P-03-95

Forsmark site investigation

Hydrochemical logging and "clean up" pumping in KFM02A

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Oktober 2003

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Contents

1 Introduction

This document reports performance of and results from the activity "Hydrochemical logging in KFM02A" performed within the site investigation at Forsmark /1/. The work was conducted according to the activity plan AP PF 400-03-01 (SKB internal controlling document). Further, the report describes the "clean up" pumping that was carried out after the logging. The results from the hydrochemical logging showed that the content of remaining flushing water from the drilling was very high along the borehole and the "clean up" pumping was therefore performed in order to decrease this content.

Borehole KFM02A is the second deep telescopic borehole drilled at the site investigations in the Forsmark area /2/. The location of the borehole is shown in Figure 1-1. The borehole section 0–100 m is percussion drilled, and at the logging occasion it was cased with a stainless steel casing with the internal diameter 200 mm, whereas section 100–1002.5 m is core drilled with a diameter of 77 mm. The borehole is 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 (Instruction for cleaning borehole equipment and certain surface equipment). Basic borehole information is given in Table 1-1 below. The design of the borehole is presented in Appendix 1. A map showing the locations of all boreholes at drill site DS2 is presented in Figure 1-2.

Table 1-1. Borehole information, KFM02A at drill site DS2.

Activities performed	Date of completion	Length (m)	Comment
Percussion drilling	2002-06-10	0–100	Water bearing section at 80 m. After the hydraulic tests a casing was installed and gap grouted, sealing off water inflow in this part of the borehole.
Pumping tests and water sampling		0–100	/3, 4/
Core drilling	2003-03-12	100–1002.45	HFM05 served as source of flushing water for core drilling the cored part of KFM02A. HFM05 is a SKB chemical type of borehole /5/.
Final mammoth pumping after completion of the core drilled part	–	–	Pumped volumes: 128 m^3 after completed drilling 164 m^3 just before hydrochemical logging
Hydrochemical logging and "clean up" pumping	2003-03-31 2003-04-14 2003-04-14	100–1000 0–130 below 130	Described in this report Pumped volume: 450 m^3 Pumped volume: between 1.3 and 26 m^3

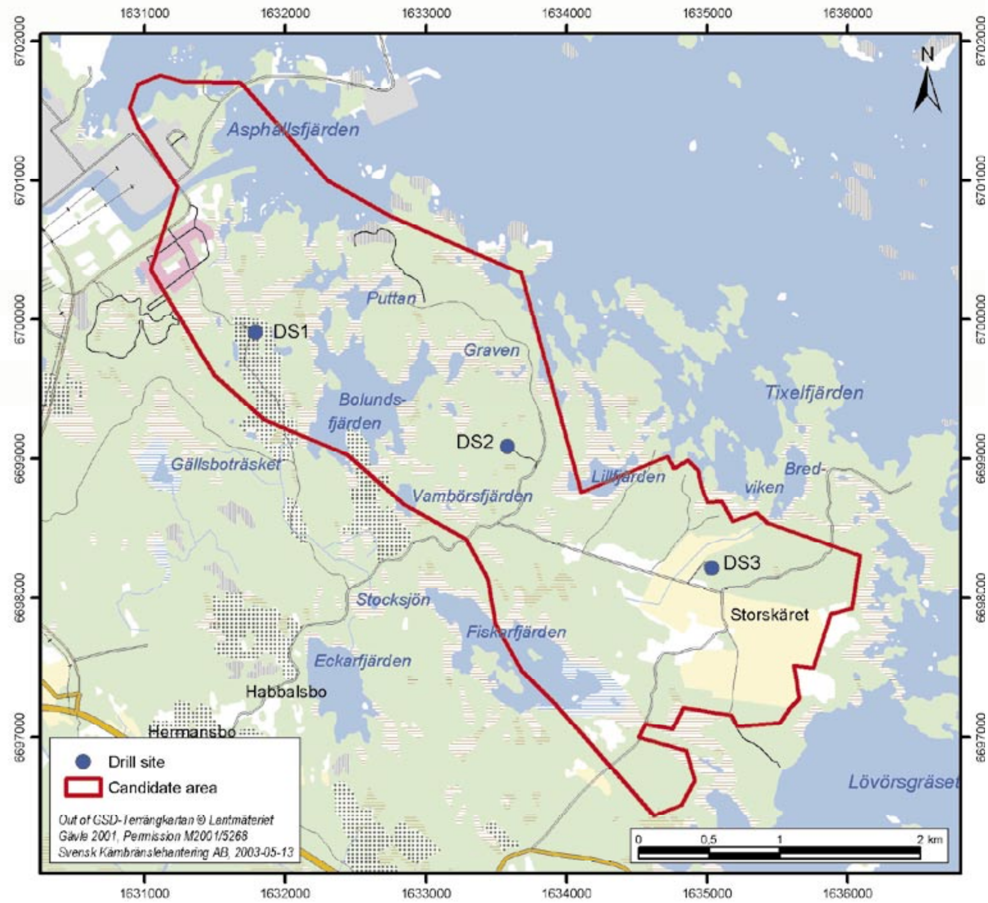

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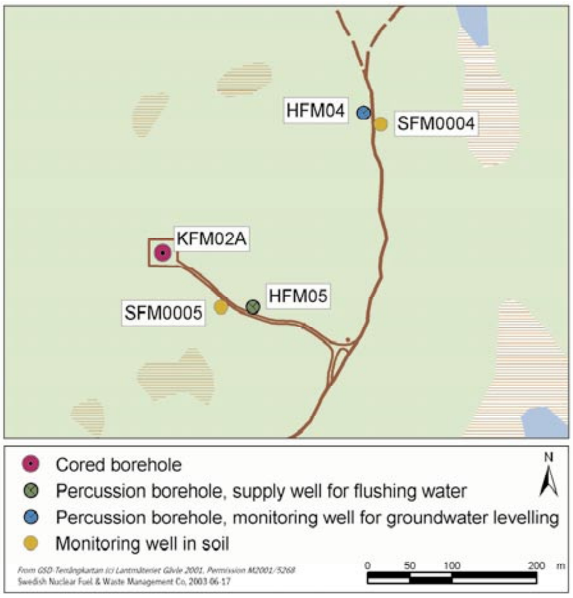
***Figure 1-1.** The investigation area at Forsmark (approximately the area inside the black square) including the candidate area selected for more detailed investigations. Drill sites DS1-3 are marked with blue circles.*



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Swedish Nuclear Fuel & Waste Management Co, 2003 06 17

***Figure 1-2.** Locations of the telescopic borehole KFM02A as well as percussion boreholes and shallow monitoring wells at drill site DS2.*

2 Objective and scope

Hydrochemical logging is performed in order to obtain an overview of the initial chemical composition along the open borehole KFM02A. The sampling technique is fast and simple even at great depth.

The analysis program is carried out according to SKB chemistry class 3 including isotope options. However, if the drilling water content in a sample is above 25%, the isotope determinations are omitted.

"Clean up" pumping is performed in order to decrease the flushing water content and/or the amount of drilling debris in a borehole. As the borehole KFM02A is of the SKB chemical type, the method "complete chemical characterisation" will be carried out in a number of borehole sections covering the identified water bearing fracture zones. This method is performed in order to obtain as complete and correct information as possible of the undisturbed groundwater chemistry in the water bearing fractures of the bedrock. Therefore, an upper limit for the allowed flushing water content in a representative water sample is set to 1%. From the hydrochemical logging results it was obvious that to reach this goal it was necessary to perform a "clean up" pumping of the borehole.

3 Equipment

3.1 Sampling equipment

The sampling equipment used for the hydrochemical logging consists of an approximately 1000 metre long polyamide tube divided into units of 50 metre. The equipment is described by Nurmi and Kukkonen /6/ and in the method description SKB MD 422.001 (Metodbeskrivning för hydrokemisk loggning).

The tube units are connected with couplings. The exact length of each tube unit is given in Table 3-1. The external and internal diameter of the tube units are 10 and 8 mm respectively. The water content in each tube unit will constitute one sample and the volume of each sample will be at least two litres. A check valve and a weight are mounted at the bottom of the tube array to prevent water outflow and to keep it straight in the borehole. At both ends of each tube unit there is a manual shut off valve. A schematic illustration of the equipment used for the hydrochemical logging is shown in Figure 3-1.

Table 3-1. Lengths of tube units.

Unit	Length [m]
1	49,870
2	49,620
3	49,630
4	49,300
5	49,200
6	49,220
7	49,700
8	50,620
9	50,250
10	49,670
11	49,720
12	49,570
13	49,870
14	49,850
15	50,010
16	49,970
17	49,280
18	49,770
19	50,080
20	49,710
Sum:	994,910
Coupling length	2,812
Weight length	0,817
Total tube length	998,539

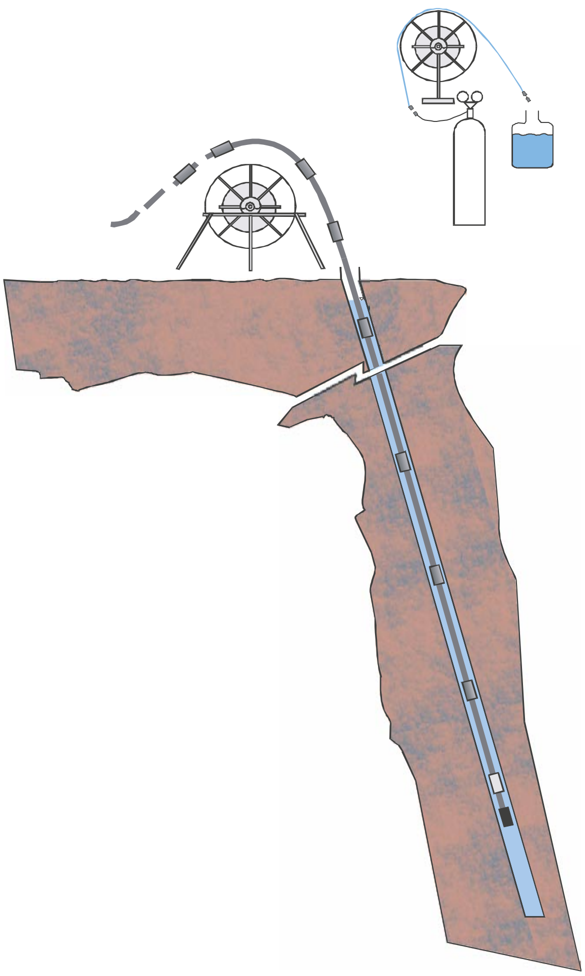


***Figure 3-1**. “Equipment for hydrochemical logging in boreholes”. At the lower end of the tube array there is a check valve and a weight connected. Each tube unit is 50 metres long.*

3.2 Pumping equipment “Clean up pumping”

For the clean up pumping the borehole was instrumented with a Petrometalic inflatable packer at a depth of 130 metre. A special adapter was made in order to connect a PEM-tube at the inlet of the packer. The top 50 meters of the tube were replaced with “O”-ring tightened plastic tubes with an internal diameter of 53.5 mm. With help of a wire winch the equipment was lowered down the borehole. Two different types of pumps were used. A Grundfoss MP1 in the plastic tube and a Grundfoss 3" in the spaced part of the borehole. As a precaution, 22 mm aluminium-rods were mounted and connected to the adapter on the packer.

4 Performance

4.1 Hydrochemical logging

Sampling of the telescopic borehole KFM02A was performed according to activity plan AP PF 400-03-01 (SKB internal controlling document) following the method described in SKB MD 422.001 (Metodbeskrivning för hydrokemisk loggning).

4.1.1 Performance of sampling

The hydrochemical logging was performed on March 31. The lowering of the tubes along the borehole started at 09:39 and at 14:58 all 20 tube units had been lowered. The uptake of the first tube unit started at 15:00, and at 18:05 the last tube unit was lifted up. The tube units were emptied using pressurized nitrogen gas and the water was portioned into plastic bottles to be analysed at different laboratories.

4.1.2 Sample treatment and chemical analyses

An overview of sample treatment and analysis routines is given in Appendix 2. The routines are applicable independent of sampling method or sampling object. An overview showing the sample portions filled at the logging occasion is given in Table 4-1. Sample portions for isotope analysis were collected but not sent to the laboratories due to their high content of remaining flushing water from the drilling. The hydrochemical data from the logging are stored in the database SICADA in field note no. 129. The SKB sample numbers are 4683–4699.

Table 4-1. Overview of samples collected at hydrochemical logging in KFM02A. Filled cells represent collected samples.

Tubes			Samples taken for analyses										Archive samples		
Tube	[m]	SKB:nr	pH, alk. cond.	Major comp.	Anions	Deut. O-18	Uranine	Cl-37	Sr-87	C isotope	3H	S-34	Filtered (+ HNO_3)	Filt.	
			250 ml	100 ml	250 ml	100 ml	100 ml	100 ml	100 ml	2x100 ml	500 ml	1000 ml	100 ml	250 ml	500 ml
20	0 50	4683	🟦 Charge balance error	🟦	🟦	x	🟦	x			x				
19	50 100	4684											🟨	🟨	🟨
17 & 18	100 200	4685	🟦	🟦	🟦	x	🟦	x	x	x	x	x			
16	200 250	4686											🟨	🟨	🟨
15	250 300	4687	🟦	🟦	🟦	x	🟦	x	x	x	x				
14	300 350	4688											🟨	🟨	🟨
13	350 400	4689	🟦	🟦	🟦	x	🟦	x	x	x	x				
12	400 450	4690											🟨	🟨	🟨
10 & 11	450 550	4691	🟦	🟦	🟦	x	🟦	x	x	x	x	x			
9	550 600	4692											🟨	🟨	🟨
8	600 650	4693	🟦	🟦	🟦	x	🟦	x	x	x	x				
7	650 700	4694											🟨	🟨	🟨
6	700 750	4695	🟦	🟦	🟦	x	🟦	x	x	x	x				
5	750 800	4696											🟨	🟨	🟨
4	800 850	4697	🟦	🟦	🟦	x	🟦	x	x	x	x				
3	850 900	4698											🟨	🟨	🟨
1 & 2	900 1000	4699	🟦	🟦	🟦	x	🟦	x	x	x	x	x			

x = samples were collected but not sent for anlyses due to high flushing water content.
Even sample numbers are archive samples, i.e. yellow cells.

4.1.3 Data handling

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 as a standard procedure on each fifth or tenth collected sample.

All analytical results were stored in the SICADA database. The applied 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 *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.

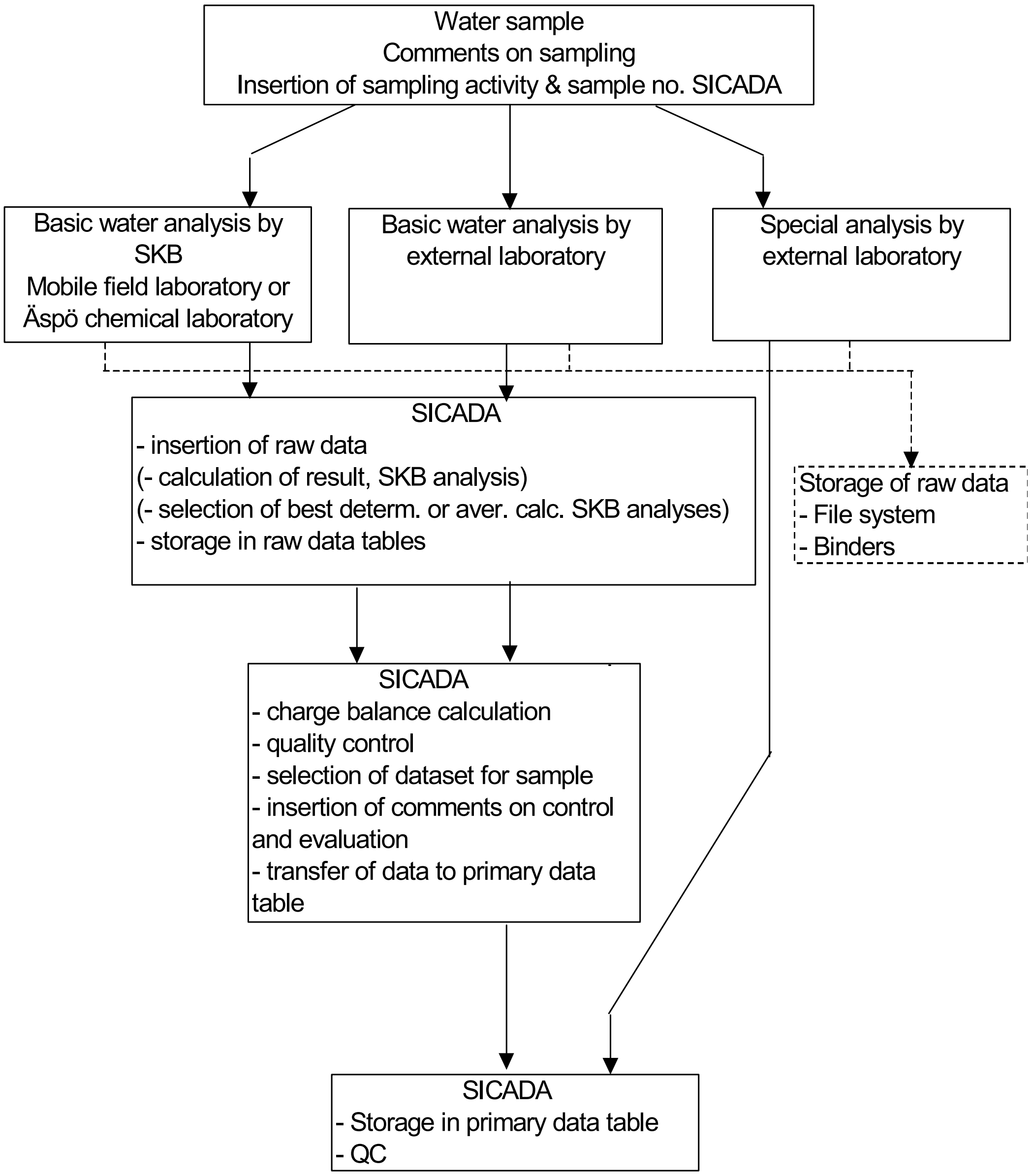


Figure 4-1. *Overview of data management for hydrogeochemical data.*

4.2 Clean up pumping

Uranine analysis of borehole water in KFM02A showed that the amount of flushing water in the water column of the borehole was high, more than 10% in the first section and up to over 80% in the deeper sections, see the results. This in spite of repeated pumping both after completed drilling (128 m^3) and shortly before the hydrochemical logging (164 m^3). As a result of this, a clean up pumping was performed in attempt to lower the amount of flushing water in the borehole.

The larger pump for the upper section of the borehole was started at 15:50 on April 10 and stopped at 13:00 on the 14:th. It ran continuously with the exception of a planned power cut on the 11:th that lasted for approximately three hours.

For the lower section the pumping was postponed until 14:25 on April 11 due to problems with adjusting the equipment. When field staff returned to the site on the 14:th, after the weekend, the pump had stopped. It was restarted at 08:45 the same day. At 10:45 field personal momentarily left the drill site, and when they returned the pump had stopped once again. It was restarted at 12:15 and ran until 13:00 when it was purposely turned off by the staff.

5 Results

5.1 Analysis results

The analysis data from the hydrochemical logging in borehole KFM02A are presented in Appendix 3. Diagrams showing the flushing water content and the electric conductivity plotted versus borehole length are presented in Figure 5-1 and 5-2 below. The results have been plotted at the mean length of each tube, for example tube number 20 representing section 0 to 50 metre is plotted at 25 metre. Isotope results are not available. The isotope determinations were omitted due to high content of remaining flushing water in the borehole.

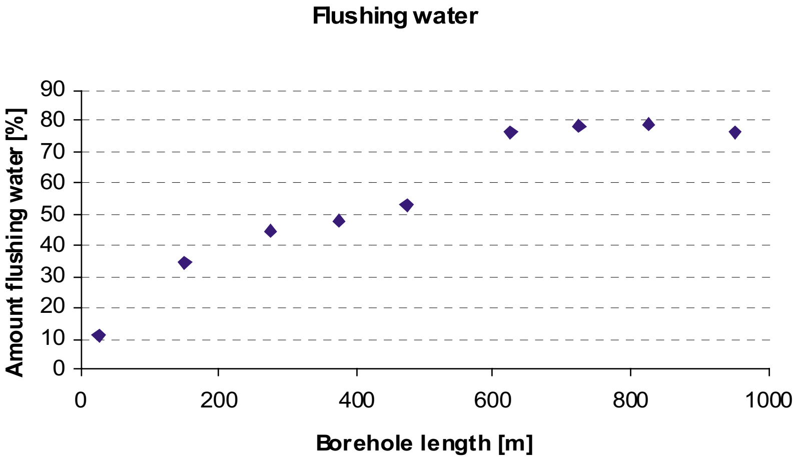


***Figure 5-1.** Flushing water content.*

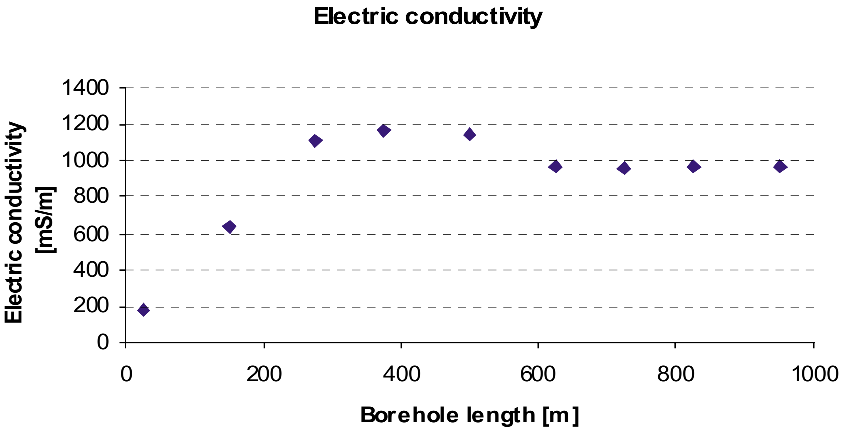


***Figure 5-2.** Electric conductivity.*

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 errors exceed ± 5% in one case (SKB:nr 4683) out of nine.

5.3 Results of "clean up" pumping

The total volume of water pumped from the upper section of the borehole was about 450 m^3. The volume pumped from the lower section is somewhere between 1.3 m^3 and 26 m^3. A pump failure occurred, and therefore the exact length of the pumping period is unknown.

The flushing water content in the lower part of the borehole remained high (50%) even after completed "clean up" pumping. The content in the upper part was however quite low (0.5%).

The total amount of Uranine used during the core drilling is given in Table 5-1, together with the estimated amount of Uranine that has been regained during he different pumping occasions. The numbers illustrate the difficulties to calculate the remaining amount of Uranine in the borehole.

Table 5-1. Amount of Uranine used in KFM02A during core drilling and amounts regained during pumping.

	Uranine (g)
Uranine addition during core drilling (according to log)	250
Uranine regained during mammoth pumping (during drilling)	230*
Uranine regained during "clean up" pumping in the upper and the lower part of the borehole (packer at 130 m)	1–25**

* Estimated amount from average value of Uranine content in the returned water and total volume of returned water. The uncertainty in the value is large.

** Start values and stop values of the Uranine concentrations are used. If the decrease in concentration is linear, the amount of Uranine will be 25 g. It is more likely that the decrease is non linear which means that the amount could be considerably less.

6 Discussion

The hydrochemical logging in KFM02A proved useful in the sense that it revealed the high content of remaining flushing water in the water along the borehole. However, the analysis data obtained will be less useful for chemical modelling work due to this fact.

The efforts made in order to lower the content of flushing water by an extra “clean up” pumping did not give the expected result. The drilling water content remained high. It will probably be necessary to perform complementary “clean up” pumping in the borehole sections that will be investigated during complete chemical characterisation in order to get representative samples.

Two factors are identified that probably cause the flushing water situation to be different in this borehole compared to the boreholes KFM01A and KFM03A, namely:

- There is one very dominant water bearing fracture zone at about 120 m along the borehole (just below the casing) /7/. Due to this, the pumping performed during drilling was less efficient especially at depth, since a major part of the pumped water originated from this fracture.
- There are only two detectable water bearing fracture zones further down in the borehole /7/. All the lost flushing water during core drilling was presumably pressed into these two zones. The water pressure caused by the drilling is quite large causing a high flow gradient into the fractures.

7 References

/1/ **SKB, 2001.** Generellt genomförande program för platsundersökningar. SKB R 01-10, Svensk Kärnbränslehantering AB.

/2/ **Claesson L-Å, Nilsson G, 2003.** Forsmark site investigation. Drilling of the telescopic borehole KFM02A at drillsite DS2. SKB P-03-52, Svensk Kärnbränslehantering AB.

/3/ **Ludvigsson J-E, Svensson T, 2003.** Forsmark site investigation. Pumping tests and flow logging. Boreholes KFM02A (0–100 m), HFM04 and HFM05. SKB P-03-34, Svensk Kärnbränslehantering AB.

/4/ **Nilsson A-C, 2003.** Forsmark site investigation. Sampling and analyses of groundwater in percussion drilled boreholes and shallow monitoring wells at DS2. Results from the percussion boreholes HFM04, HFM05, KFM02A (borehole section 0–100 m) and the monitoring wells SFM0004 and SFM0005. SKB P-03-34, Svensk Kärnbränslehantering AB.

/5/ **Claesson L-Å, Nilsson G, 2003.** Forsmark site investigation. Drilling of a flushing water well, HFM05, and one groundwater monitoring well, HFM04, at drillsite DS2. SKB P-03-51, Svensk Kärnbränslehantering AB.

/6/ **Nurmi P, Kukkonen I, 1986.** A new technique for sampling water and gas from deep drill holes. Canadian Journal of Earth Sciences, Volume 23, Number 9, 1986, pp. 1450–1454.

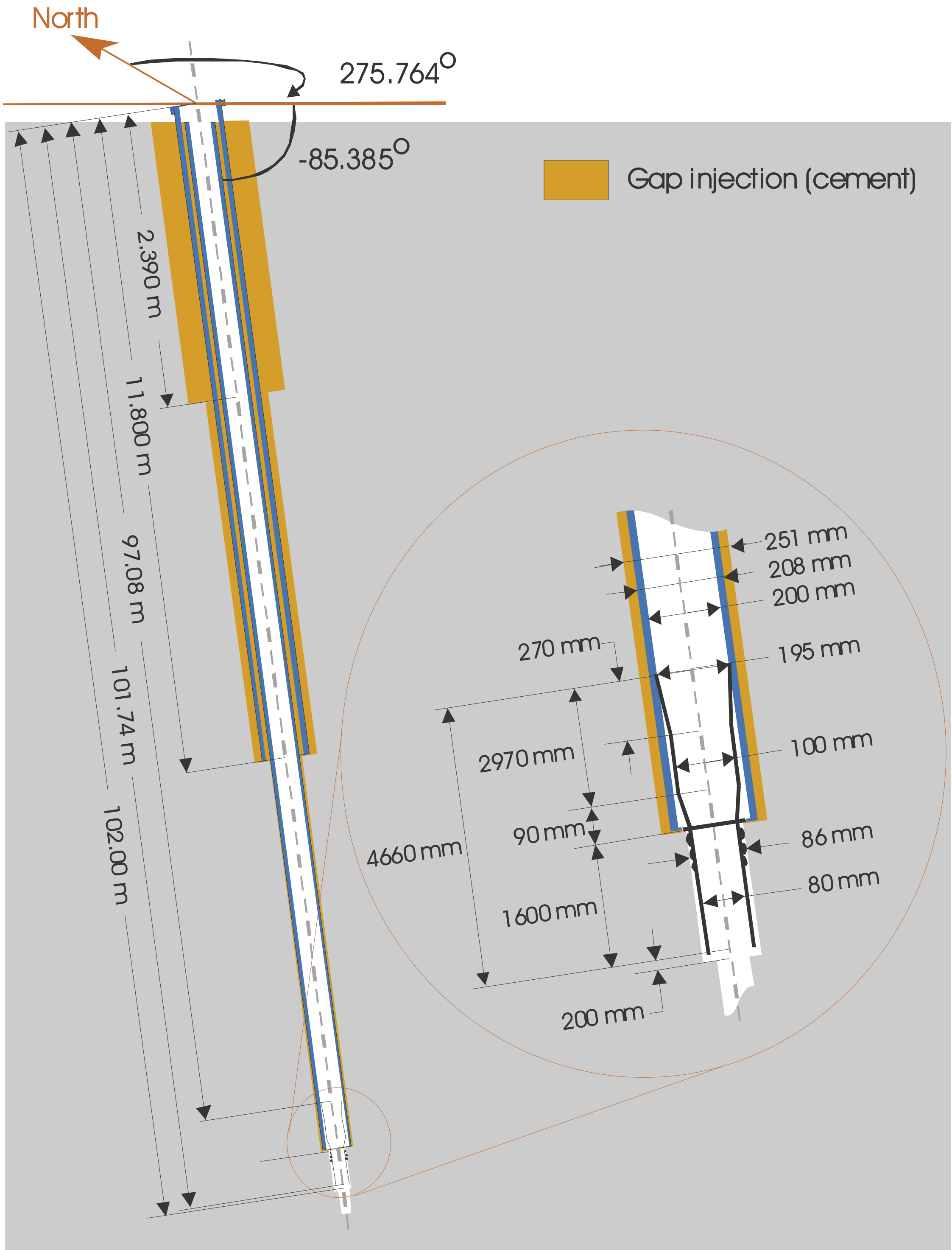
/7/ **Rouhiainen P, Pöllänen J, 2003 in prep.** Difference flow logging in borehole KFM02A. SKB P-03-84, Svensk Kärnbränslehantering AB.

Appendix 1

Design of the telescopic borehole KFM02A

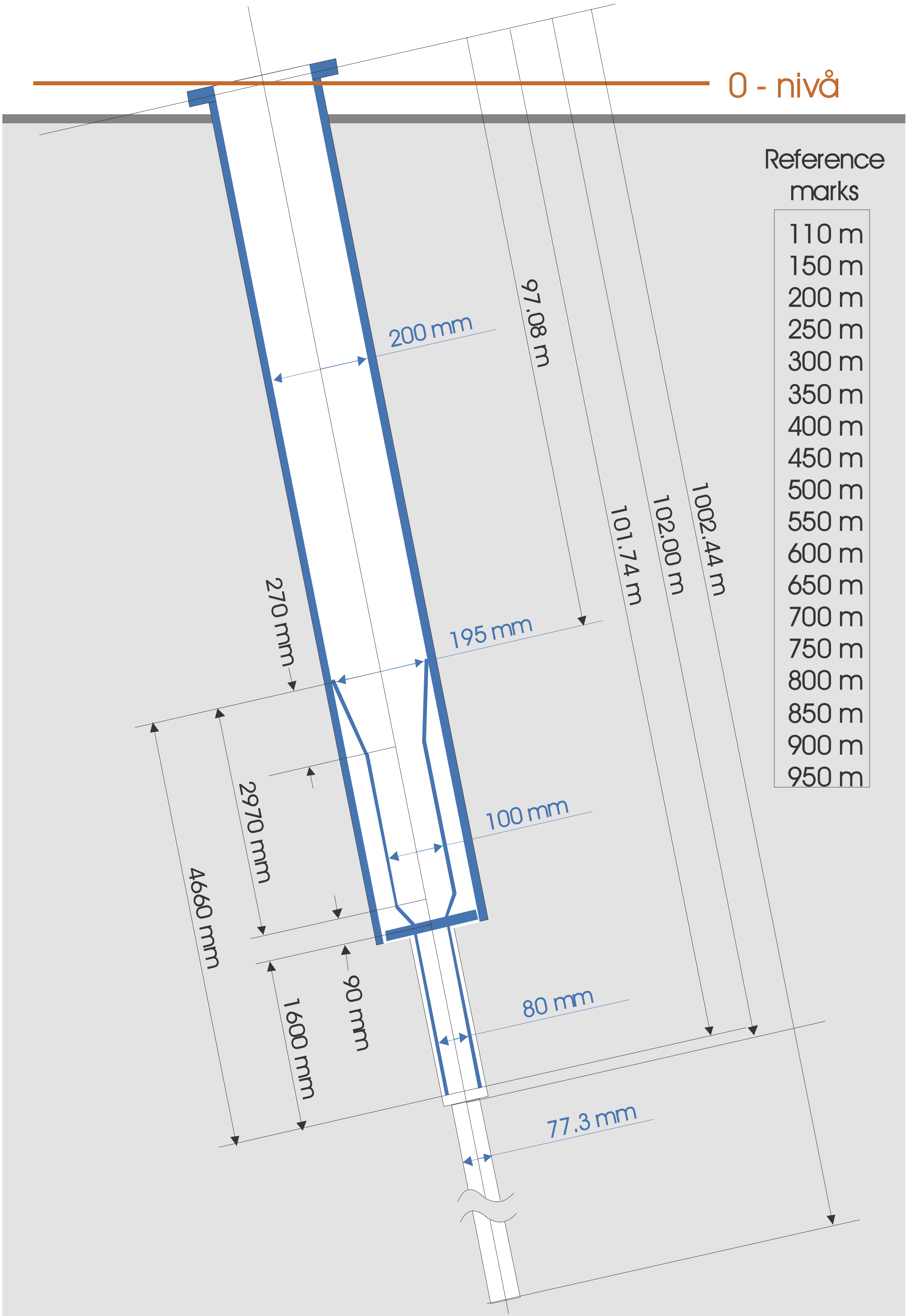
Technical data

Borehole KFM02A



Drilling reference point
Northing: 6698712.501 (m), RT90 2,5 gon V 0:-15
Easting: 1633182.863 (m), RT90 2,5 gon V 0:-15
Elevation: 7.353 (m), RHB 70

KFM02A



Drilling period		Drilling reference point	
Drilling start date:	2002-11-20	Northing:	6698712.501 (m), RT90 2,5 gon V 0:-15
Drilling stop date:	2003-03-26	Easting:	1633182.863 (m), RT90 2,5 gon V 0:-15
		Elevation:	7.353 (m), R□□ 70

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.	HCO3 pH(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, SO4, 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 HNO3)	ICP-AES ICP-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 HNO3)	ICP-AES ICP-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	NO2, NO3+NO2, NH4, PO4	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 HNO3)	ICP-AES ICP-MS	SGAB Analytica, Alcontrol	Not critical (month)

Component group	Component/ element	Sample container (material)	Volume (mL)	Filtering	Preparation/ Conservation*	Analysis method	Laboratory***	Analysis within - or delivery time to lab.
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 HNO3)	ICP-AES ICP-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 time
Environmental isotopes	2H, 18O	Plastic	100	No	- -	MS	IFE	Not critical (month)
Tritium,	3H (enhanced.)	Plastic (dry bottle)	500	No	-	LSC	Univ. Of Waterloo	Not critical (month)
Chlorine-37	Chlorine-37	Plastic	100	No	-	ICP MS		
Carbon isotopes	13C, 14C	Glass (brown)	100×2	No	-	(A)MS	Univ. Of Waterloo	A few days
Sulphur isotopes	34S	Plastic	500 –1000	Yes	-	Combustion, ICP MS	IFE	No limit
Strontium-isotopes	87Sr/86Sr	Plastic	100	Yes	-	TIMS	IFE	Days or Week
Uranium and Thorium isotopes	234U, 235U, 238U, 232 Th, 230Th,	Plastic	50	Nej	-	Chemical separat. Alfa/ gamma spectrometry	IFE	No limit
Boron isotopes	10B	Plastic	100	Yes	Yes (1 mL HNO3)	ICP – MS	SGAB Analytica	No limit
Radon and Radium isotopes	222Rn, 226Ra	Plastic	500	No	No	EDA, RD-200	IFE	Immediate transport

Component group	Component/ element	Sample container (material)	Volume (mL)	Filtering	Preparation/ Conservation*	Analysis method	Laboratory***	Analysis within - or delivery time to lab.
Dissolved gas (content and composition)	Ar, N2, CO2, O2, CH4, H2, CO, C2H2, C2H4, C2H6, C3H8	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	-	N2 atmosphere	ICP-AES ICP-MS	SGAB Analytica	Immediate transport
Humic and fulvic acids	Fractionation	Fractions are collected in plastic bottles	250	-	N2 atmosphere	UV oxidation, IR (DOC)	Paavo Ristola OY	Immediate transport
Archive samples with acid	-	Plast (washed in acid)	100×2 **	Yes	Yes (1 mL HNO3)	-	-	Storage in freeze container
Archive samples without acid	-	Plastic	250×2 **	Yes	No	-	-	Storage in freeze container
Carbon isotopes in humic and fulvic acids	13C, 14C	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 1	"Total" uncertainties 2
HCO3	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 %
SO4	IC	1	mg/L	10 %	20 %
Br-	IC	0.2	mg/L	9 %	30 %
Br-	ICP	0.001		15 %	
F-	IC	0.1	mg/L	10 %	20 %
F-	Potentiometric	-		-	
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 (Salt ≤ 0.4 %, 520 mS/m) 2 (Salt ≤3.5 %, 3810 mS/m)	mg/L	10 %	20 %
2H	MS	-	‰ dev SMOW	±1.0 ‰	-
18O	MS	-	‰ dev SMOW	±.2 ‰	-
3H	LSC	0.8 eller 0.1	TU	0.8	-
37Cl	ICP MS	0.2 ‰ (20 mg/L)	SMOC	-	-
13C	A (MS)	-	PDB	-	-
14C pmc	A (MS)	-	PMC	-	-
34 S	ICP MS	0.2 ‰	CDT	0.3 ‰	-
87Sr/86Sr	TIMS	-	No unit	± 0.000015	-
10B/11B	ICP MS	-	No unit	± 0.001	-

1 Measurement uncertainty reported by consulted laboratory

2 "Total" uncertainty estimated by experience (includes sampling and sample handling)

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

Table A3-1. Compilation April 2003. Water Composition.

Idcode	Secup	Seclow	Sample	Date	Time	Charge	Na	K	Ca	Mg	HCO3	Cl	SO4	SO4-S	Br	F-	Si	Li	Sr	I	pH	ElCond	Flushing water
	m	m	no.			Bal %	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/l	mg/L	mg/L	mg/L	mg/L	mg/L		mS/m	%
KFM02A	0	50	4683	2003-03-31	15:05	-7,43	269	7,6	162	26,1	265	530	67,2	101	2,44	1,26	4,5	0	0,31	0,02	7,7	177	11
KFM02A	50	100	4684	2003-03-31	15:14		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	xxx
KFM02A	100	200	4685	2003-03-31	15:31	-4,28	768	17,3	390	83,6	237	1939	149	109	8,93	1,57	5,3	0,01	0,69	0,03	7,5	644	35
KFM02A	200	250	4686	2003-03-31	15:43		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	xxx
KFM02A	250	300	4687	2003-03-31	15:51	-2,38	1470	30,1	683	160	164	3782	276	125	15,8	1,31	5,3	0,01	1,21	0,05	7,4	1116	45
KFM02A	300	350	4688	2003-03-31	16:13		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	xxx
KFM02A	350	400	4689	2003-03-31	16:22	-1,81	1580	32,3	707	175	154	4008	316	125	17,1	1,01	5,3	0,01	1,34	0,05	7,4	1166	48
KFM02A	400	450	4690	2003-03-31	16:29		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	xxx
KFM02A	450	550	4691	2003-03-31	16:48	-1,97	1580	34,1	671	176	165	3962	321	121	17,4	1,29	5	0,01	1,4	0,05	7,3	1145	53
KFM02A	550	600	4692	2003-03-31	17:08		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	xxx
KFM02A	600	650	4693	2003-03-31	17:17	-1,73	1360	32	530	151	195	3289	253	98,3	14	0,99	4,5	0	1,32	0,04	7,3	974	76
KFM02A	650	700	4694	2003-03-31	17:24		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	xxx
KFM02A	700	750	4695	2003-03-31	17:31	-0,98	1340	31,6	515	147	197	3173	247	92,9	13,1	2,18	4,5	0	1,27	0,04	7,3	961	78
KFM02A	750	800	4696	2003-03-31	17:41		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	xxx
KFM02A	800	850	4697	2003-03-31	17:48	-1,51	1350	31,4	530	147	201	3255	253	92,3	13,1	1,24	4,7	0,01	1,23	0,04	7,3	968	79
KFM02A	850	900	4698	2003-03-31	17:54		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	xxx
KFM02A	900	1000	4699	2003-03-31	18:05	-1,47	1350	31,5	534	146	203	3256	240	91,4	13,2	1,78	5,5	0,01	1,16	0,04	7,3	966	77

- = Archive sample

x = No result due to sampling problems

xx = No result due to analytical problems

xxx = sample not taken

- "value" = result less than detection limit

ChargeBal % = Relative charge balance error %

SICADA: water_composition, 030630