METRICATION OF FIELD EQUIPMENT AND OPERATIONS FOR BRITISH COLUMBIA SNOW SURVEYS

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By

D. B. Letvak 1/

The Hydrology Division of the B.C. Water Investigations Branch began metrication of snow survey operations in the fall of 1975. At the 1976 Western Snow Conference in Calgary we presented a review of our accomplishments to that time as well as our plans for the future. Field and office operations are almost totally metric for this 1978 snow survey season, and we have dealt with many details which will be of interest to agencies that will be going metric in the future. Metrication offered (or imposed) the opportunity to carefully review all aspects of our snow surveys and related activities, and has resulted in numerous improvements of varying scale as a side benefit.

The decision to publish the Snow Survey Bulletin in metric in 1976 was related to the production of the 1935-75 Summary of Snow Survey Measurements, which is updated every five years. By producing a metric summary just prior to beginning metric Bulletins, there was no gap during which Bulletin data was not compatible with the most recent Summary.

For a period of two years, during the 1976 and 1977 seasons, field operations were carried on in English units and the data was converted to metric immediately on receipt at the Hydrology Division office. After that, Bulletin data processing was carried out in metric, with all related backup material (computer listings) having been prepared in advance in metric. Other activities such as runoff forecasting were carried out in English units but converted to metric for publication. During these two years, streamflow data from the Water Survey of Canada was received in the traditional units, and meteorological data from the Atmospheric Environment Service was received in mixed metric and traditional units. It can be seen that there was a great deal of conversion of units taking place at Bulletin time, which required an extra measure of care in order to avoid mistakes.

It had been concluded in the early stages of planning for metrication that it was desirable to have field measurements taken either in one system of units or the other for the entire network, in order to avoid confusion in data communication. So during the period of metric Bulletins and English field measurements, experimentation and planning for metrication of field equipment was carried out, as well as the production of metric field notes and a Sampling Guide.

The field notes were basically the same format as the previous version, but in order to be easily distinguishable, they were printed in red ink and had red covers. Snow depth and water equivalent for each station are both recorded to the nearest centimetre, but the average water equivalent for the snow course is calculated to the nearest millimetre. The back of the note page has a short questionnaire about conditions at the time of sampling and room for comments. In one of the questions, a reference to inches was left in, which shows that even when you are extra careful, little slip-ups can happen. It is that type of detail that makes metrication very laborious in practice even though it is simple in principle.

The Snow Survey Sampling Guide also retained the same basic format as the previous edition, which was styled after the U.S.D.A.-S.C.S. handbook No. 169. All examples were converted to metric units, as well as the example snow course location map, and a density nomograph was added for field use. Throughout the Guide instructions were revised and improved wherever possible, and a section on safety was added. The new Guide is recognizable as metric by the cover which is printed in red ink.

The major concern, both financially and logistically, was the metrication of sampling equipment. Due to the large value of the existing inventory of 780 sampling tubes, it was not feasible to replace them, and a method of re-marking the tubes with snow depth in

1/ Hydrology Division, B.C. Water Investigations Branch.

centimetres had to be devised. It had been decided to show a scale of one centimetre increments, with every fifth centimetre marked more boldly and numbered. The inch depth scale would have to be obliterated in some manner. The local manufacturer of sampling tubes quoted a price of $25 per tube to re-mark the tubes, or a total of $19,500. Cheaper alternatives were sought.

A variety of metal and plastic adhesive tapes were investigated, with assistance from the 3M Company through one of their products representatives. It was hoped that a tape printed with the metric scale could be fixed over the inch scale and would be durable enough to stand the wear and tear. However, some preliminary testing in late-season dense granular snow with ice layers proved to be more than the tape samples could withstand. The tape was chipped off at the edges by snow and ice, and damaged by the driving wrench sliding in the tube slots. It cannot be said that the technology of these materials and adhesives was fully applied to our problem due to limited assistance and information that we were able to obtain, and perhaps it could be pursued for use in networks with less harsh conditions than our own.

The other approach was to consider stamping a metric scale on the tubing in similar fashion to the existing inch scale. This was investigated by experimenting in our workshop, manually stamping tubing supported on a mandrel, after first laying out the scale by hand measurements. It became apparent that this could be done quickly, and it was decided to design a jig which would facilitate this method. A jig was designed to support the tube while scale markings and numbers were indented by means of stamping dies. It was produced for a cost of $1,600 by the machine shop which manufactures our snow survey equipment. The jig has a number of design features which make it convenient to use and adaptable. Two mandrels were made, which screw into an end support. One mandrel is designed for use with cutter sections, and another for use with subsequent tubes. If required, new mandrels can be easily installed for use with tubes of different inside diameter or length. The mandrel is firmly supported at both ends and clamps ensure that the tube is pressed tightly against the mandrel along the part where it is stamped. A guide bar with slots at 1-cm intervals aids in quickly positioning the stamping tool guide, and this guide bar is adjustable to allow for the variable location of the cm scale on sequential 30-inch tubes. This jig proved to be an effective and efficient tool for the job of re-marking the sampling tubes.

The procedure involved cancelling out the inch numbers (not scale marks) by stamping an "X" on each digit, and indenting the metric scale and numbering on the opposite side of the tube. This is admittedly a bit more difficult to read the length of the snow core, but was necessary to avoid damaging the tubes which are weaker near the slotting.

During the re-marking program, it was necessary to make repairs or replacements to some equipment. This slowed the re-marking, but did give an opportunity to assess the condition of the entire supply of sampling kits in actual field use at one time.

An important factor in the job is the skill and attitude of the worker, since the aluminum tubing is easily damaged and requires a certain amount of discretion in handling.

The spring scales could not be re-marked by a similar technique due to the lack of room on the inner cylinder and the high degree of precision required. Therefore, our local manufacturer of sampling equipment was engaged to produce 180 inner cylinders calibrated in centimetres of water equivalent, at a cost of $45 each or a total of $8,100. The 12.5-foot capacity scale became a 4-metre scale with increments at every 2 cm of water equivalent and numbers stamped at 10 cm (w.e.) intervals; the range is from 0-340 cm of water equivalent. The 20-foot scale was converted to a 6-metre scale with marks at 5-cm intervals, numbers at 20-cm intervals, and a range from 0-480 cm of water equivalent.

The new inner cylinders were installed in our workshop, and the accuracy of each scale was calibrated (in metric units) and recorded in our new scale inventory file. We will now have the opportunity to keep an ongoing record of the accuracy of each scale in our network by testing and adjusting them in the course of field trips. It was found that an accuracy of $\pm 1\frac{1}{2}\%$ could be attained in the calibration procedure, by adjusting the number of spring coils between supports. Deep freeze tests to simulate field conditions indicated a stiffening of approximately 1% when the scales were cold, and therefore the acceptable limits for workshop calibration were set at $+2\frac{1}{2}\%$ to $-\frac{1}{2}\%$. Approximately 20% of the 170 scales tested were found to be outside this acceptable range, though most were within 5% of correct. Four scales were found to have extreme errors of +10%, -15.6%, -16.6%, and 25.5%, which was rather disturbing. It was necessary to replace the springs in some cases, but in most, calibration was achieved by adjusting the number of coils between end supports.

The logistics of the equipment metrication are summarized as follows. Each sampling kit was called in by a letter enclosed with the snow sampling notice. Parcel post was the preferred shipping method since it was determined by prior investigation to be the most economical and reliable means. This was confirmed by our experience. All kits were labelled and inventoried upon receipt which meant that all parts of all kits could be accounted for at any time. Notes were kept on repairs and replacement of components. The final step prior to returning the kits to the field was an inspection to determine that all parts were there and in satisfactory condition - this step was documented on a check list type form designed for the purpose. The observers were requested to acknowledge receipt of the kits by a means of a standard inventory card.

In all, the metrication of sampling kits took from February to December, 1977, with a period of intensive work from May through September, during which time we had one student worker occupied full-time at this task for four months, with the direction and assistance of regular staff for an estimated total of 6-7 man-months.

A summary of estimated costs related to metrication of snow survey sampling kits is as follows:

(a) Inventory: 150 kits, 780 sampling tubes, 180 spring scales.

(b)	Tube re-marking:		
	Jig	$1,600	
	Labour (Government student employment program, plus regular staff. Total = 6 man-months)	5,700	
	Total		$7,300
(c)	Scale conversion:		
	New cylinders - 180 @ $45	$8,100	
	Labour (1 man-month)	1,300	
	Total		9,400
(d)	Shipping and postal charges:	$ 300	
	Total		300
(e)	Observer handling charges:	$ 250	
	Total		250
(f)	Total cost - sampling kit metrication		$17,250

Though snow sampling is now essentially metric, we are not finished yet. Most of the instrumentation for snow pillow sites remains to be converted to metric in 1978-79. The snow course map and description file must also be revised, which is expected to take approximately 500 man-days during the next several years. This is complicated by the limited availability of metric mapping and the shortage of manpower which can be directed towards field verification of site descriptions. In relation to this program, all sampling station markers should eventually be converted to distance in metres.

Another activity relating to snow surveying which is undergoing metrication is volume runoff forecasting. This was begun during the summer of 1977 as part of the normal procedure of updating the forecast equations. The data sets which are in card form in English units were updated in English units, but converted to metric by means of a conversion subroutine as part of computer regression analysis. It is hoped that all forecast stations will have metric equations for the 1979 forecast season.

To sum up our experience with metrication up to this time, it is fair to say that it requires a lot of time, effort, and money, and causes quite a disturbance in the normal operations of a snow course network. On the other hand, it offers an excellent opportunity to review most aspects of network operation which is considered to be of secondary benefit.

There are a number of important future considerations which should be mentioned at this time. One is the question of sampling error as it relates to cutter design and inside diameter. It is not necessary to change the inside diameter of the cutter in conjunction with metrication. The relationship between the height of a column of water and its weight in ounces or grams is not relevant because our scales read in water equivalent units, not units of mass. Nevertheless, it may be appropriate to change the inside diameter in conjunction with other design features in order to improve the accuracy of sampling. We have done some preliminary testing of a variety of cutters, including the new design sharp tooth cutters with slightly smaller inside diameter (so 1 mm height of water core weighs 1 gram), and hope to carry out a more extensive program. The testing method is designed to be carried out by two men operating in the field with a truck, so that tests can be done in a variety of areas at different times in the season to ensure a broad range of snow conditions, depths, and densities. This is important because any change in equipment design must only be carried out on the basis of a test program which is both theoretically and statistically valid. Major points of the suggested procedure are outlined as follows:

1. Test site - ideally the site should be known to have a relatively flat ground surface and snow surface.

2. True water equivalent - is determined by the glacier sampling method. This involves digging a pit with one vertical wall and obtaining a series of cores in steps from the snow surface to the ground adjacent to the vertical wall of the pit. The samples are taken with a stainless steel tube of approximately 10 cm inside diameter and 40 cm long. The first sample is taken from the snow surface down to a metal plate and the snow core is weighed with a balance scale. The remaining snow is cleaned off the plate, the plate is inserted lower in the snowpack, and another core is taken. This process is repeated down to ground level. The short, large-diameter sharp-edged sampler cuts neat cores with very little compression. Since each step of the sampling can be carefully executed and visually observed, it is possible to obtain an accurate measure of the true water equivalent and density.

3. Test samples with the standard tubes and cutters to be tested can then be taken within a 1.5-metre radius of the glacier sample. It is suggested that each cutter being tested should be used until at least three consistent samples are obtained that show densities within several percent and reasonable core lengths, indicating successful sampling. This assumes that there is limited areal variability in the density of the snowpack within the test zone. The standard snow survey spring scale is used for determining the water equivalent - naturally, the scale should be accurately calibrated and periodically checked.

4. Computations - the data obtained in this method should have certain corrections applied where applicable: (a) The depth must be corrected for cutters of non-standard length such as the "2-inch" metric cutter. (b) The depth and water equivalent of each sample should be scaled up or down to correspond with the depth of the glacier sample so that water equivalents can be fairly compared. (c) The water equivalent should also be corrected for differences in cutter cross section; the metric cutter sample water equivalents should be increased by 11.74% based on a ratio of cutter areas.

5. Results - in this way, samples obtained with several cutters can be compared with the "true" water equivalent. Using this method, it should be possible to obtain a large enough group of samples to undertake a valid analysis, without requiring an expenditure of time that is beyond the capability of operational agencies such as ours. Comments from members of the Western Snow Conference are welcomed on this matter, since it would be desirable to have enough consistency and quality control in the testing technique to make results from all areas of North America comparable.

The final future consideration that should be mentioned is the total metric design of sampling equipment using materials and machining that conform entirely to SI specifications. The production of metric raw materials will be part of national metrication, but according to local suppliers, metric standards are not yet determined and there is no time frame specified. There will no doubt be a considerable time lag during industrial changeover, so our agencies should hopefully have adequate time for our own planning.

We have carried out some investigation into the application of plastics for sampling equipment, which has shown promise, When working with plastics using moulding and extrusion techniques, one can specify any dimensions (within the limitations of the material), so metrication does not cause problems. Our own investigations have centred around the possible production of a driving wrench from injection-moulded nylon. Design features have been considered, and the costs have been estimated at approximately $3,000 for the mould and $20-25 each for a production run of 50 units. The present cost of driving wrenches from our supplier is $145, so the potential for substantial long-term savings exists. We have not pursued this project due to shortage of funds and pending metrication of equipment design.

In closing, we have found metrication to be rather demanding on the resources of our Division, though it has provided many secondary benefits, from Snow Bulletin production improvements through equipment inventory and scale calibration. We hope that this description of our experiences has been of interest to other members of the Snow Conference, and that we can continue to cooperate in the areas of equipment testing and design to further advance the field of snow surveying.