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Forsmark site investigation

Snow depth, frost in ground and ice cover during the winter 2002/2003

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Studsvik RadWaste AB

November 2003

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1 Introduction

This document reports the data gained in "Registration of snow depth, depth of frost in the ground and time for ice cover/ice break-up" which is one of the activities performed within the site investigation at Forsmark /1/. The work was conducted according to activity plan AP PF 400-02-34, version 1.0 (SKB internal controlling document).

The activity comprised measurements and registrations of certain weather parameters within the Forsmark area, in winter. Three parameters, depth of snow, depth of frost penetration in the ground, and duration of ice cover was measured and registered. The map in Figure 1-1 shows positions for the various measurements.

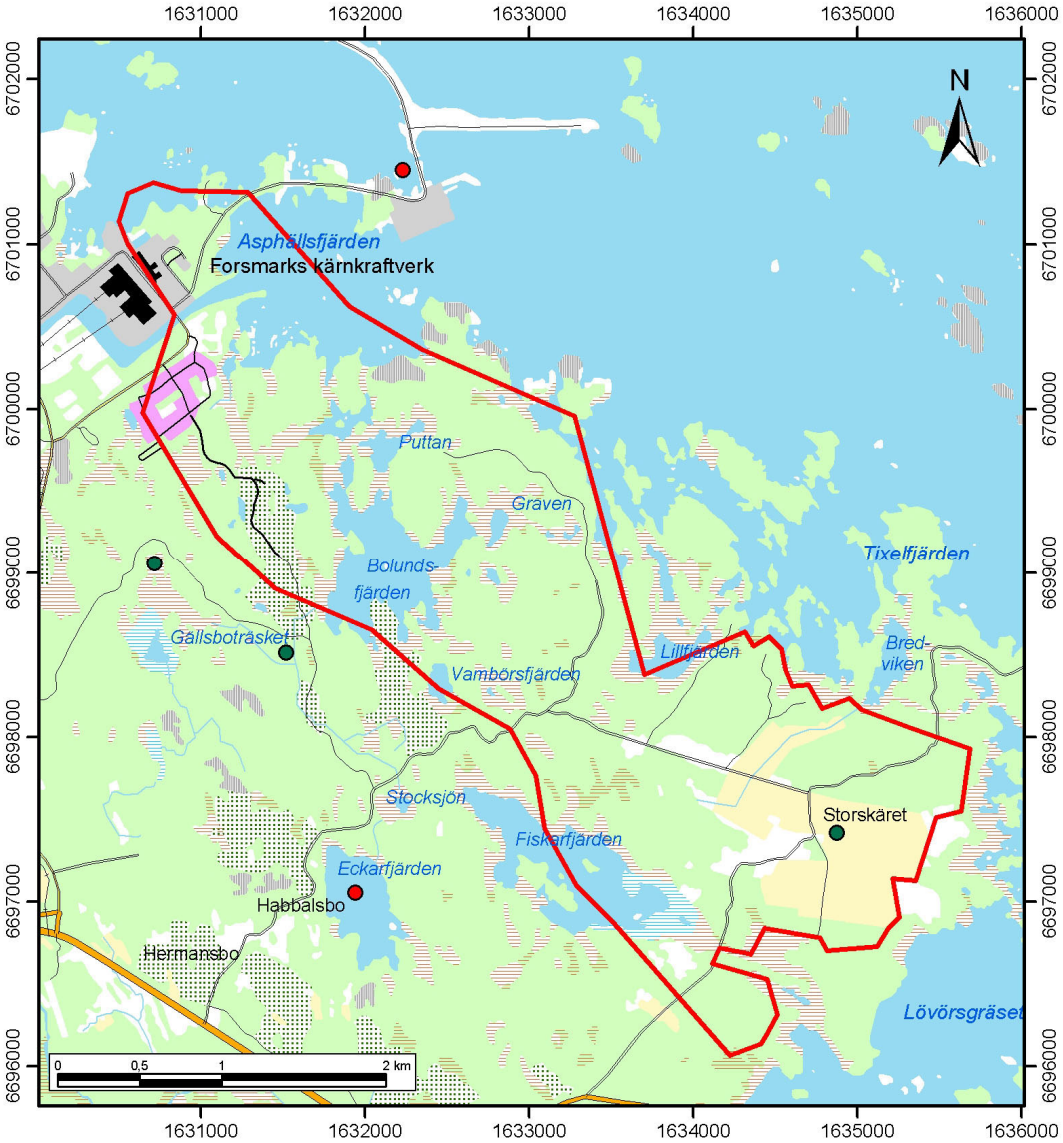

Figure 1-1. *Locations of measurements and registration for frost penetration depth in the ground (green dots), snow depth (two of the green dots), and ice cover (red dots).*

2 Objective and scope

This activity was performed in order to characterise the area considering the local climate. The obtained data are going to be used, in combination with other meteorological data, in hydrological and ecological model calculations.

3 Equipment

3.1 Description of equipment

3.1.1 Snow depth

The snow depth was measured according to SMHI's Handbook for observers (In Swedish: SMHI:s handbok för observatörer) /2/. The measuring device was made up of a measuring stick graded in centimetres.

3.1.2 Frost depth in ground

The frost depth in the ground was measured according to SMHI's Handbook for observers /2/. The measurements are performed with a specific measuring device consisting of a protective tube with a disc and a protective hood. The measurement tube, which includes a solution consisting of methylene blue and distilled water, is installed inside the protective tube. When the water freezes the blue colour disappears, a fact that is utilized when observing penetration of frost in the ground. The measurement tube is graded in centimetres.

The disc mentioned above, which is used as marker of the ground level, and the protective hood are normally the only visible parts of the equipment, see Figure 3-1. However, installation of the device at Forsmark was rather tricky due to the large content of boulders in the ground. As a consequence, a small part of the measuring tube could not be pressed down into the soil layer. However, this has no influence on the results of the measurements.

Figure 3-1. *Measuring device for registration of frost depth in the ground.*

3.1.3 Ice cover

The observations of ice freeze-up and break down respectively were performed by visual inspections.

4 Execution

The activity was separated in five items:

1. Measurements of the co-ordinates for each measurement station.
2. Measurements of snow depth.
3. Measurements of frost depth in the ground.
4. Observations of ice freeze-up/Ice break-up.
5. Documentation.

4.1 Measurements of co-ordinates

Co-ordinates for each measurement station (see Figure 1-1) were settled according to SKB's instruction SKB MD 110.001 /3/. The co-ordinates were then noted in a specific protocol. Each object recieved a specific ID-code, see Table 4-1. For measurements of snow depth and observations of ice conditions, the objects were registered as surfaces, while the objects for frost in the ground were registered as points.

Table 4-1. ID-code numbers for the objects of this activity.

Measurement/observation parameter	ID-code	Name
Snow depth	AFM000071	Storskäret (open field)
	AFM000072	Skogsgläntan (glade)
Frost in ground	PFM002458	Storskäret (open field)
	PFM002459	Skogsgläntan (glade)
	PFM002460	Gällsboträsket (wetland)
Ice cover	AFM000010	Lake Eckarfjärden
	AFM000075	Bay at SFR

4.2 Execution of measurements and observations

4.2.1 Snow depth

Snow depth is in this case defined as the thickness of the snow layer from the snow surface to the ground. The characteristics of the site for execution of the measurements are of vital importance. The site should have a fairly smooth ground surface and the snow should not fall in drifts or be able to blow away. The sampling stations were a forest glade and a part of a field, respectively (see Figure 1-1). These two stations were selected as two extreme sites, which should give data from one sheltered area (glade) and one wind exposed area (field). The selected areas were marked with poles of such a length that they would be seen even at maximum snow depth, see Figure 4-1.

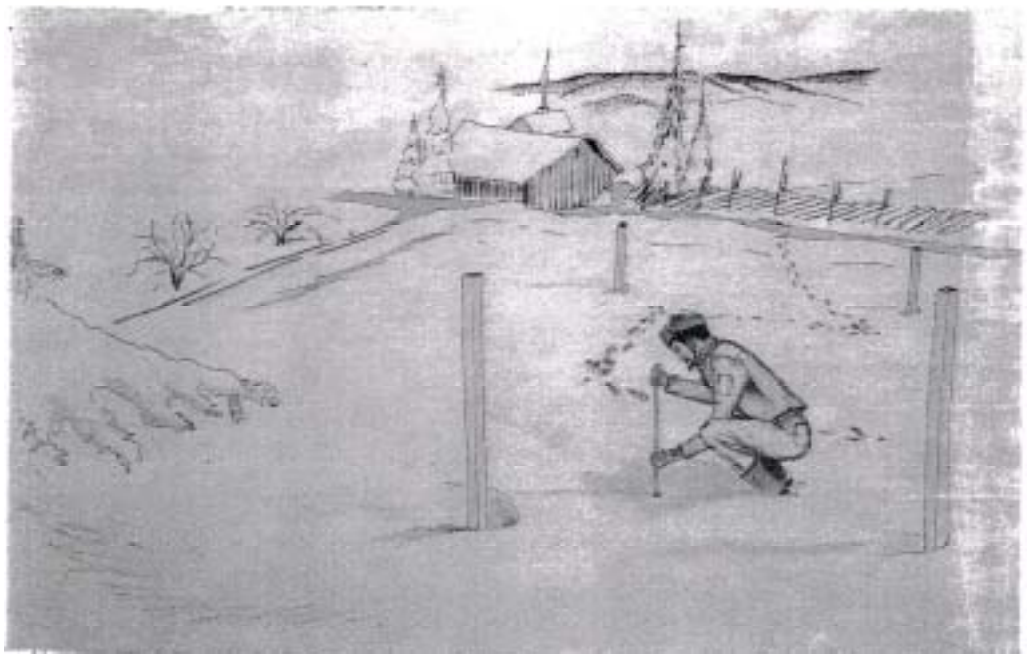

Figure 4-1. *Measurement of snow depth, from SMHI's Handbook for observers /2/.*

Measurements were made once a week, starting from the autumn's first snowfall, continuing until the snow was completely melted in spring.

The measurements were performed with a graded measuring stick, which was vertically squeezed through the snow layer until the ground was hit. The snow depth was read in centimetres. The snow depth was determined at six points within the measuring area. The average snow depth was then calculated.

The measurements were carried out once a week at both measurement stations, even if no new snow had been falling, since packing, melting and evaporation should be considered as well.

4.2.2 Frost depth in ground

For measurement of frost penetration depth in the ground, equipment according to section 3.1.2 was used. The measurements were carried out on three sites representative for the local conditions considering soil characteristics and topography. Two of the sites, the forest glade and the field, were the same as those for measurements of snow depth. The third place was situated in a wetland, (see Figure 1-1). The soil types at the three stations were clayey till (Storskäret, PFM00002458), sandy till (Skogsgläntan, PFM00002459) and gyttja clay (0,7 m) underlayered by sandy till (Gällsboträsket, PFM00002460).

The measuring device is read by observing the uncoloured part of the tube solution, i e the frozen part, which indicates the border between ice and water.

The measurements were performed once a week in connection with registration of snow depth.

4.2.3 Ice cover

Observations of ice freeze-up/ice break-up were made for a sea bay near SFR and for one of the lakes in the area (Lake Eckarfjärden).

The sea ice conditions were registered every morning during working days and once a week at the lake. While ice freeze-up was observed on the lake, the other lakes in the area were observed as well, to check the representativity of the Lake Eckarfjärden.

The time for the first ice freeze-up, which is important to register, is defined as the first occasion during the season when a lasting ice freeze-up occurs (after that no occasional break-up occurs until spring). The last ice break-up, is defined as the time when the ice cover from the winter season finally breaks up. Short periods in early autumn with thin ice covers were neglected, as well as ice rests during springtime.

4.3 Data handling and documentation

The activity leader for Surface ecosystems executed all measurements and observations in the activity. The field note (FN) of the primary data of this activity registered in SICADA is “Forsmark 122”. Exclusively primary data registered in SICADA should be used for model calculations and other assessments of the site.

5 Results

5.1 Snow depth

The average snow depth at the two stations for snow depth measurements is presented in Figure 5-1. The complete set of *primary data* is presented in Appendix 1, Table 1 and 2.

As expected, the graphs in Figure 5-1 show that the snow depth was larger at the more sheltered area (the glade). At this site the snow cover also persisted longer. The pattern of high and low values is quite similar between the two observed places.

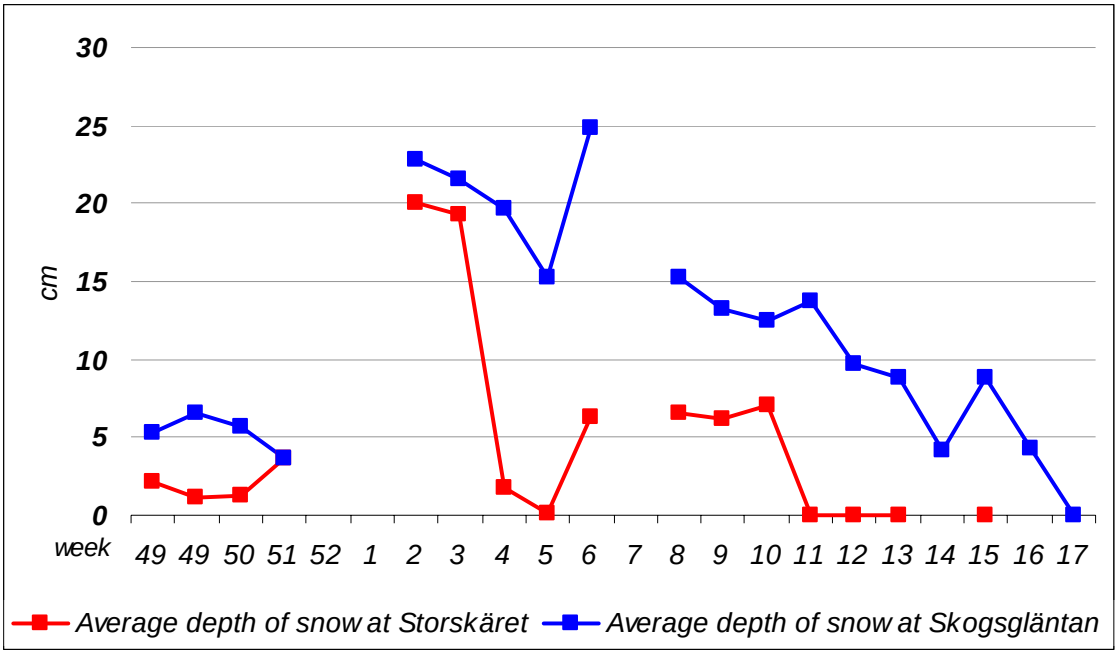

Figure 5-1. Snow *depth at Storskäret (AFM000071), red line, and at Skogsgläntan (AFM000072), blue line, during the winter 2002/2003.*

5.2 Frost penetration depth in ground

The measured penetration depth of frost in the ground at the three stations, Storskäret (PFM002458), a field, Skogsgläntan (PFM002459), a glade, and Gällsboträsket (PFM002460), a wetland, is presented in Figure 5-2a-c. The complete sets of primary data are presented in Appendix 2, Table 1-3.

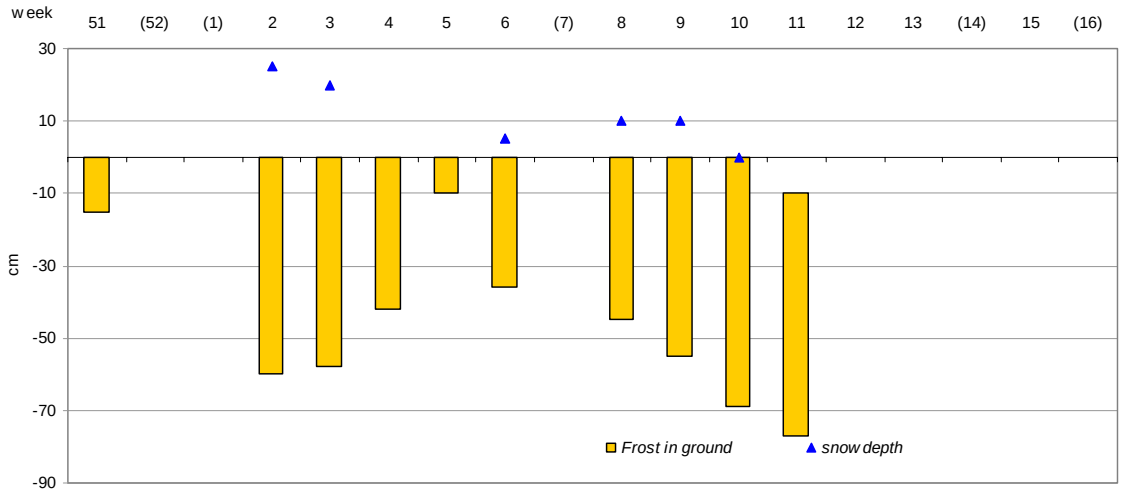

Figure 5-2a. *Penetration depth of frost in the ground at station Storskäret (PFM002458). Weeks with number in brackets indicate that no measurement has been performed.*

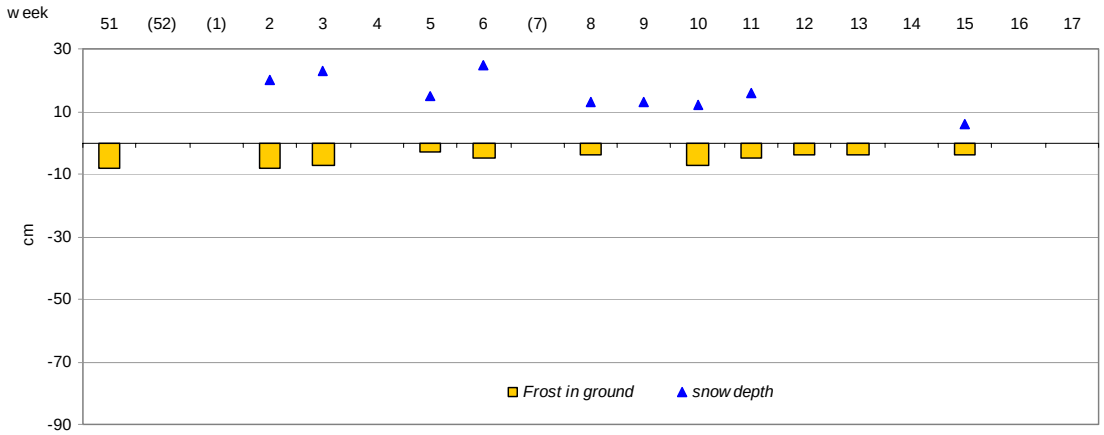

Figure 5-2b. *Penetration depth of frost in the ground at station Skogsgläntan (PFM002459). Weeks with number in brackets indicate that no measurement has been performed.*

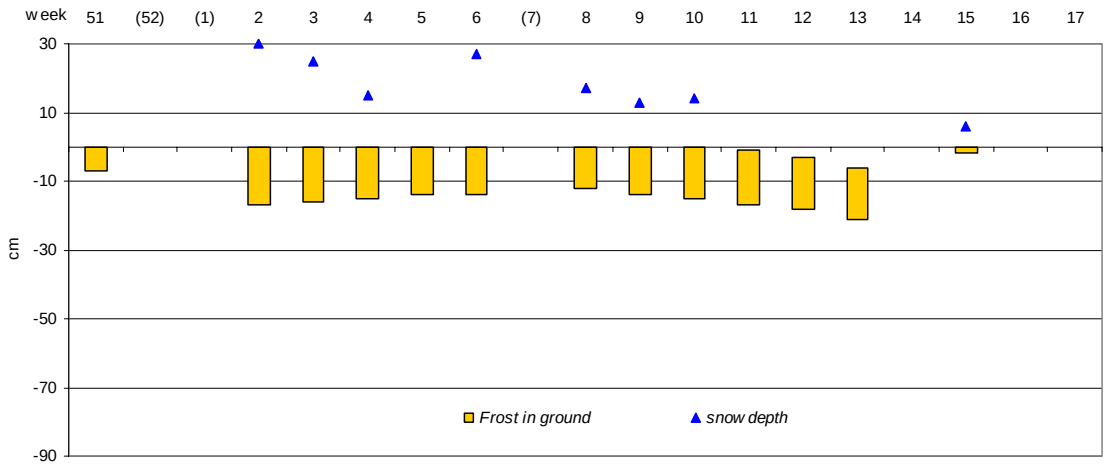

Figure 5-2c. *Penetration depth of frost in the ground at station Gällsboträsket (PFM002460). Weeks with number in brackets indicate that no measurement has been performed.*

For the two stations Gällsboträsket and Skogsgläntan the penetration depths of frost are low compared to those at the station Storskäret. As mentioned before, the two earlier are situated in sheltered places, whereas the station at Storskäret is situated in the middle of a field and is exposed to winds to a much larger degree. This may be part of the explanation. The snow cover may also have some significance for the ground frost, see section 5.1. Another important factor is the soil type at the different stations. Because of the small amount of data no thorough discussion of the results is presented here.

5.3 Ice cover

Ice conditions observed in the Forsmarks area are shown in Table 5-1. Lake Eckarfjärden was selected as representative for the large lakes in the area concerning ice cover. When the ice froze and broke up, the conditions in the other lakes in the area were controlled and no larger deviations were found. The data from Lake Eckarfjärden can therefore be used also for the other large lakes in the area.

Table 5-1. Time for ice freeze-up and ice break-up in Lake Eckarfjärden and in a bay of the Baltic sea at the Forsmarks area.

	Date for ice freeze-up	Date for ice break-up	Period with ice cover (days)
Lake Eckarfjärden (AFM000010)	2002-11-12	2003-04-02	141
Sea bay at SFR (AFM000075)	2003-01-07	2003-03-31	83

5.4 Discussion

The winter 2002/2003 was the first registration period for this activity and therefore there are no data for comparison. It could be interesting to compare this data with other meteorological data such as air temperature and wind velocity for the period. During 2003, local measurements of temperature, wind velocity and direction, precipitation, air moisture and global radiation have been initiated. This data will be valuable for interpreting the winter data for 2003/2004 from this activity.

From a hydrological point of view it is interesting to supplement the snow depth data with the water content of the snow. This can easily be done by sampling and weighting snow using a plexiglas tube of known diameter and a simple scale. This will be done in the registrations planned for the coming years.

6 References

1 **SKB, 2000.** Variabler i olika ekosystem, tänkbara att beskriva vid platsundersökning för ett djupförvar. SKB R-00-19, Svensk Kärnbränslehantering AB.

2 **SMHI.** Handbok för observatörer. Internal document.

3 **SKB, 2002.** Instruktion för inmätning och avvägning av objekt. SKB MD 110.001, Svensk Kärnbränslehantering AB.

Appendix 1

Primary data from snow depth measurements during the winter 2002/2003

The data collected during the snow depth measurements are presented below as individual measurements as well as the calculated average snow depth and a visual estimate of the coverage degree. S=completely or almost covered ground, SB=more than half of the ground snow covered but not completely covered, BS=more than half of the ground free of snow but not completely, B=the ground completely or almost completely free of snow.

Table 1. Snow depth at Storskäret (AFM000071) during the winter 2002/2003.

Date	Point 1 (cm)	Point 2 (cm)	Point 3 (cm)	Point 4 (cm)	Point 5 (cm)	Point 6 (cm)	Average Snow Depth (cm)	Snow Coverage
2002-12-02	1.5	1.5	3.0	1.5	3.0	3.0	2.2	SB
2002-12-06	2.0	0.5	0.5	1.0	0.5	2.0	1.1	BS
2002-12-11	1.0	1.0	1.5	1.5	1.0	1.0	1.2	B
2002-12-16	3.0	5.5	1.5	1.0	5.5	5.0	3.6	B
2003-01-08	18.0	20.0	21.0	22.0	19.0	20.0	20.0	S
2003-01-13	23.0	19.0	25.0	16.0	18.0	15.0	19.3	S
2003-01-24	0.5	1.5	3.0	2.0	1.5	2.0	1.8	BS
2003-01-30	0.0	0.5	0.0	0.0	0.0	0.0	0.1	B
2003-02-05	10.0	5.0	10.0	2.0	7.0	4.0	6.3	S
2003-02-18	9.0	9.0	7.0	8.0	2.0	4.0	6.5	S
2003-02-24	8.0	2.0	11.0	3.0	7.0	6.0	6.2	S
2003-03-06	8.0	3.0	8.0	10.0	5.0	8.0	7.0	SB
2003-03-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	B
2003-03-19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	B
2003-03-26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	B
2003-04-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	B

Table 2. Snow depth at Skogsgläntan (AFM000072) during the winter 2002/2003.

Date	Point 1 (cm)	Point 2 (cm)	Point 3 (cm)	Point 4 (cm)	Point 5 (cm)	Point 6 (cm)	Average Snow Depth (cm)	Snow Coverage
2002-12-02	7.0	3.0	5.0	7.0	6.0	4.0	5.3	SB
2002-12-06	7.0	5.0	4.0	9.0	8.0	6.0	6.5	SB
2002-12-11	5.0	6.0	7.0	4.0	5.0	7.0	5.7	SB
2002-12-16	3.0	5.5	1.5	1.0	5.5	5.0	3.6	SB
2003-01-08	22.0	23.0	24.0	22.0	22.0	24.0	22.8	S
2003-01-13	21.0	22.0	23.0	19.0	21.0	23.0	21.5	S
2003-01-24	20.0	16.0	23.0	23.0	20.0	16.0	19.7	S
2003-01-30	13.0	19.0	11.0	21.0	15.0	12.0	15.2	S
2003-02-06	24.0	26.0	24.0	25.0	25.0	25.0	24.8	S
2003-02-18	16.0	18.0	16.0	14.0	13.0	14.0	15.2	S
2003-02-24	13.0	13.0	16.0	13.0	12.0	12.0	13.2	S
2003-03-06	12.0	12.0	13.0	13.0	13.0	12.0	12.5	S
2003-03-14	9.0	14.0	18.0	15.0	10.0	16.0	13.7	S
2003-03-19	10.0	19.0	3.0	9.0	2.0	15.0	9.7	S
2003-03-26	7.0	5.0	10.0	15.0	8.0	8.0	8.8	S
2003-04-02	3.0	5.0	8.0	4.0	3.0	2.0	4.2	BS
2003-04-09	5.0	6.0	8.0	8.0	11.0	15.0	8.8	S
2003-04-15	7.0	11.0	3.0	2.0	1.0	2.0	4.3	BS
2003-04-25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	B

Appendix 2

Primary data from measurements of frost penetration depth in the ground during the winter 2002/2003

The data collected during the measurements of ground frost are presented below. As the whole device was not situated within the ground, the levels for ground surface is 30 or 40 cm instead of 0 cm. The upper registration is the level of the upper border of the ground frost read from the device, whereas the lower registration is the lower border. The upper and lower level of ground frost are calculated using the level of the ground surface and the upper and lower registration, respectively. From these two levels the distribution of ground frost has been calculated.

Table 1. Frost penetration depth in ground during the winter 2002/2003 at Storskäret (PFM002458).

Date	Ground surface (cm)	Upper reg. (cm)	Lower reg. (cm)	Upper level of ground frost (cm)	Lower level of ground frost (cm)	Ground frost distribution (cm)	Comments
2002-12-16	40.0	0.0	55.0	0.0	15.0	15.0	
2003-01-08	40.0	0.0	100.0	0.0	60.0	60.0	Snow depth 25 cm
2003-01-13	40.0	0.0	98.0	0.0	58.0	58.0	Snow depth 20 cm
2003-01-24	40.0	0.0	82.0	0.0	42.0	42.0	
2003-01-30	40.0	0.0	50.0	0.0	10.0	10.0	
2003-02-05	40.0	0.0	76.0	0.0	36.0	36.0	Snow depth 5 cm
2003-02-18	40.0	35.0	85.0	0.0	45.0	45.0	Snow depth 10 cm
2003-02-24	40.0	0.0	95.0	0.0	55.0	55.0	Snow depth 10 cm
2003-03-06	40.0	0.0	109.0	0.0	69.0	69.0	No snow
2003-03-14	40.0	50.0	107.0	10.0	67.0	67.0	
2003-03-19	40.0	0.0	0.0	0.0	0.0	0.0	
2003-03-26	40.0	0.0	23.0	0.0	0.0	0.0	
2003-04-09	40.0	0.0	40.0	0.0	0.0	0.0	

Table 2. Frost penetration depth in ground during the winter 2002/2003 at Skogsgläntan (PFM002459).

Date	Ground surface (cm)	Upper reg. (cm)	Lower reg. (cm)	Upper level of ground frost (cm)	Lower level of ground frost (cm)	Ground frost distribution (cm)	Comments
2002-12-16	40.0	0.0	48.0	0.0	8.0	8.0	
2003-01-08	40.0	0.0	48.0	0.0	8.0	8.0	Snow depth 20 cm
2003-01-13	40.0	0.0	47.0	0.0	7.0	7.0	Snow depth 23 cm
2003-01-30	40.0	0.0	43.0	0.0	3.0	3.0	Snow depth 15 cm
2003-02-06	40.0	0.0	45.0	0.0	5.0	5.0	Snow depth 25 cm
2003-02-18	40.0	10.0	44.0	0.0	4.0	4.0	Snow depth 13 cm
2003-03-06	40.0	0.0	47.0	0.0	7.0	7.0	Snow depth 12 cm
2003-03-14	40.0	0.0	45.0	0.0	5.0	5.0	Snow depth 16 cm
2003-03-19	40.0	39.0	44.0	0.0	4.0	4.0	
2003-03-26	40.0	0.0	44.0	0.0	4.0	4.0	
2003-04-02	40.0	0.0	0.0	0.0	0.0	0.0	
2003-04-09	40.0	0.0	44.0	0.0	4.0	4.0	Snow depth 6 cm
2003-04-15	40.0	0.0	40.0	0.0	0.0	0.0	
2003-04-25	40.0	0.0	40.0	0.0	0.0	0.0	

Table 3. Frost penetration depth in ground during the winter 2002/2003 at Gällsboträsket (PFM002460).

Date	Ground surface (cm)	Upper reg. (cm)	Lower reg. (cm)	Upper level of ground frost (cm)	Lower level of ground frost (cm)	Ground frost distribution (cm)	Comments
2002-12-16	30.0	0.0	37.0	0.0	7.0	7.0	
2003-01-08	30.0	0.0	47.0	0.0	17.0	17.0	Snow depth 30 cm
2003-01-13	30.0	0.0	46.0	0.0	16.0	16.0	Snow depth 25 cm
2003-01-24	30.0	0.0	45.0	0.0	15.0	15.0	Snow depth 15 cm
2003-01-30	30.0	0.0	44.0	0.0	14.0	14.0	
2003-02-06	30.0	0.0	44.0	0.0	14.0	14.0	Snow depth 27 cm
2003-02-18	30.0	0.0	42.0	0.0	12.0	12.0	Snow depth 17 cm
2003-02-24	30.0	0.0	44.0	0.0	14.0	14.0	Snow depth 13 cm
2003-03-06	30.0	0.0	45.0	0.0	15.0	15.0	Snow depth 14 cm
2003-03-14	30.0	31.0	46.0	1.0	16.0	16.0	
2003-03-19	30.0	33.0	45.0	3.0	15.0	12.0	
2003-03-26	30.0	36.0	45.0	6.0	15.0	11.0	
2003-04-02	30.0	0.0	0.0	0.0	0.0	0.0	
2003-04-09	30.0	0.0	32.0	0.0	2.0	2.0	Snow depth 6 cm
2003-04-15	30.0	0.0	30.0	0.0	0.0	0.0	
2003-04-25	30.0	0.0	30.0	0.0	0.0	0.0	