# STANDARD OPERATING PROCEDURE

MAINTENANCE AND SAMPLING PROCEDURE

**MANUAL SNOW SURVEYING**

FEDERAL SNOW SAMPLER

SOP 6.02

| Version | Author | Job title | Date | Changes |
|---|---|---|---|---|
| 1.0 | Frank Weber | Field Programs Manager | Dec 4, 2017 | New Document |
| 1.0 | Tony Litke | Snow Program Coordinator | Dec 4, 2017 | Review |
| 1.0 | Frank Weber | Field Programs Manager | Dec 19, 2017 | Additional notes from Snow School |
| 1.1 | Frank Weber | Field Programs Manager | Dec 9, 2018 | Added email, phone data submission |
| 1.2 | Frank Weber | Field Programs Manager | Dec 9, 2019 | Minor edits |
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| 1.3 | Frank Weber | Field Programs Manager | Jan 9, 2023 | 7th day of the month is included in survey period |
| 1.4 | Frank Weber | Field Programs Manager | May 2, 2023 | Added photo of core recovery |
| 1.5 | Frank Weber | Field Programs Manager | Dec 6, 2023 | Removed requirement for Banker's rounding; removed unused submission codes; changed WC submission to SharePoint |
| 1.6 | Frank Weber | Field Programs Manager | Feb 19, 2024 | Flipped Fig 2 |
| 1.7 | Frank Weber | Field Programs Manager | Nov 26, 2024 | Added site criteria for new sites |
| 1.8 | Frank Weber | Field Programs Manager | Dec 19, 2024 | Updated sampling area diameter for new sites |
| | | | | |

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# 1 PURPOSE AND SCOPE

Standard Operation Procedures (SOPs) list instrumentation that is approved for use in the program, define minimum sensor siting criteria, and describe installation procedures, maintenance procedures and measurement standards for BC Hydro's Hydrometeorologic Monitoring Program (HMP).

Field staff shall follow SOPs.

Shall, should and may reflect mandatory, recommended and optional items, respectively.

- ☐ Checkboxes are used for equipment and task lists

1. Numbered lists (1,2,3,…,a,b,c,…) provide step-by-step instructions

Changes and improvements to SOPs shall be reported to the program manager. Once the program manager approves the changes, MS Word documents of the SOP are updated with track changes turned on. When deemed necessary a new version of the SOP is issued.

This standard operating procedure is designed to assist field personnel with the collection of manual snow survey data.

Manual snow survey data are collected for the BC Snow Survey Program and to verify automated snow sensors (e.g., snow pillows and scales).

# 2 EQUIPMENT

## 2.1 Equipment Checklist

The items listed below will be required in the field to conduct the work outlined in this SOP.

- Approved instrumentation: Federal Snow Sampler (as supplied by Geo Scientific Ltd., Figure 1)
  - ☐ Carrying case
  - ☐ 4-6 Tubes in 76.2 cm sections (metric; graduations every 1 cm). A 1.485" ID 16-tooth hardened cutter with blunt teeth is fitted to the first section (Figure 3).
  - ☐ Thread protectors
  - ☐ 2 Spring scales; graduated in cm SWE; 4 and 6 m snow depth scales. Ensure that scales have a serial number engraved (Figure 2).
  - ☐ Drive wrench
  - ☐ Cradle and spare anti-slip hockey tape
  - ☐ Spanners
  - ☐ Plastic sampling bag (for bulk sampling)
  - ☐ Snow Knife or similar tool
  - ☐ Cleaning pole
  - ☐ Cleaning rag rope with weight
  - ☐ Bottle of food grade silicone fluid
  - ☐ Anti-seize compound for greasing threads
  - ☐ Metal plate for multi section sampling in deep snowpack

- ☐ Calibration weights (Figure 2): 50 cm equ., 75 cm equ., 100 cm equ. and 200 cm equ.
- ☐ Snow survey forms
- ☐ Calculator
- ☐ 2 pencils
- ☐ Snow course map, if new to the station
- ☐ This SOP

Figure 1: Federal Snow Sampler

Figure 2: Inner workings of a scale

Figure 3: Cutter with blunt teeth

Figure 4: Scale calibration weights

## 2.2 Equipment Maintenance

- Do not bend the tubes and handle with care
- Ensure that the tubes are properly cleaned and coated with silicone inside and out
- Ensure that coupling threads are properly cleaned and coated with grease such that tubes can be screwed together without binding
- Assure the rivets that hold the cutter and threads in place are tight. If not, replace.

## 2.3 Equipment Calibration

Check the calibration of the spring scales on an annual basis. This should be done in June to allow for spare equipment to be purchased in time for the next January snow surveys.

1. Use the form shown in Table 1
2. Record Tare weight in column 1
3. Apply the first weight and record the scale reading in column 3
4. Compute the calculated weight by subtracting the tare weight from the scale reading
5. In an ideal case, the applied and calculated weights are identical. Calculate the relative error as indicated in Table 1.
6. Repeat steps 2-4 with the remainder of the test weights.

As long as the relative error at any of the tests weights is within -0.5% and +2.5% (source: undocumented BC ENV procedure), the scale is functional.

If any of the checks for a specific applied weight fail but by very little, retry, and perhaps retry outside in cold conditions. If any of the checks for a specific applied weight still fail then replace the scale.

Keep a record of scale checks and submit the form to BC Hydro.

**Tolerance: -0.5% - +2.5% (at 18ºC)**

**Table 1: Calibration check**

| Scale No.: | | | | |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) |
| Tare weight (cm equivalent) | Applied weight (cm equivalent) | Scale reading (cm equivalent) | Calculated weight (cm equivalent) | Relative error (%) |
| | | | (3)–(1) | ((4)–(2)/(2))*100 |
| | 50 | | | |
| | 75 | | | |
| | 100 | | | |
| | 150 | | | |
| | 200 | | | |

| | | | | |
|---|---|---|---|---|
| | 250 | | | |
| | 300 | | | |
| | 350 | | | |
| | 425 | | | |

# 3 SNOW COURSE SITE

## 3.1 Snow Course Site Criteria

The classification into sensor siting criteria and classes provides additional information that can be used by data users to better interpret the data. The system also sets general optimum standards for monitoring sites.

The desired class criteria are highlighted in green, while classes acceptable to BC Hydro are highlighted orange in Table 2.

The crown closure of existing sites is generally left as is, as this maintains homogeneous environmental conditions. New sites shall be established with appropriate obstruction angles, which help maintain site conditions homogeneous over time.

Examples of good and very good Snow Course sites are provided in Figure 5, Figure 6 and Figure 7.

## 3.2 Sampling Stations

A Snow Course typically consists of 5 or 10 defined sampling stations. In some cases individual stations may have been discontinued. A sampling station consists of a sampling area and two reference markers that allow the surveyor to triangulate to the sampling spot (Figure 8).

**Table 2: BC Hydro Snow Course Site Classification**

| | Criteria | Class 1 | Class 2 | Class 3 | Class 4 | Class 5 | Comments |
|---|---|---|---|---|---|---|---|
| **1** | Slope | 0° - 15° | 15° - 25° | N/A | N/A | Beyond Class 3 | |
| **2** | Drainage | Well drained | High subsurface water table | Episodic standing water | Periodic standing water | Beyond Class 4 | |
| **3** | Diameter of cleared sampling area | Half of the height of surrounding forest, to a minimum of 10 m | N/A | N/A | N/A | Beyond Class 1 | New sites only |
| **4** | Ground vegetation | No shrubs, trees and deadfall within 2 m radius of all sampling locations | N/A | N/A | N/A | Beyond Class 1 | |
| **5** | Snow disturbance activities | >50 m away | >25 m away | >10 m away | N/A | Beyond Class 3 | |

| | Criteria | Class 1 | Class 2 | Class 3 | Class 4 | Class 5 | Comments |
|---|---|---|---|---|---|---|---|
| **6** | Snow drifting | minimal | some | significant | N/A | Beyond Class 3 | Up to class 3 only in the alpine |
| **7** | Skier and snow mobile traffic | none | some | N/A | N/A | Beyond Class 2 | |
| **8** | Avalanche hazard | none | none | none | Zone A, B[1] | Zone C | |

- A sampling area is an area of 1.5 m radius (or 3 m diameter, Figure 9)
- The 2 reference plates are marked (i) with the station number and (ii) horizontal distance including units of measurement from the tree trunks to the sampling spot (preferably in m).
- Install the reference plates well above the maximum snowpack.

## 3.3 Ground Conditions at a Sampling Station

The ground surface of a snow sampling station should meet the following characteristics:

- Well-drained
- Free of shrubs and trees to minimize the occurrence of air pockets in the snowpack (Figure 10)
- Free of deadfall to minimize the occurrence of air pockets in the snowpack (Figure 11)

## 3.4 Site Maintenance

- ☐ Keep the sampling areas free of shrubs trees and deadfall
- ☐ Replace missing reference plates
- ☐ Assure reference plates readable and remove branches that cover the plates (Figure 12). It is often best to do this during the time of maximum snowpack, i.e., in April or May.

[1] BC Hydro Avalanche Zone classification

**Figure 5: A very good snow course location, Lady Laurier 4A07. Natural open area protected from wind by mature forest.**

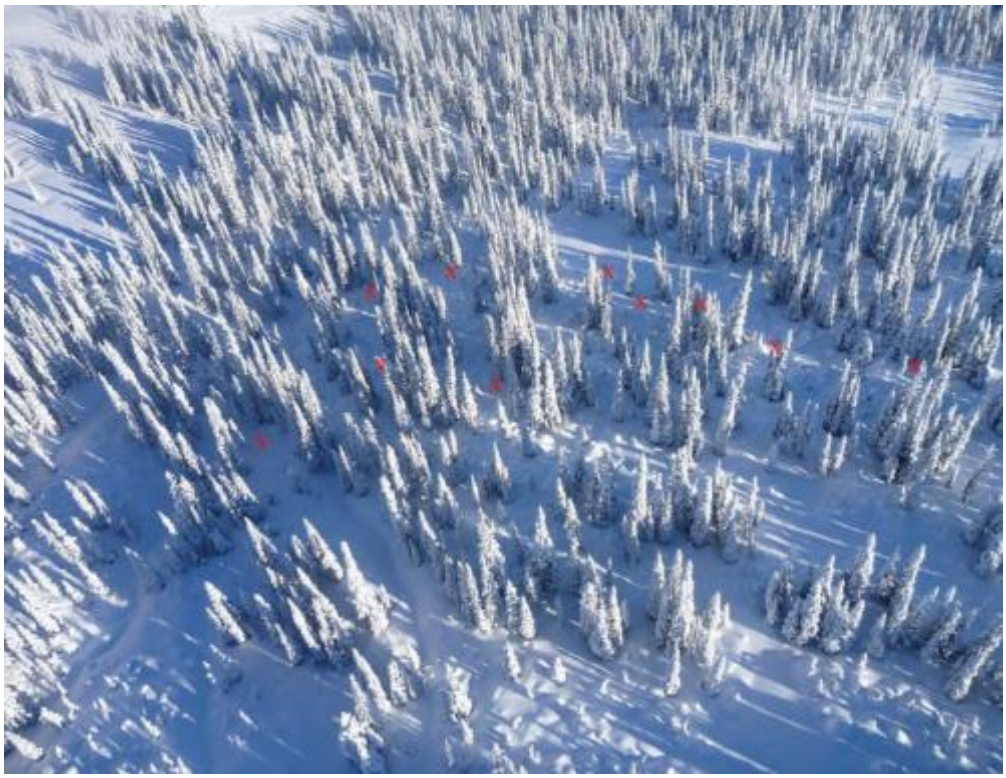


**Figure 6: A good snow course location, Pine Pass 4A02. Mature open forest.**

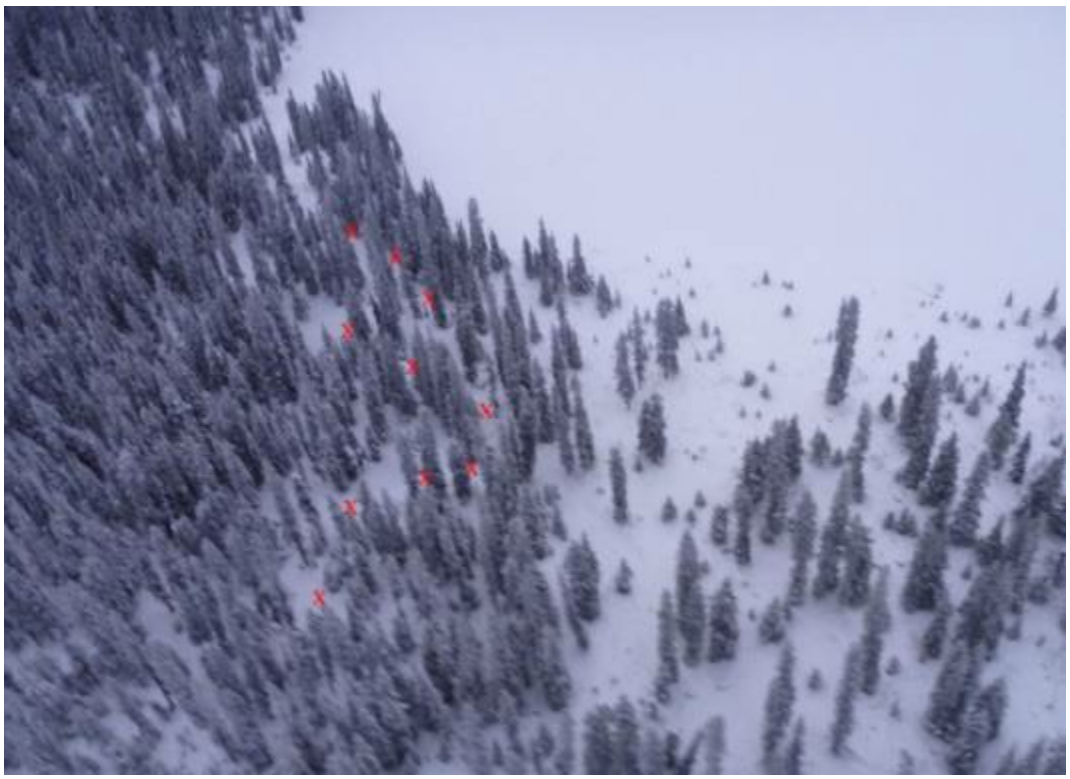


Figure 7: A good snow course location, Sikanni Lake C01. Mature open forest.

Figure 8: Sampling station with 2 reference plates - installed above the maximum snowpack - from which the sampling location can be riangulated.

Figure 9: Core cutter marks and evidence of sampling within a 1.5 m radius.

Figure 10: Well-maintained sampling area; small trees were removed.

Figure 11: Deadfall in the sampling area that must be removed.

Figure 12: Cutting branches to keep reference plates visible.

# 4 SNOW SURVEY PERIOD

Nominal sampling dates are January 1, February 1, March 1, April 1, May 1, May 15, June 1 and June 15.

Manual snow survey samples have to be obtained 6 days before or after the nominal sampling date to be included in the long-term record of the BC Snow Program.

**To be useful for BC Hydro operational water supply forecasting, 1st of the month snow surveys have to be submitted by the end of the 3rd working day of the month at the latest.**

Table 3 shows the sampling period requirements for inclusion of the data in the long-term archive in orange and for operational water resource management in green.

**Table 3: Sampling Period for the core sampling season**

| Earliest | Nominal date | Latest |
|---|---|---|
| Dec 26 | Jan 1 | Jan 7 |
| Jan 26 | Feb 1 | Feb 7 |
| Feb 23 (24) | Mar 1 | Mar 7 |
| Mar 26 | April 1 | Apr 7 |
| Apr 25 | May 1 | May 7 |
| May 9 | May 15 | May 21 |
| May 26 | Jun 1 | Jun 7 |
| Jun 9 | Jun 15 | Jun 21 |

# 5 SNOW SURVEY SAMPLING PROCEDURE

## 5.1 Standard Procedure

The sampling procedure requires that a number of measurements are conducted; some constitute the actual measurements, others are used for quality controlling the samples.

**Be careful not to ski, snowshoe or drive over sampling stations.**

1. **Snow course map** (Figure 14)

a. Start sampling at either end of the snow course.

**2. Snow Survey form (Appendix A) – enter headings**

a. Fill in headings (station number, sampling date and time, snow course name, observers' names, number of sections used, wrench used and scale number). Number of sections, wrench and scale information can be useful for quality controlling measurements.

**3. Assemble tubes**

a. Probe snow with avalanche probe to estimate depth

b. With gloved hands assemble the tubes by screwing the tube sections together hand-tight (no wrenches).

c. To improve eye safety, always use the thread protector at the end.

**Always use 2 or more tube sections!**
**Make sure the depth scale is consecutive.**

d. Record the number of tube sections used

e. Attach driving wrench and record whether a wrench is used or not.

**4. Locate station**

a. Locate station and triangulate to find your sampling position located at the horizontal distances from the tree trunks as indicated on the reference plates.

b. Sample within 1.5 m radius of this point.

c. Before sampling look inside the tube to see if it is clean (to avoid eye injury look through the end opposite the cutter).

**In patchy snow conditions, do not seek out a snow patch to sample but record zero if the sampling location is snow free.**

**5. Push tube vertically through the snowpack**

a. Assume a wide stance and hold the sampling tubes in front of you.

b. Hold sampling tube vertically, cutter end down and drive the tube down to the ground surface preferably in one continuous motion (Figure 16).

c. Rotate the tubes clockwise to drive through any ice layer on the ground surface. The only exception to the direction of the rotation is when sampling on top of snow pillows: to not break off cutting teeth grabbing the protective chain link fence it is recommended to rotate the tubes anticlockwise.

**Note that snow surveying does NOT measure snow thickness, which is the thickness of the snowpack measured perpendicular from the ground surface. Instead, the depth of the snowpack is measured vertically.**

**6. Record depth of snow with snow plug**

a. From the scale graduations marked on the tubes read and record snow depth with dirt plug to the nearest cm in **column 1** (Figure 17).

**7. Record the core length and calculate core recovery**

a. Turn the tubes clockwise while carefully raising the tubes until you can see snow through the slots in the tubes. Record where the snow starts (Figure 18) as the core length in **column 4.**

b. Raise tubes carefully and completely out of the snow always keeping the cutter end lower than the top end so the core does not slide out.

c. Should the core slide a few centimetres out at the bottom, add that length to the value obtained from the graduated scale on the sampler and enter in **column 4**.

d. Calculate the core recovery by dividing the core length by the snow depth with plug, and record in **column 5**. The core length is usually less than 100% of the snow depth, but greater than 80% of snow depth. Core recovery is used an indicator of sample quality.

e. Core recoveries of less than 80% are acceptable provided they are consistent from one station to the next. If a core recovery of less than 80% is an outlier, resample that station.

f. Use the sampling process flow chart in Figure 24 to determine where stations should be resampled.

**8. Check for dirt plug**

a. Inspect the cutter end of the tube for dirt or organic matter that indicates the cutter head made contact with the ground surface (Figure 19). If there is no evidence of having reached the ground, resample the station.

**9. Correct the snow depth**

a. Carefully remove dirt and litter from the cutter with a knife or similar too. It is recommended resting the tube on the surveyor's shoulder while the notes keeper removes the plug (Figure 20 and Figure 21). If no help is available, rest the top end of the tubes on a tree branch or a cross member of a nearby weather station tower.

b. Throw dirt or organic debris from the dirt plug at least 2 m away from the sampling point to prevent melt holes from occurring in the sampling area.

c. Measure or estimate the thickness of the plug and enter the length of the dirt plug in **column 2.**

d. Subtract the plug thickness from the snow depth with dirt plug to obtain the snow depth without snow plug (i.e., corrected snow depth), and record in **column 3**.

**10. Weigh tube and core**

a. Using the weighting procedure used in step 4 record the weight of tube and core to the nearest cm water equivalent (Figure 22) and record in **column 6**.

**The scale must hang freely like a pendulum so be sure to hold the scale by the top ring or attached cord using a cord attached to the top ring and never by the barrel as this will cause the scale to bind.**

**Ensure that the scale slides freely in the barrel by slightly extending the scale and allowing it to return or by tapping it lightly with a pencil before taking a reading.**

**11. Empty and clean tube**

a. Lift the tube from the cradle. Turn the cutter end up and shake the tube at least 3 m away from the sampling location. If necessary, jar or tap coupling end against a rubber pad on a ski or snowshoe. Do not strike hard objects with this end unless the thread saver is affixed as the tube coupling will damage easily. If the core remains stuck inside the tube use a thin stick or cleaning tool to remove it. It may be necessary to uncouple the tube to accomplish this. Before the next sample is taken inspect the inside and make sure all snow has been removed.

**12. Weigh empty tube after the first snow sample has been taken**

a. Balance the empty tube on the cradle which is attached to the weighting scale (Figure 15).

**The scale must hang freely like a pendulum so be sure to hold the scale by the top ring or attached cord using a cord attached to the top ring and never by the barrel as this will cause the scale to bind.**

**Ensure that the scale slides freely in the barrel by slightly extending the scale and allowing it to return or by tapping it lightly with a pencil before taking a reading.**

b. If it is windy, point the tube into the wind.

c. Read the scale and record the weight of the tube only to the nearest cm in **column 7 (Appendix A).**

d. The initial weight should be app. 20 cm water equivalent.

**13. Recheck the tube weight**

a. Check the weight of the empty sampling tube every 3rd or 5th sample to ensure accuracy. The empty weight of the tube at this step should be the same as the reading obtained in step 4.

b. If this is not the case, then some snow or ice must still be in the tubing and should be removed. If snow and ice are difficult to remove, then tare the tubes before each sample and record the value accordingly with the associated sample.

**14. Compute station water equivalent**

a. Subtract the weight of tube only from the weight of tube and core to obtain the snow water equivalent. Record to the nearest cm in **column 8**.

**15. Compute station density**

a. Divide snow water equivalent by snow depth without plug and multiply by 100 to obtain percent snow density. Record to the nearest % in **column 9**.

**16. Repeat steps 5-15 for all stations**

a. Locate and sample the remaining stations following the steps 5 through 15.

**17. Compare station water equivalents and densities**

a. Use the sampling process flow chart in Figure 24 to determine where stations should be resampled.

b. When all stations have been sampled, and snow water equivalents, core recoveries and densities have been calculated, check densities for consistency. In general, densities at a given snow course on a given date should not vary significantly from one station to another. A range of station densities of 5% is permitted (USDA NRCS 1984). Snow densities are used an indicator of measurement quality.

c. If density at a particular station is out of line with the density at the other stations, i.e., its density causes the density range to exceed 5%, then that station should be resampled.

**18. Snow survey site snow depth, water equivalent and density**

a. Select the station samples that are to be included in the calculation of the snow survey average.

**Note that zero snow depth and water equivalent at any of the stations are a result and are consequently used in the calculation of the averages!**

b. Snow depth

i. As an intermediary calculation step, add up all selected snow depth without dirt plug samples to obtain the total snow depth without dirt plug. Record in the bottom section of **column 3.**

ii. Average all selected snow depth without dirt plug samples by dividing the total by the number of samples, and obtain the average snow depth without dirt plug. Record in the bottom section of **column 3** to the nearest cm.

c. Snow water equivalent

i. As an intermediary calculation step, add up all selected snow water equivalent samples to obtain the total snow water equivalent. Record in the bottom section of **column 8**

ii. Average all selected snow water equivalent samples by dividing the total by the number of samples, and obtain the average snow water equivalent. Record in the bottom section of **column 8** to the nearest tenth of cm water equivalent.

d. Density

i. Calculate the range of station densities by subtracting the lowest density from the highest density (out of all selected samples). Record in the bottom section of **column 9.**

**19. Record the final results**

a. Copy average snow depth into field 10 in the bottom section of page 1.

b. Convert snow water equivalent into units of mm by multiplying the snow water equivalent in cm by 10. Record in field 11 in the bottom section of page 1.

c. Calculate snow density by dividing the snow water equivalent (field 11) by the snow depth (field 10). Record in field 12 in the bottom section of page 1.

**20. Fill in the check list on the back of the notes**

a. Provide the sampling start and end times.

b. Provide information about weather, precipitation, surface snow condition, sampling conditions and general conditions.

c. Starting with the 2022-23 season, snow line elevation is NOT reported any more.

d. Include remarks about difficult sampling conditions, methods used to overcome difficult sampling conditions, and reasons for snow sampling irregularities.

**21. Quality-control**

a. Obtain a copy the template quality-control file (Snow Survey QC_vXX_agency_region_date_template.xls) and rename as follows e.g., Snow Survey QC_v23_Matrix_WI_20230501.xlsx. As date use the nominal sampling date.

b. Select the template sheet.

c. Select cell B10 and select the snow survey site of interest.

d. Create a copy of the sheet and rename to the BC ENV snow survey site ID, e.g., 1C05.

e. Enter the actual snow survey date into cell L10.

f. Select in cell H12 whether a bulk sample was obtained or not.

g. Paste a low-resolution copy/screenshot of the snow survey form into cell T13.

h. Transcribe the snow survey data from the field form to the yellow cells in the spreadsheet.

i. In column B choose which samples to include and which not.

j. Compare the values calculated in the field with the values calculated in the spreadsheet. If there are differences investigate and, if necessary, correct the field notes.

k. Enter your name and date to the Quality Control section on page 2 of the field data entry form.

**If the procedure outlined in this document and shown in Figure 24 couldn't be followed in its entirety, e.g., due to time constraints, and a specific sample stands out as an outlier according to the rules provided here, then it is recommended to discard that sample.**

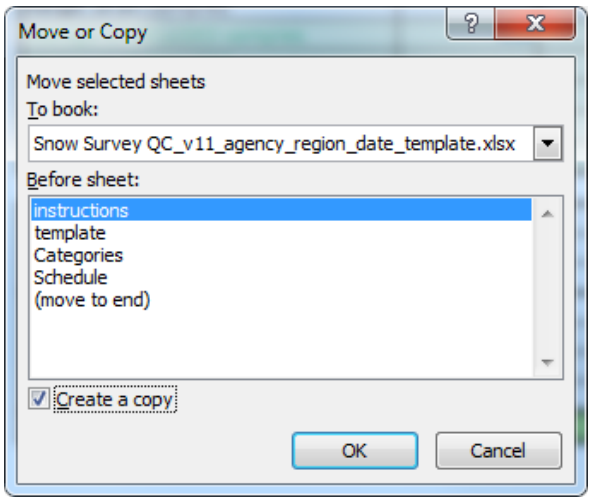



**Figure 13: Copy the template sheet in EXCEL.**

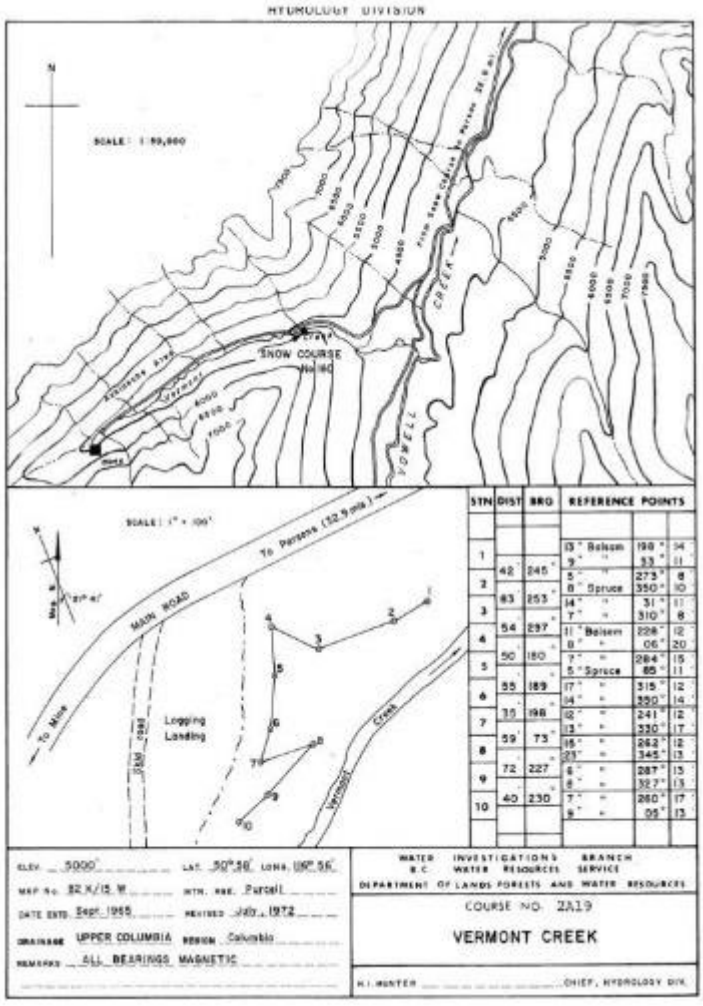



**Figure 14: Snow course map.**

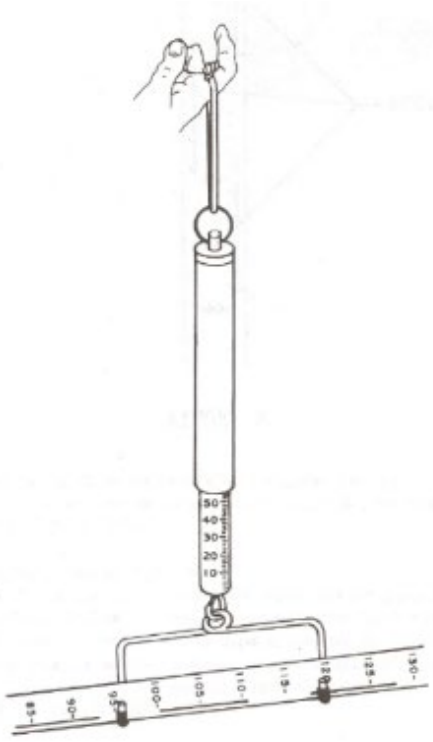


Figure 15: Balancing the tube in the cradle.

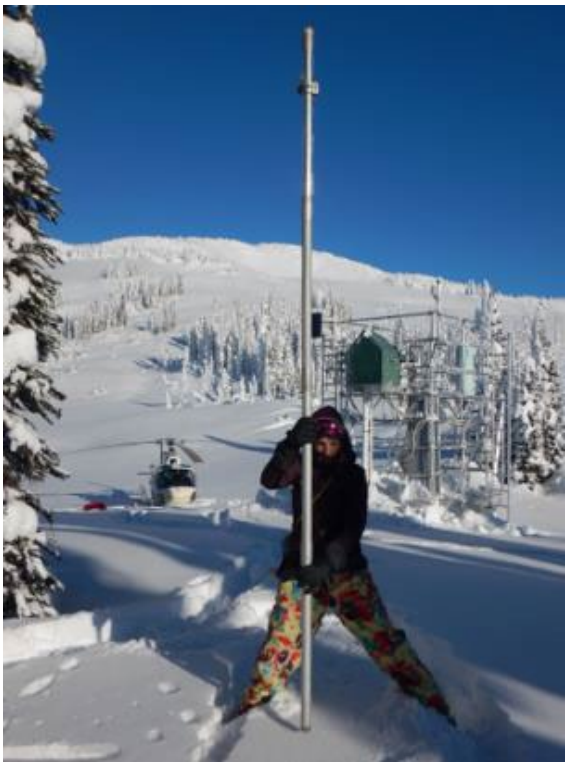


Figure 16: Hold sampling tube vertically, cutter end down and drive the tube down to the ground surface.

Figure 17: Reading the depth of snow with dirt plug.

Figure 18: Core recovery (here: 63 cm).

Figure 19: Evidence of hitting the ground surface.


Figure 20: Removal of the dirt plug; use the surveyor's shoulder to rest the tube on while the notes keeper removes the plug.


Figure 21: Removal of the dirt plug.

Figure 22: Weighting of the sample.

Figure 23: Bulk sampling (photo: Michael Macor / The Chronicle).

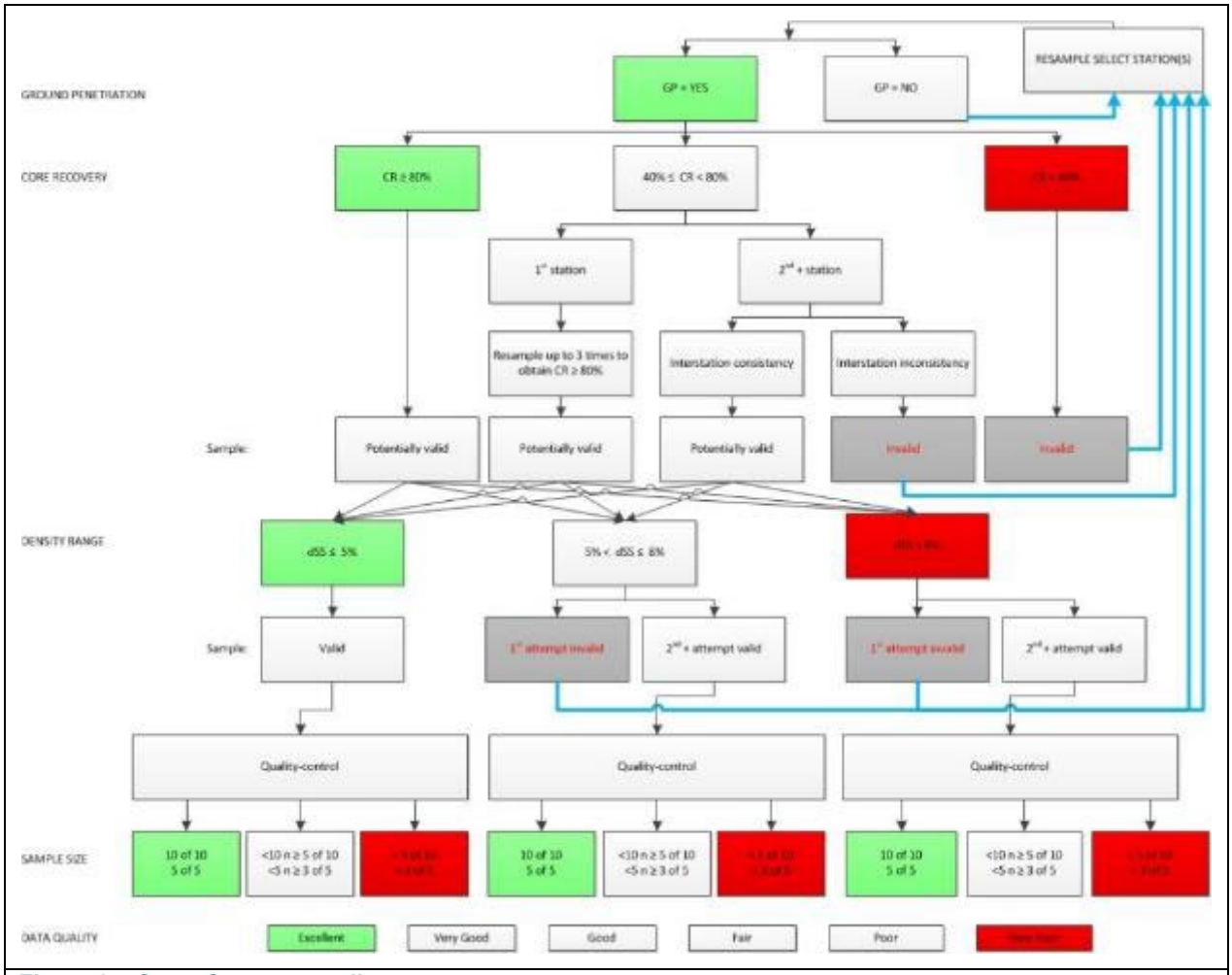



**Figure 24: Snow Survey sampling process.**

## 5.2 Bulk Sampling Procedure

Bulk sampling is recommended at snow depth of less than 50 cm.

1. **Record weight of container**
    a. Use a plastic pail or plastic bag and attach it to the weighing scale.
    b. Add enough weight (e.g., by adding snow or rocks) to obtain an initial scale reading of approximately 20 cm water equivalent.
    c. Record the scale reading (i.e., weight of 'tube') in the last row of **column 7** (Figure 25).

**Any added weight must remain in the container or attached to the scale until all samples have been collected and the weight of the snow has been recorded.**

2. **Sample each station**
    a. Sample each station in a manner as outlined in Section 5.1, Steps 4-11
    b. Do not discard the snow cores but instead empty them into the container. It is not necessary to weigh each core separately.

**Note that if a station is bare of snow, record zero for depth.**

3. **Weigh container and all cores**
    a. When all stations have been sampled weigh the container and cores. Record this reading in weight tube and core in the last row of **column 6.**
4. **Snow survey site snow depth, water equivalent and density**
    a. Snow depth
        i. As an intermediary calculation step, add up all selected snow depth without dirt plug samples to obtain the total snow depth without dirt plug. Record in the bottom section of **column 3.**
        ii. Average all selected snow depth without dirt plug samples by dividing the total by the number of samples, and obtain the average snow depth without dirt plug. Record in the bottom section of **column 3** to the nearest cm.
    b. Snow water equivalent
        i. Subtract tube/container only weight from the tube/container and cores weight. Record in the last row of **column 8.**
        ii. Copy the number into the Total field in **column 8.**
        iii. Average all selected snow water equivalent samples by dividing the total by the number of samples, and obtain the average snow water equivalent. Record in the bottom section of **column 8** to the nearest tenth of cm water equivalent.
5. **Record the final results, sampling information and quality-control**
    a. Follow steps 19-21 in Section 5.1

## 5.3 Sampling a Station in Sections

The procedure is used when problems of deep snow, core freezing in the tube and ice layers prevent the above procedures to work.

1. Thrust the tube hand-over-hand until it resists further penetration
2. Remove the tube carefully as to not disturb the hole
3. Weight and record the core length and weight tube and core
4. Empty the tube and return it carefully to the bottom of the hole
5. Again thrust the tube deeper in the snow until it resists or reaches the ground
6. Repeat above as many times as necessary to reach the ground
7. The total station depth is recoded directly
8. Total station water equivalent and core length is the sum of the individual sections.

**Manual Snow Survey - Field Data Entry Form**

Snow Course No. 4 A 0 6 — 20 Yr. 04 Mo. 23 Da.

Snow Course Name: Tuttizzi Lake

Observers' Names: S Eicher, S van de Vall

Used: No. of Tubes: 2 Driving Wrench: Yes ☑ No ☐ Scale No: 4565

| Stn. No. | Snow Depth [cm] | | | Core | | Weight [cm] | | Snow Water Equival. [cm] | Density [%] |
|---|---|---|---|---|---|---|---|---|---|
| | with dirt plug | dirt plug length | without dirt plug | Length [cm] | Recover. [%] | tube and core | tube only | | |
| | A | B | C =A-B | D | E =D/A | F | G | H =F-G | I =H/C*100 |
| 1 | 21 | 3 | 18 | 18 | 86 | | 105 | | |
| 2 | 32 | 3 | 29 | 29 | 91 | | 1 | | |
| 3 | 25 | 3 | 22 | 23 | 92 | | 1 | | |
| 4 | 12 | 5 | 7 | 12 | 100 | | 1 | | |
| 5 | 30 | 4 | 26 | 30 | 100 | | 1 | | |
| 6 | 12 | 2 | 10 | 10 | 83 | Bulk Sample | | | |
| 7 | 31 | 3 | 28 | 30 | 97 | 1 | | | |
| 8 | 35 | 2 | 33 | 35 | 100 | 1 | | | |
| 9 | 12 | 1 | 11 | 12 | ~~83~~ 100 | 1 | | | |
| 10 | 49 | 3 | 46 | 40 | 82 | 191 | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | 230 | | | | | 86 | |
| Range | | | | | | | | | |
| Total | | | 230 | | | | | 86 | |
| Avg. | | | 23.0 | | | | | 8.6 | |

Snow Depth (J): 213 cm Snow Water Equivalent (K): 86 mm

Snow Den. (L=K/10/J*100): 37 %

**Figure 25: Notes taking for Bulk Samples.**

## 5.4 Tube too short for Snow Depth

There are 2 methods to deal with snow depth greater than the length of tube.

**Not having sufficient tubes to reach ground and having to use the alternate methods described in 5.4.1 and 5.4.2 is highly discouraged.**

### 5.4.1 Tube slightly too short

This method maximizes core recovery. It is illustrated in Figure 28.

1. Drive tube to its full length into the snow
2. Dig down around the tube to a depth of 15-30 cm and make sure additional snow does not fall into the open end of the tube
3. Place a gloved hand on top of the tube and continue to force it down. When the core has reached the top of the tube you have reached the limit of this method of measurement
4. If the ground is reached, the snow depth is the sum of the tube length and the distance of from the snow surface to the top of the tube.

### 5.4.2 Tube much too short

The station is measured in multiple sections. This method is illustrated in Figure 29.

1. Dig a hole in the snow at the sampling point to a depth of 75 – 100 cm. Do a test sample in the bottom of the hole. If the ground is not reached dig deeper
2. Slide a metal plate or from flat object into the side of the hole at the depth that is below the top of the grounded tube
3. Remove and clean out the tube
4. Drive the tube from the undisturbed surface down to the metal plate
5. Measure snow depth without dirt plug and core length of the first section of snowpack (Figure 30)
6. Weight and record weight of tube and core
7. Empty the tube and discard the core
8. Remove the snow above the metal plate
9. Sample from the snow surface where the metal plate was previously installed down to the ground
10. Measure snow depth with dirt plug and core length of the second section of snowpack
11. Weight and record weight of tube and core
12. Add snow depth
13. Add water equivalent
14. Calculate core recovery and density
15. For safety reasons infill the hole before leaving

## 5.5 Four-Point Survey at Automated Snow Water Equivalent Instrumentation

Verify automated snow instrumentation at least once per snow season.

The sampling procedure follows the procedures outline above.

The sampling points are at the center of the sides of scales or pillows, or evenly spaced at round pillows.

At the end of sampling discard the snow core on top of the snow pillow.

**Do not turn the tubes clockwise when sampling on a chain-armoured pillow or the cutter teeth may get damaged. Instead rotate the tubes counterclockwise and listen for a clicking noise to confirm ground contract with chain.**

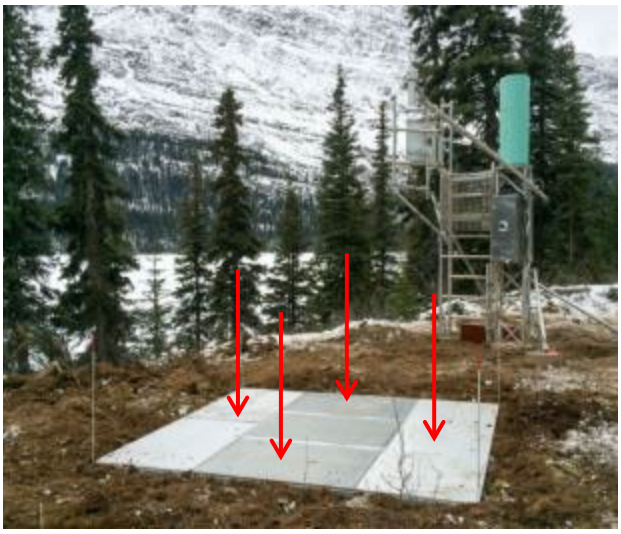


Figure 26: 4-point verification at a snow scale

Figure 27: 4-point verification at a snow pillow

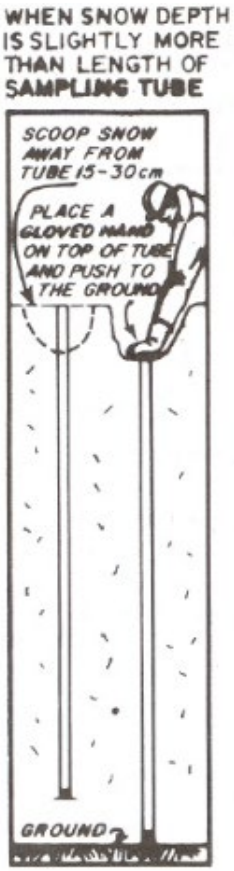



Figure 28: Method 1 – tube is slightly too short.

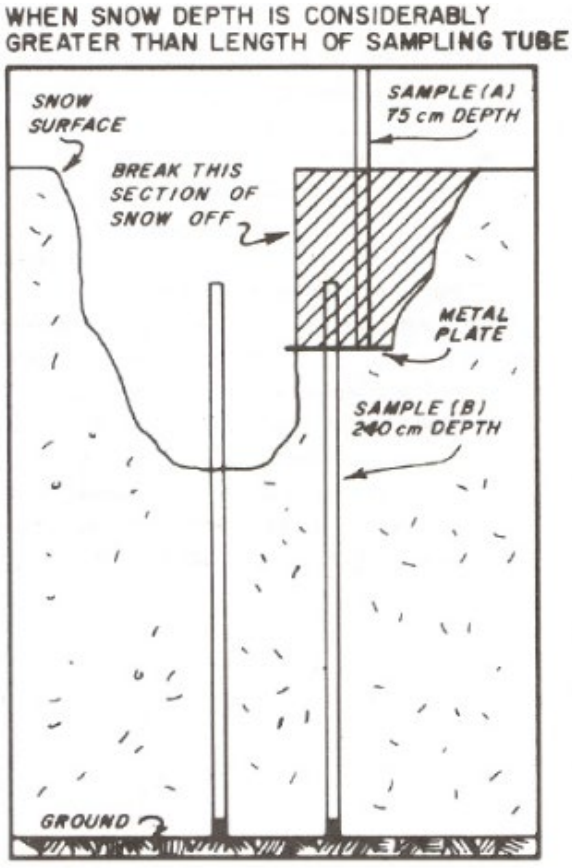
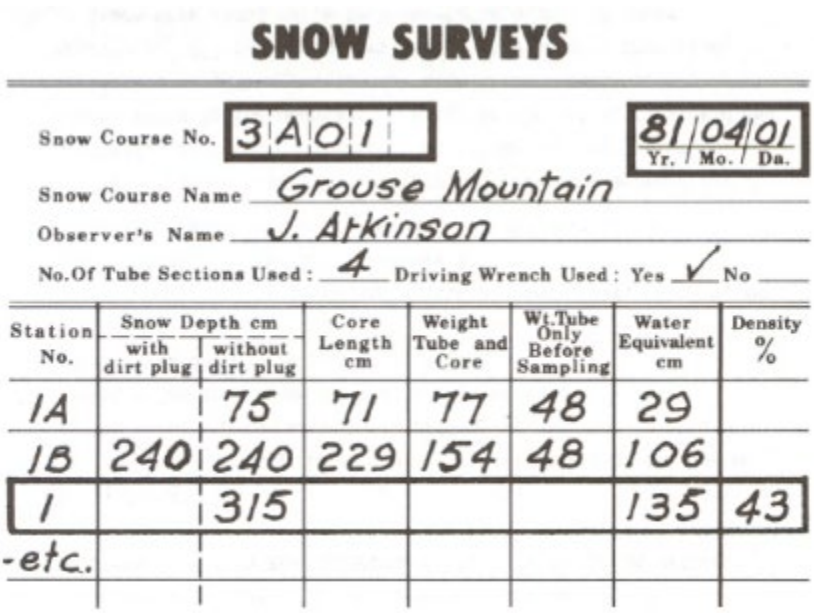



Figure 29: Method 2 – tube is much too short.



SNOW SURVEYS

Snow Course No. 3A01 — 81/04/01 (Yr. / Mo. / Da.)

Snow Course Name Grouse Mountain

Observer's Name J. Atkinson

No. Of Tube Sections Used: 4 Driving Wrench Used: Yes ✓ No

| Station No. | Snow Depth cm: with dirt plug | Snow Depth cm: without dirt plug | Core Length cm | Weight Tube and Core | Wt. Tube Only Before Sampling | Water Equivalent cm | Density % |
|---|---|---|---|---|---|---|---|
| 1A | | 75 | 71 | 77 | 48 | 29 | |
| 1B | 240 | 240 | 229 | 154 | 48 | 106 | |
| 1 | | 315 | | | | 135 | 43 |
| -etc. | | | | | | | |

**Figure 30: Notes taking for multi-section sampling.**

# 6 DIFFICULT SAMPLING CONDITIONS

Keep the sampling tube clean, coated, and in good condition.

- Deep dense snowpack
    - Thrust the tube quickly and smoothly down to the ground using continuous hand-over-hand motion. This is accomplished most effectively by two people working together. If this is unsuccessful then sampling in sections will be necessary.
    - If penetration is difficult, position the driving wrench no more than 1 m above the snow surface. This minimizes the chance of bending the tubes. Stand on the driving wrench handles. Then re-position the driving wrench further up on the tubes and repeat.
- Core freezing in the tube
    - This condition occurs where the tube temperature is above freezing and that of the snowpack is below freezing. The following steps may help to overcome this difficulty:
        - Cool the tube by setting it in the shade or burying it in the snow.
        - Clean the tube thoroughly then trust the tube rapidly through the snow without stopping until the ground is reached.
        - Take the samples in the early morning or evening when the air temperature is cooler.
        - Carry the snow core in the tube to the next station before removing it.
        - A clean well lubricated tube will help prevent the core from sticking. Thoroughly cleaning and oiling the tube (especially the cutter section) during sampling could make the difference between success and continued difficulty. If this does not work, try sampling in sections.

Re-lubrification after each station or snow course can be efficiently done by using a long rope with a weight on one end (e.g., large nut) and ball of cloth with silicone applied at the other. Feed the weight through the top end and pull the rope from the cutter end, thereby lubricating the entire multi-section tube in a single go.

- Ice layers in the snowpack
  - Apply a quick push by jerking down on the driving wrench will push the cutter through an ice layer that is not too thick.
  - As with deep snow pack you can position the driving wrench just above the snow pack and stand on it to penetrate stubborn ice layers.
  - A clean well lubricated tube will help prevent the ice layer from jamming. Thoroughly cleaning and oiling the tube (especially the cutter section) during sampling could make the difference between success and continued difficulty.
  - Cut through the ice by turning the tube clockwise.

**Never pump the tube up and down!**

**Record sampling difficulties in the remarks section.**

# 7 BC SNOW PROGRAM REPORTING

## 7.1 Submit Data via the Online BC Government Portal – preferred option

- Submit data as soon as possible, and after data have been quality-controlled.
- Submit manual snow survey and sensor (pillow, scale) verification data.
- Open in a browser – preferably Google Chrome or Firefox: https://apps.nrs.gov.bc.ca/ext/aqtsmss/
- To register for an ID use the link at the bottom of the login page (Figure 31).
- Enter data (Figure 32).
- If irregularities are to be reported then enter Sample Codes as listed in Table 4.
- Press the submit button.

## 7.2 Submit Data via email or phone

- If online submission is not possible, email the data to snow.survey@gov.bc.ca, leave a message on the snow phone 1-800-665-2246, or snow surveyors working for the GSO Hydrometeorological Monitoring Program email or phone frank.weber@bchydro.com.
- If a data entry error is made please email the change to snow.survey@gov.bc.ca as soon as possible. Do not try to re-enter the data.

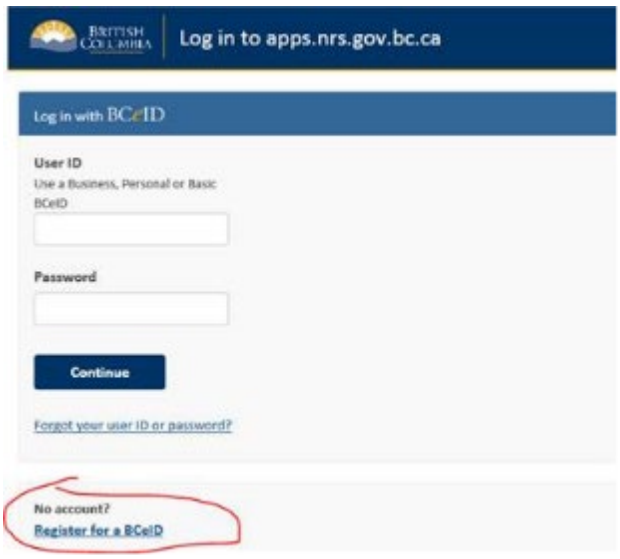



Figure 31: BC ENV Data Submission portal – login page

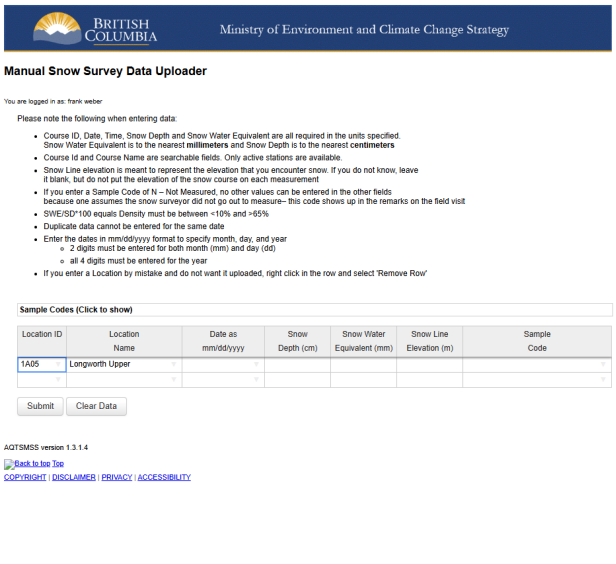



Figure 32: BC ENV Data Submission portal

### Table 4: Sample Codes

| Sample Codes | Description |
|---|---|
| Sampling Problems were encountered | e.g., significant ice lenses and crusts, icing of the tubes, low core recoveries |
| Early or late sampling | Sampling occurred more than 6 days before or after the nominal sampling date |
| Early or late sampling with problems encountered | |
| Not measured | Attempt to reach the site was made but was unsuccessful, e.g., due to unfavourable flying weather |
| Trace amount | The snowpack is too shallow for the Federal Snow Sampler to be used at all sample stations. Or, zero snow was recorded at the sampling stations but snow patches were noted in the vicinity. |
| Unscheduled survey was completed | |

## 7.3 Submit Snow Survey Quality-Control Spreadsheets

- Archive quality-control spreadsheets within 7 days of the snow survey in the appropriate regional MSSS - 1_Quality Controlled MSSS folder on the HM Program SharePoint site.
- Alternatively, email the spreadsheets to frank.weber@bchydro.com

## 7.4 Submit Snow Survey Forms

- At the end of the snow survey season take a copy of the field notes

- Mail the original field forms to the BC Snow Survey Program

  BC Ministry of Environment and Climate Change Strategy
  BC Snow Program
  PO Box 9536 Stn Prov Govt
  Victoria, BC V8W 9C4

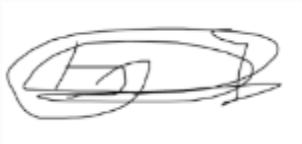
# 8 REFERENCES

BC Ministry of Environment (1981): Snow Survey Sampling Guide
BC Ministry of Environment (2005). Snow Surveys (Snow Survey forms)
UDDA NRCS (1984): Snow Survey Sampling Guide
https://www.wcc.nrcs.usda.gov/factpub/ah169/SnowSurveySamplingGuideHandout.pdf

# 9 APPROVAL

Created by: Frank Weber
*Field Programs Manager, BC Hydro*

Date: December 6, 2023



Reviewed by: *Tony Litke*
*Snow Program Supervisor, BC ENV*

Date: Dec 11, 2023

# 10 APPENDIX A

Manual Snow Survey – Field Data Entry Form

## Manual Snow Survey - Field Data Entry Form

Snow Course No. _____ Yr. _____ Mo. _____ Da. _____

Snow Course Name: _____

Observers' Names: _____

Used: No. of Tubes: _____ Driving Wrench: Yes☐ No☐ Scale No: _____

| Sto. No. | Snow Depth [cm] | | | Core | | Weight [cm] | | Snow Water Equival. [cm] | Density [%] |
|---|---|---|---|---|---|---|---|---|---|
| | with dirt plug | dirt plug length | without dirt plug | Length [cm] | Recover. [%] | tube and core | tube only | | |
| | 1 | 2 | 3 =1-2 | 4 | 5 =4/1 | 6 | 7 | 8 =6-7 | 9 =8/3*100 |
| | | | | | | | | | |
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| | | | | | | | | | |
| Range | | | | | | | | | |
| Total | | | | | | | | | |
| Avg. | | | | | | | | | |

Snow Depth (10): _____ cm Snow Water Equivalent (11): _____ mm

Snow Density (12=11/10): _____ %

Sampling start (hh:mm): _____ End: _____

## Sampling Conditions

A. **Weather**

☐ Freezing ☐ Thawing Temp: _____ °C
☐ Blowing ☐ Calm
Skies: ☐ Clear ☐ Partly Cloudy: ☐ Overcast

B. **Precipitation**

☐ None ☐ Raining ☐ Snowing

C. **Surface Snow Conditions**

Fresh fallen snow depth _____ cm
☐ Wet ☐ Dry
☐ Soft ☐ Crusted
Support on person: ☐ None ☐ On skis/snowshoe ☐ On foot
Serious drifting: ☐ No ☐ Yes* Which stations _____
Evidence of over snow traffic: ☐ Yes* ☐ No

D. **Sampling Conditions**

☐ Easy ☐ Moderately difficult* ☐ Very difficult*
Ground reached on all samples: ☐ Yes ☐ No*
Ice layer(s): ☐ In snowpack ☐ On ground
Ground under snow: ☐ Dry ☐ Damp
☐ Very wet ☐ Frozen

E. **General Conditions en Route**

Snow line elevation: _____ m
Thaw: ☐ None ☐ Sunny slopes ☐ General
Small streams: ☐ Bridged with snow ☐ Open
☐ Clear ☐ Muddy

**Remarks:** _____

_____

_____

_____

_____

_____

_____

_____

*Describe under remarks

## Quality Control

**Checked By:** _____ **Date:** _____

End of document