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Forsmark site investigation

Snow depth, snow water content and ice cover during the winter 2008/2009

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Abstract

During the winter of 2008/2009 snow depth and ice cover have been measured and observed. This type of measurements started in the winter 2002/2003 and have been ongoing since then. In addition to these parameters the water content of the snow was, at each measurement occasion, calculated from the weight of a snow sample.

Measurements and observations were conducted on a regular basis from November 2008 until April 2009.

A persistent snow cover was established at the end of November 2008 and remained more or less until the beginning of April 2009 at the station with longest snow cover duration.

The period of ice cover was 134 days in Lake Eckarfjärden and the sea bay at SFR was ice-covered for 94 days.

Sammanfattning

Under vintern 2008/2009 har de meterologiska parametrarna snödjup och istäcke mätts och observerats. Denna typ av mätningar påbörjades vintern 2002/2003 och har pågått sedan dess. Under denna aktivitet har även snöns vatteninnehåll beräknats utifrån vikten på en bestämd volym snö.

Regelbundna mätningar och observationer har gjorts från slutet av november 2008 till början av april 2009.

Vintern 2008/2009 fanns ett mer eller mindre kvarliggande snötäcke från slutet av november till början av april 2009 vid den station som hade längst kvarliggande snötäcke.

Istäcket varade 134 dagar i Eckarfjärden och 94 dagar i havsviken vid SFR.

Contents

1 Introduction

This document reports data obtained from snow measurements and ice cover observations during the winter 2008/2009. These are activities performed within the site investigation at Forsmark. The work was carried out in accordance with activity plan AP PF 400-08-007. Similar studies were performed during the winters of 2002/2003 /1/, 2003/2004 /2/, 2004/2005 /3/, 2005/2006 /4/, 2006/2007 /5/ and 2007/2008 /6/ and this activity is to a large extent carried out in the same way.

The three parameters, snow depth, snow weight and duration of ice cover, were 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 2008 until the beginning of April 2009.

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

Original data from the reported activity are stored in the primary database Sicada. Data are traceable in Sicada by the Activity Plan number (SKB AP PF 400-08-007). 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.

Figure 1-1. *Locations of measurements and registration of meteorological winter parameters.*

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

Activity plan	Number	Version
Platsundersökning Forsmark: Registrering av snödjup/ -vatteninnehåll och tider för isläggning/islossning, säsongen 2008–2009	AP PF 400-08-007	1.0
Other controlling documents	**Number**	**Version**
SMHI, Handbok för observatörer	SMHI internal document	N/A

2 Objective and scope

This activity was conducted in order to obtain data about the local climate that, in combination with other meteorological data, will be used in hydrological and ecological modelling. The activity started in November 2008 and was completed when all the snow had melted away in the beginning of April 2009.

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). A transparent plastic tube graded in centimetres, with 5 centimetres inner diameter, was used for the snow depth measurements, 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 can measure up to 200 g and is 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 freeze-up and ice break-up were performed by visual inspection.

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

4 Execution

This activity consisted of the following:

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 November 26, 2008 and April 3, 2009. Ice conditions were observed with varying frequency depending on temperature and weather conditions. Each object for measurements/observations has a specific ID-code according to Table 4-1 (cf. positions in Figure 1-1). The snow depth and snow weight objects as well as the objects where ice conditions were observed were registered as surfaces (AFM-numbers).

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. The sample stations were approximately 4×4 m and marked with poles.

Measurements were made once a week, starting on November 26, 2008, and continuing until the snow was completely melted in spring, which was on April 3, 2009. The measurements were made even if no new snow had been falling, since packing, melting and evaporation should be considered as well.

Table 4-1. ID-code numbers and co-ordinates for the objects of this activity. Coordinate system RT 90 2,5 gon V 0:–15.

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

The snow depth was measured at 6 points within each sample station and the average snow depth at each station was calculated. The depth was measured with a transparent plastic tube, which also was used to collect 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.

The snow weight was measured at all three sample stations. At each station, 6 snow samples were taken with the plastic tube and transferred to a plastic bag for weight measurements. The weight of the bag, approximately 4 g, was subtracted. If the sample weighed more than 200 g, the sample was divided into two subsamples that were weighed separately. 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 in order to avoid incorrect readings of the scale.

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

Inner diameter of plastic tube: 50 mm.
Inner area of the plastic tube (πr^2): 19.635 cm^2.
Water density: 1 g/cm^3.
Water content of the snow in mm: snow weight (g)/19.635 (cm^3) ×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.

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

It is important to register the times of the first ice freeze-up and the last ice break-up. The time of the first ice freeze-up is defined as the first occasion during the season when a lasting ice cover is established. The last ice break-up is defined as the time when the ice cover from the winter season finally breaks up in spring. Very short periods in early autumn and late spring with only thin ice cover are neglected, as well as ice remains during the spring.

4.3 Data handling

The measurements and observations were documented in field notes and then transferred to Excel-files. The primary data of this activity are registered in Sicada and are traceable by the Activity Plan number, SKB PF 400-08-007. 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) during the winter 2008/2009.

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.

No measurements were performed in week number 1 and in week number 3 when there was not snow enough for measurements. No persistent snow cover was established before week number 48 and after week number 14.

The snow weight was measured to calculate the water content of the snow. The results are presented in Figure 5-2.

5.2 Ice cover

Ice conditions observed in the Forsmark area during the winter 2008/2009 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 checked and no major deviations were observed.

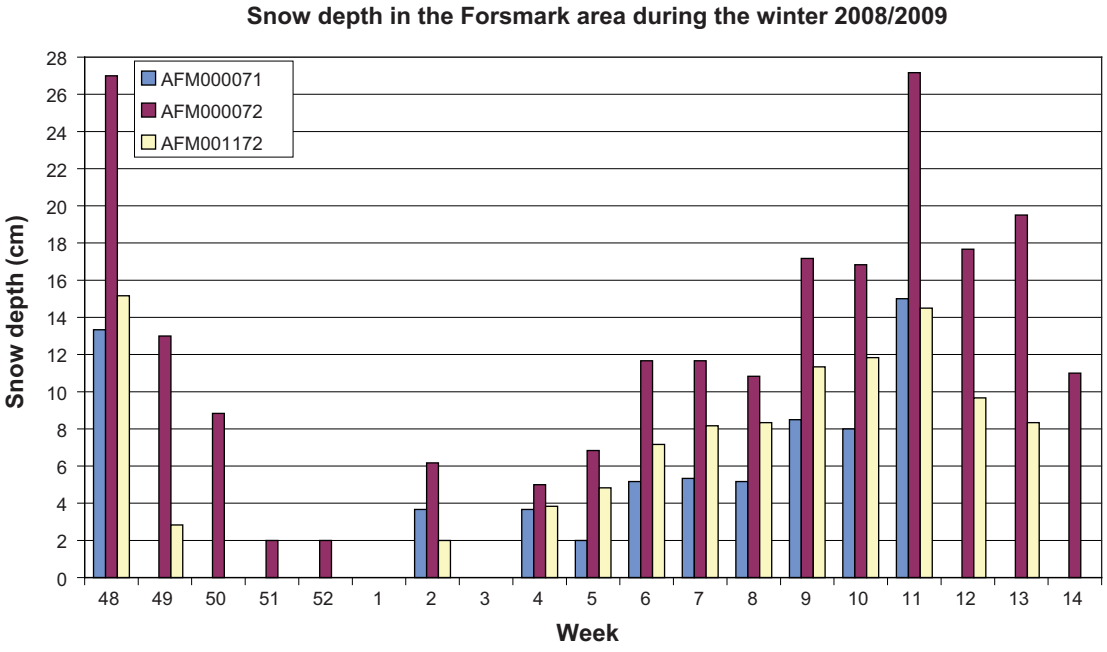

Figure 5-1. *Average snow depth during the winter 2008/2009 at three stations in the Forsmark area.*

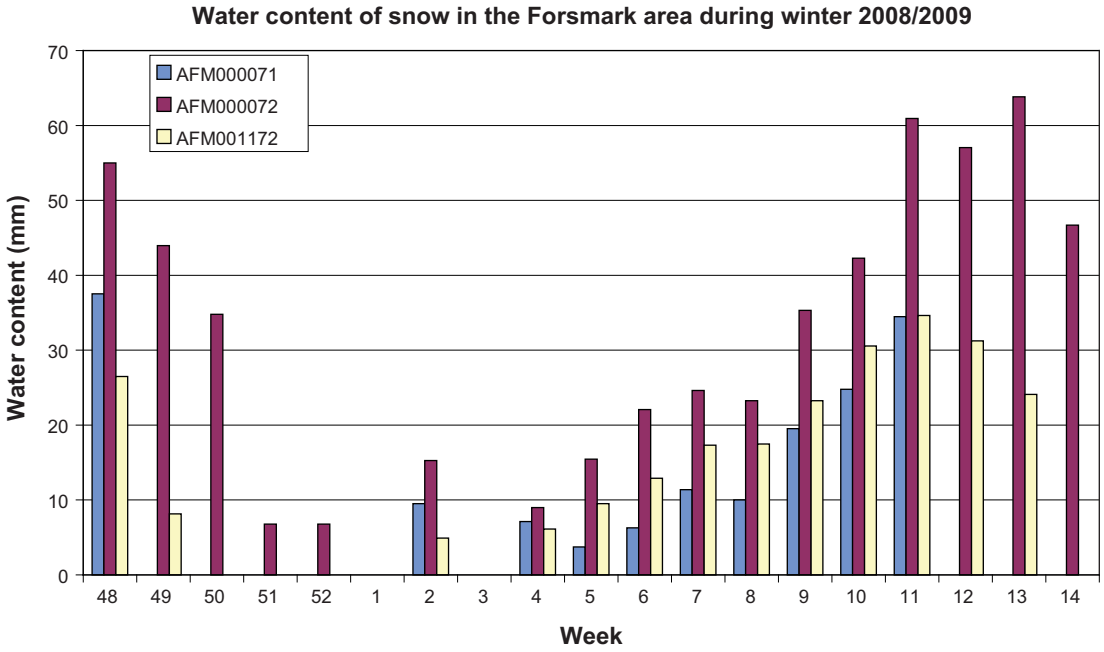

Figure 5-2. *Snow water content during the winter 2008/2009 at three stations in the Forsmark area.*

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

Station	Date for ice freeze-up	Date for ice break-up	Period with ice cover (days)
Lake Eckarfjärden (AFM000010)	2008-11-26	2009-04-09	134
Sea bay at SFR (AFM000075)	2009-01-05	2009-04-09	94

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/ **Heneryd N, 2007.** Forsmark site investigation. Snow depth, snow water content and ice cover during the winter 2006/2007. SKB P-07-81, Svensk Kärnbränslehantering AB.

/6/ **Nyberg G, Wass E, 2008.** Forsmark site investigation. Snow depth, snow water content and ice cover during the winter 2007/2008. SKB P-08-92, Svensk Kärnbränslehantering AB.

Appendix 1

Primary data from snow depth and snow weight measurements during the winter 2008/2009

The data collected during the snow depth and snow weight measurements are presented below as individual measurements as well as calculated averages of snow depth, snow weight and water content.

For each measurement, a visual estimate of the degree of coverage was made according to the following scale:

S = completely or almost completely snow-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 A-1. Snow depth, snow weight and water content at Storskäret (AFM000071) during the winter 2008/2009.

Date	Depth (cm)						Weight (g)						Snow coverage	Average snow depth (cm)	Average snow weight (g)	Water content (mm)
	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6				
2008-11-26	8	15	9	10	23	15	40	72	52	60	128	90	S	13.3	73.7	37.5
2008-12-04	0	0	0	0	0	0	0	0	0	0	0	0	B	0.0	0.0	0.0
2008-12-12	0	0	0	0	0	0	0	0	0	0	0	0	B	0.0	0.0	0.0
2008-12-19	0	0	0	0	0	0	0	0	0	0	0	0	B	0.0	0.0	0.0
2008-12-23	0	0	0	0	0	0	0	0	0	0	0	0	BS	0.0	0.0	0.0
2009-01-09	4	3	4	4	3	4	22	16	22	20	14	18	S	3.7	18.7	9.5
2009-01-16	0	0	0	0	0	0	0	0	0	0	0	0	BS	0.0	0.0	0.0
2009-01-23	4	4	3	3	4	4	16	16	10	12	16	14	S	3.7	14.0	7.1
2009-01-30	2	2	2	2	2	2	6	8	8	6	8	8	S	2.0	7.3	3.7
2009-02-06	5	5	5	6	5	5	10	12	12	16	12	12	S	5.2	12.3	6.3
2009-02-13	4	6	7	5	5	5	16	24	34	20	20	20	S	5.3	22.3	11.4
2009-02-20	5	5	6	6	4	5	18	18	24	24	16	18	S	5.2	19.7	10.0
2009-02-27	9	9	8	8	8	9	40	40	36	36	38	40	S	8.5	38.3	19.5
2009-03-06	7	8	7	9	9	8	48	44	42	54	60	44	S	8.0	48.7	24.8
2009-03-13	15	15	15	14	15	16	66	64	70	58	70	78	S	15.0	67.7	34.5
2009-03-20	0	0	0	0	0	0	0	0	0	0	0	0	B	0.0	0.0	0.0
2009-03-27	0	0	0	0	0	0	0	0	0	0	0	0	B	0.0	0.0	0.0
2009-04-03	0	0	0	0	0	0	0	0	0	0	0	0	B	0.0	0.0	0.0

Table A-2. Snow depth, snow weight and water content at the forest glade (AFM000072) during the winter 2008/2009.

Date	Depth (cm)						Weight (g)						Snow coverage	Average snow depth (cm)	Average snow weight (g)	Water content (mm)
	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6				
2008-11-26	26	28	27	29	26	26	98	110	102	120	112	106	S	27.0	108.0	55.0
2008-12-04	15	13	11	13	13	13	88	86	70	94	84	96	S	13.0	86.3	44.0
2008-12-12	10	9	6	9	10	9	74	76	54	74	70	62	S	8.8	68.3	34.8
2008-12-19	3	4	2	0	3	0	18	26	14	0	22	0	SB	2.0	13.3	6.8
2008-12-23	2	3	2	1	3	1	14	20	12	6	20	8	S	2.0	13.3	6.8
2009-01-09	4	5	7	7	5	9	18	24	34	36	24	44	S	6.2	30.0	15.3
2009-01-16	0	0	0	0	0	0	0	0	0	0	0	0	BS	0.0	0.0	0.0
2009-01-23	5	5	5	5	5	5	18	18	16	18	18	18	S	5.0	17.7	9.0
2009-01-30	7	6	7	7	7	7	30	28	30	32	30	32	S	6.8	30.3	15.4
2009-02-06	12	11	12	13	11	11	42	40	46	48	42	42	S	11.7	43.3	22.1
2009-02-13	11	12	12	12	12	11	46	48	52	50	50	44	S	11.7	48.3	24.6
2009-02-20	10	12	11	11	11	10	42	48	52	48	44	40	S	10.8	45.7	23.3
2009-02-27	16	17	18	19	17	16	66	68	72	76	70	64	S	17.2	69.3	35.3
2009-03-06	18	17	17	18	16	15	90	84	84	90	78	72	S	16.8	83.0	42.3
2009-03-13	29	24	28	27	28	27	134	108	116	116	130	114	S	27.2	119.7	60.9
2009-03-20	15	18	18	19	20	16	92	116	112	124	128	100	S	17.7	112.0	57.0
2009-03-27	19	19	19	18	22	20	126	126	124	120	134	122	S	19.5	125.3	63.8
2009-04-03	9	11	12	14	10	10	76	92	98	110	88	86	S	11.0	91.7	46.7

Table A-3. Snow depth, snow weight and water content at Jungfruholm (AFM001172) during the winter 2008/2009.

Date	Depth (cm)						Weight (g)						Snow coverage	Average snow depth (cm)	Average snow weight (g)	Water content (mm)
	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6				
2008-11-26	15	14	17	17	15	13	44	44	56	58	56	54	S	15.2	52.0	26.5
2008-12-04	2	2	3	4	4	2	14	14	16	22	22	8	S	2.8	16.0	8.1
2008-12-12	0	0	0	0	0	0	0	0	0	0	0	0	B	0.0	0.0	0.0
2008-12-19	0	0	0	0	0	0	0	0	0	0	0	0	B	0.0	0.0	0.0
2008-12-23	0	0	0	0	0	0	0	0	0	0	0	0	BS	0.0	0.0	0.0
2009-01-09	2	2	2	3	2	1	10	8	10	16	10	4	S	2.0	9.7	4.9
2009-01-16	0	0	0	0	0	0	0	0	0	0	0	0	BS	0.0	0.0	0.0
2009-01-23	4	4	5	3	3	4	12	14	16	8	10	12	S	3.8	12.0	6.1
2009-01-30	5	5	6	4	4	5	18	20	26	16	14	18	S	4.8	18.7	9.5
2009-02-06	7	8	7	8	7	6	26	28	24	28	26	20	S	7.2	25.3	12.9
2009-02-13	10	8	8	8	9	6	40	32	34	36	36	26	S	8.2	34.0	17.3
2009-02-20	9	8	8	8	9	8	34	32	30	36	38	36	S	8.3	34.3	17.5
2009-02-27	12	11	14	13	9	9	48	46	56	52	36	36	S	11.3	45.7	23.3
2009-03-06	12	15	13	10	10	11	58	80	68	52	46	56	S	11.8	60.0	30.6
2009-03-13	14	13	14	15	14	17	62	50	70	78	66	82	S	14.5	68.0	34.6
2009-03-20	11	9	11	11	9	7	68	60	70	72	56	42	S	9.7	61.3	31.2
2009-03-27	8	6	9	10	8	9	46	36	46	58	44	54	S	8.3	47.3	24.1
2009-04-03	0	0	0	0	0	0	0	0	0	0	0	0	B	0.0	0.0	0.0