless cutter developed in British Columbia for the Glacier sampling program was to serve as the control. All of the control Glacier samplers used by the various agencies during the subsequent test programs would be cut from a single length of pipe and machined to a uniform standard.

The basic cutters to be tested were the standard Federal, standard Federal sharpened, WSC 10, ESC 50, MSC, Adirondack, and McCall. A number of other secondary cutters could be tested to broaden understanding of snow sampling, but they were not expected to directly affect the results. Actual tests would be conducted for two seasons in order to compare results and improve the statistical validity.

2.2. First-year (1979) field tests

2.2.1. Control snow sampling equipment

Five identical Glacier samplers and leveling plates were constructed from stainless steel. Five standard Federal cutters were procured. The standard Federal cutters had a tooth thickness of 1.6 mm and an inside diameter of 37.7 mm. All sharpened Federal cutters were filed identically. A silicone release agent was baked on all snow tubes. Forms, procedures, and other equipment were standardized and provided to metrication members (Appendix III). Snow sampling spring scales were checked for calibration. Gram-balance scales were used for weighing cores from the Glacier sampler and other samplers.

2.2.2. The 1979 WSC 10 cutter

The 1979 WSC 10 cutter was similar to the 1978 short metric cutter but modified to incorporate better ice-cutting performance by reducing the shoulder area of the teeth and by sloping the teeth similar to the standard Federal cutter. The 16 teeth were sloped to a sharp edge at the cutter face. The cutter length was similar to 1978 short metric. The cutter area was $10~\rm{cm^2}$. Five identical 1979 WSC 10 cutters were fabricated for the 1979 field tests and provided to metrication committee members and Agricultural Research Service (ARS) of Boise, Idaho.

2.2.3. Results of 1979 WSC 10 tests

Tests revealed larger diameter cutters were the most accurate down to a lower limit at about 20 cm². The smaller cutters required for use in mountain snowpacks showed a definite overmeasurement in 1979 when compared with the Glacier sampler. The reinforcing ridge on the teeth of the 1979 WSC 10 cutter may have contributed to this overmeasurement. The data, summarized in Appendix I, Table V, contain the results from 66 test sets. Snow water equivalent in snowpacks studied ranged from 57 to 1,493 mm, and density ranged from 22 to 52 percent.

Some additional tests were performed to test a cutter with broken teeth and the McCall sampler. Also made were pit tests to verify the measurements of the Glacier sampler, comparative tests using sharpened irrigation tubing, and a test of the accuracy of a portable profile snow gauge. To ensure a true comparison, all weight measurements were correlated to the measured cutter areas for each cutter.

Results show the standard Federal cutter had the highest overmeasurement, followed by the 1978 short metric, the 1979 WSC 10, and the sharpened Federal cutter. Broken teeth added to the overmeasurement.

Many observers noted that the smaller diameter metric samplers were more difficult to drive through the snowpack and obtain a good core because of wider shoulders of the cutter and ice jamming in the cutter section. This effect was generally not serious enough to prevent samplers from obtaining acceptable measurements.

2.3. Second-year (1980) field tests

2.3.1. The 1980 WSC 10 cutter

The inside diameter of the 1979 WSC 10 cutter was difficult to control during heat treating, and it seemed to be a poor ice cutter. The 1979 WSC 10 cutter was redesigned for the 1980 season to incorporate better ice-cutting performance based on AES tests and to increase the strength of the tooth area. The number of teeth and the inside diameter remained the same as the 1979 WSC 10 metric cutter. Teeth were sharpened to the inside. As with previous equipment, uniform 1980 WSC metric cutters were provided to each metrication committee member.

2.3.2. Results of 1980 WSC 10 tests

The 1980 WSC 10 cutter showed a consistent overmeasurement similar to that obtained with the 1979 WSC 10 cutter (Appendix I, table V). It was concluded from all 1979 and 1980 tests (Farnes et al., 1980) that even a sharpened cutter of this diameter overmeasures when compared with the $\overline{\text{Glacier}}$ control sampler. As in earlier tests, it appears that sharpened cutters of about 20 cm² and larger provide data comparable with the Glacier sampler with little or no overmeasurement. Data from sharpened cutters also suggest that sampling overmeasurement increases as cutter area decreases. Blunt cutters such as the standard Federal have additional overmeasurement error related to tooth thickness. Field tests indicated that it was more difficult to drive the snow samplers with smaller diameter cutters under some snow conditions.

From the data obtained in tests through 1980, it was apparent that small-diameter samplers were prone to overmeasurement regardless of cutter design. To obtain a small-diameter sampler that would provide negligible measurement error, either the cutter area could be reduced and the sample weighed on the existing scales or the scales could be modified to compensate for overmeasurement or "overweighing." It appeared that fewer problems would develop by using a true weight on the weighing scales and adjusting the cutter diameter to compensate for the overmeasurement because some snow sampling is done using gram-balance or other standard weighing scales. This method would allow for a conversion of 1 mm of water equivalent for each gram of weight. Also, present scales could be used by converting the readings in inches to mm. The disadvantages of this procedure include the difficulty of driving a slightly smaller diameter cutter through the snowpack and the additional manufacturing costs for new cutters to modifying present equipment.

2.3.3. Large-diameter ESC 50 and ESC 40 samplers

The large-diameter ESC 50 sampler for shallower snowpacks was designed with a 50-cm^2 cutter area as originally proposed. In theory, this area would provide snow water equivalent accuracies in the \pm 1- to 2-mm range using scales similar to those used with the WSC 10 snow sampler. Based on the performance of the Adirondack and MSC samplers (Goodison, 1978; Goodison and Metcalfe, 1978), both fiberglass and clear plastic were considered to be more desirable tubing material than aluminum.

An ESC 40 sampler with a 40-cm^2 cutter area was also constructed. The availability of standard size materials necessitated using the same diameter tubing for the ESC 40 cutter as for the ESC 50 cutter. This required that the ESC 40 cutter be longer than the ESC 50 cutter because the tubing was the same size, but the cutter had a smaller inside diameter.

2.3.4. Results with the ESC 50 and ESC 40 samplers

In the first field tests conducted in Montana, it became evident that there was no simple or practical way the ESC 50 cutter could be designed to hold the snow core for the many kinds of snow conditions found in the shallower snowpacks. Even the ESC 40 cutter had some problems holding cores in some kinds of snow. The 36-tooth cutters on both samplers were quite sharp and could create a hazard to surveyors. The use of clear plastic for the snow tube was superior to either fiberglass or aluminum. The clear plastic could be readily machined to accept cutters, and core lengths could be observed without requiring slots or holes in the tubing. Visibility of the core was useful to determine when the core was detached from the soil interface and to identify cases where blocking of the core occurred. The plastic was very durable and strong even under extremely cold conditions. Subsequent drop tests of the plastic snow tube onto concrete at -40°C and other destructive-type tests have confirmed its strength and durability.

2.3.5. Results with other large-diameter samplers

2.3.5.1. PVC pipe

To confirm results that larger cutters-cutter area larger than $20~\text{cm}^2$ -do not overmeasure, tests were made using PVC pipe. Area of the pipe was $20.88~\text{cm}^2$, and it was sharpened to the inside on a grinder at approximately 45° angle. Because there was no ridge or shelf on the inside, the core would slip out if the tube was extracted vertically. The measurements were made in the walls of the metric pits similar to the procedures used for the Glacier sampler, and the core was held in the tube with a small aluminum plate. Cores were placed in containers and weighed to determine their snow water equivalent. The measurements obtained by this method were nearly identical to the Glacier sampler measurements (Appendix I, table V).

2.3.5.2. Aluminum irrigation pipe

Thin-wall aluminum irrigation pipe was also used to determine if the wall thickness of the Glacier sampler was a source of error. The irrigation pipe was sharpened to the inside and a silicone release coating was baked on, similar to the treatment used for WSC snow sampler tubing. The area of the aluminum pipe was 77.13 cm², which was only slightly smaller than the Glacier sampler. The measurements were made in a manner similar to those with the Glacier sampler. The results (Appendix I, table V) showed only a 0.6 percent difference between the Glacier sampler and the irrigation pipe and would suggest that these two samplers could be used interchangeably.

2.4. Third-year (1981) field tests

2.4.1. The 1981 WSC cutter

Following the 1980 results, it was apparent that new cutters would need to be fabricated. Comparisons of the overmeasurement of the sharpened standard Federal with the 1980 WSC 10 cutter indicated that the cutter area of the sharpened Federal needed to be reduced by 6.9 percent to compensate for the overmeasurement. The cutter area of the 1981 WSC metric

cutter should be $10.405~\rm cm^2$, and the inside cutter diameter should be $36.4~\rm mm$. The cutter shape and design were the same as those of the 1980 WSC 10 cutters. Five new cutters with the modified area were built and sent to four committee members and to Colorado State University (CSU) for field tests during the 1981 winter. The conversion factor of 1 mm of snow water equivalent for each gram of weight would still be used.

2.4.2. The 1981 ESC 30 sampler

The 1981 ESC 30 sampler had a cutter area of $30~\rm cm^2$ to improve the core-holding capability and because this size was more compatible with standard sizes of clear plastic tubing that were commercially available. The cutter had 16 teeth sharpened to the inside and an inside cutter diameter of 61.80 mm, which is equivalent to a cutter area of $30~\rm cm^2$. The teeth were sharpened to the inside similar to the 1981 WSC metric cutter. The cutter had a lip on the inside to help hold the snow cores in the tube. The tubing material was clear TENITE-BUTYRATE with a 76 mm outside diameter and 70 mm inside diameter. The tube was about 130 cm long to allow sampling of snowpacks slightly deeper than 1 m.

The WSC metric snow sampler "4 METERS" weighing scale could be used for the ESC 30 sampler by modifying the markings on the inner tube of the scale and adding a larger cradle to hold the sampler on the scale. Because there are many locations where both the ESC- and WSC-type samplers are used, equipment costs would be reduced if only one scale were required. Where both samplers were being used, two graduations could be imprinted on the same scale; i.e., one for the WSC metric sampler and one for the ESC 30 sampler. The ESC 30 scale could be imprinted in red to avoid erroneous readings in the field. Such a dual scale in red and black is currently used by the AES for the standard Federal and MSC samplers and by Leupold and Stevens for their Federal type sampler with English and metric units.

2.4.3. Results of 1981 tests

2.4.3.1. WSC metric snow sampler

If an adjustment for 6.9 percent reduction in area were applied to correct overmeasurement of snow water equivalent, the adjusted water equivalent obtained with the 1981 WSC metric cutter would be about 3 percent less than the true water equivalent indicated with the Glacier sampler (Appendix I, table V). The 1981 WSC metric cutter has an actual overmeasurement of 3.8 percent for 1981 data. Most of the 1981 tests were made in snowpacks that had ice lenses or ice layers which may have contributed to the lower-than-average bias. For example, for 1981 the standard Federal and sharpened Federal cutters had an overmeasurement of 7 and 4 percent, respectively, compared with 10 and 6 percent for all data. Additional tests with this same cutter in 1982 in more typical snowpacks seemed to indicate that part of the 1981 undermeasurement may have been related to snowpack structure. Similarly, other smaller diameter cutters showed much less overmeasurement in 1981 than in other years. This being the case, the use of the WSC metric sampler in regions where ice lenses and layers are common may yield less than true water equivalent. A graphical comparison between the 1981 WSC metric cutter and the Glacier sampler is shown in figure 1. A similar comparison of the standard Federal and Glacier samplers is shown in figure 2.

2.4.3.2. ESC 30 snow sampler

The water equivalent measured by the 1981 ESC 30 snow sampler was very similar to the measurements obtained with the ESC 50, ESC 40, and Glacier samplers (table I and Appendix I, table IV). Graphical comparison of the ESC 30 and Glacier samplers is shown in figure 3. The snow core could be held in the ESC 30 for most snow conditions, and the clear tubing material permitted visual observation of the core and snow layers. The area of the ESC 30 sampler being about three times the area of the WSC metric sampler appeared to be sufficient to improve the accuracy over snow samples obtained with the smaller diameter snow samplers in shallow snowpacks. Based on these tests, no apparent changes were necessary for final design.

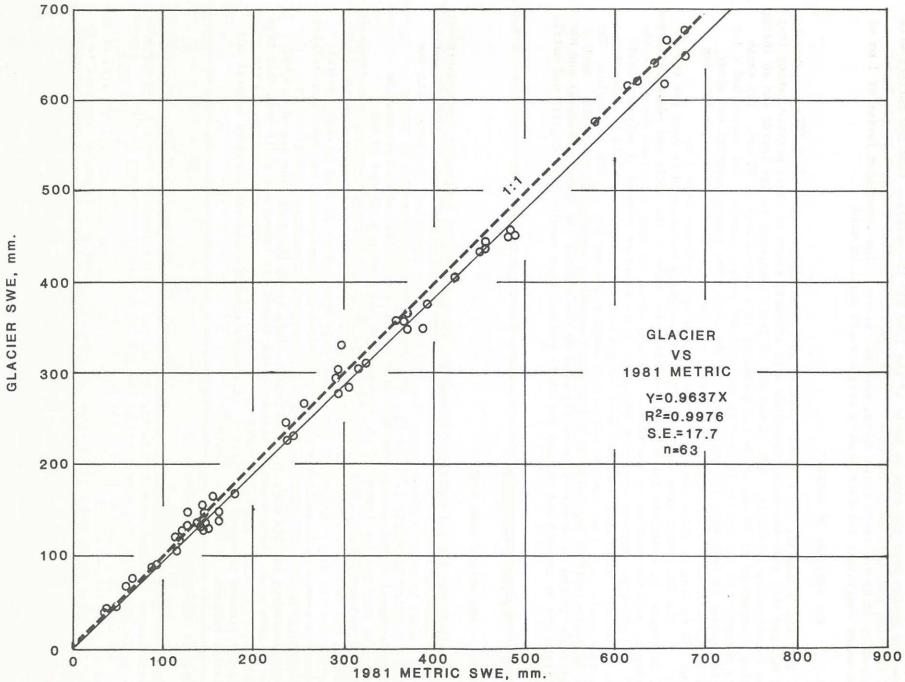
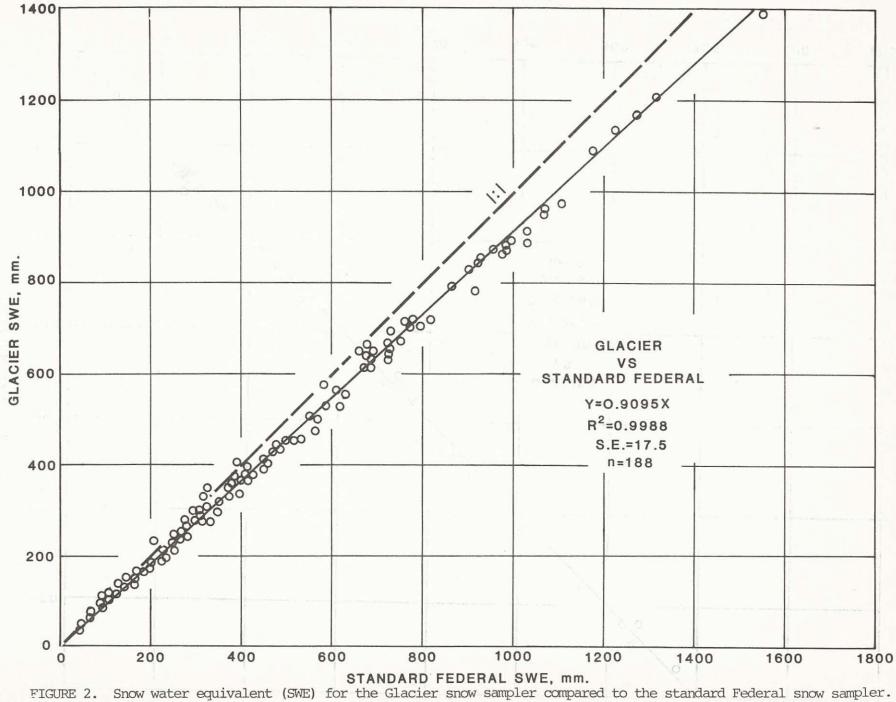
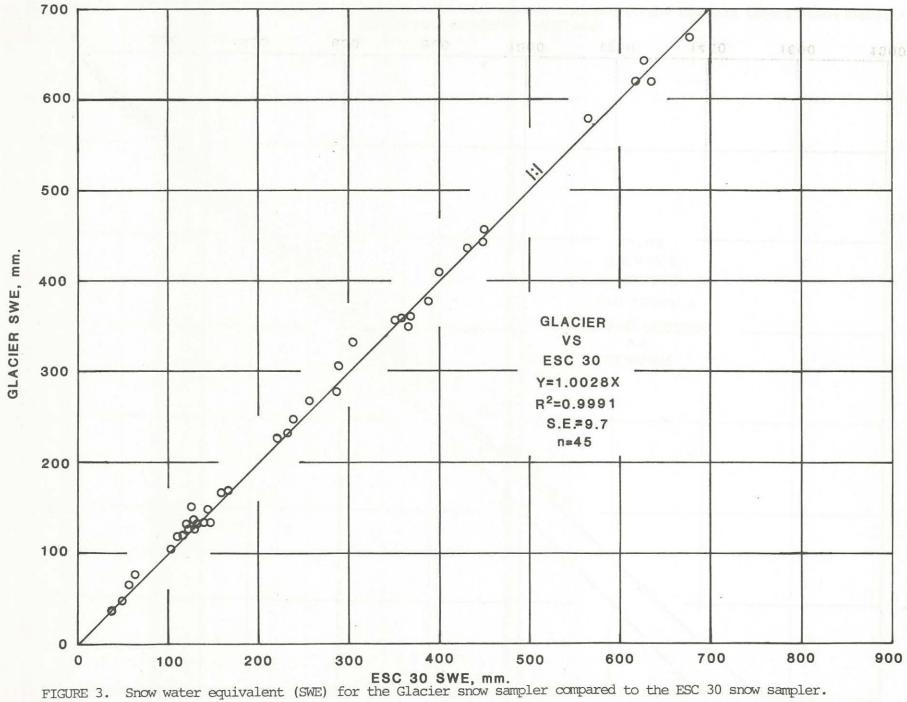


FIGURE 1. Snow water equivalent (SWE) for the Glacier snow sampler compared to 1981 WSC metric snow sampler.





2.5. Analysis of snow sampler data

Table I summarizes the average measurement error calculated for most snow samplers being used in the field and for special samplers being tested by the metrication committee. Samplers that were tested during the metrication study are compared with the Glacier sampler to determine overmeasurement. Snow samplers previously tested were compared with the standard Federal sampler with its known 10.0 percent overmeasurement bias to determine overmeasurement of each individual sampler. Where adequate data are available, regression analysis was used to determine coefficients for data with an assumed intercept of zero. A summary of this analysis is shown in Appendix I, table VII.

2.5.1. Effect of snow density on overmeasurement

Data obtained during the metrication study were arrayed into ranges of densities as determined from the Glacier sampler. These results are summarized in table II. These results do not suggest any apparent correlation between measurement error and density of the snowpack being sampled. A complete analysis of data obtained by the metrication committee showing the variation between different samplers for ranges of snow density is given in Appendix I, table VIII.

2.5.2. Small-diameter samplers

All small-diameter cutters (area ranging from 10 to 11.2 cm²) overmeasure. Where there are thin ice layers in the snowpack, the samplers overmeasure less than in snowpacks without ice layers. Normally, the overmeasurement with sharpened cutters is about 4 to 7½ percent. Cutters with blunt teeth such as the standard Federal and Leupold and Stevens have larger overmeasurement in the 10- to 12-percent range. Generally, the wider the flat surface of the tooth, the greater the overmeasurement. This additional overmeasurement is also evident in tests with the broken tooth Federal. It is assumed that when snow meets the front surface of the flat tooth, a portion of the snowpack splits and enters the tube and the remainder is forced outside the tube. This creates, in effect, a larger diameter cutter than the measured inside diameter for cutters that have flat teeth or flat surfaces.

Part of the overmeasurement with sharpened cutters is thought to be related to the resistance and forces applied to the snow particles by the sloping outside of the cutter. The inside of the cutter is smooth and parallel to the driving force and applies much less pressure than the outside surface. Hence, additional snow is forced into the cutter. This same condition also occurs with larger diameter cutters; however, the amount of snow forced into the cutter is very small when compared with the total volume of snow going into the tube, and it is not significant enough to appear as overmeasurement. It appears that this overmeasurement is insignificant or undetectable with cutters that have more than a 20-cm² area.

2.5.3. Large-diameter samplers

All large-diameter sharpened cutters (area more than 20 cm²) yield water equivalents that are very near "true" or actual values. Any deviation is generally related to sampling problems or snowpack conditions such as ice layers. Samplers that have cutter areas of more than 30 cm² generally cannot hold snow cores even with considerable lip size on the inside of the cutter. These larger diameter samplers usually require that a plate, shovel, or some other object be placed over the cutter at or near the ground surface to hold the core in the sampler. This generally causes considerable disturbance to the snow sampling area and requires considerable effort on the part of the surveyor in deeper snowpacks.

It appears that samplers with cutter areas of about 30 cm² are large enough to accurately measure snow water equivalent and yet small enough to hold the core in most snow conditions. Sampling accuracies do not seem to be affected by whether or not the cutter has teeth. However, the teeth seem to facilitate cutting through ice layers into soil to obtain soil plugs and to break the bond between the snow and soil at the soil interface.

TABLE I

OVERMEASUREMENT OF SNOW WATER EQUIVALENT AND CORRECTION FACTOR FOR VARIOUS SNOW SAMPLERS

ТҮРЕ	CUTTER AREA, cm ²	OVERMEASUREMENT (Percent)	CORRECTION FACTOR 1/
Glacier	81.9	0	1.00
Standard Federal Broken-tooth Federal Leupold and Stevens	11.2 11.2 11.2	10.0 12.1 8.0	0.91 0.89 0.93
Average of Small-Diameter Samplers with Blunt Cutters	11.2	10.0	0.91
Sharpened Federal Bowman BUNG McCall Rosen	11.2 11.2 11.2 11.2	6.2 5.1 4.2 4.0 3.5	0.94 0.95 0.96 0.96 0.97
Utah Average of Small-Diameter Samplers with Sharp Cutters	11.2	5.1	0.95
1978 Metric (short) 1978 Metric (long) 1979 Metric 1980 Metric 1981 Metric	10.0 10.0 10.0 10.0 10.0	7.6 4.0 7.6 4.5 3.8	0.93 0.96 0.93 0.96 0.96
Average of Small-Diameter Samplers with Metric Cutters	10.0-10.4	5.5	0.95
Average of all Small-Diameter Samplers with Sharp Cutters Having Good Control Data 2/	10.0-11.2	5.6	0.95
ESC 30 ESC 40 ESC 50	30.0 40.0 50.0	-0.3 0.2 -0.1	1.00 1.00 1.00
Average of ESC Samplers	30-50	-0.1	1.00
PVC Tubing Adirondack MSC Aluminum Tubing	20.9 35.7 39.1 77.1	0.0 0.1 5.7 0.6	1.00 1.00 0.95 0.99
Average of all Large-Diameter Samplers	20-50	1.0	0.99
CRREL Tubes (Volume = 500 cm ²) Profile Gage (modified)	26.5	7.1 <u>3</u> / 2.6	0.93 0.97

 $[\]underline{1}/\mathrm{To}$ obtain true SWE with various samplers, multiply measured SWE by the correction factor.

^{2/}Includes only cutters with sufficient controlled data for accurate analysis; i.e., Sharpened Federal, 1978 Metric (short), 1978 Metric (long), 1979 Metric, 1980 Metric, and 1981 Metric.

^{3/}All tests in shallow snow in Alaska

BASED ON DATA OBTAINED BY METRICATION COMMITTEE AND OTHER STUDIES OF SNOW SAMPLER ACCURACY. COMPARISONS MADE WITH GLACIER SAMPLER WHEN DATA AVAILABLE; OTHERWISE, COMPARISONS MADE WITH STANDARD FEDERAL OR COMBINATION OF GLACIER AND STANDARD FEDERAL.

TABLE II

OVERMEASUREMENT OF SNOW SAMPLERS BY DENSITY RANGES AS COMPARED WITH GLACIER SAMPLER

	GL	ACIER	SNOW	DENS	I T Y (kg m-3)				
	All Data	Under 260	260-300	310-350	360-400	Over 400			
			- Percent						
Standard Federal	10.0	9.5	10.8	9.8	9.6	10.2			
Sharpened Federal	6.2	6.1	7.7	6.8	4.8	6.7			
1978 Metric (short)	7.6	3.2	9.8	9.7	6.3	6.8			
1979 Metric	7.6	9.9	10.2	9.3	6.2	7.0			
1980 Metric	4.5	4.2	6.4	5.5	3.5	5.8			
1981 Metric	3.8	2.5	7.6	3.2	1.6				
Average of Small-Diameter Samplers with Sharp Cutters	5.9	5.2	8.3	6.9	4.5	6.6			
ESC 30	-0.3	0.1	-2.4	1.9	-1.9				
ESC 40	0.2	1.2	-0.7	1.5	-1.7				
ESC 50	-0.1			1.5	-0.6				
Average of Large-Diameter ESC Samplers	-0.1	0.6	-1.6	1.6	-1.4				

BASED ON ANALYSIS OF ALL AVAILABLE DATA OBTAINED DURING METRICATION STUDY.

2.5.4. Volumetric samplers

Samplers that are inserted horizontally into the snowpack and then extracted and weighed to determine density and/or water equivalent have their own special problems. The density and strength of the snowpack are both critical for obtaining accurate samples. Low-density or low-strength layers tend to compress as the tubes are inserted and the general tendency is to overmeasure. However, depth hoar or new snow layers may also be undermeasured because of snow collapse or snow sticking to or being moved ahead of the sampler. The condition of the sampling tubes (i.e., well waxed, clean, sharp) is also critical to accurate sampling. These types of samplers require a snow pit and are generally used only in cases where the density is required for individual layers or zones within the snowpack. Because of the need for a pit and the area of disturbance, these types of samplers are not generally used for determining water equivalent on snow courses.

2.6. Collection of auxiliary data and other tests

2.6.1. Profiles

A snow profile was obtained for each field test made by the metrication committee. The temperature profile, snow crystal size and shape, snow hardness of various layers, free water content, and surface condition were recorded. These data are included in Appendix II.

2.6.2. Pits

One additional test considered desirable by the metric working group was a volumetric (pit) check of the Glacier sampler even though it had been assumed to have no inherent measurement error because of its large size and sharp-edged cutter. During two of the metric cutter tests at California's Alpha site, the Glacier sampler was used within the 1.524 m by 1.8 m template. The samples obtained were compared with the total volume of the 2.8 m² sample, which was retrieved and weighed as it was extracted from the template-scribed pit. The volumetric data comparisons from the pits showed that the Glacier sampler had an indicated error of 2 mm or 0.2 percent.

Pit tests were also conducted in Ontario in shallow snowpacks. Where ice layers were present, results from all the samplers, including the Glacier, were more erratic. Analysis of all available data for the standard Federal sampler and pit or template prior to using the Glacier sampler as the standard indicates the standard Federal sampler overmeasures the weight of snow removed from the pit by 9.8 percent, which is similar to the 10.0 percent obtained using the Glacier sampler (Appendix I, tables IV, V, and VI).

2.6.3 Comparisons between snow sampler scales and gram-balance scales

Two field tests in 1979 compared the results of weighing the snow core from a standard Federal snow sampler with both the regular snow sampler scale and with a gram-balance scale. Results are shown in table III.

It appeared that the snow sampler scales are sufficiently accurate for use under field conditions and that differences between samples are random and probably associated with the accuracy with which the snow sampler scales can be read.

TABLE III

SWE OBTAINED WITH SNOW SAMPLER SCALE AND GRAM-BALANCE SCALE

Lick Creek, Montana - 4/26/79

Sample	Cutter Type	Snow Sampler Scale SWE in mm	Gram-Balance Scale SWE in mm	Difference in mm
2 north	Std Federal	292	288	+4
3 south	Std Federal	279	276	+3
2 south	Sharp Federal	279	276	+3
1 north	1978 Metric	241	242	-1
1 north	1979 Metric	229	234	-5
2 north	1979 Metric	248	248	0
3 north	1979 Metric	235	232	+3
1 south	1979 Metric	229	231	-2
2 south	1979 Metric	241	236	+5
1 south	1979 Metric	229	234	<u>-5</u>
	Average	250	250	3

Difference in 10-sample average is 0 percent. Average absolute difference is 1.2 percent. Maximum difference is about 2 percent. Snow sampler scale read to nearest 6 mm SWE. Gram-balance scale read to nearest gram (1 mm SWE).

Shower Falls, Montana - 4/27/79

Sample	Cutter Type	Snow Sampler Scale SWE in mm	Gram-Balance Scale SWE in mm	Difference in mm
2 west	Std. Federal	800	786	+14
3 west	Std. Federal	826	809	+17
5 west	Std. Federal	800	783	+17
2 east	Std. Federal	775	750	+25
4 east	Std. Federal	775	763	+12
1 west	1978 Metric	602	597	+5
2 west	Sharp Federal	775	772	+3
3 west	Sharp Federal	749	751	-2
4 west	Sharp Federal	762	760	+2
4 east	Sharp Federal	749	754	<u>-5</u>
	Average	e 761	752	15

Difference in 10-sample average is 1.0 percent. Average absolute difference is 2.0 percent. Maximum difference is about 3 percent. Snow sampler scale read to nearest 13 mm SWE. Gram-balance scale read to nearest gram (1 mm SWE).

2.6.4. Driving tests in deep, dense snowpacks

On June 26, 1980, a test of the driving ability of snow samplers was conducted in the Gravelly Range of southwestern Montana. The test area was a southeast-facing snowdrift approximately 60 m long, 25 m wide, and 2 to 4 m deep. The elevation was about 2,500 m. The weather was partly cloudy and the air temperature was 13° C. The snowpack density was 600 to 650 kg m⁻³.

The five different cutter bits tried on the Federal sampler included a standard Federal cutter, a 1979 metric cutter, a 2-tooth cutter, a 2-tooth fluted cutter, and a 4-tooth cutter. The depth of penetration by one person ranged from 96 to 285 cm. Two persons could drive the standard Federal up to 290 cm--with extreme difficulty. None of the tests completely penetrated the snowpack. There appeared to be no correlation between depth of penetration or cutting ability with the different types of cutters.

Additional tests were done at a nearby area with approximately 240 cm of snow depth. One person could drive the standard Federal with moderate difficulty, using any of the various cutters. The McCall sampler was relatively easy for one person to drive by hand, using either the standard McCall cutter or a modified 2-tooth or 4-tooth cutter.

Ease of driving and extraction of snow samplers in very dense snowpacks seems to be more dependent on the relationship between the maximum cutter diameter and maximum coupling diameter than on the tooth configuration. On the standard Federal sampler, the maximum diameter of the cutter is 47.1 mm, and the maximum diameter of the couplings is 50.4 mm.

The McCall tube has a much thicker tube wall thickness, but the couplings are internal so that the outside of the tube is smooth. The outside diameter of the McCall tube is 48.3 mm, and the maximum diameter of the cutter is 49.3 mm. Other snow surveyors have reported that it is easier to obtain samples in very deep, dense snowpacks with the McCall sampler than with the standard Federal or similar metric sampler.

The McCall sampler is recommended for snowpacks that are deeper than 4 m and have densities greater than $400~\rm kg~m^{-3}$ and frequent ice layers. One disadvantage of this sampler is its weight, which is over twice that of the standard Federal, but this may be offset by its ease of sampling. Special weighing scales are needed for the McCall sampler as the tube is too heavy for the "6 METERS" scale.

2.6.5 Agricultural Research Service tests

From 1975 to 1979 the Agricultural Research Service (ARS) of the U.S. Department of Agriculture evaluated the performance of snow sensors for the SCS (ARS-SCS, 1979). They were provided with a Glacier sampler, metric cutters, and procedures used by the metrication committee. Data applicable to the metrication studies are included in Appendix I, Table VI. Data collected by ARS during these studies generally agree with those obtained by the metrication committee. These data expand the data base and are particularly useful for evaluating the accuracy of the Rosen snow sampler and pit samples.

2.6.6 Colorado State University tests

From 1979 to 1981 Colorado State University (CSU) conducted research under cooperative agreement with the SCS to evaluate snow pillows (CSU-SCS, 1979-1981). CSU used a Glacier sampler, metric cutters, and followed procedures used by the metrication committee in their investigations. Data applicable to metrication of snow samplers is shown in Appendix I, table VI. Field tests indicated that the Glacier sampler compared very closely with density profiles and pit volume samples. Measurements with the other samplers were similar to those obtained by the metrication committee.

2.6.7. McMaster University tests

During May 1982, limited tests were conducted in the Canadian High Arctic to compare efficiency and ease of usage of the ESC 30, standard Federal, and MSC snow samplers (Woo, 1982). Four snow surveyors conducted the tests at Eureka and Resolute. They sampled snowpacks with hard windslabs, depth hoar, and ground ice.

The ESC 30 was more difficult to drive through icy or hard layers than the other two samplers, but in cohesive snowpacks it appeared to be slightly better than the MSC for acquiring and retaining the core. Under depth hoar conditions, both large-diameter samplers had difficulty in consistently retaining the snow core. However, the clear plastic tube of the ESC 30 allowed the snow core to be observed directly, which was useful when operating in snowpacks that collapsed when sampled. In terms of accuracy, the standard Federal sampler consistently overmeasured by about 10 percent. The MSC overmeasured by 3 to 7 percent, and the ESC 30 ranged from 2 percent undermeasurement to 5 percent overmeasurement.

2.7. Special or unusual conditions

2.7.1 Ice and shallow snow conditions

Extensive testing in Montana and Ontario has shown that larger diameter samplers provide more consistent measurements that are closer to the true water equivalent than small-diameter samplers. Ice layers in the snowpack may cause blocking in the smaller cutters or collapse of snowpack, resulting in undermeasurement (Goodison, 1978). As Bindon argued (Bindon, 1964), the percentage error in the measurement of water equivalent due to edge effect is inversely proportional to the radius of the cutter. Hence, large-diameter cutters will have proportionately smaller errors attributable to this edge effect.

2.7.2. Ice layers

As in routine snow survey work, some of the test samples were taken in snowpacks having ice lenses. When using the standard Federal and WSC 10 or metric test cutters in snowpacks having ice layers, double or multiple sampling was sometimes necessary to retrieve one valid core. In shallow snowpacks, the ice lens sometimes stuck in the cutter and blocked it, resulting in a short core. The metric cutters with their smaller diameters seemed to be more prone to this problem. However, the Glacier core increments were always more difficult to retrieve when ice layers were encountered because of the larger size of the sample and the lack of cutter teeth to assist in cutting the core. This difficulty was overcome by taking the samples in smaller increments, starting or stopping at the ice layer, or using a board and rubber mallet to drive the sampler through the ice layers where the ice was not too thick. The board-and-mallet technique was also required occasionally in the California tests for driving the ESC 30 test sampler through the ice. This often resulted in driving the tube a little deeper into the soil, which then required care in plug removal and depth adjustments. However, this large-diameter sampler would not normally be used in the deeper western snowpacks. The ESC 30 was also more difficult to drive through hard crusts and ice layers in the Arctic tests conducted by McMaster University.

2.7.3. Depth hoar

Shallow snowpacks in cold environments develop a bottom layer of poorly bonded snow granules called depth hoar. This layer may be as deep as one-half the total snow depth. Because of its very weak structure, any movement will cause this entire layer to collapse. Any form of snow sampler requires especially careful handling to make sure this snow is captured in the sampler. The smaller the diameter of the cutter, the greater the chance of losing part of the core. Where a crust or ice lens forms above the depth hoar, the depth hoar is even more difficult to retrieve because it is not firm enough to move both the snow and ice into the tube.

None of the samplers tested appeared to be superior for sampling snow with depth hoar. The main consideration for this type of condition is proper sampling techniques.

2.7.4. Isothermal snowpack

The Sierra, Cascade, and Coastal Ranges are "warm ranges" because of the marine air masses that generally predominate. The snowpack reaches isothermal conditions rapidly, usually commencing early in the snow season. This climatic condition almost never produces depth hoar and can rapidly warm new snow to the melting level as soon as surface crusting occurs. Under these conditions, the snow can metamorphose rapidly and partially melt at any time during the winter. Also, strong ice lenses that develop early in winter disappear when the snowpack becomes isothermal. In the interior mountains the snowpack does not usually become isothermal until immediately prior to melt late in spring.

2.7.5. New snow

New snow generally has much lower density than the rest of the snowpack and can present some special problems. Sampling disturbs the surface snow, which can create problems for future samplings; and this new snow can cause sampling problems and errors. New snow becomes very sticky when exposed to warm temperatures and/or bright sunlight. Snow sampling equipment must be well waxed or siliconed to prevent this snow sticking to the tube or cutter, and good sampling techniques must be used.

2.8. Further testing

Because no technology remains static and because all snow conditions do not conform to given criteria, it is recommended that testing of other snow samplers having limited data and newer metric snow measuring equipment be continued by all interested agencies involved in snow surveys. It is also recommended that future tests follow the procedure used in this study and that the WSC and ESC maintain standing metrication committees to coordinate additional testing of snow samplers and other devices and to help develop new procedures. This will ensure compatibility of data from various sources. Such an organizational function within the WSC and ESC will also facilitate widespread exchange of research information and foster increased awareness of testing activities, which may generate beneficial modifications or changes more quickly.

3.1. Proposed WSC metric snow sampler

An analysis of all the data for all years (Farnes, et al., 1982) suggests that the sharpened Federal sampler overmeasures by 6.2 percent (table I). The average overmeasurement of the 1978 (both short and long), 1979, 1980, and 1981 metric cutters, all having a similar diameter and sharpened, was 5.5 percent when compared with the Glacier sampler. It appears from this more comprehensive data base that the overmeasurement of all the tested sharpened cutters averages closer to 5.6 percent than to the 6.9 percent calculated from the smaller data array available in 1980. This also agrees with the average of 5.4 percent error when all data from the 1981 metric cutter are compared with the Glacier, standard Federal, and sharpened Federal cutters (Appendix I, table IX). This suggests that the metric cutter should have an area of 10.58 cm² (area of the standard Federal cutter 11.17 cm² \div 1.056). This would require that the cutter diameter be 36.70 mm if the cutter were to be calibrated to true scale weight. Detailed specifications follow.

3.1.1. Specifications for WSC metric snow sampler

General

The WSC metric snow sampler shall conform to specifications summarized below and illustrated in Figure 4, entitled "WSC Metric Snow Sampler."

Tubes

The tubes shall be made from 44 mm (44.45-mm OD with 1.475-mm wall thickness) 6061-T6, aluminum or equivalent. Each tube section shall represent 75 cm of snow depth. Markings are to be stamped on the tube every centimeter with zero measured from the root of cutter teeth. Numerals shall be stamped every fifth increment to represent depths of 5, 10, 15, 20 through 75 for the first section and 80, 85, etc., for the second tube and succeeding tube sections.

Slots on the snow tubes will be 3.4 mm X 8 cm on alternate sides of the stamped numerals and increments with a 1-cm separation. The first tube section will have 6 slots starting at increment 13 and extending to increment 21; the next slot will be on the opposite side of depth markings and extend from 22 to 30, etc., with the uppermost slot on the first tube extending from 58 to 66. The second tube will have 7 slots beginning at 79 and ending at 141. The third tube will have 7 slots beginning at 154 and ending at 216. The fourth tube will begin at 229 and end at 291, etc.

After the tubes are completely assembled, they will be treated with a baked-on silicone release agent Dow Corning 1-2531 resin or equivalent.

Cutter

The one-piece cutter shall be milled 4130 aircraft moly or cast 17-4 stainless alloy, heat treated and ground to 36.70 mm inside diameter. The cutter shall have 16 teeth with lands approximately 2 mm wide and grooves approximately 5 mm wide. The teeth shall have a slope angle of 7 degrees and shall be 30 mm long. The inside lip that is ground to 36.70 mm shall extend 15 mm from the point of the teeth. All leading surfaces of the teeth will be sharpened to the inside. The portion of the cutter that fits inside the tube shall be slightly larger than the tube and shall be held in the tube by a shrink fit. The letters "WSC" will be stamped on one of the grooves.

Couplings

The male and female couplings shall be slightly tapered and shall be constructed of 6061-T6 aluminum or equivalent. They shall have a shrink fit on the tubing and have a smooth surface inside the tube when screwed together. Threads are to be modified Acme with three threads per centimeter. A hole will be drilled for the spanner wrench in both the male and female couplings. Couplings will be secured to the tube with rivets. The portion of the rivet on the inside of the tube will be smooth and flush with the tube so as not to impede the snow core from moving inside the tube.

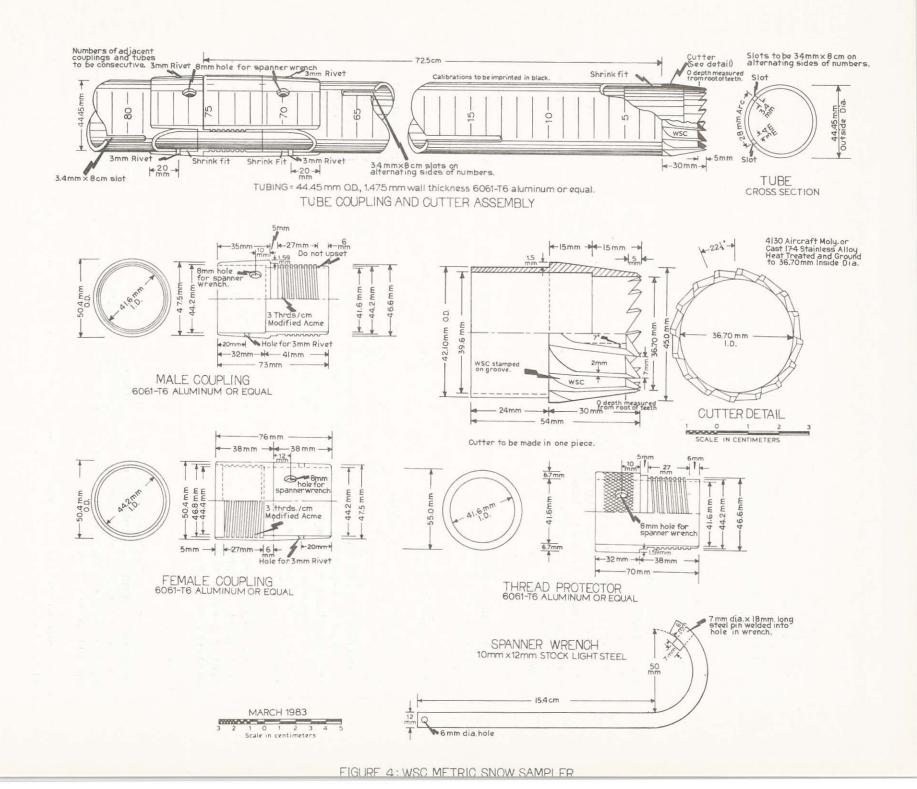
Thread Protector

The thread protector shall be constructed from 6061-T6 aluminum or equivalent and will be similar to the male coupling except that it has a slightly larger diameter and shall not be tapered. The outside section will be knurled. A hole will be drilled for the spanner wrench. It will be constructed so as to fit in the top of any tube section.

Spanner Wrench

The spanner wrench will be constructed from lightweight steel stock and be bent so as to fit smoothly around the couplings and secure each tube section so any stuck or frozen threads can be released with moderate pressure. Two spanner wrenches are required for each sampler.

Exception: Spanner wrenches of other design or material would be acceptable provided they are adequate to release stuck or frozen threads.



3.1.2. Specifications for weighing scale for WSC metric snow sampler

General

The weighing scale and cradle shall conform to specifications summarized below and illustrated in Figure 5, entitled "Weighing Scale for WSC Metric Snow Sampler." Both the inner and outer cylinders shall be constructed of 6061-T6 aluminum or equivalent. The inner cylinder shall have an outside diameter of 25.40 mm and wall thickness of 1.245 mm. The outer cylinder shall have an outside diameter of 31.75 mm and a wall thickness of 2.11 mm. The scale spring shall be a close-wound extension coil spring with an outside diameter of 19.0 mm. The spring material shall be self-tempering steel spring wire 1.63 mm in diameter. All stamped numerals and numbers will be black.

4 Meter Capacity Scale (for snow depths up to 4 meters)

The inner cylinder shall be calibrated on one side in increments equivalent to 2 cm of water. The scale shall be such that the increments will be from 0 to 340 and weigh 3,795 grams over 283.3 mm distance on the inner cylinder. Each increment shall be stamped at intervals of approximately 1.6667 mm and be equal to a weight increment of approximately 22.32 grams. Beginning with zero at the bottom of the inner cylinder, each fifth increment shall be stamped with the numerals 10, 20, 30, 40, etc., through 340. Along the scale increments adjacent to the numerals, the cylinder shall be stamped "cm water with WSC metric snow sampler." Each outer cylinder shall have the capacity stamped on it; i.e., "CAPACITY = 4 METERS."

The scale spring shall be 190.5 mm long and shall be pre-tensioned for 1,250 grams such that the weight of a 1.5-meter (2 sections) snow sampling tube (empty) will read slightly greater than zero on the scale. Scales shall be accurate to \pm 1 cm of water equivalent over the full span of the scale.

6 Meter Capacity Scale (for snow depths between 4 and 6 meters)

The inner cylinder shall be calibrated on one side in increments equivalent to 5 cm of water. The scale shall be such that the increments will be from 0 to 480 and weigh 5,357 grams over 284.2 mm distance on the inner cylinder. Each increment shall be stamped at intervals of approximately 2.96 mm and be equal to a weight increment of approximately 55.75 grams. Beginning with zero at the bottom of the inner cylinder, each fourth increment shall be stamped with the numerals 20, 40, 60, 80, etc., through to 480. Along the scale increments adjacent to the numerals, the cylinder shall be stamped "cm water with WSC metric snow sampler." Each outer cylinder shall have the capacity stamped on it; i.e., "CAPACITY = 6 METERS."

The scale spring shall be 139.7 mm long and shall be pre-tensioned for 2,250 grams such that the weight of a 3-meter (4 sections) snow sampling tube (empty) will read slightly greater than zero on the scale. Scales shall be accurate to \pm 2.5 cm of water equivalent over the full span of the scale.

Cradle

The cradle shall be constructed from 6.4-mm-diameter 5052-H34 aluminum round rod or equivalent. Surgical rubber tubing or other non-slip material to prevent the snow tubes from sliding shall cover the arms of the cradle to prevent the snow sampling tube from slipping in the cradle. The cradle shall be attached to the scale assembly by a swivel snap and swivel ring.

Note: Any direct reading gram-balance scale could be used to obtain snow water equivalent $\overline{\text{(SWE)}}$. Each 10 grams of weight would be equivalent to 1 cm of SWE.

31.8cm

38 mm

SIDE VIEW-CRADLE

6 mm

◆BITET I.D.

FIGURE 5: WEIGHING SCALE FOR WSC METRIC SNOW SAMPLER

FRONT VIEW - CRADLE

3.1.3. Specifications for driving wrench for WSC metric snow sampler

General

The driving wrench shall conform to specifications summarized below and illustrated in Figure 6, entitled "Driving Wrench for WSC Metric Snow Sampler." It shall be constructed of 355-T6 aluminum or equivalent. The driving wrench shall be such that the steel key fits in the slots on the WSC metric snow sampler and the wrench fastens securely around the snow sampler tube and does not slip on the tube when a weight of 500 kilograms is applied to the wrench with the snow tube in a vertical position. The wrench shall be easy to attach to the snow tube and easy to remove.

Exception: A driving wrench constructed from reinforced nylon or other material would be acceptable provided the strength and fastening requirements specified above are met or exceeded.

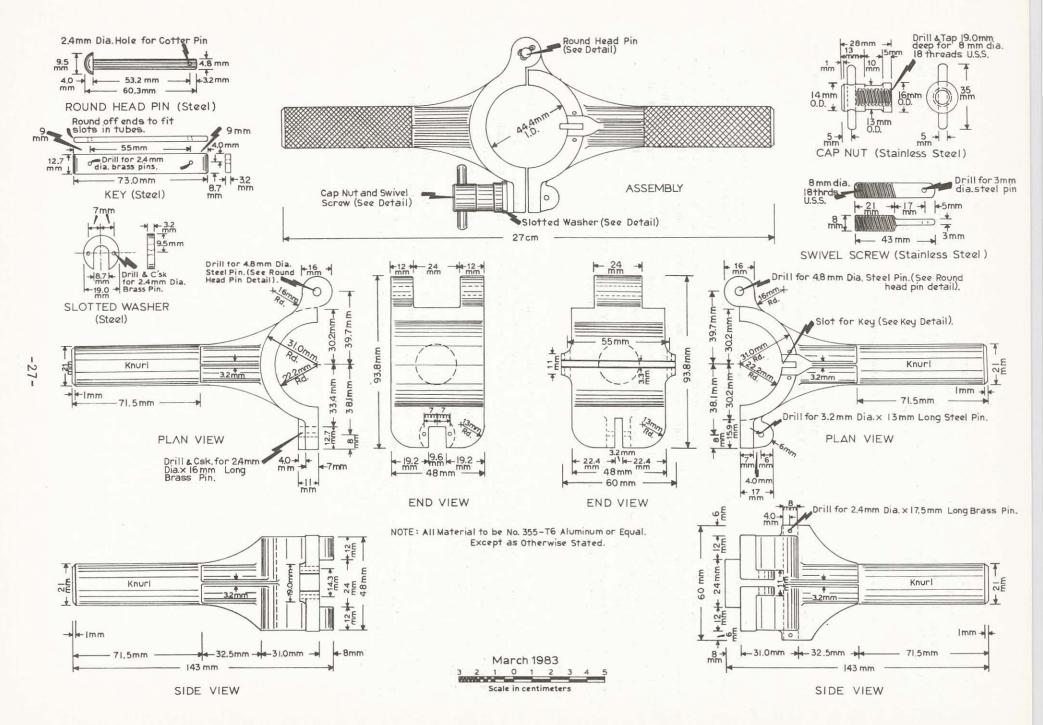


FIGURE 6: DRIVING WRENCH FOR WSC METRIC SNOW SAMPLER

3.2. Proposed ESC 30 metric snow sampler

An analysis of all the data for all years (Farnes, $\underline{\text{et}}$ $\underline{\text{al.}}$, 1982) suggests that the ESC 30 has a diameter that is large enough to measure snow water equivalent accurately and yet small enough to retain cores in most snow conditions. The 1981 ESC 30 sampler appears to be accurate and the material durable. The proposed ESC 30 metric snow sampler is almost identical to the 1981 ESC 30 snow sampler. Detailed specifications follow.

3.2.1. Specifications for ESC 30 metric snow sampler

General

The ESC 30 metric snow sampler shall conform to specifications summarized below and illustrated in Figure 7, entitled "ESC 30 Metric Snow Sampler."

Tube

Clear plastic tubing with ID of 69.85 mm and OD of 76.2 mm TENITE-BUTYRATE 516E-MH, or equivalent, with a length of 122 cm will be used for the tube. Markings are to be stamped or routed on the tube every centimeter with zero measured from the root of the cutter teeth. Numerals shall be stamped or routed every fifth increment to represent centimeter depths of 5, 10, 15, 20, etc., through 120. All markings and numerals will be red. Overall length of the sampler from root of cutter teeth to the top of driving handle will be 126 cm. The driving handle collar will be constructed of stainless steel and shall be secured to the sampling tube near the end of the tube with screws or rivets. This collar will also serve as a protector for the end of the plastic tube. The driving handles may be either permanently secured to the collar or they may be removable. The cutter end of the tube will be threaded to accept the 1 square thread/cm of the cutter.

Cutter

The one-piece cutter shall be milled 4130 aircraft moly or cast 17-4 stainless alloy, heat treated and ground to 61.80 mm. The cutter shall have 16 teeth with lands approximately 2 mm wide and grooves approximately 10 mm wide. The teeth shall have a slope angle of 7 degrees and shall be 40 mm long. The inside lip that is ground to 61.80 mm shall extend 15 mm from the point of the teeth. All leading surfaces of the teeth will be sharpened to the inside. The threads on the cutter will be square, 1 thread/cm.

Exception: In very shallow snowpack areas, the overall length of the tube could be reduced to accommodate local conditions. For snowpacks deeper than 1 m, obtain two or three sections of the WSC metric snow sampler and request the manufacturer to imprint in black the calibration for "4 METERS" weighing scale on the inner cylinder opposite the 1 m calibration that will be printed in red.

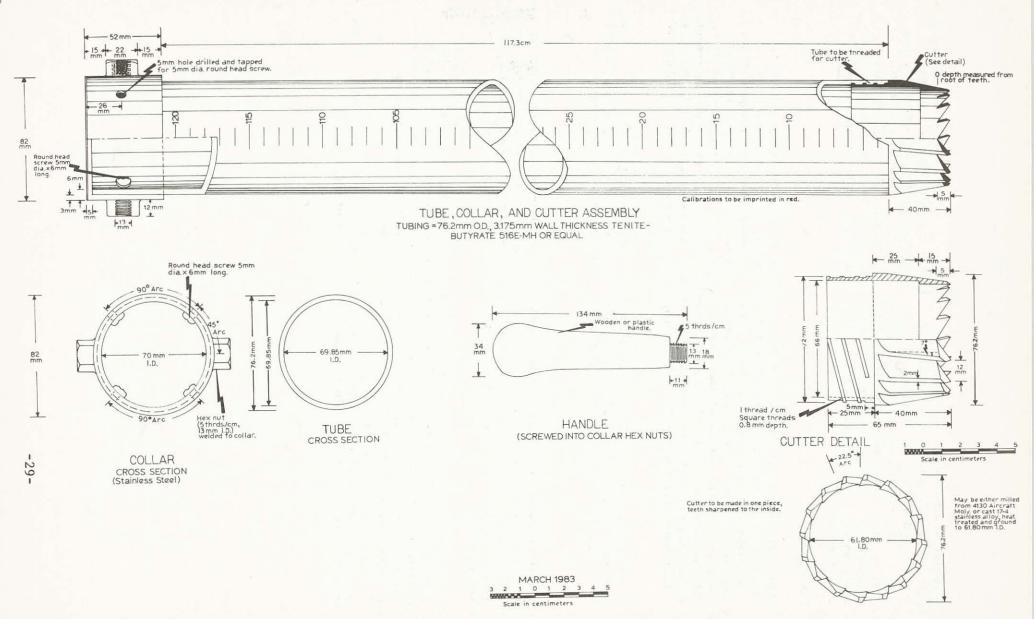


FIGURE 7: ESC 30 METRIC SNOW SAMPLER

3.2.2. Specifications for weighing scale for ESC 30 metric snow sampler

General

The weighing scale and cradle shall conform to specifications summarized below and illustrated in Figure 8, entitled "Weighing Scale for ESC 30 Metric Snow Sampler." It shall be constructed of 6061-T6 aluminum or equivalent. The inner cylinder shall have an outside diameter of 25.40 mm and wall thickness of 1.245 mm. The outer cylinder shall have an outside diameter of 31.75 mm and wall thickness of 2.11 mm. The scale spring shall be a close-wound extension coil spring with an outside diameter of 19.0 mm. The spring material shall be self-tempering steel spring wire 1.63 mm in diameter. All stamped numerals and numbers will be red.

1 Meter Capacity Scale

The inner cylinder shall be calibrated on one side in increments equivalent to 1 cm. The scale shall be such that the increments will be from 0 to 125 and weigh 3,747 grams over 279.7 mm distance on the inner cylinder. Each increment shall be stamped at intervals of approximately 2.238 mm and be equal to a weight increment of approximately 29.976 grams. Beginning with zero at the bottom of the inner cylinder, each fifth increment shall be stamped with the numerals 5, 10, 15, 20, etc., through 125. Along the scale increments adjacent to the numerals, the cylinder shall be stamped "cm water with ESC 30 metric snow sampler." Each outer cylinder shall have the capacity stamped on it; i.e., "CAPACITY = 1 METER."

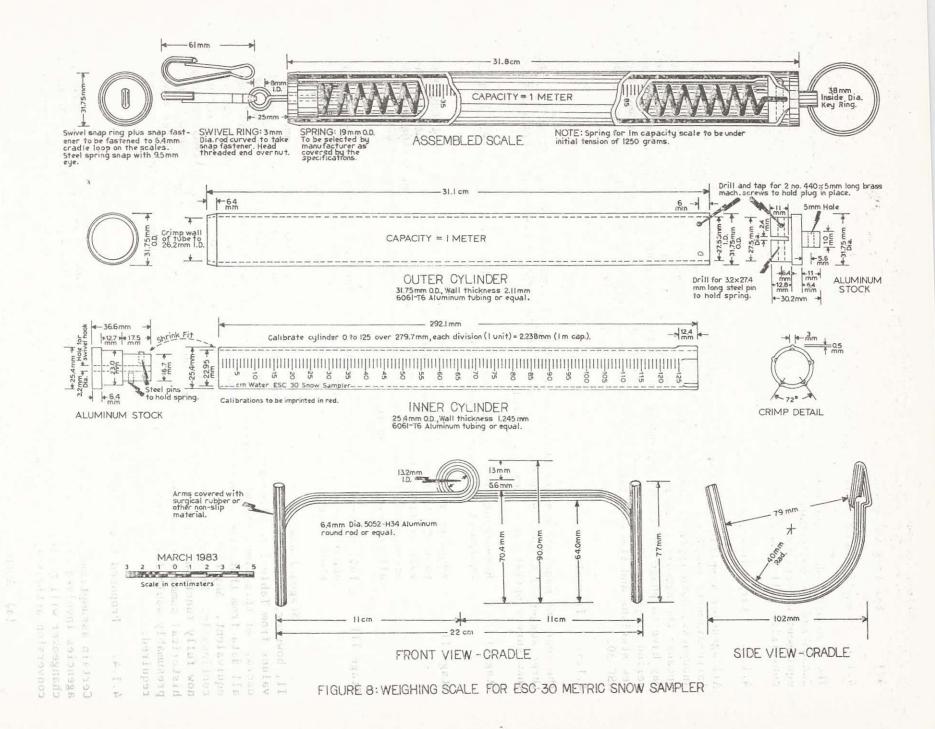
The scale spring shall be 190.5 mm long and shall be pre-tensioned for 1,250 grams such that the empty weight of the ESC 30 snow sampling tube will read slightly greater than zero on the scale. The scales shall be accurate to + 0.5 cm water equivalent.

Cradle

The cradle shall be constructed from 6.4-mm-diameter 5052-H34 aluminum round rod or equivalent. Surgical rubber tubing or other non-slip material to prevent the snow tubes from sliding shall cover the arms of the cradle to prevent the snow sampling tube from slipping in the cradle. The cradle shall be attached to the scale assembly by a swivel snap and swivel ring.

Exception: The inner cylinder for the ESC 30 weighing scale can also be marked in black with the scale increments for the "4 METERS" WSC metric weighing scale for use with either the ESC 30 sampler or WSC metric snow sampler as both scales are identical in construction and have identical spring specifications. The outer cylinder of scales with dual capacities shall be stamped "CAPACITY = 1 METER and 4 METERS."

 $\underline{\text{Note}}$: Any direct reading gram-balance scale could be used to obtain snow water equivalent $(\overline{\text{SWE}})$. Each 30 grams of weight would be equivalent to 1 cm of SWE.



4. PROPOSAL FOR CONVERTING TO METRIC

4.1. Existing equipment

4.1.1. Small-diameter snow samplers

The standard Federal and other small-diameter snow samplers are in general use throughout Canada and the United States as well as throughout many other countries. To complete the equipment conversion, a major commitment of funds, time, and energy is necessary. Full conversion will require several years.

4.1.2. Large-diameter samplers

All agencies sampling snowpacks with less than 1 m of snow depth should use a large-diameter sampler. For agencies making snow surveys in both shallow and deep snowpacks, both types of samplers will be required. New ESC 30 samplers must be purchased because the sampler is an entirely new design. Because of resource constraints, agencies may have to phase in the new equipment at existing stations. This should be done over a period of years. Spring balances should be recalibrated or replaced as appropriate. All new stations and stations taking samples for snow chemistry should be supplied with the new ESC 30.

4.1.3. Transition stages

The cost and manpower commitment can be eased by staging conversion to SI units. There are three suggested stages, each of which can be accomplished without interfering with normal snow survey operations. They are as follows:

- Stage I Re-marking of existing equipment and scales to read in metric units. All equipment components remain unchanged.
- Stage II Adopting a metric snow sampler and utilizing as much present equipment as possible by re-marking snow tubes in metric units, replacing all cutters with metric cutters, and replacing inner tubes on the spring scale to accommodate the new metric cutter. These steps should be done in concert by all cooperating agencies.
- Stage III Full conversion to SI standards. All tubing, couplings, scales, and appurtenant equipment would be manufactured to SI standards from metric stock material. Cutters and scale constants would be as for Stage II.

Stages I and III are quite flexible as to timing and rate of conversion. Stage II, however, which would institute the new cutter and adjust the historical record using values from Table I to alleviate the overmeasurement bias, must be done in concert by all users. At this time, the WSC metric cutter would replace the standard Federal cutter and all data from that time on would be considered to be absolute or to have a true water equivalent. Any exceptions would create unnecessary confusion because data are exchanged continually. British Columbia snow surveyors have completed a Stage I conversion and are now fully functional in the metric system, including instruction books, note forms, historical summaries, and current publications. Conversion of large-diameter samplers presumably would follow the same timetable, but overmeasurement adjustments would not be required.

4.1.4. Proposed conversion schedule

Certain assumptions are required when estimating lead time; namely, certainty that all agencies involved will consent to the concept of metric practice and that funds for the changeover will be available as and when required. Three decisions must be made; all conversion activities can be framed in this context.

- (a) Authority to proceed with metrication by various agencies,
- (b) Adoption of a standard metric cutter or metric sampler, and

 $% \left(c\right) =\left\{ c\right\} =\left\{ c\right\}$ (c) Agreement on the year of conversion to use of the metric cutter and samplers.

In considering the year of adoption for the standard metric cutter and metric samplers, sufficient time should be allowed for all users to accept the concept, complete a Stage I conversion if desired, and prepare files for adopting the necessary changes. Assuming year four is proposed for conversion to metric, the following schedule would be required.

- Stage I Commence planning (summer and fall of year one).
 - Re-mark tubes and replace scale inner cylinders during summer of year two.
 This step can be merged with Stage II.
 - Prepare notes and manuals as required and distribute to users during fall of year two.
 - Conversion of historic data (summer, year two).
 - Operate in metric mode for two seasons (years three and four) by direct measure or by data conversion before filing and publication.
 - Metric publication universal for the year three snow season.
- Stage II Commence planning (summer, year three).
 - Contract for manufacture of metric cutters and metric samplers to the standard metric design (fall, year three).
 - Call in all cutter sections and replace cutters with approved design; call in scales for recalibration (summer, year four).
 - Revise historical data as required to bring it into accord with measurement standards (summer, year four).
- Stage III Equipment can be built to metric standards as soon as manufacturers are prepared except that metric cutters would not be installed until year four. The rate of replacement of sampling kits after year four depends on their condition and the availability of replacement funds.

The use of re-marked tubes can be continued indefinitely using a modest replacement rate. Full metric kits could be brought into use over the next 10 to 20 years. Adoption of metric stock material as it becomes available will affect dimensioning but it should have little effect on sampling results.

4.2. Historic data records

As scheduled in Stage II, back records obtained with various snow samplers should be adjusted for overmeasurement based on the percentage obtained by this study and shown in Table I. The water equivalent should be adjusted for overmeasurement and then converted to metric units. The snow depths need to be converted to metric and densities recomputed. These conversions can be simplified by using computer techniques. New data summaries should be prepared in metric units for these adjusted data.

The back record should be adjusted and converted to metric units when the new metric equipment that does not overmeasure is placed in the field. It is recommended that the change from English to metric be done at this time and that dual units not be used. Reports would publish a cross reference between English and metric units so users of data could make their own conversion. Forecasting procedures need to be modified to use the metric units. This could be done by soft conversion of snow course data or by developing new forecast procedures based on the adjusted metric historic data. The complete revision of forecast procedures is recommended because forecast volumes or flows should also be in metric units.

4.3. Future data collection

Conducting metric snow surveys will influence several other aspects of operational snow survey programs. As suggested for Stage I, new metric snow note forms should be devised, based on those designed and adopted by British Columbia. Snow surveyors

should receive training in metric sampling, notekeeping, and point-to-point measurements on metric snow courses. It is recommended that snow course distances between sample points be changed only enough to result in even-meter distances between points. On established snow courses, changes in the sampling points are not necessary.

Both converted historic and future metric snow data should be archived in the same manner. Computer program flexibility will then allow for storing and retrieving snow course point data, course averages, ranking by order of depth or water equivalent magnitude, as well as the usual elevation and location information.

Data from aerial snow depth markers, which will likely be measured in English, or imperial, units during the immediate future, should be recorded on a new form that has space for their immediate conversion to metric. By using only metric snow data, once the change is made, it will encourage adherence to metric units when future snow measurement techniques may be adopted, such as the use of microwave or gamma ray attenuation, albedo levels, application of snow-covered area, or new versions of telemetered automatic snow sensors.

A standing metric committee composed of Eastern and Western Snow Conference members would be the best entity to recommend and coordinate data terminology and usage as well as the direction of possible future WSC- and ESC-sponsored research.

ACKNOWLEDGMENTS

The tremendous support given to this project by the staffs of the committee members is gratefully appreciated and acknowledged. The funding and support provided by the agencies of the committee members were important factors in completion of the project. This comprehensive study could not have been accomplished without their contributions.

Special acknowledgment for assisting with the extensive field measurements goes to Herman Raimundo of the California Department of Water Resources, to Glen Ford and Dave Thompson of British Columbia Ministry of the Environment, to Don Huffman and Glenn Herdina of Montana Snow Surveys, to John Metcalfe of the Canadian Atmospheric Environment Service, and to many others that participated. Also, special acknowledgment to Bruce Letvak of British Columbia Ministry of the Environment who was an early member of the metrication committee.

The committee especially wishes to acknowledge the contribution of Bob Shillinglaw of Carpenter Machine Works who was interested enough in this study to convert the theoretical designs of the committee members into machined components and prototypes that could be field tested.

Finally, the Western Snow Conference and Eastern Snow Conference must be thanked for providing the forum for discussion and cooperation among agencies. Without these two organizations, cooperation among agencies in the United States and Canada would be greatly diminished.

Many other individuals and agencies have contributed greatly in conducting tests in other regions and in providing comments. Special recognition goes to personnel at Colorado State University, Agricultural Research Service, Saskatchewan Research Council, and McMaster University.

- ARS-SCS, 1975-1979: SNOTEL Sensor Evaluation and Forecast Development Study, Cooperative Studies in Boise River Watershed, Soil Conservation Service, Portland, Oregon, Four Interim Reports.
- Bindon, H. H., 1964: The Design of Snow Samplers for Canadian Snow Surveys, <u>Proceedings of Eastern Snow Conference</u>, 21st Annual Meeting, pp. 23-28.
- California Department of Water Resources, 1976: <u>Snow Survey Evaluation in the Sierra Nevada</u>, <u>California</u>, 55 p.
- Canadian Standards Association, 1973: Metric Practice Guide, Publication Number CAN-3-001-02-73, CSAZ234.1, Rexdale, Ontario.
- Crook, Arthur G., and T. G. Freeman, 1973: Comparison of Techniques of Sampling the Arctic-Sub-Arctic Snowpack in Alaska, <u>Proceedings</u> of <u>Annual Meeting of Western Snow Conference</u>, Grand Junction, CO, pp. 62-68.
- CSU-SCS, 1979-1981: Snow Pillow System Behavior for SNOTEL Application, Cooperative Project in Colorado, Soil Conservation Service, Portland, Oregon, Two Final Reports.
- Farnes, Phillip E., 1964: Comments on Accuracy of the Federal Snow Sampler Cutter.

 Seminar on Remote Snow Survey Sentinels, Portland, OR, 3 p.
- Farnes, P. E., 1980: Snow Tube Cutters. SCS Snow Survey Workshop, Unpublished report, SCS, Portland, OR, 2 p.
- Farnes, Phillip E., Barry E. Goodison, Ned R. Peterson, and Robert P. Richards, 1980:
 Proposed Metric Snow Samplers by Western Snow Conference Metrication Committee,
 Proceedings of 48th Annual Meeting of Western Snow Conference, Laramie, Wyoming, pp. 107-119.
- Farnes, Phillip E., Barry E. Goodison, Ned R. Peterson, and Robert P. Richards, 1982:
 Metrication of Manual Snow Sampling Equipment by Western Snow Conference Metrication
 Committee, Proceedings of the 50th Annual Meeting of Western Snow Conference, Reno,
 NV, pp. 120-132.
- Freeman, T. G., 1965: Correction of Snow Tube Measurements. SCS Planning Conference, Salt Lake City, UT. Unpublished report, SCS, Portland, Oregon, 3 p.
- Goodison, B. E., 1978: Accuracy of Snow Samplers for Measuring Shallow Snowpacks: An Update, Proceedings of Eastern Snow Conference, 35th Annual Meeting, pp. 36-49.
- Goodison, B. E., and J. R. Metcalfe, 1978: Snow Sampler Field Tests 1977-1978.

 Preliminary Report to WSC Metrication Committee, 5 p.
- Letvak, D. B., 1978: Metrication of Field Equipment and Operations for British Columbia Snow Surveys, Proceedings of 46th Annual Meeting of Western Snow Conference, Otter Crest, OR, pp. 21-25.
- Metrication Committee, 1978: Metrication of Snow Sampling Equipment Working Group Report, Portland, OR, 2 p.
- Peterson, Ned R., and A. J. Brown, 1975: Accuracy of Snow Measurements. Proceedings of 43rd Annual Western Snow Conference, WSC No. 587-75, pp. 1-5.
- Woo, Ming-ko, 1982: Testing of Three Types of Snow Samplers in a High Arctic Environment. Unpublished report, Department of Geography, McMaster University, Hamilton, Ontario, 5 p.
- Work, R. A., H. J. Stockwell, T. G. Freeman, and R. T. Beaumont, 1965: Accuracy of Field Snow Surveys in Western United States, Including Alaska. <u>CRREL Technical Report</u> 163, 43 p.

APPENDIX I.	Data summary and regression analysis	Page
Table IV.	Snow sampler data obtained prior to metrication committee, 1964-1978	39-40
Table V.	Snow sampler data obtained by the metrication committee, 1979-1982	41-43
Table VI.	Snow sampler data obtained by others using some equipment similar to metrication committee, 1977-1982	44
Table VII.	Regression analysis of all snow water equivalent data	45-46
Table VIII.	Regression analysis of all snow water equivalents grouped by density	47-51
Table IX.	Regression analysis of 1981-82 snow water equivalents	52

TABLE IV SNOW SAMPLER DATA OBTAINED PRIOR TO METRICATION COMMITTEE 1964-1978 ---> All SWE in mm

ocation	No.	Date	Std. Fed. Depth cm	Standard Federal	1978 Metric (short)	Long Metric (78)	BUNG	Broken Tooth Fed.	Pit or Template	Profile Gage	McCall	Adirondack	Utah	MSC	Bowman	Rosen	L&S	CRREL 500 cm ² Tubes
Inside Dia mm NREA cm² SHARP or BLUNT To Teeth Tubing Material				37.7 11.2 Blunt 16 Alum.	35.7 10.0 Sharp 16 Alum.	35.7 10.0 Sharp 16 Alum.	37.7 11.2 Sharp 0 Alum.	37.7 11.2 Blunt 15 Alum.			37.7 11.2 SHARP 16 Alum.	67.4 35.7 SHARP O Fiberglass	37.7 11.2 SHARP 32 Steel	70.5 39.1 SHARP 16 Alum.	37.7 11.2 SHARP 16 Plastic	37.7 11.2 BLUNT 8 Alum.	37.7 11.2 BLUNT 8 Alum.	58.1 26.5 SHARP 0 Stain. Steel
Mount Hood, OR Mount Hood Mount	64-0R-1 64-0R-2 64-0R-3 64-0R-3 64-0R-6 64-0R-6 64-0R-6 64-4R-1 64-4R-3 64-4R-5 64-4R-7 64-MT-1 64-MT-2 64-MT-5 64-MT-6 64-MT-6 64-MT-6	11/19/63 12/2/63 2/3/64 2/24/64 5/12/64 5/12/64 3/11/64 3/12/64 3/17/64 3/17/64 3/18/64 5/7/64 5/7/64 5/15/64 5/21/64 5/23/64 5/25/64 2/17/66	93 84 361 371 498 155 43 51 41 46 56 48 108 109 81 109 81 33 25 8 217 173	232 294 1201 1458 2390 991 70 87 74 71 99 61 92 428 440 374 151 101 30 759			401 403 346 226 142 90 26		214 276 1077 1311 2169 843 68 79 67 69 86 56 82 399			218 283 2159 69 76 70 68 84 54 89			210 274 69 84 71 68 88 57 87	221 277 1138 1394 2233	2342	74 78 71 74 96 62 93
alpha, CA alpha,	75-MT-14 75-MT-15 75-MT-16 75-MT-17 75-MT-18 75-MT-20 75-MT-20 75-MT-21 75-MT-22 75-MT-23 75-MT-24	4/6/75 4/6/75 4/6/75 4/6/75 5/15/75 5/15/75 5/15/75 5/15/75 5/15/75 5/15/75 5/31/75	137 78 100 204 247 169 95 121 134 168	589 419 343 795 1016 843 478 849 310 841 13 89 95 140 737 279 381 203 1054 737 1219 864 356 1067 483 940 381 635 381 864 1092 1016 1029 1143 914 1511 635 1080					551 376 330 754 932 767 442 460 310 765 12 85 95 140	696 269 290 150 1059 643 1102 714 348 894 488 803 378 635 295 767 952 291 1072 775 1308 518 864	13 86 93 136			13 91 93 158	13 83 101 133		14 90 107 143	

TABLE IV SNOW SAMPLER DATA OBTAINED PRIOR TO METRICATION COMMITTEE 1964-1978 (continued)

		14	> A11 :	SWE in mm																
Location	No.	Date	Std. Fed. Depth cm	Standard Federal	1978 Metric (short)	Long Metric (78)	BUNG	Broken Tooth Fed.	Pit or Template	Profile Gage	McCall	Adirondack	Utah	MSC	Bowman	Rosen	L&S	CRREL 500 cm ² Tubes		
Inside Dia mm AREA cm² SHARP or BLUNT No Teeth Tubing Material				37.7 11.2 Blunt 16 Alum.	35.7 10.0 Sharp 16 Alum.	35.7 10.0 Sharp 16 Alum.	37.7 11.2 Sharp 0 Alum.	37.7 11.2 Blunt 15 Alum.			37.7 11.2 SHARP 16 Alum.	67.4 35.7 SHARP 0 Fiberglass	37.7 11.2 SHARP 32 Steel	70.5 39.1 SHARP 16 Alum,	37.7 11.2 SHARP 16 Plastic	37.7 11.2 BLUNT 8 Alum.	37.7 11.2 BLUNT 8 Alum.	58.1 26.5 SHARP 0 Stain. Steel		
Cooke Station, MT Fisher Creek, MT Cooke Station, MT White Mill, MT NE Entrance, MT	76-MT-2 76-MT-3 76-MT-4	12/29/75	188 112 168	368 648 419 559 165						360 588 348 494 157	19 50 70 149 174	19 49 68 132 188		20 53 75 147 197	19 52 73 154 190		20 55 78 165 213			
NOTE: PROFILE G/ Gunsight Lake, MT Spotted Bear Mtn., MT Trinkus Lake, MT Badger Pass, MT Blue Lake, MT Twin Creeks, MT Upper Holland Lake, MT Trinkus Lake, MT Trinkus Lake, MT Trinkus Lake, MT Luther Marsh, ONT	76-MT-16 76-MT-17 76-MT-18 76-MT-19 76-MT-20 76-MT-22 76-MT-23 76-MT-25 76-ON-1 76-ON-2 76-ON-3 76-ON-4 76-ON-5 77-ON-1	5 2/29/76 7 2/29/76 8 2/29/76 9 3/3/76 9 3/3/76 2 3/4/76 2 3/4/76 3/31/76 5/2/76 12/29/75 1/5/76 1/28/76 2/24/76	ARY 1976 269 107 165 300 218 117 193 199 102 114 14 23 26 38 51 40 57	889 305 508 1118 711 305 635 762 356 533 20 52 74 157 184 88					19 50 66 144 180 82 170	892 297 495 1044 701 318 594 767 361 455	84 173	82 175		84	78 186		81 187			
Alpha, CA Short Creek, MT Darkhorse Lake, MT Bloody Dick, MT Lick Creek, MT Bridger Bowl, MT Shower Falls, MT Maynard Creek, MT Copper Bottom, MT Fisher Creek, MT White Mill, MT	77-CA-1 77-MT-1 77-MT-2 77-MT-3 77-MT-4 77-MT-5 77-MT-6 78-MT-1 78-MT-2 78-MT-3 78-MT-4 78-MT-4	12/1/77 12/16/77 12/27/77 12/27/77	52 58 122 58 122 190 203 48 56 213 185	188 117 340 122 353 594 617 93 174 640 533	190 99 315 109 325 569 587 89 166 599 508	188 107 325 122 328 564 584 84	102 320 109 325 569 587 89			320										
Cooke Station, MT Lick Creek, MT Bridger Bowl, MT	78-MT-6 78-MT-7	12/27/77 12/28/77 12/29/77	150 58 142	401 132 444	384 119 406					122			122		5 9					
Lick Creek Divide, MT Cooke Station, MT White Mill, MT Fisher Creek, MT Bridger Bowl, MT Crystal Lake, MT Arch Falls, MT Little Park, MT	78-MT-8 78-MT-9 78-MT-10 78-MT-11 78-MT-12 78-MT-13	1/25/78	81 183 201 262 213 145 109	189 544 650 833 655 442 302 485	171 528 627 808 630 424 287 465	169	175			163										
Northeast Entrance, MT Northeast Entrance, MT	78-MT-16	3/14/78	152 107 122	368 387	348	358	351			319 336										
Lick Creek, MT Hood Meadow, MT	78-MT-18 78-MT-19	3/29/78 3/29/78	71 86	300 318	274 310	259	274													
Shower Falls, MT Bridger Bowl, MT Tepee Creek, MT	78-MT-20 78-MT-21 78-MT-22	3/29/78 3/30/78 3/31/78	206 183 127	798 813 462	759 744 439	759	777													
Bridger Bowl, MT Devils Slide, MT Beartooth, MT Cooke Pass, MT Star Lake, MT White Mill, MT Spur Park, MT Shower Falls, MT	78-MT-24 78-MT-25 78-MT-26 78-MT-27 78-MT-28 78-MT-29 78-MT-30	4/26/78 4/27/78 5/10/78 5/10/78 5/11/78 5/11/78 5/12/78 5/16/78	190 208 249 168 312 227 178 201	925 851 1151 902 1453 1035 820 919	846 810 1075 849 1369 796 858	803 1084 869 1346 793 830	815 1072 884 1374 759 853			742 924										
Goose Lake, MT Mt. St. Anne, BC	78-BC-1	5/30/78 1/11/78	323 205	1727 636	1611 600	1600 596	1671 599	530			604									
Mission Creek, BC Blackwall, BC Luther Marsh, ONT Luther Marsh, ONT Luther Marsh, ONT Peterborough, ONT Alpha, CA	78-BC-2 78-BC-3 78-ON-1 78-ON-2 78-ON-3 78-ON-4 78-CA-1	1/8/78 1/7/78 1/19/78 2/17/78 3/16/78 2/27/78 4/14/78	118 172 41 51 43 37 239	336 543 111 165 125 111 1016	316 516 111 164 117 116 1003	335 508 112 162 130 110 1013	320 517	335 524	110 147 145 103		308 515 108 151 114	113 150 144		120 149 150 112				115 163 138		

TABLE V SNOW SAMPLER DATA OBTAINED BY THE METRICATION COMMITTEE 1978-1982

---> All SWE in mm Broken Glacier Glacier 1978 Pit Standard Sharpened 1980 1981 Profile Alum. ESC 50 ESC 50 Utah ESC 40 ESC 30 MSC Tooth Density Glacier kg m-3 Metric Location Date Depth or McCall Adirondack CRREL Tubing Federal Federal Metric Metric Metric Gage Tubing Fiberglass Plastic (short) Template Fed. CM 37.7 71.8 61.7 70.5 99.1 77.1 51.6 Inside Dia mm 37.7 37.7 35 7 35.6 36.4 37.7 67.4 50.0 50.0 20.9 40.0 30.0 39.1 ARFA cm2 81.9 11.2 11.2 10.0 10.0 10.0 10.4 11.2 35 7 20 4 Sharp SHARP SHARP SHARP SHARP SHARP SHARP SHARP SHARP Blunt Sharp Blunt Sharp Sharp Sharp Sharp SHARP SHARP or BLUNT SHARP SHARP No Teeth ---16 32 32 32 16 16 16 15 Alum. Fiberglass Plastic PVC Steel Plastic Plastic Alum. Tubing Material Stainless Alum. Alum. Alum. Alum. Alum. Alum. ---Alum. Fiberglass Fiberglass Alum. THE FOLLOWING DATA WERE OBTAINED USING CONTROL DESIGNED AND MANUFACTURED EQUIPMENT Maynard Creek S, MT 79-MT-1 1/30/79 297 Maynard Creek N, MT 79-MT-2 1/30/79 248 236 264 249 265 226 79-MT-3 New World W. MT 1/31/79 90 90 199 236 208 236 212 215 250 79-MT-4 250 New World E. MT 1/31/79 New World N, MT 79-MT-5 189 229 209 214 Lower New World E, MT 79-MT-6 1/31/79 99 234 232 227 244 244 262 79-MT-7 100 227 251 242 Lower New World W, MT 1/31/79 241 79-MT-8 259 263 258 Porcupine S. MT 2/21/79 93 282 Porcupine W. MT 79-MT-9 245 223 243 232 231 247 Lower New World SE, MT 79-MT-10 2/26/79 139 288 400 376 460 459 462 454 426 Lower New World SW, MT 283 425 431 432 79-MT-11 2/26/79 133 379 403 417 Twenty-one Mile W. MT 79-MT-12 3/9/79 428 408 145 261 Twenty-one Mile SW, MT 79-MT-13 255 360 414 392 396 404 Twenty-one Mile SE, MT 79-MT-14 3/9/79 146 254 257 348 375 885 431 411 408 414 993 79-MT-15 3/21/79 993 1005 Star Lake NW, MT 986 972 Star Lake S. MT 79-MT-16 3/21/79 346 871 984 970 252 Fisher Creek S. MT 79-MT-17 3/22/79 359 893 983 959 978 960 Fisher Creek N. MT 79-MT-18 3/22/79 248 356 882 988 973 989 692 968 331 616 678 693 693 Cooke Station W, MT 79-MT-19 3/22/79 186 667 737 79-MT-20 3/22/79 195 342 725 725 739 Cooke Station F. MT White Mill S, MT White Mill N, MT 79-MT-21 3/22/79 339 715 809 839 817 79-MT-22 3/22/79 208 338 373 703 798 291 793 826 805 Lick Creek N. MT 79-MT-23 4/26/79 295 284 256 264 Lick Creek S. MT 79-MT-24 4/26/79 347 281 285 263 276 81 296 Shower Falls W. MT 79-MT-25 4/27/79 359 704 778 741 748 740 Shower Falls E. MT 79-MT-26 4/27/79 195 344 671 757 731 733 739 701 Clark Fork W. MT 79-MT-27 5/15/79 110 429 472 566 560 544 525 79-MT-28 5/15/79 593 558 Clark Fork E. MI 113 470 531 571 543 isher Creek NW. MI 79-MT-29 5/16/79 415 867 935 989 1004 Fisher Creek S. MT 79-MT-30 5/16/79 213 419 892 998 987 974 943 905 Star Lake N. MT 79-MT-31 5/29/79 214 417 892 958 942 924 Star Lake SW, MT 79-MT-32 889 850 903 943 901 5/29/79 204 417 928 551 567 412 495 White Mill W. MT 79-MT-33 5/30/79 126 397 500 568 569 551 581 560 White Mill E. MT 79-MT-34 5/30/79 137 405 555 390 629 622 606 613 411 391 Cooke Station W. MI 79-MT-35 5/30/79 99 394 456 440 449 425 79-MT-36 5/30/79 400 356 403 401 382 365 Cooke Station E. MI 89 398 Spaulding, CA 79-CA-I 2/28/79 318 655 660 641 626 Alpha, CA 79-CA-2 211 338 713 761 734 721 Spaulding, CA 79-CA-3 3/16/79 395 664 651 664 684 Spaulding, CA 79-CA-4 4/2/79 145 445 651 693 676 685 666 Alpha, CA 79-CA-5 4/4/79 771 742 195 362 709 731 736 Alpha. CA 79-CA-6 152 455 692 731 742 719 5/2/79 739 Forbidden Plateau, BC 79-BC-1 79-BC-2 2/9/79 153 255 390 413 402 394 Whistler Mtn, BC 2/20/79 133 231 307 335 319 314 Blackwall Pk. BC 262 442 487 467 2/21/79 169 489 488 New Copper Mtn, BC 79-BC-4 2/22/79 205 119 104 104 117 120 Newcastle Ridge, BC Whistler Mtn, BC 79-BC-5 3/9/79 319 378 1207 1315 1241 1294 79-BC-6 3/13/79 103 354 365 399 386 396 394 567 Blackwall Pk. BC 79-BC-7 161 317 511 555 532 545 New Copper Mtn. BC 79-BC-8 3/14/79 100 94 1493 1388 Newcastle Ridge, BC 79-BC-9 4/19/79 332 450 1630 1572 1612 1674 Newcastle Ridge, BC 79-BC-10 4/19/79 330 421 1550 1478 1498 1559 Whistler Mtn, BC 79-BC-11 4/21/79 130 334 434 476 454 483 Whistler Mtn. BC 396 458 473 591 623 4/21/79 325 411 Blackwall, BC 79-BC-13 4/23/79 342 534 587 564 580 162 Blackwall, BC 79-BC-14 4/23/79 335 543 976 520 596 606 Newcastle Ridge, BC 79-BC-15 5/7/79 200 488 1108 1057 1045 1102 1122 Newcastle Ridge, BC 79-BC-16 5/7/79 226 516 1167 1271 1216 1181 1239 Ottawa, ONT 79-0N-1 157 144 162 155 142 Cold Creek #1, ONT 79-0N-2 2/16/79 27 211 57 68 61 55 Cold Creek #2, ONT 79-0N-3 2/16/79 28 218 61 64 60 70 53 79-0N-4 Monticello, ONT 2/28/79 95 37 293 278 310 302 303 283 298 Monticello #1, ONT 335 124 79-0N-5 3/8/79 121 122 124 125 125 Monticello #2, ONT 79-0N-6 3/8/79 358 92 97 136 124 175 Peterborough, ONT 79-0N-7 3/19/79 29 428 138 128 126 158 114 Ottawa, ONT 79-0N-8 3/21/79 486 169 164 158

TABLE V SNOW SAMPLER DATA OBTAINED BY THE METRICATION COMMITTEE 1978-1982 (continued)

					> A11	SWE in mm																			
Location	No.	Date	Glacier Depth cm	Glacier Density kg m-3	Glacier	Standard Federal	Sharpened Federal	1978 Metric (short)	1979 Metric	1980 Metric	1981 Metric	Pit or Template	Profile Gage	McCall	Adirondack	CRREL	Alum. Tubing	ESC 50 Fiberglass	ESC 50 Plastic	PVC Tubing	Utah	ESC 40	ESC 30	MSC	Broken Tooth Fed
Inside Dia mm AREA cm² SHARP or BLUNT No Teeth Tubing Material					102 81.9 Sharp 0 Stainless	37.7 11.2 Blunt 16 Alum.	37.7 11.2 Sharp 16 Alum.	35.7 10.0 Sharp 16 Alum.	35.6 10.0 Sharp 16 Alum.	35.7 10.0 Sharp 16 Alum,	36.4 10.4 Sharp 16 Alum.			37.7 11.2 SHARP 16 Alum.	67.4 35.7 SHARP 0 Fiberglass	50.9 20.4 SHARP 16 Fiberglass	99.1 77.1 SHARP 0 Alum.	79.6 50.0 SHARP 32 Fiberglass	79.5 50.0 SHARP 32 Plastic	51.6 20.9 SHARP 0 PVC	37.7 11.2 SHARP 32 Steel	71.8 40.0 SHARP 16 Plastic	61.7 30.0 SHARP 16 Plastic	70.5 39.1 SHARP 16 Alum.	37.7 11.2 Blunt 15 Alum.
Porcupine S, MT Porcupine N, MT Tepee Creek E, MT Tepee Creek E, MT New World E, MT New World E, MT New World E, MT New World Gulch E, MT Sacajawea SC E, MT Sacajawea C, S, MT Maynard Cr. S, MT Maynard Cr. S, MT Maynard Cr. S, MT Maynard Cr. S, MT Sacajawea E, MT Sacajawea E, MT Sacajawea E, MT Maynard Cr. S, MT Mille Creek E, MT Window Rock S, MT Arch Falls E, MT	80-MT-11 80-MT-13 80-MT-13 80-MT-15 80-MT-15 80-MT-16 80-MT-17 80-MT-18 80-MT-20 80-MT-21 80-MT-22 80-MT-23 80-MT-24 80-MT-25 80-MT-26 80-MT-26 80-MT-28	2/1/80 2/1/80 2/14/80 2/14/80 2/26/80 2/26/80 2/26/80 2/28/80 2/28/80 3/14/80 3/14/80 3/14/80 4/11/80 4/11/80 4/11/80 4/22/80 4/23/80 4/23/80 4/23/80 4/28/80 4/28/80 4/28/80 4/28/80	44 44 82 79 104 118 115 128 120 151 149 147 147 144 84 86 208 219 214 62 162 165 55 55 57 61 80 84 57 61 98	216 218 221 209 240 238 246 237 296 281 283 278 242 242 242 243 333 339 324 386 388 381 382 386 381 381 381 381 381 381 381 381 381 381	95 96 181 165 250 248 290 373 379 428 414 359 489 489 272 277 790 846 830 618 630 22 197 271 271 278 206 206 203 203 203 203 203 203 203 203 203 203	97 97 97 203 268 270 320 311 404 367 471 469 342 397 530 271 273 868 968 929 907 673 687 204 194 306 230 230 376	89 89 178 177 275 318 303 395 378 459 456 329 383 503 269 270 838 886 861 641 644 654 183 282 300 209 225 340	106 106 188 184 259 263 309 294 402 375 377 3477 3477 389 521 253 258 852 899 869 868 668 668 668 668 191 183 290 300 207 307 307 307 307 307 307 307 307 307 3		87 87 188 2257 262 306 288 391 356 459 461 328 387 507 256 260 891 862 653 891 841 822 441 822 441 824 824 824 824 824 824 824 824 824 824				819 883 663 655 658 264 283 187 200	476 482 267 278	491 477 252 284	95 95 177 171	478 491 273 267	286 286 780 853 826 615 184 180 274 278 206 216 331 351	778 857 825 622 634 194 1281 187 225 349	274 286 193 207 348 373				
Spaulding, CA Alpha, CA Darrington, CA Alpha, CA	80-CA-1 80-CA-2 80-CA-3 80-CA-4 80-CA-5 80-CA-6 80-CA-7 80-CA-9 80-CA-9 80-CA-10 80-CA-11	1/2/80 1/4/80 1/30/80 1/31/80 2/14/80 2/27/80 2/28/80 3/13/80 3/26/80 3/27/80 5/1/80	55 138 162 183 175 56 272 279 235 269 172	391 315 350 356 385 432 352 391 404 422 460	215 435 567 652 673 242 957 1090 950 1134 792	227 477 609 731 751 254 1071 1168 1072 1225 914	214 452 565 708 688 253 998 1163 983 1184 892	221 463 632 690 728 253 1001 1152 976 1185	217 478 595 720 690 243 1016 1112 1015 1191 830	545 702 657 247 1046 1098 968 1181 875		660 803													
Blackwall, BC Blackwall, BC New Copper, BC New Lopper, BC New Stler, BC Newcastle Ridge, BC Blackwall, BC Blackwall, BC Blackwall, BC McBride, BC McBride, BC Whistler, BC Whistler, BC Whistler, BC	80-8C-11 80-8C-12 80-8C-13 80-8C-14 80-8C-15 80-8C-16 80-8C-17		154 156 43 44 121 120 231 228 224 145 200 125 125 125	296 291 249 225 279 282 397 389 391 314 279 328 316 321 251 254 298 322	456 454 107 99 338 339 916 888 875 456 106 631 642 314 318 373 403	535 493 94 94 397 388 1029 1037 955 518 449 724 348 354 412 387	507 477 90 90 387 385 965 972 916 518 97 444 704 702 351 353 387 373		516 478 90 90 405 427 994 927 508 94 438 733 718 354 349 398	508 471 94 91 381 348 965 949 893 495 706 691 335 327 398 388															
Alpha, CA Alpha, CA Alpha, CA Alpha, CA Alpha, CA Alpha, CA	81-CA-1 81-CA-2 81-CA-3 81-CA-4 81-CA-5 81-CA-6	2/4/81 2/17/81 3/3/81 3/18/81 4/3/81 4/16/81	109 86 99 90 157 96	241 341 367 394 367 426	263 293 363 355 576 409	279 304 409 373 582 451	267 291 376 358 568 444		275 283 378 357 586 441	269 287 378 351 576 416	273 290 369 358 578 420											į.	352 564 399		

TABLE V
SNOW SAMPLER DATA OBTAINED BY THE METRICATION COMMITTEE 1978-1982 (continued)
---- All SWE in mm

					> A11	SWE in mm																			
Location	No.	Date	Glacier Depth cm	Glacier Density kg m-1	Glacier	Standard Federal	Sharpened Federal	1978 Metric (short)	1979 Metric	1980 Metric	1981 Metric	Pit or Template	Profile Gage	McCall	Adirondack	CRREL	Alum. Tubing	ESC 50 Fiberglass	ESC 50 Plastic	PVC Tubing	Utah	ESC 40	ESC 30	MSC	Broken Tooth Fed
Inside Dia mm AREA cm ² SHARP or BLUNT No Teeth Tubing Material					102 81.9 Sharp 0 Stainless	37.7 11.2 Blunt 16 Alum.	37,7 11,2 Sharp 16 Alum.	35.7 10.0 Sharp 16 Alum.	35 K 10.0 Sharp 16 4 cum	35.7 10.0 Sharp 16 Alum,	36.4 10.4 Sharp 16 Alum			37.7 11.2 SHARP 16 Alum	67.4 35.7 SHARP 0 Fiberglass	50.9 20.4 SHARP 16 Fiberglass	99.1 77.1 SHARP 0 Alum.	79.6 50.0 SHARP 32 Fiberglass	79.5 50.0 SHARP 32 Plastic	51.6 20.9 SHARP 0 PVC	37.7 11.2 SHARP 32 Steel	71.8 40.0 SHARP 16 Plastic	61 7 30.0 SHARP 16 Plastic	70.5 39.1 SHARP 16 Alum.	17.7 11.2 61m4 15 Alost
Blackwall, BC Newcastle Ridge, BC	81-8C-1 81-8C-2		165 80	265 289	438 231	485 204	461 206		461 207	450 201	452 199														
Ettawa, ONT	81-0N-1	2/10/81	43	353	152	147	152				142				141										
New World W, MI New World E, MI Lower New World W, MI Lick Creek E, MI Skylark Trail N, MI Skylark Trail N, MI Palace Butte NN, MI Palace Butte NN, MI Palace Butte SW, MI Lick Creek E, MI Shower Lalls W, MI Lower Lalls W, MI Lisher Creek S, MI Lower Pass N, MI Lower Pass N, MI Lower Pass N, MI Lower Stalling W, MI Lower	81-MT-1 81-MT-2 81-MT-2 81-MT-3 81-MT-5 81-MT-8 81-MT-8 81-MT-8 81-MT-1 81-MT-	1/29/81 1/29/81 1/29/81 3/12/81 3/12/81 3/25/81 3/30/81 3/30/81 3/30/81 3/30/81 3/30/81 3/30/81 3/30/81 4/30/81 4/30/81 4/22/81 4/22/81 4/22/81 4/23/81 5/11/81 5/12/81 5/12/81	43 42 28 81 83 115 12 48 47 52 52 52 52 52 183 117 120 110 4 53 162 17 162 17 17 18 18 18 18 18 18 18 18 18 18 18 18 18	207 207 208 279 277 321 273 270 281 265 304 317 241 241 241 255 275 275 275 275 277 317 317 317 317 317 317 317 3	89 86 41 42 226 230 376 359 131 127 146 138 441 301 303 303 276 640 132 132 617 246 25 356 358	97 93 43 41 243 249 379 144 141 163 187 170 471 475 304 319 329 135 677 153 142 677 153 677 153 677 153 677 153 677 153 677 153 677 153 677 153 677 153 677 153 677 153 677 153 677 153 677 153 677 153 677 153 153 153 153 153 153 153 153 153 153	92 89 40 240 246 248 375 144 141 152 152 153 458 468 314 287 133 664 142 141 663 239 142 141 663 239 142 153	96 91 38 42 251 247 397 383 157 153 158 158 158 170 425 425 425 425 425 425 425 425 425 425			91 87 41 39 236 241 160 160 160 160 178 151 294 450 454 293 318 292 136 657 143 144 656 647 143 144 651 647 144 651 661 661 661 661 661 661 661 661 661											94 88 87 120 220 220 220 220 220 220 220 220 220	2.11 2.40 4.40 4.40 4.40 4.40 4.40 4.40 4.40		
other Marsh, ONI other Marsh, ONI eterborough, ONI orset, ONI eterborough, ONI eterborough, ONI other Marsh, ONI other Marsh, ONI	82-0N-1 82-0N-2 82-0N-3 82-0N-4 82-0N-5 82-0N-6 82-0N-7 82-0N-8	1/8/82 1/8/82 1/13/82 1/22/82 1/22/83 2/8/82 2/8/82 2/10/82	22 20 23 48 51 60 58 55	218 190 204 217 231 212 222 218	48 38 47 104 118 127 129 120	49 42 52 114 125 134 131					48 35 49 112 118 124 120 114												40 40 40 106 106 127 123 118	42° 46° 46° 10° 4 11° 11° 11° 11° 12° 6 12° 4	
Battle Ridge N, MT Battle Ridge N, MT Battle Ridge W, MT Battle Ridge E, MT Shower Falls N, MT Shower Falls S, MT Shower Falls W, MT Lick Creek N, MT Lick Creek N, MT	82-MT-1 82-MT-2 82-MT-3 82-MT-4 82-MT-5 82-MT-6 82-MT-7 82-MT-8 82-MT-9 82-MT-10		66 38	216 202 195 186 263 262 277 278 245 263	147 133 74 65 450 451 744 734 282 310	140 146 66 63 503 522 805 831 321 337	136 128 66 64 496 501 788 805 308 323	135 131 57 55 508 510 815 821 305 330			128 124 64 59 485 488 830 824 303 322											145 153 62 65 445 457	141 145 57 59 447 450		
Alpha, CA Alpha, CA Alpha, CA Alpha, CA	82-CA-1 82-CA-2 82-CA-3 82-CA-4	2/2/82 2/19/82 2/25/82	212 173 157 206	306 391 394 360	649 677 620 742	698 734 647 803	685 691 625 760		683 683 623 785	664 694 621 806	677 680 626 781														

TABLE VI SNOW SAMPLER DATA OBTAINED BY OTHERS USING SOME EQUIPMENT SIMILAR TO METRICATION COMMITTEE 1977-1982

Location	No.	Date	Glacier Depth cm	Glacier Density kg m-3	Glacier	Standard Federal	Sharpened Federal	1978 Metric (short)	Long Metric (78)	1979 Metric	1980 Metric	1981 Metric	Pit or Template	Rosen
Inside Dia mm					102	37.7	37.7	35.7	35.7	35 6	35.7	36.4		37.7
AREA cm ²					81.9	11.2	11.2	10.0	10.0	10.0	10.0	10.4		11.2
SHARP or BLUNT					Sharp	Blunt	Sharp	Sharp	Sharp	Sharp	Sharp	Sharp		BLUNT
No Teeth					0	16	16	16	16	16	16	16		8
Tubing Material					Stainless	Alum.	Alum.	Alum.	Alum.	Alum.	Alum.	Alum.		Alum.
DATA OBTAINED USING	SOME EQUIPME	NT AND PRO	CEDURES C	OMPARABLE	TO BUT NOT	NECESSAR	RILY UNDER	THE SAME	CONTROLLED	CONDITIO	NS AS THE	METRICA	TION COMMIT	TEE.
Trinity Mtn, ID	77-ID-1	3/25/77	86			187							192	
Trinity Mtn, ID	77-ID-2	4/8/77	56			210		189	198					184
Trinity Mtn, ID	77-ID-3	4/12/77	46			173		160	164				155	146
Trinity Mtn, ID	77-ID-4	4/20/77	91			462		452	433					438
Trinity Mtn, ID	77-ID-5	4/21/77	91			469		423	457					448
Trinity Mtn, ID	77-ID-6	4/26/77	76			395		375	372					363
Graham Station, ID	78-ID-1	3/26/78	116			521							448	
Graham Station RSG,	ID 78-ID-2	3/26/78	132			539							505	
Mores Creek, ID	78-ID-3	5/2/78	193			928							870	
Mores Creek RSG, ID	78-ID-4	5/2/78	223			940							858	
Trinity Mtn, ID	78-ID-5	5/28/78	188			1014							888	
Trinity Mtn RSG, ID	78-ID-6	5/28/78	205			1031							917	
Graham Station, ID	79-ID-1	1/27/79	74	224	166	192	167			182				
Graham SNOTEL, ID	79-ID-2	1/27/79	74			270							247	
Graham CA, ID	79-ID-3	1/27/79	79			282							276	
Graham RSG, ID	79-ID-4	1/27/79	70			264							249	
Trinity Mtn #1, ID	79-ID-5	3/7/79	205	312	640	692	692			666				
Trinity Mtn #2, ID	79-ID-6	3/8/79	201	307	618	685	688			670				
Trinity Mtn #3, ID	79-ID-7	3/8/79	195	317	618	692	676			665				
Trinity 8X10 CA, ID	79-ID-8	3/8/79	109			565							497	
Trinity 4X5 CA, ID	79-ID-9	3/8/79	106			533							475	
Trinity SNOTEL, ID	79-ID-10		115			570							513	
Trinity Hypalon, ID	79-ID-11		105			524							467	
Trinity RSG, ID	79-ID-12		120			607							504	
Columbine, CO	79-C0-1	3/20/79	188	336	632	722				670				
Columbine #1, CO	80-CO-1	2/14/80	140	301	422	439	415				430			
Columbine #2, CO	80-C0-2	2/14/80	140	290	406	432	429				448			
Willow Creek, CO	80-CO-3	3/26/80	142	277	393	419								
Columbine, CO	80-C0-4	3/26/80	201	322	648	755								
Tower, CO	80-C0-5	3/27/80	384	340	1306	1388								
Columbine, CO	80-CO-6	4/23/80	162	401	649	701								
Columbine 4P, CO	81-CO-1	3/26/81	94	270	254	278							249	
Columbine 3P, CO	81-CO-2	3/26/81	92	285	262	265							258	
Columbine LP, CO	81-CO-3	3/26/81	95	289	275	288								
Columbine NP, CO	81-CO-4	3/26/81	94	287	270	268	291							
Columbine HYP, CO	81-C0-5	3/27/81	102	296	302	325								
Columbine Trees, CO	81-CO-6	3/27/81	87	248	216	256								

NOTE: WHERE NO VALUES ARE SHOWN FOR GLACIER DENSITY AND GLACIER SWE, THE DEPTH IS FROM THE STANDARD FEDERAL SAMPLER.

TABLE VII
REGRESSION ANALYSIS OF ALL SNOW WATER EQUIVALENT DATA

<u>Y</u>		<u>X</u>	<u>_</u>	_ <u>x</u> _	R ²	S.E.	COEF	Cases
Glacier	vs.	Standard Federal	420	459	.9988	17.5	.9095	188
		Sharpened Federal	435	459	.9986	19.8	.9417	180
		1978 Metric (short)	441	472	.9980	23.5	.9291	118
		1979 Metric	518	555	.9984	24.1	.9298	107
		1980 Metric	455	473	.9985	20.1	.9569	69
		1981 Metric	295	303	.9976	17.7	.9637	63
		Broken tooth Fed.	665	742	.9996	17.2	.8921	15
		Adirondack	211	205	.9992	8.7	1.0220	13
		ESC 30	263	261	.9991	9.7	1.0028	45
		ESC 40	264	263	.9989	10.5	.9976	38
		ESC 50	424	423	.9997	8.7	1.0011	16
		MSC	112	114	.9968	7.4	.9791	16
		PVC	442	441	.9996	10.7	.9996	13
		Aluminum tube	359	362	.9998	5.6	.9942	9
Std. Fed.	vs.	Sharpened Fed.	475	459	.9994	13.6	1.0353	180
		1978 Metric (short)	482	472	.9988	19.7	1.0209	118
		1979 Metric	569	555	.9992	18.4	1.0262	107
		1980 Metric	497	473	.9992	16.1	1.0524	69
		1981 Metric	315	303	.9991	11.7	1.0335	63
		Broken tooth Fed.	732	742	.9997	16.7	.9839	15
		ESC 30	279	261	.9979	15.6	1.0631	45
		ESC 40	281	263	.9979	15.5	1.0610	38
		ESC 50	457	423	.9993	14.4	1.0868	16
		Pit or Template	451	414	.9987	22.4	1.0982	62
		BUNG	551	520	.9995	16.2	1.0557	29
		McCall	378	355	.9994	11.7	1.0578	32
		Adirondack	218	203	.9993	12.7	1.0993	32
		MSC	112	111	.9948	9.2	1.0053	31
		Bowman	109	104	.9979	6.1	1.0463	20
		Leupold & Stevens	291	291	.9997	11.8	1.0183	12
		Rosen	728	684	.9998	13.3	1.0626	10
		Utah	273	257	.9972	16.1	1.0464	7
		Profile	712	635	.9941	61.4	1.1204	34
		Profile (modified)	577	537	.9965	38.8	1.0725	21
Sharp. Fed.	vs.	1978 Metric (short)	467	472	.9990	17.3	.9897	118
		1979 Metric	550	555	.9992	18.3		107
		1980 Metric	478	473	.9991	16.5	1.0085	69
		1981 Metric	336	334	.9992	11.5	1.0018	55
		Broken tooth Fed.	700	742	.9996	17.8	.9402	15
		Adirondack	189	183	.9987	8.4	1.0333	12
		ESC 30	310	298	.9978	16.9	1.0378	37
		ESC 40	273	263	.9977	16.1	1.0356	38
		ESC 50	436	423	.9993	14.1	1.0385	16
		MSC	135	136	.9986	6.1	.9922	8

TABLE VII REGRESSION ANALYSIS OF ALL SNOW WATER EQUIVALENT DATA (continued)

<u>Y</u>			X	<u></u>	<u>x</u>	R ²	S.E.	_COEF_	Cases
1978	Metric	(short)						
		VS.	1979 Metric	688	685	.9989	24.9	1.0031	46
			1980 Metric	471	459	.9983	23.3	1.0211	38
			1981 Metric	303	298	.9987	13.3	1.0151	42
			ESC 30	300	285	.9968	20.1	1.0481	34
			ESC 40	275	263	.9965	19.9	1.0458	38
			ESC 50	445	423	.9984	21.3	1.0631	· 16
1979	Metric	vs.	1980 Metric	566	554	.9987	22.8	1.0186	39
			1981 Metric	480	475	.9998	7.8	1.0093	12
			Broken tooth Fed.	721	742	.9996	18.4	.9670	15
			Adirondack	138	128	.9966	9.7	1.0675	8
			MSC	138	136	.9944	12.4	1.0044	8
1980	Metric	vs.	1981 Metric	476	475	.9996	10.3	1.0043	12
			ESC 50	436	423	.9992	14.4	1.0411	16

Definition of Headings

Y = Dependent variable, \bar{y} = average of Y values in mm X = Independent variable, \bar{x} = average of X values in mm

R² = Coefficient of determination

S.E. = Standard error of estimate in mm

COEF = Coefficient with zero intercept; i.e., Y = COEF times X.

Cases = Number of available data points used in the analysis

TABLE VIII
REGRESSION ANALYSIS OF ALL SNOW WATER EQUIVALENTS GROUPED BY DENSITY

<u>¥</u> (0.)	<u>X</u>	Glacier Density	<u></u>	_x_	R ²	S.E.	COEF	Cases
		(kg m-3)						
Glacier vs.	Standard Federal	A11	420	459	.9988	17.5	.9095	188
		Under 260	172	186	.9977	9.6	.9132	46
		260-300	333	367	.9981	16.1	.9025	40
		310-350	471	512	.9986	19.7	.9109	44
		360-400	579	633	.9991	20.3	.9122	38
		Over 400	748	823	.9992	23.6	.9076	20
Glacier vs.	Sharpened Federal	A11	435	459	.9986	19.8	.9417	180
		Under 260	189	197	.9977	10.4	.9429	38
		260-300	333	357	.9983	14.9	.9281	40
		310-350	471	498	.9978	24.3	.9363	44
		360-400	579	605	.9989	21.3	.9541	38
		Over 400	748	799	.9992	23.8	.9375	20
Glacier vs.	1978 Metric	A11	441	472	.9980	23.5	.9291	118
0100101 .0.	(short)	Under 260	184	190	.9967	12.7	.9688	23
	(22222)	260-300	337	369	.9977	18.0	.9108	27
		310-350	496	539	.9978	25.8	.9115	27
		360-400	545	575	.9985	23.8	.9409	27
		Over 400	756	809	.9986	30.8	.9364	14
Glacier vs.	1979 Metric	A11	518	555	.9984	24.1	.9298	107
		Under 260	198	216	.9965	13.2	.9098	16
		260-300	334	365	.9963	22.0	.9074	19
		310-350	546	593	.9977	28.5	.9149	28
		360-400	651	688	.9989	24.5	.9418	25
		Over 400	753	802	.9994	20.4	.9349	19
Glacier vs.	1980 Metric	A11	455	473	.9985	20.1	.9569	69
		Under 260	215	221	.9987	8.7	.9596	14
		260-300	358	377	.9978	18.2	.9401	13
		310-350	439	457	.9975	24.7	.9478	17
		360-400	651	673	.9992	20.7	.9659	21
		Over 400	644	680	.9991	24.9	.9448	4
Glacier vs.	1981 Metric	A11	295	303	.9976	17.7	.9637	63
		Under 260	141	142	.9979	8.4	.9752	22
		260-300	318	336	.9964	22.6	.9292	18
		310-350	393	404	.9989	15.1	.9686	10
		360-400	432	437	.9994	12.3	.9844	11
		Over 400					Toba	2
Glacier vs.	ESC 30	A11	263	261	.9991	9.7	1.0028	45
		Under 260	143	143	.9987	6.8	.9992	16
		260-300	252	244	.9985	10.9	1.0245	13
		310-350	406	413	.9997	7.5	.9812	7
		360-400	335	330	.9999	4.5	1.0195	7
		Over 400						2

TABLE VIII

REGRESSION ANALYSIS OF ALL SNOW WATER EQUIVALENTS GROUPED BY DENSITY (continued)

<u>Y</u>		X	Glacier Density (kg m- ³)	<u>_</u>	<u>x</u>	R ²	S.E.	COEF	Cases
Glacier	vs.	ESC 40	A11	264	263	.9989	10.5	.9976	38
			Under 260	152	153	.9986	7.8	.9880	12
			260-300	252	246	.9983	11.9	1.0175	13
			310-350	406	412	.9995	10.5	.9852	7
			360-400	283	278	.9999	3.4	1.0174	5
			Over 400				J. 4 		1
Glacier	vs.	ESC 50	A11	424	423	.9997	8.7	1.0011	16
			310-350	307	312	.9998	4.5	.9852	8
			360-400	540	534	.9998	10.1	1.0057	8
Standard	vs.	Sharpened	A11	475	459	.9994	13.6	1.0353	180
Federal		Federal	Under 260	205	197	.9984	9.7	1.0340	38
			260-300	367	357	.9995	9.3	1.0279	40
			310-350	512	498	.9993	15.1	1.0279	44
			360-400	633	605	.9995	16.5	1.0458	38
			Over 400	823	799	.9998	12.9	1.0329	20
Standard	vs.	1978 Metric	A11	482	472	.9988	19.7	1.0209	118
Federal		(short)	Under 260	199	190	.9979	11.0	1.0581	23
			260-300	373	369	.9992	11.9	1.0107	27
			310-350	540	539	.9987	21.9	1.0026	27
			360-400	595	575	.9992	19.9	1.0305	27
			Over 400	830	809	.9991	27.1	1.0275	14
Standard	vs.	1979 Metric	A11	569	555	.9992	18.4	1.0262	107
Federal			Under 260	216	216	.9978	11.4	1.0039	16
			260-300	370	365	.9984	16.1	1.0139	19
			310-350	599	593	.9993	17.5	1.0115	28
			360-400	714	688	.9995	16.9	1.0351	25
			Over 400	831	802	.9994	22.5	1.0323	19
Standard	vs.	1980 Metric	A11	497	473	.9992	16.1	1.0524	69
Federal			Under 260	234	221	.9996	5.5	1.0536	14
			260-300	394	377	.9994	10.1	1.0439	13
			310-350	477	457	.9994	13.3	1.0408	17
			360-400	713	673	.9991	23.6	1.0606	21
			Over 400	711	680	.9999	10.9	1.0428	4
Standard	vs.	1981 Metric	A11	315	303	.9991	11.7	1.0335	63
Federal			Under 260	149	142	.9992	5.6	1.0479	22
			260-300	346	336	.9988	14.5	1.0190	18
			310-350	416	404	.9997	8.4	1.0288	10
			360-400	460	437	.9993	14.3	1.0465	11
			Over 400		-			Many Mills	2

TABLE VIII

REGRESSION ANALYSIS OF ALL SNOW WATER EQUIVALENTS GROUPED BY DENSITY (continued)

Standard vs. ESC 30	<u>¥</u>			X	Glacier <u>Density</u> (kg m- ³)	<u></u>	<u>_x</u>	R ²	S.E.	COEF	Cases
Federal	Standard	vs.	ESC	30	A11	279	261	.9979	15.6	1.0631	45
260-300	Federal				Under 260	150	142	.9984	8.2	1.0648	16
Standard vs. ESC 40											13
Standard vs. ESC 40											
Standard vs. ESC 40											
Under 260											
Standard vs. ESC 50	Standard	vs.	ESC	40	A11	281	263	.9979	15.5	1.0610	38
Standard vs. ESC 50	Federal				Under 260	159	153	.9986	8.4	1.0579	12
Standard vs. ESC 50					260-300	274	246	.9979	14.2	1.1098	13
Standard vs. ESC 50							412			1.0449	7
Over 400							278		11.8	1.0763	5
Sharpened vs. 1979 Metric All 467 472 473 473 475											1
Sharpened vs. 1978 Metric Federal (short) Mall 467 472 9990 17.3 9897 118 Federal (short) Under 260 192 190 9966 13.7 1.0269 23 260-300 364 369 9992 11.7 9861 27 310-350 525 539 9988 20.3 9767 27 360-400 571 575 9995 15.0 9990 27 Over 400 808 809 9993 22.6 9981 14 Sharpened vs. 1979 Metric Federal All 550 555 9992 18.3 9902 107 Federal Under 260 206 216 9971 12.7 9620 16 260-300 359 365 9991 11.9 9812 19 310-350 582 593 9995 14.7 9839 28 360-400 683 688 9993 20.5 9894 25 Over 400 807 802 9992 26.0 9988 19 Sharpened vs. 1980 Metric Federal Under 260 227 221 9986 9.5 1.0322 14 260-300 383 377 9991 12.8 1.0124 13 310-350 458 457 9988 18.3 9962 17 360-400 678 673 9993 20.2 1.0098 21 Over 400 693 680 9997 15.3 1.0132 4 Sharpened vs. 1981 Metric Federal All 336 334 9992 11.5 1.0018 55 Federal Under 260 173 171 9992 6.5 1.0147 14 300 337 336 9987 14.7 9993 18 350 406 404 9996 10.0 1.0086 10 400 438 437 9997 9.5 9983 11	Standard	vs.	ESC .	50	A11	457	423	.9993	14.4	1.0868	16
Sharpened vs. 1978 Metric	Federal				310-350	328	312	.9984	14.5	1.0525	8
Federal (short) Under 260 192 190 .9966 13.7 1.0269 23 260-300 364 369 .9992 11.7 .9861 27 310-350 525 539 .9988 20.3 .9767 27 360-400 571 575 .9995 15.0 .9909 27 Over 400 808 809 .9993 22.6 .9981 14					360-400	586	534	.9999	7.4	1.0967	8
Pederal (short) Under 260 192 190 .9966 13.7 1.0269 23 260-300 364 369 .9992 11.7 .9861 27 310-350 525 539 .9988 20.3 .9767 27 360-400 571 575 .9995 15.0 .9909 27 0ver 400 808 809 .9993 22.6 .9981 14	Sharpened	vs.	1978	Metric	A11	467	472	.9990	17.3	.9897	118
310-350 525 539 .9988 20.3 .9767 27 360-400 571 575 .9995 15.0 .9909 27 Over 400 808 809 .9993 22.6 .9981 14	1.77				Under 260	192	190	.9966		1.0269	
360-400 571 575 59995 15.0 59909 27					260-300	364	369	.9992	11.7	.9861	27
Over 400 808 809 .9993 22.6 .9981 14					310-350	525	539	.9988	20.3	.9767	27
Sharpened vs. 1979 Metric Federal Al1 550 555 .9992 18.3 .9902 107					360-400	571	575	.9995	15.0	.9909	27
Under 260 206 216 .9971 12.7 .9620 16 260-300 359 365 .9991 11.9 .9812 19 310-350 582 593 .9995 14.7 .9839 28 360-400 683 688 .9993 20.5 .9894 25 25 25 25 25 25 25 2					Over 400	808	809	.9993	22.6	.9981	14
260-300 359 365 .9991 11.9 .9812 19 310-350 582 593 .9995 14.7 .9839 28 360-400 683 688 .9993 20.5 .9894 25 25 25 25 25 25 25 2	Sharpened	vs.	1979	Metric		550					
310-350 582 593 .9995 14.7 .9839 28 360-400 683 688 .9993 20.5 .9894 25 25 20ver 400 807 802 .9992 26.0 .9988 19	Federal				Under 260	206					
360-400					260-300				11.9		
Over 400 807 802 .9992 26.0 .9988 19 Sharpened vs. 1980 Metric All 478 473 .9991 16.5 1.0085 69 Under 260 227 221 .9986 9.5 1.0322 14 260-300 383 377 .9991 12.8 1.0124 13 310-350 458 457 .9988 18.3 .9962 17 360-400 678 673 .9993 20.2 1.0098 21 Over 400 693 680 .9997 15.3 1.0132 4 Sharpened vs. 1981 Metric Federal All 336 334 .9992 11.5 1.0018 55 Under 260 173 171 .9992 6.5 1.0147 14 300 337 336 .9987 14.7 .9923 18 350 406 404 .9996 10.0 1.0086 10 400 438 437 .9997 9.5 .9983 11					310-350	582					
Sharpened vs. 1980 Metric Federal All 478 473 .9991 16.5 1.0085 69 Under 260 227 221 .9986 9.5 1.0322 14 260-300 383 377 .9991 12.8 1.0124 13 310-350 458 457 .9988 18.3 .9962 17 360-400 678 673 .9993 20.2 1.0098 21 Over 400 693 680 .9997 15.3 1.0132 4 Sharpened vs. 1981 Metric Federal All 336 334 .9992 11.5 1.0018 55 Under 260 173 171 .9992 6.5 1.0147 14 300 337 336 .9987 14.7 .9923 18 350 406 404 .9996 10.0 1.0086 10 400 438 437 .9997 9.5 .9983 11					360-400		688				
Federal Under 260 227 221 .9986 9.5 1.0322 14 260-300 383 377 .9991 12.8 1.0124 13 310-350 458 457 .9988 18.3 .9962 17 360-400 678 673 .9993 20.2 1.0098 21 0ver 400 693 680 .9997 15.3 1.0132 4 Sharpened vs. 1981 Metric Federal All 336 334 .9992 11.5 1.0018 55 Under 260 173 171 .9992 6.5 1.0147 14 300 337 336 .9987 14.7 .9923 18 350 406 404 .9996 10.0 1.0086 10 400 438 437 .9997 9.5 .9983 11					Over 400	807	802	.9992	26.0	.9988	19
260-300 383 377 .9991 12.8 1.0124 13 310-350 458 457 .9988 18.3 .9962 17 360-400 678 673 .9993 20.2 1.0098 21 20 20 20 20 20 20 20	Sharpened	vs.	1980	Metric							
310-350 458 457 .9988 18.3 .9962 17 360-400 678 673 .9993 20.2 1.0098 21 0ver 400 693 680 .9997 15.3 1.0132 4	Federal				Under 260						
360-400 678 673 .9993 20.2 1.0098 21 Over 400 693 680 .9997 15.3 1.0132 4 Sharpened vs. 1981 Metric All 336 334 .9992 11.5 1.0018 55 Under 260 173 171 .9992 6.5 1.0147 14 300 337 336 .9987 14.7 .9923 18 350 406 404 .9996 10.0 1.0086 10 400 438 437 .9997 9.5 .9983 11											
Over 400 693 680 .9997 15.3 1.0132 4 Sharpened vs. 1981 Metric All 336 334 .9992 11.5 1.0018 55 Federal Under 260 173 171 .9992 6.5 1.0147 14 300 337 336 .9987 14.7 .9923 18 350 406 404 .9996 10.0 1.0086 10 400 438 437 .9997 9.5 .9983 11					310-350	458	457	.9988		.9962	
Sharpened vs. 1981 Metric All 336 334 .9992 11.5 1.0018 55 Federal Under 260 173 171 .9992 6.5 1.0147 14 300 337 336 .9987 14.7 .9923 18 350 406 404 .9996 10.0 1.0086 10 400 438 437 .9997 9.5 .9983 11					360-400						
Federal Under 260 173 171 .9992 6.5 1.0147 14 300 337 336 .9987 14.7 .9923 18 350 406 404 .9996 10.0 1.0086 10 400 438 437 .9997 9.5 .9983 11					Over 400	693	680	.9997	15.3	1.0132	4
300 337 336 .9987 14.7 .9923 18 350 406 404 .9996 10.0 1.0086 10 400 438 437 .9997 9.5 .9983 11	Sharpened	vs.	1981	Metric			334				
350 406 404 .9996 10.0 1.0086 10 400 438 437 .9997 9.5 .9983 11	Federal				Under 260						
400 438 437 .9997 9.5 .9983 11											
							404				
Over 400 2						438	437	.9997	9.5	.9983	
					Over 400						2

TABLE VIII

REGRESSION ANALYSIS OF ALL SNOW WATER EQUIVALENTS GROUPED BY DENSITY (continued)

<u>Y</u>		X	Glacier Density	ÿ	_ x	R ²	S.E.	COEF	Cases
7,790			(kg m-3)						
Sharpened	vs.	ESC 30	A11	310	298	.9978	16.9	1.0378	37
Federal			Under 260	198	196	.9972	14.1	1.0358	8
			260-300	268	244	.9979	14.0	1.0938	13
			310-350	419	413	.9997	8.3	1.0204	7 7
			360-400 Over 400	338	330	.9997	6.9	1.0244	. 2
Sharpened	vs.	ESC 40	A11	273	263	.9977	16.1	1.0356	38
Federal			Under 260	154	153	.9973	11.3	1.0279	12
			260-300	268	246	.9978	14.4	1.0864	13
			310-350	419	412	.9993	13.0	1.0245	7
			360-400	288	278	.9993	10.5	1.0322	5
			Over 400						1
Sharpened	vs.	ESC 50	A11	436	423	.9993	14.1	1.0385	16
Federal			310-350	314	313	.9986	13.1	1.0052	8
			360-400	558	534	.9998	9.3	1.0480	8
1978 Metric	vs.	1979 Metric	A11	688	685	.9989	24.9	1.0031	46
(short)			Under 260						1
			260-300	393	396	.9997	8.0	.9902	6
			310-350	740	738	.9996	17.0	1.0033	12
			360-400	681	677	.9990	24.5	1.0057	14
			Over 400	819	813	.9983	36.6	1.0027	13
1978 Metric	VS.	1980 Metric	A11	471	459	.9983	23.3	1.0211	38
(short)			Under 260	228	220	.9986	9.8	1.0273	9
			260-300	423	411	.9998	6.5	1.0301	5
			310-350	422	410	.9950	35.7	1.0132	10
			360-400	674	658	.9990	24.9	1.0262	12
			Over 400						2
1978 Metric	vs.	1981 Metric	A11	303	298	.9987	13.3	1.0151	42
(short)			Under 260	160	163	.9984	8.6	.9626	13
			260-300	342	338	.9992	11.5	1.0059	16
			301-350	439	418	.9996	9.9	1.0512	7
			360-400	288	283	.9998	5.4	1.0162	5
			Over 400						1
1978 Metric	vs.	ESC 30	A11	300	285	.9968	20.1	1.0481	34
(short)			Under 260	188	196	.9993	6.5	.9670	8
			260-300	270	244	.9954	20.8	1.0973	13
			310-350	439	413	.9996	10.5	1.0650	7
			360-400	288	278	.9999	4.0	1.0376	5
			Over 410						1

REGRESSION ANALYSIS OF ALL SNOW WATER EQUIVALENTS GROUPED BY DENSITY (continued)

<u>Y</u>	<u>X</u>	Glacier Density	y	<u>x</u>	R ²	S.E.	COEF	Cases
		(kg m-3)						
1978 Metric	vs. ESC 40	A11	275	263	.9965	19.9	1.0458	38
(short)		Under 260	148	153	.9982	8.8	.9629	12
		260-300	270	246	.9951	21.4	1.0897	13
		310-350	439	412	.9997	8.6	1.0696	7
		360-400	288	278	.9994	9.7	1.0342	5
		Over 400						. 1
1978 Metric	vs. ESC 50	A11	445	423	.9984	21.3	1.0631	16
(short)		310-350	323	313	.9954	24.4	1.0422	8
		360-400	567	534	.9993	17.6	1.0691	8
1979 Metric	vs. 1980 Metric	A11	566	554	.9987	22.8	1.0186	39
		Under 260	230	223	.9996	5.8	1.0381	5
		260-300	373	356	.9960	26.9	1.0420	8
		310-350	597	585	.9987	24.4	1.0150	9
		360-400	759	743	.9995	19.2	1.0240	13
		Over 400	676	680	.9989	29.6	.9923	4
1980 Metric	vs. ESC 50	A11	436	423	.9992	14.4	1.0411	16
		310-350	314	313	.9982	14.7	1.0082	8
		360-400	559	534	.9999	8.1	1.0505	8
1981 Metric	vs. ESC 30	A11	268	261	.9981	13.9	1.0257	45
		Under 260	143	143	.9978	9.2	1.0144	16
		260-300	264	244	.9973	15.6	1.0704	13
		310-350	418	413	.9995	10.5	1.0130	7
		360-400	336	330	.9997	7.6	1.0218	7
		Over 400						2
1981 Metric	vs. ESC 40	A11	270	263	.9976	16.2	1.0211	38
		Under 260	151	153	.9966	12.6	1.0072	12
		260-300	264	246	.9973	15.6	1.0632	13
		310-350	418	412	.9993	13.1	1.0171	7
		360-400	283	278	.9985	14.5	1.0172	5
		Over 400						1
ESC 30	vs. ESC 40	- All	285	286	.9995	7.8	.9977	34
		Under 260	196	197	.9993	6.7	.9930	8
		260-300	244	246	.9991	8.6	.9928	13
		310-350	413	412	.9996	9.9	1.0040	7
		360-400	278	278	.9997	6.4	.9968	5
		Over 400		-	-	***	-	1

Definition of Headings

TABLE VIII

= Dependent variable, \bar{y} = average of Y values in mm = Independent variable, \bar{x} = average of X values in mm

X

R² = Coefficient of determination

S.E. = Standard error of estimate in mm

COEF = Coefficient with zero intercept; i.e., Y = COEF times X.

Cases = Number of available data points used in analysis

REGRESSION ANALYSIS OF 1981-1982 SNOW WATER EQUIVALENTS

Y		X	<u>_</u>	<u>x</u>	R ²	S.E.	COEF	Cases
Glacier	vs.	Standard Federal	297	317	.9986	13.8	.9329	62
		Sharpened Federal	327	338	.9986	14.4	.9622	54
		1981 Metric	297	305	.9977	17.3	.9643	62
		ESC 30	263	261	.9991	9.7	1.0028	45
Std. Fed.	vs.	Sharpened Fed.	349	338	.9995	8.9	1.0315	54
		1981 Metric	317	305	.9991	11.8	1.0336	62
		ESC 30	279	261	.9979	15.6	1.0631	45
Sharp. Fed.	vs.	1981 Metric	338	336	.9992	11.5	1.0017	54
1920.5 3.4		ESC 30	310	298	.9978	16.9	1.0378	37
1981 Metric	vs.	ESC 30	268	261	.9981	13.9	1.0257	45

Definition of Headings

TABLE IX

Y = Dependent variable, \bar{y} = average of Y values in mm X = Independent variable, \bar{x} = average of X values in mm

R² = Coefficient of determination S.E. = Standard error of estimate in mm

COEF = Coefficient with zero intercept; i.e., Y = COEF times X.

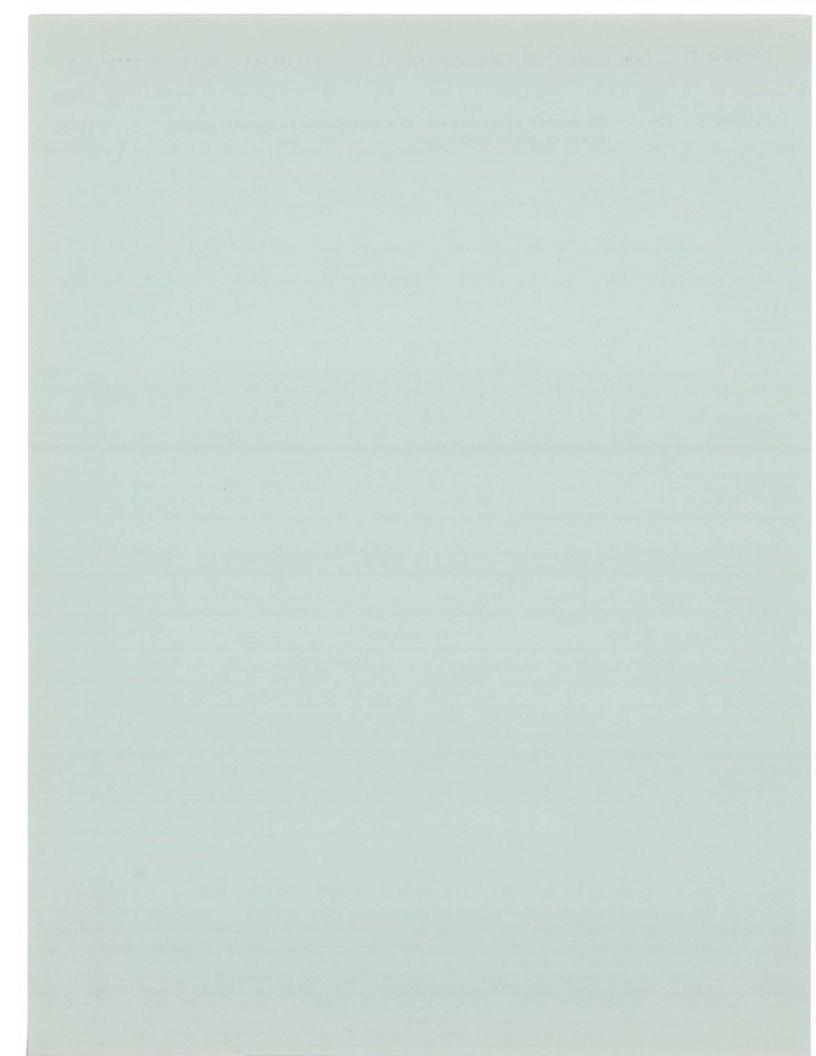
Cases = Number of available data points used in analysis

APPENDIX II.	Snow profiles	of snow	sampling	pits	by metrication	committee -	1979-1982
				in the second second			

Page

Figures 9 - 124 The number of each profile corresponds to sample number shown in table V.

55-83



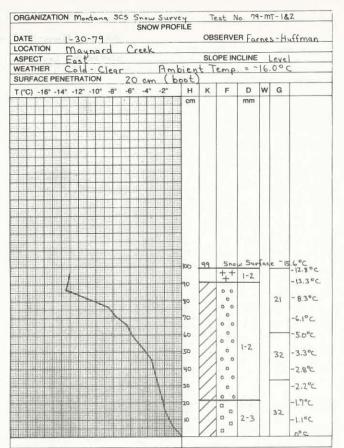


FIGURE 9. Snow profile for pit number 79-MT-1 and 2

ORGA	NIZA	IIOI	a IA	lont	4 1	, 5							lest !	10.79	-11	11-6	Dr /
								SN	OW	PROF	ILE						
DATE				1-7					_			OB	SERVE	A Fo	arn	es-	Huffmar
LOCA"	_		_0	wer	-	Neu	u U	Vos	-ld								
ASPE	CT	1	Voi	-th	-	Sh	ade	d				SLC	OPE IN	CLINE		5 %	
WEAT		-		d-		lea					Amb	oien	t Te	mp.	= '	-14,0)°C
SURF	ACE	PEN	ETF	RATH	NC		95	CY	2	(boo	ot)			,			
T (°C)	-16°	-14	-1	2° -	10°	-8°	-6°	-4	n .	2°	Н	K	F	D	W	G	
		I		П			1-11	П		11111	cm			mm			
		Ħ	T					П									
								Ш									
		Ш	Ш				ш	Ш	ш								
		ш	4	ш		-	14	Ш	4								
		ш.	+				111	44	4	Н.				1000			
		H	+				H	Н	н	Н							
					Н			Н		Ш							
					Н			Н									
			t		T												
			T		İ			П									
								П								- 1	
		Ш							ш								
		Ш		Ш		ш		Ш	ш								
		ш		Ш		-	44	Ш	ш								
		ш	+			-		ш	-#-	1							
			+		H	-	+++	Н	-	1					us.		
					H			т			105	Sno	w Su	rface	-1	4.3°C	-16.4°C
T			т		T		11		#		100	1	++++				-18.900
		Ħ	T					П			90		1,+,	0,5			-18.9°C
\sim			Т								170	-			+ 1		
	\nearrow	Ш									80	//	00			17	-15.2°C
			4								100	//	00	05-1			100.00
44.			1.4	1			44				70	//	0	02-1			-10.9°C
					\searrow			Н				//	00				
		Н	Н	Н	۳	7		Н			60	17	^ ^		1		-8.1°C
		H			H	1	X				1	//					-6.7°C
		Ш	Ħ		Ħ		N				50	/	^ ^			27	-6.1-C
							IV				40	/	^ ^				-6.0°C
							I N				140	//	V V				10000
	Ш						ш	X			30	//	1 ^ ^	3-4	1		-4.4°C
	Ш	Ш				4	44	1			100	//	1 1	3 1			
44	-	₩.	ш			-	+++		X.		20	//	^ ^				-3.4°C
							++		X			//	A A			26	-7.5°C
		Ш					11	Н	-		10	/	1 1				-7.5-6
		ш		H			##	1		\	1	/	1 ^ ^				-1.8°C
- Lunding	distribution.	Acceptable	214111	Maria de la	1		- Harrister	MI III	i sanita	(Acrillia	40	4					-1.0

FIGURE 11. Snow profile for pit number 79-MT-6 and 7

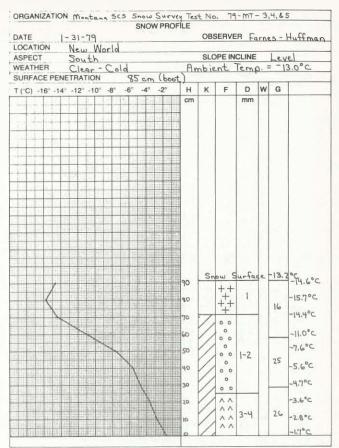


FIGURE 10. Snow profile for pit number 79-MT-3, 4 and 5

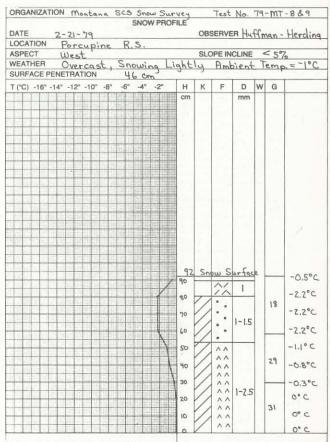


FIGURE 12. Snow profile for pit number 79-MT-8 and 9

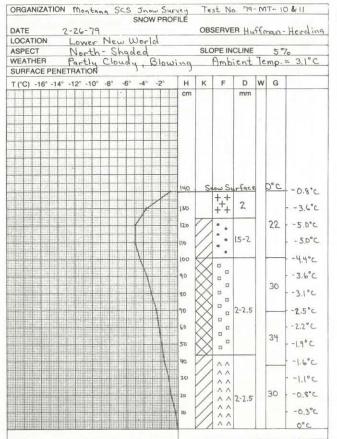


FIGURE 13. Snow profile for pit number 79-MT-10 and 11

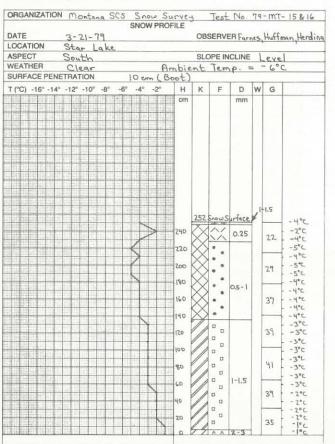


FIGURE 15. Snow profile for pit number 79-MT-15 and 16

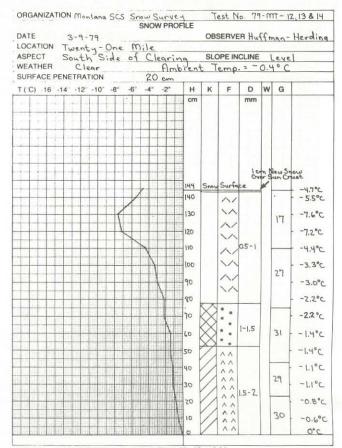


FIGURE 14. Snow profile for pit number 79-MT-12, 13 and 14

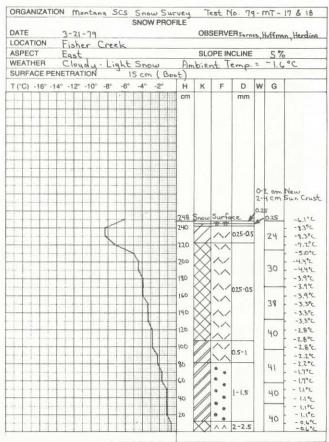


FIGURE 16. Snow profile for pit number 79-MT-17 and 18

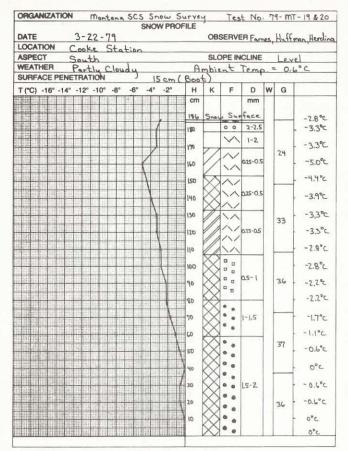


FIGURE 17. Snow profile for pit number 79-MT-19 and 20

ORGA	NIZA	TIC	N	m	ont	an	9	SC	5	S	nou	3	Sur	vey	Tes	st No	. 79-	m	- 2'	3 & 24
										SN	OW	P	ROF	ILE						
DATE				4	- 2	6-	79								OBS	SERVE	R Far	nes-	- Huff	man-Herdi
LOCAT	TION		L				23	K								1111				
ASPEC	T				th										SLC	PE IN	CLINE		Fla	+
WEAT	HER				rti		C	los	10.					A.		+ T	mp.	=		7°C
SURFA		PE					_				50		m	Bo	11	- 1	S now	6		
		-	-	-	-	-	-8		6°	-4		-2		H	K	F	D	w		1
T (°C)	-16	-14	4	-12	-	10	-8	-	-	-4		-2		-	K	-	-	VV	G	
	-	Н	-	+		+	н	H	+	Н	н	н		cm			mm			
				-	+	H		н	+	Н		+								
			1	Ħ				H				+								
		Ш	1		1	1						Ħ								
		П		Ħ					T	П										
						1						I								
			Ш		Ш			Ш		Ш	Ш	Ш								
			Щ	1	4	-		Ш	1	ш	Щ	4								
	-	ш	-	4	4	Н	Н	Н	+	н	н	4								
-	+	Н	\dashv	+	+	+	+	н	+	Н	-	+								
	-	Н	н	+	+	H	H	+	+	Н	+	+						П		
					н			н	٠	Н	-	Ħ								
				Ħ	н	Ħ				Ш		Ħ								
				T	т	T	П	T	T	П	П	Ħ								
					П	Π						П								
				П		П			П		Ш							П		
		Ш		Ш	ш					Ш	Ш	4								
				4	4		Ш			Ш		4								
	4	ш		-	+	-	Н	+	+	Н	-	+	+							
		Н		+	+	+	Н	+	+	Н	-	+		10		C	urfac			
			H	+		+		+			Ħ	Ħ		10	200	υ <u></u>	W. I'M	1		
		Н		Ħ	Ħ	Ħ		1	т	П		Ħ				0	2.0			
		П		Ħ		T				П		Ħ		70		0 0	2-4			
														60		0			34	
												Π		40		0			37	
												Ц		50	Lu I	0				All temps
							Ш	4	\perp			4			Set	00				-0.6°C
		Ш		4		+	Ш	4	+			+		40	0	0 0				Surface
					Н	+			H	Н		H			Very	0 0	1.0			ground.
		H		H	+	+			H			H		30	3	0 0	1-2			J
		Н	Н	-		+	Н			Н		H			-	0 0				
		H		Ť		1			t	Н		Ħ		20	F	0 0			35	
						t	Ш	Ħ	Ħ	Ħ		Ħ				0 0				
						Ħ			T	Ш			Ш	10		0 0				
		Ш				П			П							0 0				

FIGURE 19. Snow profile for pit number 79-MT-23 and 24

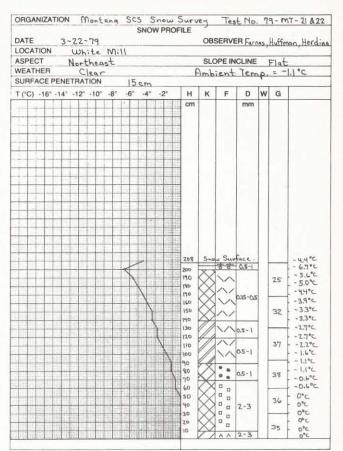


FIGURE 18. Snow profile for pit number 79-MT-21 and 22

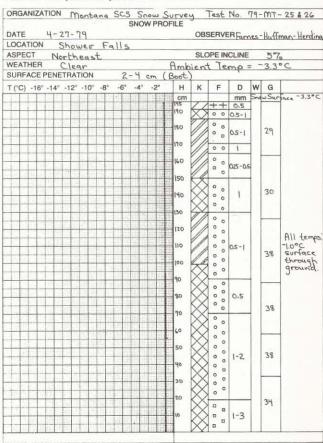


FIGURE 20. Snow profile for pit number 79-MT-25 and 26

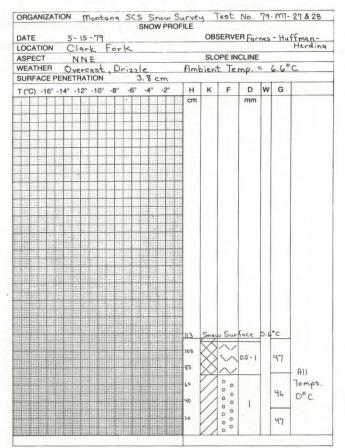


FIGURE 21. Snow profile for pit number 79-MT-27 and 28

ORGA	NIZA	TION	m	lont	an	9 5	SCS	3 5	SNO	OW	SI	ROF	ey	Tes	t No	. 79	- m	T- 3	31 & 32
DATE				-7				_	J141			. 101		OBS	SERVE	RFar	NES:	Huff	man-Herdin
LOCA	LION		St	car	· L	.ak	e												
ASPE	CT		N	E										SLC	PE IN	CLINE		< !	50
WEAT	HER			CI	20	-													
SURF	ACE	PENE	TR	ATIC	N	10			1	8 0	'n	2		A	mhii	ent 7	PW	· n =	0.6°C
T (°C)	100	4.40	40	90 4	O°	00	1 12	6°	-4		-2	-	Н	K	F	D	w	G	
1 (0)	-10	-14	-12			-0	0110	1		171111	-2	1771177	25.00	I.N.			**	u	-
-			Н			-		Н		ш	н	ш	cm			mm			
-		-	ш		н	-		₩	ш	ш	Н	ш							-
			Ш	-				Н	Ш	Ш	Ш								
			ш		ш				Ш	ш	Щ	-							
						ш			Ш	Ш	Щ								
								н	Ш	Щ		-							
							4			ш									
					Ш	Ш	ш	ш	Ш	Ш	Ш								
			Ш					ш	Ш										
			Ш		Ш	-	1	ш		ш		4							
			ш		ш	4		Ш	Ш	ш	Ш								
ш			ш			4		ш	Ш	ш	Ш								
			Ш		ш			ш	Ш	ш									
			ш																
					Ш		Ш	Ш		Ш	Ш								
								Ш											
					Ш			Ш		Ш									
			Ш					Ш	Ш	Ш									
			Ш	ш	ш		ш	Ш		Ш	Щ		204	San	o Sur	Care			
			Ш				Ш						200	1	++	Idee	-	-	+
							Ш	Ш	Ш					11	7	0.5		10	
					ш		Ш	Ш	Ш			Ш	180	//	++	0.0		18	
													10-	111	0				
			Ш		Ш								160	1/1	0				
			Ш	ш	Ш						Ц			1/1	0 0			45	
										Ш			140	///	0 0				All 4
				Ш			1							//	00			-	All temps -1.8°C
					ш		ш						120	1/	0 0	1			1.8
													1	11	0 0			49	Surface
			Ш						Ш			ш	100	1/1	00				through
			Ш						Ш				1	//	00				through
	Ш		Ш								121	Ш	80	11	200	_	-		3
			Ш	ш									1	11	^ ^			48	
				Щ.	Ш							ш	60	//	^ ^				
					Ш									//	V V			_	
													40	//	A A	2-11		44	
				ш	Ш								1"	//	10000	2-4		1.1	
			Ш	ш			Ш						20	//	A A			COV	
				Ш			Ш		4					//	^ ^			46	Water standing
and the							1									-	tim		pit.

ORGANIZATION Montana SCS Snow Survey Test No. 79-MT-29 & 30
SNOW PROFILE 5-16-79 OBSERVER Farnes-Huffman-Herding DATE LOCATION Fisher Creek ASPECT East
WEATHER Cloudy Windy Occasional Snow
SURFACE PENETRATION 8 cm (Goot SLOPE INCLINE Ambient Temp = 6°C 8 cm (Boot) D W G нк -6° T (°C) -16° -14° -12° -10° -8° -4° -2° cm mm rface O°C 200 A A 4-5 41 0 0 2-2.5 180 **::** 40 140 All temps o° c Surface through ground 0.5-1 45 100 43 80 60 39 41

FIGURE 22. Snow profile for pit number 79-MT-29 and 30

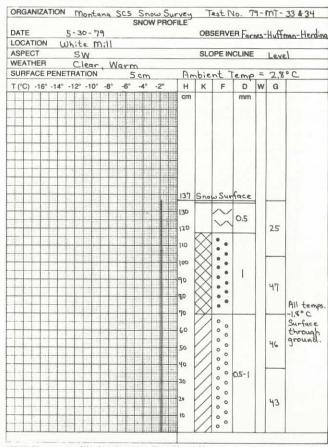


FIGURE 24. Snow profile for pit number 79-MT-33 and 34

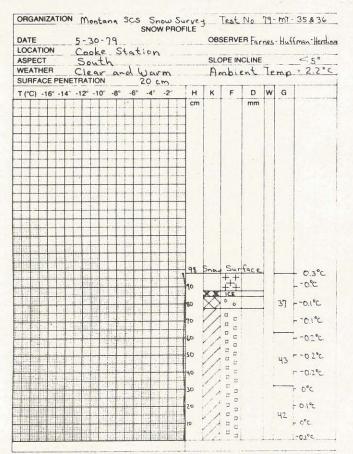


FIGURE 25. Snow profile for pit number 79-MT-35 and

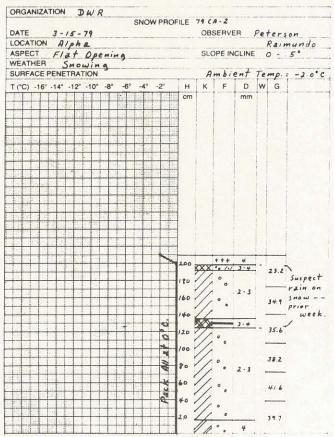


FIGURE 27. Snow profile for pit number 79-404-1

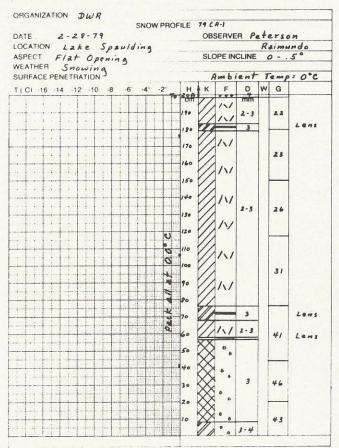
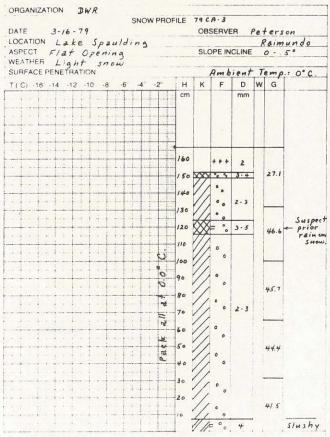
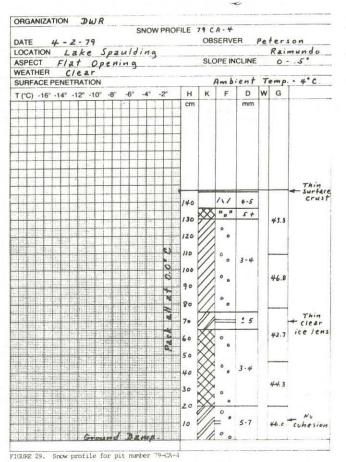


FIGURE 20. Snow profile for put master 79-CA-1





DATE		4		7.	79	,			0			FILE			R	Pe.	ers	on
LOCA				oh											-	and the same		mund
ASPE	-	E	1	L	20								SLC	PE IN	CLINE		5	
WEAT			1.0	-	4	4		5	z y		-							
SURF								r c	- 7				-					
-	-	-	-									1	1		-	1	-	
T (°C)	-16	-14	-1	2"	10	-	В	-6	-4		2"	Н	K	F	D	W	G	
												cm			mm	1/1		
						1		Ш					ř.			8 3		
			1		1						1					1 1		
					1			4			1	-						
			-	1		1					1.1		ì					
					-			4			44							
	i II	1	1	1	-	-		-			11		į.			10		
				1	1	-		-	4	-	-	-						
11	1		1.		-	-	Н			-	+-+	-				+		
		1	+	1	+	1					-	150	11					
1		-	-		4	4	-	-	-		+ +	-	1//		1	127275		
-	-	1	-	-	+	-	-	-	4	-	+	-140	11			a		
-			4	-	-	-	Н	+	1	-	+++	-	1//		8-10	no	43.c	
	-		-	-	+	+		+			+ +	130	1//		8-10		73.0	
	-	-	-		+	+	Н	-	+	-	++		1/1			Ice		7
-		-	-	-	+		Н	-	-11		+	120	//	2		4		occ arred
		++	-		+	-		+			11	-	1//	0		+		7
		++	-	-	-			-			100	110	11/			3		3
-	1	+	+	Η÷	+	+	H	+		1	11		Mo			-		· ·
			#	1	+	-			-		w	100	KXX			٠.		0
-		11	+		\pm	-			-	-		-	1/1	0 0	5-7			m
			+		+	T	Н	1			0	90	X		-	-	472	
-11		1-1		1	1	+	1	1	1		0	100						4 4
		11		1	+							-80	× X					0 4
			-		**	1			T		75	1	1/	0	-	-	_	2 2
		11	1		T			T			7	70	1/1	٥				1 0
		11			1				7		n	1	11		5 - 7			44
												60	"//	"			489	4
		T	1	I		1	T				-	50	11/	0 0		eJ 05		S: 4
											23	30	77	and the same				throughout
T		11	T		T				-		IC.	40	1/1	0	5 1			20
		T		П	T	3	T				1	40	-4	-				2 2
		T		П	1	1						30	1//	. 0			461	7 0
												30	1//	0			761	7 7
	III	T			T							20	11					t a
		T			T		1				11	20	///	0	110	٠,		2
		TI			T		T					10	1/1					Z
			IR			310			E 1917			10	11				601	ů.

FIGURE 31. Snow profile for pit nameer Trada-

DATE 4-4-79 LOCATION A/pha ASPECT F/a+0 WEATHER (/e.a.	e pening	SN	NON	/ PR	OF	ILE		SERVE	CLINE		50M munc .5°
SURFACE PENETRATIC							Am	bie	nt 7	emp.	3°C
T (C) -16 -14 -12 -1	0 -8 -6		4°	-2°		н	K	F	D	WG	
						cm			mm		
		-	-	-	-	190		111			
1 1 1 1 1 1 1				1					2 - 3		
						180		11/		25.3	'
		+	++	+		170					
						160	$\langle X \rangle$		4		
			-	-			1//				
			1			150	VA				
						140	1/	٠.	5+	37.8	1
			+	+			1//				
			Ħ			130	11	0			
		-	H			120	11	0		_	1
++++++			H	U		110	1/				
				0		110	//		3-4	39.6	
			\vdash	d	H	100	1/				
				L		90	11				
			++	H			1/1		5		
		+	Ħ	1		80	XX			41.9	
				190		70	$\Diamond \Diamond$		3-4	7.1	
		-	H	+4	H		\otimes				
			П	- M		60	1/	0			1
			\vdash	94	H	50	1/1	0			
++++++			tt		H		11			42.0	
			П			40	11	0			
		-	\vdash	+		30	1/1		4	-	1
						20	1				
			44			-	1/1			38.3	
			H		Ħ	10	1/	0			
							//				
PRE 10 SEW POSTION B. ATE 1970-02- OCATION POBILIDE SPECT Lasterly	C ENVIRON	NMEN SN	OW	PRO	OFI	LE	OBS	ERVE	R R.	3.C1 THOMPS FORD RICHARI AREA East	os
VEATHER Clear, C		020		900	-	-	SLU	C Ire	OLINE	East	.08
URFACE PENETRATIO				shoe	.)						
(C) -16 -14 -12 1				-2	1	н	K	F	D	W G	
				T		cm		No.	mm		
			-	-	-						
7 - 1 - 1 - 1 - 1			-	-							
		T									
			1	+	-						
				1							
				-		(50)		SNOW	SURFAC		
				1	+			J	July at		
		1			1	140					
			-	+	-	130					
				11		127			(.2:	- 15	
	3	1.		-			1				
			-	+		1112					
				1		100				21	LA TORN
									0.2		

0 3 1.5

- "mis |

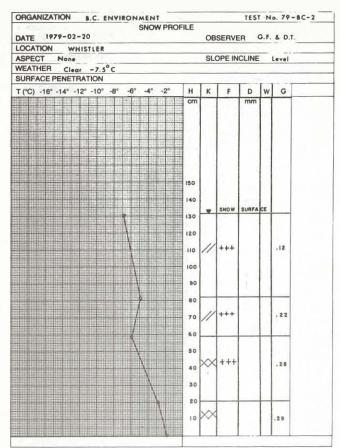


FIGURE 33. Snow profile for pit number 79-BC-2

ORGANIZAT	ION	В. С	. ENV	IRON	SNOV	V PRO	FILE	TES	ST No.	79-	в.с . т	HOMPS	ON &
DATE	197	9-02-	22					OBS	SERVE	R G	. F	ORD	BENY PE
OCATION	NEW	COPP	ER MT	N.									
ASPECT	Sou	therl	у					SLC	PE IN	CLINE			
WEATHER	Cle	ar sk	y	Air	temp.	-10	°C						
SURFACE P	ENET	RATIO	N	Snow	shoes	10	cm						
T (°C) -16°	14" -	12° -1	0° -8"	-6°	-4°	-2°	Н	K	F	D	W	G	
							cm			mm			
											П		
											П		
											П		
											П		
								1					
							60						
									111	2		20.7	
				1			50	10/					
			- K				40	XX	000	1-2		20.7	
				14				XX	0 0 0	1.2		20.7	
					V		30						
					N		20		0 0 0	2.3		20.4	
					ľλ				- 0 -	6.4		69.7	
					LA		10						
					111			1/	0 0 0	3		20.4	

FIGURE 35. Snow profile for pit number 79-BC-4

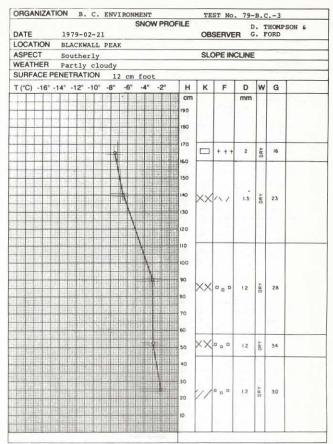


FIGURE 34. Snow profile for pit number 79-BC-3

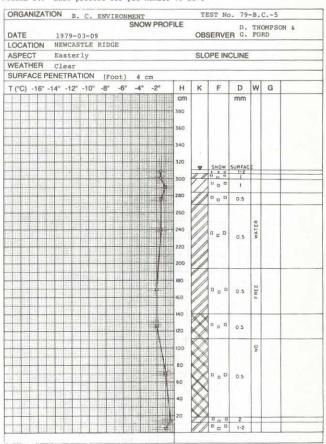


FIGURE 36. Snow profile for pit number 79-BC-5

	NIZA								SI	NO	WI	PR	OF	ILE	-	0501				ON &
DATE	-			-03			_	_	_	_	_	_	_		OB	SERVE	EH G	. F	UKD	
LOCA		W	HIS	TLE	R I	MTN						_	_							
ASPE	-														SL	OPE IN	ICLINE	2		
WEAT	HER	C	lea	r																
SURF	ACE	PENE	TR	ATI	NC		3	cm	fo	ot										
T (°C)	-16°	-14°	-1	2° -	10°	-8	o	-6	٠,	4°	-	2°		н	K	F	D	w	G	
			П		T	П	П	T		T	П			cm	-		mm			
			П				П											ш		
		Ш	П			Ш					Ħ	П		1						
			П			П					П									
																		П		
									П									П		
			Ш				Ц													
		Ш	Ш				Ш	4	1											
		Ш.				Ш	Ц	4												
444		Ш	+1		1	Ш	4	4			ш	Ш						П		
		Ш		+	+	\square	-	-	\blacksquare	+	+									
-			Н	-	+	-	-	+	Н											
			Н	-	Н	-	+	+			+	Н						ш		
		+		-	+	Н	H	+			+	H	Н							
			Н	-	+	H	Ħ	+	۰	t	H							ш		
		Ħ			T	Ħ	Ħ	1	Ħ	t	Ħ		Ш					ш		
			П		T	П	Ħ		t	t	Ħ									
							I			I				HQ.	w	SNOW	SURFAC			
						Ш								100			-			
											П			1100						
				Ш								Ш		90				1 1		
						Ш							Ш							
444				4	4	Ш	Щ	4	4	4	H	Ш	Ш	80						
-		ш	Н		+	Ш	Н				₩	Н		-	11. 1	0 0	124			
-	-	-			+	Н		+		H	18		Н	70	11	0000	1.5			
		ш	Н	+	+	Н				H	H	Н	H							
-		H	Н		+	Н		н		H	+	Н	H	60						
			Н		H	Ш			Н		H									
					1	Ш	Ħ		Ħ	t	т		H	50						
		Ш			Ħ	Ш	Ħ				Ш		m	200						
						Ш	П	Ш	Ш		Ħ	Ħ		40			-			
			Ш			Ш		Ш			Ш									
						Ш								30						
														20	90	0 0 0				
			Ш	Ш		Ш	Ш					Ш		20	11	0	- 1:			
			Ш				Ш			Ш	Ш	Ш		10						
						Ш		Щ	Ш			Ш								

FIGURE 37. Snow profile for pit number 79-BC-6

DRGA	NIZA	TIO	N	В.	C	. 1	INV	RO	NM.	EN	Г				TES	ST No.	79-	B.C	8	
														LE		SERVE	R G	. C	OULS	ON &
OCA	TION		IEW	CO	PP	ER	MT	٧.												
ASPE		-	-		-				-	_	_		_	_	SLC	OPE IN	CLINE			
				-	-	.0		_	-	_	_		_		OLC	N E 1140	OF 114C	-	-	_
WEAT										2000	- 1 -		-					_		
SURF		-	_	-	-	-		_		_	CM	-	-							_
T (°C)	-16°	-14	0 .	12"	-10)°	-8°	-6	0	-4	-	2°		Н	K	F	D	W	G	
TT	T	П	T	T	П	T	T		П	П				cm			mm			
				Т	П			П	П	П	Т	П								
				T				П			П									
								П	П			П	П							
1				Г				П	П	Ħ	Т	П								
		T		T		7	T	П				Ħ	Ш							
		11	1	1"		1	1		m	T		m	Ш							
111	1	11		1							т		Ш							
11		11		1			+	\Box		Ħ	П		Ħ							
11		11	+	1			+	П	П	Ħ		т								
11		11	1			7	1	П	Ħ			Ħ	Ш							
		11	1			1	1	П				Ħ								
		11	1	t				П												
		11	+	t	Н		1	Н		Ħ		П	m							
		11						Ħ												
++			+	+			+					1	Ш							
++-		++	+				+				Ħ	Ħ								
++		11	-	+			1	+			1									
++			+				+					111								
++-	H	11	+	+							+	۰								
++		11	+	+			-						т							
+++		11	+	+			+	1					Ħ							
++-		1	+	+	1	-	+		Н				Ħ							
++		+-	+	+	-		+			-		1	+							
+++	-	1		+			+	+			+	+	Ħ							
+++	++-	+	-	+	-		+	+		-	-	1	+							
++	-	++	+	+	-		+	+	-	-	-	+	+	1						
++	++-	1-1	+	+-	-	-	+	+		-	-	+	+	1						
-	-	-	+	+	-		+	+			-	+	+	60						
1	++-	+	-	+-	-	-	-	+			-	+	+							
-	-	-	-	-	-		+	-			+	+	+	50						
++	-	-	-	+	-		-	+			-	+-	+							
-	++	4-4	-	-	-		-	-	-		-	+-	+	40	0.00					
-	++	4-1		+	+		-	+	-	Н	-	+	-	-	A	SNOW D	SURFAC	-		-
-	-	-		-	+		-	+		Ш	-	+	11	30	-	-		-		
-	1	4		-		-	-		-		- 1		11	-		D 0 D	1			
-	++	-	-	-	-		-	+	-		-	+	4	20						
11	++		4	-	1.	-	-	4.					1			1.				
	11	110		-	1.		-	-	-			-	+	10		NAA	3			
44	11			1	1			-	1	6.		-								
		100			1	1		du.	1											1

FIGURE 39. Snow profile for pit number 79-BC-8

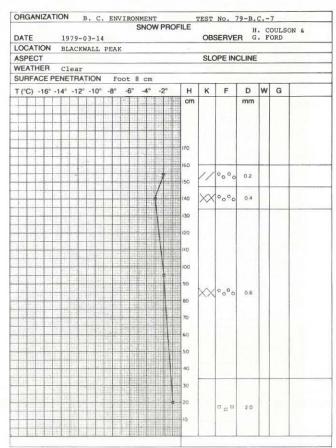
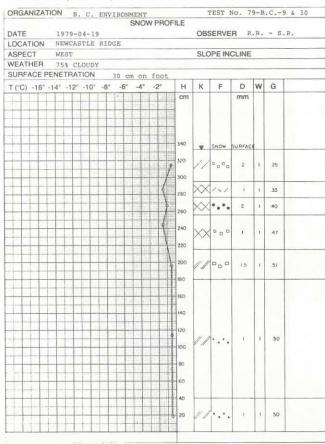


FIGURE 38. Snow profile for pit number 79-BC-7



(12 RE 40. Snow profile for pit number 79-BC-9 and 10

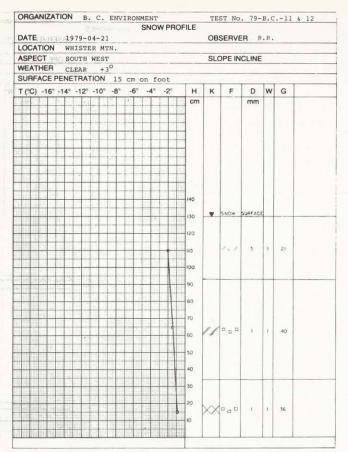


FIGURE 41. Snow profile for pit number 79-BC-11 and 12

ORGA	NIZA	TIOI	N	В.	C.	E									TI	EST N	0. 79	-B.	C15	& 16
DATE												PRO	OF	ILE		SERVE				
LOCA								SE												
ASPE	CT														SLC	PE IN	CLINE	i i		
WEAT	HER	F	AII	NIN	IG &	S	NOV	VIN	G											
SURF	ACE	PEN	ETF	RAT	TION	1	6	5 0	m	on	for	ot								
T (°C)	100	14		126	-10		00	-6		. 4		20		н	K	F	D	w	G	
1(0)	-10	-14	_	1	10		1	-6	1	7	1			cm	K	- 5	mm	44	0	
	-			t		+			1	+		H		UIII						
			1			T			T	T										
				T						I										
										I										
						1			1	4			Ш							
			-	1				-	-	4										
		-	+		-	+-	+		+	+	+	Н								
		H	+	+	1	t				1		Н								
			T	T		1		П	T	Ť										
			Т	П																
										I										
			ш	ш	ш	4			4	Ш										
			4	H		+	1	Н	4	+	+									
++		Н	+	+	-	-	+		-	+		Н		240	_					
			+	+		+			-	H						SNOW D		11	46.	
			т	T		T	T		T					220	-	EI .	0.80		7.00	
														200						
										1					11	0 0 0	10	111	49	
				1		-	-		4	1	4			180						
-			-	-	-	-	-		-	4	1	Н								
	-	H	-			+	+		Ns	7+	+		H	160						
				1		+	A	rai												
				T			T"	- 141						140	XX	0 0	1.0	ii.	.51	
										I				120	V			1		
			1							4										
				-	1	-	-		-	+	-	H		100						
		H	+	-	1	-	+	H	-	-	-	H								
		H	+	1		+	1		+	+	-			80						
			Ħ	t						1	Ħ		Ħ							
		П												60	XX	n _n n	10	0	55	
		120												40			UI TIEK	100	Her	
						4				Ц				-						
		Ш		-	Н	-	-			4			Н	20						
		Н	Ш	-	1	-	+	-	-	+		H								

FIGURE 43. Snow profile for pit number 79-FC-15 and 16

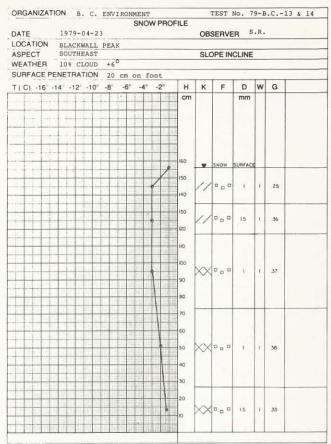


FIGURE 42. Snow profile for pit number 79-70-13 and 14

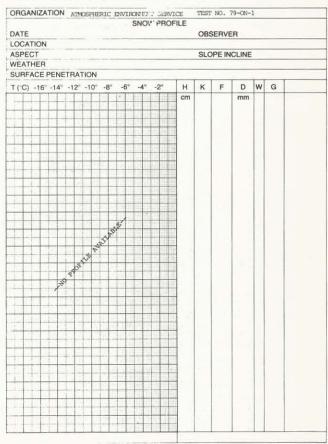


FIGURE 44. Snow profile for pit number 79-ON-1

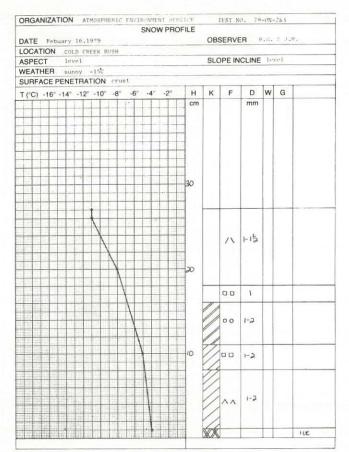
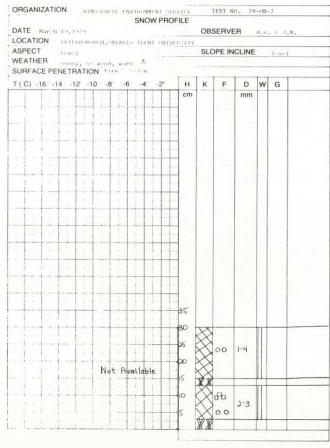


FIGURE 45. Snow profile for pit number 79-ON-2 and 3

ORGA	NIZ/	ATIO	N ,	TMOS	PHERI	CE	NVI	HONE	MENT	SERV	1CE	TES	T NOS.	79-0N	-5 8	79-	ON-6
DATE	М	arch	8.	979				SN	OW F	PROF	FILE	ОВ	SERVE	ER A.	G. 1	J.M	
LOCA	MOIT	1 10	ONTIO	ELLO	#1 8	USH	SIT	E	#2 M	ET S	ITE B	USH					
ASPE	CT	L	eve1										OPE IN	CLINE	8	Leve	1
WEAT	HER	01	verca	est w	inds	110	hit a	5°C									
SURF					21	fir		0.0		-					_	_	
0.00000	100			7.7	-		-		0 1		1	100		1			
T (°C)	-16	-14	-1	2" -11	0" -8	3"	-6"	-4	· -	2"	Н	K	F	D	W	G	
	1										cm			mm	1 1		
44	Ш	11															
		1															112
	-	1			-		-		4								1000
	1	+		-	-			Н									
		+	-	-			-				30						
	H	+	4				-	П									
		+	-	+	-		-		-	-		X					
	H	\Box	1.				-					X	A.	2-3			
	H	+	-				-		-		120	V	1		Ш		
	Н	\mathbb{H}					-				1	X					
		+					-		-			X					
					No	L P	wai	ab	e	1	1	X	de		-	_	
		++		+					-		10	1/	00	1-2			Man and
		\mathbb{H}										1			##		Som crust
		+	-		-	+	-	H	-	-	1				Ш		
		H	-			-	-	Н			1		00	1-2	Ш		
		H	-		-	+	-		-		0	_	-		ш		-
		Ħ				+		Н	+	Н							
		$^{++}$					+				==	-	-	_		_	_
	t t	Ħ	-				-	Н	-								
	Ħ	Ħ	+					Н									
		††															#1
		\Box		111				П			40						
		Ħ						Н			1						
		Ħ							-	-	1	XX	B	4.0			
		Ħ									-	XX		1.2			
H		П						П			30	X			1		
		П										X	00	2-3			
		П						П				XX	00	9 3			
		ПÌ									120	XX					
		П			N	ot	Aya	ila	ole		20	_			II,II	0100	
							П				1				1 1		
		П									1				11		
		П									1		00	1-2			
											10		2012	1 04	1		
		Ш															
		Ш									1				11		
													AA		111		

ORGANIZATION ATMOSPHERIC ENVIRONMENT SERVICE TEST NO. 79-0N-4 SNOW PROFILE DATE February 28,1979 OBSERVER J.M. LOCATION MONTICELLO, ONTARIO SLOPE INCLINE ASPECT ASPECT -WEATHER Sunny, warm fo SURFACE PENETRATION (regular 0'-1) T('C) -16 -14 -12 -10 -8 -6 -4 -2 K F D W G cm mm -1/1 12 54-1 90 0 í 10 0 0 0 15 cm crust 200 1-2

FIGURE 46. Snow profile for pit number 79-ON-4



11:11:48. Snow profile for pit number 79-0N-7

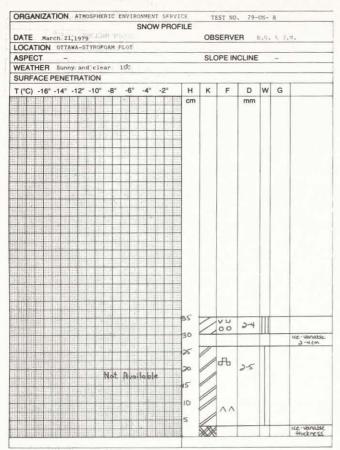


FIGURE 49. Snow profile for pit number 79-ON-8

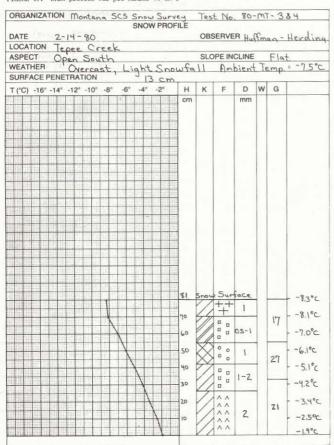


FIGURE 51. Snow profile for pit number 80-MT-3 and 4

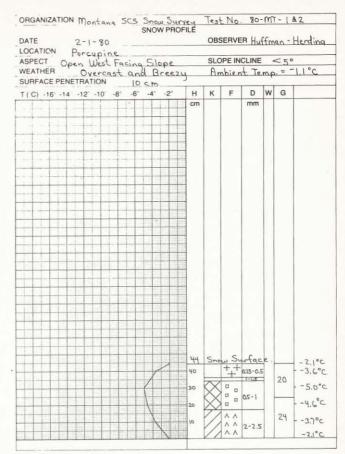


FIGURE 50. Snow profile for pit number 80-MT-1 and 2

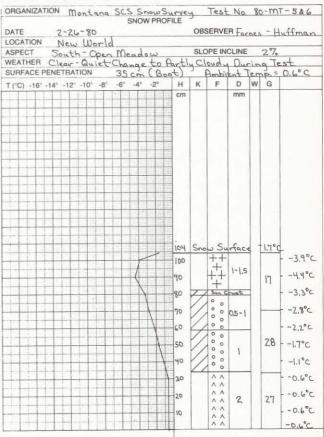


FIGURE 52. Snow profile for pit number 80-MT-5 and 6

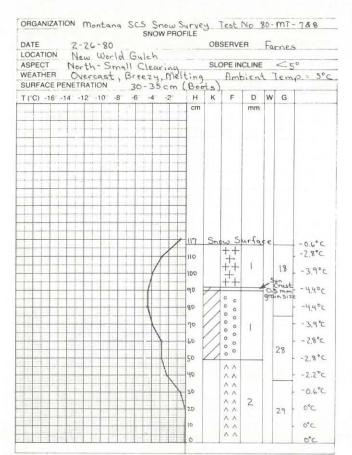


FIGURE 53. Snow profile for pit number 80-MT-7 and 8

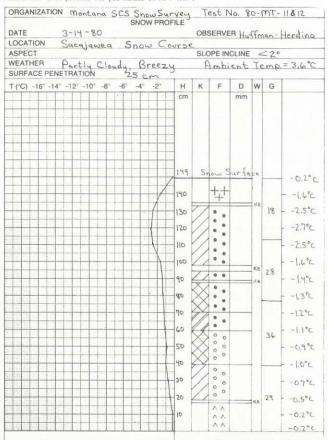


FIGURE 55. Snow profile for pit number 80-MT-11 and 12

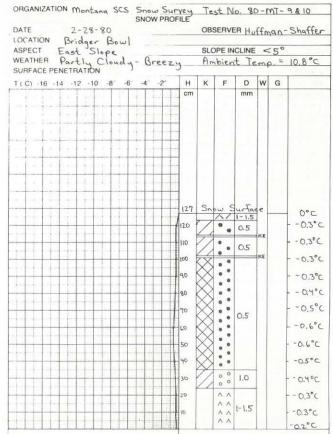


FIGURE 54. Snow profile for pit number 80-MT-9 and 10

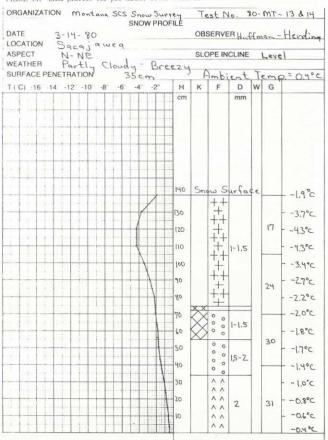


FIGURE 56. Snow profile for pit number 80-MT-13 and 14

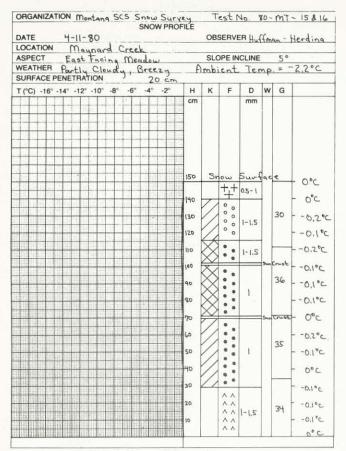


FIGURE 57. Snow profile for pit number 80-MT-15 and 16

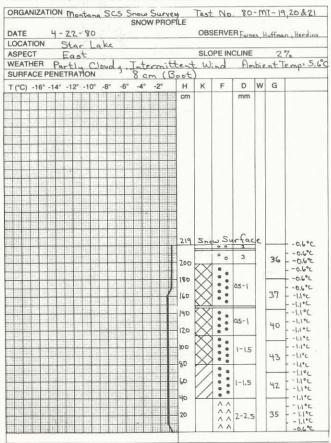


FIGURE 59. Snow profile for pit number 80-MT-19, 20 and 21

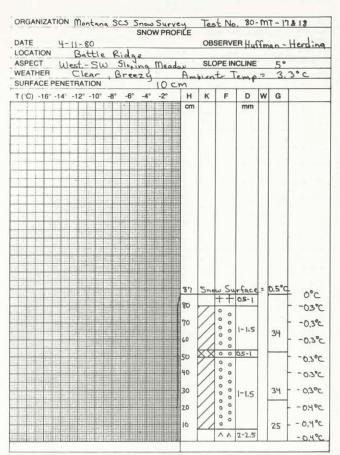


FIGURE 58. Snow profile for pit number 80-MT-17 and 18

ORG	AA	NZA	TIO	N (no	nta	na S	SCS	Sno	OW PR	OFILE	Tes	F N	5. 90) - N	T- 2	22 & 23
TAC	E		1	4-7	23-	80						OBS	SERVE	R Fare	45-	Huff	nan-Herd
OC	AT	ION		411	it	e [n:11										
SP	EC	Т		ev					N.			SLC	PEIN	CLINE			
VEA	TH	ER				. (2100	1	T	uter	mitte	+ 6	Sree-				
SUR	FA	CE				ION		-	50	m (Boot)		A.	hient	- 7	emo.	= 7.8°C
rec	21	160	14		200	-100	-8°	-6	72-73-		Н	К	F	D	w	G	1.0
1	-/	-10	-14		1	-10					cm	15		mm	**		
Н	Ħ	Н	Н		Н						- Cili						
П	П		П		Ħ									100	Н		
П			П														
Ш			Ш				Ш	Ш									
\vdash	4	+	Н	+	-		Н	Ш									
+	H		H		H		Ш				162	Sno	w Su	rface	-		0.6°C
		Ħ	Ш		Ħ						100	7	0 0	2-2.5			0°C
											150	//	• :				- 0°c
			П				Ш				130	//	: •	0,5-1			0 0
Ш	Ш		Ш		Ш						140	//				39	- 0°C
Ш		4	Н	Ш	ш		ш					(Thin	Ice La	ger			
+	-	H	Н		H		ш				(30	//	::	0.5-1			- 0°C
Н	-		Н		Н							//				-	0°C
П					I		Ш				120	//					
	Ш										110	//					- 0°C
Ш		1	Ш									//				39	
Н	-	+	Н		4						100	//				31	- 0°C
+		н	Н		H							//			П		-0.
Н			Н		Ħ						90	ŔΧ			1		- 0°c
П			Ħ									\times					- 0°C
			Ш								80	\times			П		
Ш		1	Ш		Ш						70	\times		15-2	Ш		- 0°C
Ш	ш	4	Ш	Ш	H	Ш						\times			Ш	41	
Н	-	+	Н	н	H	H					60	\otimes			Ш	11	- 0°C
Ħ			Н		Ħ							X					
П			Ħ		П						50		A A		1		- 0°C
											40		A A				- o°c
			Ш								10		A A				0.0
ш			Ш		H						30		A.A			38	- 0°C
+	H		Н										A A	2-25			
Н	H		Н		H						20		A A				- 0°C
Н			Ш		ı								^ ^				- 0°c
П			Ш		Ħ						10		^ ^			30	0.0
	111												V V				0.6°C

FIGURE 60. Snow profile for pit number 80-MT-22 and 23

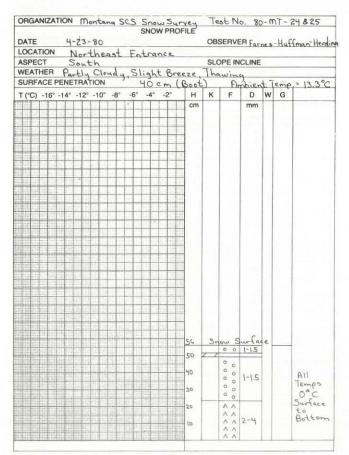


FIGURE 61. Snow profile for pit number 80-MT-24 and 25

ORGA	NIZA	TIC	N	Mo	nta	na	SC	.5	Sn	ow	S	ROF	ey	Te	st N	5. 80	- n	T-1	28 & 29
			-51	-					SI	101	N P	ROF	ILE	ODG				100	
DATE				-8		_	^	-	_		-		_	OBS	EHVE	Hege	nes	- Hu	ffman
LOCA.			W	in	yor	ا ن	20	ck	_			_	_	01.0	mare to	01 1115	-	-00	
ASPE		_	We	a.d	nu2	-	2	DF	2	u) t	0 1	-	SLU	PEIN	CLINE	_	- 6	
WEAT			P	art	lie	0	by	rd.	, ,	B	L6	220)	Δ.		-	_		
SURF		-	NET.	RAT	101	4						m		Florib		Tem			1°C
T (°C)	-16	-14	t" -	12°	-10	0 4	80	-6		4°	-2	yo .	H	K	F	D	W	G	
									Ш	L			cm			mm			
								Щ	Ш	1									
			Ш				Ш		Ш	Ш									
			4	ш			H			H	Н								
		Ш		H			H	Н	н	H									
		н	H	H			H	1	+	+	H								
						-				Н									
		Н	-	+	H		+	H		H	Н								
	Н				Н					H									
		H		+	H			H											
		н		н			Н	Н	١.	H									
		Н		H			t		т	Ħ									
		Ħ		10			t												
				Ħ		1		П		Ť									
				Т				П		T	П								
								П	П										
		П							П										
					Ш		П												
					Ш	Ш													
		Ш							Ш										1
					Ш														
					ш	910													
					Ш			Ш				ш							
					Ш														
	Ш								4	-		-							
	Ш		ш		Н		H	Н	#	+	H	Н					10	0.5	
	14	1	H	-	Н		+	\square	4	-	+		-	757		-	1		+ +0.3°C
	H	H	H	+	H	+	+			+	H	Н		X	0 0				
				+			+			+	+		50	KX	0 0				0.2°C
	H	Н		+	H		H	\mathbb{H}		+	Н			XX	0 0	1		37	
	++		H	+			+		+	+			40	X	0 0			31	0.2°C
	Н		-	+	Н		1	Н	H				1	X	0 0				0.000
			H		\Box		+		1		100		30	/ V	^ ^		1		- 0.1°C
					Н		H		1				1		^ ^				
			H				t				Ħ		20			1.5-2			- 0.2°C
							t			T	Ħ				A A	1.5-6		30	- 0.2°c
	Ħ			T.	Ħ		İ				t	111	10		A A				0.2.6
et de			ш		111		1		ш		н				A A				0.400

FIGURE 63. Snow profile for pit number 80-MT-28 and 29

Uni	JANI	LAIR) N	Ilon	ang	20	S	NO	W P	ROF	ILE		lest	No. S	50-	·mr-	26 8 27
DAT	E			28-								OB	SERVI	ERFam	85-	Haffe	nan-Heral
00	ATIC	NC	Hu	alit	e	Cr	cek	-								N.	
	PECT		N	E		-		_						ICLINE			
WE	ATHE	R	Pa	rtlu	CL	oud	4	u)as	cm		A	nbien	t Te	me	= 1	3,4°C
								-1	Bo	ot)	, H	ard	Crus	ton			
TC	C) -1	6 -1	4 -1	2 -1	0" -8	3" .	6°	-4°	-2	0	Н	K	F	D	W	G	
-			-4								cm	1		mm			
			-			-	H	+	Н								
-	14						П										
			+	-	1	4	1.	-		-							
	+			-	1-1		++	+	H	+	1						
		111		1		1											
		4	1.							4							
		-	-	-	-	-	++	+	H	-							
								1									
		1															
-						-	-	-	H					2		30	102
			1	-	-	-	1	+	H				5 wer	kice	la	ers (c	ld sun
L.					7								1	-) (11	CO	0 180	m.
	-					-	-	-	Н	4							
							Ħ	+									
									П								
				-	-	-	1	+		+			_				
						+			H		83	Sno	0 0	face 2	1		+0.7°C
											80	7	0 0	-	,		+0.3°C
						-	-	+			70	//	0 0	2			0.2°C
	+		-			-		-	H	-		/	0 0			36	
											60	/					0.2°C
	4			-		-	-		Н		50	/		1-1.5			0,3°C
	-					-		+	Н			1	0 0	2-2.5			
											40			2-2.5		22	0.5°C
											30		^ ^			32	0.2℃
Н	+			-		-	Н		Н				^ ^				
									H		20		A A	2-4			0.3℃
									Ш	Ш	10		A A			30	-0.3°C
	+			-		-	-	+	Н				100				0°C
1					لتشلينا		للنبا	illiii	HIGH	шш	-	1			_		0.0

FIGURE 62. Snow profile for pit number 80-MT-26 and 27

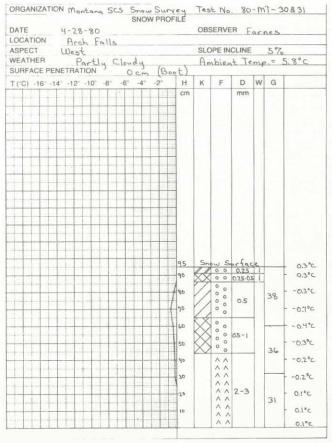


FIGURE 64. Snow profile for pit number 80-MT-30 and 31

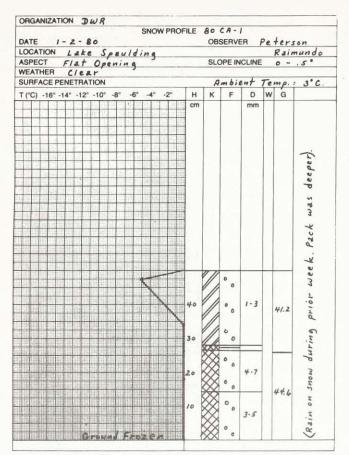


FIGURE 65. Snow profile for pit number 80-CA-1

						0.				5	SNC	W	PRO	FILE		A - 3 SERVE	D 0		.varvenas	1.
	E ATI								-	-	-	-	-		UB	SEMVE	n K	0.1		ence
	ECT		-	Me	-	J.	51	OF	1		_		_		SLC	OPE IN	CLINE	_	7 2	P
-	TH		_/	7€	a.	0 0	w		-		_	-	_	_	OLC) L 114	OLIIVL	_	- /	-
-	FAC		-	er	247	TIO	N1.	-	-	_	-	-				n	: +	-	-	
		-							-	201	-0,0			1				/		= 3°C
T (°C) -	16°	-14		12°	-10	0°	-8°	-	6°	-4		2"	Н	K	F	D	W	G	
Ш		Ш	П		L	Ш	Щ	4			Ш	1		cm			mm			
Ш	4	Н	4	4	-	Ш	щ	4	ш		4	4	44							
Н	-	Н	-		H	Н			Н	Н		+	H							
Н	н	Н	+	+	Н	Н			н		+	H	11							
Ħ		Ħ	Н		Ħ	Н					T	Ħ	Ħ							
Ш			Ш		Ħ	Ш	Ш	Ħ	Ш	Ш		T								
														7/60	-			-		
Ш		Ш	4	4		Ш	Щ	+	1	Н	4	4	1			1.1				
Ш	-	H	ш	-	H			-	-		н	+	+ /	150			1		15.2	
Н	Н	н	Н	+	н	Ш	н	+	+		н	+	1			11/			7.5.2	
Н			H	+	H	Ш	H	Ť		Ħ			Ħ	140	17	1.1	1-2			
Ħ				т	t				t	П			1		XX		-			
Ш			П		T	Ш			T				N	130	X	1//	2-4			
Ш													1	120	\times	1//	dron for		32.6	
Ш	Ш	Ш	Ш	Ш	1	Ш		4				Ш	Ш	,	44	11/	1-2			
Ш	Ш	ш	Щ	ш				-					н	110	XX	11/	1-2		-	
₩		H	ш				Н	-			н		H		77	0		1		
Ш	₩		-	-			Н	+	н	Н				100	//				40.8	
						Ш		Ш							//	100	4			
								Ť	т			Т	п	90	1/	1				
														80	11	0		1		
					Ш	Ш	Ш	Ш						0.0	1/1	0	4		39.7	
▥			Ш	Ш	Ш	Ш		Ш	Ш	Ш		Ш		70	777				31.1	
				#			Ш	4	н	H	Н				1//	0				
					н	н	Н	H	ж	H	Н	+		60	1//					
										H				H	1//	10				
							m		*	Ħ				50	1/1		2		42.0	
									Ш			H.		i	//	4				
														40	1//	10.				
														30	1	9 "				
							Ш	Ш	Ш	Ш		Щ		1		\$ 0				
						₩	Ш	ш				ш		20	X		2			-iey
															5	0	-		40.0	,
							M				H			10	XX	9 0		+		
			###				ш		ш		::::			10	NOV.	2	3			ice lay

FIGURE 67. Snow profile for pit number 80-CA-3

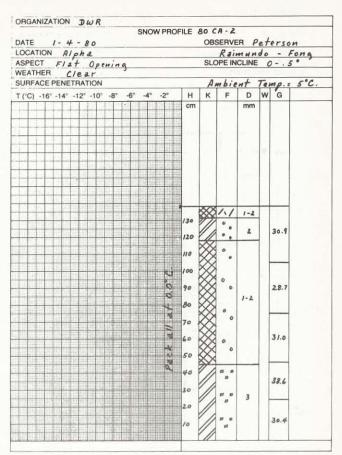


FIGURE 66. Snow profile for pit number 80-CA-2

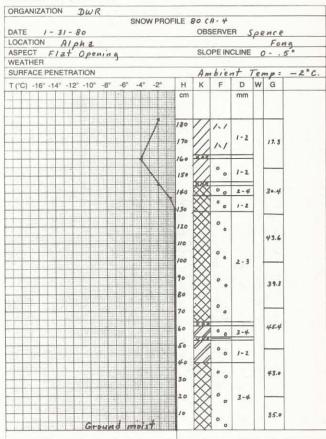


FIGURE 68. Snow profile for pit number 80-CA-4

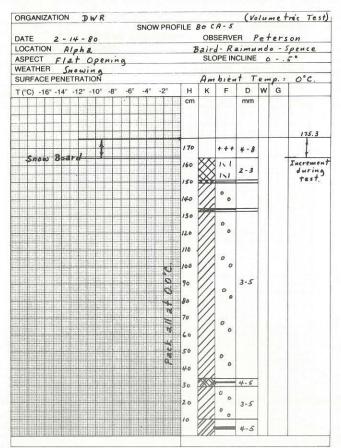


FIGURE 69. Snow profile for pit number 80-CA-5

								SN	OW	P	ROF	ILE		A - 7				
DATE								_					OBS	SERVE	R F			
LOCA	TION	- 1	Alpl	50									-			R	dim	undo
ASPE	CT	F1:	1+ (Opi	e MI	ng							SLC	PEIN	CLINE		0 -	.5°
WEAT	HER	C	63	۲.														
SURF	77770		C1011111100	11111111														
T (°C)	-16°	-14°	-12°	-10)° -	B°	-6°	-4	100	-2	0	H	K	F	D	W	G	
												cm			mm			
					Ш	Ш												
						Н				H								
				Ш														
										Н								
										H								
				Ш	Ш		Ш					260		0				
				Ш									1/1	0			25.1	
				Н							Ш	140	//				1-3-30 K	
													///	0				
												220	///	8	+ 3		26.3	
												200	1/					
		Ш		Ш					Ш		S.		//					
				₩	ш						S	180	//				36.4	
											o o		//					
											141315	160	1/				29.7	
											Ť.	140	XX		To 10	-	24.1	- Loose
		Ш											////	0	5,,991		-	ice
									Ш	Ш	7	120	11/1	0	4-5		38.5	
													R ((1) To	+6		(T.T.45)	
										Н	*	100	7/	1000				
										Ш	Ž	80	1//	0			40.5	
											4		1/1		4-5		A.	
												60	//	0				
										Ш			1/	0			43.2	
						Ш						40	***	-	+6			
												20	1//		4-5			
									П	Ш	Ш	40	111		7-3	-	46.0	

FIGURE 71. Snow profile for pit number 80-CA-7

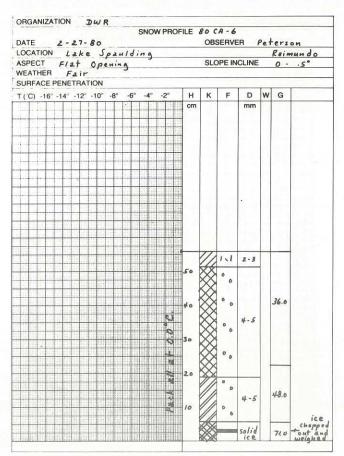


FIGURE 70. Snow profile for pit number 80-CA-6

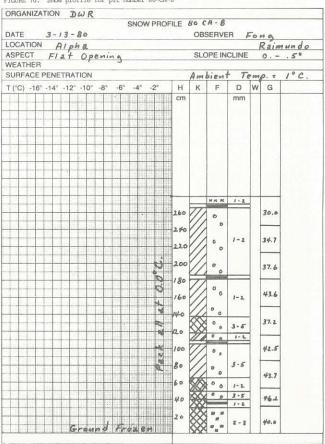
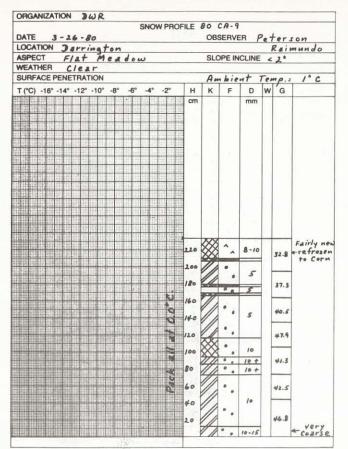


FIGURE 72. Snow profile for pit number 80-CA-8



ORGANIZATION	DWR		(7	Templ	ate Vo	lum	et	ric	Test)
		SNO	DW PROF						
DATE 5-1-	80				OBSERVE	R Pe	te	rson	1 - Fong
OCATION AI	pha			Rain	nundo.	-Spe	nce	-50	haffer
ASPECT OP	enin a				SLOPE IN	CLINE			
ASPECT OP	lear	-							
SURFACE PENE	TRATION			4	bient	Ta			13°C.
	LANGE BANK						w		,,,.
T (°C) -16° -14°	-12° -10° -8°	-6° -4'	· -2°	-	K F	D	W	G	
				cm		mm	ш		
							ш		
	-4-14-14-14-1								
									-
				170 /	1100	1.5			Two
				Z K	~	1.5	1		ice leu
	7 / 1 / 1	* * * *		160 R	X INI	.5-1	Ш	1383	
	7 1 1 1 1 1			K	XX IVI			45.1	
				150	\propto		ĪΙ		
				140 X	× .	1-1.5			
				B.					
				130 X	8011		1		1
				X	XXIVI	. 5			
				120					
				1	111			449	
				110	//	.5			
			10		111	- 1			
		7 4 4 4	100	100		1-2			
	3 1 1 1 1			4	100	1-2			
			- 12	90	10		1		
			14.	- 4	100			44.3	
			1 1	80				77.3	
				- 1	1.	a 12			
	11111		N.	70	10	1-2			
				60	//			_	
				1	// .				
			ř	50	11 0				
			9.	×	XX			47.3	
				40 0	100				
				1	// "			_	
	4444			30	// .	1			
				1	10 .				
				20 /	/			50.6	
				0	AV.	-			
				10	× 0	2+			
				1 X	0	4.1			

FIGURE 75. Snow profile for pit number 80-CA-11

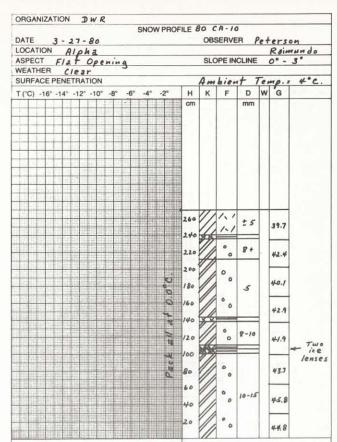
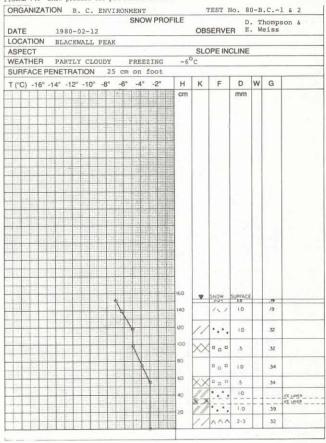
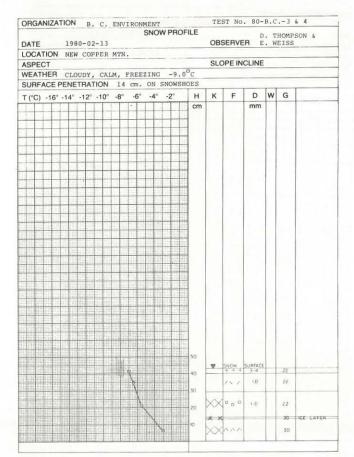


FIGURE 74. Snow profile for pit number 80-CA-10

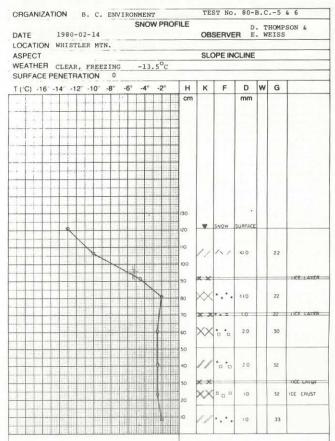


FICURE 76. Snow profile for pit number 80-BC-1 and 2



ORGA	NIZA	TION	1	В.	C.	ENV	IR	ONE	MEN	T				TI	ST No	. 80	-В.	C7	6 8
												ROF	ILE			D	Pin	HOMP	SON &
DATE												un Oyi		OBS	SERVE	R E			
LOCAT	TION	NE	WCA	STI	E F	IDC	E												
ASPE														SLC	PEIN	CLINE			
WEAT	HER	CL	EAR	, 0	ALN	, F	RE	EZI	INC	,	-8	°c							
SURFA	ACE	PENI	ETR	ATI	ON	0													
T (°C)	-16°	-14	-1	2° -	10°	-8°		6°	-4	40	-2	et .	H	K	F	D	W	G	
		Ш											cm			mm			
			4					H	Н	H		-44							
		H	Н			Н		h		Н	H								
		Ħ						Ħ											
				П		Ш	П												
						Ш													
										Ш									
								H	H	H									
				H			H	۱		Ħ	П								
						mf													
									Ш	Ш									
							ш	L	ш	H	Ш		240	1000		0000000			
				er	÷.			H	Н	H	Н			V.	D D	SURFACE		33	CRUST LAYER
					8	H		H	Н	H			220	~~~	15/	5		33	
				ď									200	XX	000	1-15		33	
					B								200	11	٠.٠.	- 5		37	
						X.		H		Ш			180	4.4					ICE LAYER
							χ			H	Н								
							- 1		H	H	H		160						
								X	Ħ	Ħ									
								ľ	X				140	11	u ^{tt} u	50		37	
						Ш			Λ				120						
									1				100						1077100
						H	Ш	H	H	1	Н		100					40	ICE LAYER
								H		Н	6			11	~^^	10		44	
								Ħ	h	Ħ			80	9.11	/3.C3/23	1.5.10		-5.4	
						Ш		Ħ		Ш			60						ICE LAYER
													60						
						Ш							40						
								H	H	H	<u>ا</u> ا			XX	000	1115		46	
				Н		Ш		\blacksquare	H	Ш	Ш		20						
						HH		Ш	14	Ш	Ш								

FIGURE 79. Snow profile for pit number 80-BC-7 and 8



Ol	RG	A٨	IIZA	TION	N	В.	. C	. 1	NV	IR					-	-		TEST	No.	ВО-В.	C	9	
ļ,											-	SNO	OW	P	HO	FI	LE		nagasion de				
							2-2			_				_		_		OBS	SERVE	H 6.	FU	KD &	D. TAPE
				NE	WC	153	LLE	RI	DG	E													
A:	SPI	EC	T															SLC	PE IN	CLINE			
W	EA	TH	ER	PA	RTI	Y	CLO	JUC	Y,	C	ALM	1					0	to +	-2°C				
SI	JRI	FA	CE	PEN	ETF	RAT	TION	V	1	5 0	cm	or	f	00	t								
Т	r°C	1	-160	-14	. 4	2"	-10	0	-8°	-(B ^a	-4	0	-2	a		н	K	F	D	W	G	
÷	1	1	10	114		-			Ť				-	Ī	Ш		cm	11		mm	-	-	
ŧ	1	Ŧ			+				+					Ħ	Ħ	Н							
t		t			+				+	17					#	Ħ							
	1	1	1		1		1	1					Ħ	П	Ħ	ı							
İ	1				UJ.				1					П	П	П							
İ					1.			T															
I									1														
1	1														Ш	Щ							
4		1			1										Ш	Ш							
4	1	4	-		1			4	-	-					Щ	Ш							
4	-	+	-		+	-		+	-	-	-				H	Н							
+	-	+	-	-	+	-		+	+		-			Н	-	Н							
ł	-	+		-	+-	-	-	-	+	+	Н			Н	-	Н							
+	+	÷	-	+	+	-			+	+					-	H							
t	1	+						1		Н	Н					Ш							
Ť	1	t							†						***		240						1
Ť					1					T	П			П	П	П	220	9		SURFACE			
				139	Ĭ.										Φ	Ш	550	11	000			33	
															*	Ш	200	66	0 0 0	5		33	
												Ш		Ш	1	Ш		199		5		33	
Ï		4						4		1			Ш	Ш		Щ	180	1	000	5		33	
4		4	-			1		-	-		1			Щ	Ţ	Щ		86	000	5		33	
4	-	+	+	-	-	-		-	-	+-	-			н	1	н	160			-			
1	+	-	+	1	-	-		+	+	+	1	H		Н	1								
+	+	-	-	-		+		+	+	-	-				1		140	11/	0 0 0	- 5		37	
		+	-	1	+	+		-	+		H	H			Н								
1	-	1	+		+	+	1				Ħ				Ħ		150	1111	000	10	+	37	
1			1			T	Ħ	T		11	Ħ				5			22	- 0 "	5		37	
T						T		T		T	T				Ħ		100	no	n n	-			
								I			П				Î		80	1	0 0	:75		.42	
															L		00	1111	000	5		3.00	
											П	Ш			F	Ш	60	111	0 "	. 9		.42	
1														Ш	L		718	1111		5		44	
4			-			-		4	4	1	H				1	Ш	40	1111		,			
1		1	-		4	-		4	4	H		Н		Ш	A								
+	-	-	-	-	-	+	-	-	+	+	+	H	Н	Ш	- 1	Ш	20	XX	٠.٠.	1.5		.44	
-		+	-	1		10	1	-	-	#	1	14		Ш	Ш	Ш				1,2400			
					1				-1		100	1111		ш	ш	1111		1	1		1		

FIGURE 80. Snow profile for pit number 80-BC-9

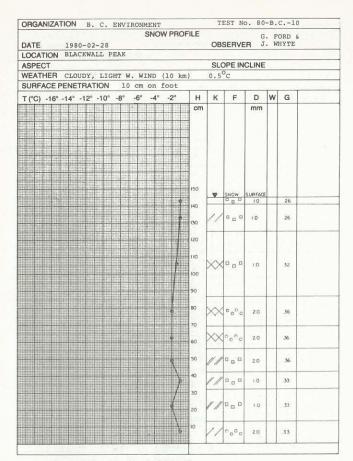


FIGURE 81. Snow profile for pit number 80-BC-10

ORGA	NIZA	TION	В.	C.	ENV	IRO	NME	INT				TE	ST NO	. 80-	B.C	12	
DATE								SNO	W F	PRO	FILE		SERVE			HYTE ORD	6
LOCA	TION	W	HIST	LER	MTN												
ASPE	CT											SLC	DPE IN	CLINE			
WEAT	HER	0	VERO	AST	, CA	LM	+	-1°c									
SURF	ACE	PEN	TRA	TIOI	V .	20	cm	on	foo	ot				Low			27.00
T (°C)	-16°	-14°	-12	° -10	° -8		6°	-4°	-2	00	Н	К	F	D	w	G	
											cm			mm			
														1000			
															1 1		
							Ш										
							ш										
							ш	Ш	ш	ш							
						Ш											
					-14												
						4											
							Ш		-		130						
												A	5NDW + + +	SURFACE	1		
				-		-	Н	-#-			120	-	7 7 7	1.0	\vdash	25	
							Ш										
										ő	110	W	151	1.0		27	
												~				3,70.0	
							ш				100	1					
											90						
						Ħ	Ħ						-				
											80						
										ф	70	//	0 11 11	10		36	
											10						
								H			60						
] 00						
											50					-	
							Ш									-	
									Ш		40	11	0 0 0	15		36	
							Ш		Ш			1	Dell's	100		1975	
			Ш					Щ	Ш		30						
			Ш						Ш								
			44	44		Ш			Ш	-	20	11	000	1.5		42	
									Ш			-	30,00				
									н		10					-	
1000 1000				11				-	Ш	•		XX	0 0 0	15		42	

FIGURE 83. Snow profile for pit number 80-BC-12

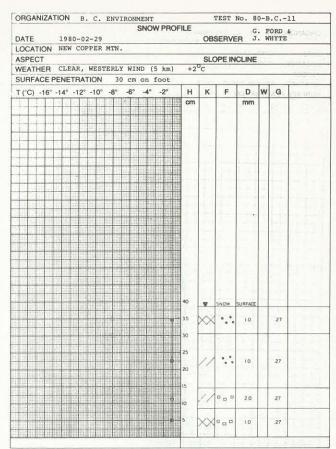


FIGURE 82. Snow profile for pit number 80-BC-11

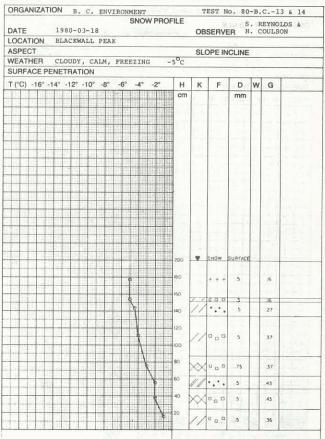


FIGURE 84. Snow profile for pit number 80-BC-13 and 14

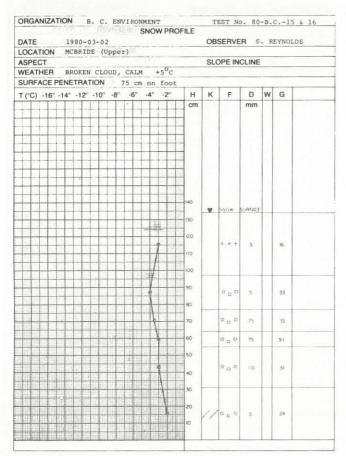


FIGURE 85. Snow profile for pit number 80-BC-15 and 16

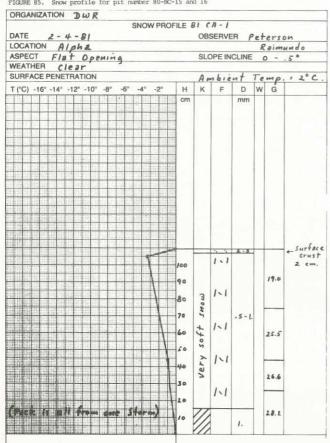


FIGURE 87. Snow profile for pit number 81-CA-1

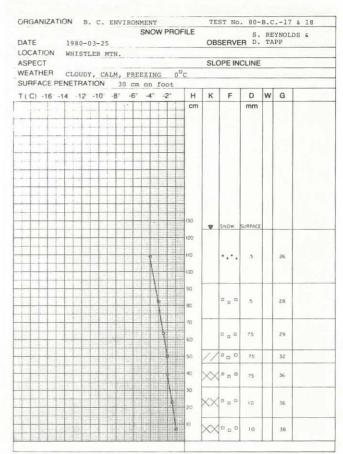
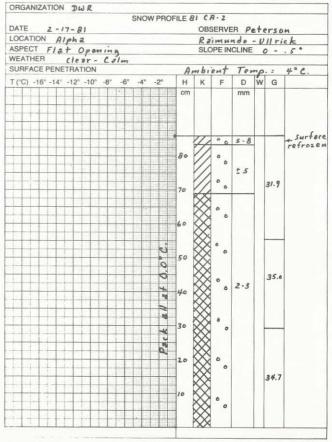


FIGURE 86. Snow profile for pit number 80-BC-17 and 18



| IGURE 88. Snow profile for pit number 81-CA-2

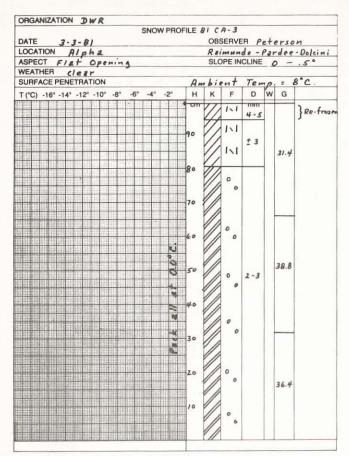


FIGURE 89. Snow profile for pit number 81-CA-3

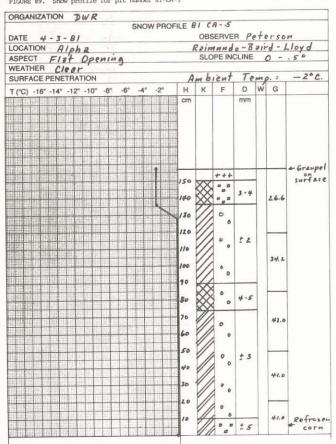


FIGURE 91. Snow profile for pit number 81-CA-5

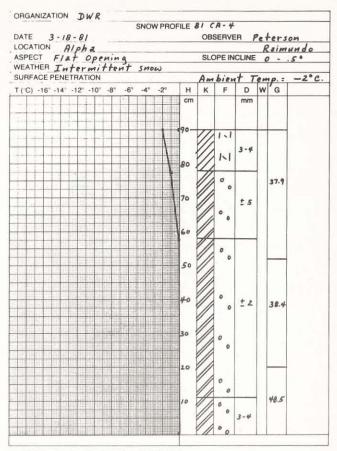


FIGURE 90. Snow profile for pit number 81-CA-4

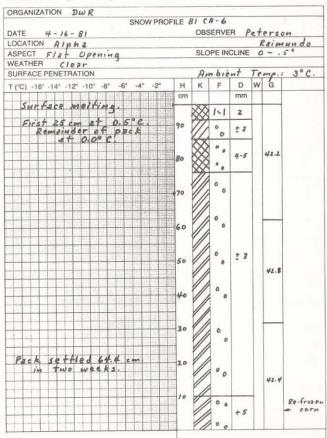


FIGURE 92. Snow profile for pit number 81-CA-6

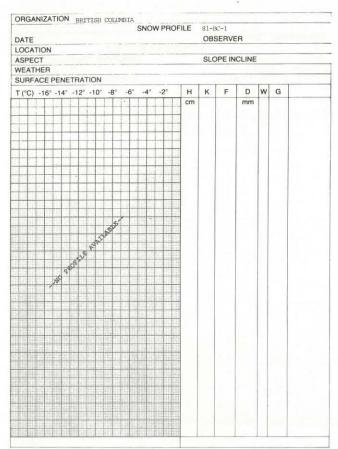


FIGURE 93. Snow profile for pit number 81-BC-1

OCCATION OTTAWA CDA MET SITE SSPECT Level SLOPE INCLINE Level VEATHER overcast, moderate wind -5t SURFACE PENETRATION If (°C) -16* -14* -12* -10* -86* -65* -46* -2* H K F D W G mm TO D D D-H SSERVER N.G. K.J.M. SLOPE INCLINE Level WEATHER overcast, moderate wind -5t SURFACE PENETRATION If (°C) -16* -14* -12* -10* -86* -65* -46* -2* H K F D W G mm TO D D D-H SSERVER N.G. K.J.M. SLOPE INCLINE Level WEATHER overcast, moderate wind -5t SURFACE PENETRATION If (°C) -16* -14* -12* -10* -86* -65* -46* -2* H K F D W G mm TO D D D-H SSERVER N.G. K.J.M. SLOPE INCLINE Level WEATHER overcast, moderate wind -5t SURFACE PENETRATION If (°C) -16* -14* -12* -10* -86* -65* -46* -2* H K F D W G mm TO D D D D D D D D D D D D D D D D D D D						tire in the	EHY	SNO	OW P	ROF	ILE			T NO.			
SEPECT level SLOPE INCLINE level												OB:	SERVE	ER II.	G. 1	11.36	
VEATHER					CDA	MET S	SITE					01.7	205 11	OL INIE			
SURFACE PENETRATION F (*C) -16* -14* -12* -10* -8* -6* -4* -2* H K F D W G Cm mm MS HS 30 30 1-2 15E 10 11-2 15E												SLC	JPE IN	CLINE	1.0	ve1	
F(C) -16* -14* -12* -10* -8* -6* -4* -2* H K F D W G							ate w	ind	-5C						-		
Cm mm HS HS DD 2-4 155 30 PJ 1-2 156 10 1-2 156 10 1-2		-	and the second second	Anna Santini	Control Manager Assessed		_	_	_	_				_		-	
HS 40 2-4 188. 30 44 1-2 188. 30 1-2 188.	(°C)	-16°	-14"	-12	-10	-8°		-4	-2	io.	Н	K	F	D	W	G	
10 CFD 1-2 15.2 15.2 15.2 15.2 15.2 15.2 15.2 15.			Ш			Ш		ш			cm			mm			
HS HO HS DD 2-H ISE DD 1-2 SS HE SS H	-	-	-	1	44	-	-			-14					Н		
HS HO JOB 2-4 JOB 1-2 JOB 1-2 JOB 1-2 JOB 1-2 JOB 1-2 JOB 1-2 JOB 1-2 JOB 1-3 JOB			H	++	++	н	-	+									
#6 #0 25 30 型 1-2 55 10 10 10 1-2		-	H		++	++	++	++									
#6 #0 95 30 型 1-2 55 10 10 10 1-2																	
#6 #0 25 30 型 1-2 55 10 10 10 1-2								111									
#6 #0 25 30 型 1-2 55 10 10 10 1-2				Ш													
#6 #0 25 30 型 1-2 55 10 10 10 1-2																	
#6 #0 25 30 型 1-2 55 10 10 10 1-2							11										
#5 #6 #6 #6 #6 #7 #8 #8 #8 #8 #8 #8 #8 #8 #8 #8 #8 #8 #8			ш			ш	44										
#6 #6 #8 30 型 I-2 25 10 2-4 10 I-2 10 I-2			-	-	++	-		+									
#5 #6 #6 #7 #6 #7 #8 #8 #8 #8 #8 #8 #8 #8 #8 #8				+		++-		+	-								
#5				-		+	++	11	+								15
#5						Ħ		11									
#5				Ш		Ħ									Ш		
#5				Ш										13.1			
HS						Ш		Ш									
#6 #6 #5 30 30 日 1-2 5 10 10 11-2 11-2 11-2 11-2 11-2 11-2 11-		1100	ш	14	444	14	44	44	4								
日 日 日 日 日 日 日 日 日 日 日 日 日 日 日 日 日 日 日						Н	-	н									
95 30 30 4 9 1-2 5 10 10 11-2 11-2 15 5						++	++	++	+	-	45						
95 30 30 4 9 1-2 5 10 10 11-2 11-2 15 5																	
30 日 1-2 15E 30 1-2 15E 50 1-2 15E						П	7	ĦŤ		T	40	111					
30 型 I-2 ICE ICE ICE ICE ICE ICE ICE ICE ICE ICE							1	Ш			25	1/	00	2-4			
30 型 1-2 1cc 20 1-2 1cc 5						1		Ш			-	6					108
5 1-2 16E			ш	ш		1	14		-	_	30	XX	nn	8.5			1,5634
5 10 1-2 16E			Ш	ш	+	$\perp \Lambda$		+	11			X	A.	1-2			
5 OD 1-2 166		-		Н.	++	-	1	-	+	-	25	00	-			_	1/5
S 1-3							1		+			1					100
s							11				90	1//		1-2			
10 S 1-2								VI			5	11					YEE.
10 s								N			2	11	-0-				
s								N			10	//	O D	1-5			
5												//					
						ш		44			5	//					
								14			5	/					

FIGURE 95. Snow profile for pit number 81-ON-1

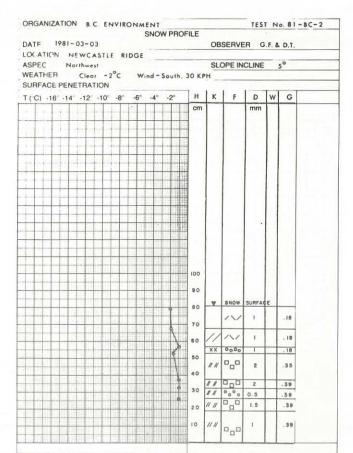
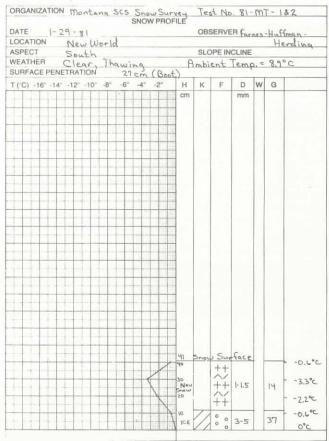
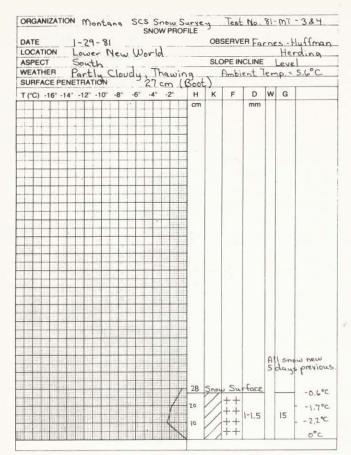


FIGURE 94. Snow profile for pit number 81-BC-2



TGURE 96. Snow profile for pit number 81-MT-1 and 2



ORGA	NIZA	TION	m	onta	inq s		SNC									748
DATE				- 25							OBS	SERVE	RHU	ffo	nen-	Herdin
OCA	TION		SI	syla	rk	T	-oui	1						10.000		
ASPE	CT		E	ter	SI	390					SLC	PE IN	CLINE		Flat	
WEAT	HER		0	verc	ast	, C	ala									
SURF	ACE	PENE	TRA	TION		1			cm							
T (°C)	100	14"	12	-10	· Po	-6°				Н	K	F	D	w	G	
1 (0)	110	-,-	11	T	TT	111	T			cm	1.5		mm		-	
				1	11		11			-						
						Ħ	Ħ							ш		
								Ų.								
							1									
-				11	1											
-		+	13	++-	1			H	Н	1						
+++			1 -			H	Ħ									
		H	11			11	††							П		
						Ħ	П									
							Ш									
		Ш	Ш				Ш	1								
	14	44	44	44		14	++	-								
				+++		++	++	+		113	Sneu	u Sur	face			-1.1°C
-	11	++-	-	++	++		+++	т	1	110		/\/				= -1:100
							11		1	100	11	0				1.7°c
			Π				Ш		I	100	11	0 0			28	1.16
			Ш						ш	90	11	0 0			20	1.7°C
		ш	ш			11			11	10	//	0 0				
			++	##		44	++	#	1	80	1/	0 0			_	-1.7°C
			H	H	++	++	++	H			1/	00				
		##	11				+		1	70	1	0		-		1.7°C
			11						1		KX				34	2
			TÍ							60	KX				3,	1.1°C
										50	XX					1.1°C
			Ш						Ш		X			-		1.1
					44		44	4	H	40	1/	0				1.1°C
		Н	+			++	+		\mathbb{H}		1/				25	1179471
			++		++	++			++	30	//	0			35	1.1°C
		ĦĦ	1 1						Ħ		//	0				
		##				11	111		Ħ	20	1/	D				1.1°C
										10	1/	0			711	1.1°C
										10	1/	0			31	1 60
			MILLED							11	1/	0				-1.1°C

FIGURE 99. Snow profile for pit number 81-MT-7 and 8

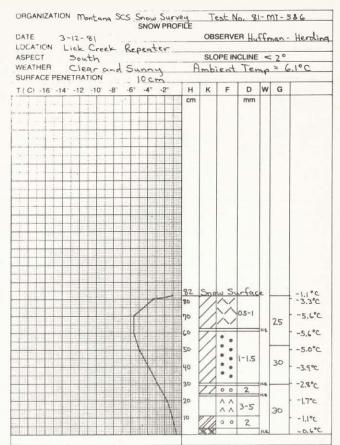


FIGURE 98. Snow profile for pit number 81-MT-5 and 6

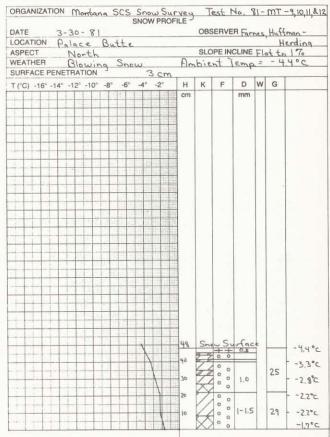
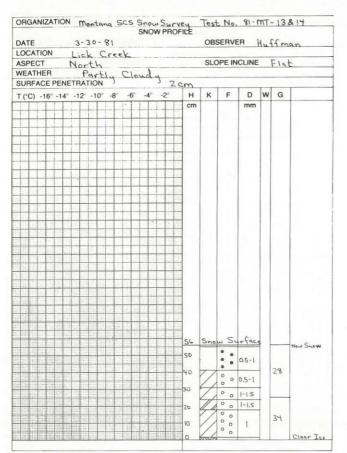


FIGURE 100. Snow profile for pit number 81-MT-9, 10, 11 and 12



ORGA	ANI	ZA	TIOI	V	0	Non	tav	na	S	CS S	S	NO NO	PF	S	ILE	4	Test	No.	81-	mT	81871-
DATE				3	-3	1 - 5	18									OB	SERVE	R For	nes	Huff	man, Herdina
OCA	TIC	N			A	rch	F	al	13												,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
ASPE	CT					w		100	-							SLC	OPE IN	CLINE	4	72	0
NEA1	THE	R		Pa.	rtl	4 (-10	u	lu	1	B	re	22	7		Amb	ient	Tem	٥. =	1.	1°C
SURF	AC	EF	EN	ETF	RAT	LIDN				c				1							
T (°C)	-1	6°	-14	-1	2°	-10		8°	-6	30	-4		2°		Н	K	F	D	W	G	
H	П			П			П	П		П	П	T	П	П	cm			mm			
										Ш	Ш		L								
				4			Ш	Н		4	4	1	1								
	H			+			H	H	Н	-	+	+	+	H							
	Н			H	Н		H	H	H	H	H	H	H								
							Ħ	Ħ	П	T	Ť	Ħ	t								
												I									
							L					I	П	П							
	Ш				H		H	H		4	4		+	H							
	H			H	H		H	H	H				H								
								f		Ħ	Ħ	H	t								
							t	l		Ħ		T	t	Ħ							
											Ш		I								
	ш						L	Ш		4	4	4	4		120	Sno	w S	erfac	4		-1.7%
							H	H		Н		H	1	Н			+,+				
							۳	H					A	H	110		++	0.5			2.2°C
												1			100	× ×	11. 11	1-5		ICE	2.8%
												I	I		100	//	11	0.5-1			2.6 C
							L			ш		1	4		90	XX		3-5	1	ICE	2.8°C
			н		H		H	H		H		11		H		41	/\/	0.5-1			
							Н	H		н	+	H	1	Н	80	7		3-5		ICE	2.2°c
							Ħ	П			Ħ			Ħ	200	//		0.5-1	3	-5	2.020
										П			1		70	X		-		ICE	2.2°C
												1	V		60	X	0 0				1,7°C
								H		H	+	+	-11	H	1	X	0 0	1-1.5			PACLES
					H		H	H	Н	H	H	H	H	H	50	SS	0 0	1,000			1,7°C
													ı	Ħ		V	^ ^		1		120
													Ш	I	40		^ ^				-1.7°C
										∭			Ш		30		A A				1.7°c
					Н					H		Ш	I				^ ^	100			1110
					H		H	H	H	H		Ш	Ш	H	20		A A	1.5-2			1.7°c
								H		H			ı				A A				
										Ш			ı		10		A A				1.7°C
								Ш		Ш		Ш	П				VV				-1,7°C

FIGURE 103. Snow profile for pit number 81-MT-17 and 18

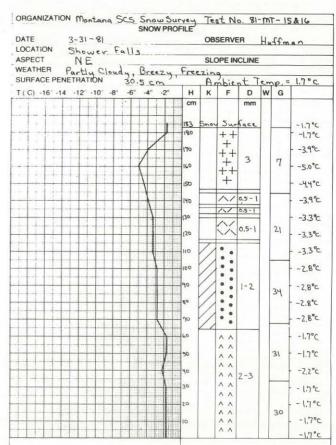


FIGURE 102. Snow profile for pit number 81-MT-15 and 16

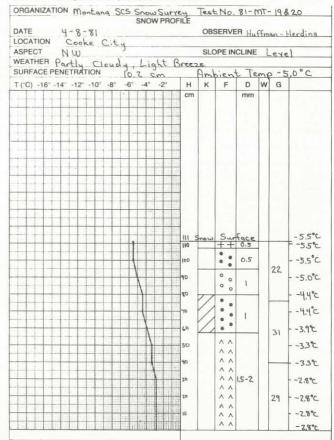


FIGURE 104. Snow profile for pit number 81-MT-19 and 20

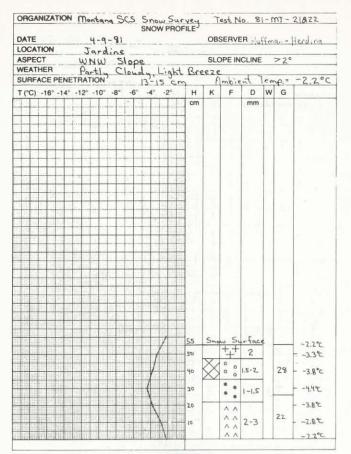


FIGURE 105. Snow profile for pit number 81-MT-21 and 22

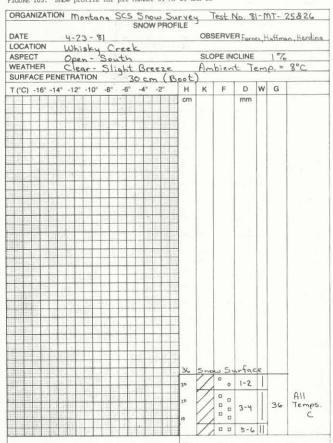


FIGURE 107. Snow profile for pit number 81-MT- 25 and 26

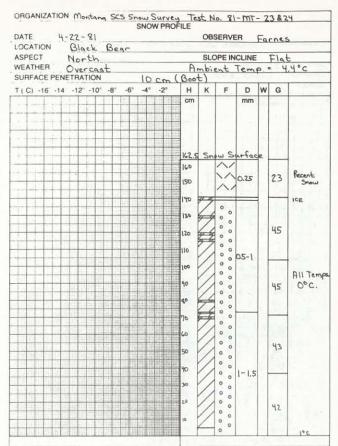


FIGURE 106. Snow profile for pit number 81-MT-23 and 24

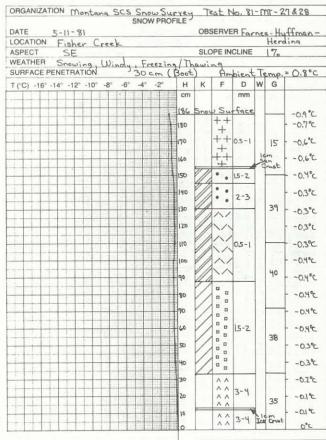


FIGURE 108. Snow profile for pit number 81-MT-27 and 28

DA.	-					-81								OBS	SERVE	R	uf.	fma	n.
_	CAT PEC	TION		C	00	ke	P	25	5_	_				01.0		CLINE			
			_		_	-	2019		-			_	0 1					12	00
SI JI	RE/	HER	PENI	FTI	RA	LION	ee	214	9,1	30	III)	Hml	DIEN	1 16	mp.		. 0.	0 (
_	-	-16°			_	-		90		-4°			н	К	F	D	w	G	
1		-10	-14	·	1	-10	-(- 1	1		<u>с</u>	cm	K	F	mm	44	G	
				t	ħ								1			- Tanta	П		
																	П		
					-						1						Н		
H					H		+			Н									
Ħ				t							t						П		
						Ш													
				H	H														
																	П		
				Н	Н														
													-	25	+				
H													10	p 35	t cm				
													Ke	wox	eato				
													T,	(50)	SHOP	3			
													Do.			(f)			
													170	Sno	w 5	erfac	e .	_	-0.2°C
															0 0				0.000
													60		0 0				0.3°C
													50		0 0	1-2		38	-0.3°C
															0			30	
H													40		0 0				0.3℃
														,	0				0.3%
													30	//	^ ^				-0.50
													20	//	A A				- 0.2°C
														//	A A	2-4		38	1.37
H													10	//	^ ^	- 1			0.32
Ш														//	11.0				-0.2°C

FIGURE 109. Snow profile for pit number 81-MT-29 and 30

DATE									SN	IOV	VF	PRO	OF	ILE		N-1 ar				
OCATI	ON																			
ASPEC	Т														SLO	PE IN	CLINE	ų.		
WEATH	ER														-					
SURFA	CE PE	ENE	TRA	ATI	ON															
T (°C) -	16° -	14°	-12	۰.	10°	-1	B°	-6		4°	-1	20		н	K	F	D	w	G	
TÌT T		П	П		П			H						cm			mm			
																	tvictors	П		
		Н	Ш	Ш	Ш	II.	Ш	Ш		Ш	Ш	Ш								
			Н	ш	н	H	H	ш		H	Ш	Н	Ш							
					H	H	Н													
					t	Ħ	Ħ													
															- 1					
					H		H		Ш											
						H	Н	Н										Н		
							H													
							r													
			Ш	Ш	Ш	3		Ш					Щ							
					43	Ý.	H													
				4		H	Н	Н	H											
			38						Ш											
		J.C	٢																	
	وال	Ť	Ш	Ш				Ш												
	/Y							Н												
		H	Н		Н	H	Н	Н	+	Н	Н	Н	Н							
				Т									Ħ							
			Ш																	
		H	Н	+	H		Н	-	+	Н			+	1						
		H	Н	+		H				Н			Н							
		Ħ		+					Ш											
		I							Ħ											
			Ш					Ш												
		H	Ш	4	1			Щ.			Ш									
		H	Н	-	+	H	Н	-	+	Н		-	-							
		H		+	-			-	-				Н							

FIGURE 111. Snow profile for pit number 82-ON-1 and 2

ORGANIZ	AT						9	S	CS	5 5	SM	VC	V P	Sur	TILE	Te	st N	0. 8	1-1	nT-	31 & 32
DATE		5					-	_				_				OB	SERVE	ER H	ut	tmar	
LOCATION	1						S	t	te	i	on										
ASPECT			30	ut	ch											SLO	OPE IN	CLINE	F	-lat	
WEATHER		- 5	in	0	vis	24	-	F	e	22	in	9	-	BI	owi	09	Am	bien	EJ	emo	0. = 0.7
SURFACE	P	ENE	TF	RA'	TIO	M			1:	5 0	20	3	(Bo	ot))				,	
T (°C) -16		14"	-1	2°	-1	0°	-8	0	-6	s°	-4	0	-2	ю	н	K	F	D	w	G	
		T	Г	Г			T		•		П				cm			mm			
	4						1						Ш			1					
	4	-	-	-		-	-	-	-	-	-	4									
	+	-	-	-	-	111		-	-	-	4										
	+	+	-	-			-	-	-	-	Н										
	+	+	1	-							+										
	T						1	7			Ħ	Ħ									
		1																			
	Ι									П									Ш		
	1						4	4		П				Ш					П		
	+	-	-	H	Н			4	-	4	Щ	Щ		Ш					Ш		
++++	+	+	-	H	Н		+	+	+	H	Н								П		
+++++	+	+	-	Н	Н		+	+		7	-	Ħ							П		
****	+	+		H				1		Ħ	Ħ	Ħ			100	_	0	face			
	T						П	П	П	П	П			1	108	200		Tace	1	_	0.800
							Ш								lab	1/	++				0.7%
							Ш	4						- 1	iw	//	+	1			-0.7 0
	4	1		Ш			4	Ц		Щ	Щ	Щ			90	1/	++	1		23	0.4%
	+	+		Н	Н	-	-	-4	-	щ	Н	Н				1/	1+			45	
	+	+	H	Н	Н		+	+	-	H	Н	H			80	K	0		1		0.4%
***	t	۰	Н	Н			Ħ	Ħ	7	Н		Ħ				X	0	1-2	ш		
	Ť		П	Т	П			Ħ	П	Ħ	Ш	П			70	X	0		1		0.3°C
	T							Ш		Ш	Ш		H		60	XX					0.3%
		П	П							Ш					100	KX		0.5 -1			-0.50
	Ш	Ш	ш	Ш	Ш		Ш	Щ	Ш	Ш	Щ		Ш	ш	50	KX	: 0	0,0	Ш	38	azec
										Ш	Ш			Ш		V	27/				arc
	Ш	4		H	Ш		ш	Ш	Ш	Щ	Щ	Ш	Ш	Ш	40		00	1.5-2			0.2°c
		+	H	Н					Ш	Ш	Ш	Ш	Ш	Ш			0 0				1150000000
			H	H	H				Ш	₩	H	\mathbb{H}	\mathbb{H}		30		A A				0.2%
	H		H	H						H	H		H	Ш			A A				177.027
	Ť	Ħ	Ħ	m					m	m			Ш		20		A.A	2-3		36	0,2°C
			П	П						Ш					I		AA	6. 3		-	0.2°c
		Ш	П												ю		A A				
		Ш	Ш						Ш		Ш	Ш	Ш	ШШ			V V				-01°C

FIGURE 110. Snow profile for pit number 81-MT-31 and 32

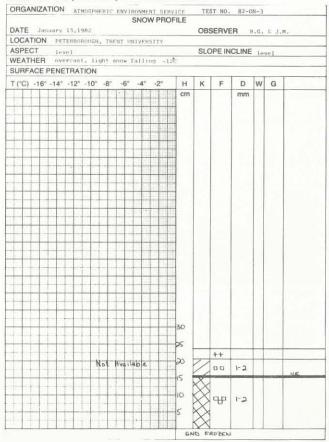


FIGURE 112. Snow profile for pit number 82-ON-3

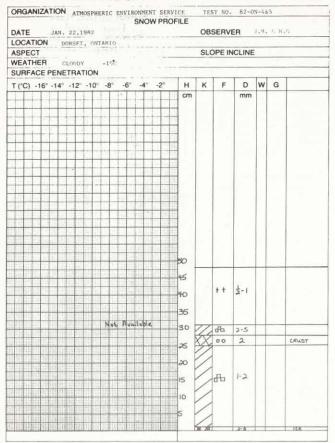


FIGURE 113. Snow profile for pit number 82-ON-4 and 5

								SNO					TEST NO				
)	ATE	Fel	ouary	10,1	982							OB	SERVE	R B	tea:	6 J.M	
		-	LUTH														
			lev									SLC	OPE IN	CLINE	1	evel	
					verci	int.	-1:0:										
					TION		-										
-	_	_				-	-6°	-4"	-2		н	K	F	D	w	G	
1	(-0)	-16	-14	-12	-10	-6	1-1		11		cm	K	-	mm	**	u	
+	-	-	-		-	H	++		H		Citi			10100			
+	+	-	-			-	++								Н		
Ħ				Ħ		Ħ			П	ш							
İ																	
									Н								
					11	-		-	Н								
4		-	-	++-		++	++	++-	+								
Н			-	++-	++-	-	++	-	+	-							
Н	#	H				++		**	11						П		
Ħ				11		11			Ħ								
						П			П				-				
		Ш				Ш					55						
Ш	ш.	ш		44		++	+++	44	+	-		-	-	-		_	
Щ	ш		-			+		-	++	-	50						
H	ш		-	+	++	++	++	++	++				++	5-1			
H		-	++	+	++	++	++		+	-	45						
Ħ	1					Ħ	11	11	Ħ		1						
Ħ		Ħ			TT	П			П		40						coust
Ħ			Ш								35		ф	1	1		
I											133	-	100		\vdash	-	New
		Ш			Ш		11		Ш		30	//	00	2.5			HVY
		ш					-	1		4		/	1				-
		ш	##	++	-	+.}	++		+	-	25						
					++-	No	t A	en it he	ria-				2	1			
H	Ш	-									20			,			
H									H		-						
Ħ					ĦĦ	Ħ					15	-	-			-	
ı											10	//	100				
											I'G	//	1.0	3			
											5	1	1				
									100			/		+			

FIGURE 115. Snow profile for pit number 82-ON-8

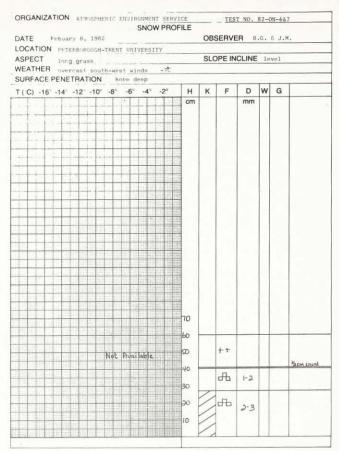
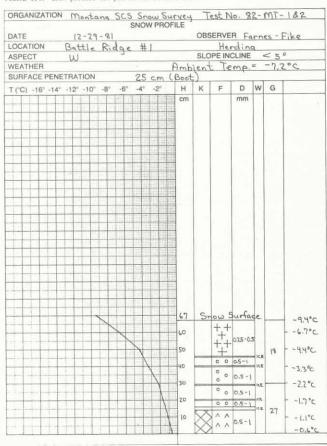


FIGURE 114. Snow profile for pit number 82-ON-6 and 7



FRERE 116. Snow profile for pit number 82-MT-1 and 3

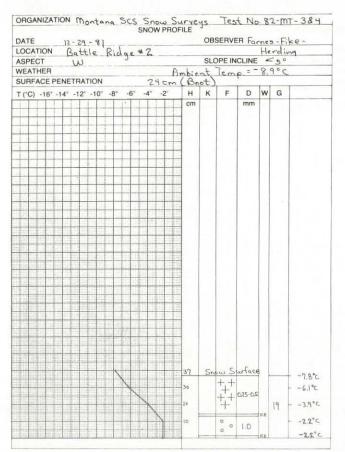
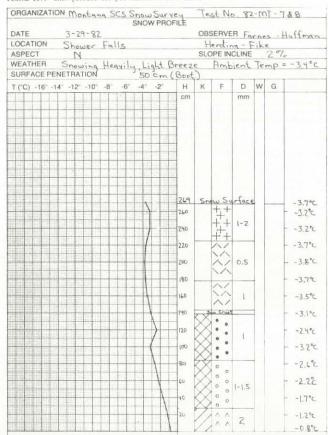


FIGURE 117. Snow profile for pit number 82-MT-3 and 4



PIGURE 119. Snow profile for pit number 82-MT-7 and We

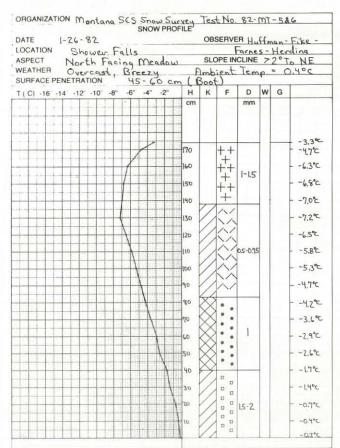
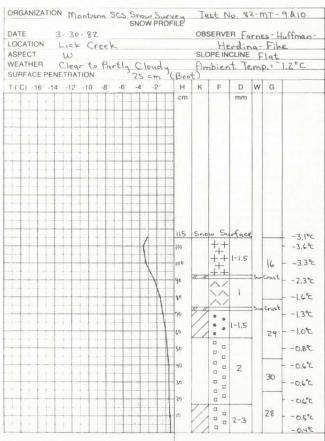


FIGURE 118. Snow profile for pit number 82-MT-5 and 6



CHOURT 120. Snew profile for pit number 82-MT-9 and 10

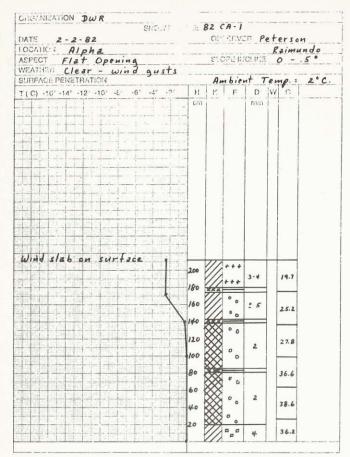


FIGURE 121. Snow profile for pit number 82-CA-1

SNOW.	IOFIL	E 8					,	
DATE 2-25-82								- Robi
LOCATION Alpha			No	ende	ck-1	Yer	a/-B	ergland
ASPECT Flat Opening			SLO	PE IIV	CLINE	0	= .	5°
WEATHER Clear								
SURFACE PENETRATION		6	mb	ient	Te	101	p. :	7°C.
T (°C) -16° -14° -12° -10° -8° -6° -4° -2	2°	н	K	F	D	W	G	
		cm			man		-	
			1					
	Tall B							
							. 1	
	-		11	+++				
	- 1	50	1//		± 1			
	-		5	+++				
	- 1	40	××		_	-	39.2	
			///	0			37.2	
	1	130	1//	0				
	1	,	1//					
	-	20	///					
		110	///					
	~	10	1//	0				
	0 1	00	11/	0	2 - 3		35.5	
		00	1//		2.3			
	0	90	1//					
	43 44 11		///	0 6			_	
	+	80	1//					
	destroit.	2000	1//					
	3	70	1//	0		100	44.7	
	M		///	0				
	9	60	11					
	U		1//			1		
	Pack	50	///	0				
			11	D		-		
		40	XX	0			45.0	
			$\times\!\!\times$	00	+ 5			
		30		00		1		
Ground wet. This test		20	XX	0		-		
			XXX			1		
followed 2 rain on snow	1	10		0	+ 5		39.2	
event on 2-15/17-82	LIL			0				

FIGURE 123. Snow profile for pit number 82-CA-3

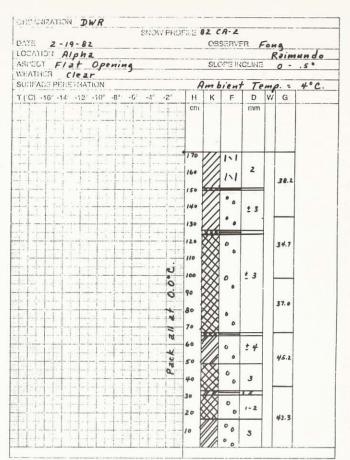


FIGURE 122. Snow profile for pit number 82-CA-2

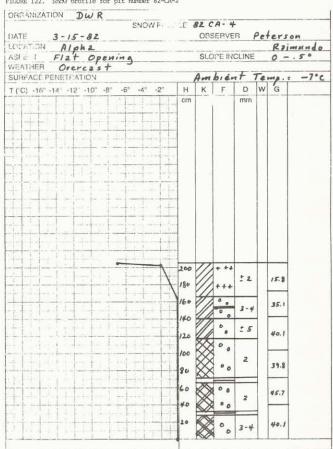
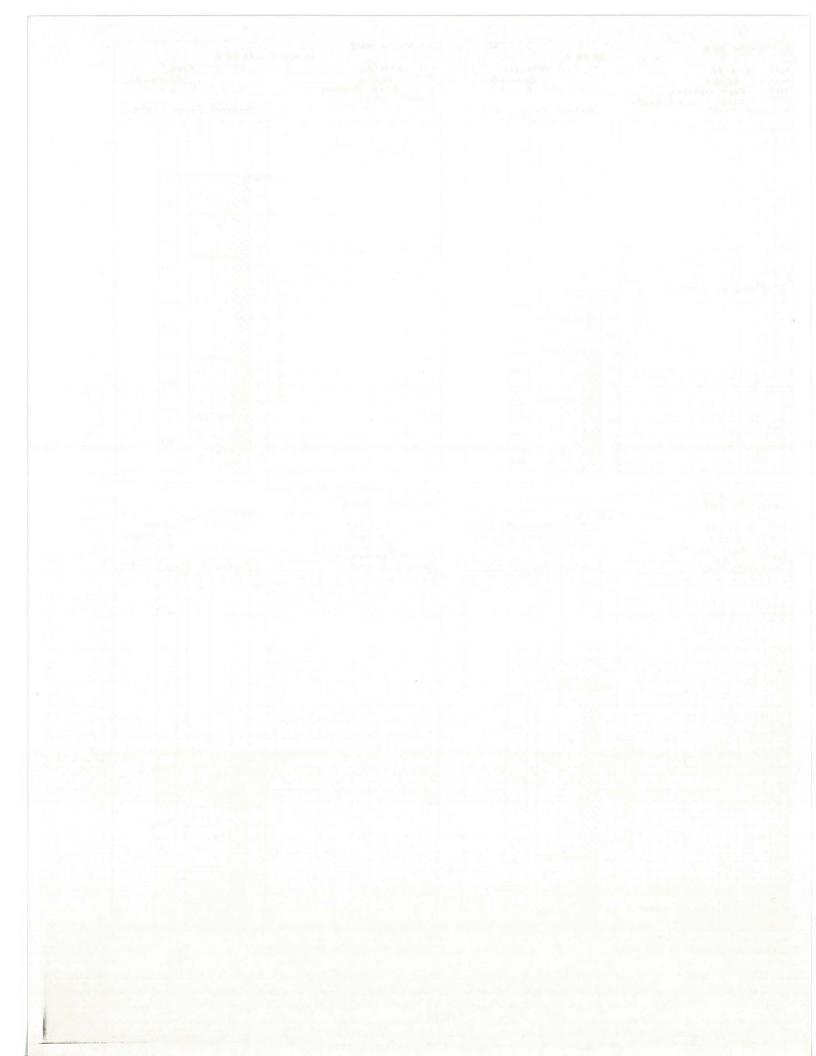
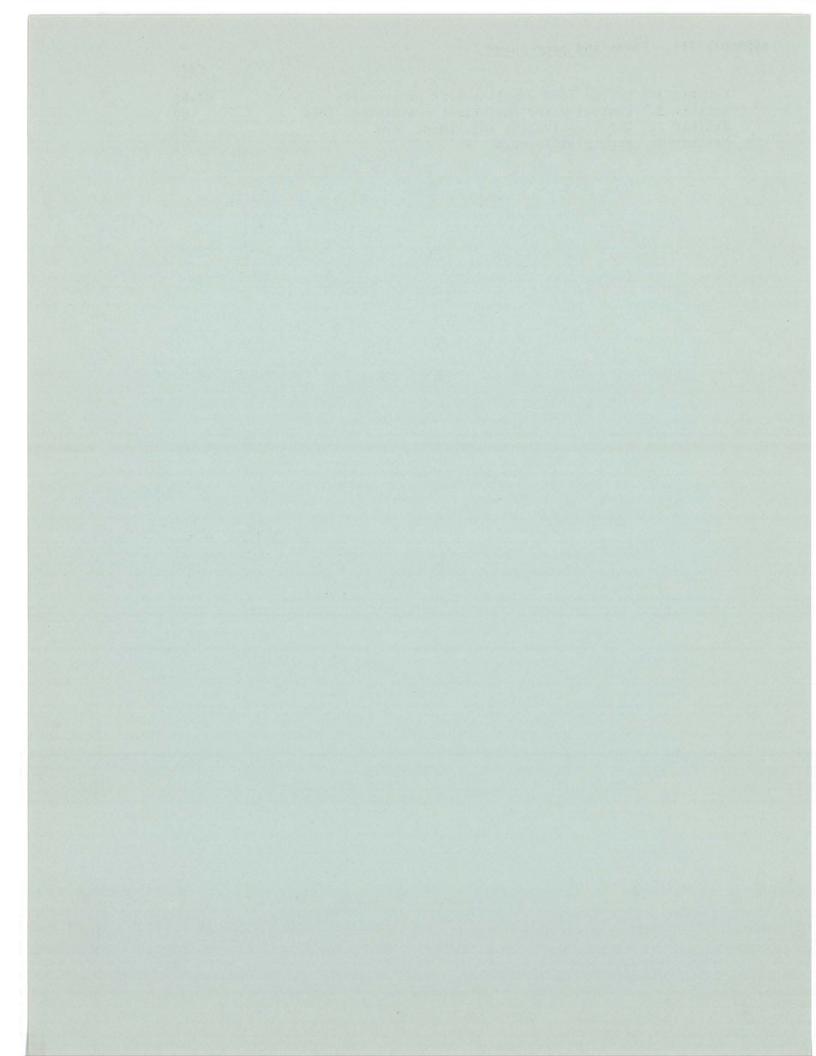


FIGURE 124. Snow profile for pit number 82-CA-4



APPENDIX III. Forms and procedures

-		Page
Exhibit 1. Exhibit 2.	Metric snow sampling test proecedures Control water equivalent measurement form	87-88 89
Exhibit 3. Exhibit 4.	Water equivalent adjustment form Snow profile form	90 91



I EQUIPMENT NEEDED

- Metal clipboard with:
 Snow Profile Chart
 Millimeter Grid
 Glacier Sampling Sheet
 Water Equivalent Adjustment Chart
- Single beam balance and weights
- 2 °C thermometers (1 digital)
- 2 Plastic buckets
- Centimeter tape measures
- Snow saw

- Metric snow sample set:
 Standard Federal cutter
 Sharpened Federal cutter
 Metric cutter
 Glacier Sampler and plate
 Other cutters to be tested
- Aluminum scoop shovel
- Tarp
- 10x hand lense

II NOTES ON PROCEDURE

- A Samples are taken along the wall of a trench dug down through the entire snow profile to the ground surface.
- B Temperature profile and glacier sampling must be done along a wall shaded from the sun.
- C If profile will be deeper than 150 cm, sampling should be carried out in 150 cm steps to prevent external interference with exposed snowpack.
- D Always wear gloves when handling the equipment.
- E Depths are recorded in cm in Column H.
- F Temperatures are recorded in $^{\circ}\text{C}$, Graph T. Temperatures are taken at intervals ranging from 10-15 cm depending on snow conditions and depth. Note air temperature.

III ADDITIONAL NOTATIONS

- A Surface condition note depth you sink in while standing. Also note crystal surface roughness (i.e., smooth, rippled, pitted or gullied).
- B Crystal shape is identified in Column F for each layer using the millimeter grid and recorded in Column D.

Feature	Units	Symbol		Subc	lassificati	on	
			а	b	C	d	е
Grain Shape		F	+++ New snow, Close to F1-F7 ¹	/\/ Often felt- like. Partly settled ²	Granular, Rounded without/ with melting ³	Granular, With facets, full cry- stals ¹	Depth hoar. Cup shaped 5
Grain Size	mm	D	0.5 very fine	0.5-1 Fine	1-2 Medium	2-4 Coarse	4 Very Coarse

- 1. Unchanged new snow crystals according to F1 to F7 of table 'Type of Particles' above or slightly transformed crystals. Original shape will be recognizable.
- 2. Crystals in advanced transformation (destructive and/or constructive metamorphism), but elements of original new snow crystals are still recognizable. Symbol for b may be mixed with type a, c or d to characterize intermediate states. Snow of type b often has a felt-like structure.

- 3. Rounded, often elongated grains formed in prevailing destructive metamorphism without melting are marked with full dots. They are usually in the size range below medium. Melting and refreezing produces characteristic rounded grains with strong bonds. They are symbolized with open circles. Grain size usually ranges from medium upward.
- 4. Usually only parts of the surface of a crystal of this type are developed as even glittering facets. Often rounded grains or cup-shaped elements are intermixed. Combined symbols of a with b, c and e are possible.
- 5. Depth hoar does not necessarily imply fully developed cup-shaped crystals. Usually only fragments of cups characterized by re-entrant angles and peculiar ledges are found (for combination of symbols see note 4).
- C. Snow hardness determined for each layer and recorded in Column K.

Feature	Units	Symbol		Subcla	assification	n	0.740 1.75
reacure	UIILS	Symbol	а	Ъ	С	d	e
Strength hardness ⁶	kp cm ⁻² kp	K R	Very	Soft	Medium	Hard	Very Hard

6. The subdivision of strength and hardness is based on the Ram hardness (4 cm diameter cone-penetrometer with 60° apex) and the following rough correlation:

	Ramsonde 4 cm diam. R (kp)	Hand Test	Shear Strength (Cohesion) K ₁ (g cm ⁻¹)
a Very soft	0-2	Fist	0-10
b Soft	2-15	4 fingers	10-75
c Medium	15-20	1 finger	75-250
d Hard	50-100	Pencil	250-500
e Very hard	> 100	Knife	> 500

The hand test indicates the object which can be pushed in the snow with a pressure of about 5 kp up to the upper limit of the given hardness class. (Unit kp stands for kg weight.)

D. Free water content is determined by gently squeezing a sample of snow in a gloved hand and observing the reaction. Free water content is recorded in Column W.

Fasture	Unita	Cremb o 1		Subc	lassifica	ation	
Feature	Units	Symbol Symbol	а	Ъ	С	d	е
Free water	%	W					
Note			Dry*	Moist	Wet	Very Wet	Slush

^{*}Note - snow with a temperature below 0°C can only be dry.

E. Density is obtained from the glacier sampler and recorded in Column G.

Sheet / of /

WESTERN SNOW CONFERENCE CONTROL WATER EQUIVALENT MEASUREMENT (Glacier Method)

SAMPLIN	G LOCATION	LEW WOR	LD Lowe	R SE	DATE _ 2 - 20	79
					ELEV/98	80
SAMPLER	: NUMBER Mo	NTANA	DIAMETER	/02	mm AREA 81.8	87 cm ²
CORE NUMBER	LENGTH (cm)	GROSS WEIGHT (g)	TARE WEIGHT (g)	NET WEIGHT (g)	$W.E. = \frac{WEIGHT}{AREA}$ (cm)	DENSITY (%) $= \frac{W.E.}{LENGTH}$
1	37.6	838.9	167.5	671.4	8.2	22
2	32.9	985.3		817.8	10.0	30
3	32.4	1070.9		903.4	11.0	34
4	36.1	1049.4	167.5	881.9	10.8	30
				NO.		
	Cum. Length				Total W.E.	Mean Density
	= <u>139.0</u> Total Meas.				= 40.0	Total W.E. Total depth
	= 139.4					= 29

REMARKS:

WESTERN SNOW CONFERENCE WATER EQUIVALENT ADJUSTMENT

Sampling Location NEW WORLD LOWER SE Date 2-26-79 Sampler Type 1979 METRIC

11		2	3	4	5	62	71	8	9
Glacier Sampler Results:	Sample Number	Test Sample Depth (cm)	Test Sample W.E. (cm)	Depth Adjustment Factor (1A)+(2)	W.E. Corrected for depth (cm) (4)x(3)	W.E. Corrected for cutter area	Test Sample W.E. Error (cm) (6)-(1B)	Percent W.E. Error (7):(1B)	Density (6)+(1)
1A Total	,	140	42	. 99	41.6	46.6			34
Measured = /39	2	/38	41	1.01	41.4	46.4			33
1B W.E. (cm)	3	137	41	1,01	41.4	46.4			33
= 40.0	4	135	38	1.03	39./	43.8			32
1C Density (%)	5	135	38	1.03	39.1	43.8			32
= 29						227.0			
						Maar	Mean ³ =	Mean ⁴ =	Mean ⁵
						Mean = 45.4	+ 5,4	+ 13.5	33

¹ Glacier sampler results assumed to be true water equivalent

² Correction factor = $\frac{\text{Standard Cutter Area}}{\text{Test Cutter Area}} = \frac{1.12}{\text{Correction factor}}$

Mean of (6) - Glacier W.E. (1B)

Mean of (7) ÷ Glacier W.E. (1B)

Mean of (6) ÷ Glacier depth (1A)

0	R	GΑ	N	ZA	TI	10	1		S	CS	5										TANA	Δ.		701		
_					_			-	lo.						SN	0	W	PR	OF	ILE						W W
-							26				-										OB	SERVE	ER Hu	FF	MAN-	- HERDINA
LOCATION NEW WORLD						_																				
ASPECT OPEN SLOPE						_									SLOPE INCLINE /-2°											
															BEGINING AIR Temp = + 0.3°C ENDING AIR + 3.1°C											
	SURFACE PENETRATION 5cm Boot T (°C) -16° -14° -12° -10° -8° -6° -4° -2°												ENDI	NG P	1/4 +	1										
Т	(°	C)		16°	-1	4		12°	-	10°	· _	8°	-	6°	-4	4°	-	2°		Н	K	F	D	W	G	
													1							cm			mm			
						H																				
																				_						
																				-						
-																										
+						H																				
İ																				129	SNOW	SURFA	ACE	oc.		00
1																		/	ø	707	311000	+ +		06		8°c
																	/	1		/30		++	2			- 3.6°c
															1	/				730		++				
															/					120	7	0 0	-	1	22	-5.0°C
																					//					
																				110			12-2			-5.0°C
															1						//					-4.4°C
															Ì					100	X	0		1 1		- 4.16
																				90	X					-3.6°c
																1				90	\times	0			30	
																				80	(X)					- 3.1°C
																					\times					6.50
																	1			70	$\langle \rangle$	0 0	2-22			-2.5°C
-																	1			15	X	0 0				-220
																				60	\times				2.4	-2.2°C
																				50	$\times\rangle$				34	-1.9°C
																		A		50	X					
																		X		40	1	A A				-1.6°C
																					//	^				
																				30	//	^				-1.1°c
																				20	/	^ ^	1 2-2/2			- 0.8 °C
																			M	20	//	^ ^			30	
																			A	10	//	^ ^				- 0.3°C
																			1		/'>	^^				o°c
il	Ш	iiiii			Ш		Ш			iliii	Ш	Ш			Hiii		Ш		Ш			/-		Ш		00

APPENDIX IV. Photographs of snow sampling procedures and equipment

			Page
Α.	Figures 125 - 133	Snow sampling procedures	95-97
В.	Figures 134 - 144	Large-diameter samplers	98-100
C.	Figures 145 - 158	Small-diameter samplers	101-104
D.	Figures 159 - 162	Weighing scales and couplings	105
E.	Figure 163	Volumetric snow pit	106



FIGURE 125 A metal plate is placed in the sidewall of the snowpit as a stop for the Glacier sampler.



FIGURE 127 The core from the Glacier sampler is weighed on a gram-balance scale to determine the snow water equivalent.



FIGURE 126 The snowpack is sampled in increments of about 35 to 38 cm to determine the snow water equivalent of the entire snow profile.



FIGURE 128 Glacier sampler being inserted vertically into the second depth increment in a snowpit.



FIGURE 129 Incremental depths are sampled with the Glacier sampler to the ground surface.



FIGURE 130 Large-diameter samples were obtained in snowpits at same time as small-diameter and Glacier samples.

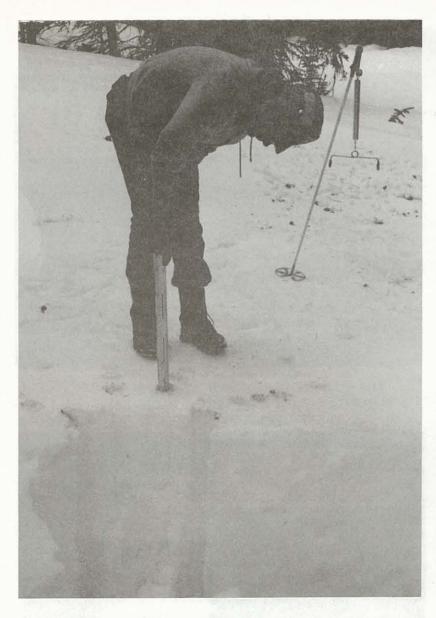


FIGURE 131 Snow samples with the small-diameter tubes like the standard Federal sampler, are taken through the entire snow profile adjacent to the Glacier samples.

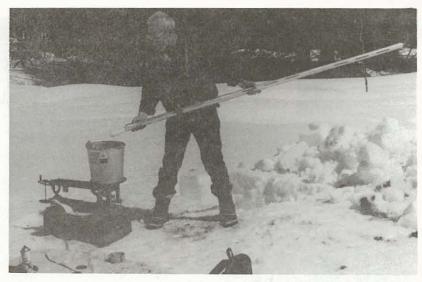


FIGURE 132 Core from a small-diameter sampler being placed in the weighing bucket on the gram-balance scale.

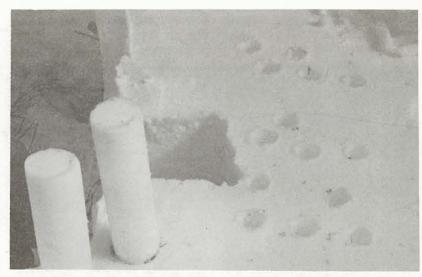


FIGURE 133 Snowtube samples with different cutters are taken around the Glacier sample.

The large cores are from the Glacier sampler.



FIGURE 134 The Glacier sampler was used to determine "true" snow water equivalent in all tests made by the Metrication Commuttee.

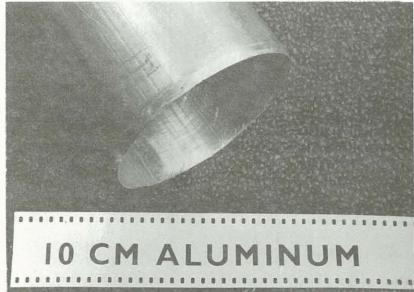


FIGURE 136 The thin wall aluminum irrigation pipe sharpened to the inside was almost the same size as the Glacier sampler and yielded identical results.



FIGURE 135 The Adirondack sampler has been used widely in shallower snowpacks throughout eastern United States and Canada.

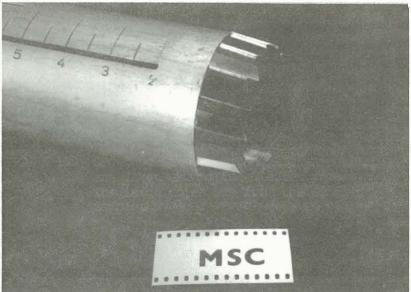


FIGURE 137 The MSC (Meteorlogical Service of Canada) sampler is the standard sampler for much of eastern Canada.

FIGURE 138 The 500 cm³ CRREL sampler is a volumetric type sampler used to obtain density profile of snowpack by inserting the tubes horizontally in the wall of a snowpit and weighing the cores of snow in the tubes.

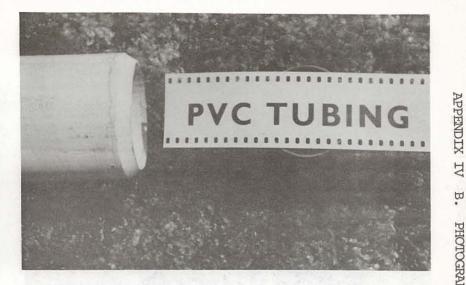


FIGURE 139 A sharpened PVC tube was also used to obtain snow water equivalent measurements.

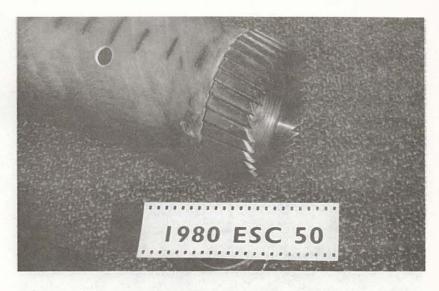


FIGURE 140 The prototype 1980 ESC 50 was the first large-diameter sampler evaluated by the Metrication Committee.

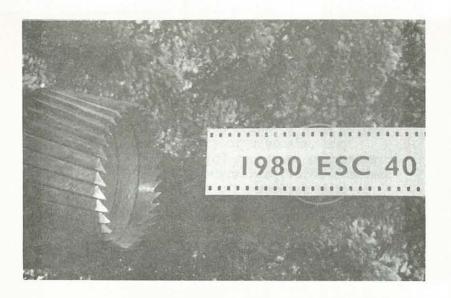


FIGURE 141 The 1980 ESC 40 cutter was similar in design to the ESC 50 but with smaller cutter area. The tube was the same size as used with the ESC 50.

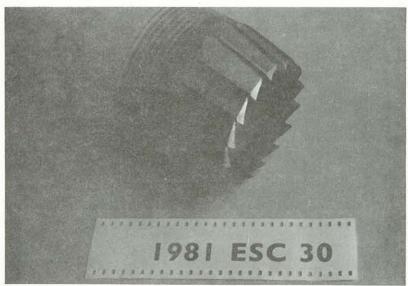


FIGURE 143 The 1981 ESC 30 is similar in design to the 1981 ESC 40 only the cutter area is smaller and smaller diameter tubing is used.

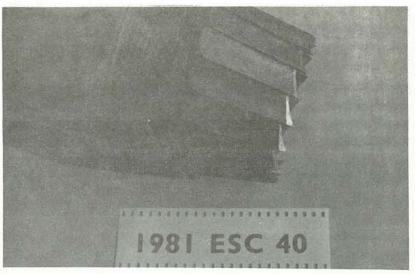


FIGURE 142 The 1981 ESC 40 cutter had fewer teeth than the 1980 ESC 40 sampler.

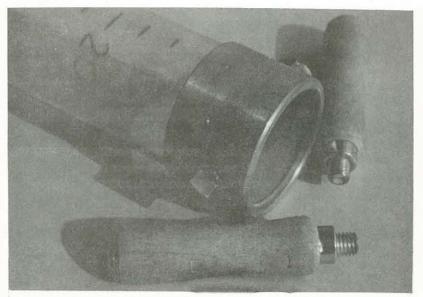


FIGURE 144 The top collar on the ESC 30 is used to secure the driving handles to the snow-tube as well as to prevent damage to the end of the tube.



FIGURE 145 The Utah cutter was a 32-tooth early day sampler used with steel snowtubes. This equipment was superseded with the standard Federal sampler.



FIGURE 147 The sharpened Federal cutter, is a standard Federal cutter with teeth sharpened to the inside.



FIGURE 146 The standard Federal cutter is widely used for snow sampling throughout the world.

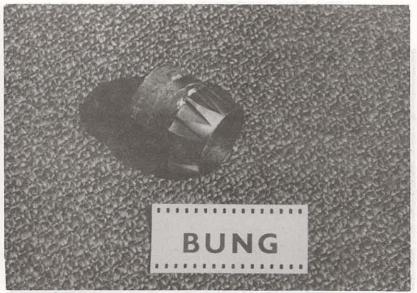


FIGURE 148 The Bung cutter is a standard Federal cutter with all of the teeth ground off.

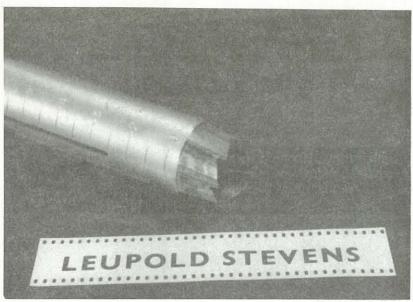


FIGURE 149 The Leupold and Stevens cutter has eight teeth. The teeth are flat faced similar to the standard Federal cutter.



FIGURE 151 The McCall cutter was developed for use in deep dense snowpacks and was used on smooth thick wall tubing with inner couplings.

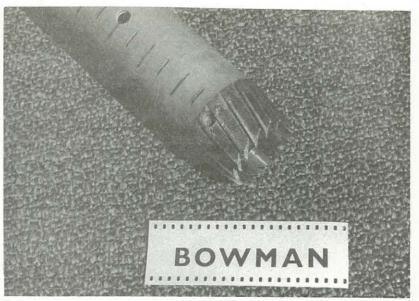


FIGURE 150 The Bowman cutter was developed for improved ice cutting and coring and was used with a fiberglass type tube.

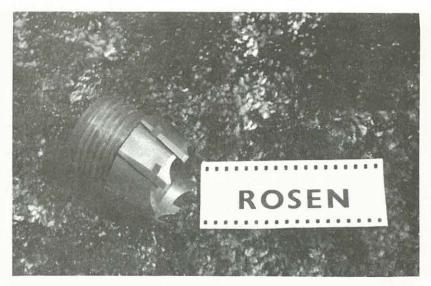


FIGURE 152 The Rosen cutter was an earlier model eight-tooth cutter that could be used in place of the standard Federal cutter.



FIGURE 153 The first metric cutter was the 1978 short metric cutter with straight teeth sharpened to the inside.



FIGURE 155 The 1979 WSC 10 metric cutter was an evolution of the 1978 long and short metric cutters and had sloping teeth with narrow lands.



FIGURE 154 The 1978 long metric cutter had the same area as the 1978 short metric but the cutter was similar to the Bowman and McCall type cutters.



FIGURE 156 The 1980 WSC 10 metric cutter was similar to the 1979 WSC 10 but incorporated a stronger design.

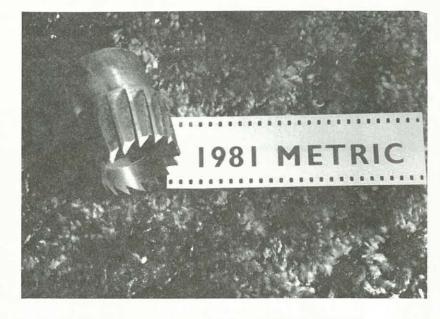


FIGURE 157 The 1981 WSC metric cutter was similar in design to the 1980 model except the cutting area was increased and shoulders rounded.



FIGURE 158 The Digiray Portable Profile
Gage has a radioactive
detector and source. The
density of each increment of
snow depth is determined as
the probe moves up or down
inside of a Federal snowtube
after the core has been
extracted.

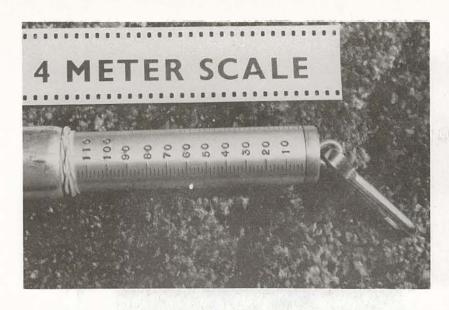


FIGURE 159 The 4 meter scale is used with the WSC metric sampler for most snowpacks and may also be used with the ESC 30 sampler with dual markings on the inner tube.

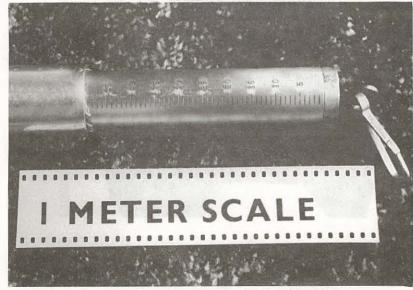


FIGURE 161 The 1 meter scale is designed for use with the ESC 30 snow sampler.

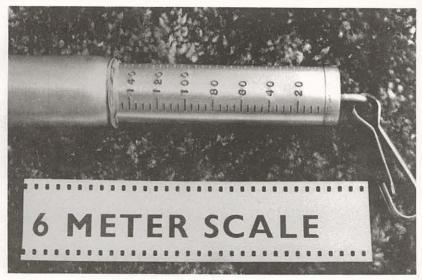


FIGURE 160 The 6 meter scale is used with the WSC metric sampler for snowpacks having depths exceeding 400 cm.



FIGURE 162 The recommended couplings for connecting tube sections, driving wrench, and spanner wrench, for the WSC metric snow sampler.



FIGURE 163 Volumetric snowpit in Ontario with sidewalls erected prior to the snow season.