

## **Monitoring Forsmark**

# **Snow depth, snow water content and ice cover during the winter 2010/2011**

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July 2011

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*Keywords:* Snow depth, Snow water content, Ice cover, AP SFK-10-006.

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## Abstract

Snow depth and ice cover have been measured and observed during the winter 2010/2011. This type of measurements started in the winter 2002/2003 and has been ongoing since then. In addition to these parameters, the water content of the snow was calculated at each measurement occasion from the weight of a snow sample.

Measurements and observations were conducted on a regular basis from the beginning of November 2010 until the middle of April 2011.

A persistent snow cover was established in the end of November 2010 and remained until the beginning of April 2011 at the station with longest snow cover duration.

The period of ice cover was 160 days in Lake Eckarfjärden, whereas the sea bay at SFR was ice-covered for 135 days.

## Sammanfattning

De meteorologiska parametrarna snödjup och istäcke har mätts och observerats under vintern 2010/2011. Denna typ av mätningar påbörjades vintern 2002/2003 och har pågått sedan dess. Under denna aktivitet har även snöns vatteninnehåll vid varje mättillfälle beräknats utifrån vikten på en bestämd volym snö.

Regelbundna mätningar och observationer har gjorts från början av november 2010 till mitten av april 2011.

Vintern 2010/2011 fanns ett bestående snötäcke från slutet av november 2010 till början av april 2011 vid den station som hade längst kvarliggande snötäcke.

Istäcket varade 160 dagar i Eckarfjärden och 135 dagar i havsviken vid SFR.

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# 1 Introduction

This document reports data obtained from snow measurements and ice cover observations during the winter 2010/2011. These are activities performed within the monitoring program at Forsmark. The work was carried out according to activity plan AP SFK-10-006. Similar studies have been performed since the winter of 2002/2003 (Aquilonius and Karlsson 2003, Heneryd 2004, 2005, 2006, 2007, Nyberg and Wass 2008, 2009, 2010).

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 results from snow weight measurements. The map in Figure 1-1 shows the positions of the measurements. The activity was performed from the beginning of November 2010 until the middle of April 2011.

Controlling documents for performing this activity are listed in Table 1-1. The activity plan is an SKB 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 SFK-10-006). 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 corresponding 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).



Figure 1-1. Locations of measurements and observations of meteorological winter parameters.

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

<b>Activity plan</b>	<b>Number</b>	<b>Version</b>
Kärnbränsleprogrammet, Projekt Kärnbränsleförvaret: Registrering av snödjup/-vatteninnehåll och tider för isläggning/islossning, säsongen 2010–2011	AP SFK-10-006	1.0
<b>Other controlling documents</b>	<b>Number</b>	<b>Version</b>
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 2010 and was completed when all snow and ice had melted in the middle of April 2011.

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 collecting 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. The weight of the snow was determined with a scale, which can measure up to 200 g and is graded with 2 g increments. The equipment used for collection of snow samples and snow weight measurement 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 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 November 26, 2010 and April 15, 2011. Ice conditions were observed with varying frequency depending on temperature and weather situation. 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).

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

Parameter	ID-code	X	Y	Type of location
<b>Snow</b>				
Depth and water content	AFM000071			Ploughed arable land
	1	6697419	1634872	
	2	6697413	1634869	
	3	6697412	1634874	
Depth and water content	4	6697416	1634877	
	AFM000072			Forest glade
	1	6698528	1631524	
	2	6698524	1631527	
3	6698529	1631527		
Depth and water content	4	6698534	1631523	
	AFM001172			Forest glade
	1	6699475	1633157	
	2	6699468	1633157	
3	6699473	1633160		
Ice cover	4	6699480	1633160	
	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. Three sample stations are used, 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 are approximately 4×4 m and marked with poles.

Measurements were made once a week, starting on November 26, 2010, and continuing until the snow was completely melted in the spring on April 15, 2011. The measurements were performed even if no new snowfall had occurred, 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 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 collected 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 served as shelters 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 ( $\pi r^2$ ): 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.



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

#### **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.

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 SFK-10-006. 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

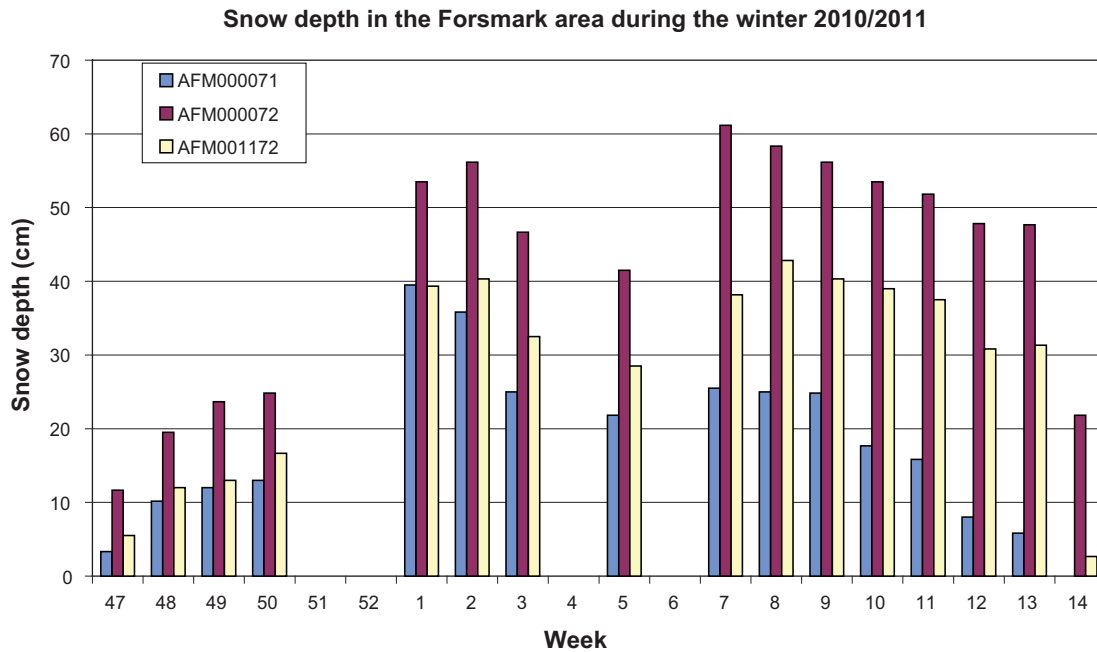
### 5.1 Snow depth and water content

Snow depth was measured at three stations (AFM000071, AFM000072 and AFM001172) during the winter 2010/2011.

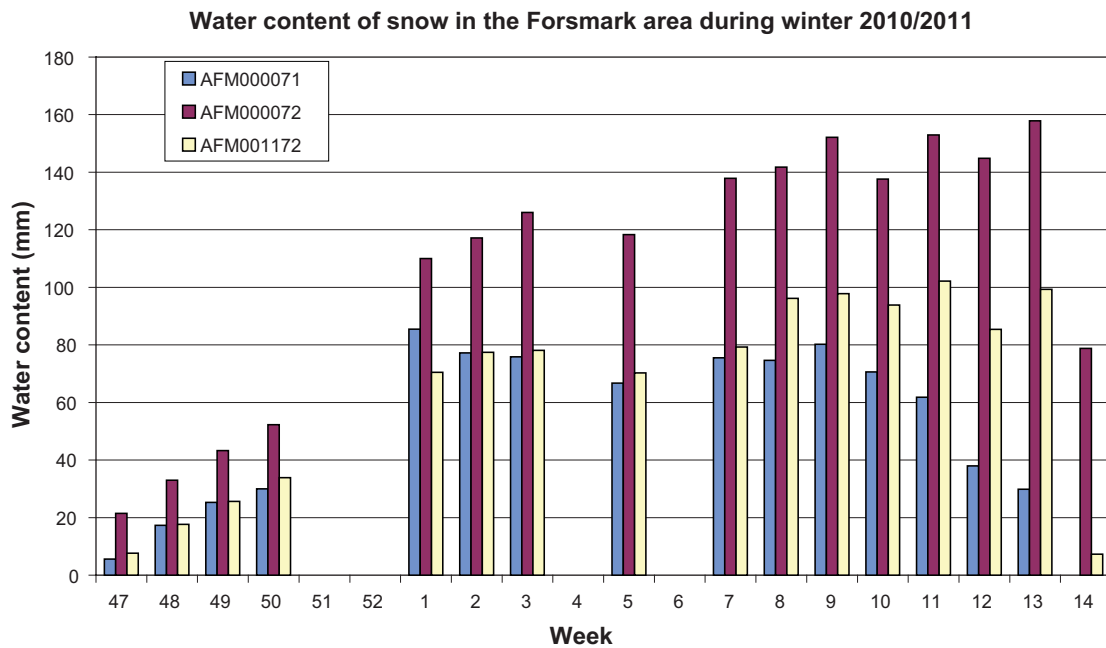
The average snow depth at the three stations is presented in Figure 5-1. The complete set of primary data is presented in Appendix 1.

No measurements were performed in weeks number 51 and 52 due to Christmas holidays or in weeks number 4 and 6. No persistent snow cover was established before week number 47 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.



*Figure 5-1. Average snow depth during the winter 2010/2011 at three stations in the Forsmark area.*



*Figure 5-2. Snow water content during the winter 2010/2011 at three stations in the Forsmark area.*

## 5.2 Ice cover

Ice conditions observed in the Forsmark area during the winter 2010/2011 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.

**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)	2010-11-09	2011-04-18	160
Sea bay at SFR (AFM000075)	2010-11-29	2011-04-13	135

## 6 References

SKB's (Svensk Kärnbränslehantering AB) publications can be found at [www.skb.se/publications](http://www.skb.se/publications).

**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.

**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.

**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.

**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.

**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.

**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.

**Nyberg G, Wass E, 2009.** Forsmark site investigation. Snow depth, snow water content and ice cover during the winter 2008/2009. SKB P-09-70, Svensk Kärnbränslehantering AB.

**Nyberg G, Wass E, 2010.** Forsmark site investigation. Snow depth, snow water content and ice cover during the winter 2009/2010. SKB P-10-45, Svensk Kärnbränslehantering AB.

### **Primary data from snow depth and snow weight measurements during the winter 2010/2011**

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 2010/2011.

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				
2010-11-26	3	4	3	2	5	3	10	12	10	8	16	10	S	3.3	11.0	5.6
2010-12-03	9	10	10	11	12	9	30	34	34	36	38	32	S	10.2	34.0	17.3
2010-12-10	12	15	10	13	11	11	50	70	35	55	43	45	S	12.0	49.7	25.3
2010-12-17	13	11	14	14	13	13	55	48	70	60	65	55	S	13.0	58.8	30.0
2011-01-05	41	40	38	39	39	40	175	175	160	167	165	165	S	39.5	167.8	85.5
2011-01-14	35	36	34	38	37	35	155	140	155	170	160	130	S	35.8	151.7	77.2
2011-01-21	23	27	26	26	25	23	120	167	155	150	165	137	S	25.0	149.0	75.9
2011-02-04	20	21	23	23	19	25	122	122	132	136	120	154	S	21.8	131.0	66.7
2011-02-18	27	23	25	26	25	27	174	120	140	150	138	168	S	25.5	148.3	75.5
2011-02-25	26	27	27	23	23	24	155	162	162	132	128	140	S	25.0	146.5	74.6
2011-03-04	27	25	24	25	24	24	175	160	148	160	152	150	S	24.8	157.5	80.2
2011-03-11	20	21	20	16	17	12	152	170	150	130	136	94	S	17.7	138.7	70.6
2011-03-18	15	14	18	16	18	14	120	104	130	130	138	106	S	15.8	121.3	61.8
2011-03-25	11	10	9	5	6	7	100	98	94	48	52	55	S	8.0	74.5	37.9
2011-04-01	2	3	7	10	9	4	28	34	64	98	88	40	S	5.8	58.7	29.9
2011-04-08	–	–	–	–	–	–	–	–	–	–	–	–	B	–	–	–
2011-04-15	–	–	–	–	–	–	–	–	–	–	–	–	B	–	–	–

**Table A-2. Snow depth, snow weight and water content at the forest glade (AFM000072) during the winter 2010/2011.**

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				
2010-11-26	10	11	13	13	15	8	35	40	48	48	55	27	S	11.7	42.2	21.5
2010-12-03	20	20	17	20	20	20	65	67	58	67	65	67	S	19.5	64.8	33.0
2010-12-10	25	23	23	25	23	23	80	75	85	90	90	90	S	23.7	85.0	43.3
2010-12-17	25	25	27	29	25	18	90	105	110	127	107	77	S	24.8	102.7	52.3
2011-01-05	52	55	50	55	53	56	205	232	187	232	212	228	S	53.5	216.0	110.0
2011-01-14	57	57	53	56	57	57	235	235	215	230	230	235	S	56.2	230.0	117.1
2011-01-21	48	49	43	46	47	47	250	265	210	255	265	240	S	46.7	247.5	126.1
2011-02-04	42	42	37	41	43	44	234	236	192	238	246	248	S	41.5	232.3	118.3
2011-02-18	62	62	58	63	60	62	276	272	222	292	280	282	S	61.2	270.7	137.8
2011-02-25	58	60	50	61	61	60	265	280	235	295	300	295	S	58.3	278.3	141.8
2011-03-04	55	56	50	57	58	61	274	298	268	308	308	336	S	56.2	298.7	152.1
2011-03-11	54	56	50	55	53	53	285	298	260	248	270	260	S	53.5	270.2	137.6
2011-03-18	51	55	48	51	53	53	318	314	272	292	312	294	S	51.8	300.3	153.0
2011-03-25	49	50	43	48	49	48	298	306	270	266	310	256	S	47.8	284.3	144.8
2011-04-01	47	50	45	49	49	46	300	328	290	338	328	276	S	47.7	310.0	157.9
2011-04-08	22	25	19	23	21	21	160	186	144	162	134	142	S	21.8	154.7	78.8
2011-04-15	–	–	–	–	–	–	–	–	–	–	–	–	B	–	–	–

Table A-3. Snow depth, snow weight and water content at Jungfruholm (AFM001172) during the winter 2010/2011.

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				
2010-11-26	7	5	4	6	6	5	20	15	12	15	15	13	S	5.5	15.0	7.6
2010-12-03	10	11	14	13	12	12	25	28	45	42	35	33	S	12.0	34.7	17.7
2010-12-10	12	15	14	10	13	14	45	62	60	35	45	55	S	13.0	50.3	25.6
2010-12-17	18	17	18	21	13	13	75	65	75	90	47	47	S	16.7	66.5	33.9
2011-01-05	39	37	41	39	41	39	135	132	158	130	152	123	S	39.3	138.3	70.5
2011-01-14	38	37	41	38	44	44	145	140	165	137	160	165	S	40.3	152.0	77.4
2011-01-21	29	32	32	32	35	35	137	148	152	138	170	175	S	32.5	153.3	78.1
2011-02-04	26	23	30	28	32	32	120	112	160	116	174	146	S	28.5	138.0	70.3
2011-02-18	40	36	41	40	42	30	188	134	156	172	180	104	S	38.2	155.7	79.3
2011-02-25	45	41	42	42	43	44	198	170	192	188	205	180	S	42.8	188.8	96.2
2011-03-04	39	39	39	43	44	38	174	172	192	208	232	174	S	40.3	192.0	97.8
2011-03-11	45	35	38	40	38	38	224	150	168	200	184	180	S	39.0	184.3	93.9
2011-03-18	40	35	37	38	37	38	210	186	186	214	204	204	S	37.5	200.7	102.2
2011-03-25	33	27	34	30	35	26	190	134	198	148	202	134	S	30.8	167.7	85.4
2011-04-01	35	24	32	34	35	28	214	154	212	206	228	156	S	31.3	195.0	99.3
2011-04-08	0	0	0	9	7	0	0	0	0	46	40	0	BS	2.7	14.3	7.3
2011-04-15	–	–	–	–	–	–	–	–	–	–	–	–	B	–	–	–