

Site investigation SFR

Hydrogeochemical characterisation of groundwater in borehole KFR101 and results from water sampling and analyses in boreholes KFR02, KFR7A, KFR08 and KFR56

Sampling during winter 2008–2009

Pernilla Thur, Kersti Nilsson
Geosigma AB

August 2009

Svensk Kärnbränslehantering AB
Swedish Nuclear Fuel
and Waste Management Co
Box 250, SE-101 24 Stockholm
Phone +46 8 459 84 00



Site investigation SFR

Hydrogeochemical characterisation of groundwater in borehole KFR101 and results from water sampling and analyses in boreholes KFR02, KFR7A, KFR08 and KFR56

Sampling during winter 2008–2009

Pernilla Thur, Kersti Nilsson
Geosigma AB

August 2009

Keywords: P-report SKBDoc id 1218202, Review statement SKBDoc id 1218205, Forsmark, AP SFR-09-003, AP SFR-08-026, Core borehole, Groundwater, Water sampling, Sample series, Chemical analyses, Major constituents, Isotopes, Trace metals, Project SFR extension.

This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the authors and do not necessarily coincide with those of the client.

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

A pdf version of this document can be downloaded from www.skb.se

Abstract

This report summarises results from chemical characterisation of groundwater in borehole KFR101. Sampling was performed at three occasions in a borehole section (280–342 m borehole length; 218–262 m.b.s.l.) intersecting the vertical or steeply dipping zone 8; first a single sample was collected in November 2008 and later on two sample series were collected in February (two days pumping) and March (eight days pumping), respectively. The investigation yielded groundwater chemistry data in accordance with SKB chemistry class 3, 4 and 5.

In this borehole, early indications of unusual groundwater conditions were obtained already from EC loggings in connection with a preceding flow logging activity. The first sample from the deep borehole section verified that the groundwater was unexpectedly dilute. The earlier mentioned EC measurements indicated that shallower water higher up in the borehole was more saline and at an expected concentration level. Due to these first observations it was necessary to repeat the sampling to check if the water composition was stable and also to consider possible artefacts and contamination sources. Furthermore, sampling was performed in several selected early boreholes (KFR02, KFR7A, KFR08 and KFR56) in the SFR facility in order to check if the water composition was changed/diluted in other boreholes connected to the deformation zones zone 8 and zone H2.

From the obtained results it is concluded that the groundwater composition in the deep borehole section in KFR101 is stable at a very dilute level compared to corresponding depths in other boreholes in the SFR investigation area. Furthermore, the water composition in the early boreholes connected to the same deformation zones has remained unchanged at a higher salinity. This together with the low $\delta^{18}\text{O}$ signature of -15% VSMOW indicates that the borehole intersects a groundwater pocket with a large contribution of glacial melt-water.

The chloride concentration in the samples from KFR101, section 280–342 m borehole length were around 1,860 mg/L and the flushing water content was 1.2%. In the early SFR boreholes, the chloride concentrations remained at between 2,800 mg/L (KFR56) and 4,520 mg/L (KFR02).

Sammanfattning

Denna rapport sammanfattar resultat från kemisk karakterisering av grundvatten i borrhålet KFR101. Provtagning genomfördes vid tre tillfällen i en borrhålssektion (280–342 m borrhålslängd, vertikalt djup 218–262 m) som korsar den vertikala till brant stående zon 8; först togs ett enda prov i november 2008, senare togs två provserier ut i februari (två dagars pumpning) respektive mars (åtta dagars pumpning). Undersökningen gav grundvattenkemiska data i enlighet med SKB:s kemiklasser 3, 4 och 5.

I detta borrhål fanns indikationer på ovanliga grundvattenförhållanden redan från de EC-loggningar som gjordes i samband med en tidigare flödesloggningsaktivitet. Första provet från den djupa borrhålssektionen verifierade att detta grundvatten var oväntat utspädd. De nämnda EC-mätningarna visade vidare att vattnet högre upp i borrhålet var saltare och låg inom ett förväntat koncentrationsintervall. På grund av dessa observationer var det nödvändigt att upprepa provtagningen för att kontrollera om vattensammansättningen var stabil och också att överväga möjliga artefakter och kontamineringskällor. Dessutom utfördes vattenprovtagning i flera utvalda tidiga borrhål (KFR02, KFR7A, KFR08 och KFR56) i SFR för att kontrollera om vattensammansättningen hade förändrats/späddes ut i andra borrhål som har samband med deformationszonerna zon 8 och zon H2.

Från de olika resultaten har det konstaterats att grundvattensammansättningen i den djupa sektionen i KFR101 ligger stabil på en mycket utspädd nivå, jämfört med motsvarande djup i andra borrhål inom undersökningsområdet för SFR-utbyggnad. Vidare håller sig vattensammansättningen oförändrad vid en högre salthalt i de tidiga borrhålen med förbindelse till samma deformationszoner. Detta, tillsammans med den låga $\delta^{18}\text{O}$ signaturen på -15‰ VSMOW indikerar att borrhålet penetrerar en grundvattenficka med stort bidrag av glacialt smältvatten.

Kloridkoncentrationen i proven från sektionen vid 280–342 m borrhålslängd i borrhålet KFR101 låg runt 1 860 mg/L och spolvattenhalten var 1,2 %. I de tidiga SFR borrhålen förblev kloridkoncentrationerna mellan 2 800 mg/L (KFR56) och 4 520 mg/L (KFR02).

Contents

1	Introduction	7
2	Objective and scope	9
3	Equipment	11
3.1	Description of equipment/interpretation tools	11
4	Performance	15
4.1	General	15
4.2	Water sampling and field measurements	15
4.3	Water sample treatment and analyses	16
4.4	Data handling and interpretation	16
4.5	Nonconformities	16
5	Results	19
5.1	Water analysis	19
5.1.1	Basic water analyses	19
5.1.2	Trace elements (rare earth metals and others)	22
5.1.3	Stable and radioactive isotopes	22
6	Summary and discussions	23
7	References	25
Appendix 1	Compilation of water analysis data	27
Appendix 2	Sampling information	31
Appendix 3	Pressure registrations during pumping and sampling (HMS) system	33
Appendix 4	Sampling and analytical methods	35

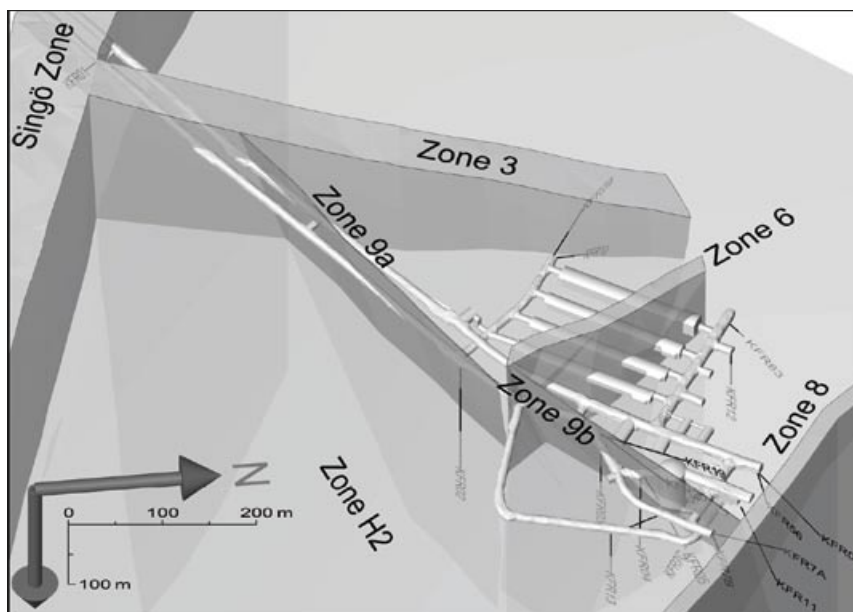


Figure 1-2. Location of boreholes KFR02, KFR7A, KFR56 and KFR08 in relation to the deformation zones zone 8 and zone H2.

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

Activity plan	Number	Version
Hydrogeokemisk karakterisering av grundvatten i borrhål KFR101	AP SFR-08-026	1.0
Hydrogeokemisk karakterisering av grundvatten i borrhål KFR102A samt kompletterande provtagning/analyser i KFR101 och i tunnelborrhålen KFR02, KFR08, KFR56 och KFR7A	AP SFR-09-003	1.0
Method descriptions	Number	Version
Metodbeskrivning för vattenprovtagning och analys i instrumenterade borrhål (under framtagning)	SKB MD 425.001	In prep.
Mätsystembeskrivning – Handhavandedel; System för hydrologisk och meteorologisk datainsamling. Vattenprovtagning och utspädningsmätning i observationshål.	SKB MD 368.010	1.0

Table 1-2. Borehole sections included in the hydrochemical sampling in March 2009 and corresponding transmissivity.

Borehole	Section borehole length [m]	Section elevation [m.b.s.l.]	Transmissivity [m ² /s]
KFR101	280–342	218–262	5.83E-06*
KFR02	119–136	204–221	6.50E-08**
KFR08	36–62	89–91	1.27E-05**
KFR08	63–104	92–95	6.56E-06**
KFR56	10–82	81–49	2.20E-07**
KFR7A	48–75	134–135	9.10E-05**

* Sicada (PFL)

** Sicada (Pressure Buildup Test)

KFR101 is an SKB chemistry-type, conventional core drilled, approximately 342 m long borehole. A technical description and design of the borehole is presented in /2/. The drilling of the borehole was completed on July 2, 2008 and tap water was used as drilling water. Information on the drilling water composition is found in Appendix 1. The site investigation area in Forsmark as well as the location of the recently drilled boreholes is shown in Figure 1-1.

2 Objective and scope

The hydrogeochemical characterisation in KFR101 was planned and conducted in order to obtain groundwater data from a sampling location intersecting zone 8. The data will contribute to the overall 3D picture of the groundwater conditions. However, early information from EC measurements during drilling of the borehole and EC measurements in connection with flow logging indicated unexpected groundwater conditions. The EC measured in the deep borehole section at 279.5–341.8 m borehole length (218–262 m.b.s.l.) was as low as 590 mS/m. Such low EC values have not been measured previously in any of the boreholes within the SFR repository. Furthermore, EC measurements in groundwater at shallower depth in the same borehole indicated the presence of more saline water on top of the diluted water. This groundwater situation has, as far as known, not been observed in any other borehole drilled by SKB.

Additional sampling was conducted in the early tunnel boreholes KFR02, KFR7A, KFR08 and KFR56 connected to zone 8 and/or zone H2. This was done in order to check if the groundwater composition had changed in any other borehole penetrating the same deformation zones.

The analytical protocol includes sampling and analyses according to SKB chemistry class 3, 4 and 5 as well as field measurements of pH, electric conductivity (EC) and temperature.

3 Equipment

3.1 Description of equipment/interpretation tools

The sampled borehole KFR101 is equipped with different borehole sections sealed off by inflated packers. Outline of the instrumentation in a cored borehole is presented in Figure 3-1.

Due to the small diameter of the standpipes an air-lift pump was used to retrieve the water samples from the sampled sections instead of a conventional pump. An outline of the sampling setup is presented in Figure 3-2 and Figure 3-3 shows the pump equipment. The pump operates with the aid of two tubes which are lowered almost to the bottom of the standpipe. The two tubes are connected to each other via a unit with non-return valves at the bottom. By applying a gas (N₂) pressure to one of the tubes it will be emptied via the other tube and the water can be collected at the surface. When the first tube is emptied, a pump control unit releases the gas pressure and the tube will be filled with water from the standpipe. Again, the gas pressure is applied by the control unit and the procedure is repeated. By using a multiple connection to the control unit and a number of pairs of tubes, more than one borehole section may be pumped at the same time.

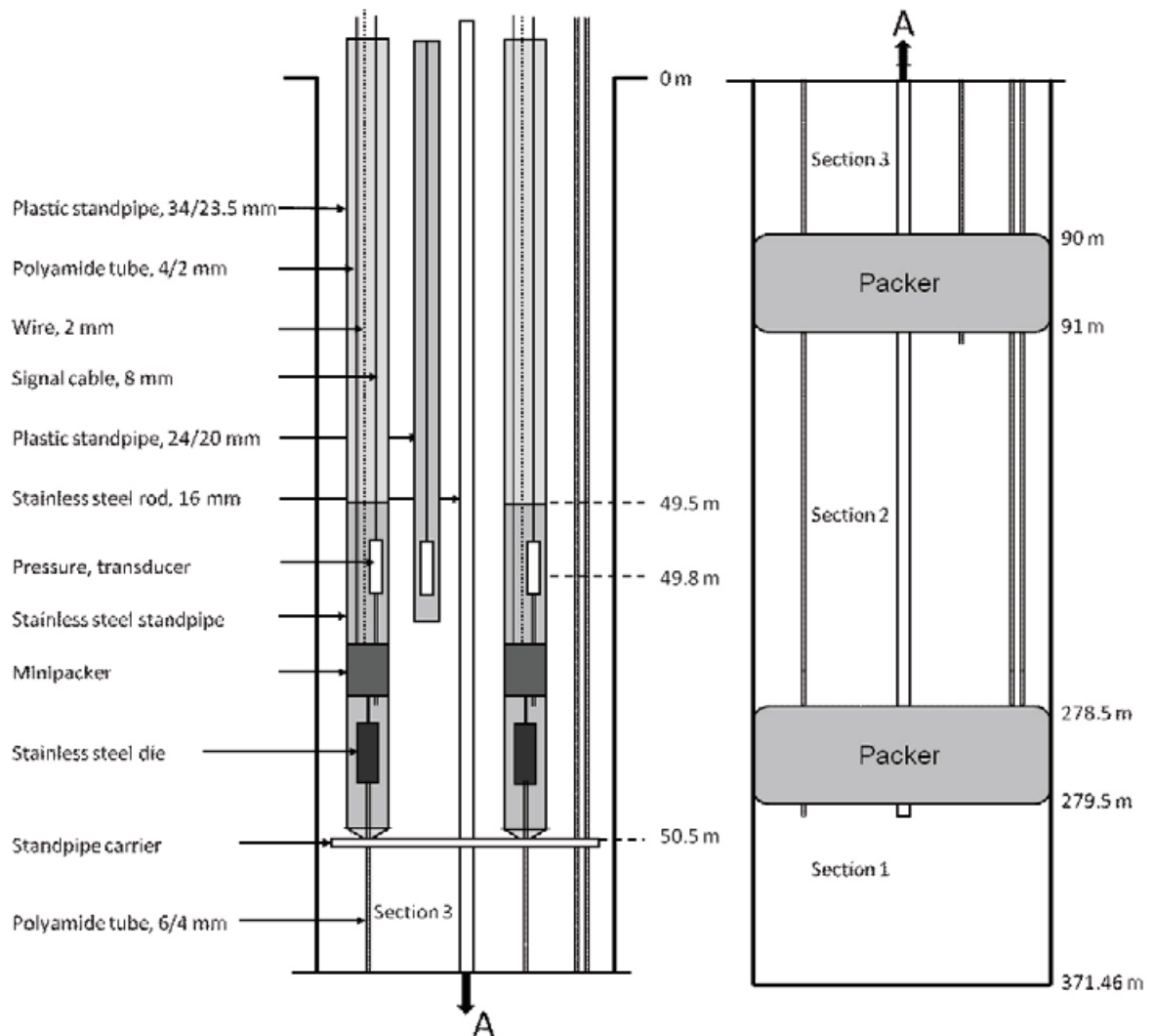


Figure 3-1. Schematic picture of the instrumentation in a conventional core drilled borehole. The positions given are valid for borehole KFR101.

The sampling conditions caused by air-lift pumping are different from those from conventional pumping, used for instance in the hydrogeochemical monitoring program. The more effective (intermittent) pump action might affect the borehole walls, and thus have an impact on the water composition. Especially constituents like hydrogen sulphide, TOC, DOC and trace metals may be affected.

All other boreholes were tunnel boreholes and sampled by opening of valves on the tubing connecting the different borehole sections to the borehole orifice.

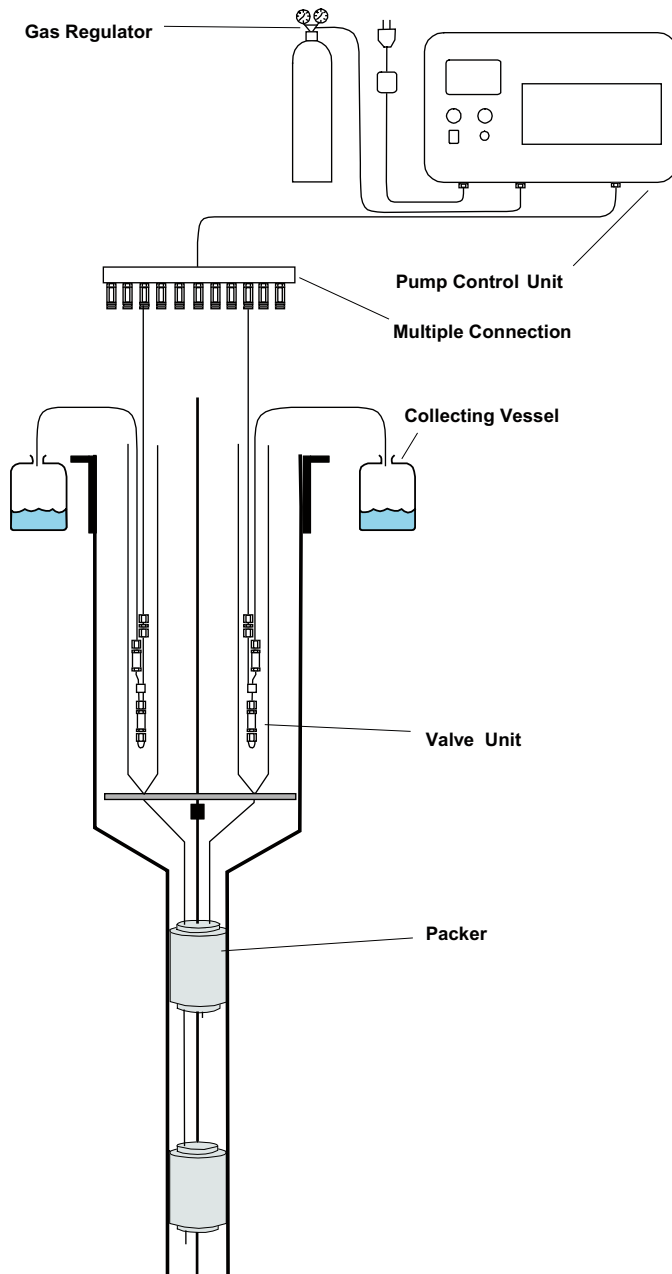


Figure 3-2. Schematic picture of the sampling setup and equipment used to perform air-lift pumping.



Figure 3-3. Air-lift pump equipment used in small diameter standpipes.

4 Performance

4.1 General

Borehole sections, sampling dates, collected samples and analyses performed are presented in Table 4-1.

4.2 Water sampling and field measurements

Prior to sampling, the water volume in each section was exchanged a good three times to obtain a representative water sample from the section. The pumped total volumes prior to the groundwater sampling are given in Appendix 2. No hydraulic connection between the sections in KFM101 was registered during the pumping period in March, see Appendix 3.

In addition to sampling of ground water, field measurements of temperature, electric conductivity (EC) and pH were conducted during the sampling period in March. The water pumped from the borehole was led through a measurement cell with probes and electrodes as well as a temperature sensor for measurements of field pH (pH_F), field electrical conductivity (EC_F) and groundwater temperature.

Sample portions intended for analysis of major constituents, iron (by spectrophotometry), DOC and nutrient salts were filtered. Disposable 0.4 µm membrane filters were fitted directly to the 6/8 mm polyamide-tube leading the pumped water from the borehole section. During the entire sampling, laboratory gloves were used to minimize the risk of contaminating the samples.

Table 4-1. Sampling data analytical protocol for, KFR101, KFR02, KFR7A, KFR08 and KFR56.

Idcode	Section [m]	Sampling Date	Sample No.	Analyses
KFR101	280–342	08-11-05	16145	Class 5
KFR101	280–342	09-02-04	16209	Class 3
KFR101	280–342	09-02-05	16210	Class 3
KFR101	280–342	09-02-06	16208	Class 3, δ ² H, ³ H, δ ¹⁸ O, pmC and δ ¹³ C
KFR101	280–342	09-03-20	16239	Class 4, pH_F, EC_F and temp.
KFR101	280–342	09-03-23	16240	Class 5, pH_F, EC_F and temp.
KFR101	280–342	09-03-25	16241	Class 4, pH_F, EC_F and temp.
KFR101	280–342	09-03-27	16242	Class 5+, pH_F, EC_F and temp.
KFR02	119–136	09-02-05	16207	Class 3
KFR7A	48–75	09-02-04	16206	Class 3
KFR08	63–104	09-02-04	16203	Class 3
KFR08	36–62	09-02-04	16204	Class 3
KFR56	9–82	09-02-04	16205	Class 3

4.3 Water sample treatment and analyses

An overview of sample treatment and analysis routines for major constituents, minor anions, trace metals and isotopes is given in Appendix 4. The routines are applicable independently of sampling method or sampling object.

4.4 Data handling and interpretation

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

Several constituents are determined by more than one method and/or laboratory. All analytical results are 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 the 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.
- Calculation of charge balance errors, equation (1). Relative errors within $\pm 5\%$ are considered acceptable.

$$\text{Relative error (\%)} = 100 \times \frac{\sum \text{cations(equivalents)} - \sum \text{anions(equivalents)}}{\sum \text{cations(equivalents)} + \sum \text{anions(equivalents)}} \quad (1)$$

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

All results from special analyses of trace metals and isotopes are inserted directly into primary data tables. In 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.

4.5 Nonconformities

- Due to lack of time, less than three section volumes were pumped from KFR101 before collection of the first sample in March. Hence, there might be some contribution in the sample from water standing in the section.
- Due to lack of time, the KFR101 sampling schedule for March was shortened. Two SKB class 5 samples and two SKB class 4 samples were collected instead of the planned two SKB class 5 samples and three SKB class 4 samples according to AP SFR-08-026 and AP SFR-09-003.

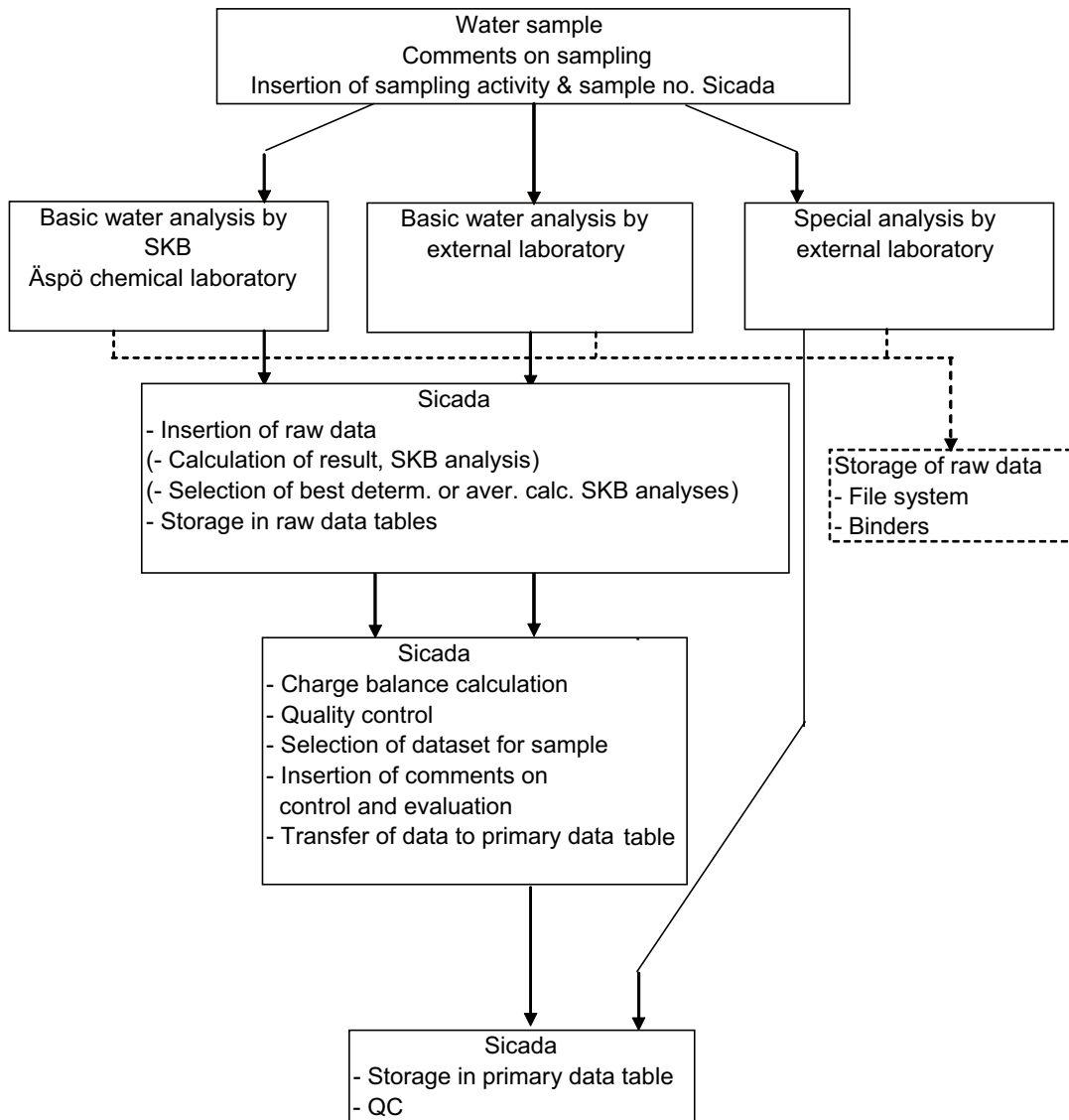


Figure 4-1. Overview of data management for hydrogeochemical data.

5 Results

Original data from the reported activity are stored in the primary database Sicada. Data are traceable in Sicada by the Activity Plan number (AP SFR-09-003 and AP SFR-08-026). 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.

5.1 Water analysis

5.1.1 Basic water analyses

The basic analyses include the major constituents Na, K, Ca, Mg, Fe, Li, Mn, S, Sr, SO_4^{2-} , Cl^- , Si, HCO_3^- , Br^- , F^- , I^- , HS^- and NH_4^+ . Samples collected according to SKB chemistry class 5 also include P, NO_2^- , NO_3^- , TOC and DOC. Furthermore, both laboratory data and field measurement data on pH and electrical conductivity (EC) were obtained from KRF101 sampling in March and the water temperature was recorded in the field.

The charge balance errors provide an indication of the quality and uncertainty of the analyses of major constituents. The errors exceed the acceptable limit of $\pm 5\%$ in some cases (SKB numbers 16203–16207 and 16209), probably due to a short pumping period before sampling resulting in an unstable water composition at the sampling occasion. The basic water analysis data and relative charge balance errors are compiled in Appendix 1, Table A1-1.

The diagram in Figure 5-1 shows chloride concentrations versus EC values from previous investigations in Forsmark as well as from the results from the reported boreholes KFR101, KFR02, KFR7A, KFR56 and KFR08. The data points follow the trend line which indicates that the EC and chloride data sets are consistent.

Figure 5-2 presents the flushing water contents in the sampled borehole section in KFR101. The content should not exceed 1% in order for a sample to be considered representative for the groundwater of the sampled section. This condition was practically met, although the flushing water content was not completely stable during the sampling period.

The concentrations of chloride, calcium and sodium are presented in Figure 5-3. The concentrations of the major constituents remained quite constant during the whole pumping and sampling periods, except for the chloride content which was slightly lower at the end of the sampling period in February.

The iron concentrations are compared in Figure 5-4. The determinations by ICP-AES, total Fe, and spectrophotometry, Fe(II) and Fe-tot, agree well, with the concentrations slightly decreasing by the end of the sampling period.

Sulphate analysed by ion chromatography (IC) is compared to sulphate determined as total sulphur by ICP-AES for KFR101, section 280–342 m in Figure 5-5. The agreement between the two analysis methods (IC and ICP-AES) is within the size of the analytical error. Both the sulphate and the sulphur concentrations show a decreasing trend over time.

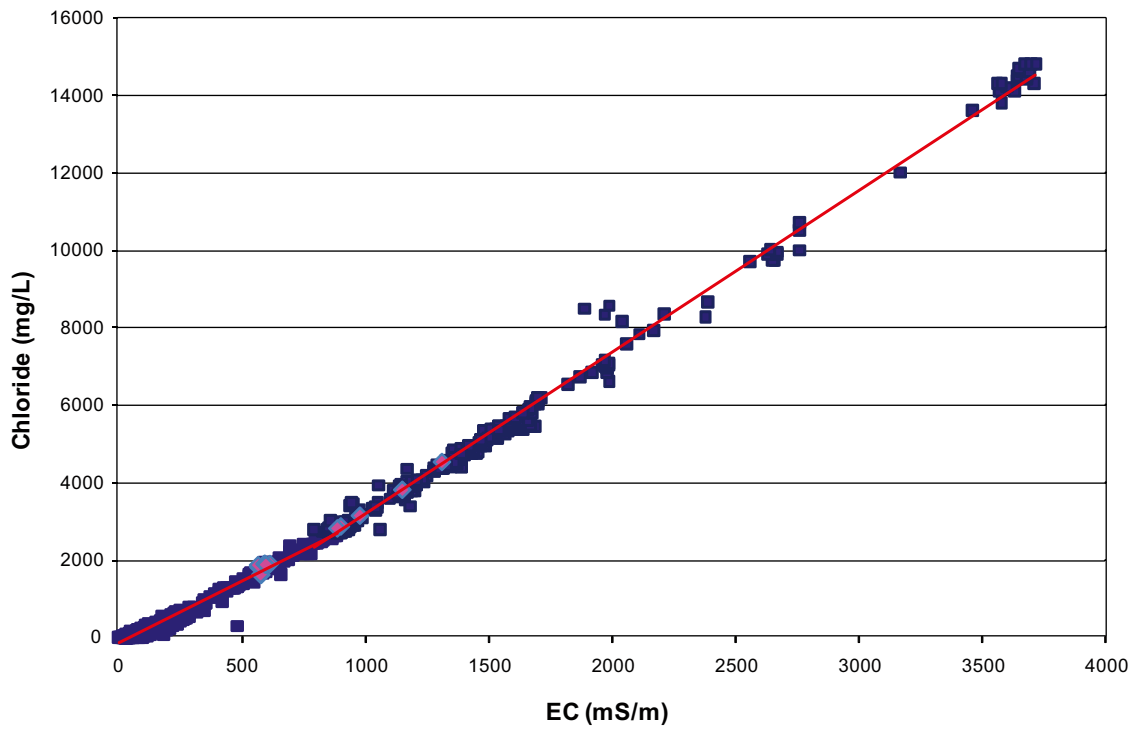


Figure 5-1. Chloride concentration versus electrical conductivity. Data from previous investigations at Forsmark are used to show the linear trend. Data from KFR101, KFR02, KFR7A, KFR56 and KFR08 are shown in pink.

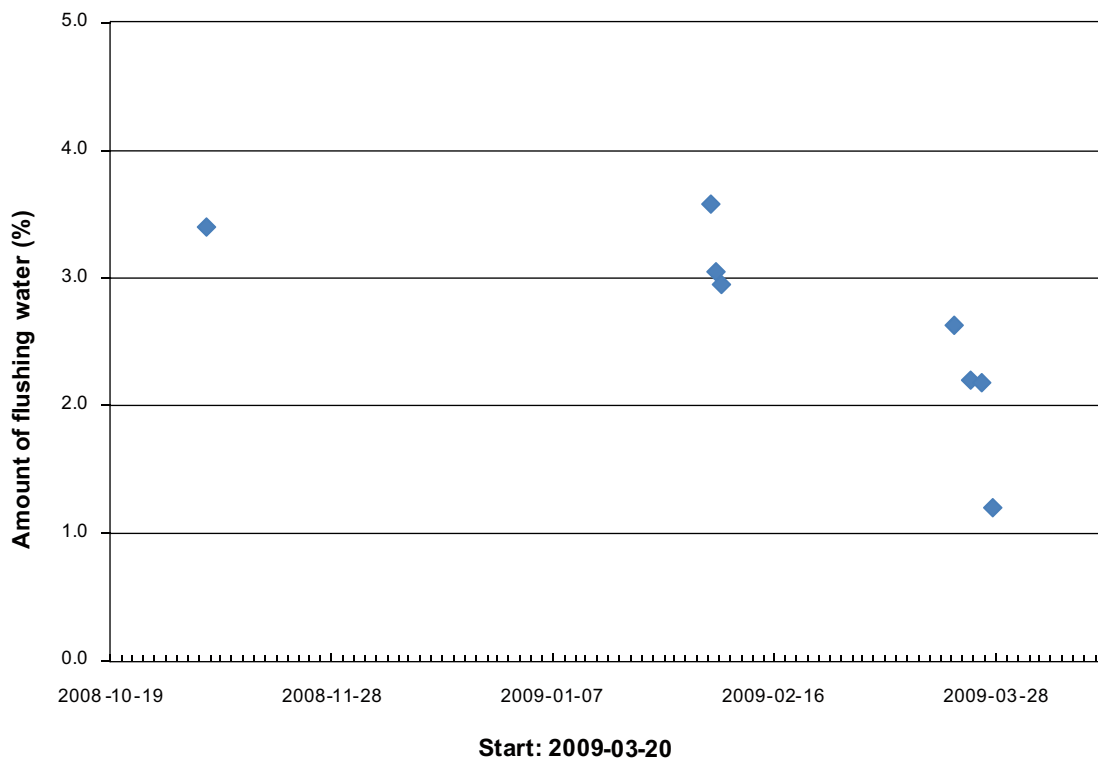


Figure 5-2. Flushing water content in the groundwater sample from KFR101, section 280–342 m.

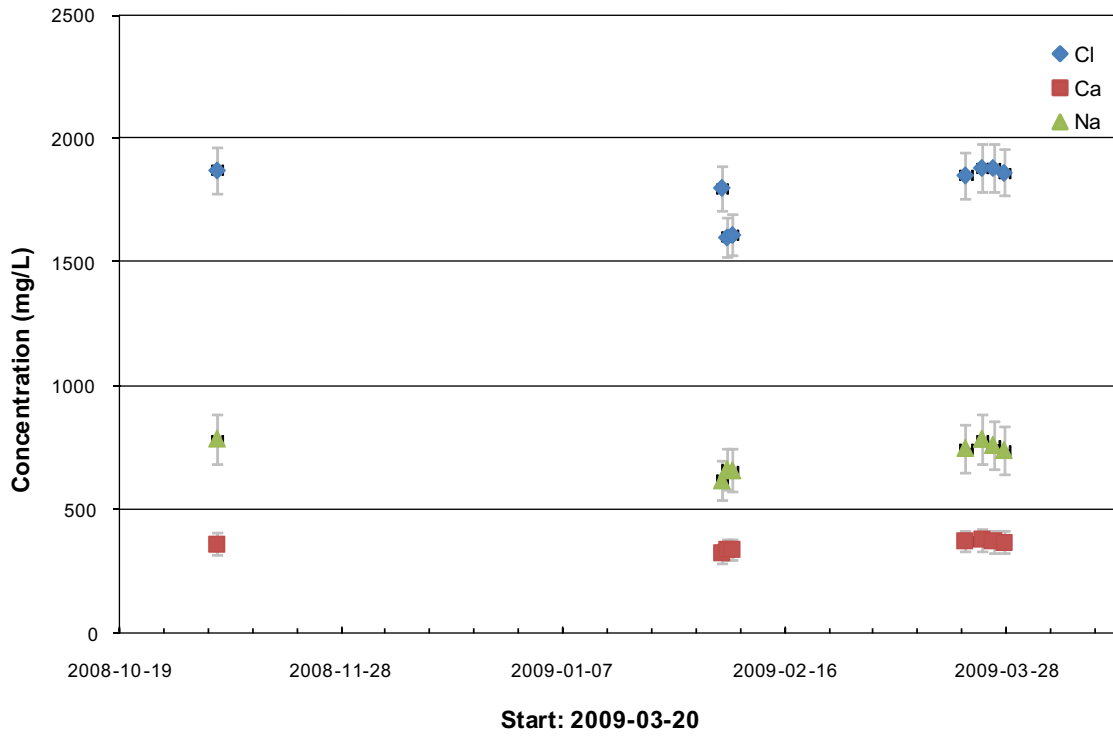


Figure 5-3. Chloride, calcium and sodium concentrations in the groundwater sample from KFR101, section 280–342 m.

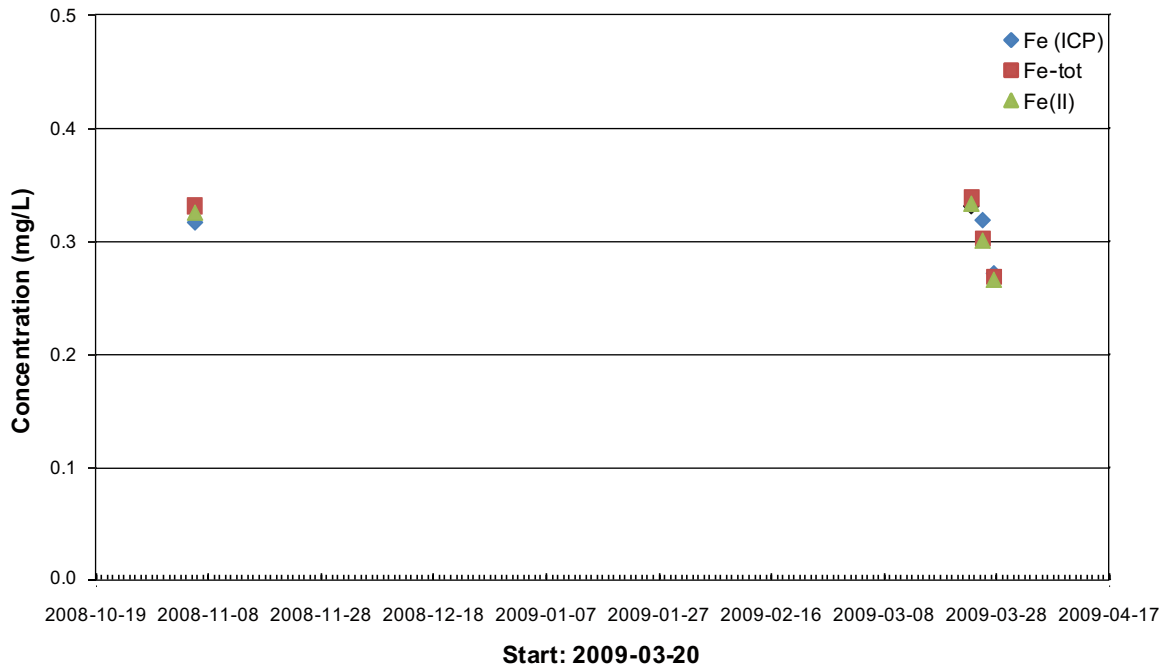


Figure 5-4. Comparisons of iron concentrations obtained by ICP-AES and by spectrophotometry, KFR101, section 280–342 m.

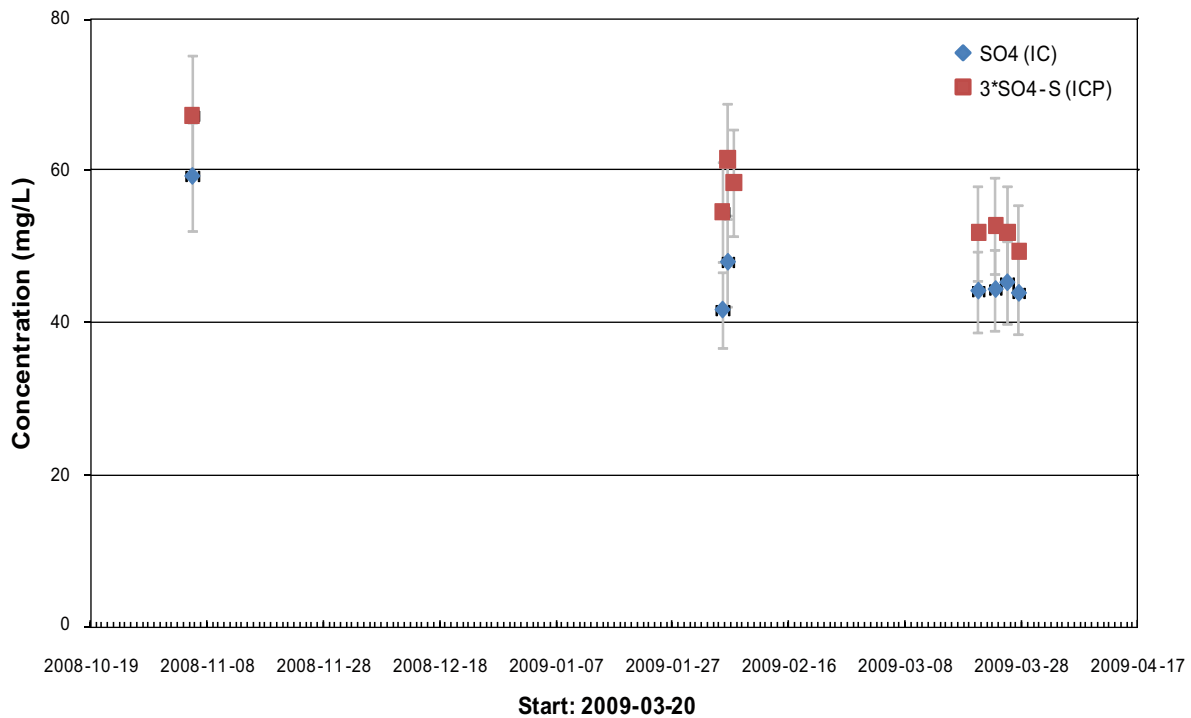


Figure 5-5. Sulphate (SO4 by IC) compared to total sulphate calculated from total sulphur ($3 \times SO_4-S$ by ICP) versus date, KFR101, section 280–342 m.

5.1.2 Trace elements (rare earth metals and others)

The analyses of trace elements include Cr, Cu, Co, Ni, Mo, Pb, Zn, Sb, Al, U, Th, B, As, Sc, Cd, Hg, V, Rb, Y, Zr, In, Cs, Ba, La, Hf, Tl, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb as well as Lu and are compiled in Appendix 1, Table A1-2. Due to low natural concentrations and frequent use in different equipment, the risk of contamination is high for common metals like Cr, Cu, Co, Ni, Mo, Zn and Al.

5.1.3 Stable and radioactive isotopes

The isotope determinations include the stable isotopes δ^2H , $\delta^{18}O$, $^{10}B/^{11}B$, $\delta^{34}S$, $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ as well as the radioactive isotopes 3H (TU), ^{14}C (pmC), ^{238}U , ^{234}U , ^{230}Th , ^{226}Ra and ^{222}Rn . Available isotope data are compiled in Appendix 1, Tables A1-3 and A1-4. The sulphur isotope ratio ($\delta^{34}S$) value decreased significantly between the sampling occasion in November and the sampling occasion in March.

6 Summary and discussions

The hydrogeochemical investigation in KFR101, section 280–342 m borehole length (218–262 m.b.s.l.), includes sampling at three different occasions; November 2008 (a single sample), February 2008 (sample series, three samples) and March 2009 (sample series, four samples). Some observations regarding the performance and the results are listed below:

- The observed EC (600 mS/m) is unusually low and has not been measured in any other borehole within the SFR repository site. Furthermore, from previous EC logging it is concluded that the salinity in the shallower parts of the borehole is higher than in the deep section. Repeated sampling at three occasions (November 2008, February 2009 and March 2009) and generally quite stable water composition over the time period make it less probable that the low salinity is an artefact from the drilling or from the sampling procedure.
- No significant changes of the groundwater conditions were observed in the boreholes KFR02, KFR7A, KFR08 and KFR56. Thus mixing of different groundwater regimes due to heavy pumping has not occurred in these boreholes. Therefore, it is less probable that the dilute water at depth in KFR101 is caused by mixing with surface water from land.
- The oxygen-18 signature in KFR101, section 280–342 m (218–262 m.b.s.l.), is among the lowest measured within the SFR repository site and indicates a significant contribution from glacial melt-water.
- The collected samples from the borehole section in KFR101 showed low flushing water contents (1%) and the water composition was generally stable through the sampling periods. However, for sulphate and sulphur, there is a somewhat decreasing trend over time.
- Pumping in KFR101, section 280–342 m (section no. 1) did not cause any clear responses in the other borehole sections. The absence of responses indicates that there is no short circuiting between the sections that can affect the samples.
- The uranium concentration was relatively high, and somewhat decreasing with time (57 mg/L in the last sample in March).

7 References

- /1/ **SKB, 2008.** Geovetenskapligt undersökningsprogram för utbyggnad av SFR. SKB R-08-67, Svensk Kärnbränslehantering AB.
- /2/ **Nilsson G, Ullberg A, 2009.** Site investigation SFR. Drilling of the cored boreholes KFR101, KFR102B, KFR103 and KFR104. SKB P-09-13, Svensk Kärnbränslehantering AB.

Compilation of water analysis data

Table A1-1. Water composition

Idcode	Secup m	Seclow m	Sample no.	Sampling date	RCB %	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	HCO ₃ ⁻ mg/L	Cl ⁻ mg/L	SO ₄ ²⁻ mg/L	SO4-S mg/L	Br mg/l	F ⁻ mg/L	Si mg/L	Fe mg/L	Fe-tot mg/L	Fell mg/L	Mn mg/L	Li mg/L	Sr mg/L
KFR101	279.50	341.76	16145	2008-11-05	0.25	783	10.3	360	41.1	72.7	1,870	59.3	22.4	10.5	1.45	4.84	0.316	0.331	0.325	0.432	0.0305	5.67
KFR101	279.50	341.76	16209	2009-02-04	-7.93	618	4.40	322	27.6	71.4	1,800	41.7	18.2	9.61	1.51	4.87	-	-	-	-	0.0254	4.69
KFR101	279.50	341.76	16210	2009-02-05	0.64	662	5.68	336	31.3	70.6	1,600	48.0	20.5	9.97	1.56	5.12	-	-	-	-	0.0271	4.91
KFR101	279.50	341.76	16208	2009-02-06	0.48	658	5.24	338	30.4	69.7	1,610	-	19.5	-	-	5.11	-	-	-	-	0.0272	4.94
KFR101	279.50	341.76	16239	2009-03-20	-0.53	746	6.43	372	33.0	69.3	1,850	44.2	17.3	10.6	1.58	5.38	0.339	-	-	-	0.0282	5.58
KFR101	279.50	341.76	16240	2009-03-23	0.47	782	6.67	378	33.9	69.4	1,880	44.4	17.6	10.5	1.59	5.42	0.331	0.338	0.333	0.469	0.0311	5.97
KFR101	279.50	341.76	16241	2009-03-25	-0.88	758	6.07	371	32.8	68.1	1,880	45.3	17.3	12.2	1.56	5.28	0.318	0.302	0.300	0.456	0.0294	5.69
KFR101	279.50	341.76	16242	2009-03-27	-1.45	738	5.76	366	31.3	67.5	1,860	43.9	16.5	10.1	1.57	5.21	0.271	0.268	0.265	0.452	0.0294	5.64
KFR02	119.00	136.00	16207	2009-02-05	-5.43	1,340	5.78	1,100	132	83.6	4,520	360	156.0	16.6	1.35	6.18	-	-	-	-	0.0596	15.1
KFR7A	48.00	74.70	16206	2009-02-04	-8.07	1,350	13.3	587	154	111	3,800	440	156.0	13.1	1.37	5.82	-	-	-	-	0.0447	6.50
KFR08	63.00	104.00	16203	2009-02-04	-6.81	1,320	15.4	384	127	118	3,130	398	161.0	10.5	1.38	5.67	-	-	-	-	0.0379	4.51
KFR08	36.00	62.00	16204	2009-02-04	-7.37	1,150	6.63	400	101	124	2,850	-	138.0	-	1.28	6.23	-	-	-	-	0.0374	5.11
KFR56	9.00	81.70	16205	2009-02-04	-7.74	1,220	23.1	268	127	129	2,800	372	149.0	9.53	1.12	6.14	-	-	-	-	0.0312	3.06
PFR000123	Drilling water			2008-06-26	-4.08	28.2	1.19	31.7	2.00	88.6	10.7	67.00	24.1	0.029	<0.2	1.27	-	-	-	-	<0.004	0.042

Idcode	Secup m	Seclow m	Sample no.	Sampling date	I ⁻ mg/L	pH_L	pH_F	DOC mg/L	TOC mg/L	HS ⁻ mg/L	Drill water %	Uranine µg/L	EC_L mS/m	EC_F mS/m	NH ₄ N mg/L	NO ₂ N mg/L	NO ₃ N mg/L	NO ₂ N+NO ₃ N mg/L	PO ₄ P mg/L	P mg/L	Temp. °C
KFR101	279.50	341.76	16145	2008-11-05	0.0940	7.93	-	1.5	1.5	0.022	3.40	6.80	593	-	0.121	0.0002	0.0022	0.0025	0.0068	0.0158	-
KFR101	279.50	341.76	16209	2009-02-04	-	7.79	-	-	-	-	3.58	7.15	570	-	-	-	-	-	-	-	-
KFR101	279.50	341.76	16210	2009-02-05	-	7.76	-	-	-	-	3.05	6.10	580	-	-	-	-	-	-	-	-
KFR101	279.50	341.76	16208	2009-02-06	-	7.86	-	-	-	-	2.95	5.90	578	-	-	-	-	-	-	-	-
KFR101	279.50	341.76	16239	2009-03-20	0.096	7.83	7.96	-	-	-	2.63	5.25	568	578	-	-	-	-	-	-	8.3
KFR101	279.50	341.76	16240	2009-03-23	0.102	7.78	7.96	1.3	1.3	0.105	2.20	4.40	616	580	0.0741	0.0002	0.0013	0.0015	0.0005	0.00904	7.1
KFR101	279.50	341.76	16241	2009-03-25	0.107	7.81	8.00	1.2	1.1	-	2.18	4.35	595	583	0.0739	-	-	<0.0003	0.0004	-	7.5
KFR101	279.50	341.76	16242	2009-03-27	0.106	7.79	7.84	1.7	2.0	0.070	1.20	2.40	599	582	0.0448	0.0002	0.0005	0.0007	0.0004	0.00524	6.3
KFR02	119.00	136.00	16207	2009-02-05	-	7.42	-	-	-	-	-	-	1,310	-	-	-	-	-	-	-	-
KFR7A	48.00	74.70	16206	2009-02-04	-	7.34	-	-	-	-	-	-	1,150	-	-	-	-	-	-	-	-
KFR08	63.00	104.00	16203	2009-02-04	-	7.48	-	-	-	-	-	-	979	-	-	-	-	-	-	-	-
KFR08	36.00	62.00	16204	2009-02-04	-	7.66	-	-	-	-	-	-	902	-	-	-	-	-	-	-	-
KFR56	9.00	81.70	16205	2009-02-04	-	7.74	-	-	-	-	-	-	888	-	-	-	-	-	-	-	-
PFR000123	Drilling water			2008-06-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

-- = Not analysed

pH_L; EC_L = Laboratory measurements of pH and EC

pH_F; EC_F = Field measurements of pH and EC

<"value" = value below reporting limit

RCB% = Relative charge balance error %

Sicada: water_composition

Table A1-2. Trace metals

Idcode	Secup m	Seclow m	Sample no.	Sampling date	U ug/L	Th ug/L	B ug/L	As ug/L	Sc ug/L	Cd ug/L	Hg ug/L	V ug/L	Rb ug/L	Y ug/L	Zr ug/L	In ug/L	Cs ug/L
KFR101	279.50	341.76	16145	2008-11-05	67.2	<0.2	875	2.8	<0.4	<0.02	<0.002	0.118	14.2	0.558	<0.1	<0.2	0.301
KFR101	279.50	341.76	16240	2009-03-23	62.0	<0.2	949	2.1	<0.4	0.0406	<0.002	0.0624	12.6	1.06	<0.1	<0.2	0.264
KFR101	279.50	341.76	16242	2009-03-27	57.1	<0.2	915	1.8	<0.4	<0.02	<0.002	0.117	12.3	0.926	<0.1	<0.2	0.284
Idcode	Secup m	Seclow m	Sample no.	Sampling date	Ba ug/L	La ug/L	Hf ug/L	Tl ug/L	Ce ug/L	Pr ug/L	Nd ug/L	Sm ug/L	Eu ug/L	Gd ug/L	Tb ug/L	Dy ug/L	Ho ug/L
KFR101	279.50	341.76	16145	2008-11-05	515	<0.02	<0.02	<0.05	0.0308	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.0230	<0.02
KFR101	279.50	341.76	16240	2009-03-23	571	0.0698	<0.02	<0.05	0.0557	<0.02	0.0261	<0.02	0.0519	0.0248	<0.02	0.0413	<0.02
KFR101	279.50	341.76	16242	2009-03-27	558	0.0779	<0.02	<0.05	0.0738	<0.02	0.0408	<0.02	0.0448	0.0246	<0.02	0.0382	<0.02
Idcode	Secup m	Seclow m	Sample no.	Sampling date	Er ug/L	Tm ug/L	Yb ug/L	Lu ug/L	Cr ug/L	Cu ug/L	Co ug/L	Ni ug/L	Mo ug/L	Pb ug/L	Zn ug/L	Sb ug/L	Al µg/L
KFR101	279.50	341.76	16145	2008-11-05	0.0275	<0.02	0.0277	<0.02	<0.04	<0.2	0.300	1.02	18.1	<0.1	3.09	0.151	27.5
KFR101	279.50	341.76	16240	2009-03-23	0.0477	<0.02	0.0452	<0.02	0.303	<0.2	0.362	3.91	13.8	<0.1	2.17	0.234	6.54
KFR101	279.50	341.76	16242	2009-03-27	0.0433	<0.02	0.0347	<0.02	0.348	0.5920	0.440	4.17	12.6	0.105	7.23	0.180	17.3

<"value" = value below reporting limit

Sicada: trace_metals_I and trace_metals_II

Table A1-3. Isotopes I

Idcode	Secup m	Seclow m	Sample no	Sampling date	$\delta^2\text{H}$ dev SMOW	^3H TU	$\delta^{18}\text{O}$ dev SMOW	$^{10}\text{B}/^{11}\text{B}$ no unit	$\delta^{34}\text{S}$ dev CDT	$\delta^{13}\text{C}$ dev PDB	$^{87}\text{Sr}/^{86}\text{Sr}$ no unit	^{14}C pmC	$\delta^{37}\text{Cl}$ dev SMOC
KFR101	279.50	341.76	16145	2008-11-05	-105.1	1.4	-14.4	0.2370	37.5	-12.79	0.716462	A	A
KFR101	279.50	341.76	16208	2009-02-06	-105.5	1.2	-14.8	-	-	A	-	A	-
KFR101	279.50	341.76	16239	2009-03-20	-109.5	1.3	-15.0	-	-	-	-	-	-
KFR101	279.50	341.76	16240	2009-03-23	-108.5	1.0	-15.1	0.2367	11.8	-13.88	0.716496	A	A
KFR101	279.50	341.76	16241	2009-03-25	-110.0	<0.8	-15.1	-	-	-	-	-	-
KFR101	279.50	341.76	16242	2009-03-27	-109.8	<0.8	-15.1	0.2370	12.2	-14.12	0.716484	A	A
PFR000123	Drilling water			2008-06-26	-74.5	10.5	-9.30	0.2438	5.0	-13.40	0.724391	105.47	0.16

A = Results will be reported later

<"value" = value below reporting limit

Sicada: isotope_I

Table A1-4. Isotopes II

Idcode	Secup m	Seclow m	Sample no.	Sampling date	^{238}U mBq/kg	^{235}U mBq/kg	^{234}U mBq/kg	^{230}Th mBq/kg	^{232}Th mBq/kg	^{226}Ra Bq/L	^{222}Rn Bq/L At time of analysis	^{222}Rn Bq/L At time of collection
KFR101	279.50	341.76	16145	2008-11-05	x	x	x	x	x	2.34	68.9	270
KFR101	280.00	342.00	16242	2009-03-27	744	29.4	2422	0.38	0.13	3.03	95.5	228

x = No results due to analytical problems

Sicada: isotope_II

Sampling information

Idcode:section	Tube volume [dm ³]	Section volume [dm ³]	Total volume [dm ³]	Pumping time	Flow rate [mL/min]	Pumped/discharged volume [dm ³]	Sampling date	Sample no.	Pressure responses in other sections of the borehole
KFR101:1	20.9	105.3	126.2	c. 24 h	c. 160	c. 230	2008-11-05	16145	-
"	"	"	"	3 h 45 min	c. 105	c. 24	2009-02-04	16209	-
"	"	"	"	25 h 50 min	c. 40	c. 62	2009-02-05	16210	-
"	"	"	"	49 h 40 min	c. 40	c. 120	2009-02-06	16208	-
"	"	"	"	23 h 40 min	115	163	2009-03-20	16239	no
"	"	"	"	94 h 37 min	100	589	2009-03-23	16240	no
"	"	"	"	143 h 8 min	160	1,055	2009-03-25	16241	no
"	"	"	"	190 h 38 min	370	2,109	2009-03-27	16242	no
KFR02:2	3.8	28.3	32.1	c. 15 h	c. 250	c. 220	2009-02-05	16207	-
KFR7A:1	1.9	44.4	46.3	c. 5 h	c. 400	c. 120	2009-02-04	16206	-
KFR08:1	0.9	68.1	69.0	c. 5 h	c. 920	c. 280	2009-02-04	16203	-
KFR08:2	0.4	43.2	43.6	c. 5 h	c. 790	c. 240	2009-02-04	16204	-
KFR56:1	0.3	120.8	121.1	c. 5 h	c. 1,400	c. 420	2009-02-04	16205	-

Pressure registrations during pumping and sampling (HMS) system

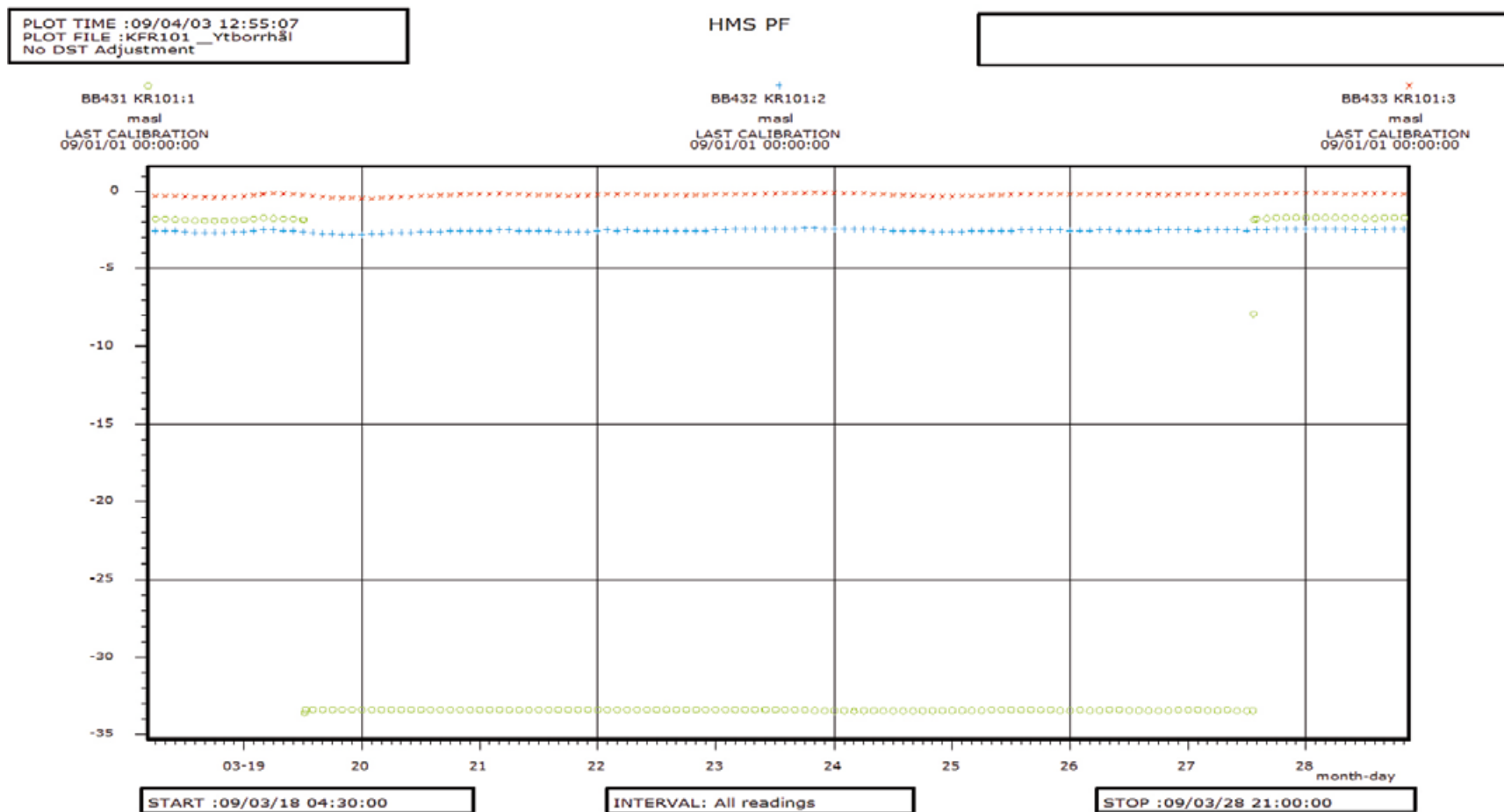


Figure A2-1. Pumping and drawdown in KFR101:1 in March 2009. None of the other sections were affected by the pumping.

Sampling and analytical methods

Table A4-1. Sample handling routines and analytical methods.

Component group	Component/element	Sample container (material)	Volume (mL)	Filtering	Preparation/ Conservation*	Analysis method	Analysis within–or delivery time to lab.
Anions 1.	HCO ₃ pH(lab) cond (lab)	Plastic	250	Yes (not in the field)	No	Titration Pot. meas, Cond. meas	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 ⁻ , SO ₄ , Br ⁻ , F ⁻) ISE (F ⁻)	Not critical (month)
	Br, I	Plastic	100	Yes (not in the field)	No	ICP MS	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-AES ICP-MS	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-AES ICP-MS	Not critical (month)
Fe(II), Fe(tot)	Fe(II), Fe(tot)	Plastic (Acid washed)	500	Yes	Yes (5 mL HCl))	Spectrophotometry Ferrozine method	As soon as possible the same day
Hydrogen sulphide	HS-	Glass (Winkler)	About 120x2	No	Ev 1 mL 1 M NaOH+ 1 mL 1M ZnAc	Spectrophotometry	Immediately or if conserved, a few days
Environmental metals	Al, As, Ba, B, Cd, Co, Cr, Cu, Hg, Mo, Ni, P, Pb, V, Zn	Plastic (Acid washed)	100	Yes	Yes (1 mL HNO ₃)	ICP-AES ICP-MS	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 (Acid washed)	100	Yes	Yes (1 mL HNO ₃)	ICP-AES ICP-MS	Not critical (month)
Component group	Component/ element	Sample container (material)	Volume (mL)	Filtering	Preparation/ Conservation*	Analysis method	Analysis within–or delivery time to lab.
Dissolved organic Carbon, dissolved inorganic Carbon	DOC, DIC	Plastic	250 25	Yes	Frozen, transported in isolated bag	UV oxidation, IR Carbon analysator Shimadzu TOC5000	Short transportation time

Component group	Component/element	Sample container (material)	Volume (mL)	Filtering	Preparation/Conservation*	Analysis method	Analysis within–or delivery time to lab.
Total organic Carbon	TOC	Plastic	250 25	No	Frozen, transported in isolated bag	UV oxidation, IR Carbon analyser Shimadzu TOC5000	Short transportation time
Environmental isotopes	² H, ¹⁸ O	Plastic	100	No	– –	MS	Not critical (month)
Tritium, Chlorine-37	³ H (enhanced.) Chlorine-37	Plastic (dry bottle) Plastic	500 100	No No	– –	LSC MS	Not critical (month)
Carbon isotopes	¹³ C, ¹⁴ C	Glass (brown)	100×2	No	–	(A)MS	A few days
Sulphur isotopes	³⁴ S	Plastic	500 –1000	Yes	–	Combustion, MS	No limit
Strontium-isotopes	⁸⁷ Sr/ ⁸⁶ Sr	Plastic	100	Yes	–	TIMS	Days or Week
Uranium and Thorium isotopes	²³⁴ U, ²³⁵ U, ²³⁸ U, ²³² Th, ²³⁰ Th,	Plastic	50	Nej	–	Alfa spectroscopy	No limit
Boron isotopes	¹⁰ B	Plastic	100	Yes	Yes (1 mL HNO ₃)	ICP – MS	No limit
Radon and Radium isotopes	²²² Rn, ²²⁶ Ra	Plastic	500	No	No	LSS	Immediate transport
Dissolved gas (content and composition)	Ar, N ₂ , CO ₂ , O ₂ , CH ₄ , H ₂ , CO, C ₂ H ₂ , C ₂ H ₄ , C ₂ H ₆ , C ₃ H ₈	Cylinder of stainless steel	200	No	No	GC	Immediate transport
Colloids	Filter series and fractionation (see below)	Polycarbonate filter	0.45, 0.2 and 0.05 μm	–	N ₂ atmosphere	ICP-AES ICP-MS	Immediate transport
Humic and fulvic acids	Fractionation	Fractions are collected in plastic bottles	250	–	N ₂ atmosphere	UV oxidation, IR (DOC)	Immediate transport
Archive samples with acid	–	Plast (washed in acid)	100×2**	Yes	Yes (1 mL HNO ₃)	–	Storage in freeze container
Component group	Component/ element	Sample container (material)	Volume (mL)	Filtering	Preparation/Conservation*	Analysis method	Analysis within–or delivery time to lab.
Archive samples without acid	–	Plastic	250×2**	Yes	No	–	Storage in freeze container
Carbon isotopes in humic and fulvic acids	¹³ C, ¹⁴ C (pmc)	DEAE cellulose (anion exchanger)	–	–	–	(A)MS	A few days
Nutrient salt + silicate	NO ₂ , NO ₃ , NO ₂ +NO ₃ , NH ₄ , PO ₄ , SiO ₄	Sample tubes, plastic	25×2	Yes (in the field)	No, frozen immediately***	Spectrophotometry	Short transportation time

Component group	Component/element	Sample container (material)	Volume (mL)	Filtering	Preparation/ Conservation*	Analysis method	Analysis within–or delivery time to lab.
Total concentrations of Nitrogen and Phosphorous	N-tot, P-tot	Plastic	100	No	No, frozen immediately***	Spectrophotometry	Short transportation time
Particulate Carbon, Nitrogen and Phosphorous	POC, PON, POP	Plastic	1000	Yes (within 4 h) prepared filters. Blank filters	Filtering, the filters are frozen immediately 2 filters/sample	Elementar-analysator (N, C) own method 990121 (P)	Short transportation time
Chlorophyll	Chlorophyll a, c and pheopigment	Plastic	1000–2000	Yes (within 4 h)	Filtering, the filters are frozen immediately	Spectrophotometry Fluorometry	Short transportation time
Oxygen	Dissolved O ₂	Winkler, glass	2×ca 120	No	Mn (II) reagent Iodide reagent	Spectrophotometry SIS SS-EN 25813	Within 3 days
Archive samples for supplementary radio nuclides		Plastic	5000	No	50 mL HNO ₃	–	Storage in freeze container

* Suprapur acid is used for conservation of samples.

** Minimum number. The number of archive samples can vary depending on the number of similar samples collected at the same occasion.

*** The sample is transported in frozen condition to the laboratory. It is possible that the silicate concentration can change due to polymerisation for this reason.

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
MS	Mass Spectrometry
TIMS	Thermal Ionization Mass Spectrometer
LSC	Liquid Scintillation Counting
(A)MS	(Accelerator) Mass Spectrometry
GC	Gas Chromatography
LSS	Liquid Scintillation Spectroscopy

Table A4-2. Reporting limits and measurement uncertainties, updated 2008.

Component	Method ¹	Reporting limits (RL), detection limits (DL) or range ²	Unit	Measurement uncertainty ³
pH	Potentiometric	3–10	pH unit	±0.1
EC	Electrical Conductivity meas.	1–150 150–10,000	mS/m	5% 3%
HCO ₃	Alkalinity titration	1	mg/L	4%
Cl ⁻	Mohr-titration	≥ 70	mg/L	5%
Cl ⁻	IC	0.5 – 70		8%
SO ₄	IC	0.5	mg/L	12%
Br ⁻	IC	DL 0.2, RL 0.5	mg/L	15%
Br	ICP SFMS	0.001, 0.004, 0.010 ⁴	mg/L	25% ⁵
F ⁻	IC	DL 0.2, RL 0.5	mg/L	13%
F ⁻	Potentiometric	DL 0.1, RL 0.2		12%
I ⁻	ICP SFMS	0.001, 0.004, 0.010 ⁴	mg/L	25% ⁵
Na	ICP AES	0.1	mg/L	13%
K	ICP AES	0.4	mg/L	12%
Ca	ICP AES	0.1	mg/L	12%
Mg	ICP AES	0.09	mg/L	12%
S(tot)	ICP AES	0.16	mg/L	12%
Si(tot)	ICP AES	0.03	mg/L	14%
Sr	ICP AES	0.002	mg/L	12%
Li	ICP AES	0.004	mg/L	12.2%
Fe	ICP AES	0.02	mg/L	13.3% ⁶
Fe	ICP SFMS	0.0004, 0.002, 0.004 ⁴	mg/L	20% ⁶
Mn	ICP AES	0.003	mg/L	12.1% ⁵
Mn	ICP SFMS	0.00003, 0.00004, 0.0001 ⁴	mg/L	53% ⁶
Fe(II), Fe(tot)	Spectrophotometry	DL 0.006, RL 0.02	mg/L	0.005 (0.02–0.05 mg/L) 9% (0.05–1 mg/L) 7% (1–3 mg/L)
HS ⁻	Spectrophotometry, SKB	SKB DL 0.006, RL 0.02	mg/L	25%
HS ⁻	Spectrophotometry, external laboratory	0.01	mg/L	0.02 (0.01–0.2 mg/L) 12% (>0.2 mg/L)
NO ₂ as N	Spectrophotometry	0.1	µg/L	2%
NO ₃ as N	Spectrophotometry	0.2	µg/L	5%
NO ₂ +NO ₃ as N	Spectrophotometry	0.2	µg/L	0.2 (0.2–20 µg/L) 2% (> 20 µg/L)
NH ₄ as N	Spectrophotometry, SKB	11	µg/L	30% (11–20 µg/L) 25% (20–50 µg/L) 12% (50–1200 µg/L)
NH ₄ as N	Spectrophotometry external laboratory	0.8	µg/L	0.8 (0.8–20 µg/L) 5% (> 20 µg/L)
PO ₄ as P	Spectrophotometry	0.5	µg/L	0.7 (0.7–20 µg/L) 3% (> 20 µg/L)
SiO ₄	Spectrophotometry	1	µg/L	2.5% (>100 µg/L)
O ₂	Iodometric titration	0.2 – 20	mg/L	5%
Component	Method ¹	Reporting limits (RL), detection limits (DL) or range ²	Unit	Measurement uncertainty ³
Chlorophyll a, c pheopigment ⁷	/1/	0.5	µg/L	5%
PON ⁷	/1/	0.5	µg/L	5%
POP ⁷	/1/	0.1	µg/L	5%
POC ⁷	/1/	1	µg/L	4%
Tot-N ⁷	/1/	10	µg/L	4%
Tot-P ⁷	/1/	0.5	µg/L	6%
Al,	ICP SFMS	0.2, 0.3, 0.7 ⁴	µg/L	17.6% ⁶
Zn	ICP SFMS	0.2, 0.8, 2 ⁴	µg/L	15.5, 17.7, 25.5% ⁶
Ba, Cr, Mo,	ICP SFMS	0.01, 0.04, 0.1 ⁴	µg/L	Ba 15% ⁴ , Cr 22% ⁵ Mo 39% ⁶
Pb	ICP SFMS	0.01, 0.1, 0.3 ⁴	µg/L	15% ⁶
Cd	ICP SFMS	0.002, 0.02, 0.5 ⁴	µg/L	15.5% ⁶
Hg	ICP AFS	0.002	µg/L	10.7% ⁶
Co	ICP SFMS	0.005, 0.02, 0.05 ⁴	µg/L	25.9% ⁶
V	ICP SFMS	0.005, 0.03, 0.05 ⁴	µg/L	18.1% ⁶
Cu	ICP SFMS	0.1, 0.2, 0.5 ⁴	µg/L	14.4% ⁶

Component	Method ¹	Reporting limits (RL), detection limits (DL) or range ²	Unit	Measurement uncertainty ³
Ni	ICP SFMS	0.05, 0.2, 0.5 ⁴	µg/L	15.8% ⁶
P	ICP SFMS	1, 5, 40 ⁴	µg/L	16.3% ⁶
As	ICP SFMS	0.01 (520 mS/m)	µg/L	59.2% ⁶
La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu	ICP SFMS	0.005, 0.02, 0.05 ⁴	µg/L	20%, 20%, 25% ⁶
Sc, In, Th	ICP SFMS	0.05, 0.2, 0.5 ⁴	µg/L	25% ⁶
Rb, Zr, Sb, Cs	ICP SFMS	0.025, 0.1, 0.25 ⁴	µg/L	15%, 20%, 20% ⁵ 25% ⁶
Tl	ICP SFMS	0.025, 0.1, 0.25 ⁴	µg/L	14.3% ^{5 and 6}
Y, Hf	ICP SFMS	0.005, 0.02, 0.05 ⁴	µg/L	15%, 20%, 20% ⁵ , 25% ⁶
U	ICP SFMS	0.001, 0.005, 0.01 ⁴	µg/L	13.5%, 14.3%, 15.9% ⁵ 19.1%, 17.9%, 20.9% ⁶
DOC	UV oxidation, IR Carbon analysator	0.5	mg/L	8%
TOC	UV oxidation, IR Carbon analysator	0.5	mg/L	10%
δ ² H	MS	2	‰ SMOW ⁸	0.9 (one standard deviation)
δ ¹⁸ O	MS	0.1	‰ SMOW ⁸	0.1 (one standard deviation)
³ H	LSC	0.8	TU ⁹	0.8
δ ³⁷ Cl	A (MS)	0.2	‰ SMOC ¹⁰	0.2 ¹⁷
δ ¹³ C	A (MS)	–	‰ PDB ¹¹	0.3 ¹⁷
¹⁴ C pmc	A (MS)	–	PMC ¹²	0.4 ¹⁷
δ ³⁴ S	MS	0.2	‰ CDT ¹³	0.4 (one standard deviation)
⁸⁷ Sr/ ⁸⁶ Sr	TIMS	–	No unit (ratio) ¹⁴	0.00002
¹⁰ B/ ¹¹ B	ICP SFMS	–	No unit (ratio) ¹⁴	–
Component	Method ¹	Reporting limits (RL), detection limits (DL) or range ²	Unit	Measurement uncertainty ³
²³⁴ U, ²³⁵ U, ²³⁸ U, ²³² Th, ²³⁰ Th	Alfa spectr.	0.0001	Bq/L ¹⁵	≤5% (Counting statistics uncertainty)
²²² Rn, ²²⁶ Ra	LSS	0.015	Bq/L	≤5% (Counting statistics uncertainty)

¹ Many elements may be determined by more than one ICP technique depending on concentration range. The most relevant technique and measurement uncertainty for the concentrations normally encountered in groundwater are presented. In cases where two techniques were frequently used, both are displayed.

² Reporting limits (RL), generally 10×standard deviation, if nothing else is stated. Measured values below RL or DL are stored as negative values in SICADA (i.e. –RL value and –DL value).

³ Measurement uncertainty reported by the laboratory, generally as ± percent of measured value in question at 95% confidence interval.

⁴ Reporting limits at electrical cond. 520 mS/m, 1440 mS/m and 3810 mS/m respectively.

⁵ Measurement uncertainty at concentrations 100×RL.

⁶ Measurement uncertainty at concentrations 10×RL.

⁷ Determined only in surface waters. PON, POP and POC refers to Particulate Organic Nitrogen, Phosphorous and Carbon, respectively.

⁸ Per mille deviation¹⁶ from SMOW (Standard Mean Oceanic Water).

⁹ TU=Tritium Units, where one TU corresponds to a tritium/hydrogen ratio of 10⁻¹⁸ (1 Bq/L Tritium = 8.45 TU).

¹⁰ Per mille deviation¹⁶ from SMOC (Standard Mean Oceanic Chloride).

¹¹ Per mille deviation¹⁶ from PDB (the standard PeeDee Belemnite).

¹² The following relation is valid between pmC (percent modern carbon) and Carbon-14 age: pmC = 100 × e^{((1950–y)–1.031t/8274)} where y = the year of the C-14 measurement and t = C-14 age.

¹³ Per mille deviation¹⁶ from CDT (the standard Canyon Diablo Troilite).

¹⁴ Isotope ratio without unit.

¹⁵ The following expressions are applicable to convert activity to concentration, for uranium-238 and thorium-232: 1 ppm U = 12.4 Bq/kg²³⁸U, 1 ppm Th = 3.93 Bq/kg²³²Th.

¹⁶ Isotopes are often reported as per mill deviation from a standard. The deviation is calculated as: δ‰ = 1000 × (K_{sample} – K_{standard}) / K_{standard}, where K = the isotope ratio and ‰ = ²H, ¹⁸O, ³⁷Cl, ¹³C or ³⁴S etc.

¹⁷ SKB estimation from duplicate analyses by the contracted laboratory.