P-03-49

Forsmark site investigation

Sampling and analyses of groundwater in percussion drilled boreholes at drillsite DS3

Results from the percussion boreholes HFM06 and HFM08

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April 2003

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Contents

1 Introduction

This document reports the performance of and results from sampling of percussion boreholes after drilling. The work was conducted according to activity plan AP PF 400-02-39 (SKB internal controlling document) within the site investigation at Forsmark /1/. The document presents groundwater-chemical data from the percussion boreholes HFM06 and HFM08 drilled in hard rock at drillsite DS3 /2/. Data were obtained during the period January 2003–March 2003.

Borehole KFM03A is the third telescopic borehole drilled at the site investigations in the Forsmark area. The location of the borehole, which is currently being drilled, is shown in Figure 1-1. The borehole is planned to be c. 1000 m deep, and the borehole section 0–100 m is percussion drilled. During drilling, the groundwater yield from this part of the borehole was too low to allow sampling. Section 100–1000 m will be core drilled with a diameter of c. 77 mm. Drilling is supposed to be completed in June 2003.

Out of GSD-Terrängkartan © Lantmäteriet
Gävle 2001, Permission M2001/5268
Svensk Kärnbränslehantering AB, 2003-05-13

***Figure 1-1.** The investigation area at Forsmark (approximately the area inside the black square) including the candidate area selected for more detailed investigations. Drillsites DS1-3 are marked with blue circles.*

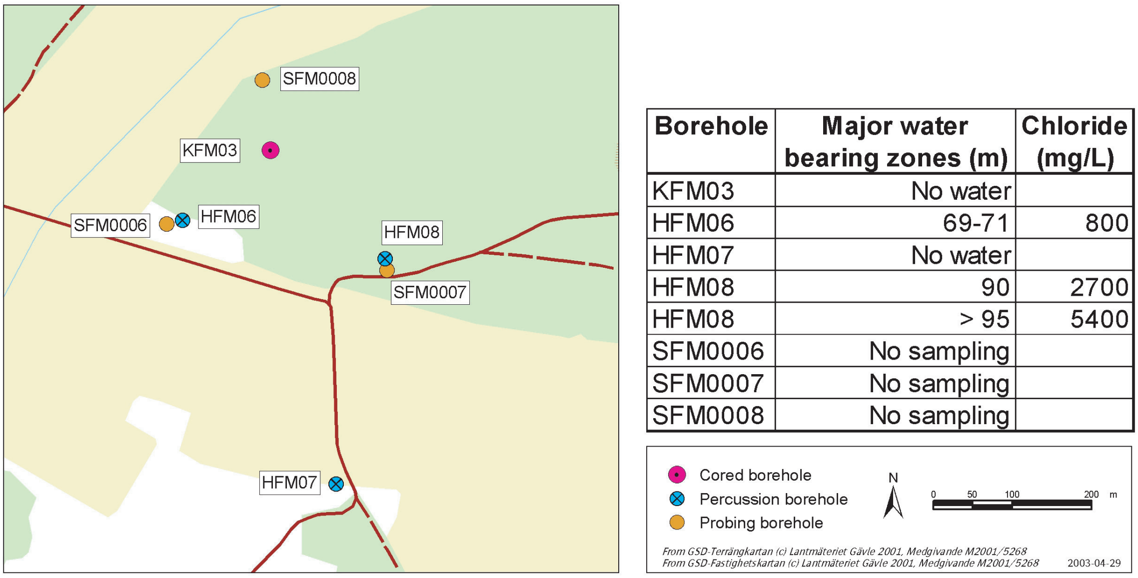
The locations of all boreholes at drillsite DS3 are illustrated in Figure 1-2. A third percussion drilled borehole at this site, HFM07, was, like section 0–100 m in borehole KFM03A, characterized by a low groundwater-yield, and was excluded from sampling.

So far, groundwater sampling has not been conducted in the monitoring wells SFM0006, SFM0007 and SFM0008 (see Figure 1-2), drilled in the unconsolidated overburden at drillsite DS3 /3/. The first sampling is planned to occur in May 2003.

The percussion boreholes HFM06 and HFM08 were drilled at relatively short distances from the telescopic borehole KFM03A, see Figure 1-2. Borehole HFM06 was drilled with the primary purpose to serve as a supply well for the flushing water needed for drilling the core drilled part of borehole KFM03A. The borehole HFM06 is like the telescopic borehole KFM03A of the so called SKB chemical type, see method descriptions MD 620.003 (Method description for drilling cored boreholes) and 610.003 (Method description for percussion drilling). A borehole being of SKB chemical type entails cleaning procedures of all in-hole equipment to be used in the borehole during and after drilling according to level 2 in the cleaning instructions in MD 600.004 (Instruktion för rengöring av borrhålsutrustning och viss markbaserad utrustning).

Boreholes HFM08, as well as HFM07, were drilled primarily as monitoring wells for groundwater levelling in the shallow part of the bedrock. However, also for these boreholes, cleaning according to level 2 in MD 600.004 was applied in order to let these boreholes serve as reserve flushing water wells.

Basic borehole information is given in Table 1-1 below. The designs of the boreholes are presented in Appendix 1. A map showing the locations of the boreholes at drillsite DS3, depth of dominating water bearing fracture zones and chloride concentrations is presented in Figure 1-2.



Borehole	Major water bearing zones (m)	Chloride (mg/L)
KFM03	No water	
HFM06	69-71	800
HFM07	No water	
HFM08	90	2700
HFM08	> 95	5400
SFM0006	No sampling	
SFM0007	No sampling	
SFM0008	No sampling	

From GSD-Terrängkartan (c) Lantmäteriet Gävle 2001, Medgivande M2001/5268
From GSD-Fastighetskartan (c) Lantmäteriet Gävle 2001, Medgivande M2001/5268 2003-04-29

Figure 1-2. *Locations of boreholes and monitoring wells at drillsite DS3, water bearing zones and typical chloride concentrations.*

Table 1-1. Borehole information, percussion boreholes at drillsite DS3.

Borehole	Date of completion	Length (m)	Water bearing zones (length along borehole, m)	Comment
HFM06	2003-01-14	110.7	69–71	Source of flushing water for drilling the cored part of KFM03A
HFM07	2003-0128	122.5	Low groundwater-yield	
HFM08	2003-02-12	143.5	90	
KFM03A	2003-03-28	Borehole section 0–100 m	Low groundwater-yield	Casing only 12 m into the bedrock. Section 12–100 m is stable and low-fractured and does not need a casing.

Sampling of HFM06 and HFM08, which both have a diameter of 140 mm or a few millimetres less, was accomplished a short time after drilling, in connection with pumping tests and flow logging carried out within the programme for hydrogeological investigations /4/. The time separation for pumping/logging/sampling between the two boreholes was a few weeks, see Table 4-1. No other borehole tests were carried out in the boreholes in question prior to the hydrotest/water sampling campaign.

2 Objective and scope

Sampling and analysis of groundwater from boreholes HFM06 and HFM08 was performed in order to:

- Check the suitability of HFM06 to serve as a supply well for the flushing water needed for drilling the cored part of the telescopic borehole KFM03A. Pumping capacity and water quality are critical parameters when assessing the suitability of a potential flushing water well.
- Gain data on the groundwater composition of so called “first strike” groundwater, i.e. groundwater sampled before the impact of short circuiting between fractures of different hydrogeochemical character has become significant.
- Obtain groundwater-chemical data from the shallow part of the bedrock (to approximately 200 m depth) at drillsite DS3.

Of primary interest in this activity was to investigate if the groundwater in borehole HFM06 was of sufficient quality to be used as flushing water for drilling the cored part of telescopic borehole KFM03A. Core drilling of a 1000 m long borehole will consume 1000 m^3 or more flushing water. As borehole KFM03A is of SKB chemistry type, the content of organic components in the flushing water should be low, preferably below 5 mg/L. The reason for this is that introduction of hydrocarbons may affect the microbiological flora in the borehole, which, consequently, would obstruct a reliable characterization of the in situ microbiological conditions.

Sampling and analysis was performed according to the SKB class 3 procedure /1/.

3 Equipment

3.1 Sampling equipment used in percussion boreholes

The sampling in boreholes HFM06 and HFM08 was performed in connection with hydraulic tests with the HTHB (HydroTester för HammarBorrhål) pump & packer equipment described in SKB MD 326.001 (Mätsystembeskrivning för hydrotest-utrustning för hammarborrhål – HTHB). The equipment allows pumping from packed off sections in boreholes of diameter 165 mm and 140 mm (± a few millimetres) using a single- or double packer system. The in-hole equipment includes a packer system, a measurement tube, an enclosed pump, and a combined pressure sensor and data logger. An overview of the HTHB equipment is given in Figure 3-1 below.

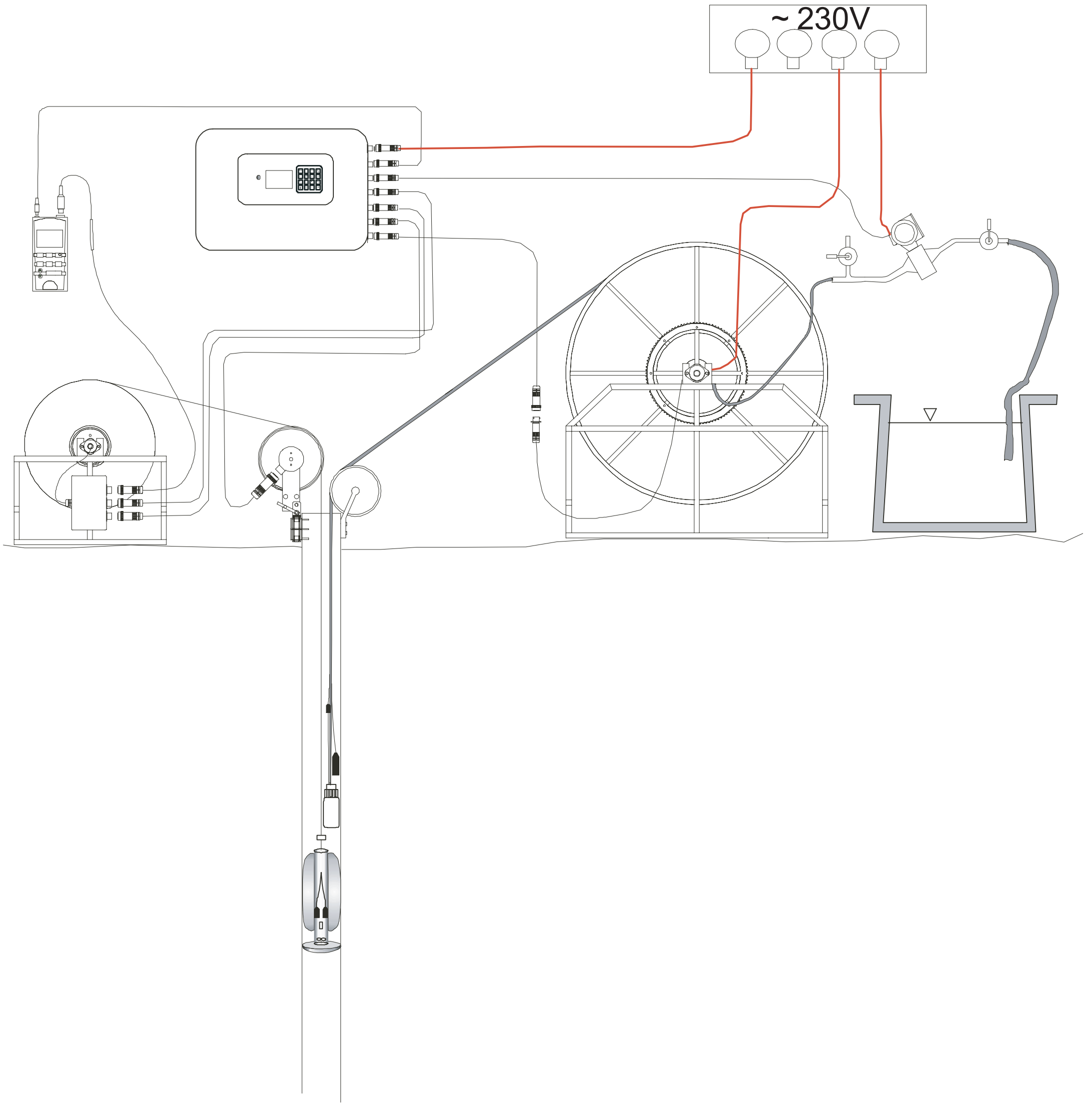


Figure 3-1. *The HTHB (HydroTester för HammarBorrhål) equipment, configured for pumping at "open hole" conditions in combination with flow logging.*

4 Performance

4.1 Sampling

Sampling of the percussion boreholes at drillsite DS3 was performed according to activity plan AP PF 400-02-39 (SKB internal controlling document) following the method described in SKB MD 423.002 (Metodbeskrivning för vattenprovtagning i hammarborrhål efter borrning).

The sampling started in borehole HFM06, and HFM08 was sampled a few weeks later. An extra sampling was then conducted in HFM06 in March 2003 in order to check the drinking water quality. Generally, pumping was performed during 10 hours, and samples were collected twice or three times during the pumping period. Table 4-1 displays the pumping times and sampling occasions during the pumping tests.

Sampling and analyses was performed according to SKB class 3, and isotope determinations were performed in the last sample collected for each borehole and sampling occasion. Total organic carbon (TOC) was determined in samples from HFM06 to investigate its suitability as a source for flushing water. The parameters iron, manganese, hydrogen-sulphide and iodide are not included in class 3 and therefore not determined.

Table 4-1. Pumping times and sampling occasions in percussion boreholes at drillsite DS3.

Borehole	Section m	Pump start	Pump stop	Sampl. Time	Comments
HFM06	0–110.7	030121 10:04	030121 12:50	030121 11:55	Pump stop due to el. power failure
HFM06	0–110.7	030121 14:17	030121 21:02	030121 16:52 030121 21:50	
HFM06	0–110.7	–	–	2003-03-06	Check of drinking water quality (not in connection with pump test)
HFM08	0–143.5	030218 09:30	030218 18:28	030218 09:30 030218 18:05	
HFM08	0–93	030220 09:02	030220 13:53	030220 13:40	Sample collected above packer

4.2 Sample treatment and chemical analyses

An general overview of sample treatment and analysis methods is given in Appendix 2. The routines are applicable independent of sampling method or sampling object.

4.3 Data handling

The field measurement data were manually registered directly in the SICADA table "hydrogeol_field_measurement" as soon as possible after performance of the field work.

The following routines for quality control and data management are generally applied for hydrogeochemical analysis data, independent of sampling method or sampling object.

Several components are determined by more than one method and/or laboratory. Moreover, control analyses by an independent laboratory are performed routinely on each fifth or tenth collected sample.

All analytical results are stored in the SICADA database. The applicable hierarchy path "Hydrochemistry/Hydrochemical investigation/Analyses/Water" in the database contains two types of tables, raw data tables and primary data tables (final data tables).

Data on basic water analyses are inserted into raw data tables for further evaluation. The evaluation results in a final reduced data set for each sample. These data sets are compiled in a primary data table named "water_composition". The evaluation is based on:

- Comparison of the results from different laboratories and/or methods. The analyses are repeated if a large disparity is noted (generally more than 10%).
- Calculation of charge balance errors. Relative errors within ± 5% are considered acceptable (in surface waters ± 10%).

$$\text{Rel. Error (\%)} = 100 \times \frac{(\sum \text{cations(equivalents)} - \sum \text{anions(equivalents)})}{(\sum \text{cations(equivalents)} + \sum \text{anions(equivalents)})}$$

- General expert judgement of plausibility based on earlier results and experiences.

All results from *"biochemical" components and special analyses of trace metals and isotopes* are inserted directly into primary data tables. In those cases where the analyses are repeated or performed by more than one laboratory, a "best choice" notation will indicate those results which are considered most reliable.

An overview of the data management is given in Figure 4-1.

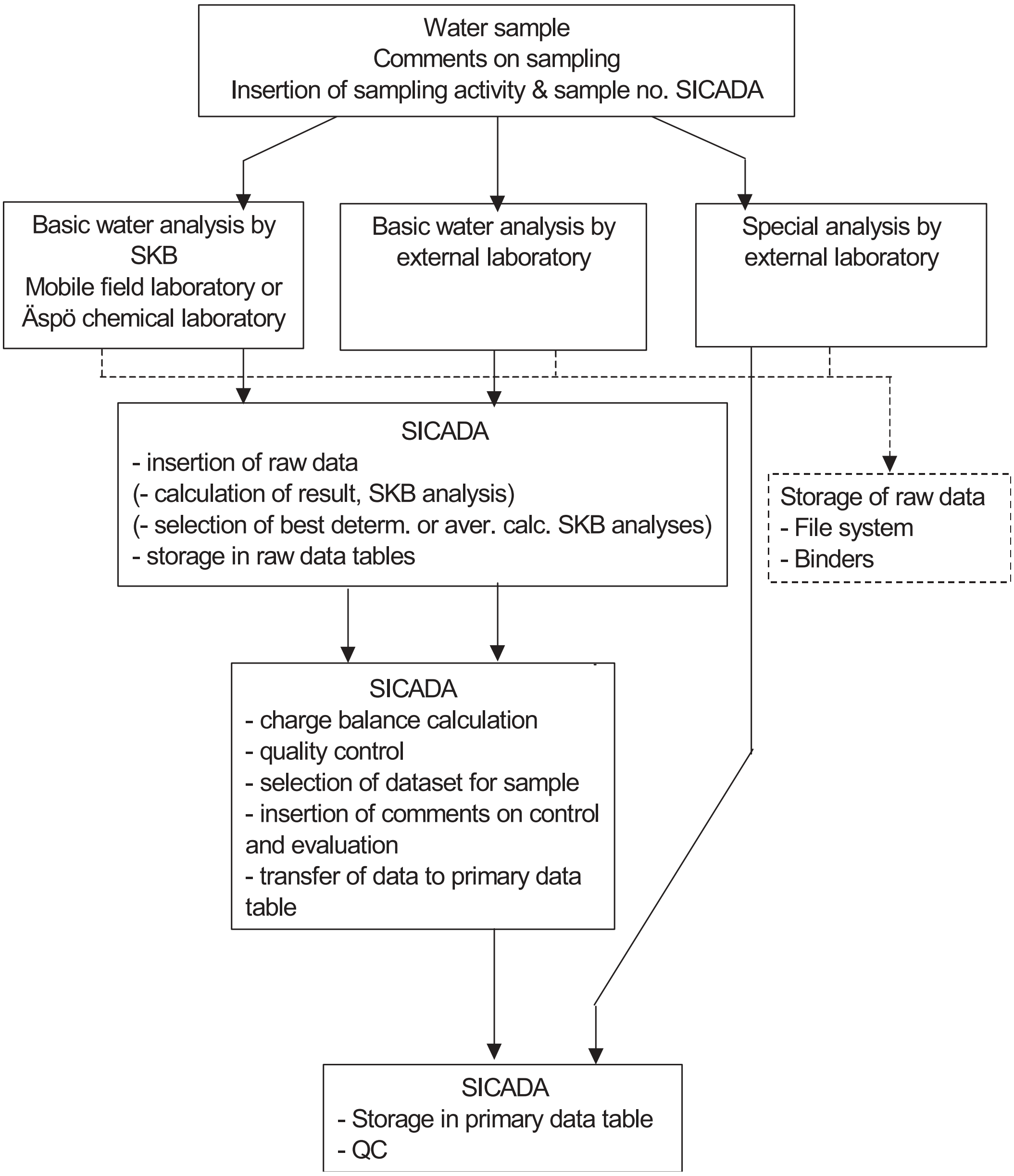


***Figure 4-1.** Overview of data management for hydrogeochemical data.*

5 Results

5.1 Analysis results from HFM06 and HFM08

The analytical data from percussion boreholes HFM06 and HFM08 reported from the consulted laboratories and inserted into the database SICADA before 2003-04-01 are presented in Appendix 3 and 4. Isotopes and isotope ratios (except for $^{10}B/^{11}B$) have not been reported within that time limit and are not included.

Samples were collected two or three times during the pumping test. The water compositions of the samples differ considerably due to pumping time in HFM06, but not at all in HFM08. Generally, the last sample in each sampling series should be regarded as the one most representative.

The concentration of Total Organic Carbon (TOC) in the samples collected in HFM06 was found to be between 5.1 and 5.8 mg/L which is exactly on the limit to be acceptable in a flushing water. Although with some hesitation, it was decided that the water could be used as flushing water for the core drilling of KFM03A without further measures.

5.2 Quality of the analyses

Comparison between results from different laboratories and methods indicates that the agreement is acceptable in most cases. Generally, the difference in concentrations between each controlled component is less than 10%.

The charge balance errors give an indication of the quality and uncertainty of the analyses of the major components. The relative charge balance errors are calculated for the selected sets of data, see Appendix 3. The error is close to +6% in one case but below ± 3% in the remaining six cases, which is regarded as quite satisfactory.

6 Future work

6.1 Percussion boreholes

The initial sampling of percussion boreholes at drillsite DS3 (reported here), performed according to the SKB class 3 procedure, will in the future be repeated on a regular basis in a long-term monitoring programme. This will include a selection of boreholes, and samples will be collected regularly with a frequency of twice a year from one or two packed off sections in each borehole. Sampling and analysis within the frame of the monitoring programme will be performed according to the SKB class 5 procedure /1/.

6.2 Monitoring wells

The three monitoring wells at drillsite DS3, SFM0006, SFM0007 and SFM0008, see Figure 1-2, situated close to the planned deep borehole KFM03A, have not yet been sampled and are therefore not reported in the present report. Early this year (2003), a number of ”not drillsite connected” monitoring wells have been drilled within or close to the candidate area. Some of them are intended for groundwater sampling and chemical analyses. A sampling programme (activity plan) is being written, which includes the ”drill site connected” wells as well as the new ”not drill site connected” hydrogeochemistry wells (totally 16 wells). This new programme for sampling of near-surface groundwater will be connected to the surface water sampling programme. Sampling in the wells will be performed four times during 2003, at the same campaigns as for the sampling of surface water in the area of investigation. The first sampling occasion in the monitoring wells at drillsite DS3 will be included in this programme. The sampling times during 2003 and early in 2004, as well as types of analytical procedures applied are presented in Table 6-1.

The programme will probably continue for several years according to this structure.

Tabell 6-1. Sampling times during 2003/early 2004 and types of analytical procedures applied in shallow monitoring wells.

Year	2003	2003	2003	2003	2003	2003
Month	March	April	May	Juni	July	August
Week*			19 (SKB class 5) test run		28 (SKB class 3)	

Year	2003	2003	2003	2003	2004	2004
Month	September	October	November	December	January	February
Week*		42 (SKB class 5)			3 (SKB class 3)	

* Week numbers when sampling of monitoring wells is planned to be performed

7 References

/1/ **SKB, 2001.** Platsundersökningar – undersökningsmetoder och generellt genomförandeprogram. SKB R-01-10, Svensk Kärnbränslehantering AB.

/2/ **Claesson L-Å, Nilsson G, 2003.** Forsmark site investigation. Drilling of a flushing water well, HFM06, and two groundwater monitoring wells, HFM07 and HFM08, at drillsite DS3.SKB P-03-58, Svensk Kärnbränslehantering AB.

/3/ **Claesson L-Å, Nilsson G, 2003.** Forsmark site investigation. Drilling of groundwater monitoring wells SFM0006, SFM0007 and SFM0008 in soil at drillsite DS3. SKB P-03-57, Svensk Kärnbränslehantering AB.

/4/ **Ludvigsson J-E, Källgården J, 2003.** Forsmark site investigation. Pumping tests and flow logging. Boreholes KFM03A (0–100 m), HFM06, HFM07 and HFM08. SKB P-03-36, Svensk Kärnbränslehantering AB.

Appendix 1

Designs of boreholes

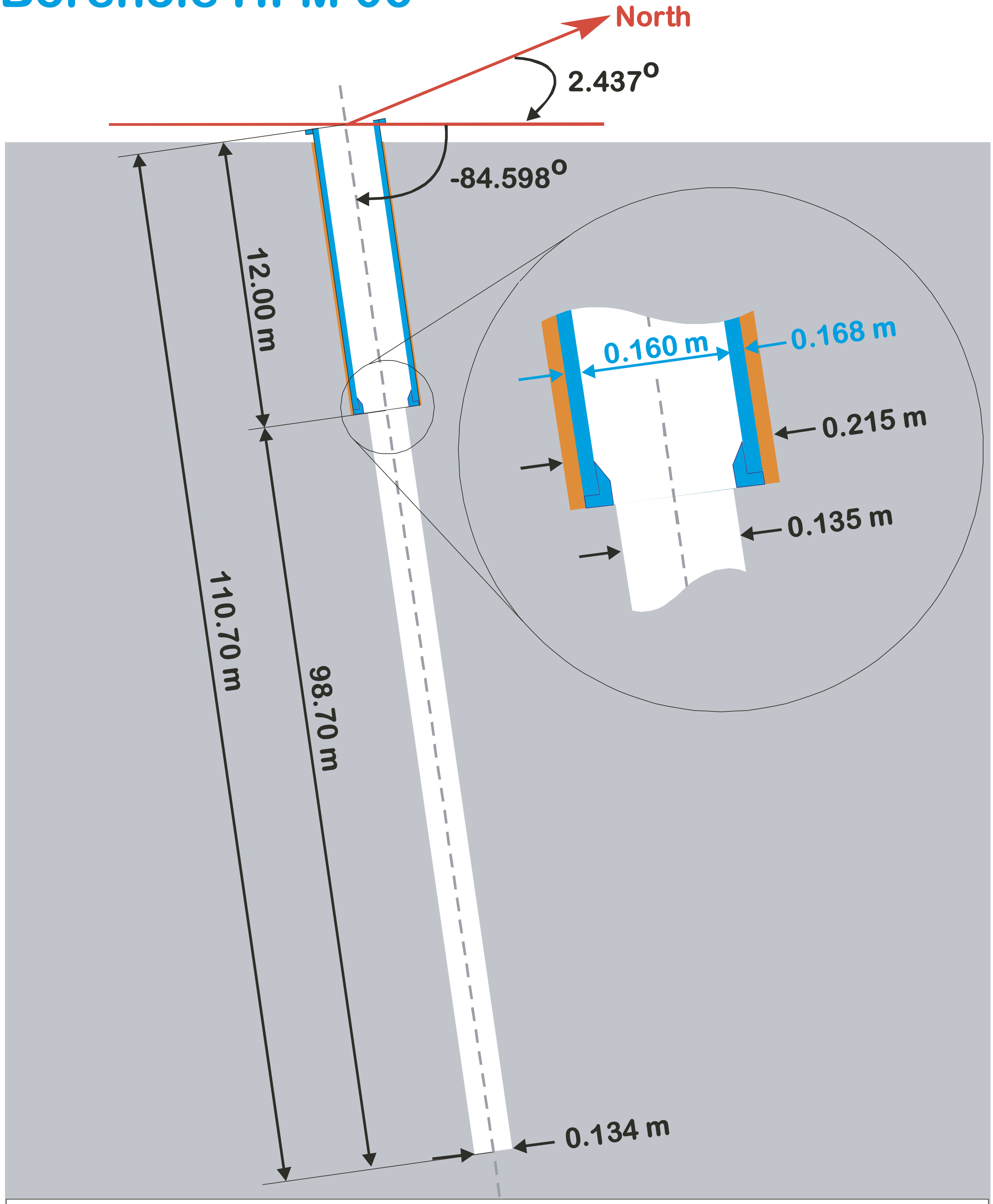
HFM06

HFM07

HFM08

Technical data

Borehole HFM 06



Drilling reference point

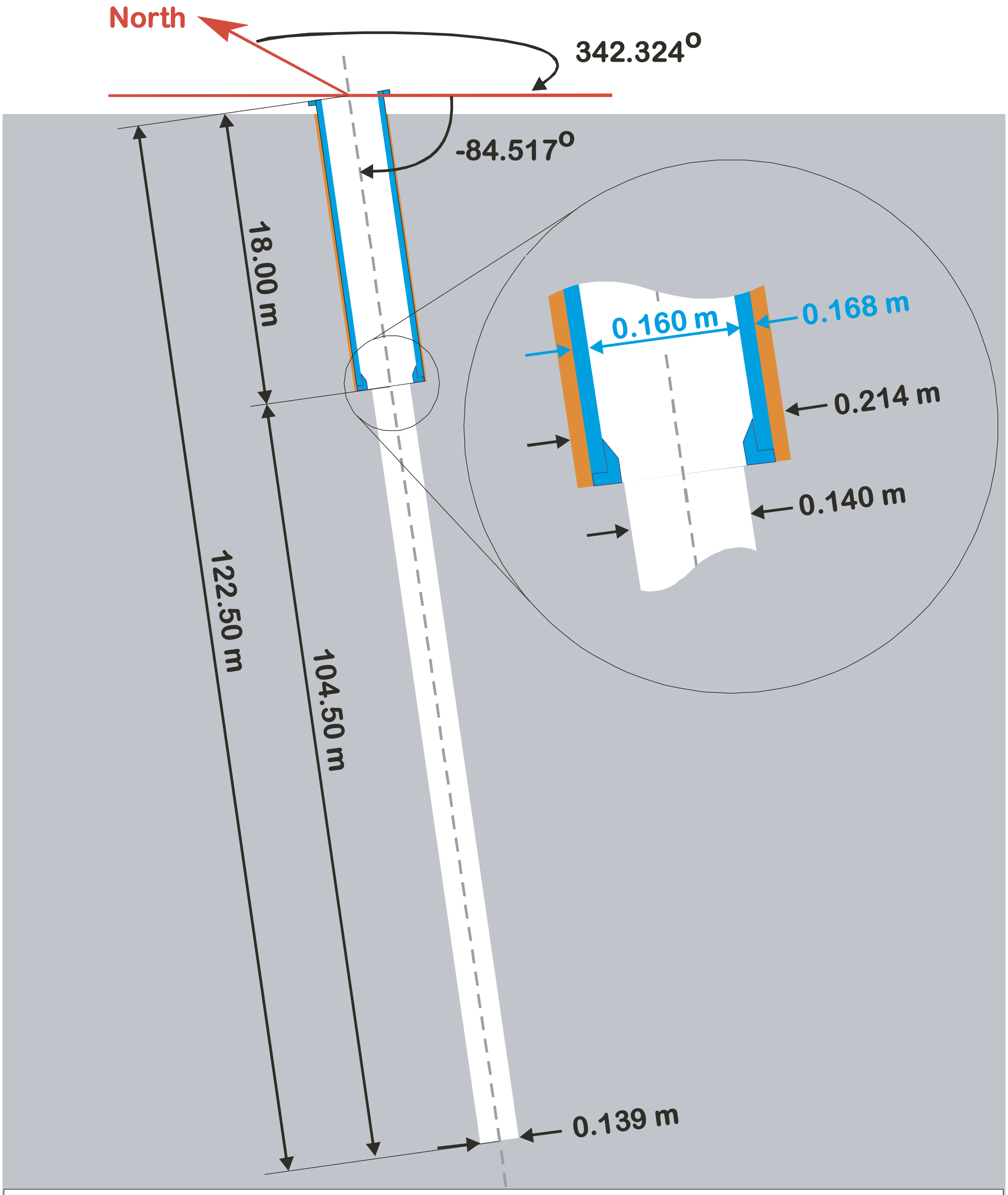
Northing:	6697752.012 (m), RT90 2,5 gon V 0:-15
Easting:	1634522.188 (m), RT90 2,5 gon V 0:-15
Elevation:	6.637 (m), RHB 70

Drilling period

Drilling start date:	2002-12-18
Drilling stop date:	2003-01-14

Technical data

Borehole HFM 07



Drilling reference point

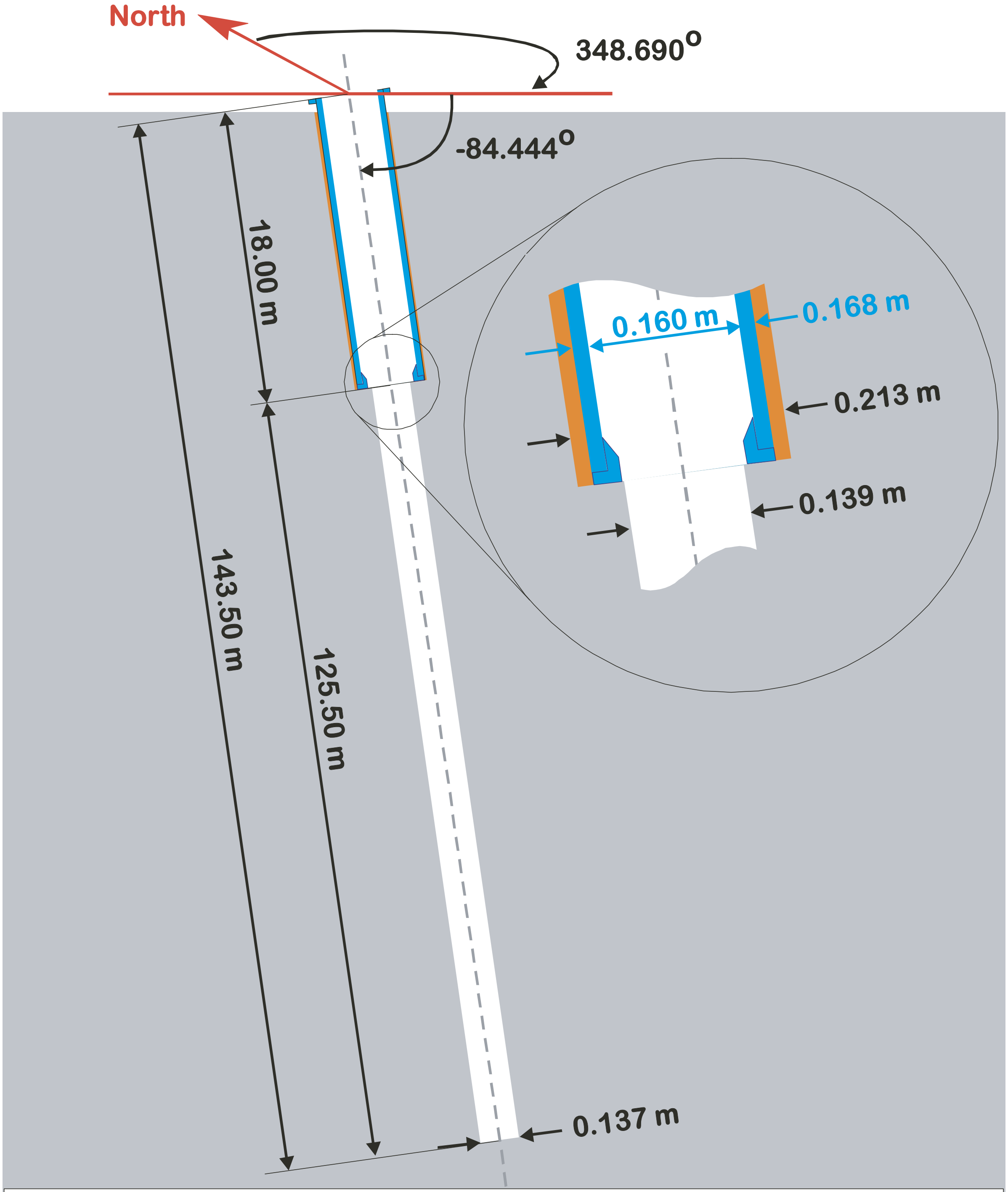
Northing:	6697416.248 (m), RT90 2,5 gon V 0:-15
Easting:	1634715.687 (m), RT90 2,5 gon V 0:-15
Elevation:	5.781 (m), RHB 70

Drilling period

Drilling start date:	2003-01-16
Drilling stop date:	2003-01-28

Technical data

Borehole HFM 08



Drilling reference point

Northing:	6697703.205 (m), RT90 2,5 gon V 0:-15
Easting:	1634777.502 (m), RT90 2,5 gon V 0:-15
Elevation:	7.132 (m), RHB 70

Drilling period

Drilling start date:	2003-01-29
Drilling stop date:	2003-02-12

Appendix 2

Overview of sample treatment and analysis routines

Table A2-1. Overview of general sample handling routines and analysis methods.

Component group	Component/ element	Sample container (material)	Volume (mL)	Filtering	Preparation/ Conservation*	Analysis method	Laboratory****	Analysis within – or delivery time to lab
Anions 1.	HCO$_3$p H(lab) cond (lab)	Plastic	250	Yes (not in the field)	No	Titration Pot. meas, Cond. meas	Mobile field lab. Alcontrol	The same day – maximum 24 hours
Anions 2	Cl, SO$_4$, Br$^-$, F$^-$, I$^-$	Plastic	100	Yes (not in the field)	No	Titration (Cl$^-$) IC (Cl$^-$, SO4, Br$^-$, F$^-$) ISE (F$^-$)	Äspö:s chemistry lab. Alcontrol	Not critical (month)
	Br, I	Plastic	100	Yes (not in the field)	No	ICP MS	Paavo Ristola OY SGAB Analytica	Not critical (month)
Cations, Si and S according to SKB class 3	Na, K, Ca, Mg, S(tot), Si(tot), Li, Sr	Plastic (at low conc. acid washed bottles)	100	Yes (not in the field)	Yes (not in the field, 1 mL HNO$_3$)	ICP-AESICP-MS	SGAB Analytica, SLU, Umeå	Not critical (month)
Cations, Si and S according to SKB class 4 and 5	Na, K, Ca, Mg, S(tot), Si(tot), Fe, Mn, Li, Sr	Plastic (Acid washed)	100	Yes (immediately in the field)	Yes (1mL HNO$_3$)	ICP-AESICP-MS	SGAB Analytica, SLU, Umeå	Not critical (month)
Fe(II), Fe(tot)	Fe(II), Fe(tot)	Plastic (Acid washed)	500	Yes	Yes (5 mL HCl))	Spectrophotometry Ferrozine method	Mobile field lab.	As soon as possible the same day
Hydrogen sulphide	HS–	Glass (Winkler)	About 120×2	No	Ev 1 mL 1 M NaOH+ 1 mL 1M ZnAc	Spectrophotometry	Alcontrol Äspö's chemistry lab.	Immediately or if conserved, a few days
Nutrient salts	NO$_2$, NO$_3$+NO$_2$, NH$_4$, PO$_4$	Plastic	250	No	No	Spectrophotometry	Äspö:s chemistry lab. Alcontrol	Maximum 24 hours
Environmental metals	Al, As, Ba, B, Cd, Co, Cr, Cu, Hg, Mo, Ni, P, Pb, V, Zn	Plastic	100	Yes	Yes (1 mL HNO$_3$)	ICP-AESICP-MS	SGAB Analytica, Alcontrol	Not critical (month)
Lantanoids, U, Th and so on.	Sc, Rb, Y, Zr, I, Sb, Cs, La, Hf, Tl, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, U, Th	Plastic	100	Yes	Yes (1 mL HNO$_3$)	ICP-AESICP-MS	SGAB Analytica, Alcontrol	Not critical (month)
Dissolved organic Carbon, dissolved inorganic Carbon	DOC, DIC	Plastic	250 25	Yes	Frozen, transported in isolated bag	UV oxidation, IR Carbon analysator Shimadzu TOC5000	Paavo Ristola OY Dept. of System ecology, SU	Short transportation time
Total organic Carbon	TOC	Plastic	250 25	No	Frozen, transported in isolated bag	UV oxidation, IR Carbon analysator Shimadzu TOC5000	Paavo Ristola OY Dept. of System ecology, SU	Short transportation times

Component group	**Component/ element**	**Sample container (material)**	**Volume (mL)**	**Filtering**	**Preparation/ Conservation***	**Analysis method**	**Laboratory********	**Analysis within – or delivery time to lab**
Environmental isotopes	^{2}H, ^{18}O	Plastic	100	No	–	MS	IFE	Not critical (month)
Tritium,	^{3}H (enhanced.)	Plastic (dry bottle)	500	No	–	LSC	Univ. Of Waterloo	Not critical (month)
Chlorine-37	Chlorine-37	Plastic	100	No	–	ICP MS		
Carbon isotopes	^{13}C, ^{14}C	Glass (brown)	100′2	No	–	(A)MS	Univ. Of Waterloo	A few days
Sulphur isotopes	^{34}S	Plastic	500–1000	Yes	–	Combustion, ICP MS	IFE	No limit
Strontium-isotopes	$^{87}Sr/^{86}Sr$	Plastic	100	Yes	–	TIMS	IFE	Days or Week
Uranium and Thorium isotopes	^{234}U, ^{235}U, ^{238}U, ^{232}Th, ^{230}Th	Plastic	50	Nej	–	Chemical separat. Alfa/gamma spectrometry	IFE	No limit
Boron isotopes	^{10}B	Plastic	100	Yes	Yes (1 mL HNO_3)	ICP – MS	SGAB Analytica	No limit
Radon and Radium isotopes	^{222}Rn, ^{226}Ra	Plastic	500	No	No	EDA, RD-200	IFE	Immediate transport
Dissolved gas (content and composition)	Ar, N_2, CO_2, O_2, CH_4, H_2, CO, C_2H_2, C_2H_4, C_2H_6, C_3H_8	Cylinder of stainless steel	200	No	No	GC	Paavo Ristola OY	Immediate transport
Colloids	Filter series and fractionation (see below)	Polycarbonate filter	0.45, 0.2 and 0.05 µm	–	N_2 atmosphere	ICP-AESICP-MS	SGAB Analytica	Immediate transport
Humic and fulvic acids	Fractionation	Fractions are collected in plastic bottles	250	–	N_2 atmosphere	UV oxidation, IR (DOC)	Paavo Ristola OY	Immediate transport
Archive samples with acid	–	Plast (washed in acid)	100×2**	Yes	Yes (1 mL HNO_3)	–	–	Storage in freeze container
Archive samples without acid	–	Plastic	250×2**	Yes	No	–	–	Storage in freeze container
Carbon isotopes in humic and fulvic acids	^{13}C, ^{14}C	DEAE cellulose (anion exchanger)	–	–	–	(A)MS	The Ångström laboratory, Uppsala	A few days

* Suprapur acid is used for conservation of samples.

** Minimum number, the number of archive samples can vary depending on how many similar samples that are collected at the same occasion.

**** Full name and address is given in Table A2-3.

Abbreviations and definitions:

IC	Ion chromatograph
ISE	Ion selective electrode
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectrometry
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
INAA	Instrumental Neutron Activation Analysis
MS	Mass Spectrometry
LSC	Liquid Scintillation Counting
(A)MS	(Accelerator) Mass Spectrometry
GC	Gas Chromatography

Table A2-2. Reporting limits and measurement uncertainties.

Component	Method	Reporting limits or range	Unit	Measurement uncertainties [3]	"Total" uncertainties [4]
HCO_3	Alkalinity titration	1	mg/L	4%	Time delay affects the results
Cl^-	Mohr- titration	>70	mg/L	5%	<10%
Cl^-	IC	1–100		6%	20%
SO_4	IC	1	mg/L	10%	20%
Br^-	IC	0.2	mg/L	9%	30%
Br^-	ICP	0.001		15%	
F^-F^-	ICPotentiometric	0.1 –	mg/L	10% –	20%
I^-	ICP	0.001	mg/L	15%	20%
Na	ICP	0.1	mg/L	4%	10%
K	ICP	0.4	mg/L	6%	20%
Ca	ICP	0.1	mg/L	4%	10%
Mg	ICP	0.09	mg/L	4%	10%
S(tot)	ICP	0.160	mg/L	21%	20%
Si(tot)	ICP	0.03	mg/L	4%	15%
Sr	ICP	0.002	mg/L	4%	10%
Li	ICP	0.2[1] 2[2]	mg/L	10%	20%
Fe	ICP	0.4[1] 4[2]	mg/L	6%	10%
Mn	ICP	0.03[1] 0.1[2]	µg/L	8%	10%
Fe(II), Fe(tot)	Spectrophotometry	0.02 (DL=0.005 mg/L)	mg/L	22%	30%
HS^-	Spectrophotometry	SKB 0.03 (DL=0.002) Alcontrol (DL= 0.003)	mg/L	20%	30%
NO_2 as N	Spectrophotometry	0.1	µg/L	2%	20%
NO_3 as N	Spectrophotometry	0.2	µg/L	5%	20%
NO_2+NO_3 as N	Spectrophotometry	0.2	µg/L	0.2 (0.2–20 mg/L) 2% (> 20 mg/L)	20%
NH_4 as N	Spectrophotometry	0.8	µg/L	0.8 (0.8–20 mg/L) 5% (> 20 mg/L)	20%
		50 (SKB)			20%
PO_4 as P	Spectrophotometry	0.7	µg/L	0.7 (0.7–20 mg/L) 3% (>20 mg/L)	20%
SiO_2	Spectrophotometry	1	µg/L	3% (>200 mg/L)	
O_2	Jodometrisc titration		µg/L		
Chlorophyll a, c pheopigment[6]	See table A1-2	0.5	µg/L	5%	

Component	**Method**	**Reporting limits or range**		**Unit**	**Measurement uncertainties** [3]	**”Total” uncertainties** [4]
PON[6]	See table A1-2	0.5		µg/L	5%	
POP[6]	See table A1-2	0.1		µg/L	5%	
POC[6]	See table A1-2	1		µg/L	4%	
Tot-N[6]	See table A1-2	10		µg/L	4%	
Tot-P[6]	See table A1-2	0.5		µg/L	6%	
Al, Zn	ICP	0.2		µg/L	12%	20%[5]
Ba, Cr, Mo, Pb	ICP	0.01		µg/L	7–10%	20%[5]
Cd, Hg	ICP	0.002		µg/L	9 resp 5%	20%[5]
Co, V	ICP	0.005		µg/L	8 resp 5%	20%[5]
Cu	ICP	0.1		µg/L	8%	20%[5]
Ni	ICP	0.05		µg/L	8%	20%[5]
P	ICP	1		µg/L	6%	10%
As	1CP	0.01		µg/L	20%	Correct order of size
La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb	ICP	0.0051	0.05[2]	µg/L	10%	Correct order of size
Sc, In, Th	ICP	0.05[1]	0.5[2]	µg/L	10%	Correct order of size
Rb, Zr, Sb, Cs, Tl	ICP	0.025[1]	0.25[2]	µg/L	10%	Correct order of size
Y, Hf	ICP	0.005[1]	0.05[2]	µg/L	10%	Correct order of size
U	ICP	0.001[1]	–	µg/L	12%	Correct order of size
DOC, DIC	See table A1-1	0.1		Mg/L	20%	50%
TOC	See table A1-1	0.1		Mg/L	20%	50%
^{2}H	MS	2		‰ dev SMOW	1.0‰	
^{18}O	MS	0.1		‰ dev SMOW	0.2‰	
^{3}H	LSC	0.8 or 0.1		TU	0.8	Correct order of size
^{37}Cl	ICP MS	0.2‰ (20 mg/L)		SMOC	–	
^{13}C	A (MS)	–		PDB	–	
^{14}C pmc	A (MS)	–		PMC	–	Correct order of size
^{34} S	ICP MS	0.2‰			0.3‰	
^{87}Sr/^{86}Sr	TIMS	–		No unit	<±0.000020	
^{10}B/^{11}B	ICP MS	–		No unit	–	
^{234}U, ^{235}U, ^{238}U, ^{232}Th, ^{230}Th, ^{222}Rn, ^{226}Ra	Alfa spectr. LSC	0.1 (^{234}U, ^{238}U, ^{226}Ra) 0.3 (^{235}U) 0.05 (^{232}Th, ^{230}Th)		Bq/L	0.05 Bq/L	Correct order of size

[1] Salt ≤0.4% (520 mS/m)

[2] Salt ≤3.5% (3810 mS/m)

[3] Measurement uncertainty reported by consulted laboratory

[4] “Total” uncertainty estimated by experience (includes sampling and sample handling)

[5] Valid for surface water samples collected by metal free “Ruttner sampler”, filtered and acidified in the field. The risk of contamination varies depending on sampling method.

[6] Determined only in surface waters and near surface groundwater

Table A2-3. Consulted laboratories, full name and address.

Äspö waterchemical laboratory (SKB)
Mobile field laboratory, Forsmark (SKB)

Inainööritoimisto
Paavo Ristola Oy
Teollisuus-ja
Voimalaitoskemia
Rajantorpantie 8, C-talo
01600 Vantaa
FINLAND

Dept. of System ecology
Stockholm University
10691 Stockholm

Analytica AB
Aurorum 10
977 75 Luleå
(Nytorpsvägen 16
Box 511
183 25 Täby)

Environmental Isotope Laboratory
Dep. Of earth sciences
University of Waterloo
Waterloo, Ontario
N2L 3G1 CANADA

Institutt for energiteknik (IFE)
Insituttveien 18
P.O Box 40
2027 Kjeller
NORGE

Alcontrol Nordic AB
Box 905
531 19 Lidköping

The Ångström laboratory
Box 534
SE-751 21 Uppsala

Environmental research laboratory (SLU), Luleå

Alcontrol
Box 1083
581 10 Linköping

Appendix 3

Water composition, compilation of basic water analysis data

Idcode	Secup m	Seclow m	Sample no.	Date	Time	Charge Bal %	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	HCO3 mg/L	Cl mg/L	SO4 mg/L	SO4-S mg/L	Br mg/l	F⁻ mg/L	Si mg/L	Fe mg/L	Mn mg/L	Li mg/L	Sr mg/L	pH	TOC mg/L
HFM06	0,0	110,7	4463	2003-01-21	11:55	5,68	384	17,6	73,3	20,4	231	476	135	44,1	1,87	1,70	5,0	_	_	0,01	0,43	7,7	5,7
HFM06	0,0	110,7	4464	2003-01-21	16:52	0,36	447	19,1	92,9	27,0	418	586	156	50,0	2,25	1,60	5,1	_	_	0,01	0,60	7,6	5,8
HFM06	0,0	110,7	4465	2003-01-21	21:50	–0,40	519	21,4	125	37,2	404	797	173	55,5	3,02	1,48	5,2	_	_	0,02	0,85	7,6	5,1
HFM06	0,0	110,7	4618	2003-03-06	08:55	–0,78	629	28,2	175	54,5	372	1110	208	71,6	3,71	1,80	4,7	_	_	0,02	1,25	7,6	_
HFM08	0,0	143,5	4521	2003-02-18	09:30	0,83	2240	68,0	760	289	113	5160	512	169	20,2	1,33	4,6	_	_	0,05	6,48	7,3	_
HFM08	0,0	143,5	4522	2003-02-18	18:05	–1,98	2210	67,8	754	287	115	5420	534	168	24,1	1,43	4,8	_	_	0,05	6,36	7,3	_
HFM08	0,0	93,0	4535	2003-02-20	13:40	2,68	1150	32,6	572	139	173	2690	319	115	11,0	0,78	6,6	_	_	0,03	4,16	7,3	_

– = Not analysed

x = No result due to sampling problems

xx = No result due to analytical problems

– "value" = result less than detection limit

ChargeBal % = Relative charge balance error %

SICADA: water_composition, 030101–030301

Appendix 4

Isotopes I, compilation of H-, O-, B-, S-, Cl- and C-isotopes and isotope ratios.

Idcode	Secup m	Seclow m	Sample no	Date	Time	D dev SMOW	Tr TU	O-18 dev SMOW	^{10}B/^{11}B no unit	S-34 dev CDT	Cl-37 dev SMOC	C-13 dev PDB	^{87}Sr/^{86}Sr no unit	C-14 pmc	AGE_BP years
HFM06	0,0	110,7	4463	2003-01-21	11:55	–	–	–	0,24	–	–	–	–	–	–
HFM06	0,0	110,7	4464	2003-01-21	16:52	–	–	–	0,24	–	–	–	–	–	–
HFM06	0,0	110,7	4465	2003-01-21	21:50	A	A	A	0,24	A	A	A	A	A	A
HFM06	0,0	110,7	4618	2003-03-06	08:55	–	–	–	0,24	–	–	–	–	–	–
HFM08	0,0	143,5	4521	2003-02-18	09:30	–	–	–	0,24	–	–	–	–	–	–
HFM08	0,0	143,5	4522	2003-02-18	18:05	A	A	A	0,24	A	A	A	A	A	A
HFM08	0,0	93,0	4535	2003-02-20	13:40	A	A	A	0,24	A	A	A	A	A	A

– = Not analysed

A = Results will be reported later

x = No result due to sampling problems

xx = No result due to analytical problems

SICADA: h_o_isotopes, b_s_cl_sr_isotopes 030101–030301

Appendix 5

Drinking water parameters

Idcode	Secup m	Seclow m	Sample no	Date	Time	Hbakt no/100 mL	Kbakt no/100 mL	Ecoli no/100 mL	Smell_Lab	Muddy	Colour no.
HFM06	0,0	110,7	4618	2003-03-06	08:55	–100	–1	–1	No	No	15

Idcode	Secup m	Seclow m	Sample no	Date	Time	Hardness Germ. dH	NH_4_N mg/L	NO_2_N mg/L	PO_4_P mg/L	COD-Mn mg/L	Rn Bq/L
HFM06	0,0	110,7	4618	2003-03-06	08:55	35,3	0,69	0,002	0,016	6,2	286

Microbiological judgement:

suitable

Chemical judgement:

suitable with remarcs due to radon, fluoride, sulphate, chloride, hardness and ammonium

– = Not analysed

x = No result due to sampling problems

xx = No result due to analytical problems

– "value" = result less than detection limit

SICADA: WellChemistry 1 T, 030101–030301, 1 av 1