

**P-07-81**

## **Forsmark site investigation**

# **Snow depth, snow water content and ice cover during the winter 2006/2007**

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April 2007

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*Keywords:* Snow depth, Snow water content, Ice cover, AP PF 400-07-010.

Data in SKB's database can be changed for different reasons. Minor changes in SKB's database will not necessarily result in a revised report. Data revisions may also be presented as supplements, available at [www.skb.se](http://www.skb.se).

A pdf version of this document can be downloaded from [www.skb.se](http://www.skb.se).

## **Abstract**

During the winter of 2006/2007 snow depth and ice cover have been measured and observed. It is the fifth consecutive year that these measurements and observations have been performed. In addition to these parameters the water content of the snow was calculated from the weight of a snow sample at each measurement. Unlike previous years the ground frost penetration depth was not registered during this activity.

The first snow of the season fell the first day of November 2006 but no persistent snow cover was established until late January 2007. Then the ground was more or less snow-covered until mid March.

The period of ice cover was 98 days in Lake Eckarfjärden and the sea bay at SFR was ice-covered for 60 days.

## Sammanfattning

Under vintern 2006/2007 har de meteorologiska parametrarna snödjup och istäcke mätts och observerats. Det är femte året i rad som dessa parametrar har registrerats. Under denna aktivitet har även snöns vatteninnehåll beräknats utifrån vikten på en bestämd volym snö. Till skillnad från tidigare år har ingen mätning av tjäldjup utförts under denna aktivitet.

Säsongens första snö föll första november men låg inte kvar. Därefter dröjde det till sent i januari innan ett varaktigt snötäcke etablerades. Snön låg sedan kvar till i mitten av mars.

Istäcket varade 98 dagar i Eckarfjärden och 60 dagar i havsviken vid SFR.

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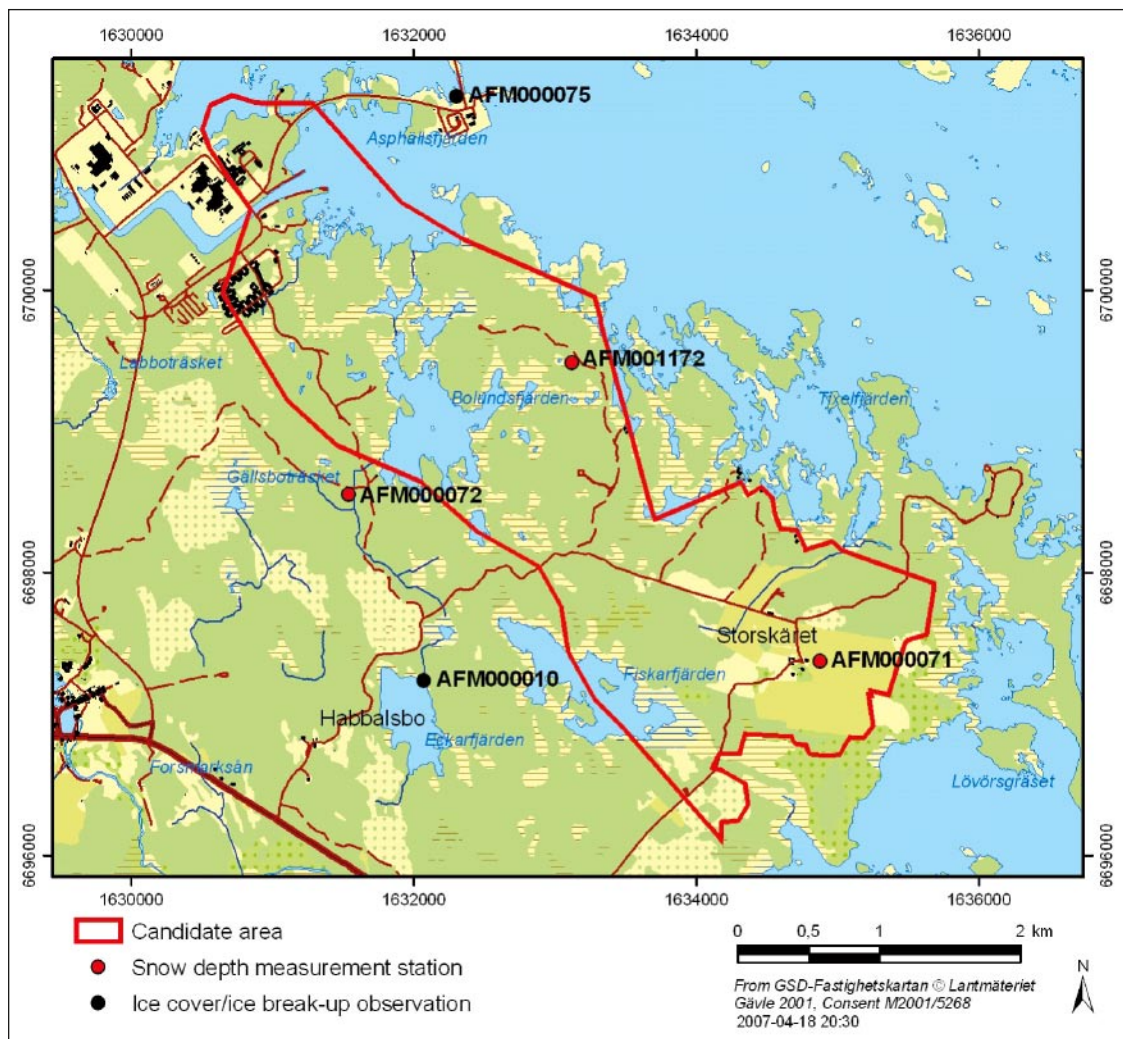
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# 1 Introduction

This document reports the data gained in "Registration of snow depth and time for ice cover/ice break-up", which is one of the activities performed within the site investigation at Forsmark. The work was carried out in accordance with activity plan SKB PF 400-07-010. Similar studies were performed during the winters of 2002/2003 /1/, 2003/2004 /2/, 2004/2005 /3/ and 2005/2006 /4/ and this activity is in large parts carried out in the same way.

The activity comprised measurements and registrations of certain weather parameters in the Forsmark area in winter. Three parameters; snow depth, snow weight and duration of ice cover was measured and registered in the field. The water content of the snow was calculated using the results from the snow weight measurements. The map in Figure 1-1 below shows the positions for the measurements. The activity was performed from November 2006 until late March 2007.

In Table 1-1 controlling documents for performing this activity are listed. The activity plan is SKB's internal controlling document.



**Figure 1-1.** Locations of the snow depth/water content measurement stations and the ice cover/ice break-up observation points.

**Table 1-1. Controlling documents for performance of the activity.**

<b>Activity plan</b>	<b>Number</b>	<b>Version</b>
Registration of snow depth, ground frost penetration depth and time for ice cover/ice break up	AP PF 400-07-010	1.0
<b>Other controlling documents</b>	<b>Number</b>	<b>Version</b>
SMHI, Handbok för observatörer	SMHI internal document	N/A

Original data from the reported activity are stored in the primary database Sicada. Data are traceable in Sicada by the Activity Plan number (AP PF 400-07-010). Only data in databases are accepted for further interpretation and modelling. The data presented in this report are regarded as copies of the original data. Data in the databases may be revised, if needed. Such revisions will not necessarily result in a revision of the P-report, although the normal procedure is that major revisions entail a revision of the P-report. Minor revisions are normally presented as supplements, available at [www.skb.se](http://www.skb.se).

## 2 Objective and scope

This activity was conducted in order to obtain data about the local climate which, in combination with other meteorological data, will be used in hydrological and ecological modelling. The activity started at the first snowfall of the season and was completed when all the snow had melted away in mid March 2007.

The following parameters were measured:

- Snow depth at three locations.
- Snow weight at three locations.
- Time for ice freeze-up and ice break-up at two locations.

The snow weight was used to calculate the water content of the snow.



## 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) /5/. A transparent plastic tube graded in centimetres, with 5 centimetres inner diameter, was used for the snow depth measurement, see Figure 3-1.

#### 3.1.2 Snow weight

The snow weight was measured by taking a snow sample with the transparent plastic tube mentioned above. A spatula was used to keep the sample in the tube so it could be transferred to a plastic bag. To measure the weight, a scale was used. The scale could measure up to 200 g and was graded with 2 g increments. The equipment used to take snow samples and measure the snow weight is shown in Figure 3-1.

#### 3.1.3 Ice cover

The observations of ice-coverage and ice-breakup were performed by visual inspections.



*Figure 3-1. Equipment used to measure snow depth and snow weight.*

## 4 Execution

This activity consisted of three different items:

1. Measurements of snow depth, snow weight and determination of water content.
2. Observations of ice freeze-up and ice break-up.
3. Documentation.

### 4.1 General

Measurements of snow depth and snow weight were made once a week between January 23 and March 22, 2007. Ice conditions were observed with varying regularity depending on temperature and weather conditions. Each object for measurements/observations has a specific ID-code according to Table 4-1. The snow depth and snow weight objects as well as the objects where ice conditions were observed were registered as surfaces (AFM-numbers).

**Table 4-1. ID-code numbers and co-ordinates for the objects of this activity.**

Parameter	ID-code	X	Y	Type of location
Snow				
Depth and water content	AFM000071			Ploughed arable land
	1	6697419	1634872	
	2	6697413	1634869	
	3	6697412	1634874	
	4	6697416	1634877	
Depth and water content	AFM000072			Forest glade
	1	6698528	1631524	
	2	6698524	1631527	
	3	6698529	1631527	
	4	6698534	1631523	
Depth and water content	AFM001172			Forest glade
	1	6699475	1633157	
	2	6699468	1633157	
	3	6699473	1633160	
	4	6699480	1633160	
Ice cover	AFM000010	6697230	1632050	Lake
	AFM000075	6701371	1632303	Sea bay

## 4.2 Execution of measurements and observations

### 4.2.1 Measurements of snow depth, snow weight and determination of water content

Snow depth is in this case defined as the thickness of the snow cover from the snow surface to the ground. The site should have a fairly smooth ground surface and the snow should not fall in drifts or be able to blow away. There were three sample stations, one in an open field at Storskäret, one in a forest glade southwest of Lake Bolundsfjärden and one in a forest glade close to Jungfruholm, see Figure 1-1. The sample stations were approximately 4×4 m and marked with poles.

Measurements were made once a week, starting at January 23 and continuing until the snow was completely melted in spring, which was March 22. The measurements were made even if no new snow had been falling, since packing, melting and evaporation should be considered as well.

The snow depth was measured at 6 points within each sample station and the average depth of the station was calculated. The depth was measured with a transparent plastic tube which also was used to take snow samples for water content determination. The tube was pressed down through the snow layer until it hit the ground and the depth was measured to the nearest centimetre, see Figure 4-1.



*Figure 4-1. Measurement of snow depth with plastic tube at Storskäret, AFM000071.*

The snow weight was measured at all three sample stations. At each sample station 6 snow samples were taken with the plastic tube and transferred to a plastic bag for measurement of the weight of each sample. The weight of the bag, approximately 4 g, was subtracted. If the sample weighed more than 200 g, the sample was divided in two subsamples that were weighed separately. In these cases the weight of the bag was subtracted for each measurement. The average snow weight of the station was then calculated. In cases of hard wind, the body of the person performing the measurement and natural objects in the vicinity was used to block the wind to avoid incorrect readings on the scale.

On the basis of average snow depth and snow weight the water content was determined with the following calculations:

Inner diameter of plastic tube: 50 mm.

Inner area of the plastic tube ( $\pi r^2$ ): 19.635 cm<sup>2</sup>.

Water density: 1 g/cm<sup>3</sup>.

Water content of the snow in mm: snow weight (g)/19.635 (cm<sup>2</sup>) × 10.

#### **4.2.2 Observations of 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 ice conditions were observed every morning during working days for the sea and approximately once a week for the lake. 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 cover is established, i.e. when there are no occasional ice break-ups until spring. The last ice break-up is defined as the time when the ice cover from the winter season finally breaks up and no occasional freeze-ups occur. Short periods in early autumn with only thin ice cover were neglected, as well as ice remains during spring.

### **4.3 Data handling**

All measurements and observations in the activity were made by SKB. The measurements and observations were noted in field protocols and then transferred to Excel-files. The primary data of this activity are registered in Sicada and are traceable by the Activity Plan number, AP PF 400-07-010. Only primary data registered in Sicada should be used for model calculations and other assessments of the site.

### **4.4 Nonconformities**

The activity was conducted without nonconformities.

## 5 Results

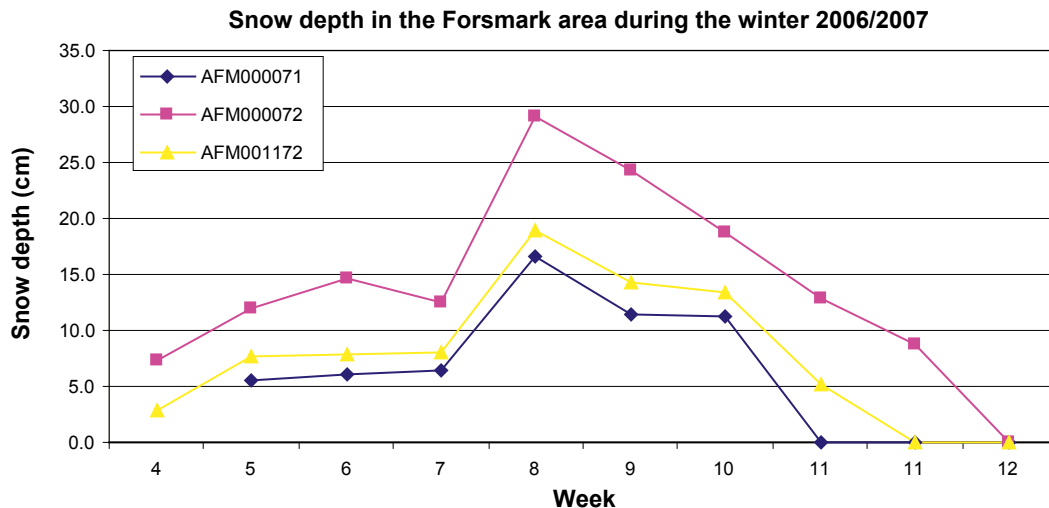
### 5.1 Snow depth and water content

Snow depth was measured at three stations (AFM000071, AFM000072 and AFM001172) for the whole season. The snow weight was measured at these three stations to calculate the water content in the snow.

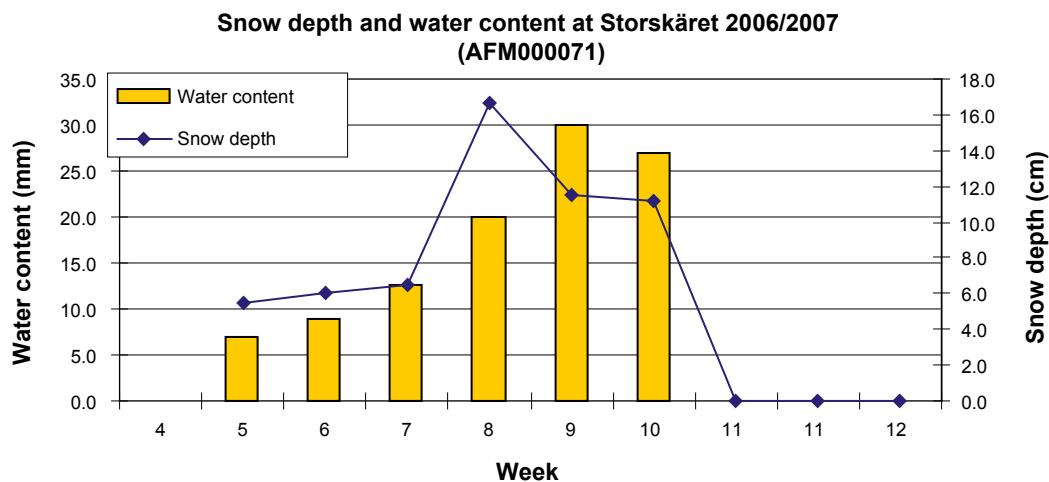
The average snow depth at the three stations is presented in Figure 5-1. The complete set of primary data is presented in Appendix 1.

The first snow fell on the first day of November but no persistent snow cover was established until late January 2007. The ground was more or less snow-covered until mid March. The snow cover was thickest in the forest glade and thinnest on the open field at Storskåret.

The snow weight was measured to calculate the water content of the snow. The results are presented in Figures 5-2a–c below.



*Figure 5-1. Average snow depth during the winter 2006/2007 at three stations in the Forsmark area.*



*Figure 5-2a. Snow depth and water content at Storskåret (AFM000071). (N.B. Two measurements/ observations were performed during week no. 11.)*

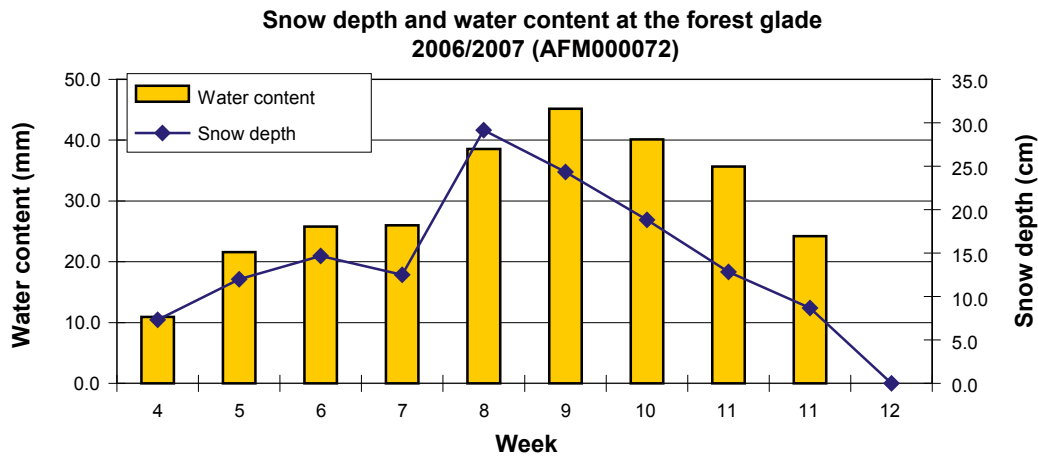


Figure 5-2b. Snow depth and water content at the forest glade (AFM000072). (N.B. Two measurements were performed during week no. 11.)

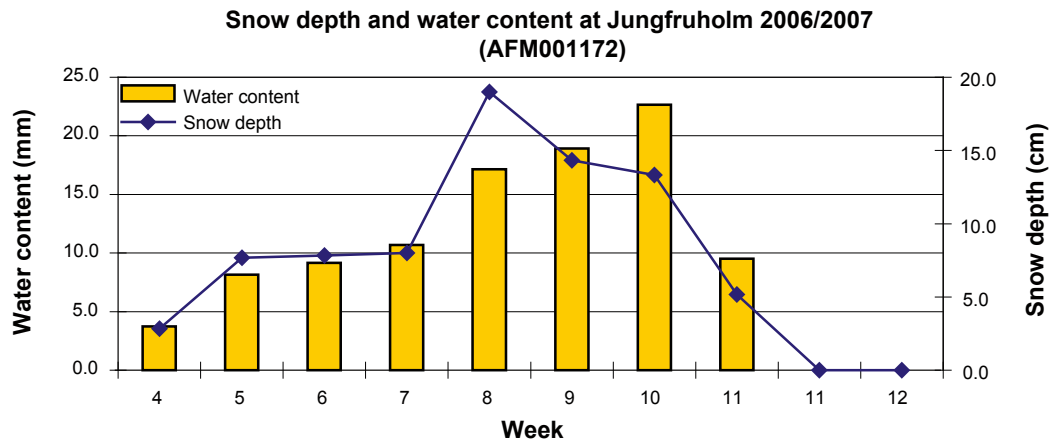


Figure 5-2c. Snow depth and water content at Jungfruholm (AFM001172). (N.B. Two measurements were performed during week no. 11.)

## 5.2 Ice cover

Ice conditions observed in the Forsmark area during the winter 2006/2007 are shown in Table 5-1. Lake Eckarfjärden was selected as representative for the lakes in the area concerning ice cover. When the ice froze and broke up, the conditions in other lakes in the area were controlled and no larger deviations were observed.

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

Station	Date for ice freeze-up	Date for ice break-up	Period with ice cover (days)
Lake Eckarfjärden (AFM000010)	2006-12-18	2007-03-26	98
Sea bay at SFR (AFM000075)	2007-01-22	2007-03-22	60

## 6 References

- /1/ **Aquilonius K, Karlsson S, 2003.** Forsmark site investigation. Snow depth, frost in ground and ice cover during the winter 2002/2003. SKB P-03-117, Svensk Kärnbränslehantering AB.
- /2/ **Heneryd N, 2004.** Forsmark site investigation. Snow depth, ground frost and ice cover during the winter 2003/2004. SKB P-04-137, Svensk Kärnbränslehantering AB.
- /3/ **Heneryd N, 2005.** Forsmark site investigation. Snow depth, ground frost and ice cover during the winter 2004/2005. SKB P-05-134, Svensk Kärnbränslehantering AB.
- /4/ **Heneryd N, 2006.** Forsmark site investigation. Snow depth, ground frost and ice cover during the winter 2005/2006. SKB P-06-97, Svensk Kärnbränslehantering AB.
- /5/ **SMHI.** Handbok för observatörer. Internal document.

### **Primary data from snow depth and snow weight measurements during the winter 2006/2007**

The data collected during the snow depth and snow weight measurements are presented below as individual measurements as well as calculated average snow depth, snow weight and water content. At each measurement a visual estimate of the coverage degree was made according to the following scale: S = completely or almost completely covered ground, SB = more than half of the ground snow covered but not completely, BS = more than half of the ground free of snow but not completely, B = the ground completely or almost completely free of snow.



**Table A1. Snow depth, snow weight and water content at Storskäret (AFM000071) during the winter 2006/2007.**

Date	Point 1, depth (cm)	Point 1, weight (g)	Point 2, depth (cm)	Point 2, weight (g)	Point 3, depth (cm)	Point 3, weight (g)	Point 4, depth (cm)	Point 4, weight (g)	Point 5, depth (cm)	Point 5, weight (g)	Point 6, depth (cm)	Point 6, weight (g)	Average snow depth (cm)	Snow coverage	Average snow weight (g)	Water content (mm)
2007-01-23														BS		
2007-01-31	4.0	10.00	6.0	14.00	7.0	18.00	4.0	10.00	5.0	10.00	7.0	20.00	5.5	SB	13.67	7.0
2007-02-08	7.0	22.00	7.0	18.00	4.0	20.00	7.0	22.00	5.0	6.00	6.0	18.00	6.0	S	17.67	9.0
2007-02-13	8.0	28.00	7.0	26.00	8.0	26.00	4.0	18.00	7.0	28.00	5.0	22.00	6.5	SB	24.67	12.6
2007-02-21	13.0	17.00	16.0	44.00	22.0	68.00	14.0	24.00	16.0	28.00	19.0	54.00	16.7	S	39.17	19.9
2007-03-01	14.0	61.00	8.0	33.00	6.0	24.00	10.0	96.00	13.0	58.00	18.0	82.00	11.5	S	59.00	30.0
2007-03-06	10.0	42.00	11.0	50.00	8.0	38.00	19.0	96.00	10.0	48.00	9.0	44.00	11.2	S	53.00	27.0
2007-03-12	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	B	0.00	0.0
2007-03-13	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	B	0.00	0.0
2007-03-22	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	B	0.00	0.0

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**Table A2. Snow depth, snow weight and water content at the forest glade (AFM000072) during the winter 2006/2007.**

Date	Point 1, depth (cm)	Point 1, weight (g)	Point 2, depth (cm)	Point 2, weight (g)	Point 3, depth (cm)	Point 3, weight (g)	Point 4, depth (cm)	Point 4, weight (g)	Point 5, depth (cm)	Point 5, weight (g)	Point 6, depth (cm)	Point 6, weight (g)	Average snow depth (cm)	Snow coverage	Average snow weight (g)	Water content (mm)
2007-01-23	8.0	24.00	7.0	12.00	6.0	20.00	8.0	24.00	7.0	21.00	8.0	28.00	7.3	S	21.50	10.9
2007-01-31	12.0	38.00	9.0	36.00	13.0	44.00	12.0	42.00	13.0	48.00	13.0	46.00	12.0	S	42.33	21.6
2007-02-08	15.0	56.00	13.0	42.00	15.0	46.00	14.0	60.00	16.0	54.00	15.0	46.00	14.7	S	50.67	25.8
2007-02-13	11.0	54.00	13.0	58.00	12.0	40.00	10.0	38.00	14.0	58.00	15.0	58.00	12.5	S	51.00	26.0
2007-02-21	30.0	88.00	31.0	83.00	28.0	76.00	30.0	72.00	26.0	61.00	30.0	74.00	29.2	S	75.67	38.5
2007-03-01	24.0	86.00	22.0	78.00	24.0	82.00	24.0	92.00	26.0	102.00	26.0	92.00	24.3	S	88.67	45.2
2007-03-06	19.0	76.00	18.0	82.00	16.0	71.00	20.0	68.00	20.0	84.00	20.0	92.00	18.8	S	78.83	40.1
2007-03-12	13.0	68.00	17.0	82.00	12.0	68.00	13.0	76.00	11.0	60.00	11.0	66.0	12.8	S	70.00	35.7
2007-03-13	7.0	36.00	8.0	38.00	8.0	46.00	9.0	58.00	10.0	56.00	10.0	51.00	8.7	SB	47.50	24.2
2007-03-22	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	B	0.00	0.0

**Table A3. Snow depth, snow weight and water content at Jungfruholm (AFM001172) during the winter 2006/2007.**

Date	Point 1, depth (cm)	Point 1, weight (g)	Point 2, depth (cm)	Point 2, weight (g)	Point 3, depth (cm)	Point 3, weight (g)	Point 4, depth (cm)	Point 4, weight (g)	Point 5, depth (cm)	Point 5, weight (g)	Point 6, depth (cm)	Point 6, weight (g)	Average snow depth (cm)	Snow coverage	Average snow weight (g)	Water content (mm)
2007-01-23	2.0	6.00	4.0	12.00	3.0	6.00	3.0	7.00	2.0	5.00	3.0	8.00	2.8	S	7.33	3.7
2007-01-31	7.0	18.00	7.0	12.00	8.0	18.00	9.0	16.00	8.0	20.00	7.0	12.00	7.7	SB	16.00	8.1
2007-02-08	7.0	18.00	9.0	18.00	6.0	14.00	7.0	14.00	7.0	16.00	11.0	28.00	7.8	S	18.00	9.2
2007-02-13	7.0	16.00	8.0	24.00	8.0	20.00	10.0	28.00	8.0	20.00	7.0	18.00	8.0	S	21.00	10.7
2007-02-21	16.0	24.00	20.0	32.00	20.0	30.00	18.0	48.00	26.0	42.00	14.0	26.00	19.0	S	33.67	17.1
2007-03-01	12.0	40.00	17.0	40.00	20.0	41.00	11.0	36.00	13.0	26.00	13.0	40.00	14.3	S	37.17	18.9
2007-03-06	13.0	34.00	13.0	42.00	11.0	49.00	13.0	58.00	16.0	38.00	14.0	46.00	13.3	S	44.50	22.7
2007-03-12	6.0	22.00	4.0	16.00	4.0	18.00	4.0	16.00	6.0	20.00	7.0	20.00	5.2	BS	18.67	9.5
2007-03-13	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	S	0.00	0.0
2007-03-22	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	S	0.00	0.0