P-10-40

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Hydrochemical monitoring of groundwaters and surface waters

Results from water sampling in the Forsmark area, January–December 2009

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Preface

This report is a compilation of three different activities performed year 2009 within the hydrochemical monitoring programme in Forsmark.

1) Hydrochemical monitoring of groundwaters in percussion – and core drilled boreholes by Cecilia Berg, Johan Harrström, Stig Jönsson, Ann-Chatrin Nilsson and Pernilla Thur, Geosigma AB.
2) Hydrogeochemical monitoring of near surface groundwaters in soil pipes by Micke Borgiel and Susanne Qvarfordt, Sveriges Vattenekologer AB.
3) Hydrogeochemical monitoring of surface waters by Micke Borgiel and Susanne Qvarfordt, Sveriges Vattenekologer AB.

Abstract

The fifth year (2009) of hydrochemical monitoring of groundwaters, surface waters and precipitation in Forsmark is documented in the report.

The hydrochemical monitoring programme 2009 included water sampling from:

- percussion- and core boreholes equipped with installations for long-term pressure monitoring, tracer tests and water sampling in packed off borehole sections, sampling and analysis performed twice (spring and autumn),
- near surface groundwaters (sampling four times a year),
- private wells (once per year in October),
- surface waters (eleven sampling occasions per year).

Due to the somewhat different performance of the hydrogeochemical monitoring of the deep groundwaters during the autumn 2009 compared to previous years, some new findings and knowledge were obtained:

1) Removal of water volumes corresponding to three to five times the volume of the borehole section (the routine procedure) is seldom enough to obtain a complete exchange of the water present in the borehole section when the pumping starts.
2) It is likely that the elevated sulphide concentrations observed in the monitoring programme /1/ is due to contamination from initial water present in the borehole sections when the pumping starts. This water may have a very high sulphide concentration. Dirty water in tubes and in stand pipes may also contribute to the enhanced sulphide concentration.
3) Plug flow calculations will be introduced in the future as a new routine procedure to estimate the water volumes to be removed, in order to exchange the section water volume, prior to groundwater sampling in delimited borehole sections.

During the autumn sampling, sample series of five samples per sampling location were collected during continuous pumping in thirteen selected borehole sections. Furthermore, special efforts were put on cleaning of stand pipes and exchange of water prior to sampling. The analytical protocol was rather extensive and included sulphide and uranium analyses for each sample in the thirteen series. Besides the sample series, single samples were collected from the remaining 20 borehole sections, but here the analytical protocol was reduced to a minimum (major constituents and the isotopes tritium, deuterium and oxygen-18). The changes in the programme were introduced, mainly, in order to check for sulphide and uranium concentration trends during pumping in order to obtain more information concerning the sulphide – and uranium issues /1/. However, the sample series also provides a check of the overall stability of the groundwater composition during sampling.

Generally, the overall groundwater composition was stable within the thirteen sample series. The sulphide concentrations showed clearly decreasing trends during pumping as expected, but pump failures caused sudden increases and breaks in the trends. The fact that most of the series did not reach a stable sulphide concentration indicated that the total pumped groundwater volume removed from the borehole section was often insufficient in order to obtain final representative samples. For nine of the borehole sections (the ones without pump failures) the contribution to each sample from the initial section water was estimated by plug flow calculations. The contributions coincided very well with the sulphide concentration trends. The uranium, on the other hand, did not show any clear concentration trends and it is concluded that there is no connection between pumped groundwater volume and uranium concentration. The pH in the groundwaters from KFM07A and KFM08D continued to be very high also in the samples collected in the spring 2009 /1/. However, in the autumn they were in a more reasonable range. It is possible that the extra cleaning efforts had an impact on some introduced cement contamination source.

The sampling of shallow groundwaters from soil pipes during 2009 confirms the knowledge and conclusions presented in reports from earlier investigation periods. Seasonal and annual variations in groundwater composition during the period 2005 to 2009 are presented in the report. The nitrogen

concentration in the groundwater from soil pipe SFM0037 continued to be somewhat high also in August 2009, and especially the phosphate concentration was very high at that occasion.

The sampled surface waters in the Forsmark area show similar seasonal variations as last year. Seasonal and annual variations in surface water composition during the period 2005 to 2009 are presented in the report. The waters are well buffered with high alkalinity, high pH and high calcium concentrations, and waters affected or recently affected by brackish sea water show high sodium chloride concentrations. Elevated tritium concentrations have been observed occasionally in samples collected close to the cooling water outlet from the nuclear power plant (Lake Biotestsjön). This occurred once during 2009 (August).

Sammanfattning

Femte årets hydrokemiska monitering (2009) av grundvatten, ytvatten och nederbörd i Forsmark dokumenteras i rapporten.

Det hydrokemiska moniteringsprogrammet 2009 omfattade vattenprovtagning i:

- hammarborrhål och kärnborrhål försedda med utrustning för långtidsövervakning av tryck, utspädningsmätningar och vattenprovtagning i avgränsade borrhålssektioner, provtagning/analys utförd två gånger under året (vår och höst),
- ytnära grundvatten i jordrör, utfört fyra gånger under året,
- privata brunnar, utfört vid ett tillfälle i oktober,
- ytvatten, utfört vid elva provtagningstillfällen.

De förändringar som infördes i den hydrogeokemiska övervakningen av grundvatten i borrhål under hösten 2009 jämfört med tidigare år, medförde nya insikter och kunskaper:

1) Omsättning av vattenvolymer som motsvarar tre till fem gånger borrhålssektionens volym (enligt rutin) är sällan tillräckligt för att erhålla ett fullständigt utbyte av det vatten som står i sektionen när pumpningen påbörjas.
2) Det är troligt att de höga sulfidhalter som observerats under moniteringsprogrammet /1/ beror på inblandning av initialt sektionsvatten som finns i borrhålssektionen när pumpningen påbörjas. Detta vatten kan ha mycket hög sulfidhalt. Vatten i slangar och vattenståndsrör kan också bidra till kontamineringen.
3) Pluggflödesberäkningar kommer att införas som en ny rutin i framtiden för att beräkna de vattenvolymer som måste omsättas innan uttag av grundvattenprov i avgränsade borrhålssektioner.

Under höstprovtagningen togs fem prov per provpunkt i tretton utvalda borrhål/borrhålssektioner under pågående pumpning. Dessutom gjordes speciella insatser vad gäller rengöring av vattenståndsrör och omsättning av vatten innan provtagning. Analysomfatningen var relativt stor och inkluderade sulfid och uran i varje prov inom de tretton provserierna. Förutom provserierna togs ett prov från var och en av de återstående 20 borrhålssektionerna, men här var analysomfattningen reducerad till ett minimum (huvudkomponenter samt isotoperna tritium, deuterium and syre-18). Förändringarna i programmet introducerades huvudsakligen för att undersöka sulfid- och urantrender under pumpning och ge mer underlag för att lösa frågeställningarna rörande sulfid och uran /1/. Provserierna ger samtidigt en kontroll av stabiliteten hos övrig grundvattensammansättning.

Grundvattensammansättningen var i huvudsak stabil inom de tretton provserierna. Sulfidkoncentrationerna visade, som förväntat, tydligt nedåtgående trender under pumpningen men pumpstopp orsakade omedelbara ökningar och trendbrott. Förhållandet att de flesta provserier inte uppnådde en stabil sulfidkoncentration visade att de totalt pumpade grundvattenvolymerna ofta inte var tillräckliga för att erhålla slutliga representativa prov. För nio av borrhålssektionerna (de utan pumpstopp) uppskattades andelen av det vatten som fanns i sektionen innan pumpningen startade i varje prov med hjälp av pluggflödesberäkningar. Bidragen av initialt sektionsvatten visade stor samstämmighet med trenderna i sulfidkoncentration. Urankoncentrationen, å andra sidan, visade inga tydliga trender inom provserierna, och slutsatsen är att det inte finns något samband mellan uranhalter och pumpade grundvattenvolymer. Grundvattnen från KFM07A och KFM08D uppvisade fortsatt höga pH värden också i proven som togs under våren 2009 /1/. Under hösten däremot, var värdena mer normala. Det är möjligt att den extra rengöring som gjordes hade påverkan på någon okänd kontamineringskälla (cement).

Grundvattenproven från jordrören under 2009 bekräftar den information och de slutsatser som presenterats från tidigare undersökningsperioder. Säsongsvariationer och årliga variationer i grundvattensammansättningen under perioden 2005 till 2009 presenteras i rapporten. Kvävekoncentrationen i grundvattnet från jordröret SFM0037 visade något höga värden också i augusti 2009 och även fosfatkoncentrationen var mycket hög vid detta tillfälle.

De provtagna ytvattnen i Forsmarksområdet visar liknande säsongsvariation som förra året. Säsongsvariationer och årliga variationer under perioden 2005 till 2009 presenteras i rapporten. Vattnen är välbuffrade med hög alkalinitet, högt pH och höga kalciumkoncentrationer och vatten som påverkas eller nyligen har påverkats av bräckt Östersjövatten visar höga natriumkloridkoncentrationer. Tillfälligt förhöjda tritiumvärden har observerats vid enstaka tillfällen i prov som tagits nära kylvattenutloppet från kärnkraftsreaktorerna (Biotestsjön), vilket hände en gång under 2009.

Contents

1 Introduction

The site investigations in Forsmark (PLU) /2/ to locate an underground repository for high level radioactive waste were finished in June 2007, and a less intensive long-term monitoring phase commenced. The monitoring programme /3, 4/ encompasses several geoscientific and ecological disciplines. The hydrogeochemical monitoring includes regular sampling and analyses of deep and shallow groundwaters, surface waters and precipitation. This document reports the performance and results from sampling and analyses within the hydrogeochemical monitoring programme during the period January–December 2009. Results from earlier investigation periods are presented or referred to in /1/.

The controlling documents for the hydrogeochemical monitoring activities are listed in Table 1-1. Both activity plans and method descriptions are SKB's internal controlling documents. Original data from the reported activities are stored in the primary database Sicada. Data are traceable in Sicada by the activity plan numbers (AP PF 400-07-038, AP PF 400-07-045, AP PF 400-07-055, and AP PF 400-09-003). 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 database may be revised, if needed. However, such revision of the database will not necessarily result in a revision of this report, although major revisions are the normal procedure for a P-report. Minor revisions are normally presented as supplements, available at www.skb.se.

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

Activity plans	Number	Version
Hydrokemisk monitering av djupt grundvatten (hammarborrhål och kärnborrhål) 2008–2009.	AP PF 400-07-038	1.0
Hydrokemisk monitering av ytnära grundvatten (jordrör och privata brunnar) under 2008–2009.	AP PF 400-07-045	1.0
Hydrokemisk monitering av ytvatten 2008–2009.	AP PF 400-07-055	1.0
Hydrokemisk övervakningsprogram av djupt grundvatten hösten 2009.	AP PF 400-09-003	1.0
Method documents	**Number**	**Version**
Hydrogeokemisk provtagning i borrhål med fasta manschettinstallationer (ny version av SKB metodbeskrivning under framtagning).	SKB MD 425.001	In prep.
Hydrologisk och meteorologisk datainsamling, vattenprovtagning och utspädningsmätning i observationshål. SKB mätsystembeskrivning – handhavandedel.	SKB MD 368.010	1.0
Ytvattenprovtagning vid platsundersökningar. SKB metodbeskrivning.	SKB MD 900.004	2.0
YSI. Multiparametersystem för vattenmätningar. SKB mätsystembeskrivning.	SKB MD 910.003	1.0
Provtagning och Provhantering. SKB-rutin.	SKB MD 452.001	7.0

Water sampling and measurement procedures are also described in SKB PIR-04-09 "Metodik för provtagning av ekologiska parametrar i hav", SKB PIR-04-06, "Metodik för provtagning av ekologiska parametrar i sjöar och vattendrag", and SKB PIR-04-12, "Översikt över provhanterings- och analysrutiner för vattenprov" (SKB internal documents).

2 Groundwaters in percussion- and core drilled boreholes

2.1 Objectives and scope

The long-term hydrogeochemical monitoring programme for percussion drilled and core drilled boreholes aims at creating long time series of data. The main objective is to check the stability of the water composition and observe possible changes for example due to disturbance from the drilling in early samples. The monitoring will also allow identification of possible perturbation effects from earlier investigations in the area. Special issues of concern within the monitoring programme for year 2009 were: 1) the enhanced sulphide concentrations revealed in several boreholes already from the start of the monitoring programme, 2) the continued high uranium concentrations in some borehole sections and 3) increase in pH in boreholes KFM07A and KFM08D.

The monitoring programme comprises groundwater sampling twice a year in 33 borehole sections delimited by stationary straddle-packers. In this context "stationary" means that the equipment stays in the borehole for several years unlike at other, short-term investigations where the equipment is removed when the investigation is completed.

The general yearly monitoring programme includes field measurements of pH, electrical conductivity and temperature as well as groundwater sampling according to SKB chemistry class 3 in the spring and SKB class 5 in the autumn /3/. However, the programme was extended during the second sampling campaign in the autumn 2009, in order to achieve more data and better understanding of the elevated sulphide concentrations and the high uranium concentrations. Special efforts were also put on cleaning and preparing the borehole equipment and borehole sections prior to the sampling. Sample series (including five samples each) were collected from 13 of the 33 borehole sections according to SKB chemistry classes 3, 4 and 5. The sampling in the remaining borehole sections was reduced from SKB chemistry class 5 to class 3. Results from the few sample series collected during previous monitoring during 2008 and in spring 2009 indicated that the sulphide concentration is dependent on the pumped volume. Therefore, the first purpose with the sample series was to follow the expected decreasing sulphide trends and, hopefully, get reliable stable values from the last samples in the series. Secondly, sample series will also be valuable in order to verify that the concentrations of the other components are stable, since a single sample is only a snapshot, and there may be a trend versus time and pumped water volume in the water composition associated with the successively exchanged water volume. Especially trace metals and TOC/DOC may vary with the pumped volume.

2.2 Sampled boreholes and borehole sections

The site investigation area in Forsmark and the location of the boreholes included in the hydrogeochemical monitoring programme 2009 are displayed in Figure 2-1. Table 2-1 lists the boreholes and borehole sections. The borehole sections sampled as sample time series (five samples in each series) during continuous pumping are given in italic font.

KFM01A, KFM02A and KFM03A are SKB chemistry-type, subvertical, and approximately 1,000 m long, telescopic boreholes, whereas KFM01D, KFM02B, KFM04A, KFM06A, KFM06C, KFM07A, KFM08A, KFM08D, KFM10A, KFM11A and KFM12A are inclined telescopic boreholes also of the chemistry-type. HFM01, HFM02, HFM04, HFM13, HFM15, HFM16, HFM19, HFM21, HFM27 and HFM32 are percussion boreholes with lengths varying between 99.5 and 221.7 metres. References to technical descriptions and designs of the boreholes as well as descriptions of the installations for long-term monitoring of pressures and chemical compositions are given in /1/.

Figure 2-1. *General overview of the Forsmark site investigation area. Sampled boreholes within the monitoring program 2009 are marked with blue (percussion boreholes) and pink (cored boreholes) filled circles.*

2.3 Borehole history

In order to evaluate the results and understand possible observed trends in the groundwater composition, it is important to have information about previous investigations in each borehole and to understand their implications on the groundwater chemistry. Investigations which are likely to affect subsequent water sampling are hydraulic pumping and injection tests, tracer tests, SWIW-tests and tracer dilution tests. Besides preceding investigations in a specific borehole/borehole section, ongoing activities in nearby situated boreholes, e.g. pumping tests, core drilling and interference tests may affect the results from water sampling and analyses.

2.3.1 Cored boreholes

The flushing water contents in the groundwater samples are important information when evaluating chemical data from core drilled boreholes. The dye Uranine was added as a tracer to the flushing water during drilling and is used to calculate the flushing water content in the groundwater samples. However, Uranine has also been used in some of the late investigations in several borehole sections and in some cases the flushing water content in the samples from a specific borehole section cannot be calculated any longer.

Table 2-1. Boreholes and borehole sections included in the monitoring programme for percussion- and core drilled boreholes during 2009 and corresponding transmissivity values. Sample series were collected in the autumn 2009 from the borehole sections given in italic font.

Borehole [Idcode:section]	Section [mbl]#	Section elevation [m.b.s.l]##	Transmissivity [m^2/s]
KFM01A:5	*109.0–130.0*	*105.0–126.2*	*1.0 E–7**
KFM01D:2	*429.0–438.0*	*339.6–346.5*	*8.0 E–7**
KFM01D:4	*311.0–321.0*	*248.6–256.4*	*2.0 E–7**
KFM02A:3	*490.0–518.0*	*481.0–508.9*	*2.1 E–6**
KFM02A:5	*411.0–442.0*	*402.4–433.2*	*2.5 E–6**
KFM02B:2	491.0–506.0	476.4–491.2	3.0 E–5**
KFM02B:4	410.0–431.0	396.7–417.4	2.0 E–5**
KFM03A:1	*969.5–994.5*	*956.7–981.5*	*5.5 E–7**
KFM03A:4	*633.5–650.0*	*622.9–639.3*	*2.4 E–6**
KFM04A:4	230.0–245.0	193.0–206.3	2.0 E–5*
KFM06A:3	738.0–748.0	618.7–626.8	1.2E–7*
KFM06A:5	341.0–362.0	289.6–307.4	3.5 E–6*
KFM06C:3	647.0–666.0	519.9–534.2	5.3 E–8*
KFM06C:5	531.0–540.0	431.4–438.3	1.1 E–6*
KFM07A:2	*962.0–972.0*	*791.5–798.9*	*5.0 E–7**
KFM08A:2	*684.0–694.0*	*546.9–554.2*	*1.0 E–6**
KFM08A:6	*265.0–280.0*	*221.6–233.9*	*1.0 E–6**
KFM08D:2	*825.0–835.0*	*658.7–666.4*	*2.0 E–8***
KFM08D:4	*660.0–680.0*	*530.2–545.9*	*2.0 E–7***
KFM10A:2	*430.0–440.0*	*296.8–302.8*	*3.0 E–5**
KFM11A:2	690.0–710.0	585.8–601.8	1.0 E–6*
KFM11A:4	446.0–456.0	385.4–393.8	6.0 E–7*
KFM12A:3	270.0–280.0	222.4–231.0	1.0 E–6*
HFM01:2	33.5–45.5	31.1–42.9	4.0 E–5***
HFM02:2	38.0–48.0	34.9–44.9	5.9 E–4***
HFM04:2	58.0–66.0	53.9–61.9	7.9 E–5***
HFM13:1	159.0–173.0	132.6–144.6	2.9 E–4***
HFM15:1	85.0–95.0	55.7–62.5	1.0 E–4***
HFM16:2	54.0–67.0	50.7–63.7	3.5 E–4***
HFM19:1	168.0–182.0	130.8–141.5	2.7 E–4***
HFM21:3	22.0–32.0	14.6–23.0	4.0 E–5***
HFM27:2	46.0–58.0	40.1–51.1	4.0 E–5***
HFM32:3	26.0–31.0	25.0–29.9	2.3 E–4***

mbl = metres borehole length.
m.b.s.l. = metres below sea level [RHB 70 = the national levelling system].

* From injection tests.
** From differential flow logging.
*** From HTHB flow logging.

Injection tests with the PSS equipment /1/ was conducted in almost all cored boreholes after the initial hydrogeochemical characterisation campaign. The relatively small water volumes added to the borehole during injection tests were marked with the dye Uranine to the same concentration as the flushing water, i.e. 0.2 mg/L, and the effect on the Uranine concentration in the groundwater should be negligible. The activities during 2008 that may have contributed significantly to the concentrations of Uranine and/or trace metals in the samples collected during 2009 are listed in Table 2-2. Activities performed during earlier years are presented in /1/.

2.3.2 Percussion boreholes

Flushing water was not used during drilling of percussion boreholes, and therefore remaining flushing water is not a problem. However, dilution tests conducted in percussion boreholes prior to chemical sampling may possibly affect the section water. Since the shallow borehole sections in the percussion boreholes generally yield much water and the injected volumes during the dilution tests are small, they are not likely to cause significant effects. Interference tests with heavy pumping, on the other hand, are likely to affect the representativeness of the samples from percussion boreholes. Such tests, involving pumping in HFM14 located close to HFM15, were conducted during 2006, 2007 and during 2008. The activities performed in the percussion boreholes during 2008, which might have an impact on the sample quality are listed in Table 2-3. Activities performed during earlier years are presented in /1/.

Table 2-2. Investigations/activities in cored boreholes during 2008 that might affect the quality of subsequently collected water samples during 2009.

Borehole [Idcode]	Section [mbl]	Date [yymmdd]	Activity	Comment
KFM01A	109.0–130.0	080108 to 080115	HY212	0.0360 g Amino-G Acid injected, total volume of injected fluid 3.47×10^{-5} m^3.
	109.0–130.0	081128 to 081203	HY212[1]	0.0335 g Amino-G Acid injected, total volume of injected fluid 3.34×10^{-5} m^3.
KFM01D	311.0–321.0	080115 to 080121	HY212	0.0326 g Amino-G Acid injected, total volume of injected fluid 3.14×10^{-5} m^3.
	311.0–321.0	081128 to 081203	HY212[1]	0.0313 g Amino-G Acid injected, total volume of injected fluid 3.12×10^{-5} m^3.
KFM01D	429.0–438.0	080108 to 080115	HY212	0.0425 g Amino-G Acid injected, total volume of injected fluid 4.090×10^{-5} m^3.
	429.0–438.0	081128 to 081203	HY212[1]	0.0388 g Amino-G Acid injected, total volume of injected fluid 3.870×10^{-5} m^3.
KFM02A	411.0–442.0	081117 to 081125	HY212[1]	0.0626 g Amino-G Acid injected, total volume of injected fluid 6.240×10^{-5} m^3.
	490.0–518.0	081117 to 081125	HY212[1]	6.6228 g Amino-G Acid injected, total volume of injected fluid 6.600×10^{-3} m^3.
KFM02B	410.0–431.0	081117 to 081121	HY212[1]	0.0476 g Amino-G Acid injected, total volume of injected fluid 4.750×10^{-5} m^3.
	491.0–506.0	081117 to 081121	HY212[1]	0.0485 g Amino-G Acid injected, total volume of injected fluid 4.840×10^{-5} m^3.
	633.5–650.0	081201 to 081208	HY212[1]	0.0587 g Amino-G Acid injected, total volume of injected fluid 5.850×10^{-5} m^3.
KFM04A	230.0–245.0	081121 to 081125	HY212[1]	0.0357 g Amino-G Acid injected, total volume of injected fluid 3.560×10^{-5} m^3.
KFM06A	341.0–362.0	080118 to 080129	HY212	0.0619 g Amino-G Acid injected, total volume of injected fluid 5.960×10^{-5} m^3.
	341.0–362.0	081210 to 081219	HY212[1]	0.0469 g Amino-G Acid injected, total volume of injected fluid 4.680×10^{-5} m^3.
	738.0–748.0	080125 to 080201	HY212	0.0586 g Amino-G Acid injected, total volume of injected fluid 5.870×10^{-5} m^3.
	738.0–748.0	081210 to 081219	HY212[1]	0.0586 g Amino-G Acid injected, total volume of injected fluid 5.840×10^{-5} m^3.
KFM06C	531.0–540.0	080125 to 080129	HY212	0.0456 g Amino-G Acid injected, total volume of injected fluid 4.390×10^{-5} m^3.
	531.0–540.0	081210 to 081219	HY212[1]	0.0440 g Amino-G Acid injected, total volume of injected fluid 4.390×10^{-5} m^3.
	647.0–666.0	080118 to 080201	HY212	0.0663 g Amino-G Acid injected, total volume of injected fluid 6.390×10^{-5} m^3.
	647.0–666.0	081210 to 081219	HY212[1]	0.0668 g Amino-G Acid injected, total volume of injected fluid 6.660×10^{-5} m^3.
KFM08A	265.0–280.0	080201 to 080208	HY212	0.0347 g Amino-G Acid injected, total volume of injected fluid 3.480×10^{-5} m^3.
	265.0–280.0	081212 to 081223	HY212[1]	0.0351 g Amino-G Acid injected, total volume of injected fluid 3.500×10^{-5} m^3.
KFM08A	684.0–694.0	080128 to 080208	HY212	0.0569 g Amino-G Acid injected, total volume of injected fluid 5.480×10^{-5} m^3.
	684.0–694.0	081212 to 081223	HY212[1]	0.0565 g Amino-G Acid injected, total volume of injected fluid 5.630×10^{-5} m^3.
KFM08D	660.0–680.0	080128 to 080204	HY212	0.0770 g Amino-G Acid injected, total volume of injected fluid 7.710×10^{-5} m^3.
	660.0–680.0	081212 to 081223	HY212[1]	0.0664 g Amino-G Acid injected, total volume of injected fluid 6.620×10^{-5} m^3

Borehole [Idcode]	Section [mbl]	Date [yymmdd]	Activity	Comment
KFM08D	825.0–835.0	080201 to 080208	HY212	0.0642 g Amino-G Acid injected, total volume of injected fluid 6.430×10^{-5} m^3.
	825.0–835.0	081212 to 081223	HY212[1]	0.0636 g Amino-G Acid injected, total volume of injected fluid 6.340×10^{-5} m^3.
KFM10A	430.0–440.0	081205 to 081212	HY212[1]	0.0425 g Amino-G Acid injected, total volume of injected fluid 4.240×10^{-5} m^3.
KFM11A	446.0–456.0	080121 to 080204	HY212	0.0420 g Amino-G Acid injected, total volume of injected fluid 4.050×10^{-5} m^3.
	446.0–456.0	081125 to 081203	HY212[1]	0.0444 g Amino-G Acid injected, total volume of injected fluid 4.430×10^{-5} m^3.
KFM11A	690.0–710.0	080128 to 080204	HY212	0.0687 g Amino-G Acid injected, total volume of injected fluid 6.880×10^{-5} m^3.
	690.0–710.0	081125 to 081203	HY212[1]	0.0699 g Amino-G Acid injected, total volume of injected fluid 6.970×10^{-5} m^3.
KFM12A	270.0–280.0	080204 to 080208	HY212	0.0319 g Amino-G Acid injected, total volume of injected fluid 3.190×10^{-5} m^3.
	270.0–280.0	081201 to 081208	HY212[1]	0.0322 g Amino-G Acid injected, total volume of injected fluid 3.210×10^{-5} m^3.

[1] HY212 = Dilution test natural gradient /5/.

Table 2-3. Investigations/activities in percussion boreholes during 2008–2009 that might affect the quality of collected water samples.

Borehole [Idcode]	Section [mbl]	Date [yymmdd]	Activity	Comment
HFM01	33.5–45.5	080122–080128	HY212	0.0395 g Amino-G Acid injected, total volume of injected fluid 3.960×10^{-5} m^3.
		081205–081212	HY212[1]	0.0407 g Amino-G Acid injected, total volume of injected fluid 4.060×10^{-5} m^3.
HFM02	38.0–48.0	080114–080118	HY212	0.1204 g Amino-G Acid injected, total volume of injected fluid 1.160×10^{-4} m^3.
		081205–081212	HY212[1]	0.1103 g Amino-G Acid injected, total volume of injected fluid 1.100×10^{-4} m^3.
HFM04	58.0–66.0	081117–081128	HY212[1]	0.0285 g Amino-G Acid injected, total volume of injected fluid 2.840×10^{-5} m^3.
HFM13	159.0–173.0	081121–081125	HY212[1]	0.0468 g Amino-G Acid injected, total volume of injected fluid 4.670×10^{-5} m^3.
HFM15	85.0–95.0	080125–080204	HY212	0.0366 g Amino-G Acid injected, total volume of injected fluid 3.530×10^{-5} m^3.
		081201–081205	HY212[1]	0.0360 g Amino-G Acid injected, total volume of injected fluid 3.590×10^{-5} m^3.
HFM16	54.0–67.0	080118–080125	HY212	0.0458 g Amino-G Acid injected, total volume of injected fluid 4.410×10^{-5} m^3.
		081205–081210	HY212[1]	0.0503 g Amino-G Acid injected, total volume of injected fluid 5.010×10^{-5} m^3.
HFM19	168.0–182.0	080114–080118	HY212	0.0476 g Amino-G Acid injected, total volume of injected fluid 4.590×10^{-5} m^3.
		081201–081205	HY212[1]	0.0445 g Amino-G Acid injected, total volume of injected fluid 4.440×10^{-5} m^3.
HFM21	22.0–32.0	080109–080114	HY212	0.0410 g Amino-G Acid injected, total volume of injected fluid 3.950×10^{-5} m^3.
		081121–081125	HY212[1]	0.0384 g Amino-G Acid injected, total volume of injected fluid 3.830×10^{-5} m^3.
HFM27	46.0–58.0	080204–080208	HY212	0.0400 g Amino-G Acid injected, total volume of injected fluid 4.010×10^{-5} m^3.
		081203–081208	HY212[1]	0.0403 g Amino-G Acid injected, total volume of injected fluid 4.020×10^{-5} m^3.
HFM32	26.0–31.0	090316–090320	HY212[1]	0.0202 g Uranine injected, total volume of injected fluid 2.010×10^{-5} m^3.

[1] HY212 = Dilution test natural gradient /5/.

2.4 Equipment

2.4.1 Installations in a borehole test sections with connected standpipe

The monitored boreholes are divided into different borehole sections sealed off by inflated rubber packers. Pressure is measured on-line in standpipes hydraulically connected to each section and transmitted to the SKB Hydro Monitoring System (HMS). An outline of the instrumentation in a telescopic drilled borehole is presented in Figure 2-2. In such a borehole maximum 10 pressure sections can be installed, whereof two also may be especially equipped for water sampling and circulation of tracer.

The selected sections (circulation sections) for water sampling or circulation of tracer during flow measurements are equipped in a slightly different way than the sections for pressure measurement purposes (pressure sections). Three tubes connect to the circulation sections; the tube for pressure measurements, the tube connecting the section to the standpipe in the upper-most part of the borehole and the tube leading all the way to the ground surface (see Figure 2-3).

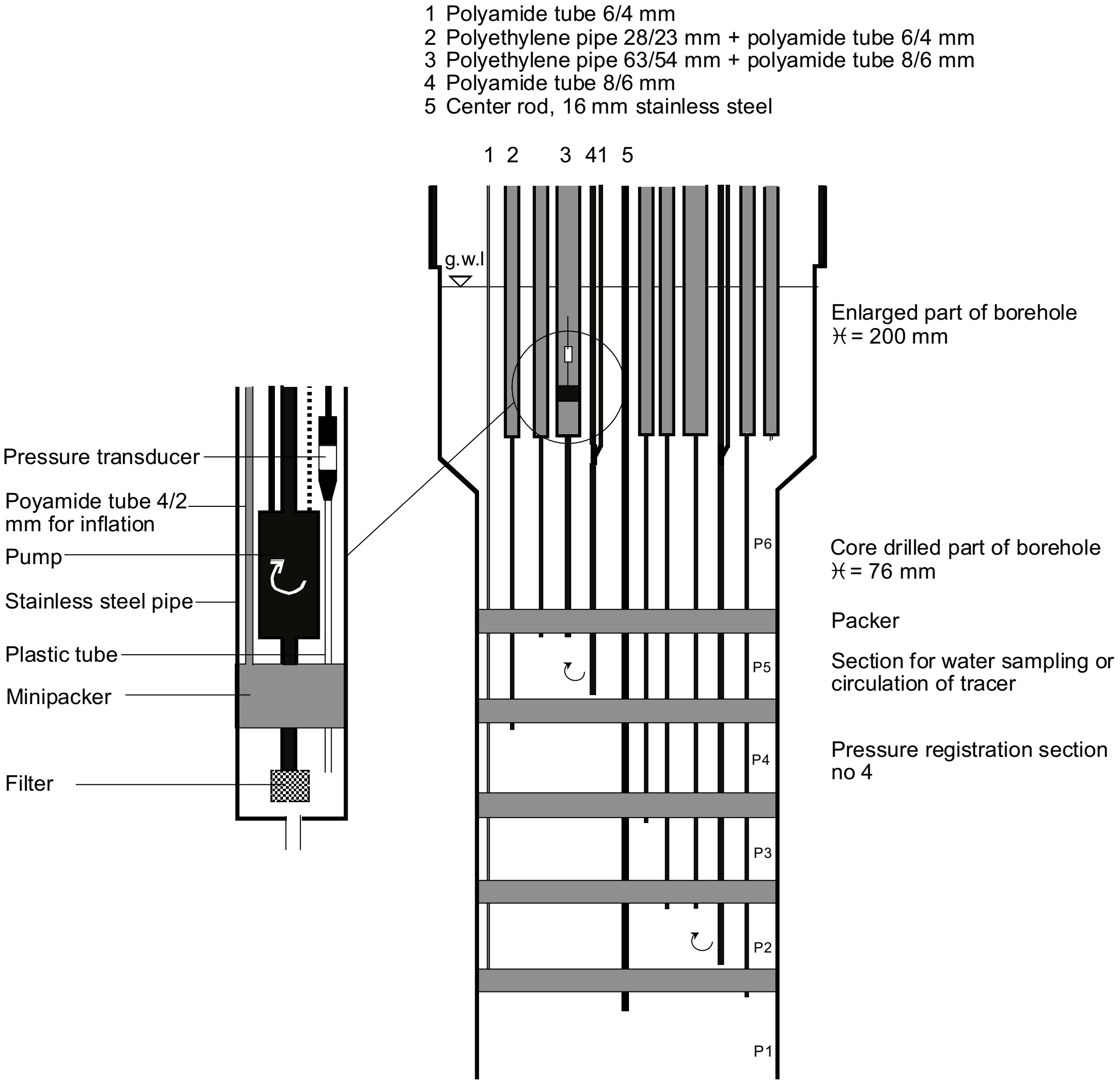


Figure 2-2. Instrumentation in a telescopic drilled core borehole. Enlarged picture shows the installations in the coarse standpipe aimed for water sampling and circulation of tracer. (The smaller standpipes for pressure measurements are not wide enough for the pump.)

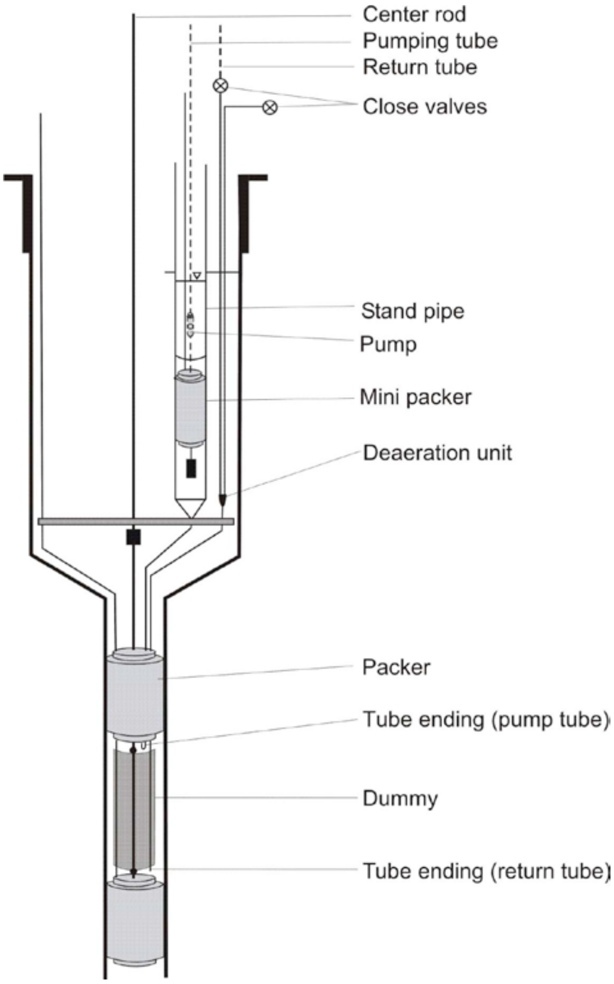


***Figure 2-3.** Outline of a test section for water sampling and equipment in a connected standpipe.*

The system is built up of the following components:

Packers. A packer consists of a rubber tube (length 1 m) mounted on a stainless steel shell. At the gables the rubber tube is fixed with a pressed sleeve (see Figure 2-4). All metal components in the packer are made of acid proof stainless steel, and the rubber tube is made of polyurethane. The length of the pressed sleeve is c. 70 mm and it has an outer diameter of c. 72 mm. The packer is supplied with lead-throughs, the number of which depends on the number of sections below, to enable hydraulic connections between the sections and the ground surface. For expansion/deflation, the packer is connected to a nitrogene gas bottle at the ground surface by a 6/4 mm polyamide tube.

***Figure 2-4.** Rubber packer with stainless steel lead-throughs.*

Centre rod. The centre rods carrying the borehole equipment are made of acid proof stainless steel and have a diameter of 16 mm.

Dummy. In order to minimize the water volume in the test section, a plastic dummy made of polyethylene (PEHD1000) is mounted on the centre rod between the packers (see Figure 2-5). The outer diameter of the dummy in a 76 mm borehole is c. 73 mm and in a 140 mm percussion borehole c. 130 mm. The length between the packer (rubber part) and the dummy gable is c. 0.66 m. The tubes passing the section are attached to the dummy by plastic tape (PVC, "Nitto 225").

Tubes. The tubes used to connect the sections to the standpipes for pressure measurements and water sampling, return tube for circulation and the tube for expansion of the packers are all of the same type and made of polyamide plastics. The diameters of the tubes in a 76 mm borehole are 8/6 mm for the pumping tube and the return tube and 6/4 mm for the tubes for pressure measurements and packer expansion. In percussion boreholes all tubes are 8/6 mm.

Standpipes. The standpipes used for pumping a test section are built up by 2 m PVC pipes with o-ring sealings and with an inner diameter of 53.5 mm. The total length of the standpipe is normally c. 40 m in a core borehole and c. 30 m in a percussion borehole. The bottommost 2 m of the standpipe, connected to the polyamide tube from the test section, are made of stainless steel. This is to resist the pressure from a minipacker expanded in the standpipe. This pipe has a trap for mud or dirt in the bottom, to prevent clogging (see Figure 2-6).

Minipacker. To exclude the water volume in the standpipe during water sampling or circulation of tracer a minipacker with a lead trough is placed near the bottom of the standpipe. During water sampling a filter is mounted below the packer, on the lead trough, and a pump on the upper side of the lead trough (see Section 2.4.3). The distance from the minipacker to the bottom of the standpipe is c. 0.63 m.

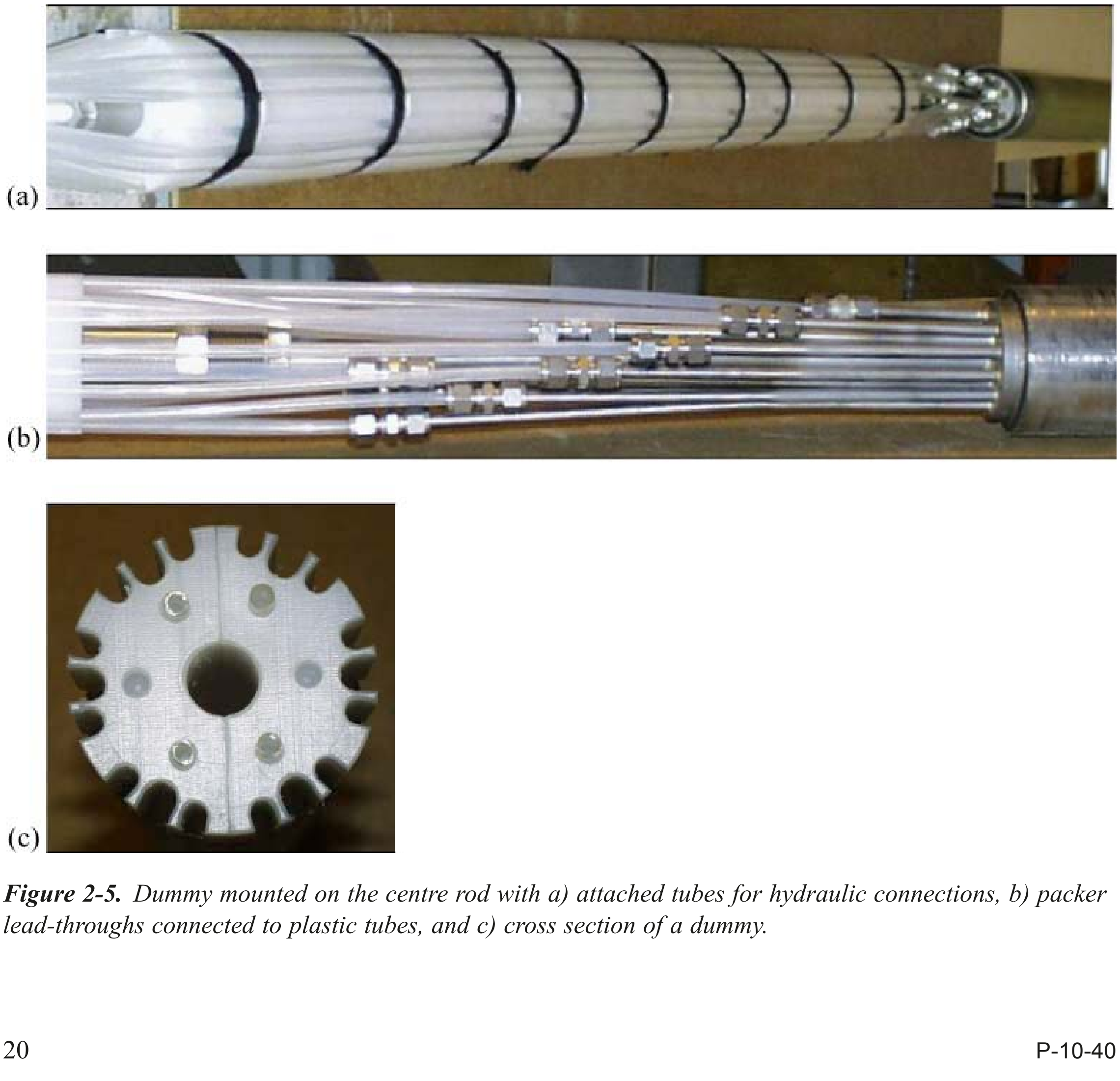


__Figure 2-5.__ Dummy mounted on the centre rod with a) attached tubes for hydraulic connections, b) packer lead-throughs connected to plastic tubes, and c) cross section of a dummy.

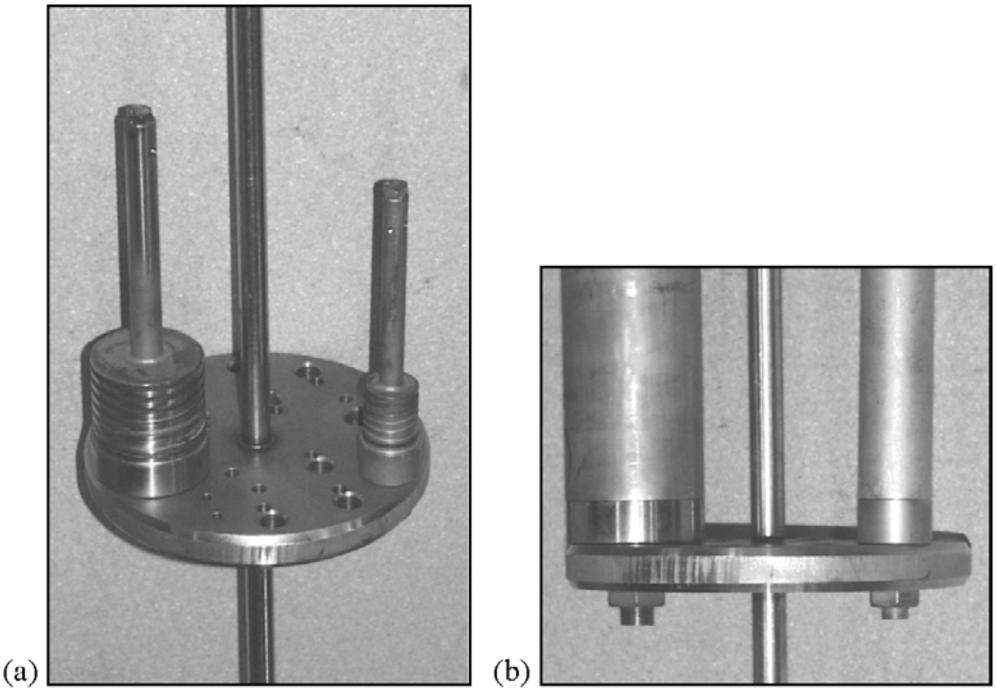


Figure 2-6. a) *Bottom plugs with mud trap for a small and a coarse standpipe. b) Stainless steel pipe mounted.*

2.4.2 Rinse pump equipment

Special rinse pumping and cleaning of standpipes was performed prior to the autumn field campaign 2009. This extra cleaning included only the sections where sample series were collected. The pumping was sometimes conducted using electrical pumps but more often by applying a gas-driven pumping technique, because the electrical pumps did not function satisfactory.

The gas-controlled pump (Figure 2-7) consists of two connected tubes of which the smaller one is equipped with a non-return valve (upper non-return valve). The two tubes are connected to a Y-connection and to another non-return valve at the bottom. The tubes are lowered to the bottom of the plastic stand pipe and then filled with water. A control unit linked to a gas-bottle (nitrogen gas) with regulator is connected to the thicker one of the two tubes. During the pumping phase the control unit releases gas, causing the lower non-return valve to close and water to be pushed up through the smaller tube, until the pressure is released by the control unit. Then the upper non-return valve closes, and simultaneously the thicker tube is again filled with water (recovery phase). The procedure is repeated and an intermittent pumping is achieved. The lengths of the pumping and recovery phases are adjusted by the control unit and depend on the hydraulic transmissivity of the pumped borehole section and the distance to the water table in the standpipe.

The branching at the outlet from the control unit allows up to 11 sections to be pumped simultaneously. However, during the reported sampling activity, maximum two sections were pumped at the same time.

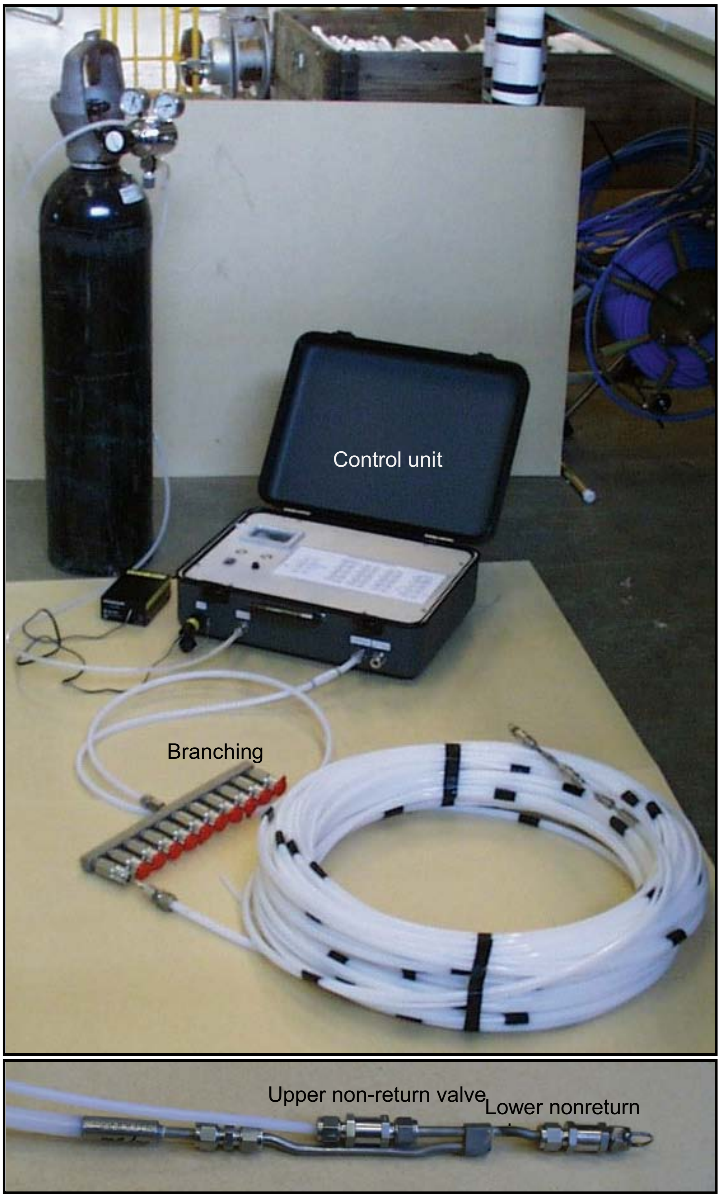


__Figure 2-7.__ Control unit with branching and one pair of pumping tube connected. The smaller picture shows the Y-connection with upper and lower non-return valve.

2.4.3 Sampling equipment

Twelve identical pump equipments (GEOPUMP UV45) were used to retrieve the water samples from the sampled sections. An outline of the sampling setup is presented in Figure 2-8.

Figure 2-9 shows the lowering of the pump into the standpipe. The water passes through a coarse filter to eliminate large particles that may be present in the water, then through a by-pass tubing past the mini-packer which confines the groundwater included in the section and thereafter through the downhole pump on the way to the surface. The flow rate is controlled by varying the capacity of the downhole pump with a voltage regulator at the surface.

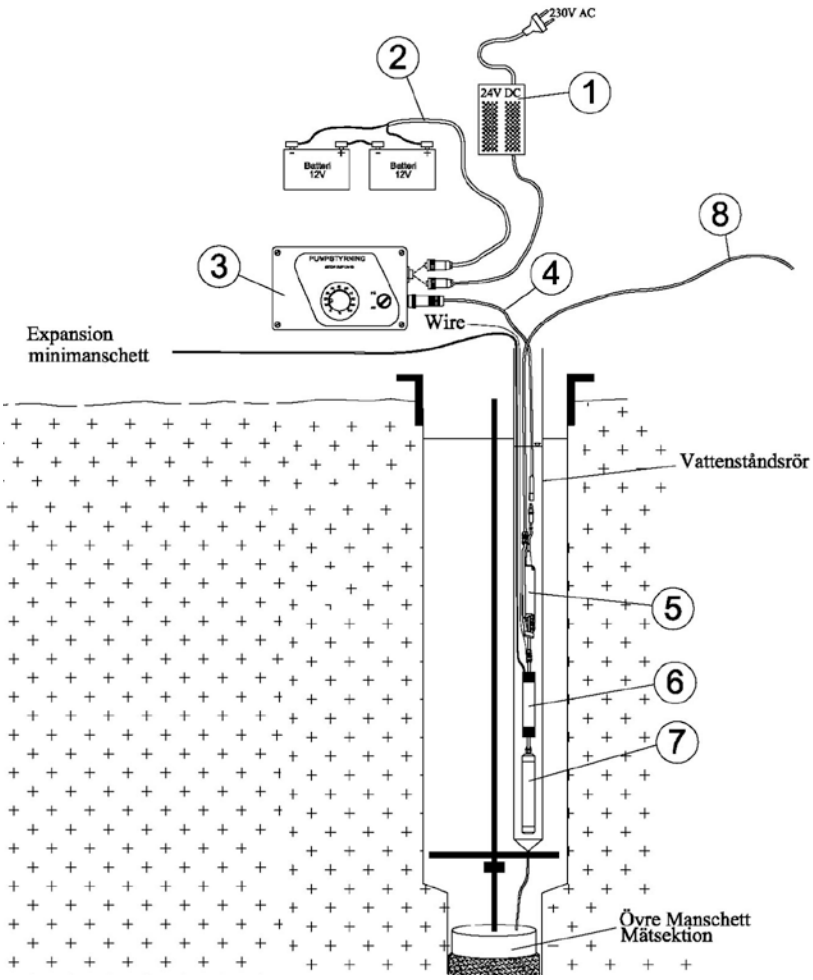


Figure 2-8. *Equipment setup used for sampling of water from circulation sections in monitored percussion drilled and telescopic boreholes. 1) voltage regulator (24 VDC), 2) battery cable (not used), 3) pump regulator, 4) pump cable, 5) pump (GEOPUMP UV 45), 6) small inflatable packer (PU 45), 7) filter (SF 45), 8) 8/6 mm polyamide tube to pump.*

Figure 2-9*. Lowering of equipment in the water stand-pipe in order to pump water from the borehole section. From the bottom: filter, small inflatable packer and pump.*

2.5 Performance

2.5.1 General

Monitored boreholes and borehole sections, sampling dates, collected samples and analyses performed are presented in Table 2-4. SKB class 3+ includes the isotopes δ^2H, δ^{18}O and ^{3}H.

2.5.2 Rinse pumping

Rinse pumping was performed in all the sections included in the extended sampling. The first step was to clean the standpipes by forcing the water out with high speed using nitrogen gas, a so called airlift. The gas blow procedure was repeated 4–5 times, and the water level in the standpipe was allowed to recover before the next gas blow. The water was collected for judgment of colour, smell etc. The cleaning of the plastic standpipes had a visible effect on the water colour and smell. The water from the first blow was often grey or black and had an unpleasant smell.

Table 2-4. Boreholes, borehole sections, sampling dates, collected samples and analyses performed.

Borehole	Section	Sampling No. 1			Sampling No. 2		
[Idcode]	[mbl]	Date	Sample No.	Analyses	Date	Sample No.	Analyses
KFM01A	109–130	2009-05-11	16304	Class 4	2009-10-06	Series3)	Class 4, 5 and 5+
KFM01D	429–438	2009-05-11	16305	Class 4	2009-10-07	Series3)	Class 4, 5 and 5+
		2009-05-19	16312–16315	2)			
KFM01D	311–321	2009-05-11	16306	Class 4	2009-10-08	Series3)	Class 4, 5 and 5+
KFM02A	490–518	2009-05-08	16299	Class 4	2009-10-26	Series3)	Class 4, 5 and 5+
KFM02A	411–442	2009-05-08	16301	Class 4	2009-10-27	Series3)	Class 4, 5 and 5+
KFM02B	491–506	2009-05-08	16300	Class 4	2009-10-26	16583	Class 3+
KFM02B	410–431	2009-05-08	16302	Class 4	2009-10-26	16584	Class 3+
KFM03A	969.5–994.5	2009-04-30	16289	Class 3+	2009-11-04	Series3)	Class 4, 5 and 5+
KFM03A	634–650.5	2009-04-28	16279	Class 3+	2009-11-03	Series3)	Class 4, 5 and 5+
KFM04A	230–245	2009-05-04	16288	Class 3+	2009-10-15	16452	Class 3+
KFM06A	738–748	2009-05-06	16293	Class 3+	2009-10-12	16538	Class 3+
KFM06A	341–362	2009-05-06	16296	Class 3+	2009-10-13	16357	Class 3+
KFM06C	647–666	2009-05-08	16298	Class 3+	2009-10-15	16552	Class 3+
KFM06C	531–540	2009-05-06	16294	Class 3+	2009-10-13	16541	Class 3+
KFM07A	962–972	2009-05-19	163111)	Class 3+	2009-11-04	Series3)	Class 4, 5 and 5+
KFM08A	684–694	2009-04-28	16281	Class 3+	2009-10-20	Series3)	Class 4, 5 and 5+
KFM08A	265–280	2009-04-28	16280	Class 3+	2009-10-21	Series3)	Class 4, 5 and 5+
KFM08D	825–835	2009-04-30	16291	Class 3+	2009-10-20	Series3)	Class 4, 5 and 5+
KFM08D	660–680	2009-04-28	16284	Class 3+	2009-10-12	Series3)	Class 4, 5 and 5+
KFM10A	430–440	2009-05-12	16307	Class 3+	2009-10-09	Series3)	Class 4, 5 and 5+
KFM11A	690–710	2009-05-04	16292	Class 3+	2009-10-15	16549	Class 3+
KFM11A	446–456	2009-05-04	16287	Class 3+	2009-10-15	16550	Class 3+
KFM12A	270–280	2009-05-06	16297	Class 3+	2009-10-15	16551	Class 3+
HFM01	33.5–45.5	2009-04-28	16282	Class 3+	2009-10-07	16522	Class 3+
HFM02	38–48	2009-04-30	16285	Class 3+	2009-10-07	16521	Class 3+
HFM04	58–66	2009-05-06	16295	Class 3+	2009-10-14	16548	Class 3+
HFM13	159–173	2009-05-12	16303	Class 3+	2009-10-08	16533	Class 3+
HFM15	85–95	2009-05-12	16308	Class 3+	2009-10-09	16534	Class 3+
HFM16	168–182	2009-05-06	16283	Class 3+	2009-10-12	16539	Class 3+
HFM19	54–67	2009-05-12	16310	Class 3+	2009-10-09	16536	Class 3+
HFM21	22–32	2009-04-30	16290	Class 3+	2009-10-14	16540	Class 3+
HFM27	46–58	2009-04-30	16286	Class 3+	2009-10-07	16520	Class 3+
HFM32	26–31	2009-05-12	16309	Class 3+	2009-10-08	16535	Class 3+

1) Water "pumped" using nitrogen lifting.
2) Sample numbers 16312–16315 are only analysed for HS^-.
3) The sample numbers in series are displayed in Table 2-7.

Secondly, pumping was performed in order to exchange the total volumes (hoses + section + standpipe) at least three times. However, due to problems with the pumps this criterion was not fulfilled in all sections. The pumping was carried out using electrical pumps and/or using a technique with gas driven pumping, see Section 2.4.1. The electrical conductivity was measured during the pumping periods to check if the overall water composition was stable.

The start and stop dates for the cleaning (including cleaning of the standpipes) are listed in Table 2-5 together with total pumped volumes and observations made on the first water from the standpipes. The HMS (Hydro Monitoring System) was used to obtain the exact time records for pump stops due to pump failure, since pump stops are reflected by pressure changes in the borehole section. This information was needed in order to calculate the pumped water volumes from each borehole section. At the end of the pumping periods the water was clear and uncoloured. After the clean-up pumping, the sections were allowed to recover for about a week prior to the hydrogeochemical sampling.

2.5.3 Water sampling and field measurements

In addition to sampling of ground water, field measurements of temperature, electric conductivity and pH were conducted. 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 and trace metals (by ICP technique), DOC, iron (by spectrometry) and nutrient salts were filtered on-line. Disposable 0.4 µm 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.

All the sampled sections were monitored by the HMS system for pressure monitoring during the whole field campaign. Pressure diagrams for each borehole and sampling occasion are given in Appendix 1. Short circuiting, indicated by pressure responses in one or more sections other than the pumped ones, can be observed in a few cases. Information on flow rates, pumped volumes and short circuiting phenomena are reported in Appendix 2.

Table 2-5. Rinse pumping and exchanged water volumes in the sections included in the extended sampling programme.

Borehole [Idcode: section]	Start	Stop	Total volume [L]	Exch. volume [L]	Exch. factor	Colour of water from first blowing of standpipe
KFM01A:5	2009-09-15 10:23	2009-09-23 10:05	105	180	1.7	Grey with tones of green (Uranine)
KFM01D:2	2009-09-15 12:28	2009-09-23 15:46	102	260	2.5	Grey with tones of green (Uranine)
KFM01D:4	2009-09-15 12:28	2009-09-23 15:46	99	360	3.6	Grey with tones of green (Uranine)
KFM02A:3	2009-09-18 12:45	2009-10-12 15:50	125	275	2.2	Black with flakes
KFM02A:5	2009-09-18 12:45	2009-10-12 15:50	121	324	2.7	Grey/yellow
KFM03A:1	2009-09-18 13:35	2009-10-12 15:10	136	316	2.3	Almost clean
KFM03A:4	2009-09-18 13:35	2009-10-12 15:10	114	259	2.3	Grey with some black flakes, insect parts. Tones of green (Uranine)
KFM07A:2	2009-09-15 15:30	2009-09-23 10:05	119	220	1.8	Black with flakes looking like fur
KFM08A:2	2009-09-14 13:30	2009-10-01 12:53	111	103	0.9	Dark grey with some litter/flakes
KFM08A:6	2009-09-15 09:15	2009-10-01 12:53	106	245	2.3	Dark grey with some litter/flakes
KFM08D:2	2009-09-15 09:55	2009-10-01 10:51	115	220	1.9	Grey/black with small particles
KFM08D:4	2009-09-15 09:55	2009-10-01 10:51	118	227	1,9	Grey/black with small particles. Tones of green (Uranine)
KFM10A:2	2009-09-18 10:45	2009-10-02 12:26	104	280	2.7	Very black with grey flakes

2.5.4 Extended sampling in series

The extended sampling (sampling series) was performed in 13 borehole sections in seven different boreholes. Each series consisted of five samples distributed with respect to pumped total section volumes (including also the volume of the tube connecting to the section) according to Table 2-6. The first sample was collected when the withdrawn volume corresponded to the volume of the tube connecting the section to the surface.

The equipment (pump, packer, tube and cable) was cleaned with 70% EtOH while lowered into the standpipe, and a new filter was fitted on the pump when the section was changed.

The pumping flow rate was adjusted in order to follow the sampling schedule. In sections with low hydraulic transmissivity, a low flow rate had to be used, and the whole series could not be collected during one day. If the sampling was performed earlier or later than scheduled, subsequent sampling occasions were also moved to maintain the desired difference in pumped volume between the sampling occasions as far as possible.

The collected samples and the exchanged water volumes prior to each sample are presented in Table 2-7. The discrepancy between actual volumes pumped and those prescribed is partly due to the preliminary section volumes used during the planning of the field campaign, partly due to practical reasons (sampling was not performed in the middle of the night). The correct total section volumes were calculated after the sampling and were generally larger than the preliminary ones. The option to continue the pumping and collect additional samples, if the electric conductivity was unstable was never used, since this situation never occurred.

Generally the sampling was carried out successfully. However, there were some pump stops. In most cases it was possible to restart the pump, but at a few occasions, the pump had to be replaced with a new one before pumping could continue. In sections where pump stops occurred, or where the flow rate varied, an average flow rate was calculated from periods when the pump was functioning. When calculating the total pumped volume, the pump stops were considered. The pumping periods in the sections where pump stops occurred are documented in Appendix 3.

2.5.5 Basic sampling (no sample series)

Prior to sampling, the water volume in each section was exchanged at least three times to obtain a representative water sample from the section. The pumped total volumes from each section prior to sampling are given in Table 2-8. The basic sampling generated SKB class 3 samples with δ^2H, ^{3}H, ^{18}O.

When pump stops occurred or where the flow rate varied, an average flow rate, from when the pump was functioning, was used to calculate the exchanged water volumes, and the pump stops were considered.

Table 2-6. Samples, planned pumped volumes prior to sampling and analytical protocol.

Sample number	Pumped volume	Analytical protocol
1	1 tube volume	SKB class 4 with TOC and U
2	1 section volume	SKB class 4 with TOC and U
3	2 section volumes	SKB class 5 (excl. U-, Th-, Ra-, Rn- isotopes)[1)]
4	3 section volumes	SKB class 4 with TOC and U
5	5 section volumes	SKB class 5+

[1)] In KFM02A:2, KFM02A:5 and KFM03A:4 the isotope options were included.

Table 2-7. Samples and pumped volumes prior to sampling.

Borehole [Idcode: section]	Flow rate [L/min]	Sampling 1			Sampling 2			Sampling 3			Sampling 4			Sampling 5		
		Sample number	No of tube volumes pumped	Total volume pumped [L]	Sample number	No of section volumes pumped	Total volume pumped [L]	Sample number	No of section volumes pumped	Total volume pumped [L]	Sample number	No of section volumes pumped	Total volume pumped [L]	Sample number	No of section volumes pumped	Total volume pumped [L]
KFM01A:5	0.80	16505	0.61	2.1	16506	0.80	23.6	16507	1.80	48.8	16508	2.51	66.8	16512	4.11	107.2
KFM01D:2	0.56	16509	0.88	10.9	16510	0.56	19.5	16518	1.33	29.1	16511	2.21	40.2	16519	3.49	56.4
KFM01D:4	0.86	16523	1.06	9.6	16524	0.86	19.4	16525	1.70	29.5	16526	2.46	38.6	16527	4.23	60.0
KFM02A:3	0.73	16568	0.95	13.5	16569	0.73	40.8	16570	1.50	69.0	16571	2.25	96.6	16572	3.79	152.7
KFM02A:5	0.84	16573	0.86	10.2	16574	0.84	41.4	16575	1.71	72.3	16576	2.59	103.2	16577	4.35	165.3
KFM03A:1	0.61*	16578	1.22	33.8	16579	0.61	54.7	16580	0.70	58.0	16581	1.88	98.5	16582	4.98	205.0
KFM03A:4	0.74	16605	0.92	16.8	16606	0.74	33.3	16607	1.55	49.8	16608	2.36	66.3	16609	3.98	99.3
KFM07A:2	1.08*	16561	5.42	149.0	16610	1.08	165.1	16611	1.61	173.0	16611	2.77	190.4	16612	8.66	278.4
KFM08A:2	0.88	16563	1.02	20.1	16564	0.88	32.8	16565	1.98	49.2	16566	2.79	61.3	16567	4.59	88.1
KFM08A:6	0.91	16553	1.08	8.4	16554	0.91	24.0	16555	2.25	48.0	16556	3.13	63.8	16557	4.54	89.0
KFM08D:2	1.38*	16558	1.16	27.3	16559	1.38	48.3	16560	2.27	62.0	–	–	–	16562	4.20	91.3
KFM08D:4	0.72*	16543	0.88	16.6	16544	0.72	34.4	16545	1.63	57.0	16546	3.16	95.2	16547	5.42	151.2
KFM10A:2	0.59	16528	0.87	10.8	16529	0.59	20.5	16530	1.32	30.5	16531	2.05	40.5	16532	4.28	71.0

* Pump stops have occurred during pumping. The average flow rate is given from periods when the pump worked.

Table 2-8. Pumped volumes prior to class 3 sampling.

Borehole [Idcode:section]	Flow rate [mL/min]	Sample number	No of section volumes pumped	Pumped volume [L]
KFM02B:2	0.44	16583	5.2	114
KFM02B:4	0.5	16584	5.7	140
KFM04A:4	0.165	16452	8.3	176
KFM06A:3	0.045	16538	11.1	187
KFM06A:5	0.15	16357	7.8	209
KFM06C:3	0.025*	16552	2.0	71
KFM06C:5	0.138*	16541	3.2	54
KFM11A:2	0.18	16549	8.1	248
KFM11A:4	0.18	16550	17.0	245
KFM12A:3	0.263*	16551	7.8	124
HFM01:2	0.285	16522	10.4	380
HFM02:2	0.24	16521	12.4	310
HFM04:2	0.36	16548	21.0	480
HFM13:1	0.22	16533	8.5	249
HFM15:1	0.22	16534	9.2	272
HFM16:2	0.9	16539	8.7	339
HFM19:1	0.3	16536	9.3	315
HFM21:3	0.21	16540	7.6	217
HFM27:2	0.205	16520	7.3	263
HFM32:3	0.26	16535	3.9	67

* Pump stops occurred during pumping. The average flow rate was used to calculate volumes, and the pump stops were considered.

2.5.6 Water sample treatment and analyses

An overview of general 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.

2.5.7 Nonconformities

- Due to the previously encountered pumping difficulties in KFM07A:2, the sampling equipment and performance in this borehole were slightly modified in October 2009. An extra tube (open to atmosphere) was connected to the small packer, allowing gas to be evacuated instead of accumulating at the pump inlet. The section was first pumped with the mini packer released to test the capacity of the section. The packer was then expanded and the pumping was carried out the normal way. The pumped volume prior to collection of the first sample should include also the capacity test volume. Since the packer was not expanded, a portion of the pumped water originated from the standpipe and not from the section. This is accounted for when calculating the pumped volume.
- Due to several pump failures, the pumping in KFM08D:4 was not continuous. The pump was lifted and replaced twice during the pumping period. Some archive samples were omitted at the third sampling occasion (sample number 16546), since the pumped stopped during the sampling.
- The on-line membrane filter sometimes caused pump stops due to too high back pressure. A syringe with filter was used for all the samples from KFM08D:2 and the last sample from KFM08D:4.
- In KFM08D:2 the flow rate was very low. Therefore the water was collected in a large bottle and then divided into different sample portions. Sample portions for HS^-, ^3H, Fe and trace element analyses were, however, collected directly in the correct bottles according to the routine procedure.

- From KFM08A:2, the fourth sample (class 4) was omitted due to the low flow rate and scheduled sampling in the middle of the night.
- Due to the very low flow rate, only two section volumes of water were exchanged prior to the sampling in section KFM06C:3, instead of at least three according to the activity plan.

2.5.8 Data handling and interpretation

The general routines for quality control and data management applied for hydrogeochemical analysis data, independently of sampling method or sampling object are presented in Appendix 4.

2.6 Results

2.6.1 Basic water analysis

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

The laboratory measurements and field measurements of pH and Eh are compared in Figures 2-10 and 2-11, respectively. The compared pH values deviate more than the measurement uncertainty due to temperature differences and time delay. The bad agreement between several of the compared EC values are probably due to erroneous measurements and some of the most obvious outliers are rejected in the database Sicada. A surprising observation from the groundwater monitoring during previous years has been the increasing pH trend and the elevated pH values observed in KFM07A.

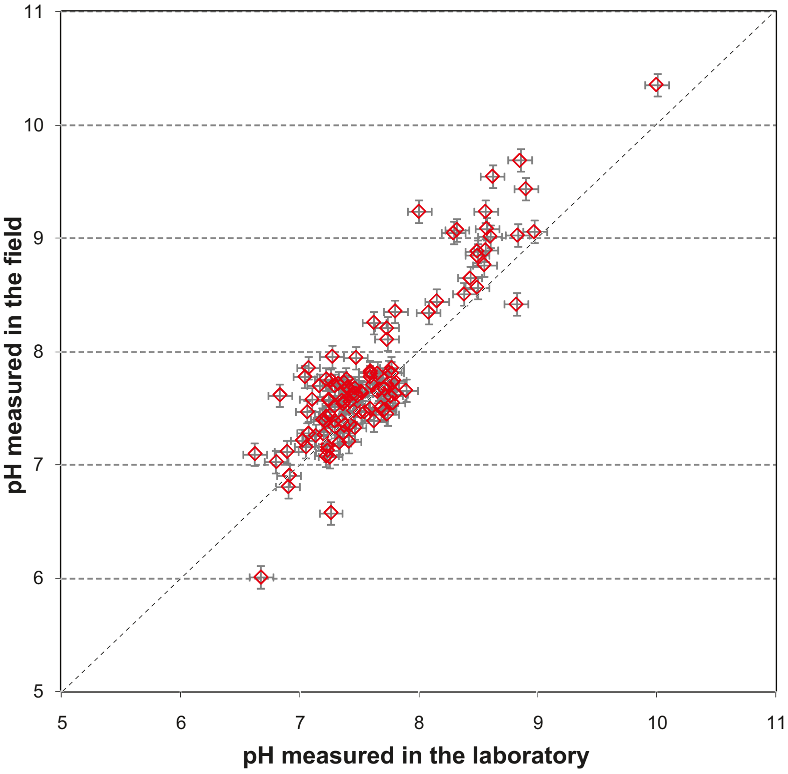


Figure 2-10. *Comparison between laboratory measurements and field measurements of pH. The laboratory measurements are performed at 25 °C, whereas the field measurements are performed at the actual water temperature.*

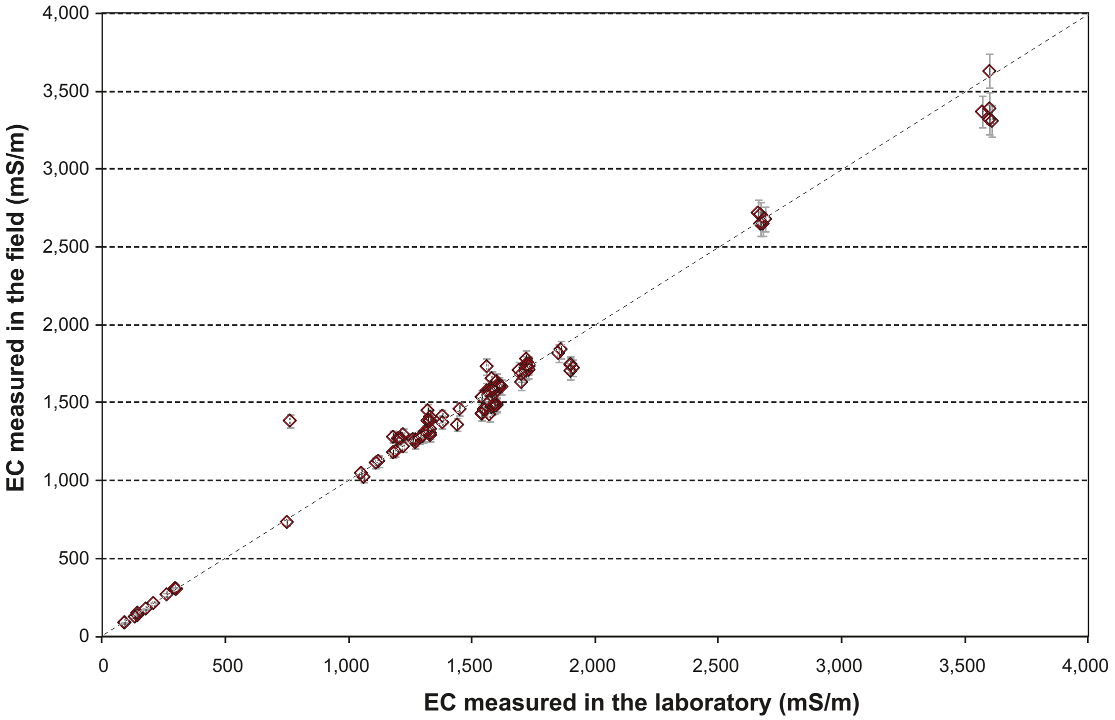


Figure 2-11. *Comparison between laboratory measurements and field measurements of EC.*

The pH in the groundwater from KFM07A remains very high also in the samples collected in the spring 2009 (exceeding pH =10). However, the five samples collected in the autumn show pH values in a more reasonable range (field values in the range 8.9 to 9.3 and laboratory values between 8.3 and 8.6). The reason may possibly be that the extra cleaning efforts in the stand pipe and the exchange of water prior to sampling helped to avoid contamination from an unidentified known concrete source.

For samples collected in core drilled telescopic boreholes, the flushing water content is an important parameter. However, since the dye Uranine, which is used to mark the flushing water during drilling, was used also in other investigations, see Table 2-2, it is not always possible to calculate the amount of flushing water emerging from the drilling of the borehole. Figure 2-12 and Figure 2-13 present Uranine concentrations in collected samples from hydrogeochemical monitoring. The concentrations from the initial chemical characterisations (CCC) /1/ in corresponding borehole sections are given for comparison. In October 2009 collection of sample series was performed in some boreholes. In these cases a mean value from the three latest sampling occasions are calculated and reported in the diagrams. Standard deviations from these occasions are shown as error bars in the diagram. The nominal Uranine concentration in the drilling water was 200 µg/L.

Chloride concentrations are presented in Figure 2-14 and Figure 2-15 (cored boreholes) and Figure 2-16 (percussion boreholes) together with the initial concentrations (CCC) from chemical characterisation (core drilled boreholes) /1/ or sampling during pumping tests (percussion boreholes) /1/. For percussion boreholes the initial concentrations are not quite comparable as the early sampling was performed at open borehole conditions from the entire borehole and not from packed off sections. In October 2009, sample series were collected in some of the boreholes. In these cases a mean value from the three latest sampling occasions are calculated and reported in the diagrams. Standard deviations from these occasions are shown as error bars in the diagram. Generally the chloride concentrations were quite stable, especially in cored boreholes.

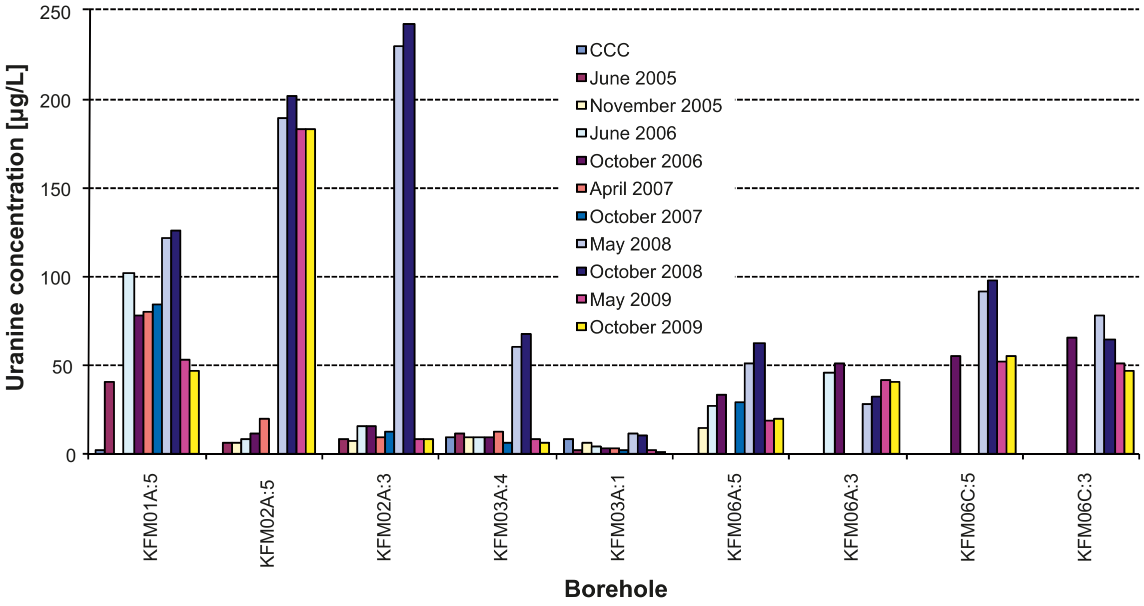


***Figure 2-12.** Uranine concentrations in water samples from core drilled boreholes included in the hydrogeochemical monitoring program.*

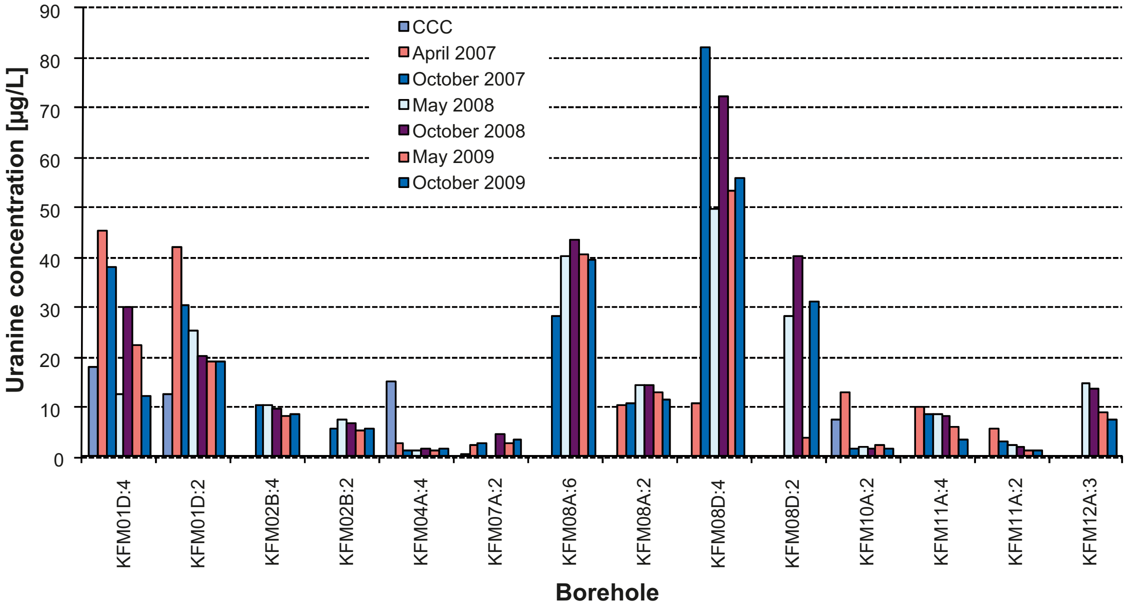


***Figure 2-13.** Uranine concentrations in water samples from core drilled boreholes included in the hydrogeochemical monitoring program.*

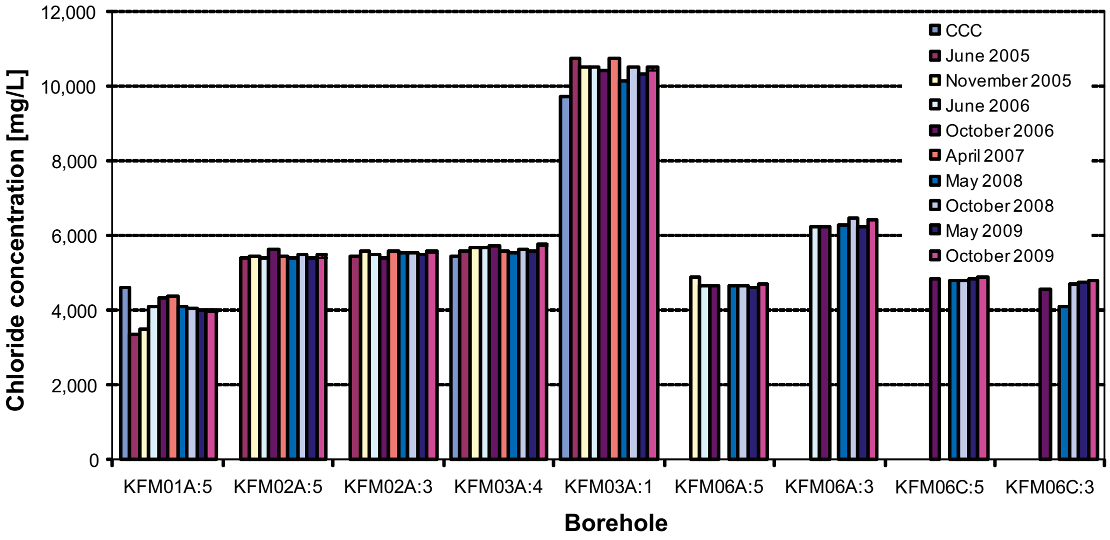


Figure 2-14. *Chloride concentrations in samples collected in core boreholes included in the monitoring program.*

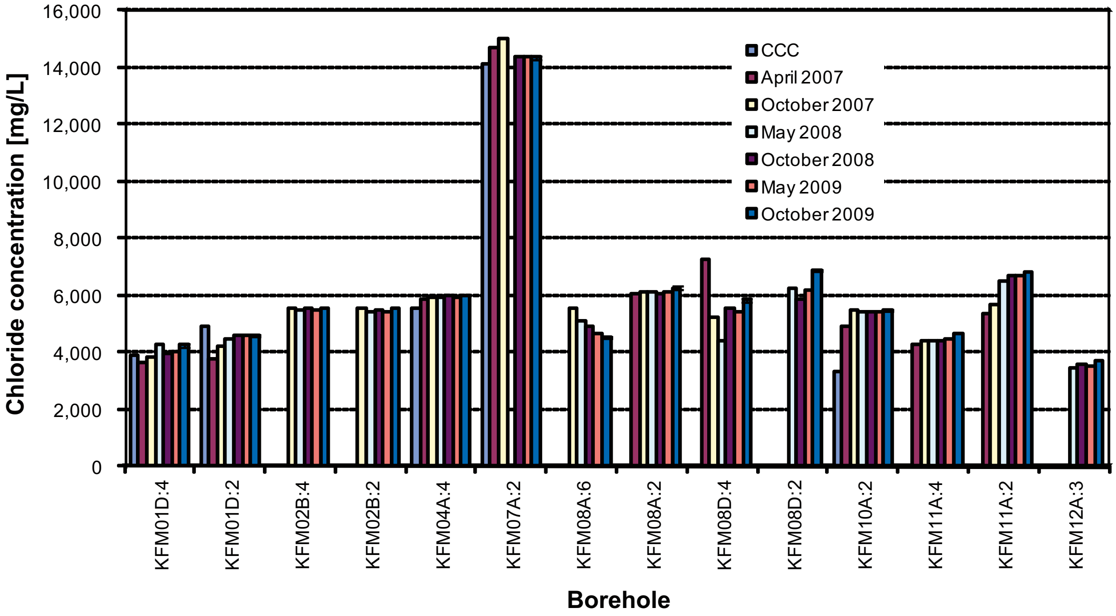


Figure 2-15. *Chloride concentrations in samples collected in core boreholes included in the monitoring program.*

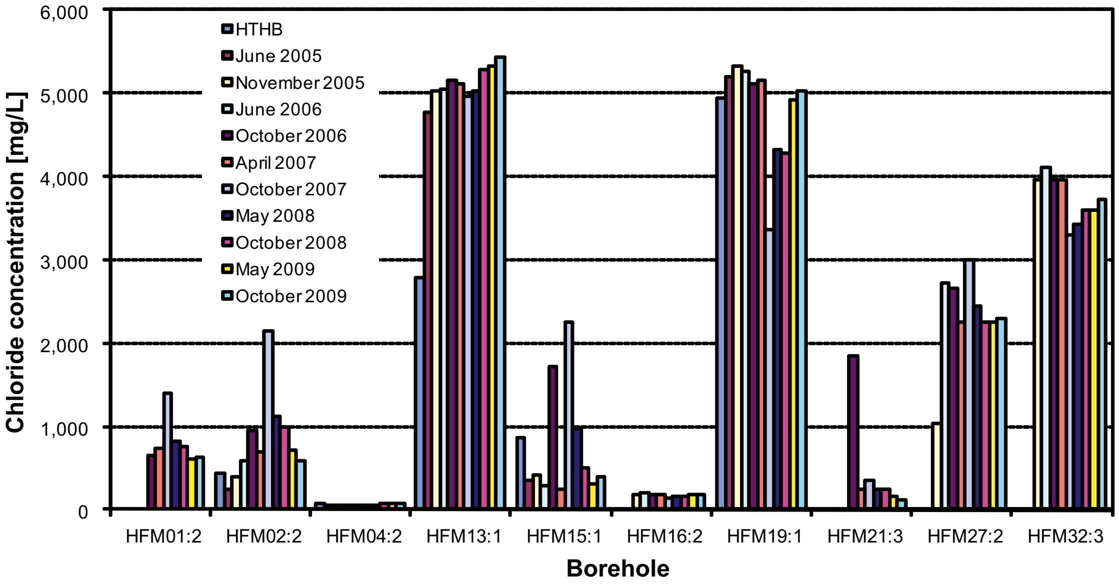


Figure 2-16. *Chloride concentrations in samples collected in percussion boreholes included in the monitoring program.*

2.6.2 Trace elements (rare earth metals and others)

The analyses of trace elements include Al, As, B, Ba, Cd, Cr, Cu, Co, Hg, Ni, Mo, Pb, V, Zn, U, Th, Sc, Rb, Y, Zr, In, Sb, Cs, La, Hf, Tl, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb as well as Lu and are compiled in Appendix 5. Due to low natural concentrations and frequent use in different equipments, the risk of contamination is high for common metals like Cr, Cu, Co, Ni, Mo, Zn and Al. The use of caesium or caesium together with rubidium in SWIW-tests might also have contaminated some of the samples.

2.6.3 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, ^{235}U, ^{234}U, ^{230}Th, ^{232}Th ^{226}Ra and ^{222}Rn. All samples were analysed for δ^2H, $\delta^{18}O$ and ^3H. All other isotopes were determined once in the core bored sections (SKB class 5 sampling). Available isotope data are compiled in Appendix 5.

2.6.4 The sulphide issue

Generally the sulphide concentrations have increased between the initial chemical investigations and the subsequent groundwater monitoring in the corresponding borehole sections. Table 2-9 compiles sulphide concentrations in samples collected during the monitoring programme since the start in 2005 /1/ as well as from initial hydrogeochemical investigations (CCC) in corresponding borehole sections. The sulphide concentration trends within each sample series from October 2009 are plotted in Appendix 6. An observation from the trend plots is that the sulphide concentration immediately increases after pump failures/stops. One hypothesis is that the high sulphide contents originate from the volume of water (initial section water) that is present in the borehole section before the start of pumping. In that case the decrease in sulphide concentration during pumping should coincide with an increasing amount of formation water (originating directly from water bearing fractures in the surrounding rock). To test this hypothesis the sulphide concentrations in each sample in nine sample series were compared to the estimated ratio between initial section water and formation water from the fractured rock. The comparison and the conclusions drawn are described below.

Exchange of water in the test sections related to sulphide concentration during water sampling

Sample series from borehole sections without interruption in the pumping was selected for the comparison of sulphide concentrations and ratios between initial section water and formation water. The reason is that the sulphide concentration increases after a break in the pumping before a new reduction takes place, giving a more complex situation. An explanation could be that a pump stop will cause a remixing with initial section water captured in non-active parts of the borehole section.

Before the discharged water from a borehole section entirely consists of formation water from the fractured rock, the initial section water between the water bearing fractures and the outlet from the section has to be replaced. In what way and how long time this will take depends to a high degree on the distribution of water bearing fractures along the borehole and on the hydraulic transmissivity of the fractures.

Two different situations are illustrated in Figure 2-17. A single water bearing fracture (**A** and **B**) with high hydraulic transmissivity, located in the upper/nearest part of the borehole section close to the outlet from the section is favourable, since the water volume in the part of the borehole section beneath the fracture will stay trapped, regardless of the removal of water from the section (i.e. it is a dead volume). If, on the other hand, there are several fractures in the section (**C** and **D**), borehole water between the fractures will contribute to the sample until formation water from the last fracture reaches the outlet. In this case there is a good possibility that some residual water will remain in the borehole section when sampling commences.

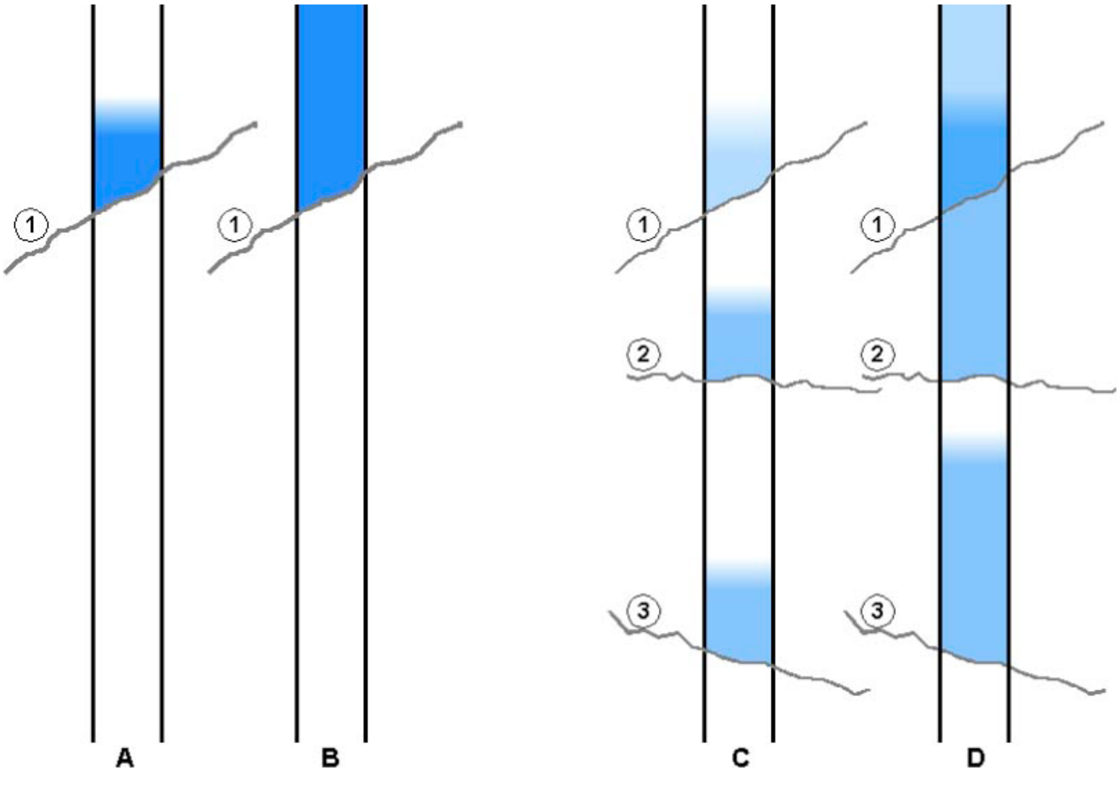


Figure 2-17. *Estimation of initial section water contribution to the samples. The colour strength illustrates the amount of new formation water in a borehole section during pumping. A and B show a situation with one water yielding fracture. Shortly after pump start (A) the water from the only fracture has not reached the outlet from the section. After a certain time (B), all the water leaving the section is formation water. C and D show a situation with three fractures yielding similar contribution to the total flow. Shortly after pump start (C), no formation water has reached the outlet from the section. After a certain time (D), corresponding to the previous situation B, formation water from fracture 1) has reached the outlet, formation water from fracture 2) has passed fracture 1). Formation water from fracture 3) has not yet reached fracture 2).*

Table 2-9. Sulphide concentrations [mg/l] in sample series from the monitoring programme with start in 2005. Available concentrations from previous hydrogeochemical investigations, CCC, /1/ are given for comparison.

Borehole	CCC	June-05	Oct-05	June-05	Oct-06	Apr-07	Oct-07	Jan-08*			May-08	Oct-08	May-09	Oct-09**				
[Idcode: section]								series 1	series 2	series 3				series 1	series 2	series 3	series 4	series 5
KFM01A:5	0.014				0.922						0.328	0.428	0.356	3.11	0.667	0.474	0.405	0.313
KFM01D:4	0.009					0.287							0.279	2.45	1.04	0.228	0.163	0.136
KFM01D:2	0.006					3.29		13.4	1.7	2.38	3.7	5.39	2.8	5.98	3.3	2.97	3.2	3.85
KFM02A:5	<0.002		0.058		0.129						0.315	0.956	0.533	0.462	1.13	0.831	0.576	0.323
KFM02A:3	0.009		0.066	0.065	0.167		0.219				0.118	0.22	0.159	0.682	0.351	0.146	0.126	0.115
KFM02B:4													0.062					
KFM02B:2													0.042					
KFM03A:4	<0.002	0.133	0.701		0.538		0.219					0.147		0.865	0.766	0.205	0.173	0.158
KFM03A:1	0.033		0.838		0.587		0.245					1.15		2.06	1	0.675	0.222	0.109
KFM06A:5	<0.002		0.614		0.108							0.298						
KFM06A:3												2.41						
KFM07A:2	0.134					0.116	0.011					0.963		0.044	0.024	0.034	0.037	0.029
KFM08A:6												0.088		3.84	1.26	0.272	0.179	0.138
KFM08A:2	0.012							0.19	X	0.025		0.031		0.058	0.044	0.027	0.026	0.024
KFM08D:4	<0.006							3.33				0.031		0.94	0.482	0.408	0.34	0.625
KFM08D:2												0.97		0.548	0.462	0.391	0.459	
KFM10A:2												0.073		0.032	0.042	0.047	0.055	0.066
KFM11A:4	0.012						0.172					0.393						
KFM11A:2	0.04						0.145					0.307						

* Sample series, three samples: 1) after exchange of one tube volume (tube from borehole section to standpipe), 2) after exchange of one section volume and 3) after exchange of at least three section volumes of water.

** Sample series, five samples: 1) after exchange of one tube volume (tube from borehole section to standpipe), 2) after exchange of one section volume, 3) after exchange of two section volumes, 4) after exchange of three section volumes, and 5) after exchange of five section volumes of water.

In Figure 2-18 the accumulated contribution to the total flow from different flow anomalies (fractures) in the two circulation sections in borehole KFM02A is illustrated. The anomalies are numbered from the top of section and downwards. The height of the bars represents the accumulated part of the totally discharged flow from a certain anomaly and all the earlier above. The numbers above the bars give the estimated times in hours after pump start (travel times) until water from a certain anomaly contributes to the water reaching the outlet in the uppermost part of the borehole section.

For example, anomalies 1–4 in section KFM02:5 contribute with c. 43% of the total flow when the flow from anomaly 4 has reached the outlet after c. 1.14 hours. At this time the rest of the flow at the outlet consists of initial section water originally located between anomaly 4 and 5 until water from anomaly 5 starts to contribute to the water at the outlet after c. 1.22 h.

The travel times are calculated assuming that the flow in the borehole is a plug flow. In reality, depending on flow velocities, roughness of surfaces and geometric conditions in the borehole section, the flow velocity has a certain distribution across the borehole. In this case where the borehole is filled with dummy and tubes, it is reasonable to assume that it will take at least 1.5–2 times (based on experience) the calculated travel times before most of the water from a certain anomaly reaches the outlet. However, a minor part of the flow will be faster than the calculated plug flow and reach the outlet before the estimated travel times shown in the diagram.

In the calculations of the travel times, the distribution of flow rates from different flow anomalies is assumed to be the same as during the differential flow logging with the PFL (Posiva Flow Logging) method.

Figure 2-19 shows the sulphide concentration in samples collected during the pumping in section 3 in borehole KFM02A. To facilitate the comparison between Figures 2-18 and 2-19 the elapsed time (after pump start) in Figure 2-19 is reduced with the time for the water to pass the tube connecting the section to the ground surface. The first sample in Figure 2-19 is collected before any water from the uppermost anomaly (1) has reached the top of section, which means that the water in this sample to 100% should consist of initial section water. The dominating anomaly (6) should begin to influence the pumped water after c. 1½ hours and give almost full contribution to the total flow after c. 2.5–3 hours (se discussion above). This coincides in time with a pronounced reduction in sulphide concentration. When the two last samples are collected, almost 100% of the discharged water should consist of formation water from fractures according to the calculations shown in Figure 2-18, assuming that the calculated travel times should be multiplied by a factor of 1.5–2 before the major part of the water from an anomaly contributes to the discharge water at the outlet.

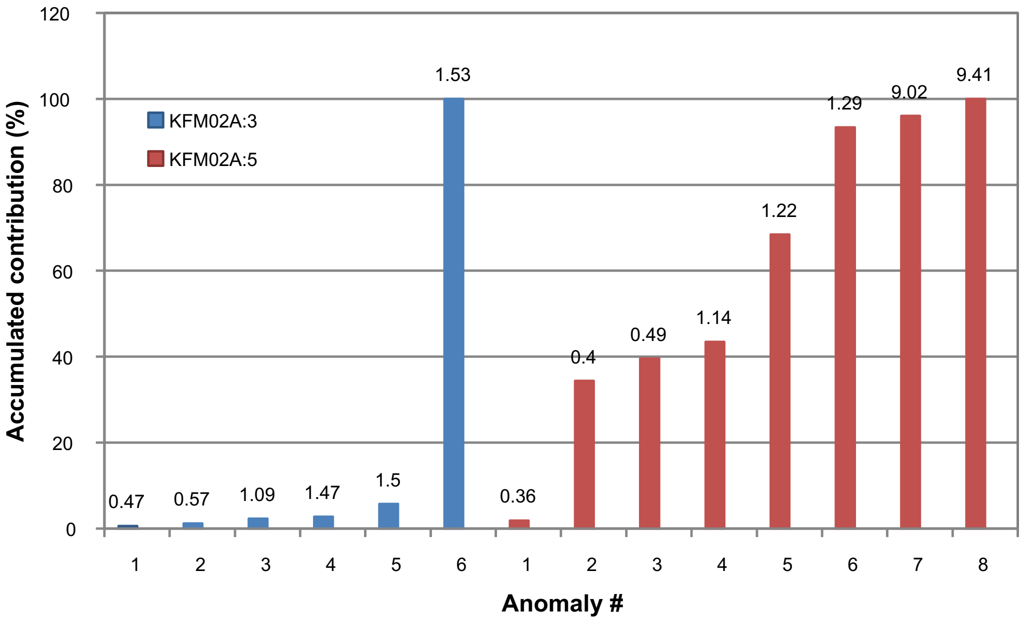


Figure 2-18. *Accumulated contribution (in % of total flow) from flow anomalies, numbered from the uppermost anomaly and downwards. The numbers above the bars indicate calculated travel time (in hours) from anomalies to top of section.*

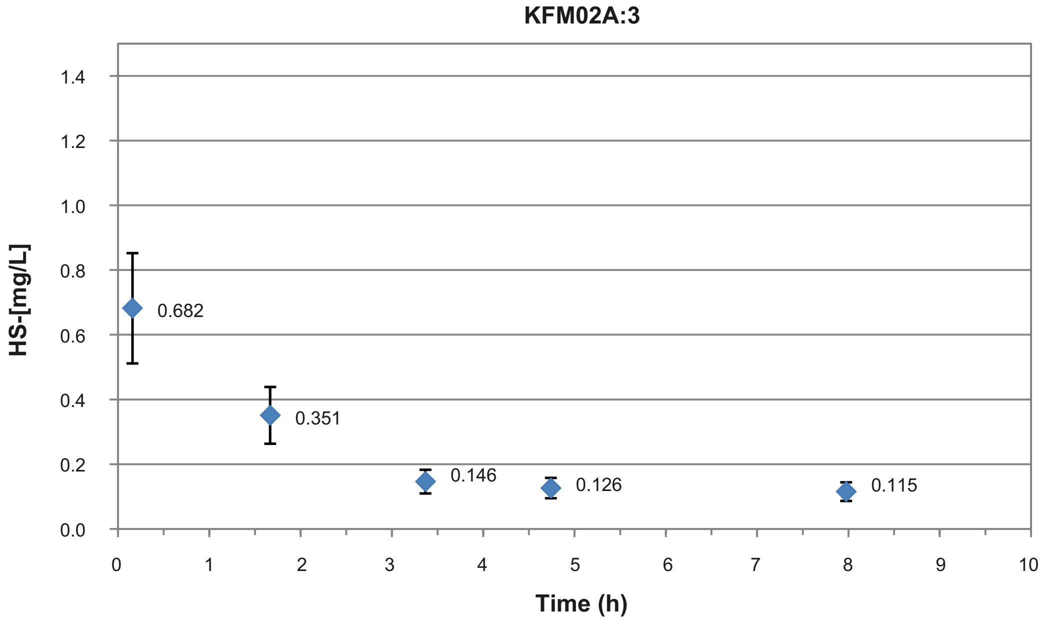


Figure 2-19. *Sulphide concentration in samples taken in borehole section KFM02A:3. Time after pump start is reduced for the travel time from top of section to ground surface.*

The position of a data point in Figures 2-19 and 2-20 represents the mid-time since water sampling takes about 15–20 minutes for each sample. Therefore, when the first sample from section 5 in KFM02A is collected (Figure 2-20), a certain amount of the water originates from the tube between the section and ground surface. This could explain the relatively low concentration in the first sample.

According to Figure 2-18, water from anomaly 2 should begin to influence the discharged water after c. 0.4 h, and after c. 2.6 h (2×1.29 h) more than 90% of the water should consist of formation water from anomalies 1–6. The sulphide concentration continues to decrease even after this time, and since the water from anomaly 7 never reaches the surface during the sampling, the final sample will have an amount of c. 7% originating from the water present in the section before start of pumping.

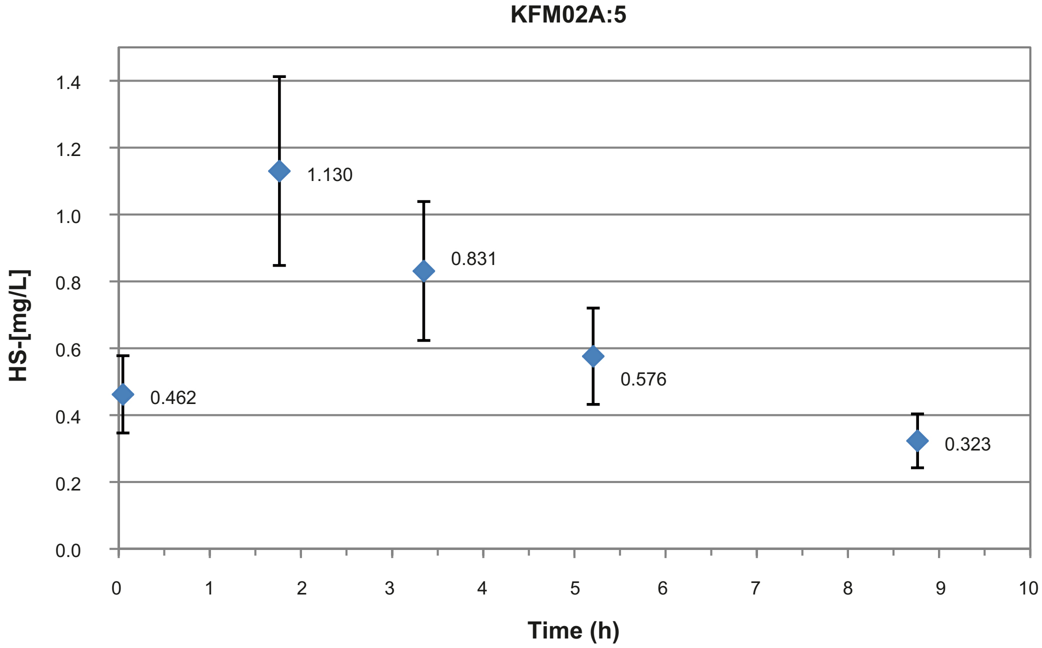


Figure 2-20. *Sulphide concentration in samples taken in borehole section KFM02A:5. Time after pump start is reduced for the travel time from top of section to ground surface.*

The corresponding diagrams for the remaining 7 sections included in the study are given in Appendix 7. For these sections the following results were obtained:

KFM01A:5. The first sample in KFM01A should consist of close to pure initial section water while sample 2 should mainly consist of formation water since both anomaly 2 and 3 will contribute to the sampled water. This coincides well with a pronounced reduction in sulphide concentration between samples 1 and 2. When the final sample is collected anomaly 5 does not contribute to the discharged water to 100%, meaning that a small amount (maybe one or a few percent) still consists of initial section water.

KFM01D:2. According to the calculations an increasing part of the flow from a single fracture should have reached the outlet from the section after c. 0.3–0.7 hours from pump start. A reduction in sulphide concentration occurs between the first sample which is collected after c. 16 minutes and the second sample after c. 88 min, which means a good agreement with calculated travel times.

KFM01D:4. Also this section has one dominating flow anomaly according to the PFL logging. The result with an early decrease in sulphide concentration after the first sample, which is taken before the water from the anomaly should have reached the outlet at the top of the section, is well in accordance with the calculated travel time from the anomaly (c. 0.5–1 h).

KFM03A:4. The most pronounced decrease in sulphide concentration occurs somewhere between 1.5–2.5 h, which is somewhat later than expected from the calculations, 0.8–1.6 h.

KFM08A:2. The sulphide concentration is very low already in the first sample and decreases somewhat during the pumping. This coincides quite well with the calculations of travel time, since a single anomaly will give contribution to the discharged water before the first sample is collected.

KFM08A:6. The dominating part of the flow (c. 99%) from existing fractures should have reached the outlet from the section after c. 0.7–1.4 h, which is in god accordance with observed decrease in sulphide concentration.

KFM10A:2. In section 2 in borehole KFM10A a major part of a dominating flow anomaly will contribute to the discharged water already when the first sample is taken. The sulphide concentration in this section is low compared to many other borehole sections involved in the campaign. The small increase over time could be a result of changing flow distribution between the two fractures, resulting in an increasing admixture of initial section waters from below. Water from anomaly 2 does not reach the outlet before the last sample is taken.

Taken into account all possible uncertainties in the calculations (se the separate section below), the result of the comparison between changes in sulphide concentration during water sampling and calculated admixture of formation water support the hypothesis that high sulphide concentrations originate from the initial section water which is present in the sections before the pumping starts. An increasing amount of formation water from the surrounding rock results in a decreasing sulphide concentration.

The results from section 2 in KFM01D diverge from the others by having considerably higher sulphide concentrations. A possible explanation could be a possible contribution of water via a short flow path from a neighbouring section. During the pumping in section 2, a pressure response is seen in section 3, which means that such a contribution is most probable.

Also the concentration in the final samples from each section supports the hypothesis (Table 2-10). The highest values are found, section KFM01D:2 disregarded, in those sections (KFM01A:5 and KFM02A:5) where there is still a contribution of water from the initial section volume. In KFM10A:2 the sulphide concentration in the final sample is low although c. 4% of the flow consists of initial section water. This may be due to low initial concentration in the section water.

Table 2-10. Final sulphide concentrations, calculated remaining initial section water and calculated total interchange time at the given flow rates.

Borehole: section	Calculated remaining initial section water	Final sulphide concentration (mg/L)	Flow rate during sampling (L/min)	Elapsed pumping time when final sample is collected (hours)	Calculated interchange time (hours)
KFM01A:5	≈ 2%	0.313	0.257	7.00	11.7
KFM01D:2	≈ 0%	3.820*	0.205	4.15	0.7
KFM01D:4	≈ 0%	0.136	0.240	3.96	0.9
KFM02A:3	≈ 0%	0.115	0.300	7.98	3.1
KFM02A:5	≈ 7%	0.323	0.300	3.35	18.8
KFM03A:4	≈ 0%	0.158	0.300	5.35	1.6
KFM08A:2	≈ 0%	0.024	0.205	6.50	1.4
KFM08A:6	≈ 1%	0.138	0.240	6.07	34.8 (1.5**)
KFM10A:2	≈ 4%	0.066	0.285	3.76	13.3

* Possible influence by leakage of initial section water from section 3.

** Interchange time if two small anomalies adding c. 1% to the total flow is excluded.

Uncertainties in the calculations

There are a number of uncertainties involved in the calculations and assumptions made:

1. The assumption of plug flow could be fulfilled to a higher or lower degree. If the flow is turbulent, it is more similar to a plug flow, with an even flow velocity distribution over the cross section, than if the flow is laminar. With a laminar flow, the velocities over the cross section have a certain parabolic shape with considerably higher velocities in the centre of the cross section compared to the mean velocity (plug flow velocity). One could expect that a certain amount of water from a flow anomaly could reach the top of section before the calculated plug flow time, and that an increasing amount of formation water from that anomaly reaches the top of section over time.

   The flow velocity distribution depends on geometric conditions, roughness of surfaces and flow velocities. Therefore, the time until full contribution of formation water from a certain anomaly is reached, corresponding to its hydraulic transmissivity, varies from fracture to fracture. The number 1.5–2 times the plug flow time, assumed above, before most of the formation water from a certain anomaly has reached the outlet should be considered as a rough value based on experience.

2. The flow distribution between anomalies may vary depending on the pumped flow rate and drawdown. It may also change over time during pumping. During pumping for the PFL logging a normal drawdown was c. 10 m. This is the same magnitude as during pumping for the water sampling in many borehole sections, but in some sections the drawdown could be considerably lower. Though, the flow distribution from the PFL should be fairly good in most cases.

3. Analytical uncertainties for sulphide and uncertainties in the measured pump flow rate are probably less significant compared to the uncertainties in point 1 and 2.

2.6.5 The uranium issue

During the site investigations 2002 to 2007 elevated uranium concentrations were encountered in some of the investigated boreholes/borehole sections /1/. These uranium concentrations continue to be very high also later on in the monitoring programme, and the samples from 2009 are no exception. In section KFM02A:3 (the most extreme) the concentration amounts to between 147 and 175 µg/L in the sample series collected in October. The uranium concentration trends in the sample series are presented in diagrams in Appendix 6. As shown, no overarching uranium trend can be observed. The concentration decreases somewhat in KFM01A:5 and KFM03A:1, and increases in KFM03A:4 and KFM08A:2. The other boreholes show changes or scattered values over time.

2.7 Summary and discussions

Groundwaters from a total of 33 borehole sections in 24 boreholes have been sampled at two occasions during 2009. Special efforts were made in the autumn of 2009 in 13 out of the 33 borehole sections included in the monitoring programme in order to avoid identified contamination risks and check the stability of the groundwater composition (especially the sulphide and uranium concentrations).

The measures taken were:

- Additional cleaning and complete exchange of water in the stand pipes in contact with the groundwater samples, followed by the minimum removal of three section volumes of water in the borehole sections. This was to ensure that after the cleaning and pumping procedure, each stand pipe contained groundwater only from its connected borehole section and not a mixture representing the entire borehole.
- The borehole sections were allowed to settle for one to two weeks prior to sampling.
- Sample time-series including five samples from each borehole section were collected during continuous pumping when 1) one tube volume, 2) one section volume, 3) two section volumes, 4) three section volumes, and finally 5) five section volumes were removed from the borehole sections.
- Estimations of the contribution from the initial section water to each sample in the time-series were conducted using simple plug flow calculations.

The most important findings are summarised below.

- Sample series (five samples) collected during continuous pumping show clearly decreasing sulphide concentration trends in most borehole sections. However, in most of the sampled borehole sections, the concentrations did not reach stable values during the pumping/sampling period. Furthermore, pump stops that occurred in some of the boreholes caused retrogression of the sulphide concentrations and jumps in the trend lines. The hypothesis that the high sulphide contents originate from the volume of water (initial section water) that is present in the borehole section before the start of pumping was supported by estimations of the contribution of remaining initial water to each sample by plug flow calculations. The plug flow calculations also indicated that the groundwater volumes removed from the borehole sections prior to sampling were insufficient in most cases. Plug flow calculations will be a powerful tool in order to estimate the groundwater volumes that should be removed before sampling of groundwater in boreholes in the bedrock. The previous routine procedure implying pumping and removal of three to five section volumes of water before sampling is unsuitable, because the bedrock does not behave as a porous medium.
- The sample series do not show any clear uranium concentration trend with pumped volume and the uranium concentration in KFM02A continued to be very high.
- pH in the groundwater from KFM07A and KFM08D continues to be very high also in the samples collected in the spring 2009 (exceeding pH =10). However, the samples collected in the autumn show pH values in a more reasonable range (field values in the range 8.9 to 9.6 and laboratory values between 8.0 and 8.9). The reason may possibly be that the extra cleaning efforts in the stand pipe and the exchange of water prior to sampling helped to avoid contamination from an introduced cement source. High pH in groundwater samples is most often explained by contact with injected cement. However, no likely contamination source of this kind is known in these relatively deep borehole sections. Cement was, however, used in the upper part in both boreholes.
- Hydraulic contact was observed between two or more borehole sections in several boreholes during pumping (KFM01D, KFM03A, KFM06A, KFM07A, KFM08A, KFM08D and KFM11A), see Appendix 2. The observed responses may be due to short circuiting of groundwater through fracture systems connecting two or more borehole sections or caused by leaking connections in the equipment between sections.

3 Near surface groundwaters

3.1 Objectives and scope

Near surface groundwaters were investigated in order to increase the understanding of processes that occur at the interface between the geosphere and the near surface ecosystem. Furthermore, sampling and analyses of groundwaters from shallow monitoring wells may be used to identify discharge areas. Wells located close to drill sites were monitored in order to identify eventual changes in the water composition due to drilling activities.

An extensive, two-years-long sampling campaign designed to characterise near surface groundwaters in different types of environments within the candidate area /1/ was in July 2005 followed by a reduced monitoring programme. The site investigation of the candidate area was concluded in June 2007, but the monitoring programme continues /3/ in order to monitor the water composition and obtain long time-series of data. During the reported period, January–December 2009, sampling was performed at four occasions, in January, April, August and October. Five monitoring wells (stand pipes) and one pipe equipped with a BAT-type filter tip were sampled, all in the prioritised north-western part of the candidate area. Furthermore, sampling was also conducted in three private wells to check the drinking water quality (one sampling occasion).

The private wells are sampled mainly in order to obtain initial information on the drinking water quality and to monitor possible changes in the water composition during the site investigation period. The private well data are of limited use for the chemical modelling as they are more or less affected by human activities. However, some additive information on the salinity distribution in the candidate area may be gained.

The monitoring activity includes water sampling for chemical analysis as well as direct measurements in the field of parameters such as ORP (redox potential), pH, dissolved oxygen, electrical conductivity and water temperature. The analytical protocol includes major constituents, nutrient salts, silica, carbon species as well as isotopes and trace metals, see Tables 3-1 and 3-2.

3.2 Sampling objects

The monitoring programme for near surface groundwater includes five stand pipes and one BAT-type pipe. The wells/pipes are of the following types:

1. Single stand pipes made of HDPE located close to drill sites.
2. Double and single stand pipes made of HDPE. Double pipes means that one of the pipes is equipped with a permanently installed sensor for logging the groundwater pressure and the other pipe is intended for hydrogeochemical sampling.
3. Stand pipes installed in the sediment below the water layer in Lake Bolundsfjärden (Figure 1-1). These pipes are made of ordinary, non-stainless iron. Stand pipes located in till below fen are of the same type.
4. Pipes equipped with BAT-type filter tips as described in Section 3.3.3.

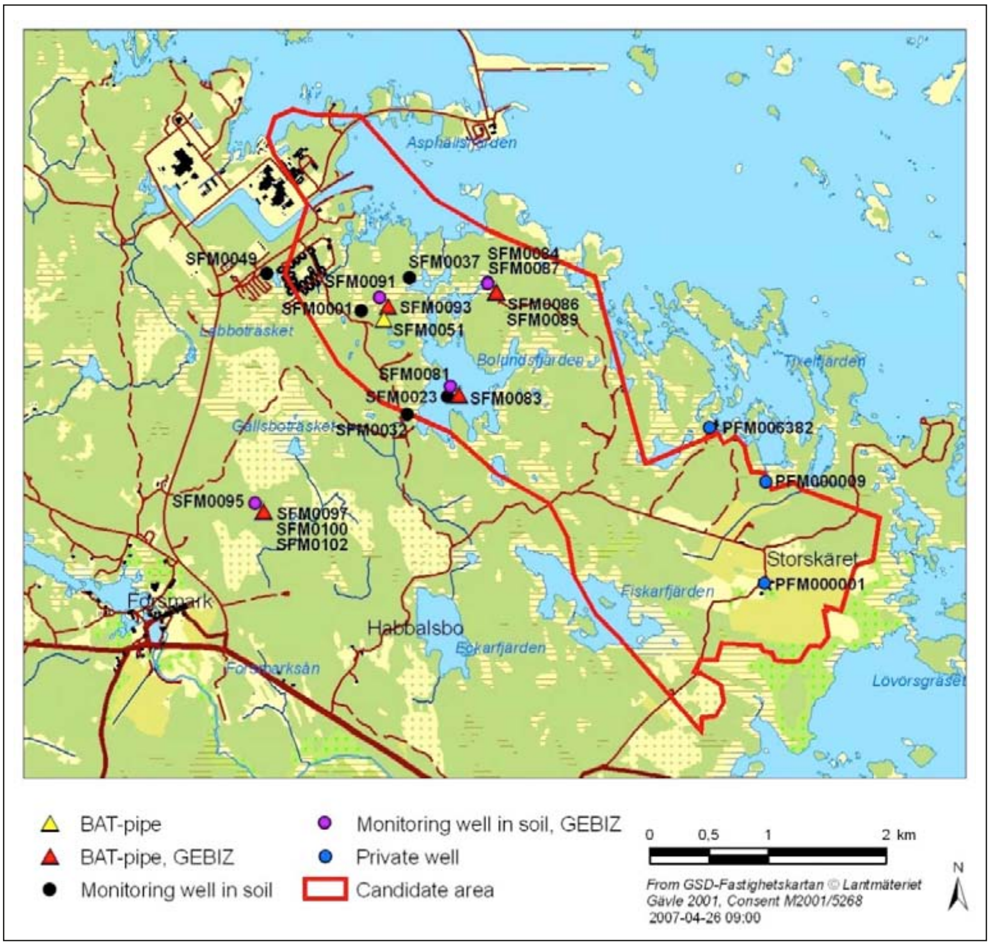
For pipe types 1) to 3), the positions of the filter/screen part, and for type 4) the position of the BAT-type filter tip, correspond to the upper and lower section limits (Secup and Seclow) in the Sicada database. The section limits refer to the top of the stand pipe (Top Of Casing or TOC).

The sampled monitoring wells and their stand pipe types are listed in Table 3-1. The locations of the different sampling objects, including the three regularly sampled private wells, are displayed in Figure 3-1.

Table 3-1. List of sampling objects, type of sampling, type of object and to which sampling programme each object belongs.

Idcode	Comments on sampled object	Type[a]	Programme
SFM0001	Stand pipe connected to drill site	A	Monitoring
SFM0023	Stand pipe in sediment below water surface (steel pipe)	C	Monitoring
SFM0032	Double-pipe for chemistry	B	Monitoring
SFM0037	Double-pipe for chemistry	B	Monitoring
SFM0049	Double-pipe for chemistry	B	Monitoring
SFM0051	BAT-system, drill site 1	D	Monitoring
PFM000001	Drinking water well		
PFM000009	Drinking water well		
PFM006382	Drinking water well		

[a] Code used to distinguish between different types of soil monitoring wells/stand pipes included in the monitoring programme.



From GSD-Fastighetskartan © Lantmäteriet Gävle 2001, Consent M2001/5268 2007-04-26 09:00

Figure 3-1. Location of sampling objects in the monitoring programme for near surface groundwaters, including different types of soil monitoring wells and private wells. GBIZ (Geosphere Biosphere Interface Zone) is a special project and no sampling was conducted in these wells during year 2009.

3.3 Equipment

3.3.1 Sampling equipment

Groundwater samples from the shallow soil monitoring stand pipes were collected using four online pumping setups, each one consisting of a submersible electrical pump (12V, Awimex) connected to a 10–20 m long polyamide-tube (Tecalan) of 8/6 mm outer/inner diameter. The inner metal part of the pumps was coated with Teflon. Manually operated electrical regulators (powered by 12 V, 7 Ah cells) were used to adjust the water flow to a maximum of 1 litre/minute. Disposable filters (Millipore, 0.45 µm, ∅ = 22 mm) were fitted directly to the tube from the pump when collecting the sample portions for trace metals and ferrous iron. Separate sampling set-ups were used for the stand pipe made from ordinary iron, i.e. for pipe SFM0023, in order to minimize the risk to contaminate other samples.

3.3.2 Multi parameter sondes

Field measurements were performed with a multi parameter sonde (YSI 600 QS). A terminal (YSI 650 MDS) is connected to the sonde through a cable for logging data, Figure 3-2. Calibration of the sonde was conducted according to the measurement system description SKB MD 910.003, see Table 1-1. The measured parameters in near surface groundwaters included pH, water temperature, oxygen, ORP (redox potential) as well as electrical conductivity. Measurements were conducted in a simple flow-through cell constructed from a plastic bottle. The upper part of the bottle fitted tightly to the sonde and had a narrow outlet for the circulating water.

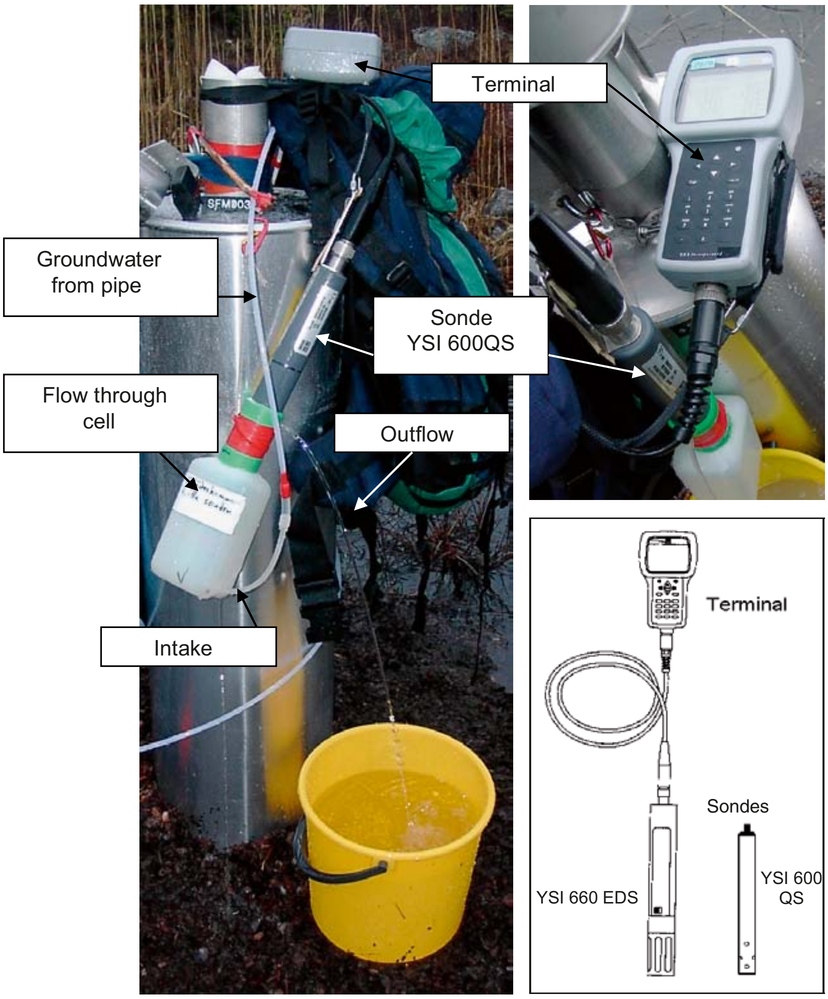


***Figure 3-2.** The measurement sonde YSI 600 QS and its terminal in field use. The schematic presentation shows the sonde used for groundwater (YSI600QS) and the sonde used for surface water monitoring (YSI660EDS).*

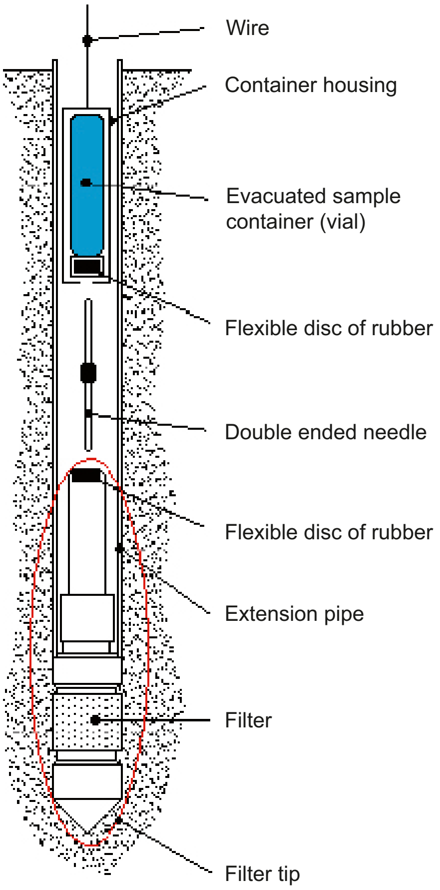


Figure 3-3. *Outline of BAT-sampler system and the BAT-type filter tip.*

3.3.3 BAT-equipment

Water sampling in the stand pipes equipped with BAT-type filter tips was performed with a GeoN BAT-type groundwater sampler. The sampler carries an evacuated and hermetically closed glass sample container (500 mL) and a vial. The vial is fitted with a cap with a rubber disc, similar to the disc in the filter tip. The needle of the sampler, which is "double-ended", penetrates through the two rubber discs, thus connecting the filter tip to the vial cap, see Figure 3-3. Due to the vacuum in the vial, water will be sucked from the aquifer, through the filter and the needle, into the vial.

3.4 Performance

3.4.1 Sampling programme

Sampling scheme

The sampling scheme for the sampling programme is given in Table 3-2. The bottles were filled and the analyses performed according to the different SKB chemical classes (class 3 and class 5, respectively) as summarised in Table 3-3.

Presampling preparations

Prior to the sampling campaign, sample bottles were cleaned, labelled and packed in insulated boxes/bags according to established routines (SKB MD 452.001, see Table 1-1). Acid additions were made in advance to the bottles intended for trace metal analyses. Bottles with acid added were put in a separate plastic bag and kept away from the other sample containers in order to avoid contamination. The different pumping setups were washed and rinsed with deionised water before use and all parts of equipment were kept well protected in plastic bags or in tight containers. The disposable filters (Millipore, 0.45µm, Ø=22 mm) were rinsed with sample water before sampling. Calibration of the sonde was performed according to the measurement system description SKB MD 910.003.

Table 3-2. Sampling scheme January–December 2009.

Year	Month	Week	Sampling object*	Sampling and analysis class & options
2009	January	3	Shallow monitoring wells, A, B, C	SKB class 5
			BAT-pipes, D	SKB class 5
2009	April	16	Shallow monitoring wells, A, B, C	SKB class 3 & isotopes
			BAT-pipe, D	SKB class 5
2009	August	33	Shallow monitoring wells, A, B	SKB class 5
			Shallow monitoring wells, C	SKB class 3 & isotopes
			BAT-pipe, D	SKB class 5
2009	October	41	Shallow monitoring wells, A, B, C	SKB class 3 & isotopes
			Private wells	Drinking water
			BAT-pipe, D	SKB class 5

* The sampling object types A, B, C and D are defined in Table 3-1.

Table 3-3. Sample portions/bottles and preparation procedures for class 3 and class 5 /3/.

Class 3 and 5:	🟦
Class 5:	🟪

Bottle volume (mL)	Number of bottles	SKB Label	Components	Preparation	Filling instructions
100	1	Green, Br/I	Br, I*		Fill up
100	1	Green, D/O	Deuterium ^{2}H, ^{18}O	–	Fill up
250	2	Green, Anj. /Green	Anions (Br, SO_4, Cl, F), Alkalinity, pH, Electric conductivity	–	Fill up
500	1	Green, ^{3}H	Tritium, ^{3}H	–	Fill up from bottom, Flow over × 3
100	1	Green, N/P	Tot-N, Tot-P	–	Fill 80% of the volume
25	1	Green, T	TOC	–	Fill 80% of the volume
250	2	Green, arkiv	*For the archives*	–	Fill 80% of the volume
25	4	Green	Ammonia, NOx, Silicate	Filtering with syringe/0.45 µm filter	
25	2	Green, D	DOC, DIC	Filtering with syringe/0.45 µm filter	Fill 80% of the volume
125	1	Red	Major constituents; cations[1a] and S, Si. Environmental metals[1b], trace metals[1c], B10/B11*	Acid addition (1 mL conc. HNO_3) Filtering with syringe/0.45 µm	Fill up
100	2	Red, arkiv	*For the archives*	Acid addition (1 mL conc. HNO_3) Filtering with syringe/0.45 µm	Fill 80% of the volume
250	1	Red	Fe(II)/Fetot	Acid addition (2.5 mL conc. HCl) Filtering with 0.45 µm filter	Fill up
1,000	1	^{34}S	^{34}S**		Fill up
1,000	1	U/Th	U/Th-isotoper**		Fill up
1,000	1	Ra/Rn	^{226}Ra, ^{222}Rn**		Fill up
100	2	C-iso	^{13}C, pmC**		Fill up
100	1	^{37}Cl	^{37}Cl**		Fill up
100	1	^{87}Sr	^{87}Sr/^{86}Sr**		Fill up
Winkler bottles 125	2	HS	HS*	0.5 ml ZnAc + 0.5 ml NaOH and mix	Flow over × 3

[1a] Na, K, Ca, Mg, Si, Fe, Mn, Li, Sr.
[1b] Al, As, Ba, B, Cd, Co, Cr, Cu, Hg, Mo, Ni, P, Pb, V, Zn (only class 5 samples).
[1c] 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 (only class 5 samples).
* Only class 5 samples.
** Only sampled once a year.

Table 3-4. List of collected samples during the period January to December 2009 (X = collected sample).

Id code	Name or location	Week/ Year 3/09	16/09	33/09	41/09	Sum (X)
Sonde						
YSI 600 QS		X	X	X	X	**4**
Soil wells						
SFM 0001	Drill site 1	X	X	X	X	**4**
SFM 0023	Bolundsfjärden	X	X	X	X	**4**
SFM 0032	SV-Bolundsfjärden	X	X	X	X	**4**
SFM 0037	N-Bolundsfjärden	X	X	X	X	**4**
SFM 0049	Bostadsområdet	X	X	X	X	**4**
BAT pipes						
SFM0051	Drill site 1	X	X	X	X	**4**
Private wells						
PFM 000001	F3:3				X	**1**
PFM 000009	F3:34				X	**1**
PFM 006382	F3:38. Tixelfjärden				X	**1**
Sum (X)		**6**	**6**	**6**	**9**	**27**

Sampling and measurements

The groundwater sampling procedure as described below was generally applied in groundwater pipes and wells, except for the BAT-pipes and the drilled private wells. In the private wells the water was collected directly from the tap.

First, the groundwater level in the pipe was established by sounding and the water volume of the pipe was calculated. The pump with its tubing was lowered carefully in order to prevent dirt from entering the pipe. The water inlet of the submersible pump (Awimex) was lowered to the filter/screen section of the pipe or just above. Pumping was then performed at a maximum flow rate of one litre per minute. The pumped water was disposed of at least 10 m away from the sampling object, where it filtrated back into the ground. The pumping phases were as follows:

- *Exchange of water volume in pipe and tubes:* The water volume was exchanged three to five times (depending on the exchange/recovery time) prior to the actual sampling.
- *Sampling:* All sample bottles, except the ones with added acid, were rinsed three times with pumped water. Disposable filters were used for filtration of water portions for trace metals, Fe(+II) and DOC/DIC. The filters were fitted directly on the outlet tube from the pump. Each filter was rinsed with sample water (approx. 30 mL) before the sample portion/filtrate was collected. The bottles containing acid were the last ones to be filled in order to prevent acid contamination in the other sample portions. Disposable plastic gloves were used during the sampling. The samples were transported back from the field in insulated bags.
- *Field measurement:* A flow-through cell was connected to the pumping setup and measurements were performed with the sonde (YSI 600 QS). The results were recorded when the electrodes and sensors in the flow-through cell showed stable values (minimum 10 minutes). A judgement of the plausibility of the values was made in the field and accepted values were noted in the field protocol.

Sampling performance using BAT-system

Sampling of the BAT-type filter tip pipe followed the sampling scheme for the regular shallow soil pipes. The approximate time to fill one 500 mL container was 15 minutes for SFM0051.

A total of four sample containers were filled from the BAT-pipe in order to obtain enough water for the analyses. In order to exchange the water volume in the BAT-pipe before sampling, the first sample container filled was not used for the analyses. The use of the sample volumes and the analyses performed are listed in Table 3-5.

Table 3-5. Sample containers and analyses, bat pipe SFM0051.

Sample container no.	Analyses and determinations			Total volume
1	Chloride, bromide, fluoride and sulphate by IC (200 mL+50 mL)	Alkalinity titr, pH and EC (150 mL)	δ^2H, δ^{18}O (100 mL)	500 mL
2	Tritium (500 mL)			Approx. 500 mL
3	Fe (+II), (Fe(tot) (200 mL)	Major constituents, trace elements, ^{10}B/^{11}B by ICP AES/MS (125 mL)	5 mL of HCl was added to the container prior to sampling	325 mL

3.4.2 Sample handling and analyses

Measurements/analyses of pH$_{(lab)}$, electrical conductivity$_{(lab)}$ and alkalinity as well as spectrophotometric analyses of total iron and ferrous iron, Fe(+II), were conducted immediately at the site in the mobile field laboratory. An overview of sample treatment and analytical routines for major constituents, minor anions, trace metals and isotopes is given in Appendix 4. The routines are applicable independent of sampling method or type of sampling object.

3.4.3 Data handling

The general routines for quality control and data management applied for hydro-chemical analysis data, independently of sampling method or sampling object are presented in Appendix 4.

3.4.4 Nonconformities

No nonconformites occurred regarding the regular monitoring programme for near surface groundwaters during the reported time period (Table 3-4).

3.5 Results

3.5.1 Field measurements

The results from the field measurements on pH, electrical conductivity, dissolved oxygen, water temperature and redox potential (ORP) are presented in Appendix 8.

pH-measurement

Field measurements of pH are plotted against the corresponding laboratory values in Figure 3-4. Some deviation is reasonable considering the change of water temperature, and the time delay prior to the laboratory measurement. However, in a few cases, the disagreement seems to be greater than expected. The four data points having the largest differences between field and laboratory values are from the stand pipe (SFM0023) in Lake Bolundsfjärden. Also in 2008, large differences in field and laboratory values were observed for two stand pipes (SFM0023 and SFM0081) in Lake Bolundsfjärden /6/. These two pipes yield little water (ca 3–4 L) and the inflow is very slow (ca 24 h), which means that the field measurements have to be performed the day before the water is sampled for laboratory analyses. Thus, the measurements in the field and in the laboratory are not conducted in exactly the same waters, which may explain the large differences in pH-values.

Electrical conductivity

Electrical conductivity field values are plotted versus corresponding laboratory values in Figure 3-5 and show good agreement.

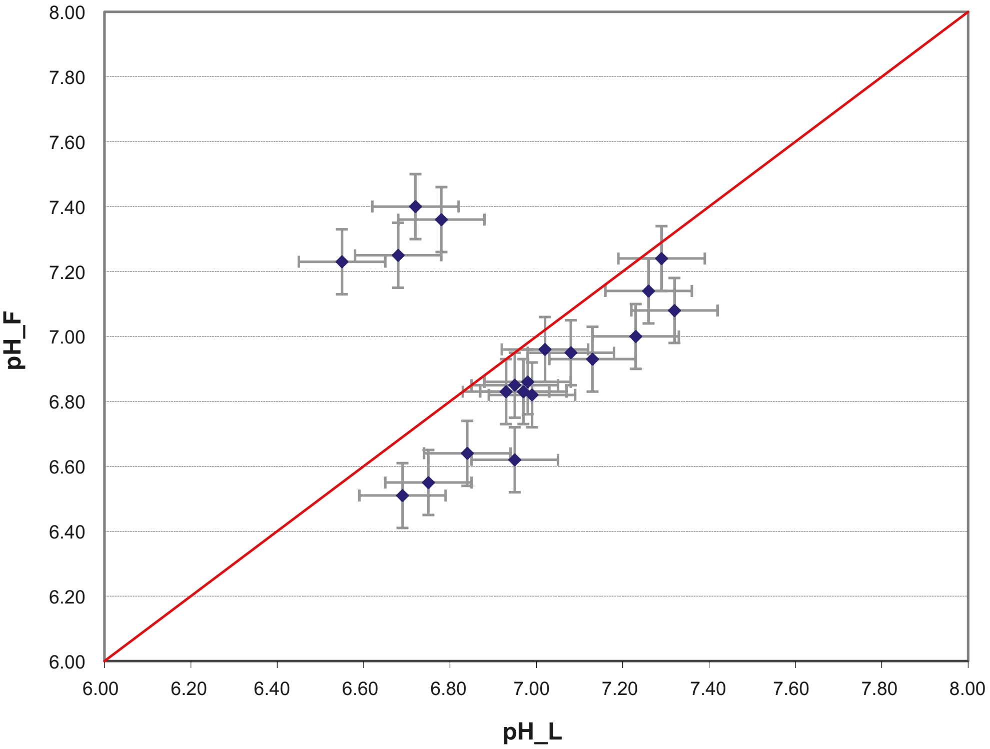


Figure 3-4. *Field-pH (pH_F) values versus laboratory-pH (pH_L) values. Field-pH and laboratory-pH values are measured at prevailing water temperature and at 25°C respectively. The measurement uncertainty is shown as error bars.*

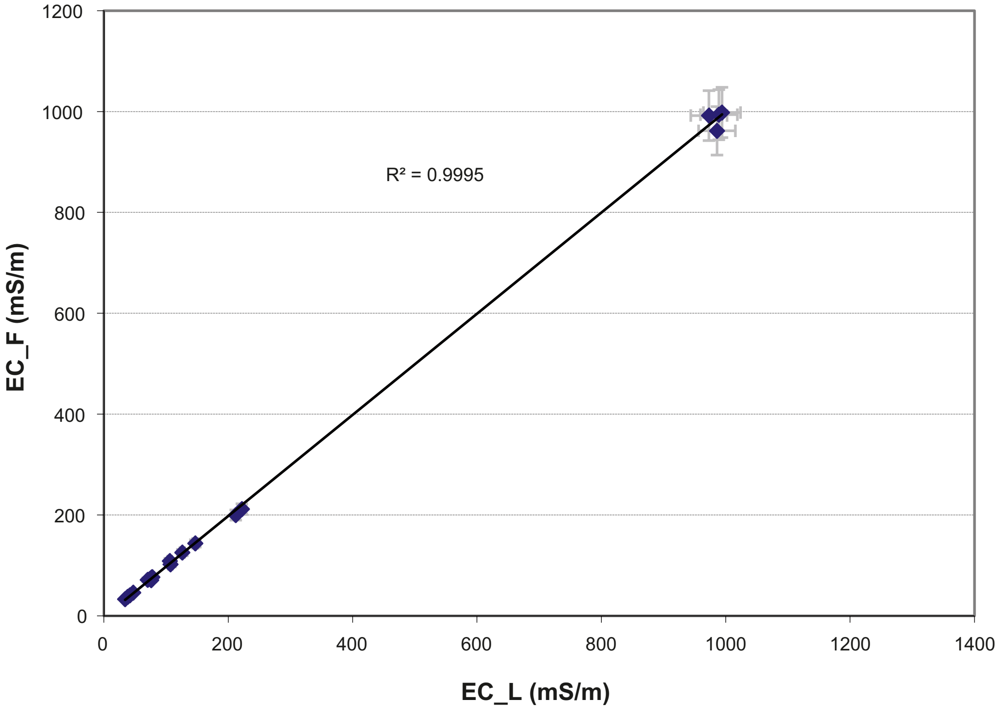


Figure 3-5. *EC (Electrical Conductivity) at 25°C. Field measurements (EC_F) versus laboratory values (EC_L). The measurement uncertainty is shown as error bars.*

Dissolved oxygen

The measurements of dissolved oxygen were checked in April 2005 by comparison to results from laboratory analyses /7/. This control showed that, generally, the field measurement values were somewhat higher, especially at oxygen concentrations below 4 mg/L. Field measurements of dissolved oxygen are presented in Appendix 8.

ORP-measurements and redox conditions

ORP-measurements (Oxidising-Reducing Potential) have been conducted using the multipurpose measurement sonde. The recorded ORP-values (potential against Ag/AgCl reference electrode) should be used with great caution and merely considered as an indication of the redox conditions in the waters. Measured ORP-values are presented in Appendix 8.

3.5.2 Water analyses

Basic components

The basic water analyses include the major constituents Na, K, Ca, Mg, Sr, S, SO_4^{2-}, Cl^-, Si and HCO^{3-} as well as the minor constituents Fe, Li, Mn, Br, F, I and HS^-. Furthermore, batch measurements of pH and electrical conductivity are included. The basic water analysis data are compiled in Appendix 9. The charge balance errors give an indication of the quality and uncertainty of the analyses of major constituents. The errors exceed the acceptance limit ± 5% in two cases. Duplicate analyses by a second laboratory or another method are conducted regularly for some of the analysed constituents as a further check of the reliability of the analyses.

The chloride concentrations are plotted against the corresponding electrical conductivity values in Figure 3-6 as a rough check, and the data agree well with an assumed trend line. The bromide analyses are often uncertain. For example the detection limit of bromide by ion chromatography (< 0.2 mg/L) is often too high for fresh waters. Therefore, duplicate analyses by ICP (bromine) have been performed for most samples. Selected bromide/bromine values for each sample are plotted against the corresponding chloride concentrations in Figure 3-7 as a consistency check.

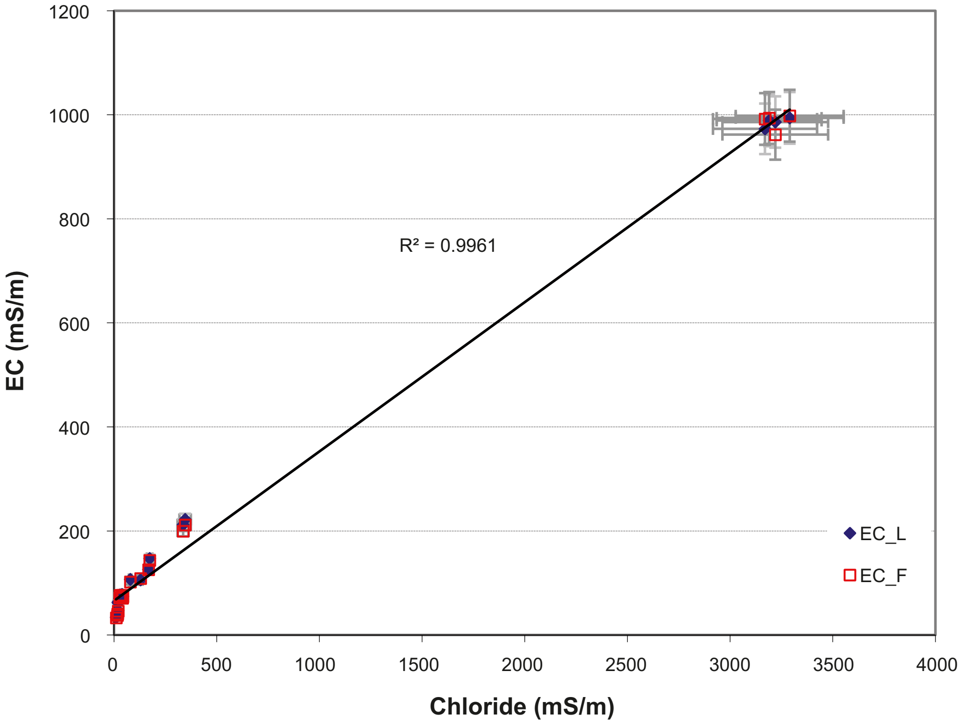


Figure 3-6. *EC (Electrical Conductivity) at 25°C versus chloride concentrations. EC_L = Laboratory value, EC_F = Field value. The measurement uncertainty is shown as error bars.*

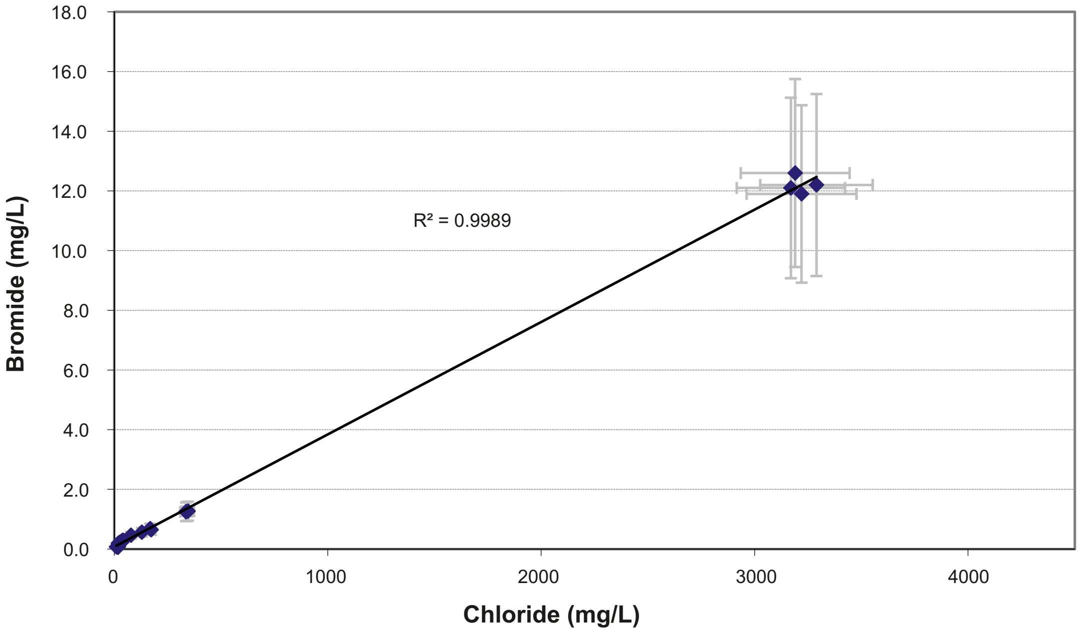


Figure 3-7. *Bromide concentrations versus chloride concentrations. The measurement uncertainty is shown as error bars.*

Sulphate by ion chromatography and sulphate calculated from total sulphur by ICP are compared in Figure 3-8 and most samples show a satisfactory agreement. However, several samples with high sulphide concentrations diverge. The total sulphur by ICP increases disproportionately at high sulphide concentrations due to hydrogen sulphide gas entering the plasma. In the obvious cases the ICP results are rejected in Sicada.

Total silicon concentrations by ICP, and SiO_4 as silicon concentrations (SiO_4-Si) by spectrophotometry, are compared in Figure 3-9. Here the values diverge, but somewhat higher total silicon concentrations may be expected since not all silicon in the water is in the form of SiO_4.

The iron concentrations determined by ICP-AES (total Fe) and by spectrophotometry (Fe(+II) and Fe-tot) are compared in Figure 3-10. The total iron concentrations determined by ICP agree well with the results obtained by spectrophotometry.

Surface water supplements

The analytical protocol for shallow groundwaters include the surface water supplements/options NH_4_N, NO_2_N, NO_3_N+NO_2_N, NO_3_N, tot-N, tot-P, PO_4_P, TOC, DOC and DIC. The analytical data are compiled in Appendix 9. The DIC values should be used with care and bicarbonate values (by alkalinity titration) are considered more reliable.

The concentrations of the different nitrogen, phosphorous and carbon compounds are expected to show seasonal variation depending on decomposition processes and varying redox conditions. However, this variation is more pronounced in surface waters than in the present shallow groundwaters. Figures 3-12a to 3-12e show the variations of total nitrogen, ammonium and phosphate in the sampled groundwaters from the five soil-pipes included in the long term monitoring programme.

Very high concentrations of total nitrogen were observed in stand pipe SFM0037 in August and October 2008 compared to earlier measurements. The nitrogen concentration was somewhat high also in August 2009 and the phosphate concentration was very high (more than three times higher than any previous value).

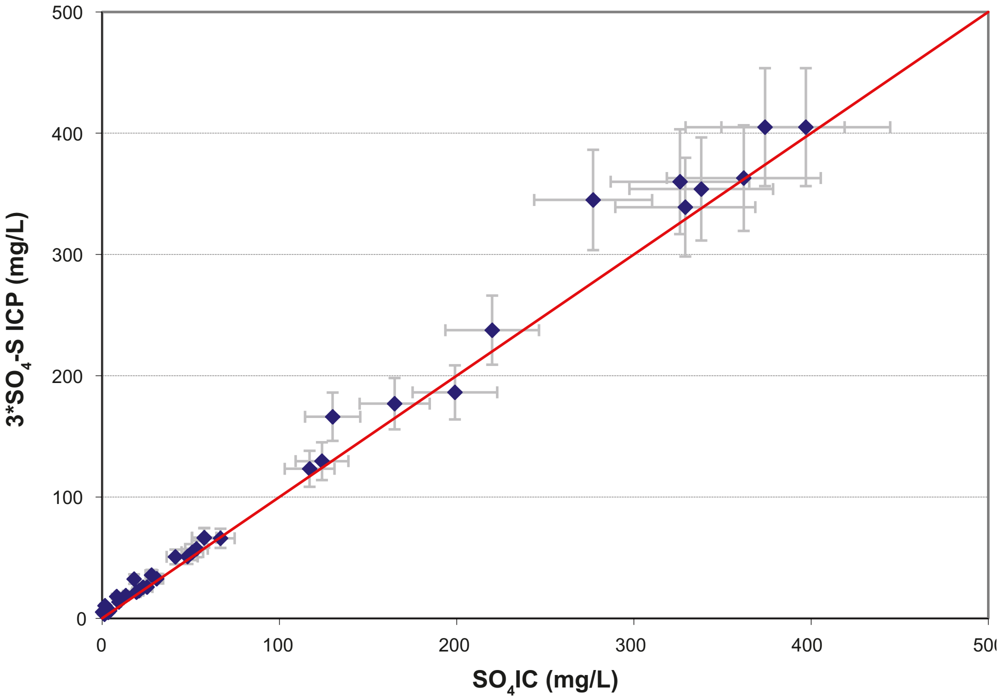


Figure 3-8. *Sulphate (SO$_4$ by IC) versus sulphate calculated from total sulphur (3×SO$_4$-S) by ICP. The measurement uncertainty is shown as error bars.*

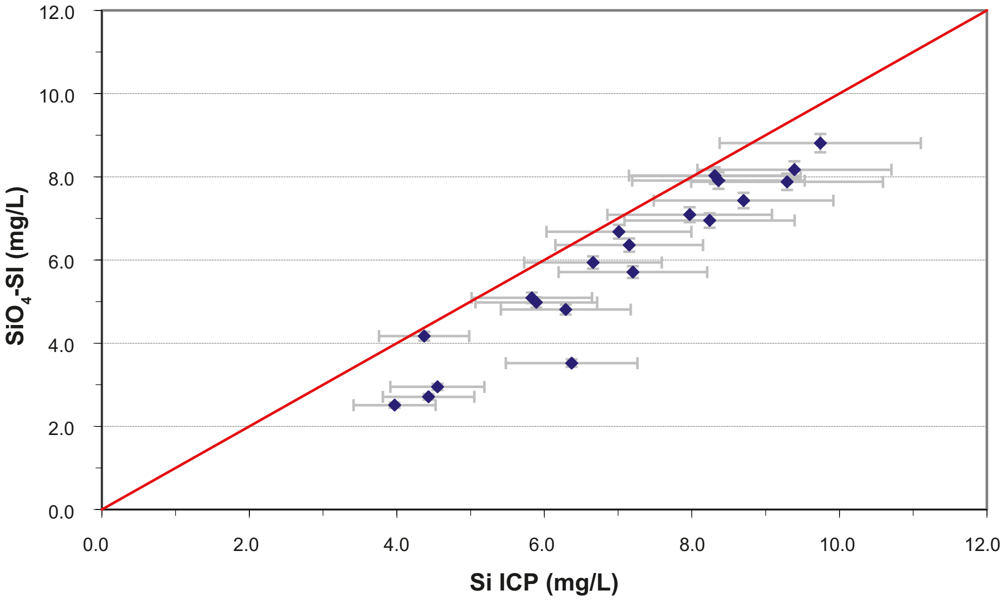


Figure 3-9. *SiO$_4$-Si determined by spectrophotometry versus total Si analysed by ICP. The measurement uncertainty is shown as error bars.*

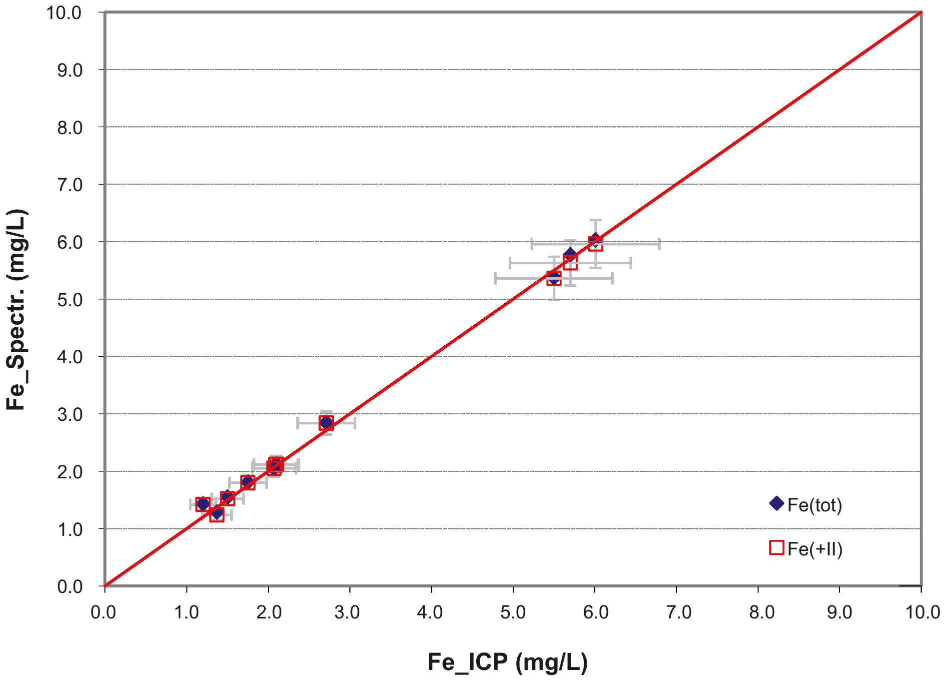
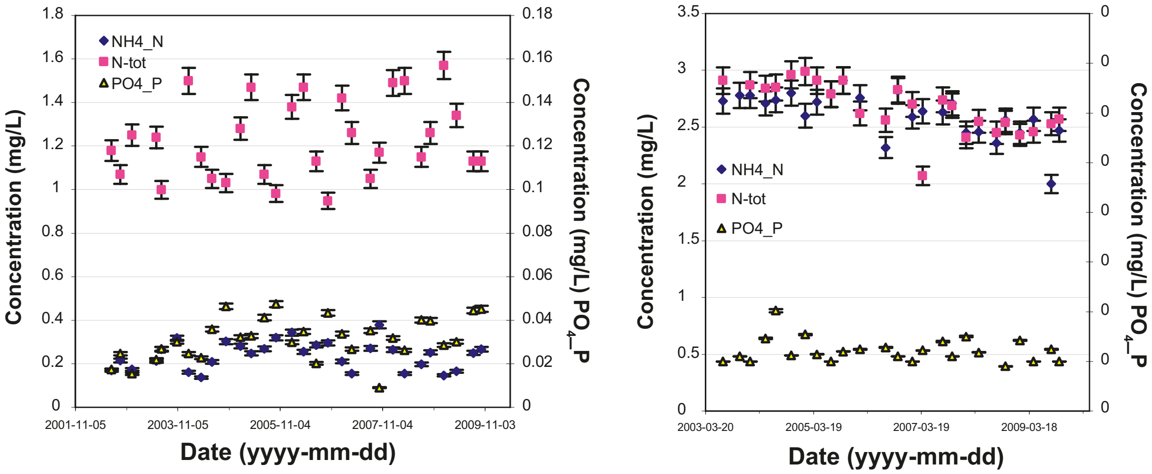


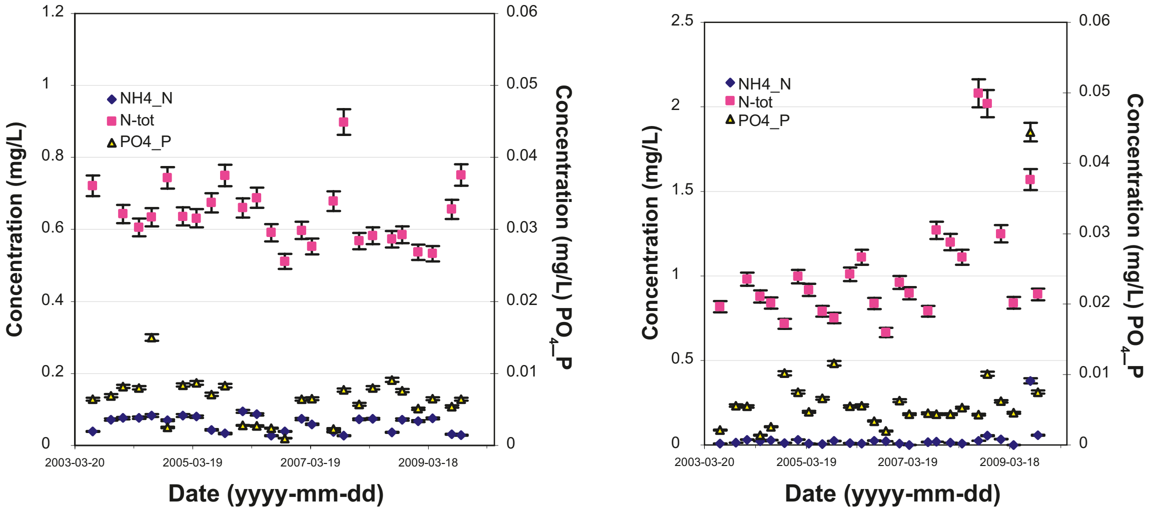
Figure 3-10. *Comparison of iron concentrations obtained by ICP and by spectrophotometry (Fetot and FeII).*

Figure 3-11. *Testing the ice on Lake Bolundsfjärden.*



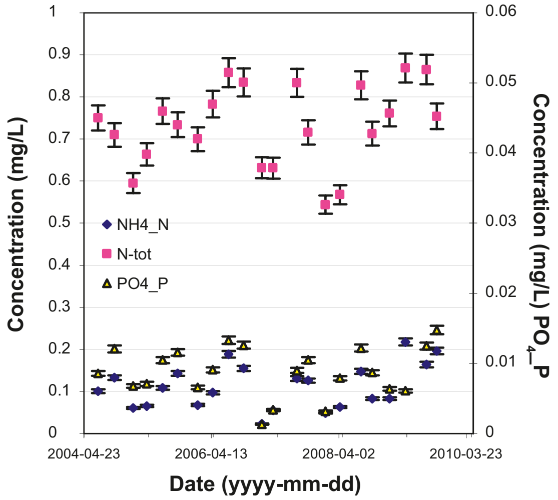
a) SFM0001

b) SFM0023



c) SFM0032

d) SFM0037



e) SFM0049

Figures 3-12a to e. *Ammonium, total nitrogen and phosphate concentrations in shallow groundwaters versus sampling date. Note that phosphate concentrations refer to the secondary Y-axis.*

Drinking water quality (private wells)

Data on drinking water quality in the investigated private wells are presented in Appendix 9.

Trace metals

The analyses of trace and rare earth elements include Al, As, Sc, Cd, Cr, Cu, Co, Hg, Ni, Zn, Pb, V, U, Th, Rb, Y, Zr, Mo, In, Sb, Cs, Ba, La, Hf, Tl, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu. The trace element data are compiled in Appendix 9.

These elements are generally present at low concentrations in the groundwater and the risk for contamination is high. Especially data on common metals such as Al, Cr, Cu, Co, Ni and Zn must be used with caution. Generally, the borehole data conform well but outliers exist.

Isotopes

The isotope determinations include the stable isotopes δD, $\delta^{18}O$ and $^{10}B/^{11}B$ as well as the radioactive isotope ^{3}H (TU). The isotope data are compiled in Appendix 9.

3.6 Summary and discussion

The chemical investigation routines for near surface groundwaters are well established after more than five years of field work, reporting and data administration and this year of the long-term monitoring programme has passed without any major nonconformities or surprises. However, two out of 38 samples showed relative charge balance (RCB) errors exceeding ± 5% (sample nos. 16253 and 16348).

The statements/findings regarding the character of the near surface groundwaters within the monitoring programme remain unchanged.

Very high concentrations of total nitrogen were observed in stand pipe SFM0037 during August and October 2008 compared to earlier measurements. The nitrogen concentration was somewhat high also in August 2009, and the highest concentration of phosphate ever measured was observed at the same occasion. The high concentrations are difficult to explain but continued monitoring will yield more information.

3.6.1 Summary of results 2005–2009

The data obtained during the period January 2005 to December 2009 have been compiled in order to investigate the variation patterns of some selected components within and between years. The sampling dates and the number of collected samples are presented in Table 3-6 and the different concentration trends are presented in Figures 3-13 to 3-21. The type and number of performed analyses vary between years and sites.

The pH in the groundwaters from January 2005 to December 2009 vary less than one unit (Figure 3-13) with one exception, the standpipe SFM0032, due to a deviating low value in October 2005, see Figure 3-13. This is more or less true also for the variation between standpipes, since all values, except three, amount to between pH 6.6 and pH 7.6.

The, by far, most marine character is found in SFM0023 (stand pipe in Lake Bolundsfjärden) followed by SFM0001 and SFM0037. This is shown by high sodium, potassium and chloride concentrations see Figures 3-16, 3-18 and 3-20. The groundwater in SFM0023 shows higher concentrations than the Baltic Sea. This together with the low bicarbonate (HCO_3) concentration (Figure 3-14) and TOC (Figure 3-15) indicate that the water has an older and deeper character (contribution of Littorina Sea water). From the decreasing salinity trends (Figures 3-16, 3-18 and 3-20) it may be concluded that the Littorina contribution to the groundwater of SFM0023 is decreasing with time.

Some of the seasonal fluctuations are repeated every year but, generally, the fluctuation patterns are not very obvious. The groundwater in the sampling location SFM0001 seems to be the most affected by seasonal variations.

Table 3-6. Collected samples (X) during the period January 2005 and December 2009.

Year	Month	SFM0001	SFM0023	SFM0032	SFM0037	SFM0049	SFM0051
2005	January	X	X	X	X	X	X (February)
	April	X	X	X	X	X	X (May)
	July	X	X	X	X	X	X
	October	X	X	X	X	X	X
2006	January	X	X	X	X	X	X
	April	X		X	X	X	X (May)
	July	X	X	X	X	X	X
	October	X	X	X	X	X	X
2007	January	X	X	X	X	X	X
	March	X	X	X	X	X	X (April)
	August	X	X	X	X	X	X
	October	X	X	X	X	X	X
2008	January	X	X	X	X	X	X
	April	X	X	X	X	X	X
	August	X	X	X	X	X	X
	October	X	X	X	X	X	X
2009	January	X	X	X	X	X	X
	April	X	X	X	X	X	X
	August	X	X	X	X	X	X
	October	X	X	X	X	X	X
Sum		**20**	**19**	**20**	**20**	**20**	**20**

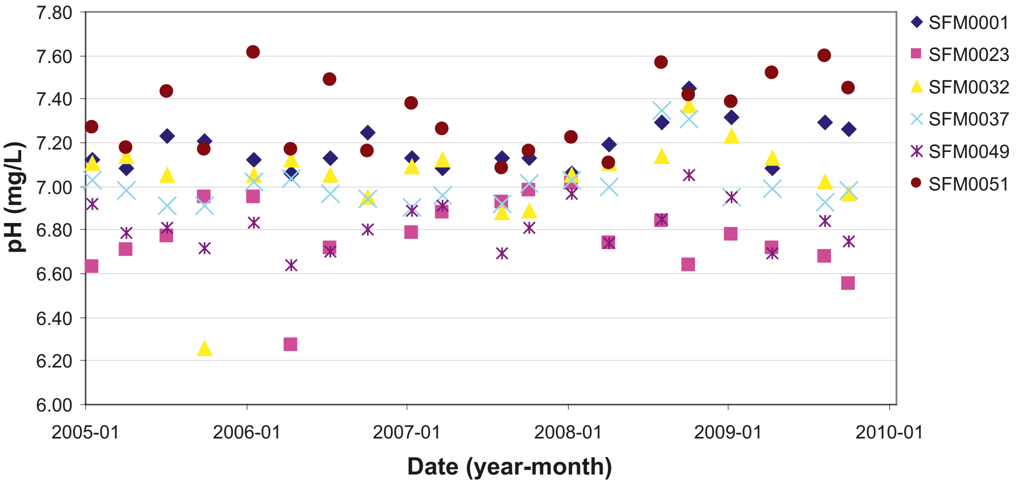


Figure 3-13. *Measured pH in near surface groundwaters, January 2005–December 2009.*

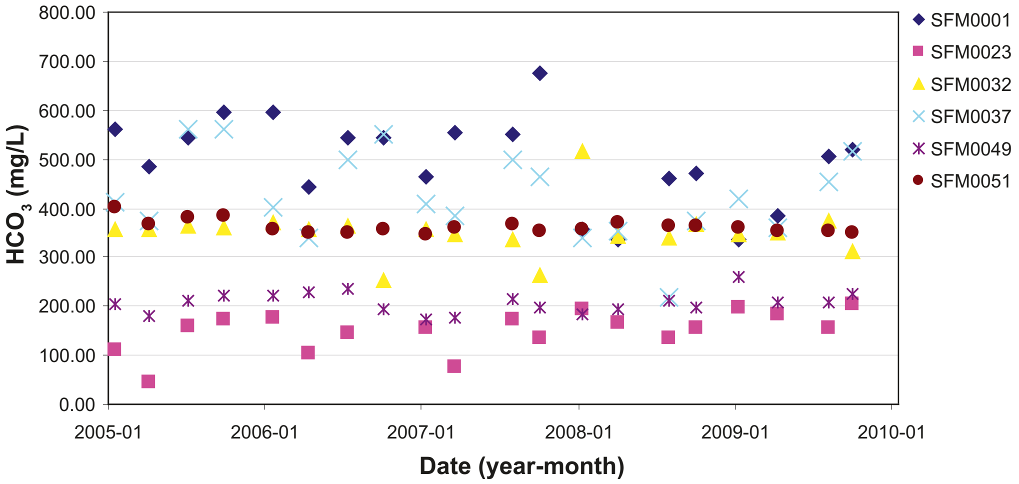


***Figure 3-14.** Bicarbonate concentrations in near surface groundwaters, January 2005–December 2009.*

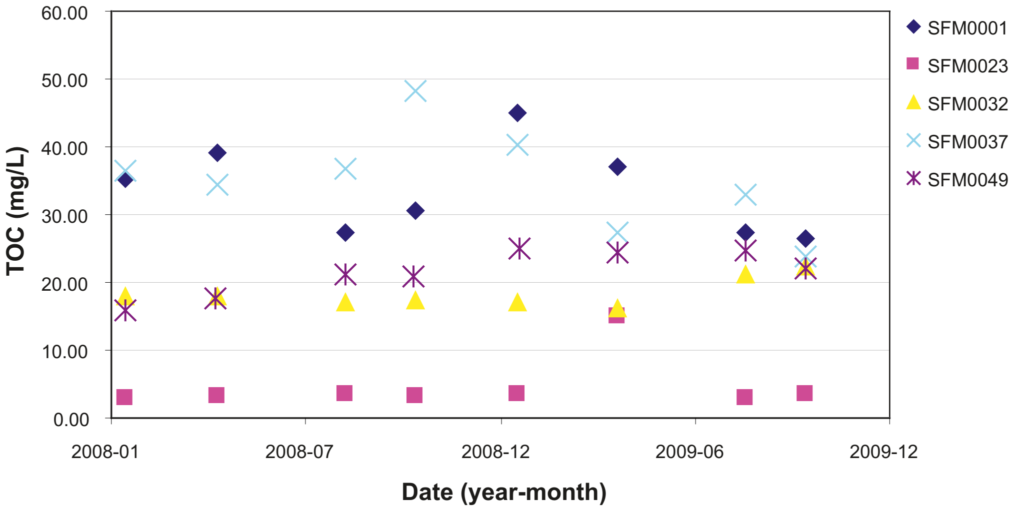


***Figure 3-15.** Total organic carbon (TOC) in near surface groundwaters, January 2005–December 2009.*

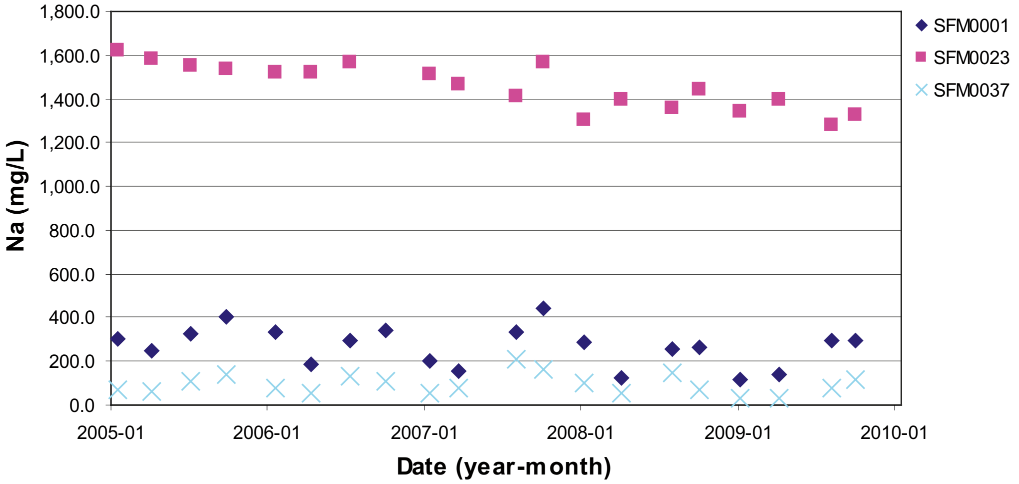


***Figure 3-16.** Sodium concentrations in the stand pipes SFM0001, SFM0023 and SFM0037, January 2005–December 2009.*

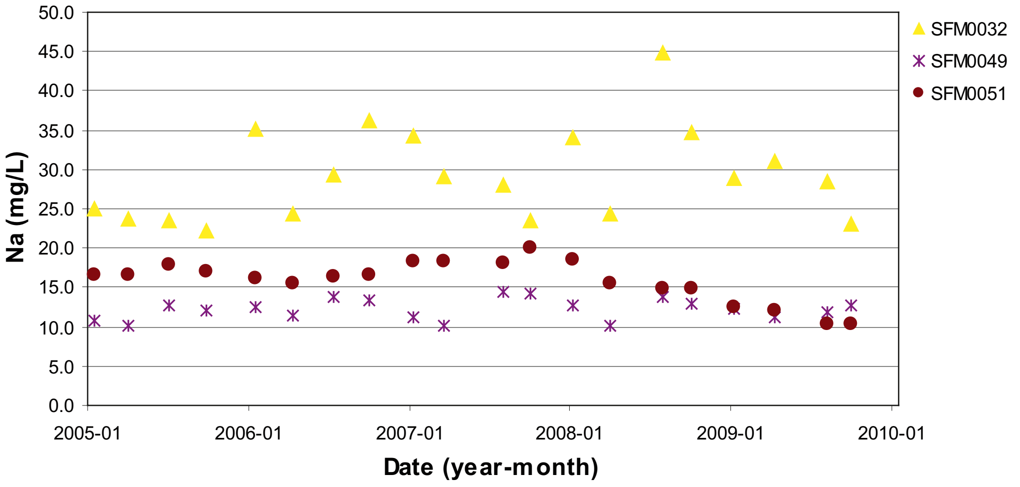


Figure 3-17. *Sodium concentrations in the stand pipes SFM0032, SFM0049 and SFM0051, January 2005–December 2009.*

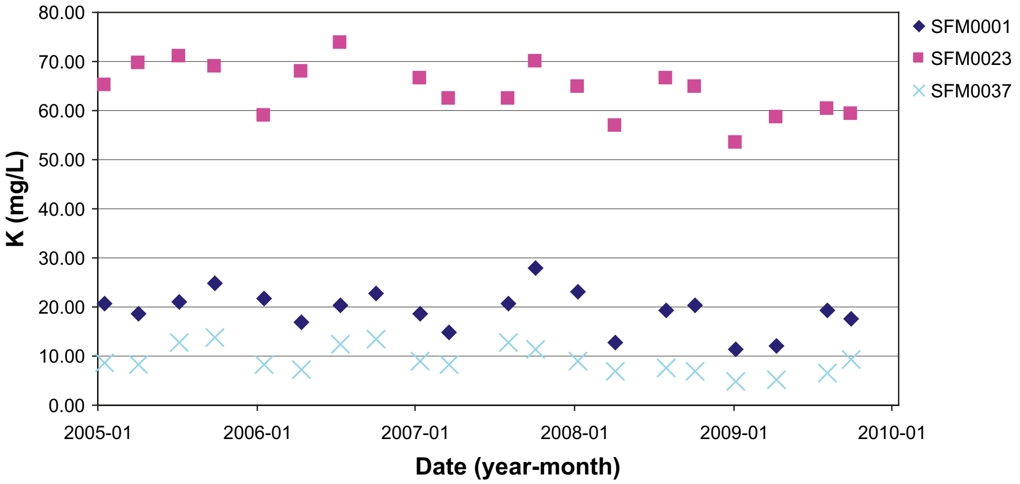


Figure 3-18. *Potassium concentrations in the stand pipes SFM0001, SFM0023 and SFM0037, January 2005–December 2009.*

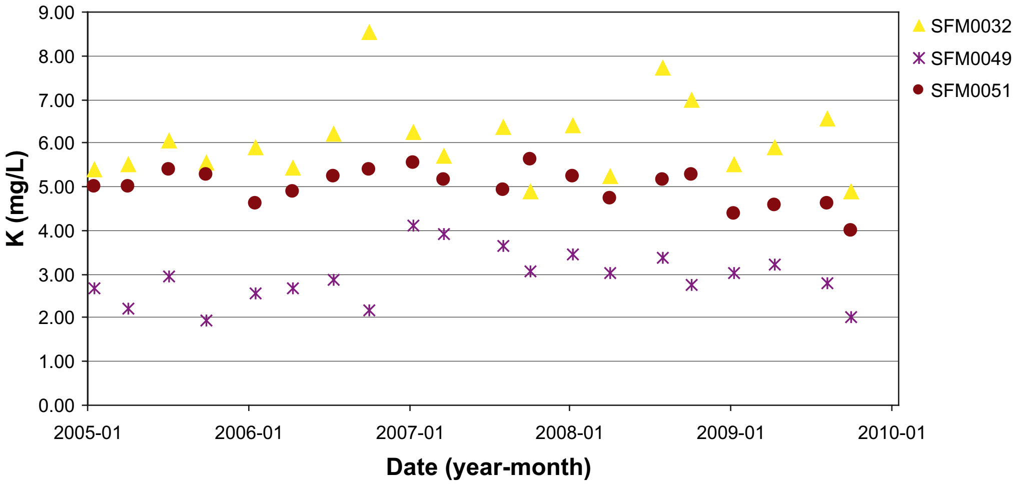


Figure 3-19. *Potassium concentrations in the stand pipes SFM0032, SFM0049 and SFM0051, January 2005–December 2009.*

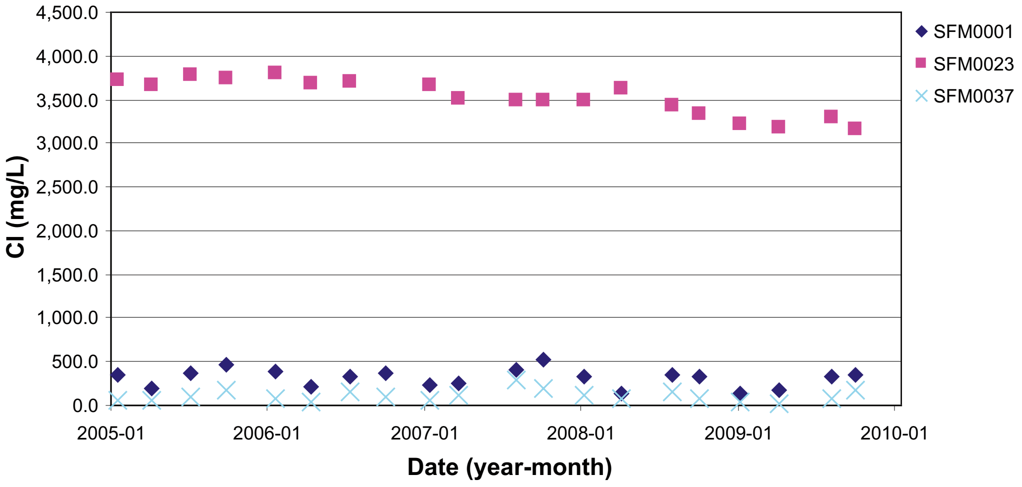


Figure 3-20. *Chloride concentrations in the stand pipes SFM0001, SFM0023 and SFM0037, January 2005–December 2009.*

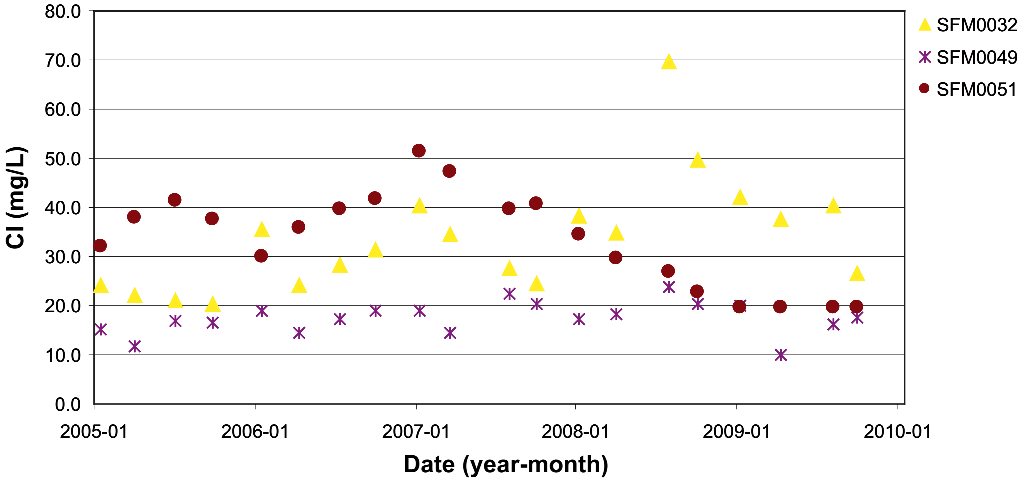


Figure 3-21. *Chloride concentrations in the stand pipes SFM0032, SFM0049 and SFM0051, January 2005–December 2009.*

4 Surface waters

4.1 Objectives and scope

The ongoing surface water monitoring programme started in July 2004 and focuses on sampling locations in the prioritised north-western part of the Forsmark candidate area. The main objectives are to create long-time series of data in order to obtain further information on natural variations and also to allow identification of eventual perturbation effects from the completed investigation activities.

The sampling locations are presented in Figure 4-1, whereas Table 4-1 lists the location id-codes, coordinates and names together with clarifying comments. The sampling scheme for the period January–December 2009 is given in Table 4-2.

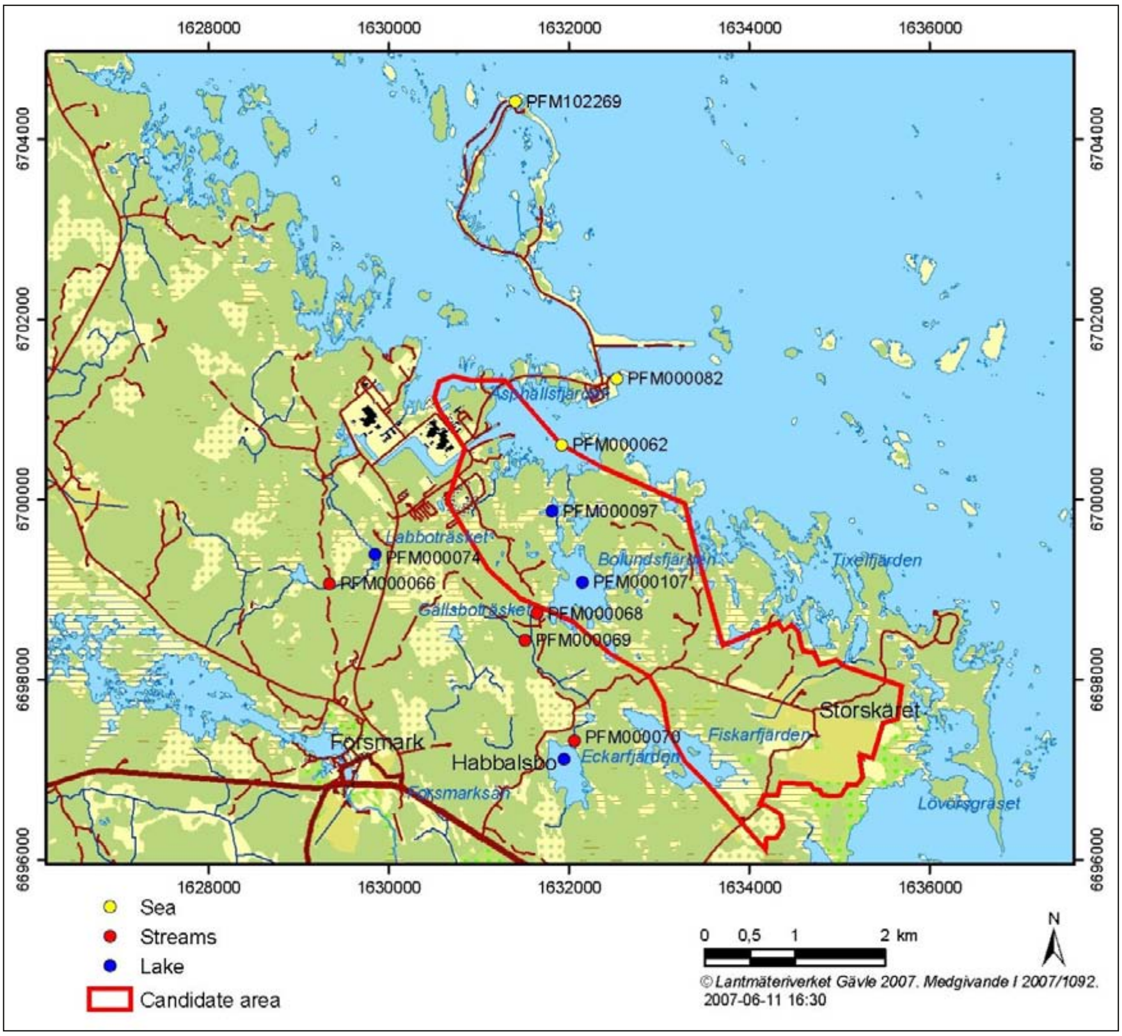


Figure 4-1. Sampling locations within the monitoring programme. One location constitutes an alternative for a regular sampling position (see Table 4-1). The sampling location in Lake Eckarfjärden (blue filled circle) is PFM000117.

Table 4-1. Sampling locations (Id-code, coordinates, name and comments).

Sampling locations	Coordinates (RT90 RHB70)	Name	Comments
Lakes			
PFM000074	16 29 854, 66 99 393	Labboträsket	
PFM000097*	16 31 814, 66 99 868	Norra bassängen	
PFM000107	16 32 065, 66 99 031	Bolundsfjärden	
PFM000117	16 31 946, 66 97 118	Eckarfjärden	
Shallow sea bays and deep sea location			
PFM000062	16 31 921, 67 00 605	SV-Forslingens grund	
PFM000082	16 32 528, 67 01 336		Alternative to PFM00062
PFM102269	16 31 405, 67 04 412	Cooling water outlet, Lake Biotestsjön	Check of tritium contamination
Streams			
PFM000066	16 29 343, 66 99 064	Öster Gunnarsboträsket	
PFM000068	16 31 641, 66 98 735	Kungsträsket	
PFM000069	16 31 510, 66 98 440	Bolundsskogen	
PFM000070	16 32 061, 66 97 319	Norr Eckarfjärden	

* Only sonde measurements.

Table 4-2. Surface water sampling scheme from January 2009 to December 2009.

Year	Month	Week	Programme type*
2009	January	3	E
2009	February	7	M
2009	March	11	M
2009	April	16	E
2009	May	20	M
2009	June	25	M
2009	August	33	E+
2009	September	36	M
2009	October	41	E
2009	November	45	M
2009	December	49	M

* M = main programme (SKB class 3 including surface water supplements), E = extended programme (SKB class 5 including surface water supplements), E+ = extended programme and special isotopes (δ^{37}Cl, δ^{13}C, ^{14}C (pmC), ^{87}Sr/^{86}Sr, δ^{34}S, U- and Th-isotopes as well as Ra- and Rn-isotopes).

The monitoring programme includes water sampling and sonde measurements in the different lake systems; Lake Bolundsfjärden, Lake Eckarfjärden and Lake Labboträsket. Measurements are performed also in Lake Norra Bassängen in order to monitor salinity changes. One regular sampling location represents a shallow sea bay (Forslingens grund). Sampling of stream water is conducted at four localities (Kungsträsket, Bolundsskogen, Norr Eckarfjärden, Öster Gunnarsbo) and an electrical conductivity logger is installed in Lilleputt-sundet, also to monitor salinity changes. Furthermore, due to observed enhanced tritium contents in the surface waters close to the nuclear power plant, samples for tritium analyses are collected each month close to the cooling water outlet in Lake Biotestsjön.

Sampling for chemical analysis as well as direct measurements of physical and chemical parameters such as ORP (Oxidising Reducing Potential), pH, dissolved oxygen, electrical conductivity, salinity, measurement depth, barometric pressure, turbidity, chlorophyll, light penetration, PAR (Photosynthetic Active Radiation) and water temperature were conducted at eleven occasions during the reported time period. The extent of the sampling varied at different occasions. Analyses of major

Figure 4-2. *Sampling equipment for collecting water from a stream.*

constituents and surface water supplements (nutrient salts, chlorophyll etc) were conducted frequently (once a month), whereas extended analyses including also isotopes and trace elements were performed once per season, i.e. in January, April, August and October. Some special isotopes (δ^{37}Cl, δ^{13}C, ^{14}C (pmC), ^{87}Sr/^{86}Sr, δ^{34}S, U- and Th-isotopes as well as Ra- and Rn-isotopes) were determined only once, in August.

4.2 Sampling locations and sampling scheme

The monitoring programme includes four lakes, one shallow sea bay location and four streams. Furthermore, a location close to the outlet of cooling water from the nuclear power plant is sampled in order to investigate eventual tritium contamination.

4.3 Equipment

4.3.1 Sampling equipment

Water samples were collected using an online pumping setup consisting of an electrical peristaltic pump system, PPS (ASF Thomas SR 10/100, powered by 12 VDC, 7 Ah cells), connected to 4–8 m long Teflon-tubes (FEP 140) of 5 mm inner diameter. A manually operated regulator (ELFA, DCM 24–40 pwm) was used to adjust the water flow to a maximum of 1.3–2.9 litres/minute (depending on tube length, tube diameter and pumping level). The sampling equipment is presented in Figure 4-3.

4.3.2 Multi parameter sondes

Field measurements were performed using a multi parameter sonde (YSI 6600 EDS). A terminal (YSI 650 MDS) is connected to the sonde through a cable for logging data (Figure 4-4). Calibration of the sonde was carried out according to the measurement system description SKB MD 910.003 (SKB internal controlling document, see Table 1-1). Table 4-3 describes the parameters measured by the the sonde YSI6600 EDS and the sonde YSI600QS, which is used in the sampling of near surface ground waters and as backup.

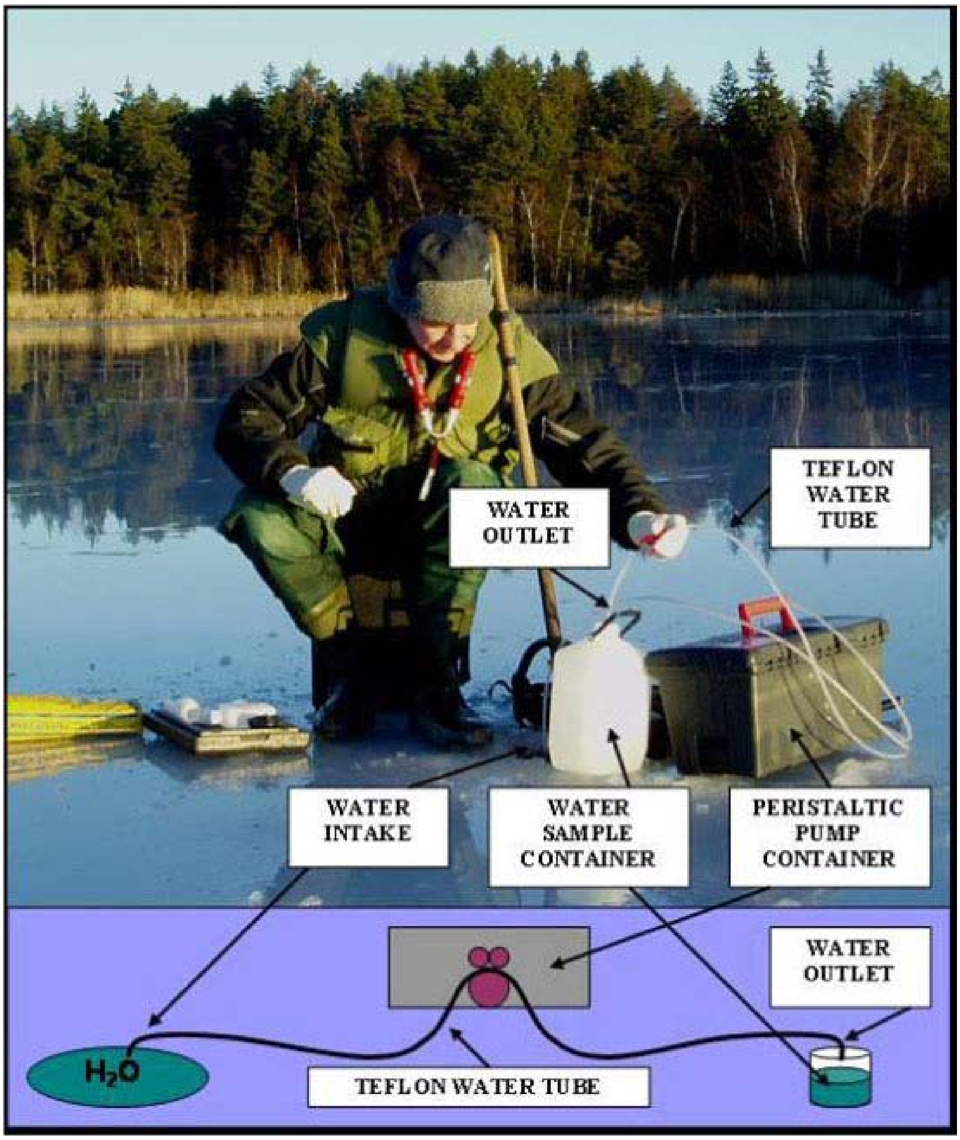


Figure 4-3. Winter sampling of surface water using the peristaltic pump system (PPS). A schematic presentation of the PPS is also shown.

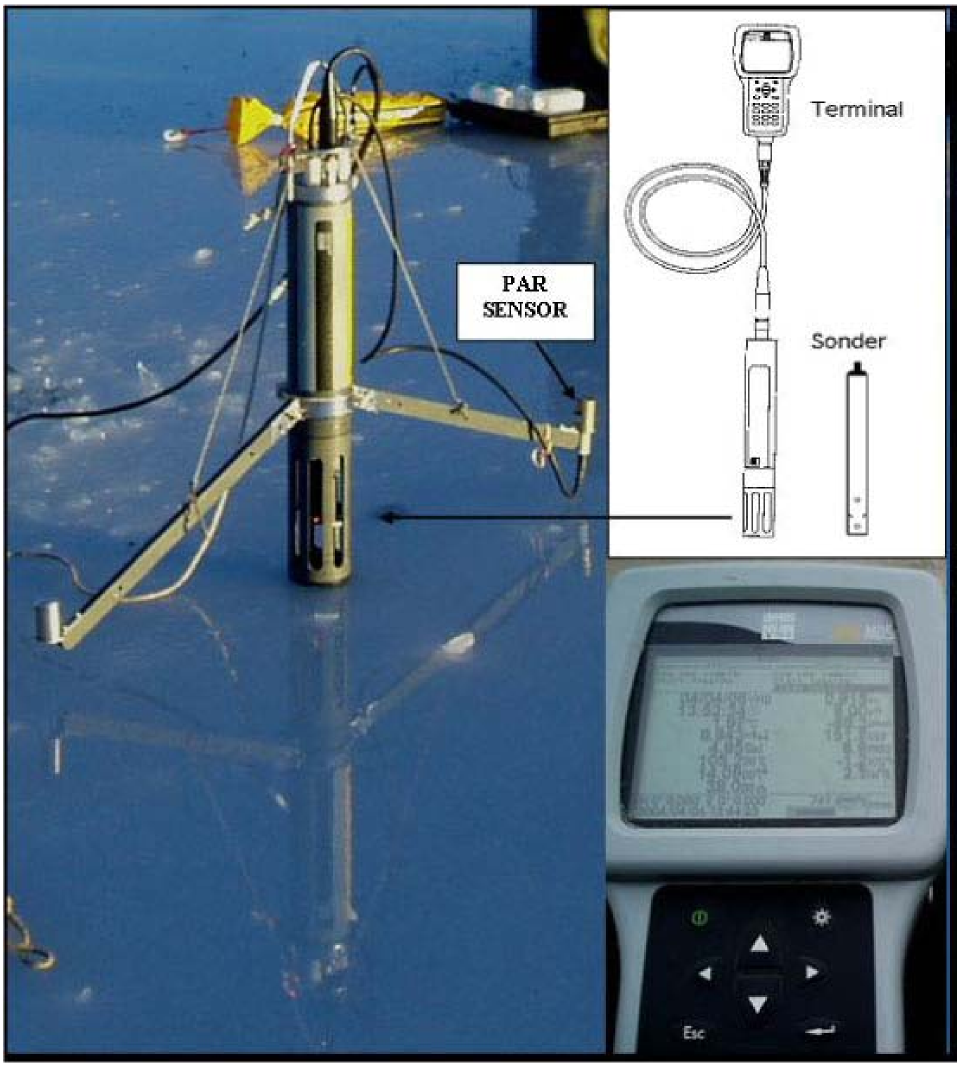


Figure 4-4. The measurement sonde equipped with a PAR sensor used in the field investigations of surface waters. The smaller sond in the schematic presentation is mainly used for measurements of near surface groundwaters. Also shown is a close-up of the terminal during measurements.

Table 4-3. Parameters measured by the two YSI sondes.

Parameter	YSI 6600 EDS	YSI 600 QS
Date/time	Yes	Yes
Temperature (°C)	Yes	Yes
pH	Yes	Yes
Dissolved oxygen (mg/L)	Yes	Yes
ORP (Redox potential, mV)	Yes	Yes
Electrical conductivity (mS/cm)	Yes	Yes
Salinity (ppt)	Yes	Yes
Depth (m)	Yes	Yes
Barometric pressure (mm Hg)	Yes	Yes
Turbidity (NTU)	Yes	No
Chlorophyll (µg/l)	Yes	No
Light / PAR* (µmoles s^{-1} m^{-2})	Yes	No

* Photosynthetic Active Radiation.

4.3.3 General field equipment

- Ruttner samplers were used as back up if the portable pump system should fail.
- The exact positions of the sampling locations were determined using a GPS (Garmin 172C) with an average accuracy of +/– 0.5–1.0 m.
- Water depth was measured using an echo sounder (Plastimo, Echotest, LCD digital sounder) with an accuracy of +/– 0.05 m.
- Water transparency was estimated using a Secchi disc and an aqua scope.
- Disposable filters (Millipore, 0.40 µm, ∅ = 22 mm) were used together with 60 mL syringes to filter specific sample portions of the sampled water in the field.
- Stopwatch (GUL), a water-filled plastic bottle (50 mL) and measuring-tape (Hultafors) were used for flow/runoff estimates in stream waters.
- Digital cameras (Olympus 400 mju) were used for documentation of stream waters.

4.4 Performance

4.4.1 Presampling preparations

Prior to sampling, the sample bottles were cleaned (according to the routines for respective SKB class), labeled and packed in insulated boxes/bags. Acid additions were made in advance to bottles intended for trace metal analyses; these were placed in separate plastic bags to avoid contamination. The peristaltic pump system (PPS), including the Teflon tubes, was washed using acid (0.5 M HCl) and rinsed with deionised water before use. The equipment was kept well protected in plastic bags or in tight containers. Calibration of the sondes was performed according to the measurement system description SKB MD 910.003.

4.4.2 Water sampling

Water samples were collected using the peristaltic pump system (PPS), and Ruttner samplers were used as backup if the PPS should fail. Lake and sea water samples were collected close to the surface (at 0.5 m depth). In case of ice coverage during winter, water was also collected from approximately 0.5 m above the lake or sea bottom, in order to sample water both above and below stratification in the lake. Stream water samples were collected at approximately 0.1 m depth. The PPS and sample bottles were rinsed with water from the sampling locations prior to filling, except for bottles with acid additions. The disposable filters (Millipore) were rinsed with sample water before filtering and sampling commenced. To avoid contamination, the field crew wore rubber gloves, and great care was taken not to contaminate bottles or equipment. Bottles and samples containing added acid were handled and stored separately to avoid contaminating other sample portions.

Each sample consists of several sample portions labeled with the same sample number. The preparation of the sample portions in the field differs depending on their use. Details on collected sample portions, components to be analysed and sample preparations are summarised in Table 4-4.

4.4.3 Field measurements

The multi parameter sonde was used for measurements of pH, water temperature, barometric pressure, ORP, PAR (Photosynthetic Active Radiation), turbidity, electrical conductivity, salinity, dissolved oxygen and chlorophyll. Light penetration was measured in lakes and at sea locations with a secchi disc according to the Swedish standard BIN SR 111. Photo documentation of stream waters was performed to facilitate evaluation of the investigation data. Photos were taken of each marked out (using a wooden stake) stream water sampling location.

In stream waters measurements were performed using the YSI 6600 EDS sonde, if the water level was high enough, otherwise the smaller YSI 600 QS sonde was employed. Chlorophyll, PAR and turbidity data were not reported for streams.

Table 4-4. Sample volumes, components and preparation of samples.

🟦 Main monthly programme.
🟩 Modified performance in the extended programme.
🔷 Extended programme four times per year.
🟪 Once a year for lake and sea sites only.

Bottle volume (mL)	Number of bottles	SKB labels	Analyses	Comments	Preparation in field	Filling instructions
250	1	Green	pH, EC, alkalinity, color determination			Fill up
250	1	Green, Anj.	Cl, SO_4, Br, F			Fill up
100	1	Green, Br	Br			Fill up
125	1	Green, HK	Major cations, SO_4-S, Si	Acid washed		Fill up
2,000–2,500	1	Green	PON, POP, POC, chlorophyll a, c and pheophytin			Fill up
100	1	Green, N/P	Tot-N, tot-P			Fill 80%
25	2	Green, D	DIC, DOC		Filtering with syringe/ 0.45 µm filter	Fill 80%
25	1	Green, T	TOC			Fill 80%
25	2	–	Nutrients: NH_4, NO_2, NO_3, PO_4		Filtering with syringe/ 0.45 µm filter	Fill up
1,000	1	Green, Susp.	Suspended material			Fill up
125[a]	2	Green, O_2	O_2	Calibrated Winkler, glass bottle	1 mL Mn(II) reagent + 2 mL alkaline iodine reagent and mix	Flow over 3×
125[a]	2	Green, HS	HS^-	Winkler, glass bottle	1 mL ZnAc + 1 mL 1M NaOH and mix	Flow over 3×
100	1	Green, Br, I	Br, I	Additional anal. in class 5 samples		Fill up
125	1	Red, HK	Major cations, SO_4-S, Si, environmental metals	Acid washed, additional anal. in class 5 samples		Fill up
25	3	–	Nutrients: NH_4, NO_2, NO_3, PO_4		Filtering with syringe/ 0.45 µm filter	Fill up
100	1	Green, D/O	Deuterium, ^{18}O			Fill up
500	1	Green, ^3H	Tritium, ^3H			Flow over 3×
100	2	Red, Arkiv	Archives	Syradiskad	Filtering with syringe/ 0.45 µm filter	Fill up
250	2	Green, Arkiv	Archives			Fill up
125	1	Red, HK	Major cations, SO_4-S, Si, environmental metals, trace metals, B, As, In, 10B/11B	Acid washed, additional anal. in class 5^+ samples		Fill up
1,000	1	Green, Ra/Rn	Ra^{226}, Rn^{222}			Fill up
1,000	1	Green, U/Th	U/Th-isotopes			Fill up
100	1	Green, ^{37}Cl	^{37}Cl			Fill up
100	1	Green, ^{87}Sr	$^{87}Sr/^{86}Sr$			Fill up
1,000	1	Green, ^{34}S	^{34}S			Fill up
100	2	Green, C-iso	^{13}C/pmC			Fill up

[a] Winkler samples only when sonde measurements of oxygen show values below 4 mg/L.

At lake and sea localities the multiple sonde (YSI 6600 EDS) was used to measure a profile at each sampling point. Measurements were conducted at every metre from the surface to the bottom, see Table 4-5. In addition, PAR was logged just below the surface and during the ice season above the ice, in the air. PAR measurements were performed at discrete depths and as continuous PAR-profile loggings. PAR-profiles were obtained by setting the sonde mode to ‘continuous logging’. The sonde was then submerged from surface to bottom and hoisted up again. The produced PAR-data were used for regression analyses of PAR versus depth.

A simple “floating bottle” method /6/ was applied to measure water flow/runoff in the streams as a complement to the regular method using discharge weirs and gauges. The cross-section mean area of the stream was estimated, forming a rectangle, see Figure 4-5. The time for the bottle (close to neutral in weight in water) to float the distance (L) from point A to B was measured with a stopwatch. This procedure was repeated three times in each stream. The average water velocity (m/s) multiplied with the average area (m^2) resulted in a rough water runoff estimate (m^3/s).

Table 4-5. Logging depths at sampling locations in lakes and shallow sea bays.

Sampling locations	Name	Sonde logging depth (m)											
		0.5	1	1.5	2	2.5	3	4	4.5	5	6	6.5	7
Lakes													
PFM000074	Labboträsket	X											
PFM000097	Norra bassängen	X											
PFM000107	Bolundsfjärden	X	X										
PFM000117	Eckarfjärden	X	X	X									
Shallow sea bays													
PFM000062	SV-Forslingens grund	X	X		X		X						
PFM000082	Alternative to PFM00062	X	X		X		X	X		X	X	X	

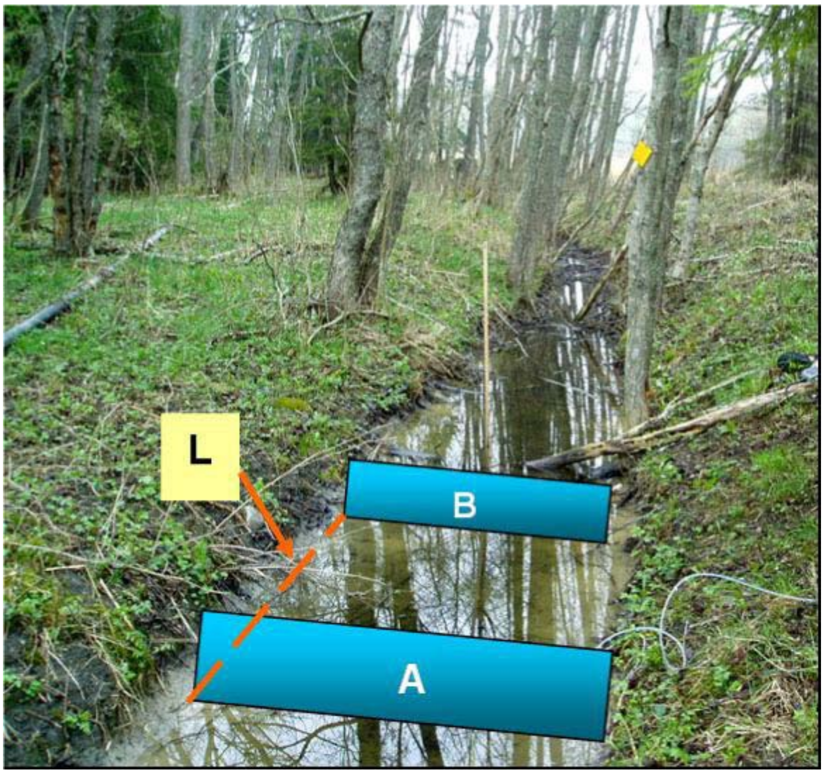


__Figure 4-5.__ Schematic presentation for estimating water runoff in natural stream waters (see text for explanation). Sampling location PFM000073 (Söder Bredviken).

4.4.4 Sample treatment and chemical analyses

An overview of sample treatment and analytical methods is given in Appendix 4. The routines are applicable independently of sampling method or type of sampling object.

4.4.5 Data handling/post processing

Two field protocols (activity log and sampling protocol) contain metadata (id-code, date, time, sample no., field crew etc), a few measured data and weather observations, as well as comments on field conditions which may influence the analytical results. The field protocols supply basic information for creating activities and activity comments in the SKB Sicada database. In addition, the few measured parameters and weather conditions, noted on the sampling protocol, are stored as data tables in Sicada.

Furthermore, deviations from the sampling programme or from the normal routines, if any, are also documented in special reports/comment files. The comment files are stored in the Sicada file archive, see Table 4-6.

Analytical data

The routines for quality control and data management described Appendix 4 are generally applied for hydrogeochemical analysis data, independently of sampling method or type of sampling object.

Field measurement data

The logged data from sonde measurements are exported digitally from the YSI Terminal 650-MDS to the specified Sicada data table. The original raw data file, calibration file and calibration protocol from each sonde, as well as photographs and comments on sampling and measurements, are stored in the Sicada file archive, see Table 4-6.

Other relevant information and data

Information about weather conditions and related parameters during the sampling occasions are compiled in a separate table in Sicada called "Weather_data" which contains the following columns:

Air temperature
Cloudiness
Precipitation
Wind velocity
Wind direction
Light penetration (lakes and sea)
Runoff/Water flow
Water depth
Snow/ice depth

These data are not presented in this report.

Table 4-6. File types stored in the Sicada file archive.

Type of file	Example of file name	No. per sampling session
Raw data file	L580438.dat	1 or 2*
Comments	Noterat V38.doc	1
Calibration data file	000113CF.txt	1 or 2*
Calibration protocol	Stora sonden V38år04.xls	1 or 2*
Photography	PFM66.jpg	1–4
Light data file	PAR-profiler V38_04.xls	1

* Depending on the number of measuring sondes used.

Figure 4-6. *The sampling site in the stream PFM0070. Sonde measurements in progress.*

4.4.6 Nonconformities

The only nonconformities that occurred during the reported sampling period was that flow measurements in the streams could not be performed due to ice or too much water vegetation. The reasons for deviations from the programme are compiled in Tables 4-7 and 4-8.

Table 4-7. Collected samples and conducted measurements.

Year 2009		**Week**											**Sum**
		3	**7**	**11**	**16**	**20**	**25**	**33**	**36**	**41**	**45**	**49**	
Sonde													
YSI 6600		X	X	X	X	X	X	X	X	X	X	X	**11**
Sea	**Name**												
PFM000062	SV-Forslingen	X	X	X	X	X	X	X	X	X	X	X	**11**
PFM000082	Alt PFM000062												**0**
PFM102269	Biotesten	X*	X*	X*	X*	X*	X*	X*	X*	X*	X*	X*	**11**
Stream													
PFM000066	Ö-Gunnarsbo	X	X	X	X	X	X	X	X	X	X	X	**11**
PFM000068	Kungsträsket	X	X	X	X	X	X	X	X	X	X	X	**11**
PFM000069	Bolundsskogen	X	X	X	X	X	X	X	X	X	X	X	**11**
PFM000070	N-Eckarfjärden	X	X	X	X	X	X	X	X	X	X	X	**11**
Lakes													
PFM000074	Labboträsket	X	X	X	X	X	X	X	X	X	X	X	**11**
PFM000097	Norra Bassängen	B	B	B	B	B	B	B	B	B	B	B	**11**
PFM00107	Bolundsfjärden	X	X	X	X	X	X	X	X	X	X	X	**11**
PFM00117	Eckarfjärden	X	X	X	X	X	X	X	X	X	X	X	**11**
Sum		**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	

Explanations and abbreviations:
X: Sample taken.
B: No sample, only field measurements with sonde.
* Only tritium and anions samples.

Table 4-8. Comments on measurements/water sampling.

Year 2009		Week										
		3	7	11	16	20	25	33	36	41	45	49
Sea	**Name**											
PFM000062	SV-Forslingen											
PFM000082	Alt PFM62											
PFM102269	Utlopp Biotesten											
Stream												
PFM000066	Ö-Gunnarsbo	C	CZ	C				F	F	F	F	
PFM000068	Kungsträsket	C	C	C				B	F	F	F	
PFM000069	Bolundsskogen		CZ	CZ						F	F	
PFM000070	N-Eckarfjärden		CZ	C		F		B	B	F	F	
Lakes												
PFM000074	Labboträsket	Z	Z	Z								
PFM000097	N. bassängen	Z	Z	Z								
PFM00107	Bolundsfjärden	AZ	AZ	AZ								
PFM00117	Eckarfjärden	AZ	AZ	AZ								

Explanations to codes/abbreviations:
A: Two samples collected. Surface and bottom water sampled separetely due to winter stagnation in lake.
B: Too much water vegetation, no flow measurement.
C: Water completely frozen, no flow measurement.
F: Flow rate too low, no flow measurement.
Z: Winkler samples (2) collected, due to low oxygen level.

4.5 Results

4.5.1 General

The surface water investigation period from January to December 2009 includes records of 105 water analyses (i.e. number of analysed samples) and records of 176 field measurements. Furthermore, the accompanying field documentation is quite extensive. The data are compiled in the attached Appendices 10 to 13 and stored in the Sicada database where they are traceable by the activity plan number.

Fresh waters in the Forsmark area are well buffered with high alkalinity, high pH and high calcium concentrations. In addition, waters affected or recently affected by brackish sea water still show high sodium chloride concentrations. The relationship between the position of the coastline and the salinity of the water samples collected at the sampling locations in the area has been demonstrated in /7/. Furthermore, a detailed evaluation of surface water data from March 2002 to March 2004 was presented in /8/.

The results presented and compiled in this section are restricted to field work performed between January and December 2009. Besides the regular sampling locations, sampling has been performed close to the cooling water outlet into Lake Biotestsjön at eleven occasions during the period.

4.5.2 Field measurement data

The field measurement data including redox potential, pH, dissolved oxygen, electrical conductivity, salinity, measurement depth, barometric pressure, turbidity, chlorophyll, light penetration, and water temperature are compiled in Appendix 10. The PAR-profile logs are presented as diagrams including regression constants in Appendix 11. Three sets of data are of lower quality: 1) water flow rate estimations by the float method, 2) sonde measurements (YSI 6600 EDS) of chlorophyll, and 3) turbidity measurements, also by the sonde.

- The water flow rate estimations by the float method are of low accuracy compared to measurements using discharge weirs and gauges. They were performed in order to allow comparison between early data obtained when there was no other available method and new data from installed measurement stations (Appendix 12).

- The chlorophyll measurements have been problematic, possibly due to the fact that humic substances and chlorophyll have similar fluorescence in the wavelength used by the sonde. Since the inland waters show high concentrations of humic substances and the sonde interprets humus as chlorophyll, the amount of chlorophyll tends to be overestimated.
- The turbidity measurements performed in the sea and in lakes often display negative values. This may be due to bad probe sensitivity in clear waters (turbidity weak waters).

Comments on the low quality of chlorophyll and turbidity data as well as explanations to these circumstances are stored in the Sicada database.

4.5.3 Water analyses

Major components

The basic water analyses include the major constituents Na, K, Ca, Mg, Sr, S, SO_4^{2-}, Cl^-, Si and HCO_3^- as well as the minor constituents Fe, Li, Mn, Br, F^-, I and HS^-. Furthermore, batch measurements of pH and electrical conductivity are included. The basic water analysis data are compiled together with field measurements of pH and water temperature in Appendix 13.

The charge balance errors give an indication of the quality and uncertainty of the analyses of major constituents. None of the 94 samples/datasets show errors exceeding ± 10% and in seven cases the errors exceed ± 5%.

To provide a rough check of the data, the electrical conductivity values are plotted versus the corresponding chloride concentrations in Figure 4-7. As shown, the surface water data generally agree well with a regression line.

Sulphate by ion chromatography and sulphate calculated from total sulphur by ICP are compared in Figure 4-8. As shown, within the analytical error most of the sulphur is present as sulphate. However, divergent values may be due to high sulphide concentrations. The total sulphur by ICP increases disproportionately at high sulphide concentrations due to hydrogen sulphide gas entering the plasma.

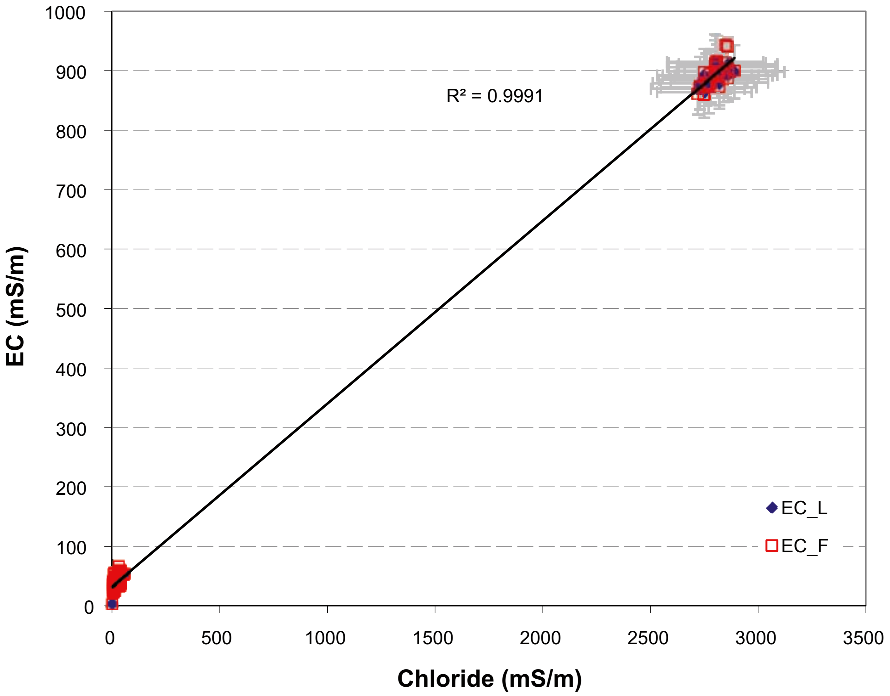


Figure 4-7. *EC (Electrical Conductivity) versus chloride concentrations. EC_L = Laboratory value, EC_F = Field value. The measurement uncertainty is shown as error bars.*

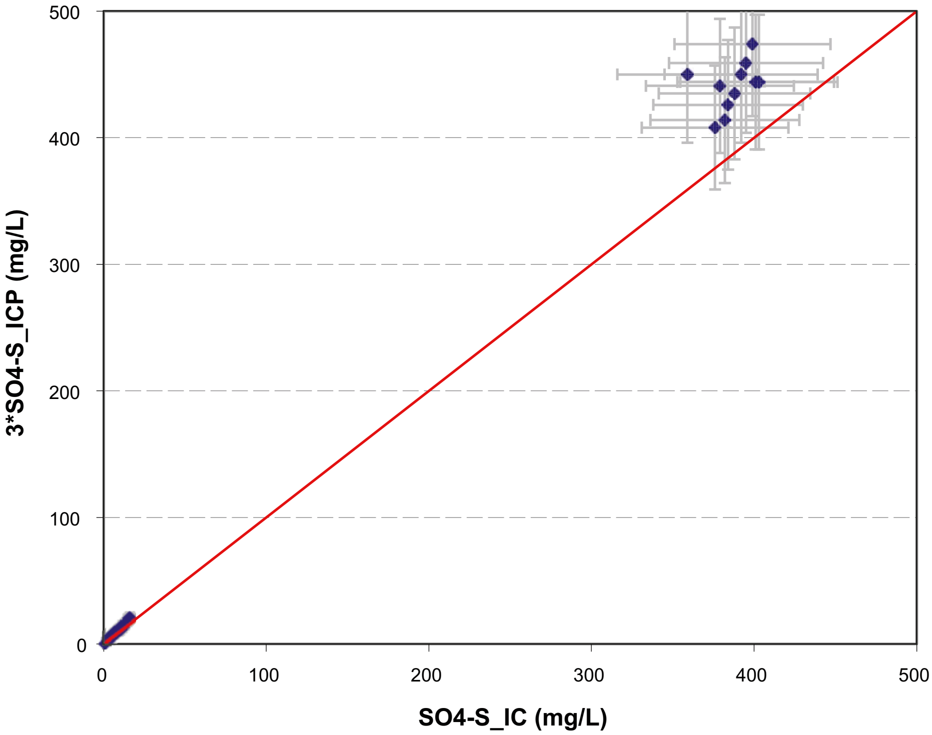


Figure 4-8. *Sulphate (SO_4^- by IC) versus sulphate calculated from total sulphur (3×SO_4^-S) by ICP. The measurement uncertainty is shown as error bars.*

As established earlier /9/, bromide determinations by ion chromatography may be difficult at high chloride concentrations. Selected bromide values (in most cases ICP results) for each sample are plotted versus the corresponding chloride concentrations in Figure 4-9 as a consistency check. The points do not differ too much from the linear trend and the data are therefore considered acceptable.

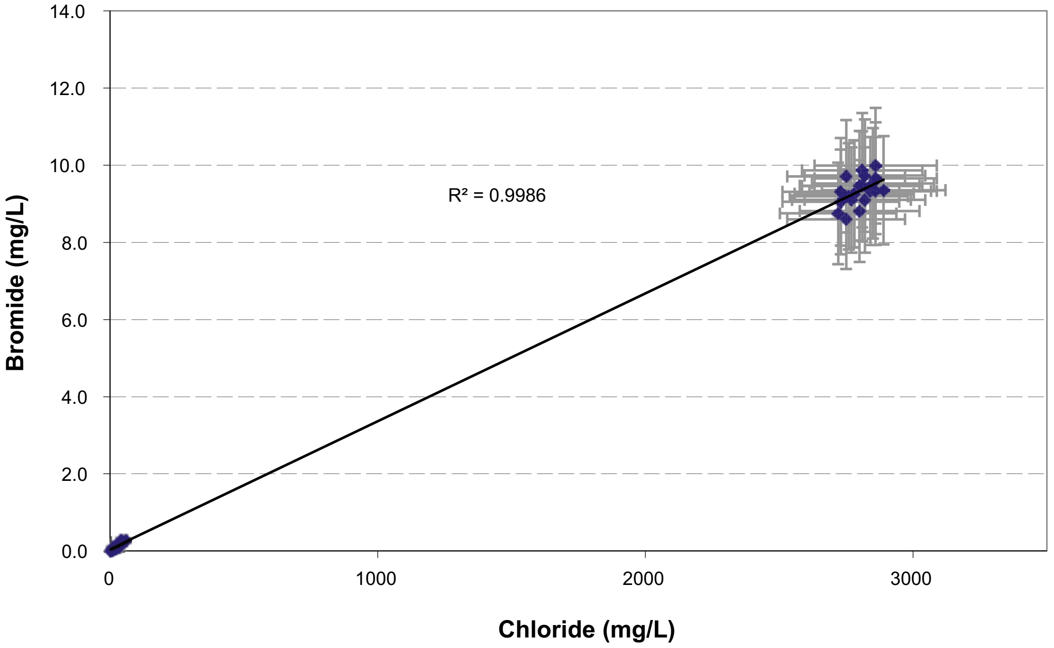


Figure 4-9. *Bromide versus chloride. The measurement uncertainty is shown as error bars.*

Surface water supplements

The surface water supplements include NH_4-N, NO_2-N, NO_3-N+NO_2-N, NO_3-N, tot-N, tot-P, PO_4-P, TOC, DOC, DIC and sometimes at a few sampling occasions also dissolved oxygen. The analytical data are compiled in Appendix 13. The DIC values should be used with care and bicarbonate values (by alkalinity titration) are considered more reliable.

Isotopes

The isotope determinations include the stable isotopes δD, δ^{18}O, ^{10}B/^{11}B, δ^{34}S, δ^{13}C, δ^{37}Cl and ^{87}Sr/^{86}Sr as well as the radioactive isotopes Tr (TU), ^{14}C (pmC), ^{238}U, ^{235}U, ^{234}U, ^{232}Th, ^{230}Th, ^{226}Ra and ^{222}Rn. The isotope data are compiled in Appendix 13.

Tritium

It has been suggested that the adjacent nuclear power plant may have influenced the natural conditions for the tritium and ^{14}C isotopes /9/. Some relation between the presence of these isotopes and distance from the nuclear power reactors was observed during a previous sampling period, March 2004–June 2005. In order to better understand the tritium data, repeated tritium determinations from close to the outlet of reactor cooling water (PFM102269) commenced in July 2005.

Elevated tritium values from the outlet of cooling water have been observed in July 2005 /10/, in three samples from the period July 2006–June 2007 /11/ and in three samples from 2008 /1/. During 2009 one sample, collected in August, showed elevated tritium concentration, see Figure 4-10.

Trace metals

The analyses of trace elements include Al, As, Cd, Cr, Cu, Co, Hg, Ni, Zn, Pb, V, Mo and Ba. The trace element data are compiled in Appendix 13. These elements are generally present at low concentrations in the groundwater, and the risk for contamination is high. Especially data on common metals like Al, Cr, Cu, Co, Ni and Zn must be used with caution. Generally, the distribution of data is location specific, but outliers do exist; significantly large deviating concentrations for a sampling location are rejected in the Sicada database.

4.5.4 Water composition

The relative proportions between the major constituents calcium, magnesium, sodium, potassium, sulphate and chloride differ between the different sampling locations (freshwater bodies and the sea water). Figures 4-11 and 4-12 show the relative proportions of the most common cations and anions, respectively.

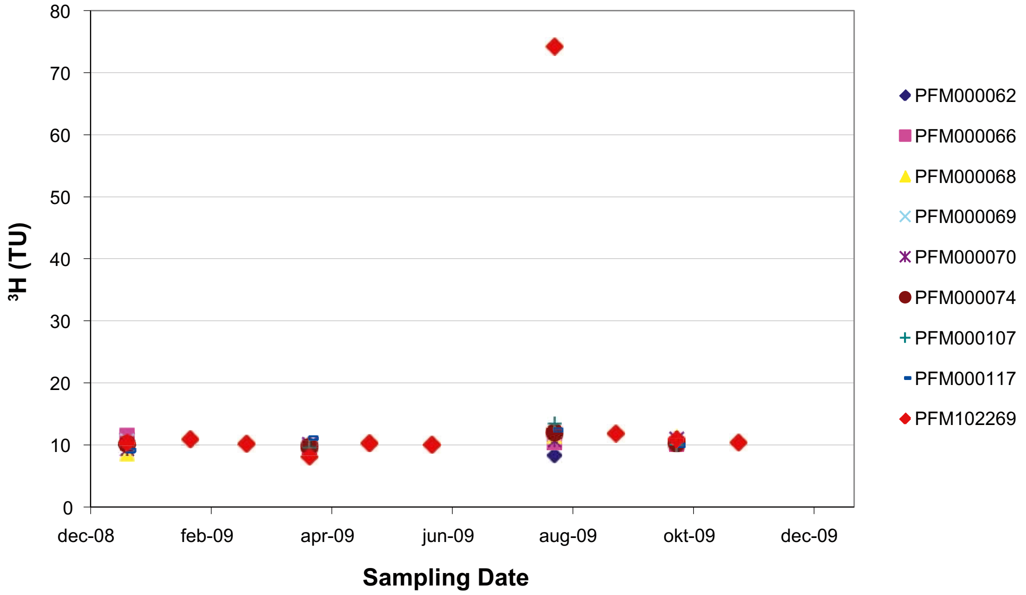


__Figure 4-10.__ Tritium concentrations during January–December 2009.

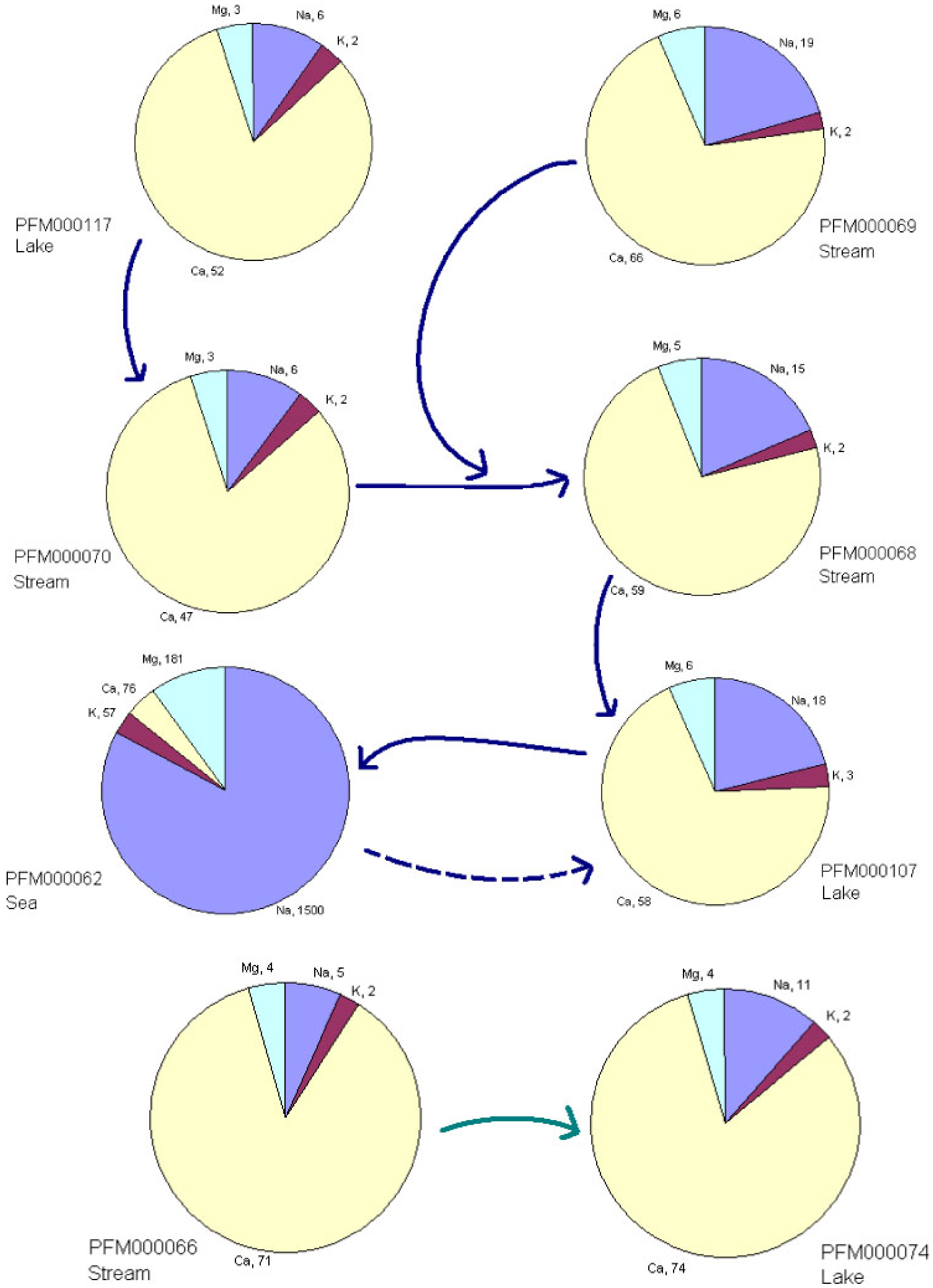


Figure 4-11. *Relative proportions of the cations* Na^+*,* K^+*,* Ca^{2+}*,* Mg^{2+}*,* NH_4*_N based on average values during the sampling period. The average values (mg/L) are displayed after each cation in the diagrams. The arrows show the path of the surface water between the lakes and streams. The occasional inflow of sea water into Lake Bolundsfjärden (PFM 000107) is indicated by a dotted arrow. The Lake Labboträsket (PFM000074) and the stream PFM000066 belong to a different catchment area.*

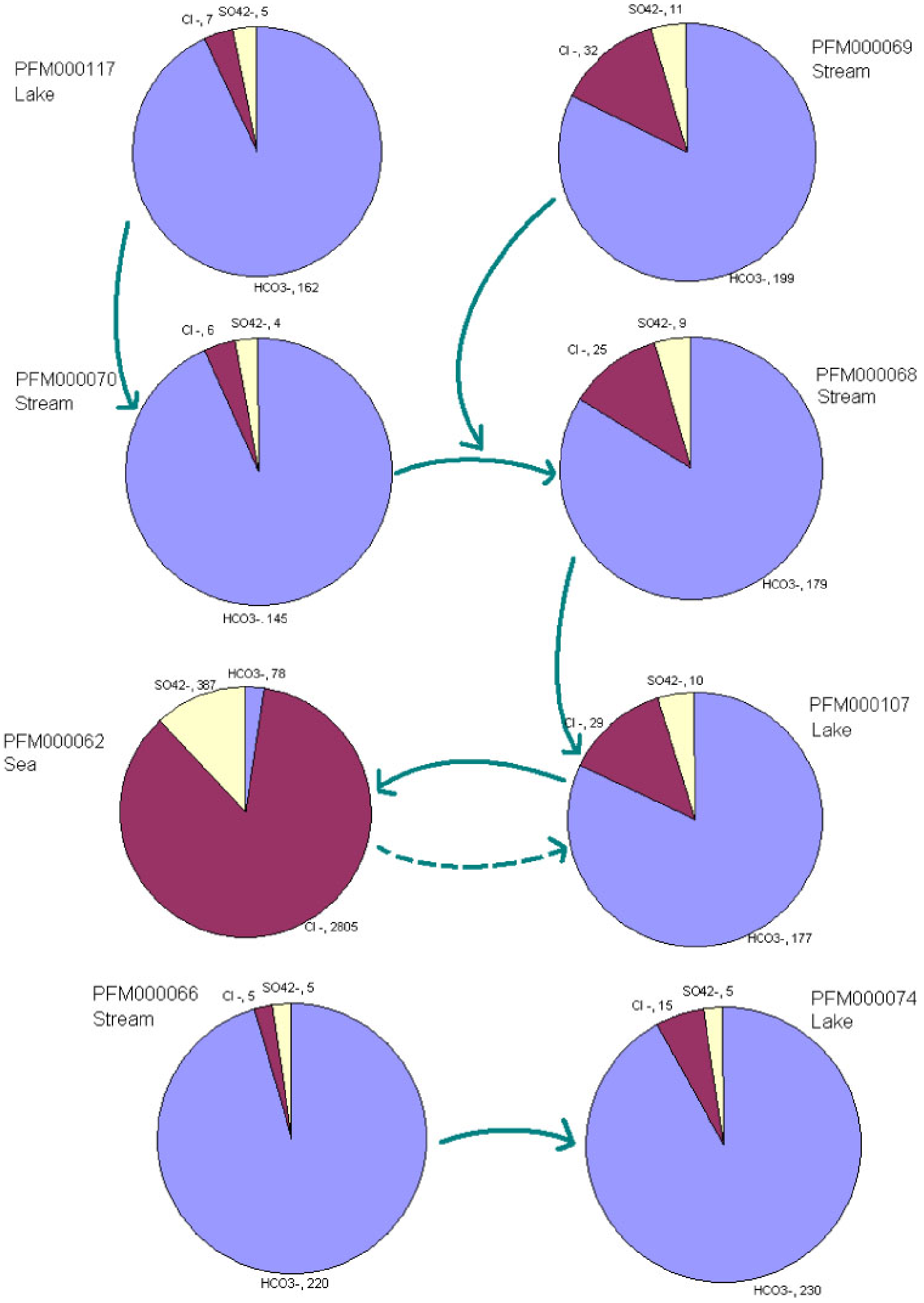


Figure 4-12. *Relative proportions of the anions Cl^-, HCO^{3-}, SO_4^{2-}, PO_4^{2-}_P, NO_3_N+ NH_2_N based on the average values (given in the diagrams in mg/L) during the sampling period. The arrows show the path of the surface water between the lakes and streams. The occasional inflow of sea water into Lake Bolundsfjärden (PFM 000107) is indicated by a dotted arrow. The Lake Labboträsket (PFM000074) and the stream PFM000066 belong to a different catchment area.*

In the investigated lakes and streams, bicarbonate is by far the most common anion, which is explained by the limestone rich surroundings. Lake Bolundsfjärden (PFM000107) is, however, characterized by irregular inflow of brackish sea water. During 2009 as well as during 2008, however, no significant inflow of sea water occurred into Lake Bolundsfjärden.

4.5.5 The NP-ratio in the surface water

The nutrients, nitrogen and phosphorus, are often the limiting factors for the primary production. Primary producers such as plants and phytoplankton use nitrogen and phosporus in a ratio of about 16 mol nitrogen to 1 mol phosphorous (also known as the Redfield ratio) or 7:1 in terms of mass. A ratio deviating from 16 (or 7) indicates that the primary production is limited by either nitrogen or phosphorus. When nitrogen is present in excess the ratio will be higher than 16, indicating that lack of phosphorus is limiting the growth. Whereas lower ratios indicate nitrogen limitations, which may favour growth of blue green algae able to use nitrogen from the air. In fresh water, phosphorus is usually the limiting nutrient, whereas in the oceans it is usually nitrogen.

Figure 4-13 shows the relationship between nitrogen and phosphorous in the surface water of the investigated streams, lakes and coastal bays in the Forsmark area. The lakes and streams are phosphorus limited with high concentrations of nitrogen. The coastal bay in the Baltic Sea (PFM000062) is also phosphorous limited, although the ratio is much lower.

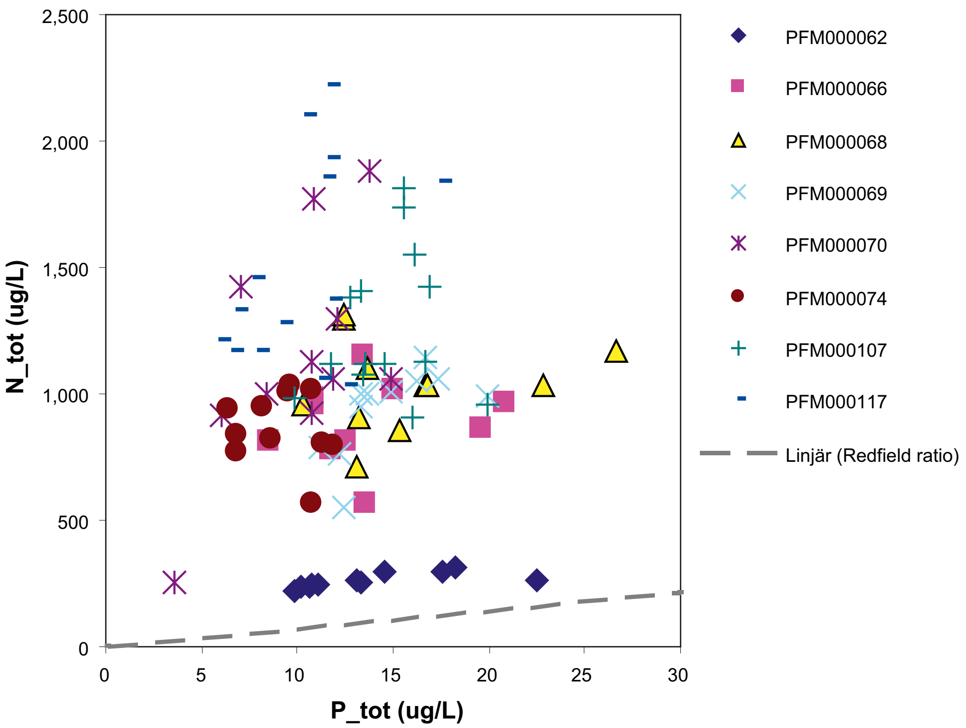


***Figure 4-13.** The relationship between nitrogen and phosphorus in the surface water of the investigated streams, lakes and coastal bays in the Forsmark area. The Redfield ratio (7:1) is indicated. Values above and below the line indicate phosphorus limitation and nitrogen limitation, respectively.*

4.6 Summary and discussion

The chemical investigation routines for surface waters are well established after more than five years of field work, reporting and data administration, and this period of the long-term surface water monitoring programme has passed without any major nonconformities or surprises. The main experiences and conclusions from surface water sampling and analyses during the sampling period January to December 2009 are summarised below:

- The statements/findings regarding the character of the surface waters after five years of sampling and analyses remain unchanged.
- Sampling performed close to the outlet of cooling water from the power plant revealed one enhanced tritium value during the reported time period.
- Fresh waters in the Forsmark area are well buffered with high alkalinity, high pH and high calcium concentrations.

4.7 Summary of data, 2005–2009

Hydrochemical data from the period January 2005 to December 2009 have been plotted in Figures 4-15 to 4-34 to reveal seasonal variations as well as fluctuations between different years. The sampling dates and number of collected samples are presented in Table 4-9. The type and number of performed analyses vary between years and sites.

Figure 4-14. *Winter sampling of lake water.*

Table 4-9. Collected samples (X) during the period January 2005 to December 2009.

Year	Month	PFM62	PFM66	PFM68	PFM69	PFM70	PFM74	PFM107	PFM117	PFM102269
2005	January	X	X	X	X	X	X	X	X	
	February	X	X	X	X	X	X	X	X	
	March		X	X	X	X	X	X	X	
	April	X	X	X	X	X	X	X	X	
	May	X	X	X	X	X	X	X	X	
	June	X	X	X	X	X	X	X	X	
	July	X	X	X	X	X	X	X	X	X
	August	X	X	X	X	X	X	X	X	
	September	X	X	X	X	X	X	X	X	
	October	X		X	X	X	X	X	X	
	November	X	X	X	X	X	X	X	X	
	December	X	X	X	X	X	X	X	X	
2006	January		X	X	X	X	X	X	X	X
	February		X	X	X	X	X	X	X	X
	March		X	X	X	X	X	X	X	X
	April	X	X	X	X	X	X			X
	May	X	X	X	X	X	X	X	X	X
	June	X	X	X	X	X	X	X	X	X
	July	X					X	X	X	X
	August	X					X	X	X	X
	September	X		X		X	X	X	X	X
	October	X					X	X	X	X
	November	X	X	X	X	X				X
	December	X	X	X	X	X	X	X	X	X
2007	January	X	X	X	X	X		X		X
	February	X	X	X	X	X	X	X	X	X
	March	X	X	X	X	X	X	X	X	X
	April	X	X	X	X	X	X	X	X	X
	May	X	X	X	X	X	X	X	X	X
	May	X	X	X	X	X	X	X	X	X
	June	X	X	X	X	X	X	X	X	X
	August	X		X			X	X	X	X
	September	X					X	X	X	X
	October	X		X	X		X	X	X	X
	November	X	X	X	X	X	X	X	X	X
	December	X	X	X	X	X				X
2008	January	X	X	X	X	X	X	X	X	X
	February	X	X	X	X	X	X			X
	March	X	X	X	X	X		X	X	X
	April	X	X	X	X	X	X	X	X	X
	May	X	X	X	X	X	X	X	X	X
	June	X	X	X	X	X	X	X	X	X
	August	X					X	X	X	X
	September	X	X	X	X	X	X	X	X	X
	October	X	X	X	X	X	X	X	X	X
	November	X	X	X	X	X	X	X	X	X
	December	X	X	X	X	X				X
2009	January	X	X	X	X	X	X	X	X	X
	February	X	X	X	X	X	X	X	X	X
	March	X	X	X	X	X	X	X	X	X
	April	X	X	X	X	X	X	X	X	X
	May	X	X	X	X	X	X	X	X	X
	June	X	X	X	X	X	X	X	X	X
	August	X	X	X	X	X	X	X	X	X
	September	X	X	X	X	X	X	X	X	X
	October	X	X	X	X	X	X	X	X	X
	November	X	X	X	X	X	X	X	X	X
	December	X	X	X	X	X	X	X	X	X
Sum		**55**	**50**	**54**	**52**	**52**	**54**	**54**	**53**	**47**

Salinity, pH and major components

The seasonal variation in pH values during the period January 2005 to December 2009 is presented in Figures 4-15 to 4-17. Generally, pH is highest in late summer around August and lowest in winter (January–March). Naturally, the largest pH-variations are observed in the lakes, the streams comes next and the sea sampling location show very small variation. Since the relative concentrations of the bicarbonate concentrations are pH dependent, these concentrations follow more or less the same pattern, Figures 4-18 and 4-19. The bicarbonate (HCO_3) in the fresh waters mainly originates from calcium bicarbonate and the calcium concentrations vary in a similar pattern, see Figure 4-20. The EC (Electrical Conductivity) is a measure of the salinity and it, generally, shows an irregular variation, Figures 4-21, 4-22 and 4-23. An exception is Lake Eckarfjärden with a clear seasonal variation, i.e. high EC during winter-early spring and low EC during late summer. The sea water inflow into Lake Bolundsfjärden in early 2007 is clearly indicated in Figures 4-21 and 4-24.

Nutrients

The ammonium (NH_4) concentration trends are displayed in Figures 4-25, 4-26, and 4-27, and the phosphate (PO_4) trends are presented in Figures 4-28, 4-29, and 4-30. The ammonium concentrations in fresh waters peak during summer (August) while the phosphate concentrations peak during winter. In sea water the highest concentrations of both phosphate and ammonium are observed in winter (Figures 4-27 and 4-30).

Carbon

Total organic carbon (TOC) generally varies between 15–25 mg/L, with no discernable seasonal pattern (Figure 4-31). However, during winter and early spring 2009, TOC values of near 40 mg/L were recorded. Naturally, dissolved organic carbon (DOC) varies in a similar way and in the same range (Figure 4-32) since most of the carbon species is present as a small fraction that passes the 0.40 micrometer filter.

Tritium

The tritium contents in the stream and lake waters show little seasonal or interannual variation (Figure 4-33). Elevated tritium concentrations have been observed occasionally in water samples from close to the outlet of reactor cooling water. During 2009, this occurred once, in August, see Figure 4-34.

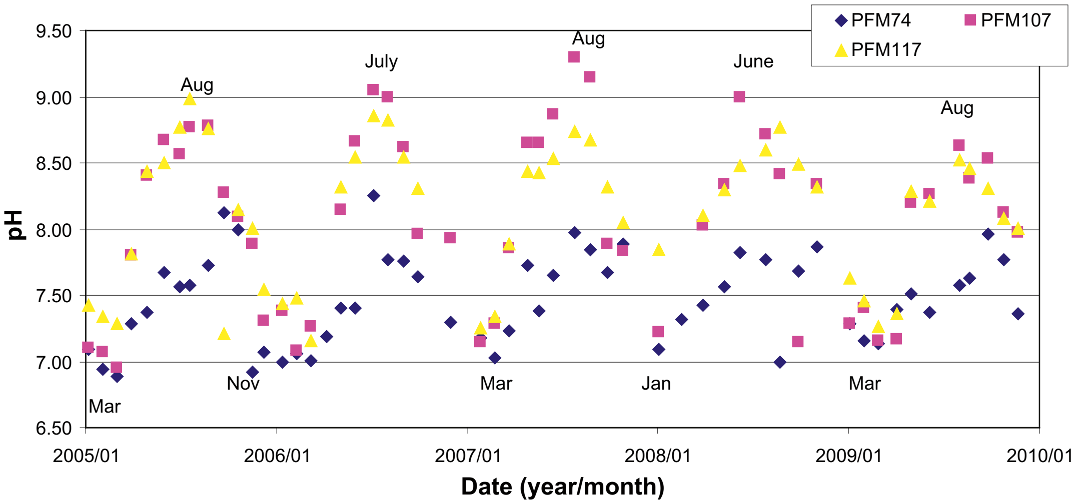


Figure 4-15. *pH in the three lakes Labboträsket (PFM 74), Bolundsfjärden (PFM 107) and Eckarfjärden (PFM117). The months in which the pH peaks and drops are indicated.*

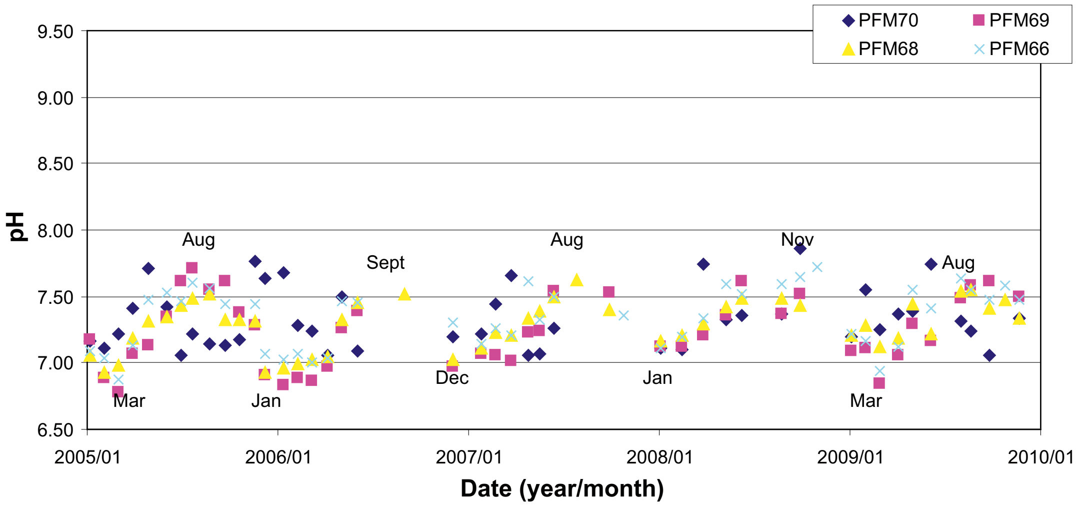


Figure 4-16. *pH in the four investigated streams (PFM66, 68,69 and 70). The months in which the pH peaks/drops are indicated.*

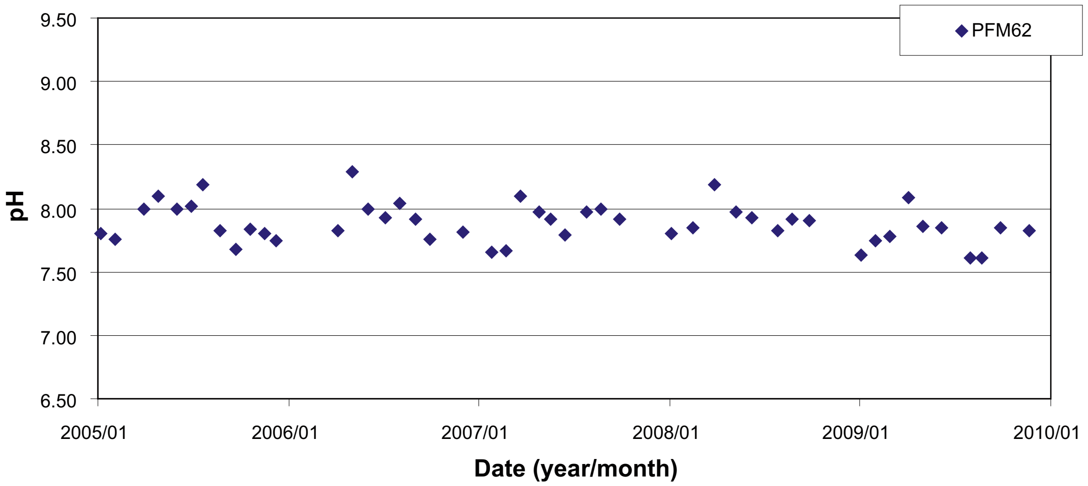


Figure 4-17. *pH at the site situated in the coastal bay (PFM62).*

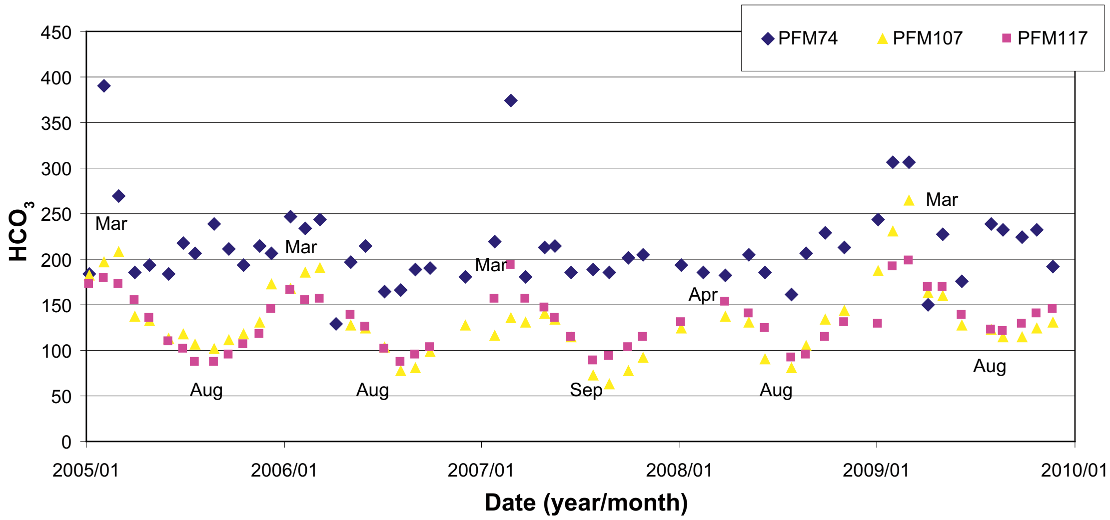


Figure 4-18. *Bicarbonate concentrations in Lake Labboträsket (PFM 74), Lake Bolundsfjärden (PFM 107) and Lake Eckarfjärden (PFM117). The months with peaks or drops are indicated.*

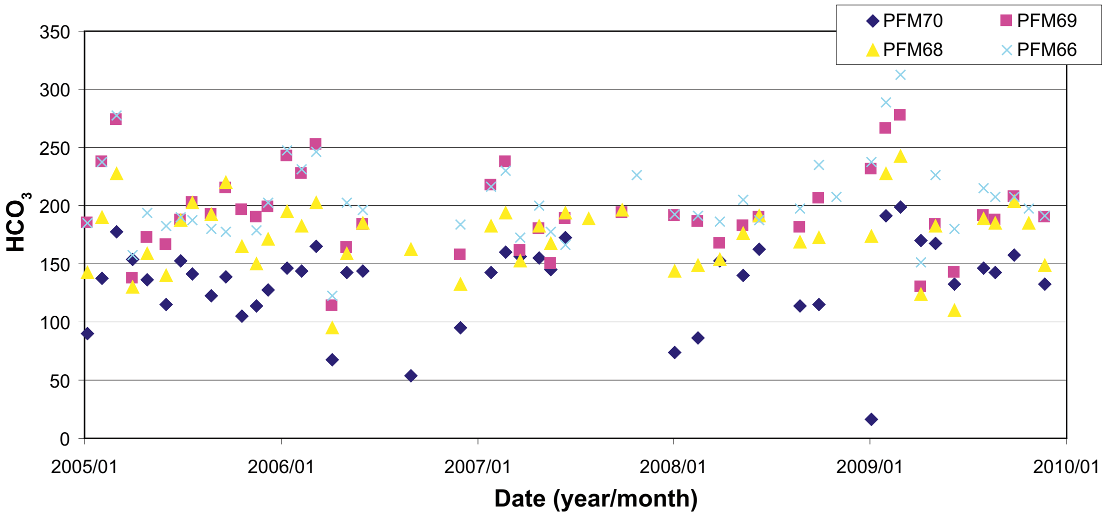


Figure 4-19. *Bicarbonate concentrations in the stream sampling locations (PFM 66, PFM68, PFM69 and PFM70).*

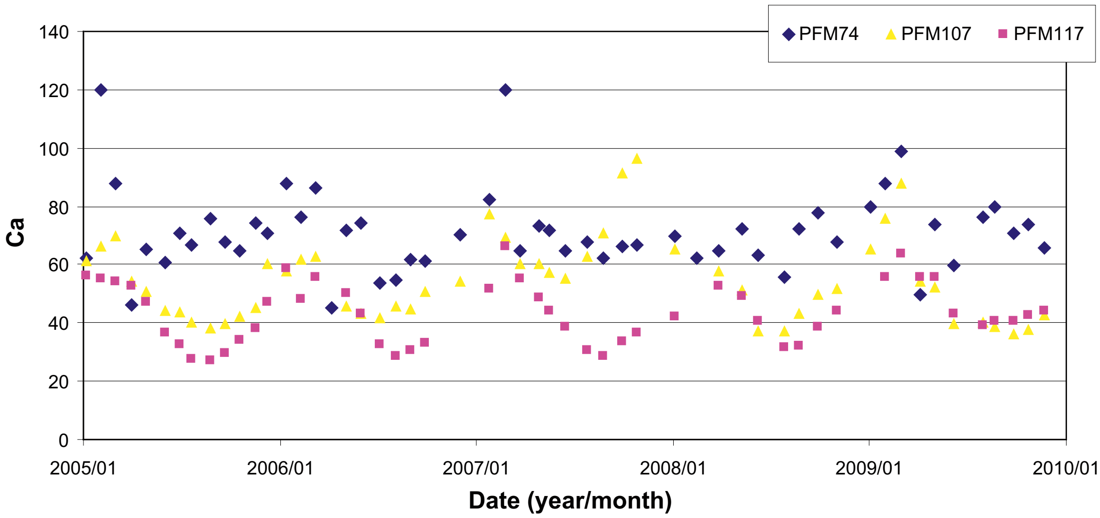


Figure 4-20. *Calcium concentrations in the three lakes Labboträsket (PFM 74), Bolundsfjärden (PFM 107) and Eckarfjärden (PFM117).*

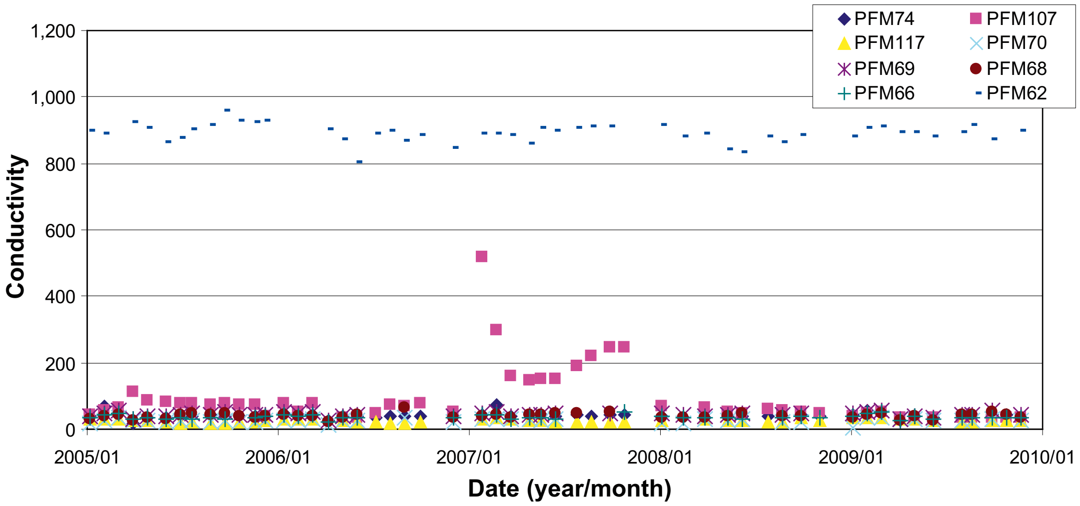


Figure 4-21. *Electrical conductivity in the three lakes (PFM74, 107 and 117), four streams (PFM66, 68, 69 and 70) and one coastal bay (PFM62).*

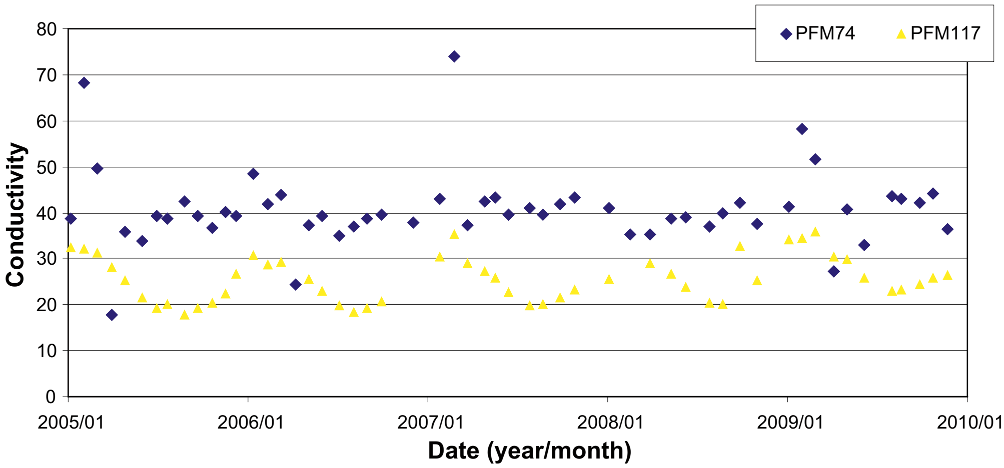


Figure 4-22. *Electrical conductivity in two of the lakes Labboträsket (PFM 74), and Eckarfjärden (PFM117).*

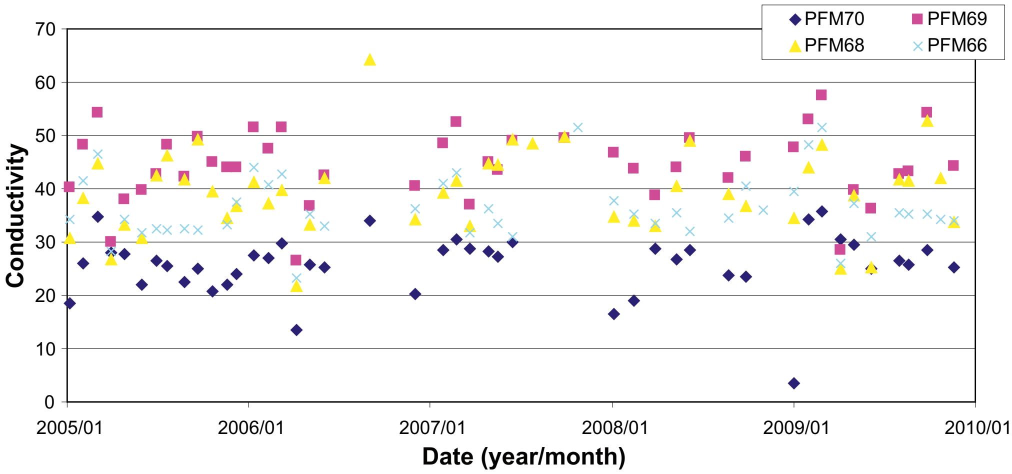


Figure 4-23. *Electrical conductivity in the four investigated streams (PFM 66, 68, 69 and 70).*

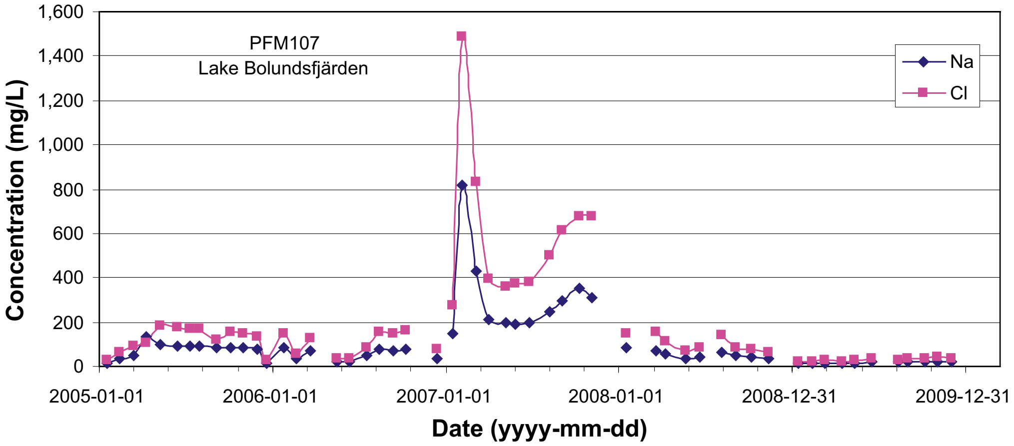


Figure 4-24. *Concentrations of sodium (Na^+) and chlorine (Cl^-) in Lake Bolundsfjärden (PFM 107).*

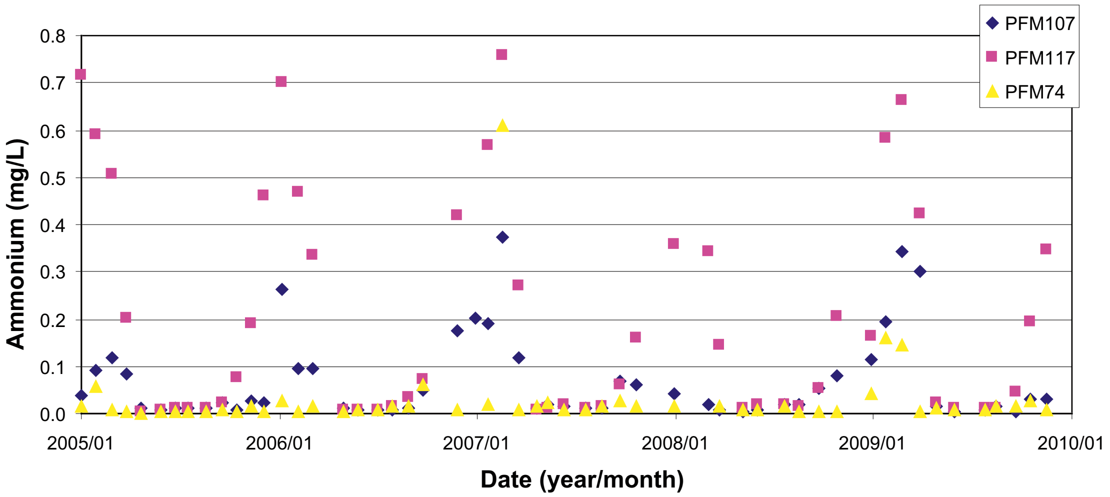


***Figure 4-25.** Concentrations of ammonium (NH_4) in the three lakes Labboträsket (PFM74), Bolundsfjärden (PFM 107) and Eckarfjärden (PFM117).*

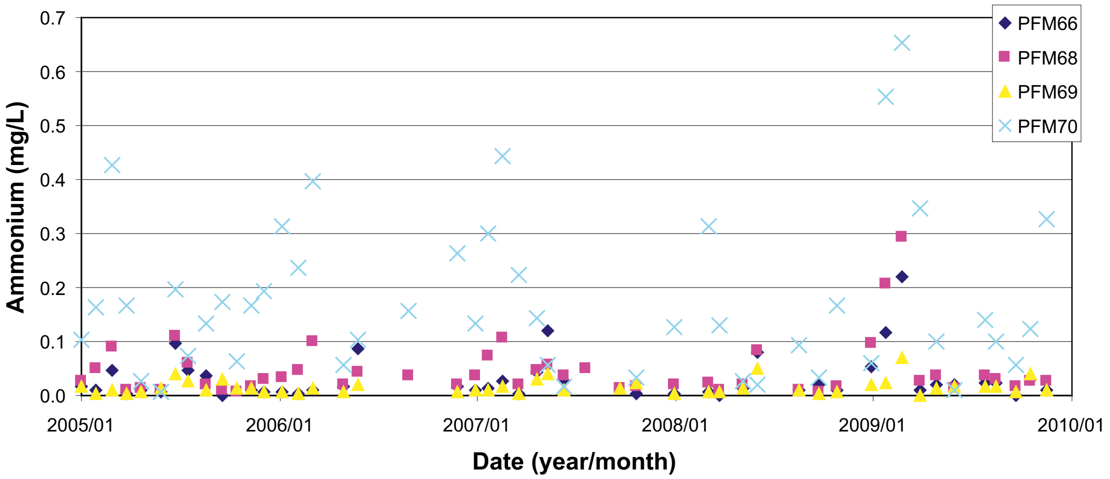


***Figure 4-26.** Concentrations of ammonium (NH_4) in the four investigated streams (PFM66, 68, 69 and 70).*

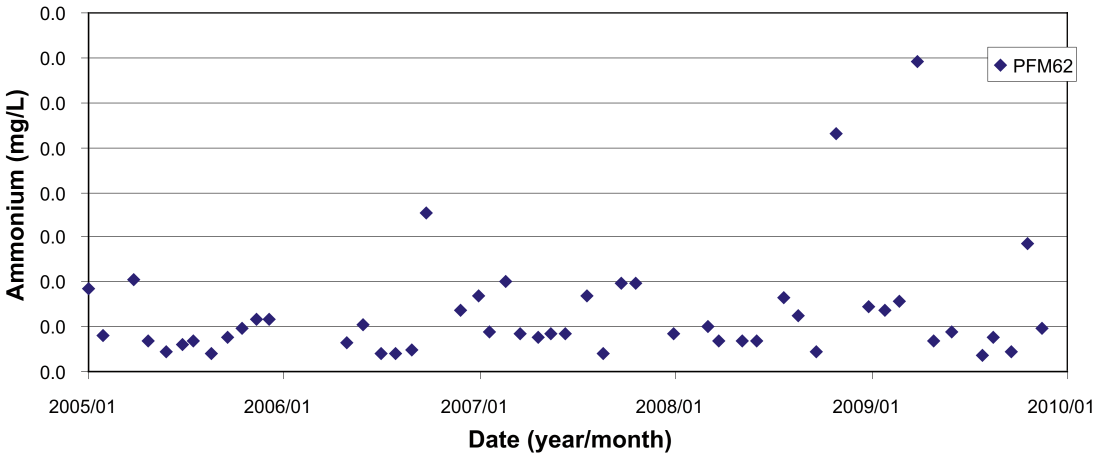


***Figure 4-27.** Concentrations of ammonium (NH_4) in the coastal bay (PFM62).*

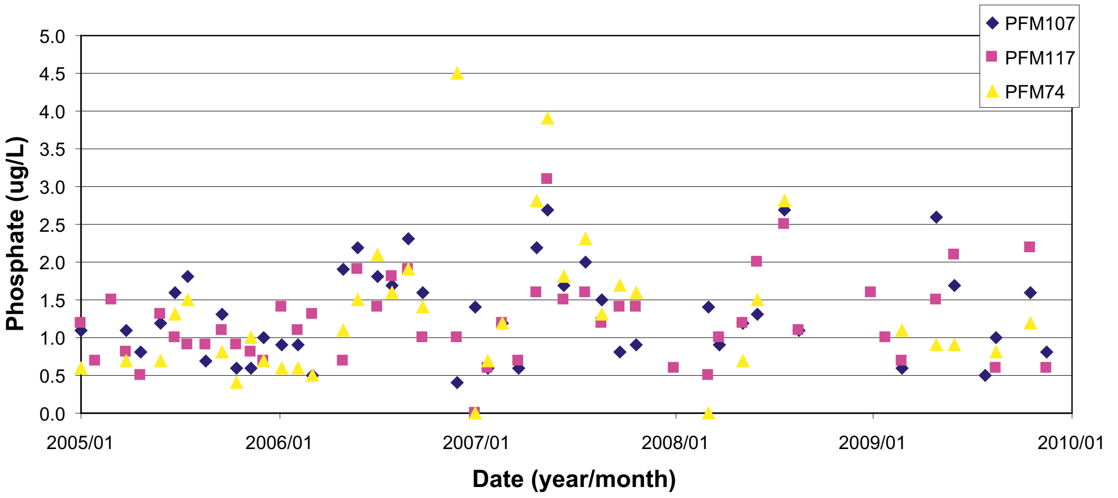


Figure 4-28. *Concentrations of phosphate (PO$_4$) in the three lakes Labboträsket (PFM74), Bolundsfjärden (PFM 107) and Eckarfjärden (PFM117).*

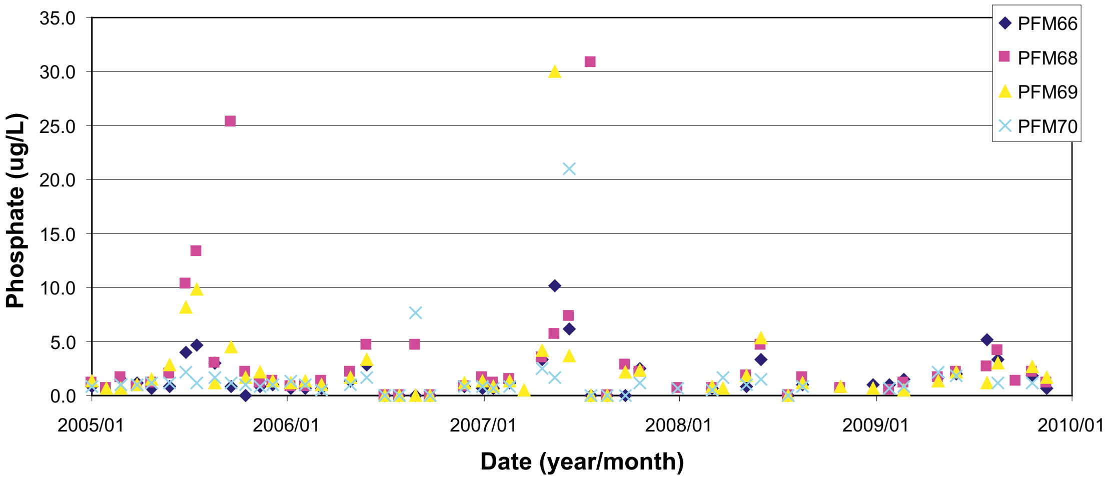


Figure 4-29. *Concentrations of phosphate (PO$_4$) in the four investigated streams (PFM66, 68, 69 and 70).*

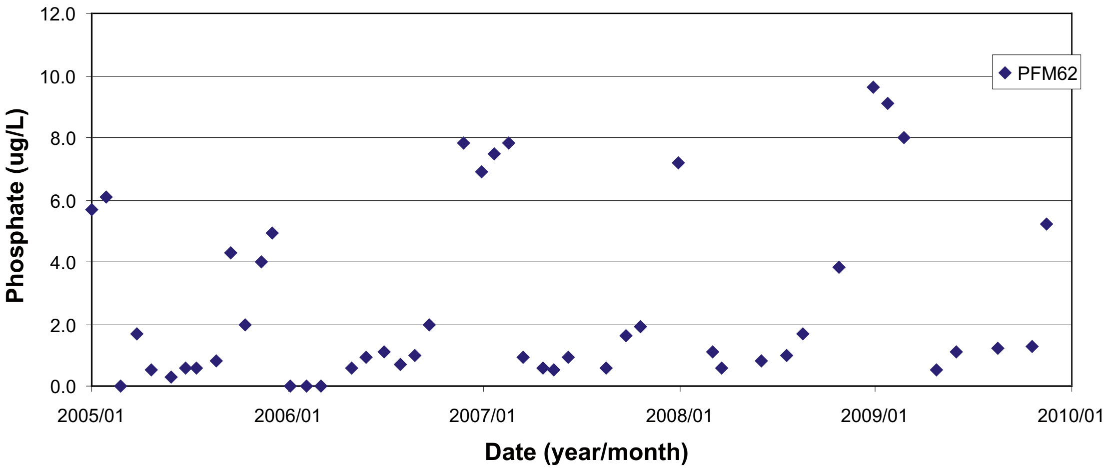


Figure 4-30. *Concentrations of phosphate (PO$_4$) in the coastal bay (PFM62).*

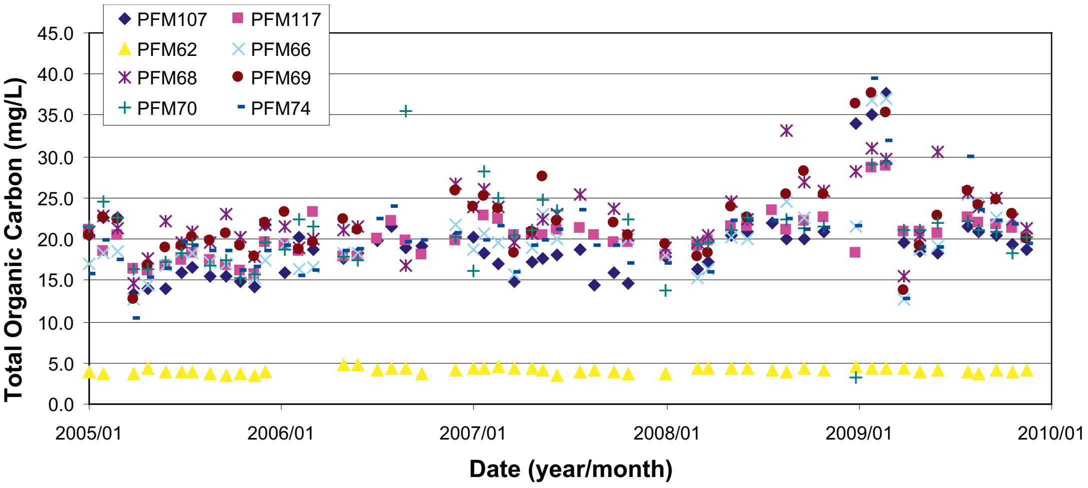


Figure 4-31. Total organic carbon (TOC) in the three lakes (PFM74, 107 and 117), the four streams (PFM66, 68, 69 and 70) and the coastal bay (PFM62).

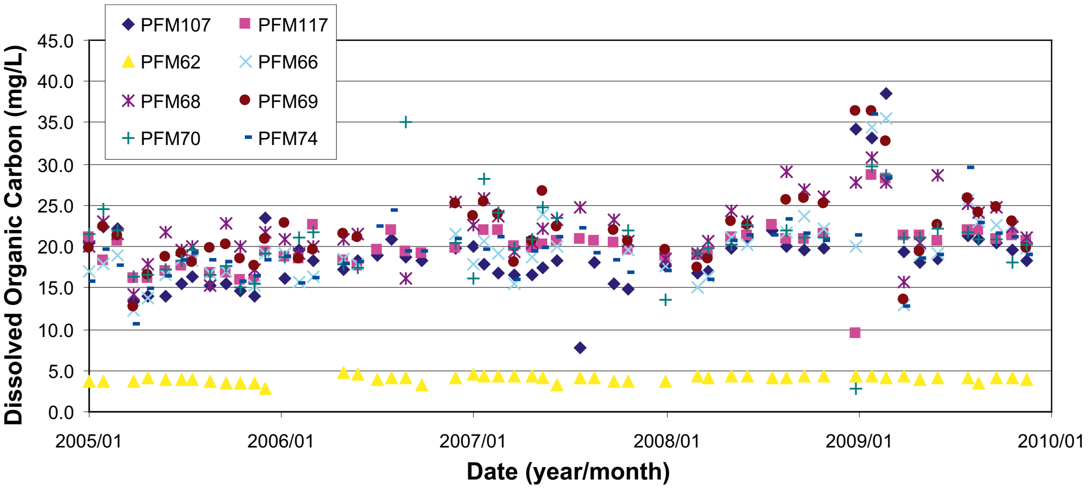


Figure 4-32. Dissolved organic carbon (DOC) in the three lakes (PFM74, 107 and 117), the four streams (PFM66, 68, 69 and 70) and the coastal bay (PFM62).

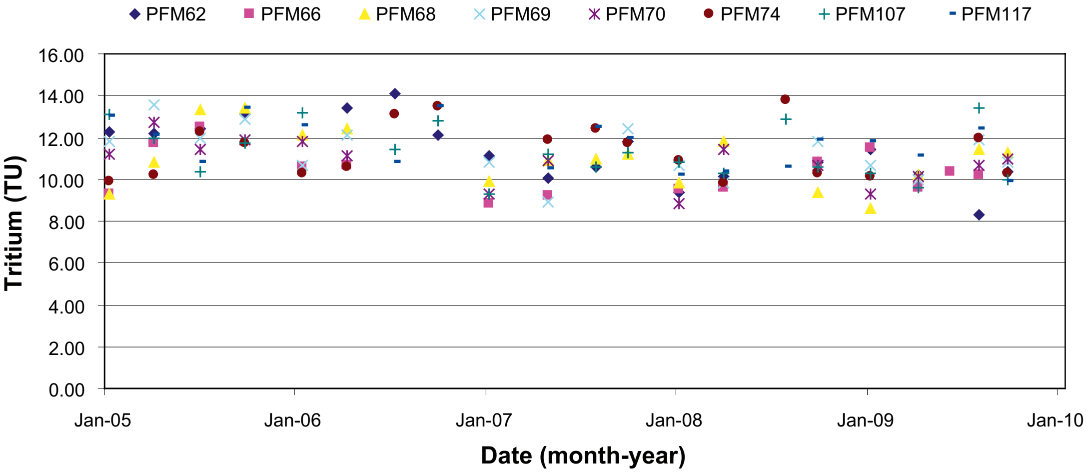


Figure 4-33. Recorded tritium concentrations in the investigated streams (PFM66, 68, 69 and 70) and lakes (PFM74, 107 and 117) during the sampling period January 2005–December 2009.

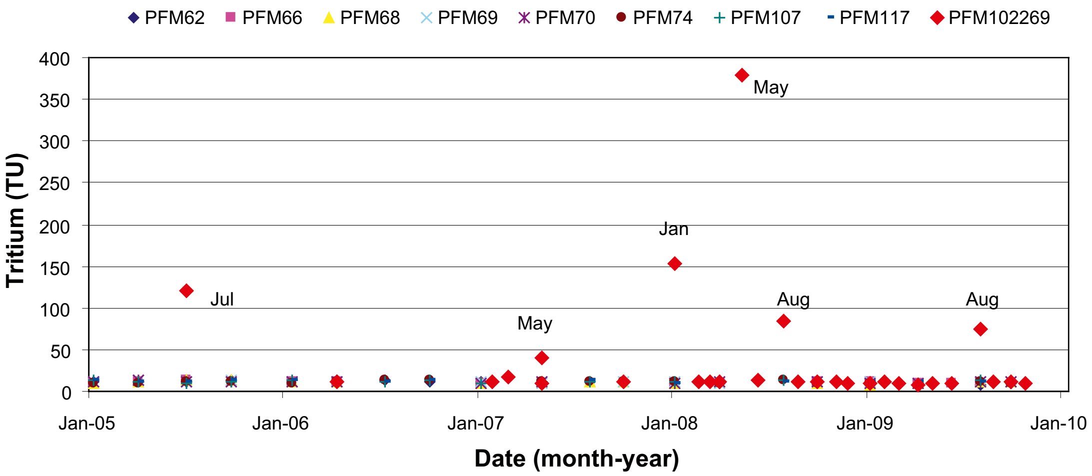


Figure 4-34. *Recorded tritium concentrations in the reactor cooling water (PFM102269) and, for comparison, the investigated streams (PFM66, 68, 69 and 70) and lakes (PFM74, 107 and 117) from the sampling period January 2005–December 2009. The month in which elevated values were noted are indicated.*

5 References

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

/1/ **Berg C, Harrström J, Nilsson K, Nilsson A-C, Borgiel M, Qvarfordt S, 2009.** Forsmark site investigation. Hydrochemical monitoring of groundwaters, surface waters and precipitation. Results from water sampling in the Forsmark area, January 2008–December 2008. SKB P-09-51, Svensk Kärnbränslehantering AB.

/2/ **SKB, 2001.** Site investigations. Investigation methods and general execution programme. SKB TR-01-29, Svensk Kärnbränslehantering AB.

/3/ **SKB, 2007.** Programme for long-term observations of geosphere and biosphere after completed site investigations. SKB R-07-34, Svensk Kärnbränslehantering AB.

/4/ **SKB, 2005.** Forsmark site investigation. Programme for further investigations of geosphere and biosphere. SKB R-05-14, Svensk Kärnbränslehantering AB.

/5/ **Wass E, 2009.** Forsmark site investigation. Groundwater flow measurements in permanently installed boreholes. Test campaign no. 4, 2008. SKB P-09-30, Svensk Kärnbränslehantering AB.

/6/ **Johansson P-O, 2005.** Forsmark site investigation. Manual discharge measurements in brooks, April 2002–April 2005. SKB P-05-153, Svensk Kärnbränslehantering AB.

/7/ **Nilsson A-C, Karlsson S, Borgiel M, 2003.** Forsmark site investigation. Sampling and analyses of surface waters. Results from samplings in the Forsmark area, March 2002 to March 2003. SKB P-03-27, Svensk Kärnbränslehantering AB.

/8/ **Sonesten L, 2004.** Evaluation of surface water chemistry data from the Forsmark area. March 2002–March 2004. SKB R-05-41, Svensk Kärnbränslehantering AB.

/9/ **Nilsson A-C, Borgiel M, 2005.** Forsmark site investigation. Sampling and analyses of surface waters. Results from sampling in the Forsmark area, March 2004 to June 2005. SKB P-05-274, Svensk Kärnbränslehantering AB.

/10/ **Nilsson A-C, Borgiel M, 2007.** Forsmark site investigation. Sampling and analyses of surface waters. Results from sampling in the Forsmark area, July 2005 to June 2006. SKB P-07-95, Svensk Kärnbränslehantering AB.

/11/ **Nilsson A-C, Borgiel M, 2008.** Forsmark site investigation. Sampling and analyses of surface waters. Results from sampling in the Forsmark area, July 2006 to June 2008. SKB P-08-17, Svensk Kärnbränslehantering AB.

Appendix 1

Pressure registrations during pumping and sampling, HMS system

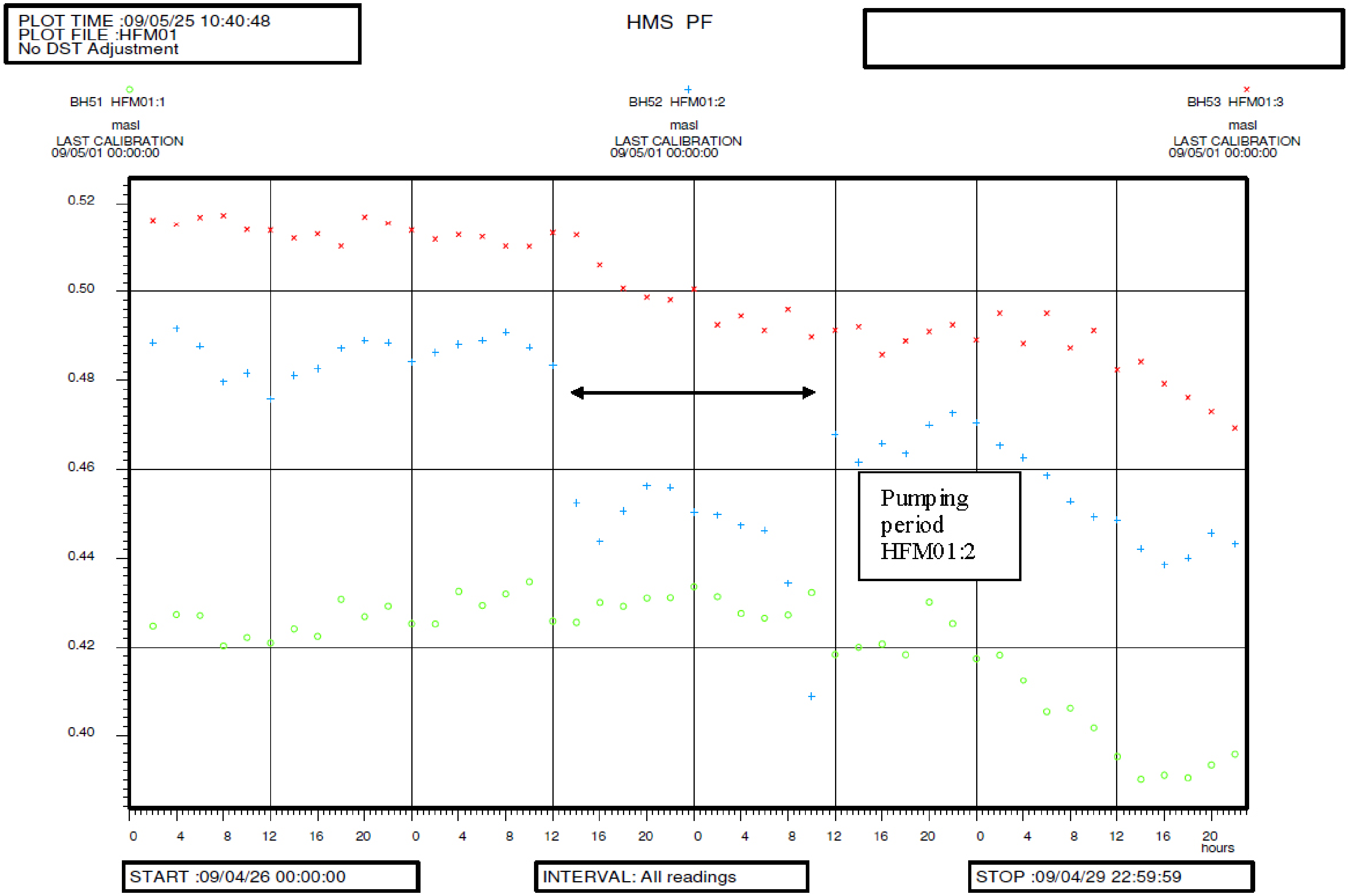


Figure A1-1. Pumping and minor drawdown in HFM01:2 in April 2009. None of the other sections were affected by the pumping.

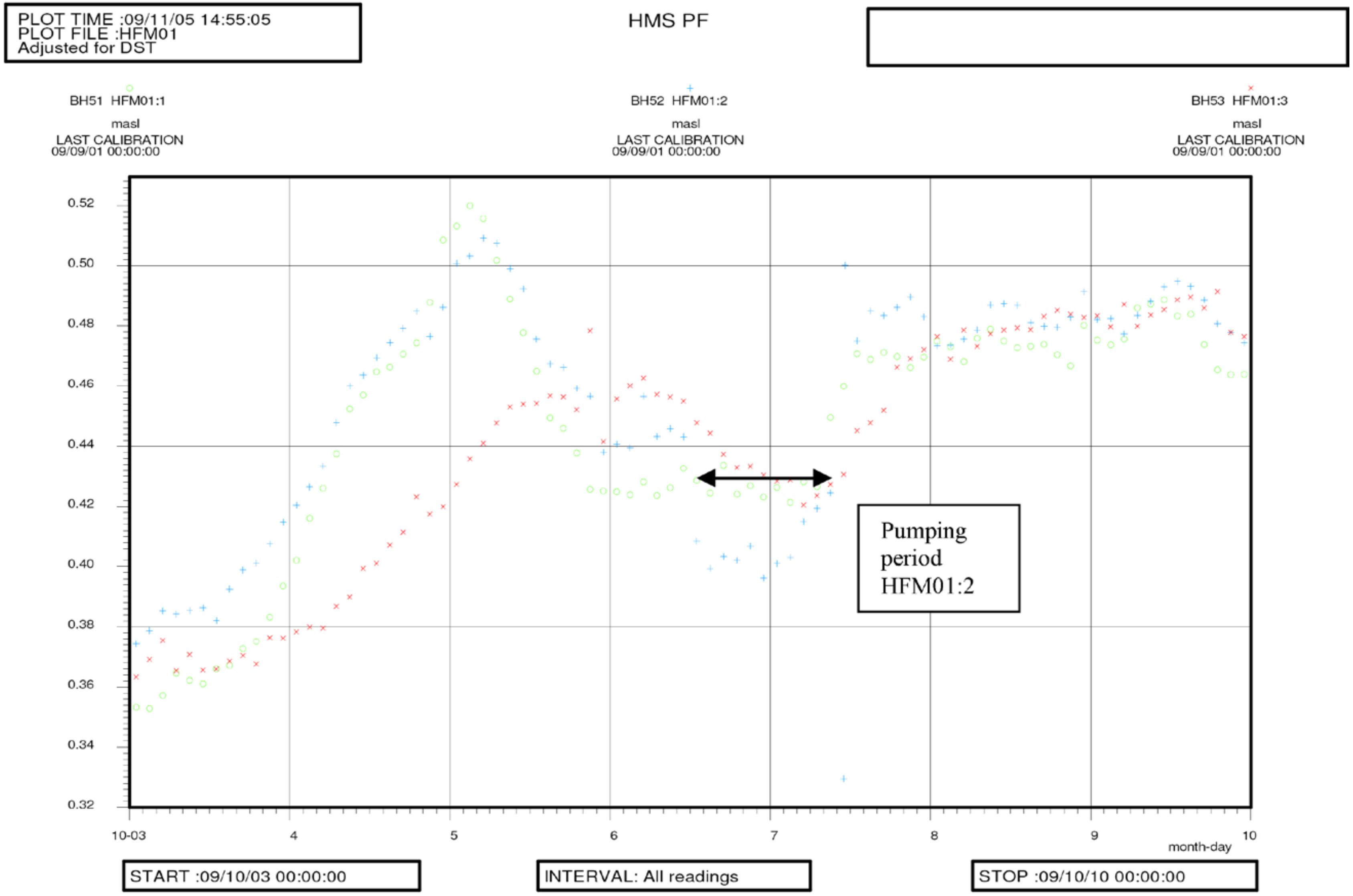


Figure A1-2. *Pumping and drawdown in HFM01:2 in October 2009. None of the other sections were significantly affected by the pumping.*

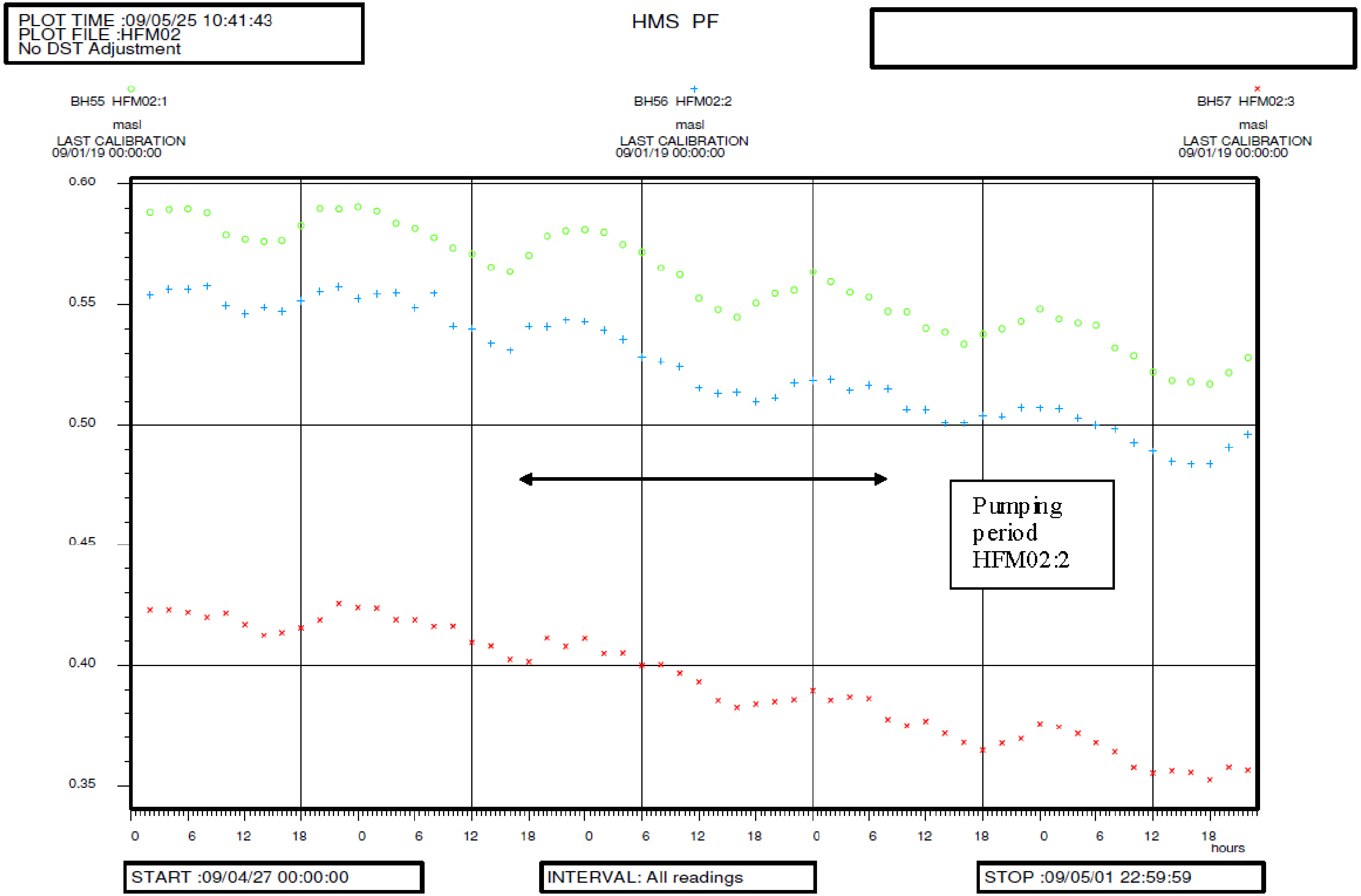


Figure A1-3. *Pumping in HFM02:2 in April 2009. No significant drawdown was observed in any of the borehole sections.*

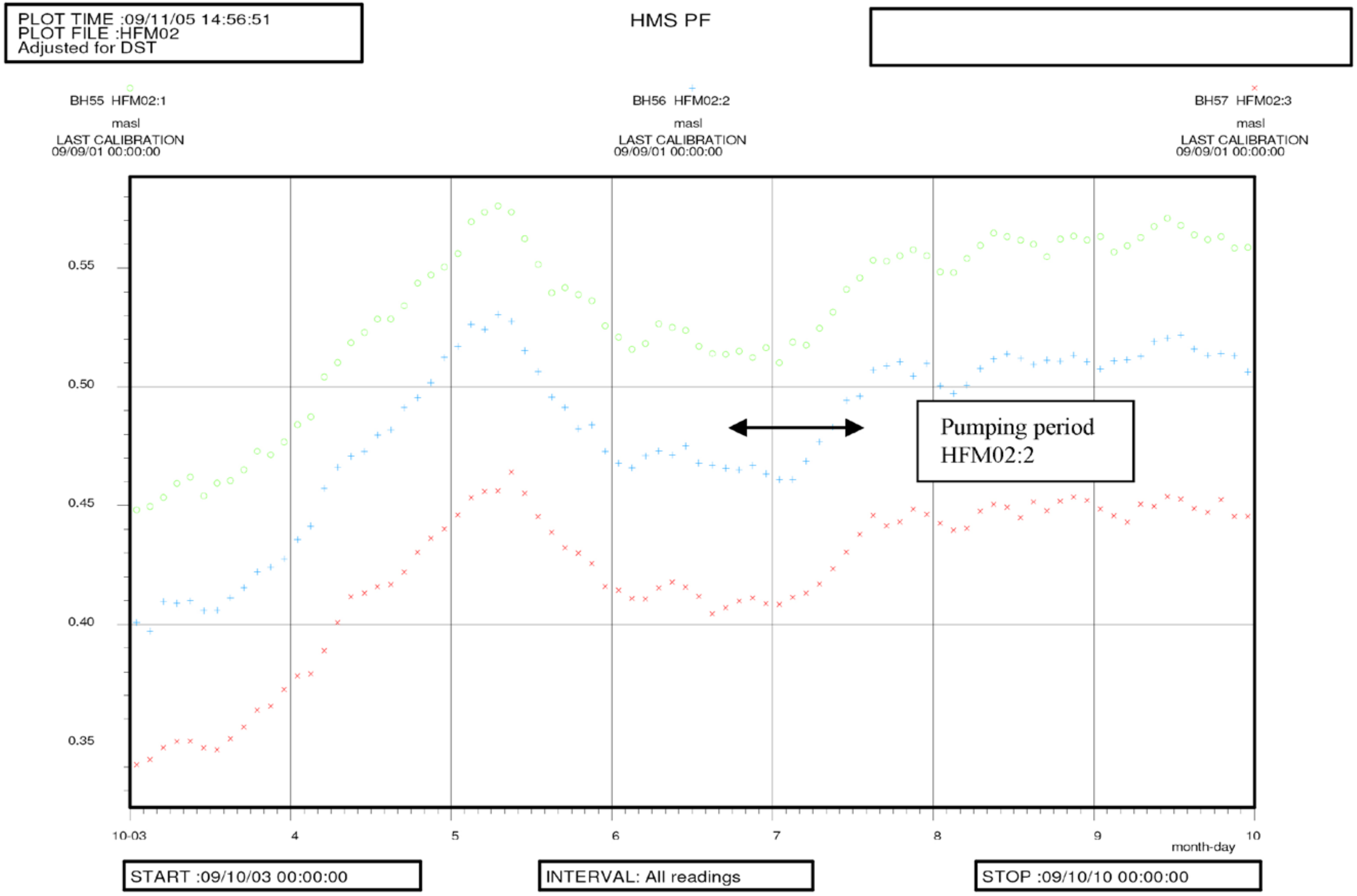


Figure A1-4. *Pumping in HFM02:2 in October 2009. No significant drawdown was observed in any of the borehole sections.*

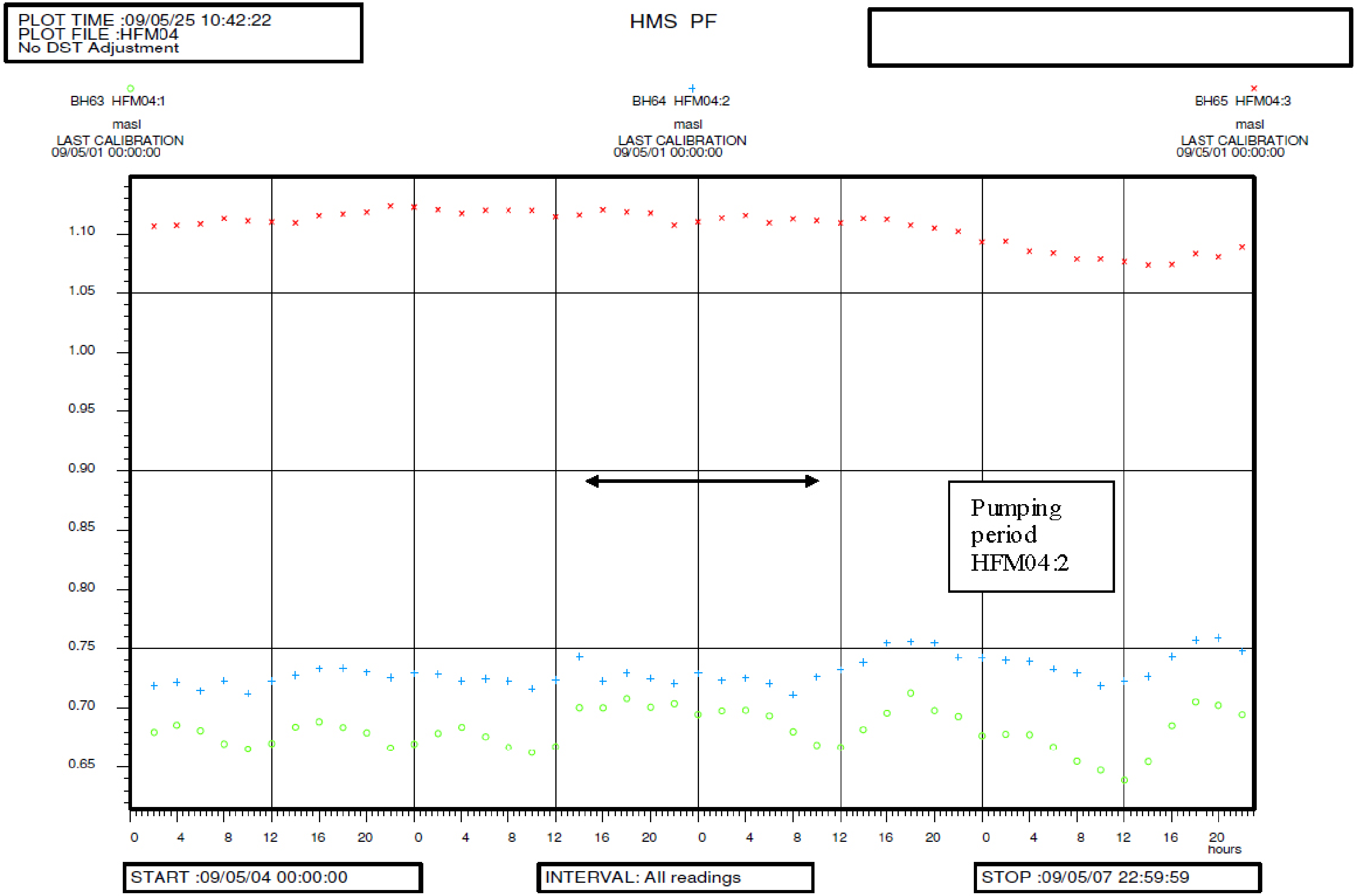


Figure A1-5. *Pumping in HFM04:2 in May 2009. No significant drawdown was observed in any of the borehole sections.*

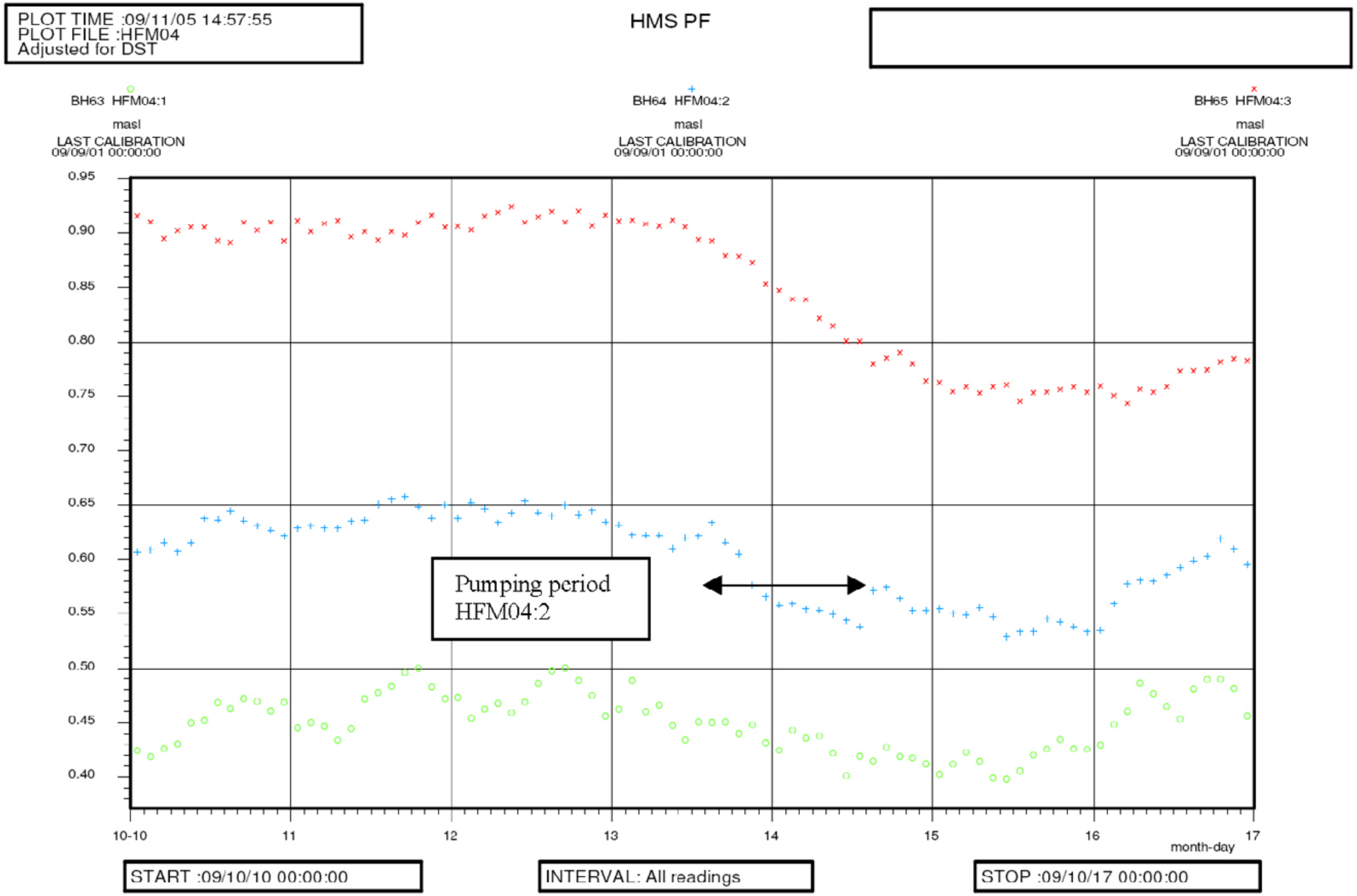


Figure A1-6. *Pumping in HFM04:2 in October 2009. No significant drawdown was observed in any of the borehole sections.*

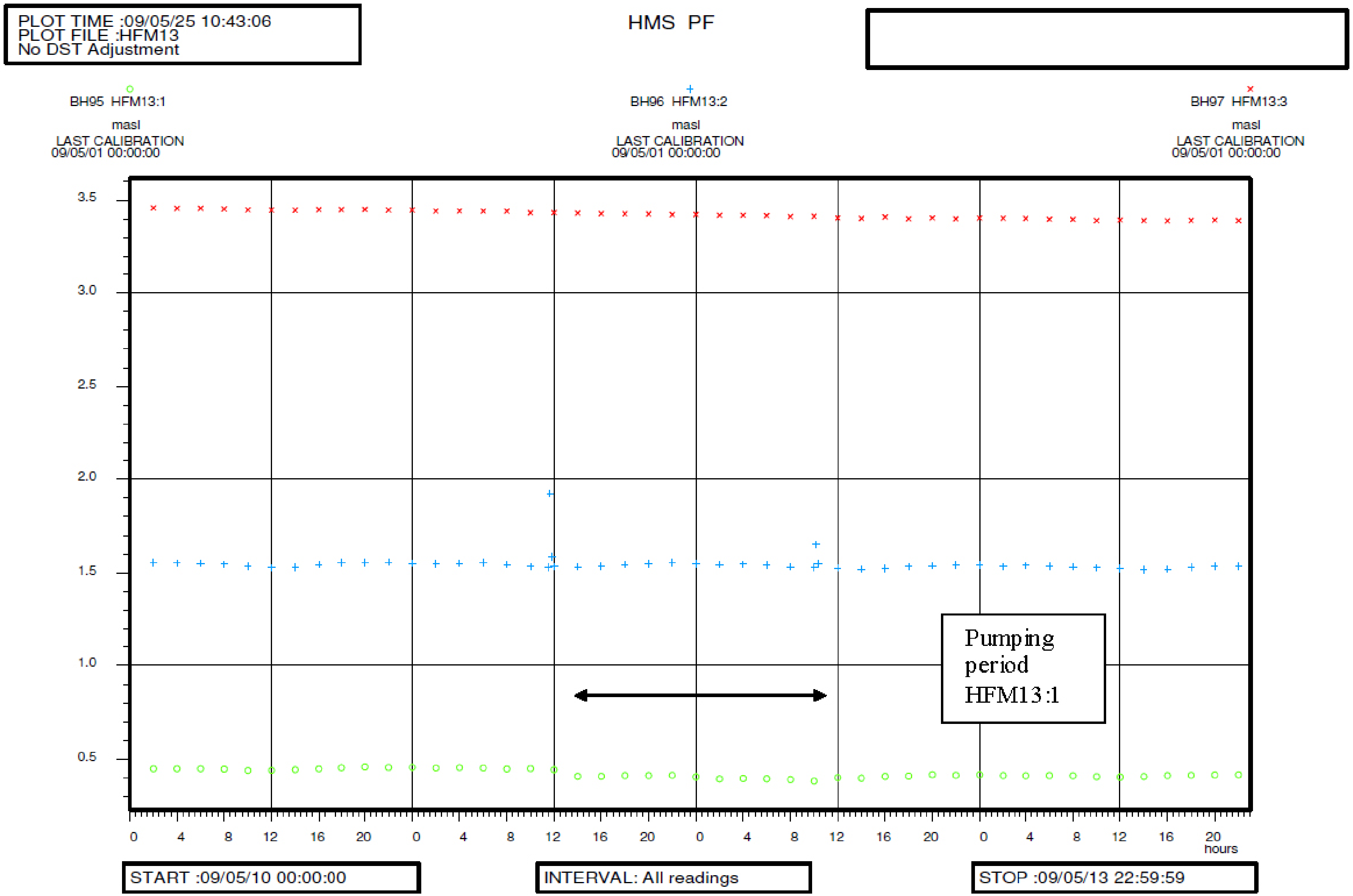


Figure A1-7. *Pumping in HFM13:1 in May 2009. No significant drawdown was observed in any of the borehole sections.*

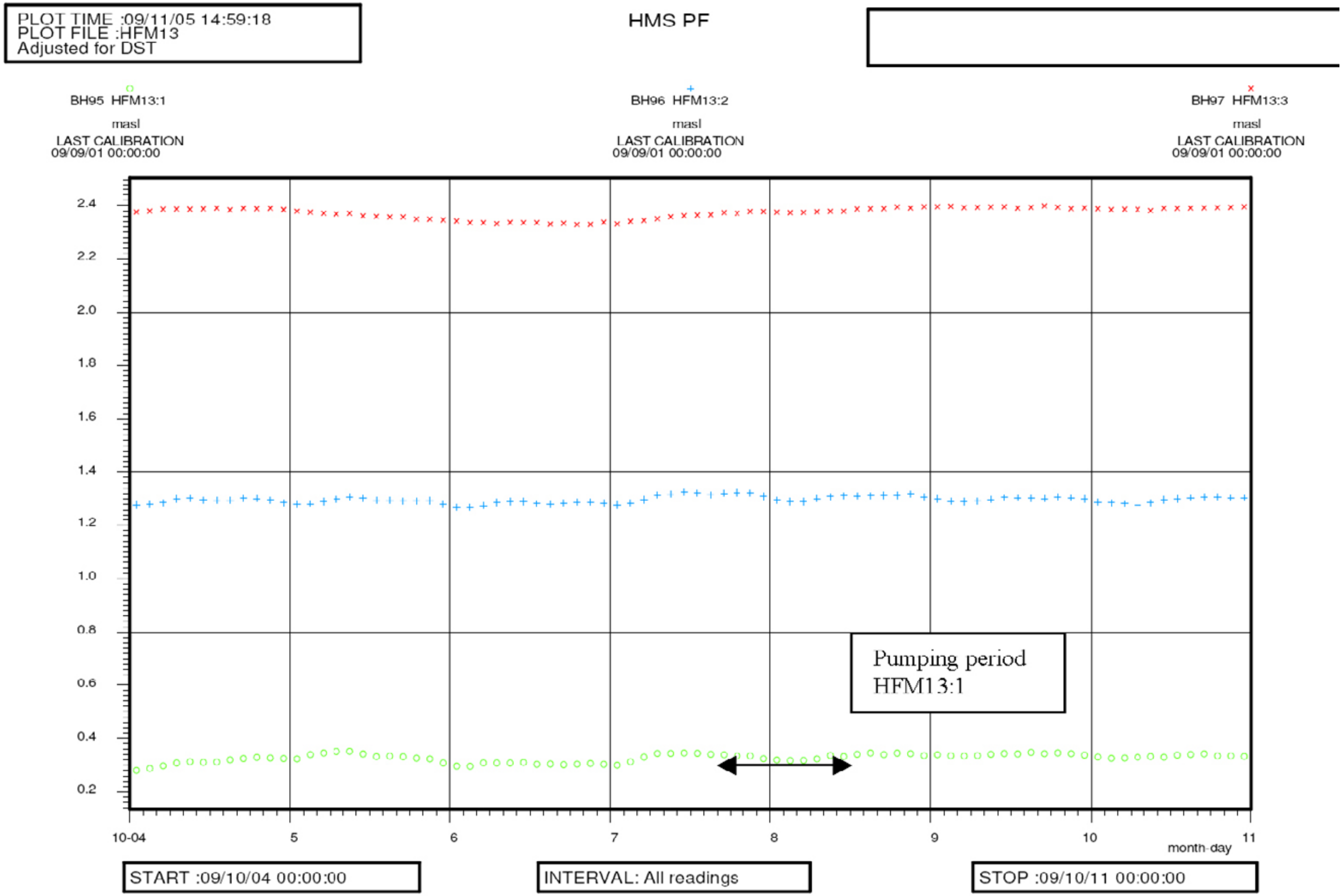


Figure A1-8. *Pumping in HFM13:1 in October 2009. No significant drawdown was observed in any of the borehole sections.*

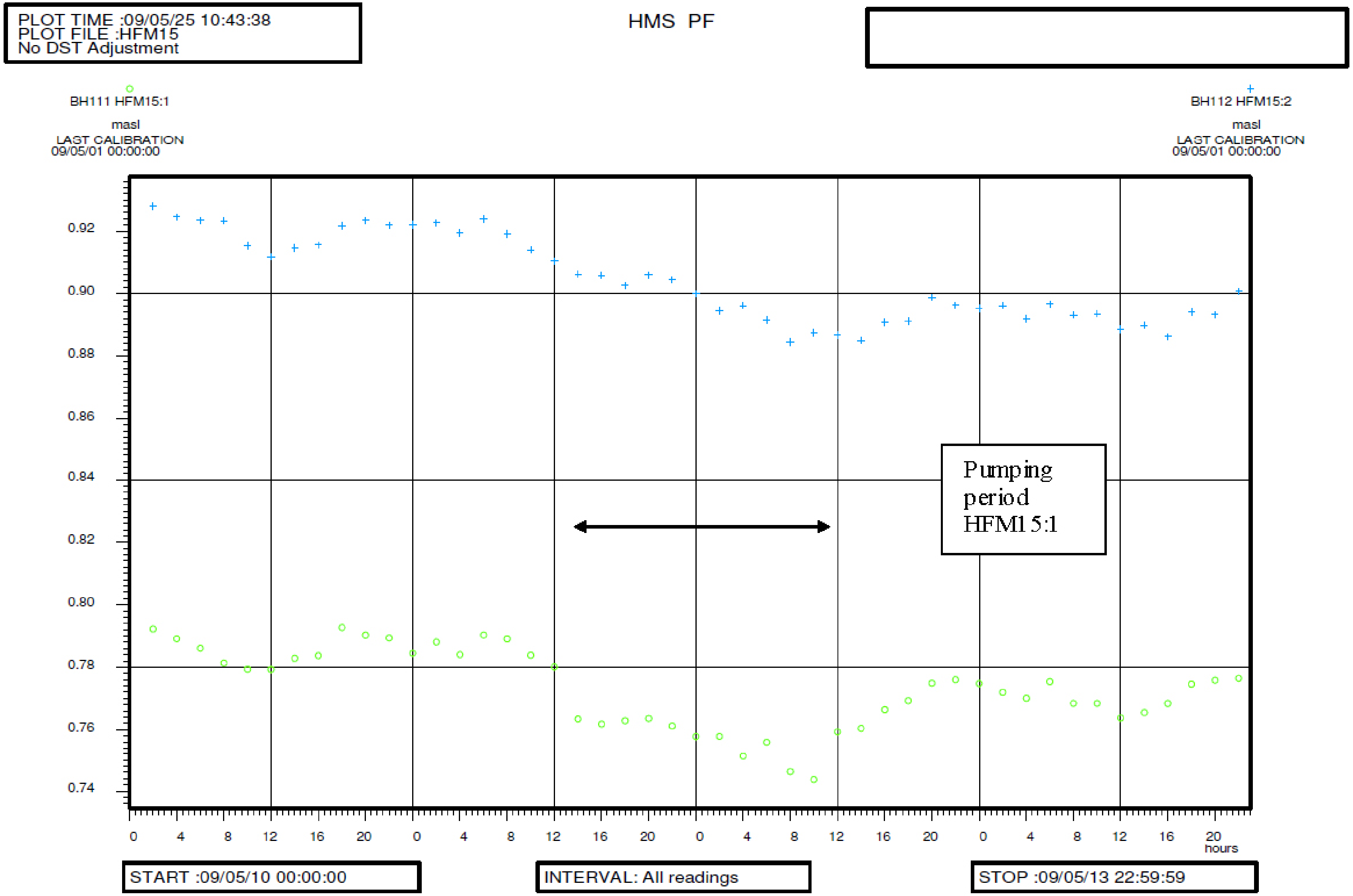


Figure A1-9. *Pumping in HFM15:1 during May 2009. No significant drawdown was observed in any of the borehole sections.*

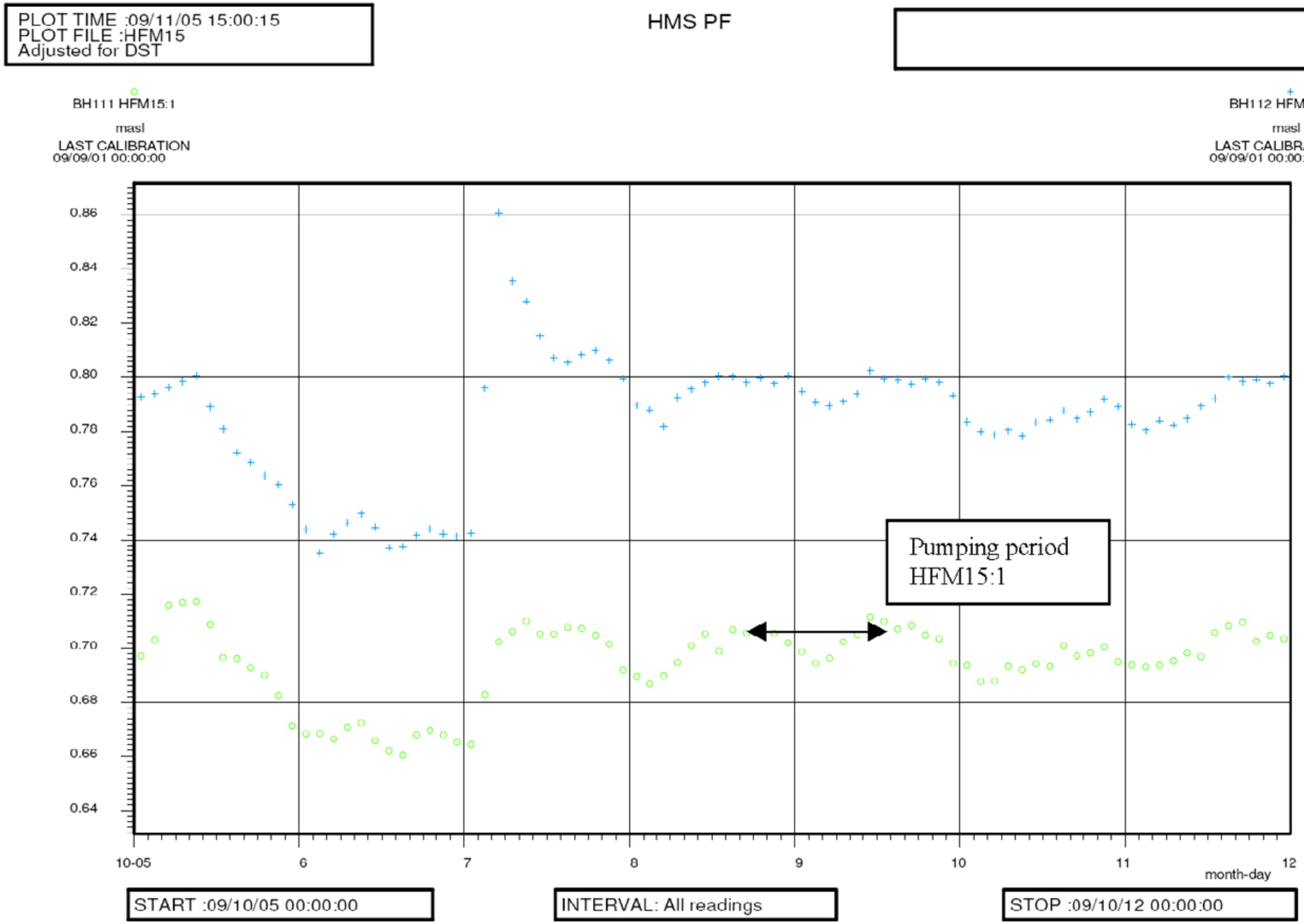


Figure A1-10. *Pumping in HFM15:1 in October 2009. No significant drawdown was observed in any of the borehole sections.*

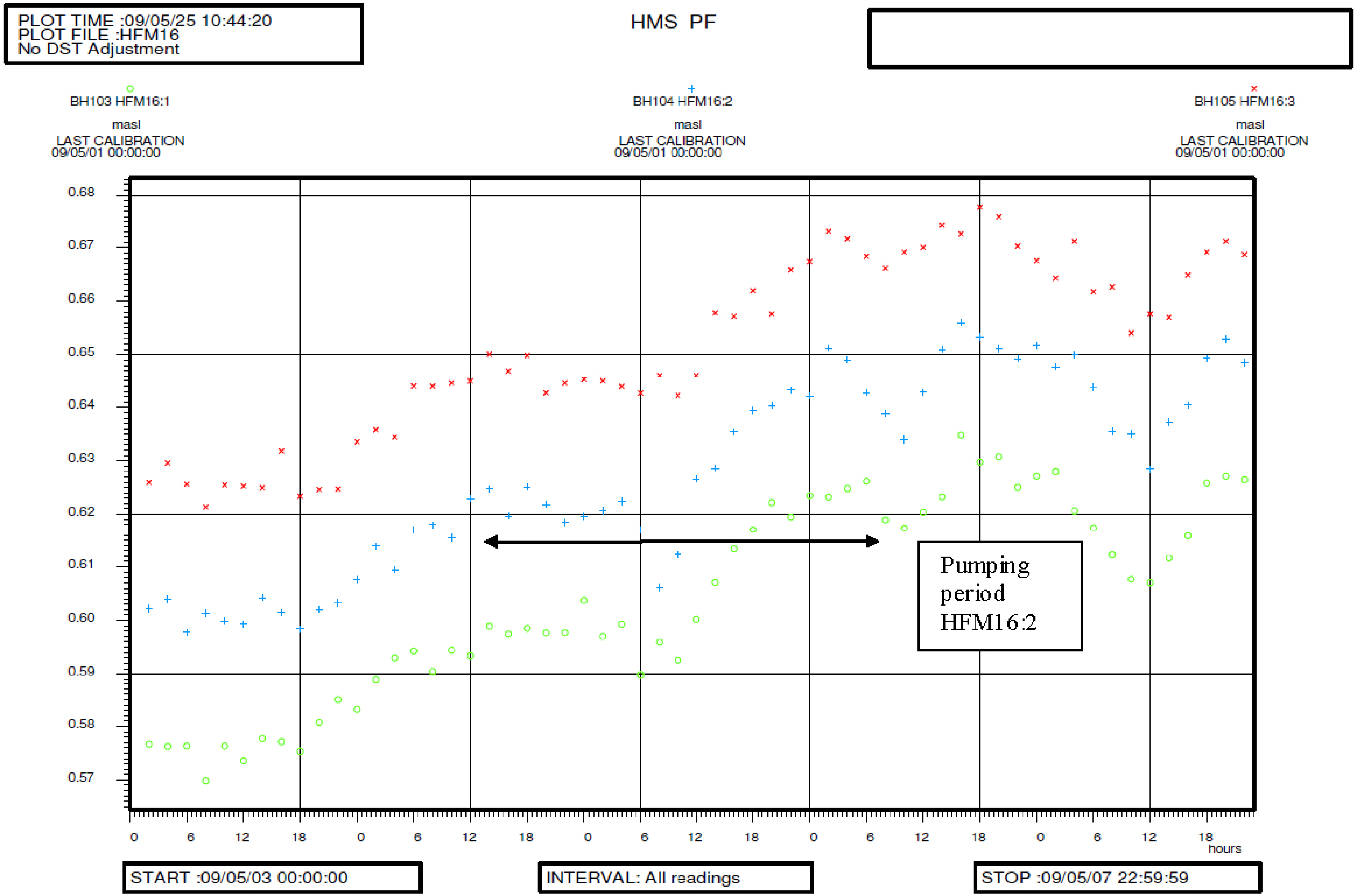


Figure A1-11. *Pumping in HFM16:2 in May 2009. No significant drawdown was observed in any of the borehole sections.*

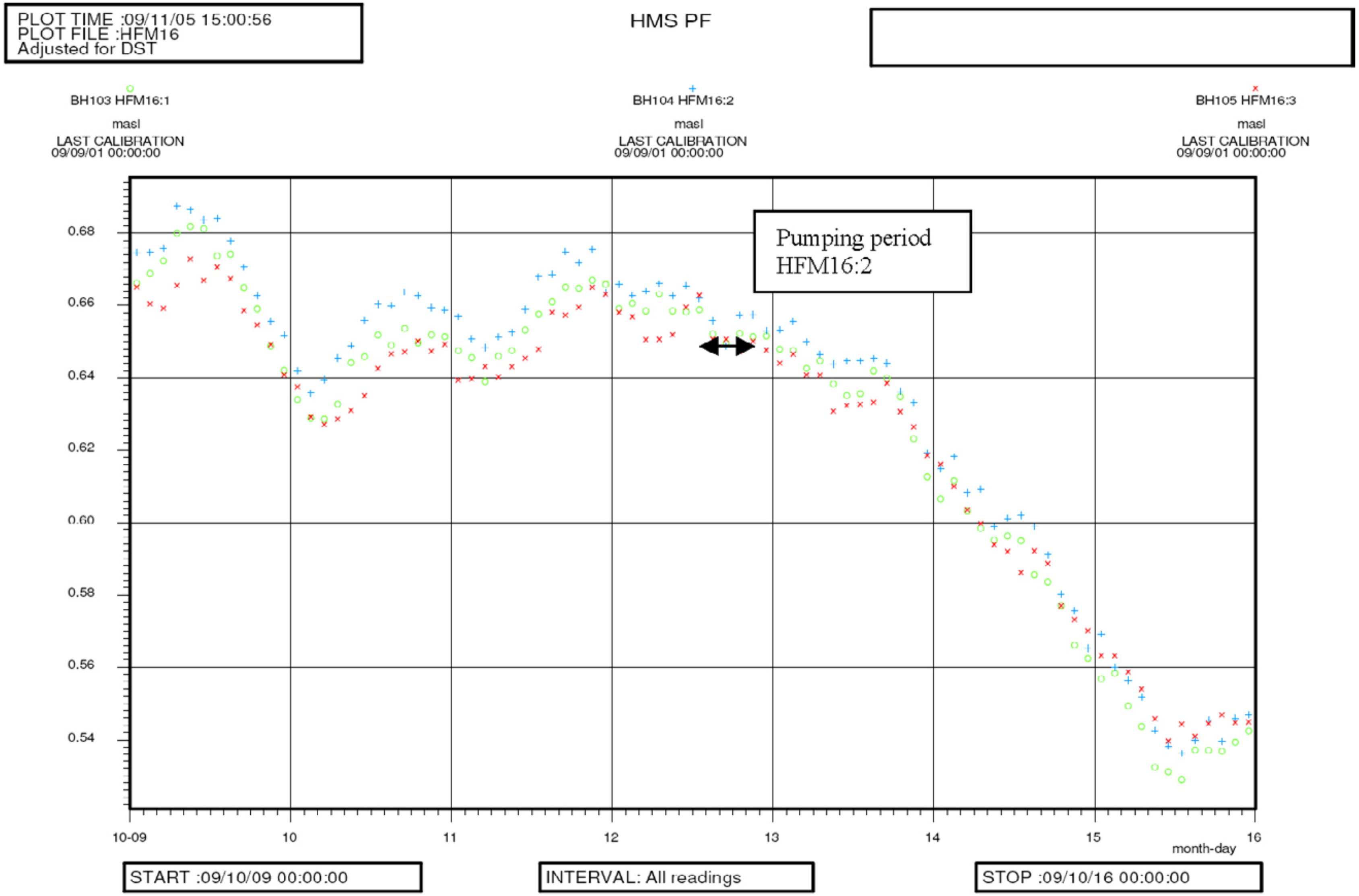


Figure A1-12. *Pumping in HFM16:2 in October 2009. No significant drawdown was observed in any of the borehole sections.*

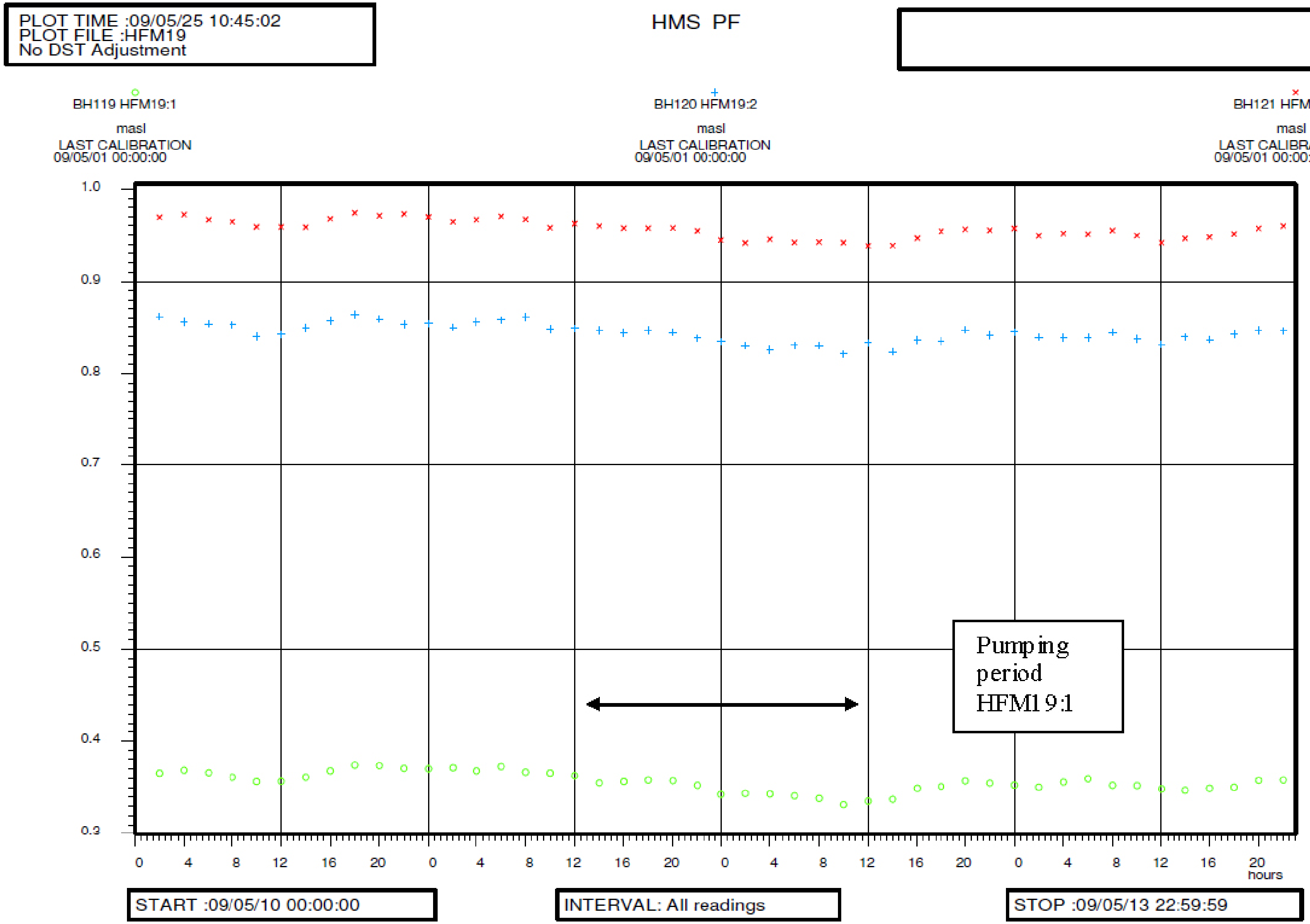


***Figure A1-13.** Pumping in HFM19:1 in May 2009. No significant drawdown was observed in any of the borehole sections.*

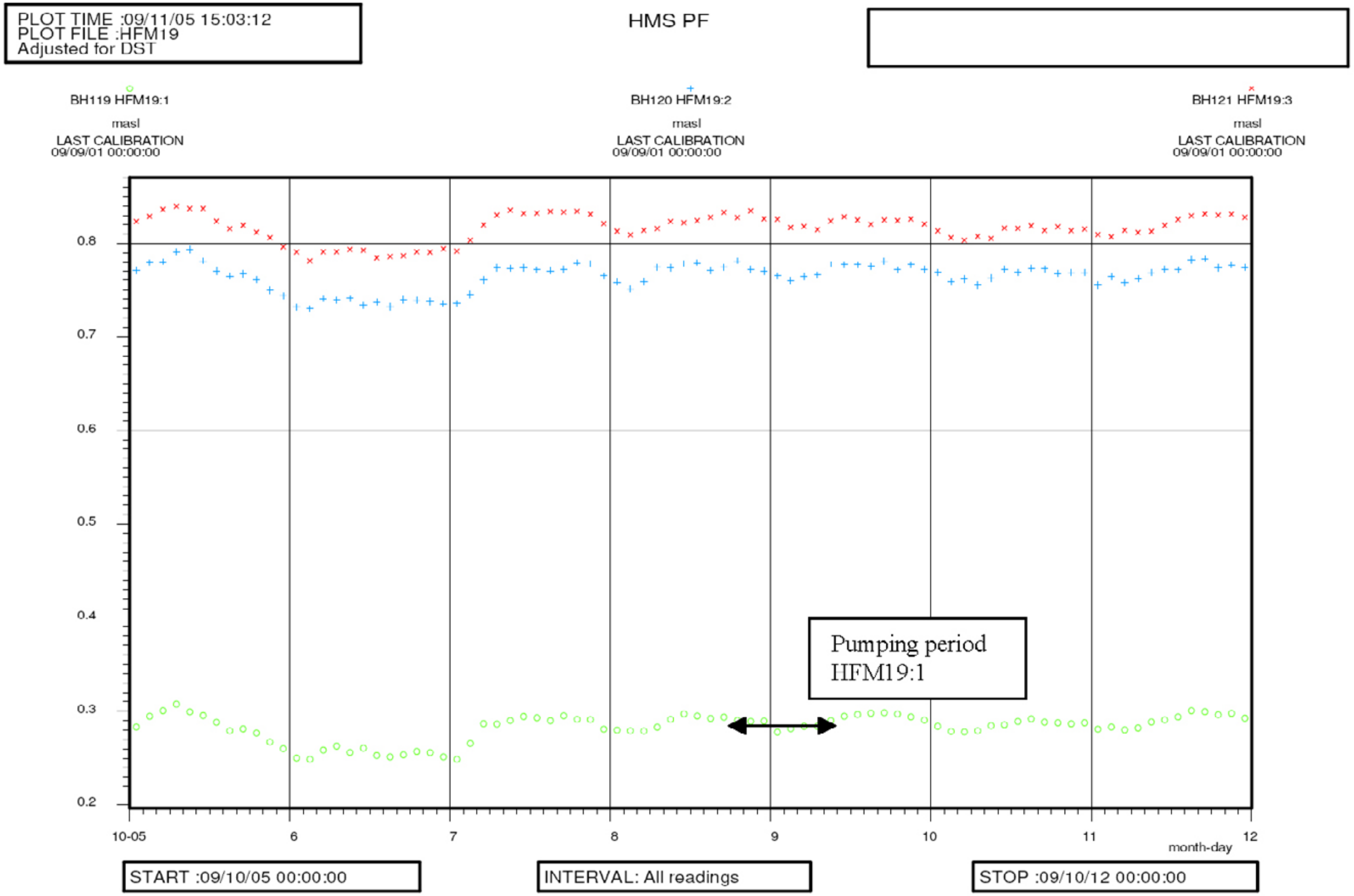


Figure A1-14. *Pumping in HFM19:1 in October 2009. No significant drawdown was observed in any of the borehole sections.*

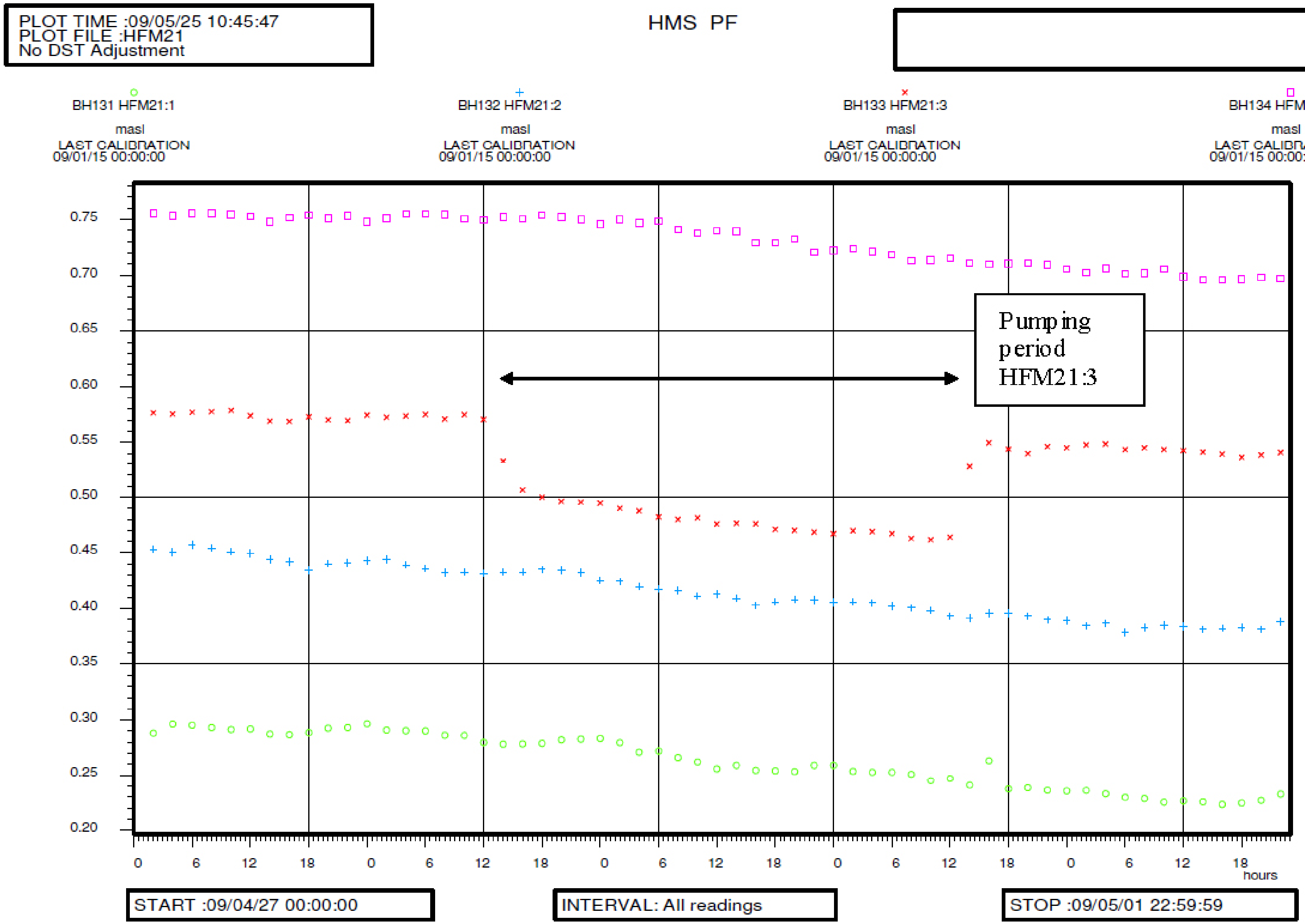


Figure A1-15. *Pumping and drawdown in HFM21:3 in April–May 2009. None of the other sections were affected by the pumping.*

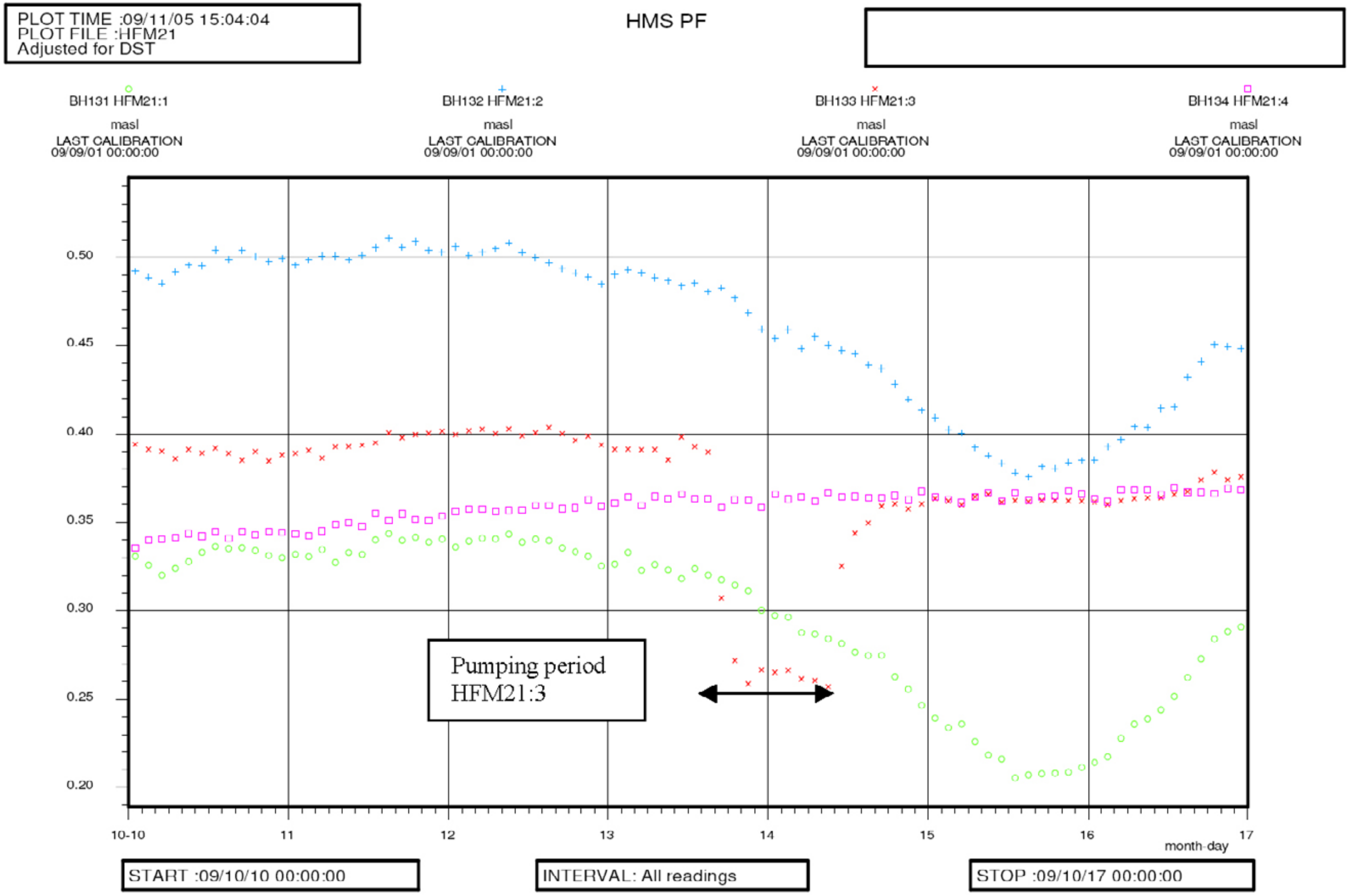


Figure A1-16. *Pumping and drawdown in HFM21:3 in October 2009. None of the other sections were affected by the pumping.*

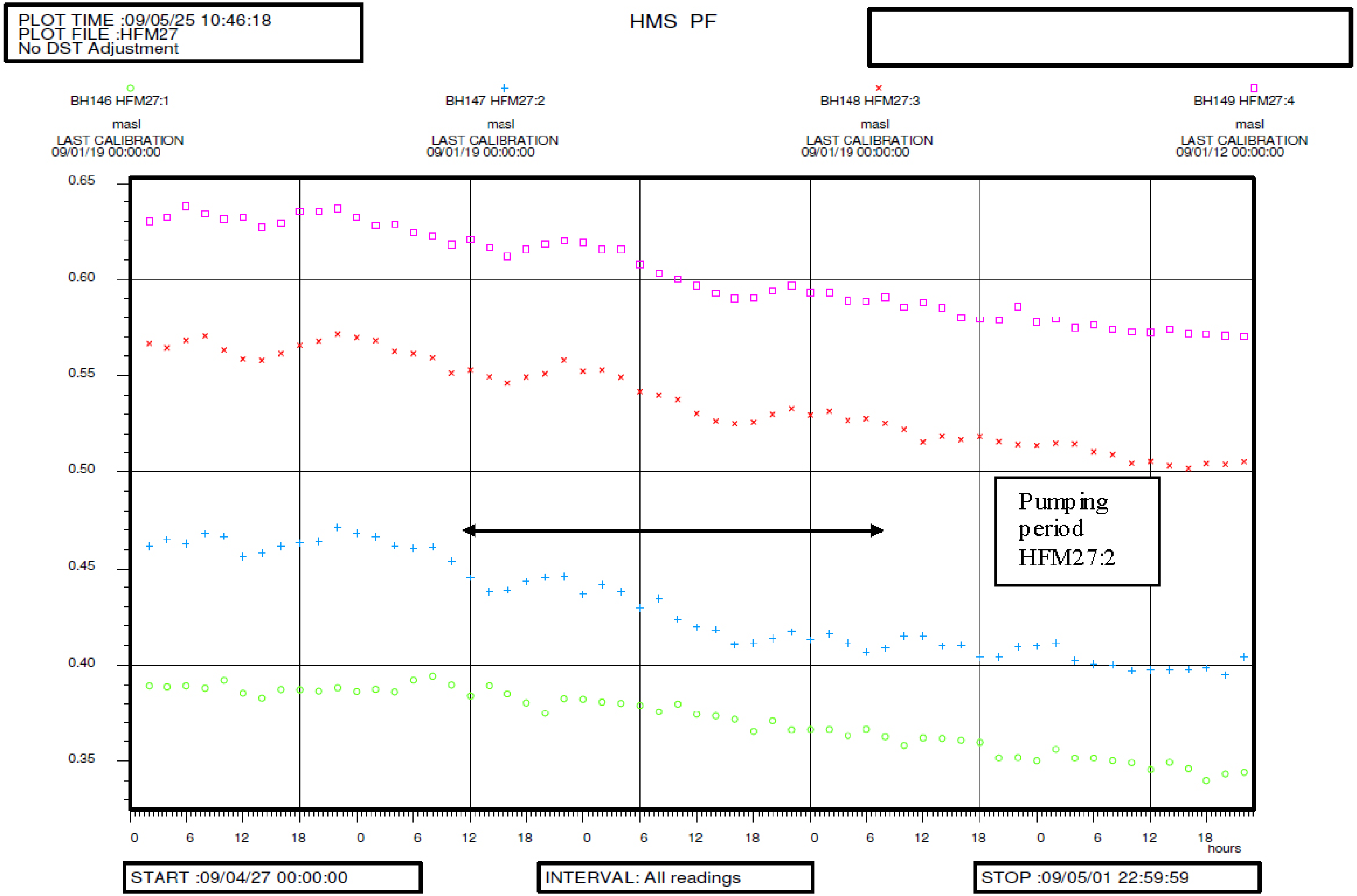


Figure A1-17. *Pumping in HFM27:2 in April–May 2009. No significant drawdown was observed in any of the borehole sections.*

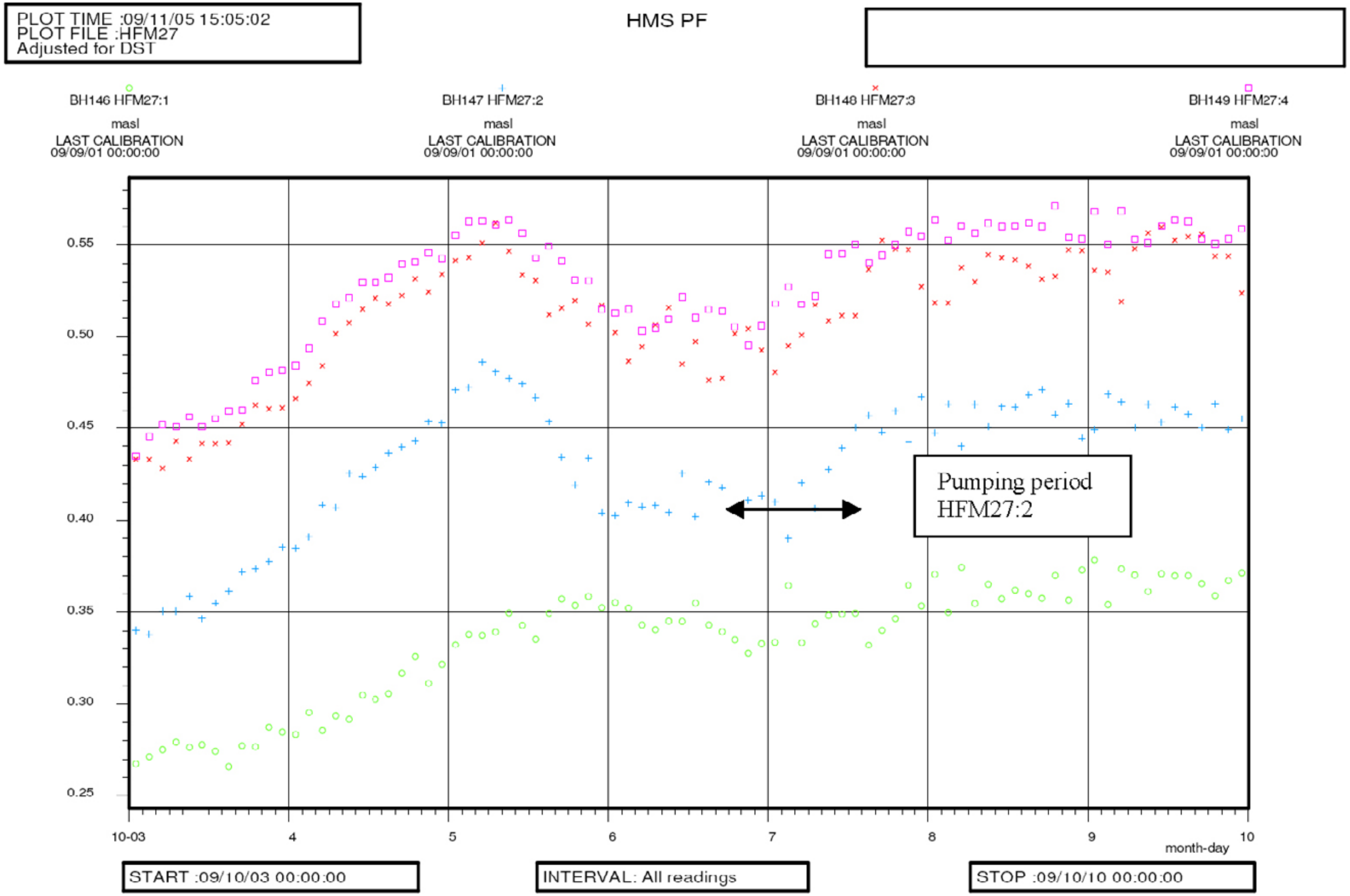


Figure A1-18. *Pumping in HFM27:2 in October 2009. No significant drawdown was observed in any of the borehole sections.*

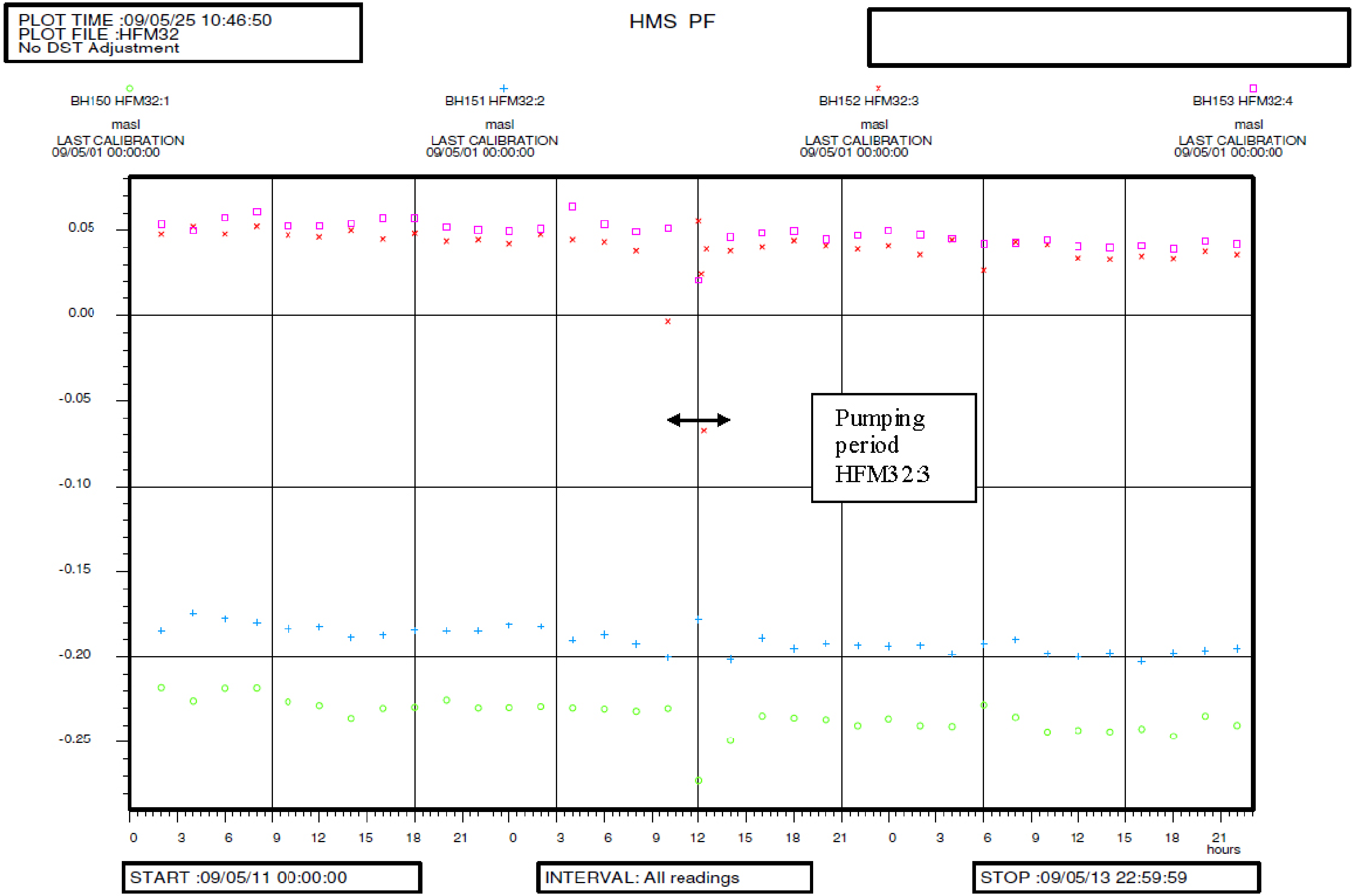


Figure A1-19. *Pumping in HFM32:3 in May 2009. No significant drawdown was observed in any of the borehole sections. The pressure changes seen at pump stop is probably from the pipes affecting the sections.*

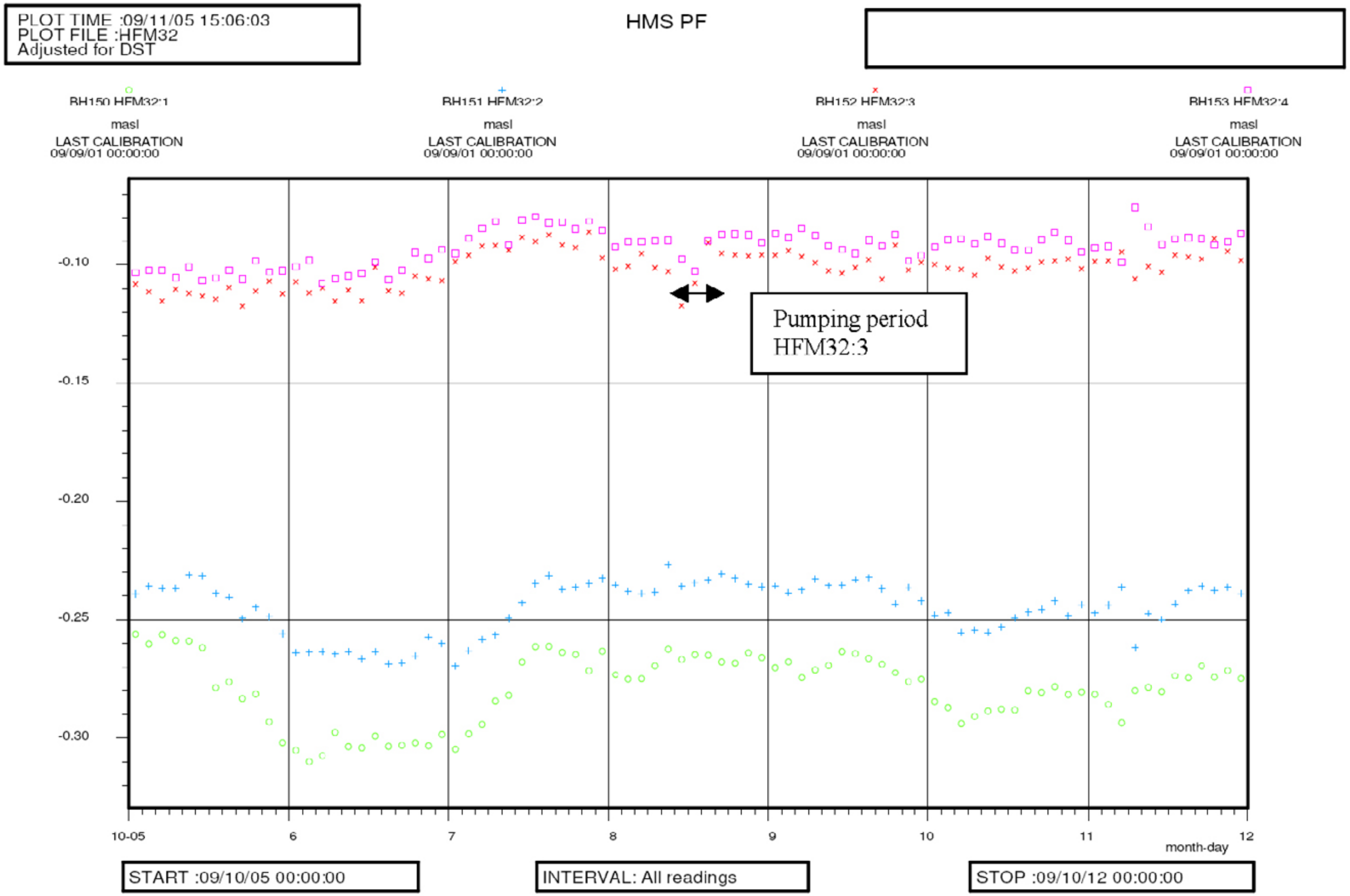


Figure A1-20. Pumping in HFM32:3 in October 2009. No significant drawdown was observed in any of the borehole sections. The pressure changes seen at pump stop is probably from the pipes affecting the sections.

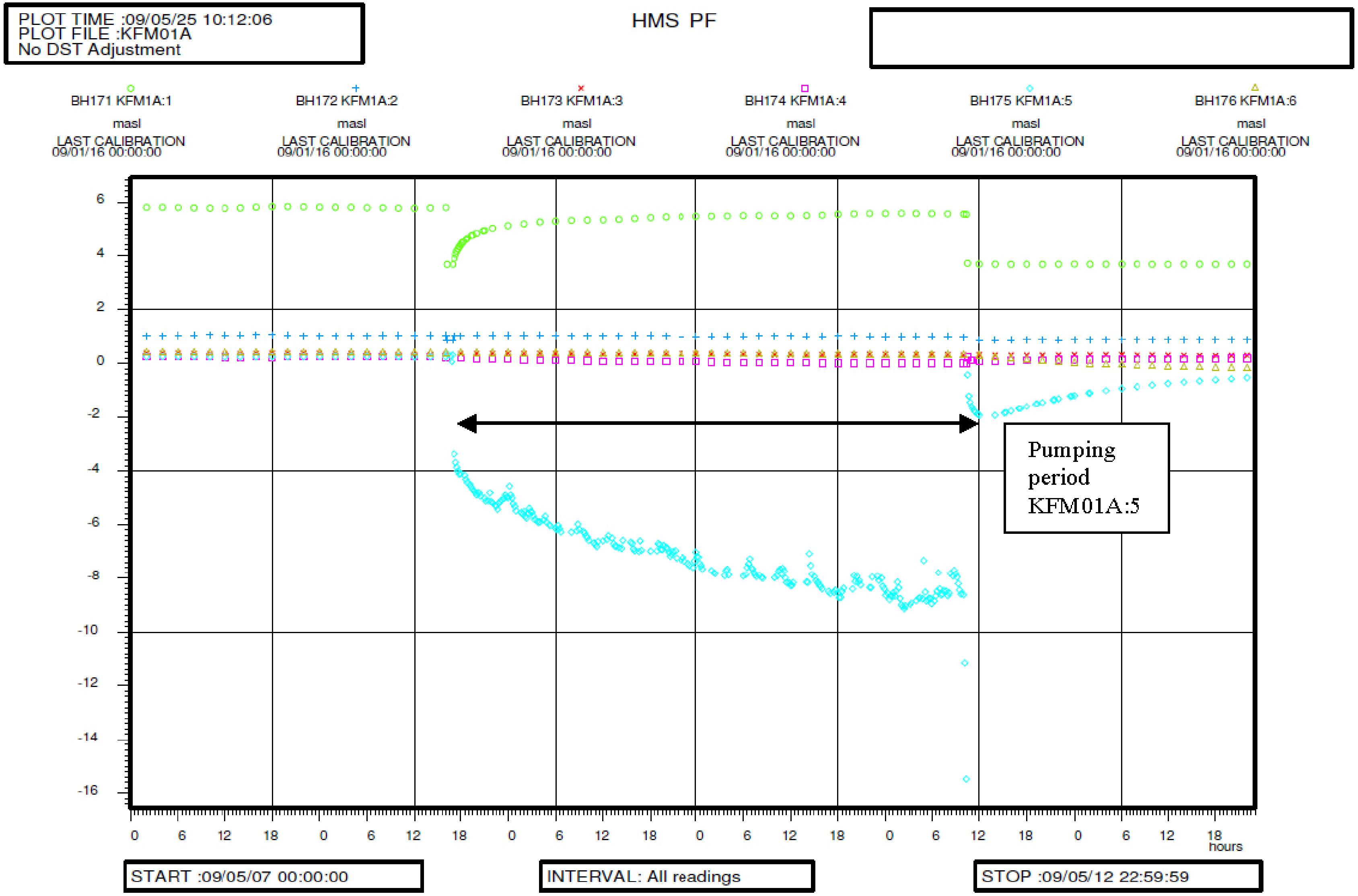


Figure A1-21. *Pumping and drawdown in KFM01A:5 in May 2009. A small response was observed in KFM01A:4. The pressure changes in KFM01A:1 are caused by deflation of the packers.*

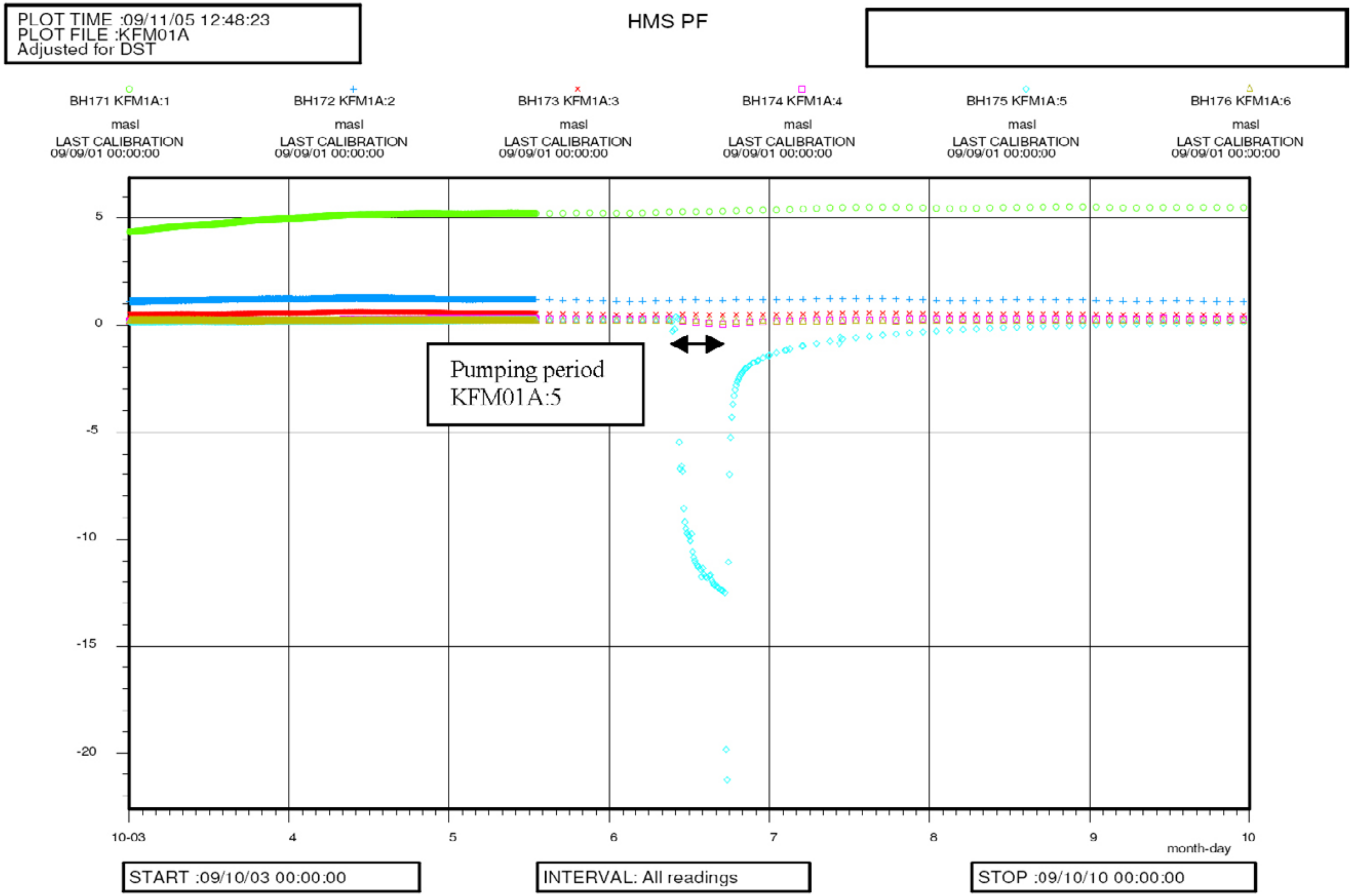


Figure A1-22. *Pumping and drawdown in KFM01A:5 during October 2009. A small response was observed in KFM01A:4, but none of the other borehole sections were affected by the pumping.*

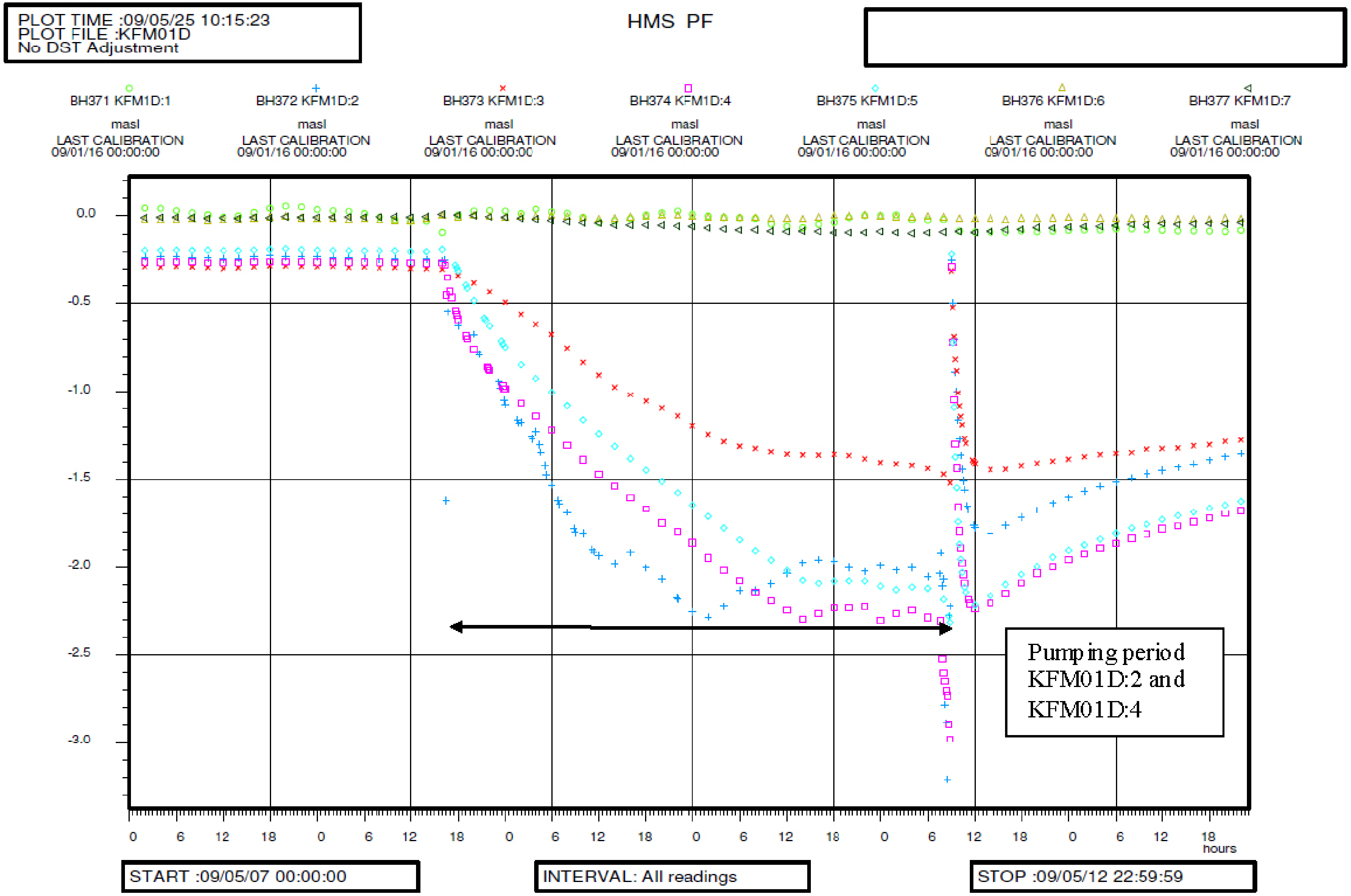


Figure A1-23. *Pumping and drawdown started simultaneously in KFM01D:4 and KFM01D:2 in May 2009. Clear responses was observed in KFM01D:3 and :5. Some response was seen in KFM01D:7 as well.*

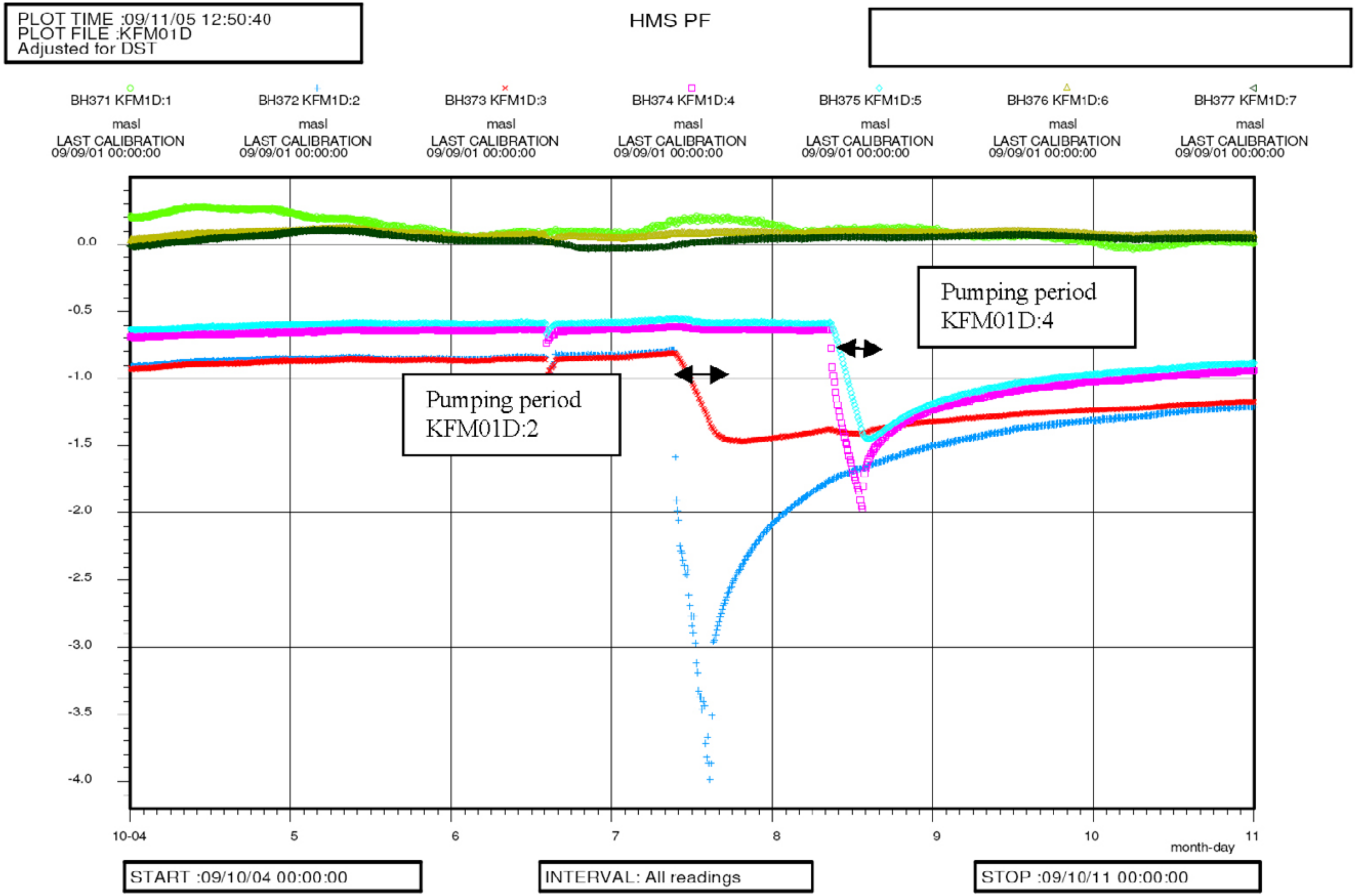


Figure A1-24. *Pumping and drawdown in KFM01D:2 and KFM01D:4 in October 2009. A clear response was observed in KFM01D:3 when pumping in KFM01D:2, and there is also a response in KFM01D:5 when pumping in KFM01D:4.*

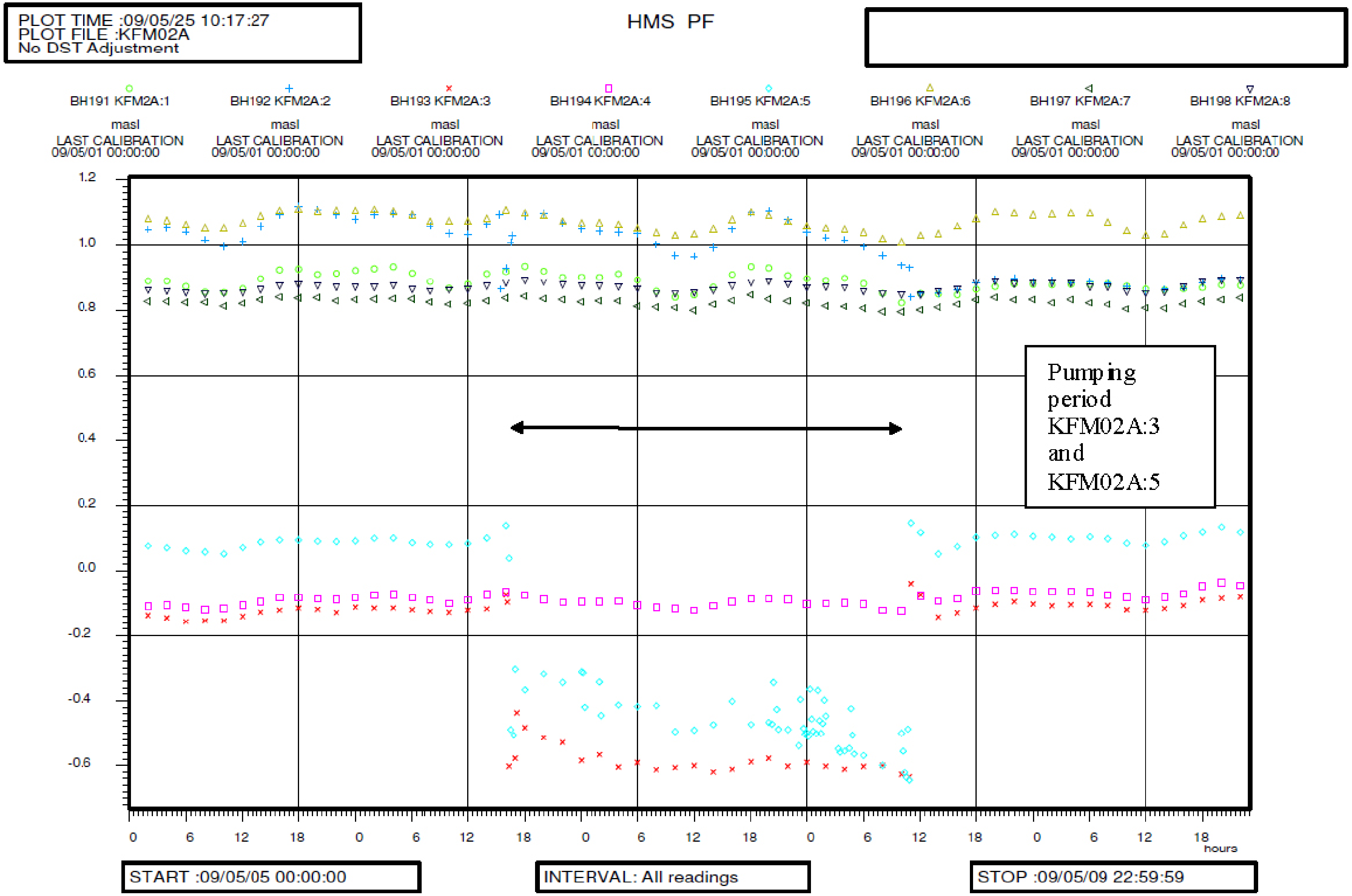


Figure A1-25. *Pumping and drawdown in KFM02A:3 and KFM02A:5 in May 2009. Pumping was performed in both sections simultaneously. None of the other borehole sections were affected by the pumping.*

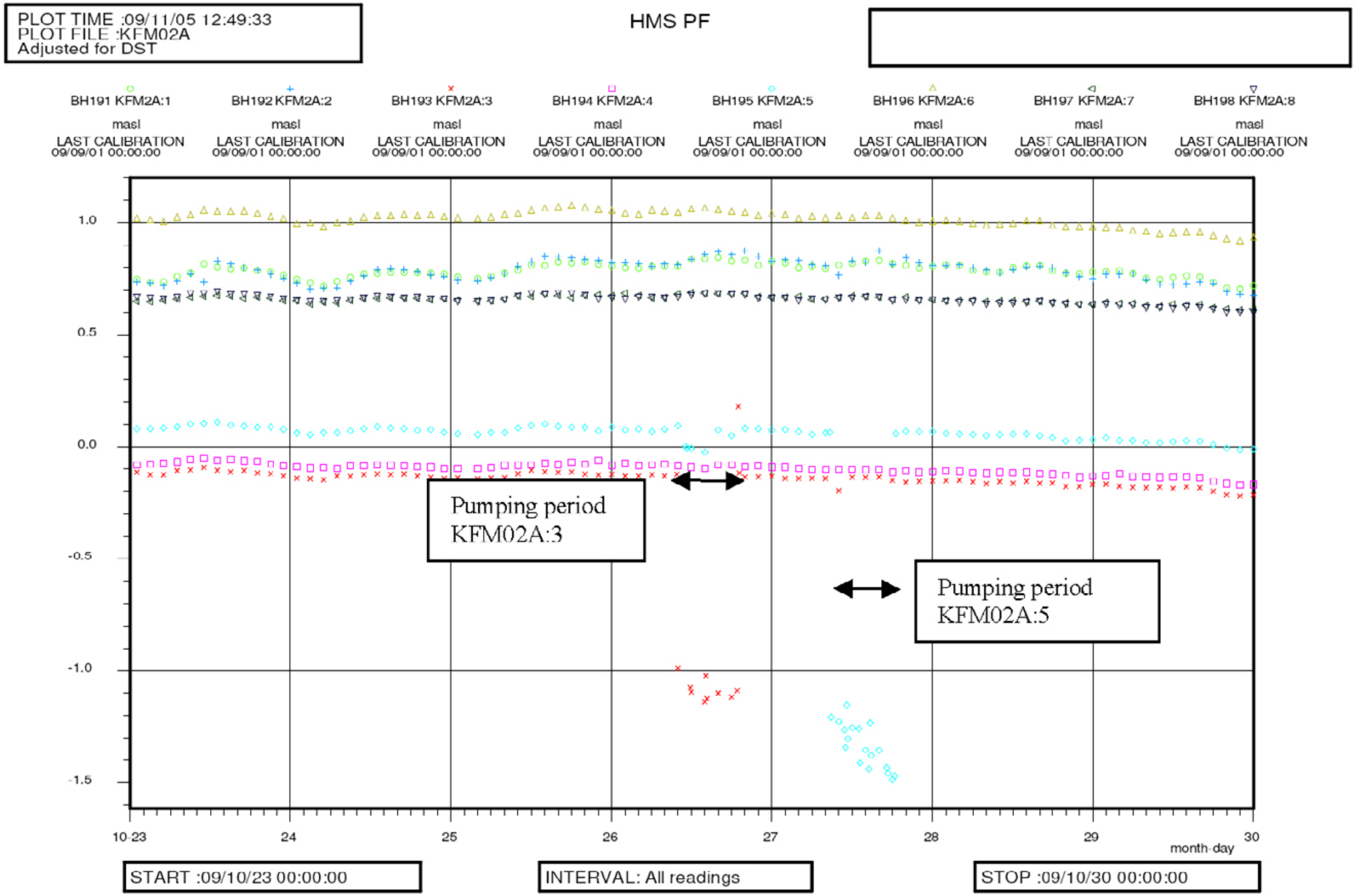


Figure A1-26. *Pumping and drawdown in KFM02A:3 and KFM02A:5 in October 2009. Pumping was performed simultaneously in both sections. KFM02A:5 was slightly affected by the pumping in section 3.*

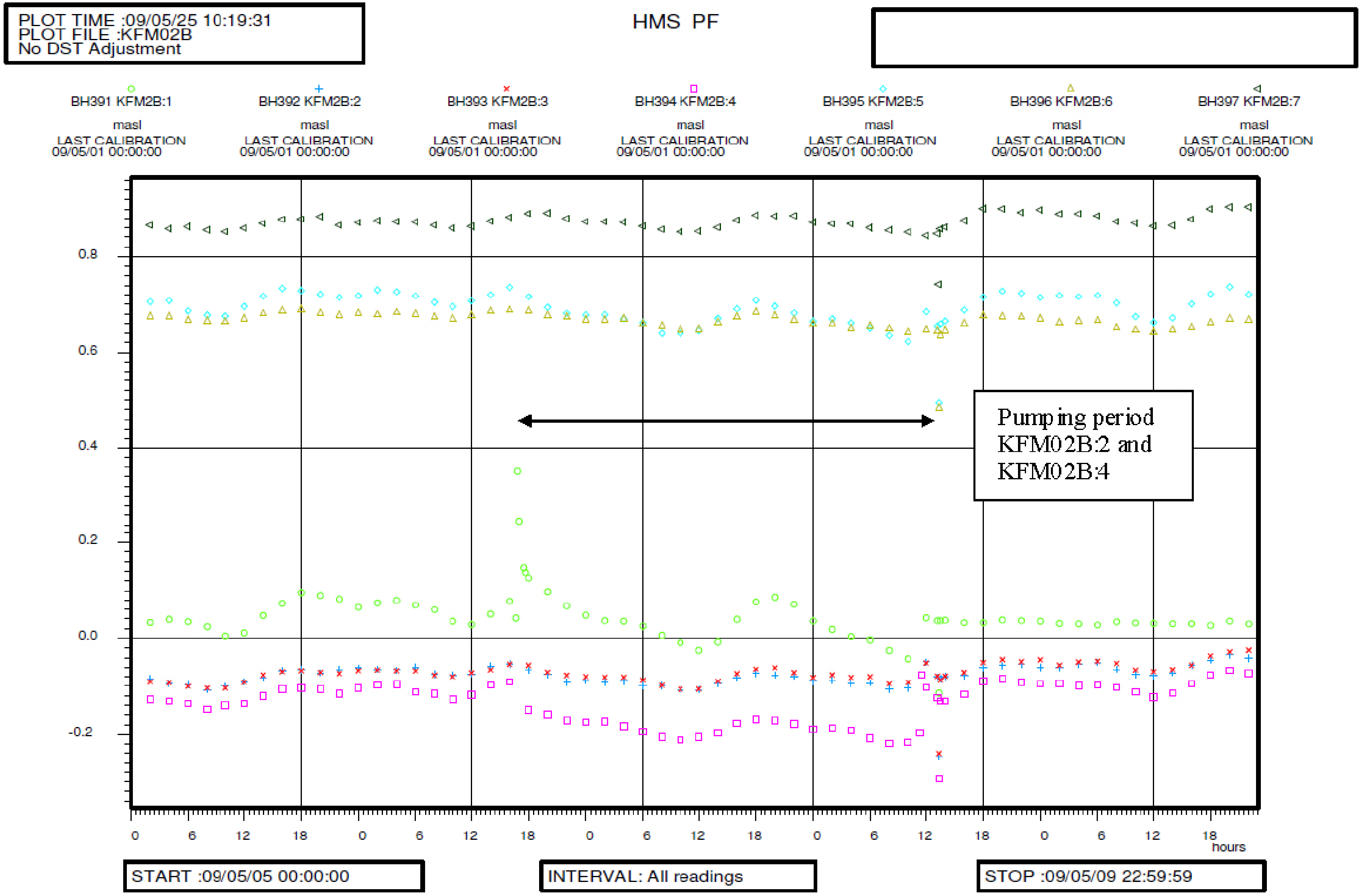


Figure A1-27. Pumping in KFM02B:2 and KFM02B:4 in May 2009. Pumping was performed simultaneously in both sections. The pressures in the other sections were not significantly affected by the pumping.

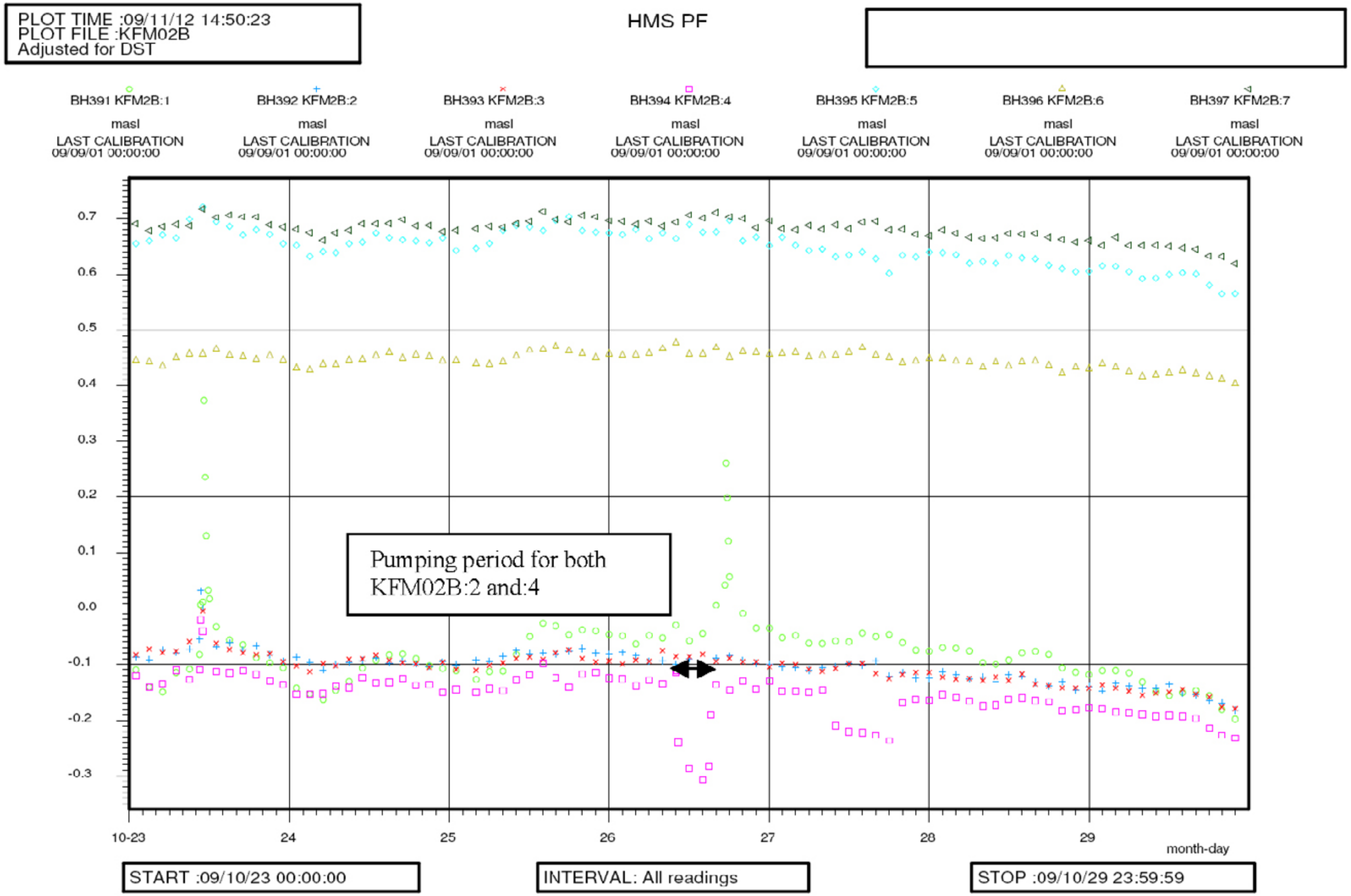


Figure A1-28. *Pumping in KFM02B:2 and KFM02B:4 in October 2009. Pumping was performed simultaneously in both sections. The pressures in the other sections were not significantly affected by the pumping.*

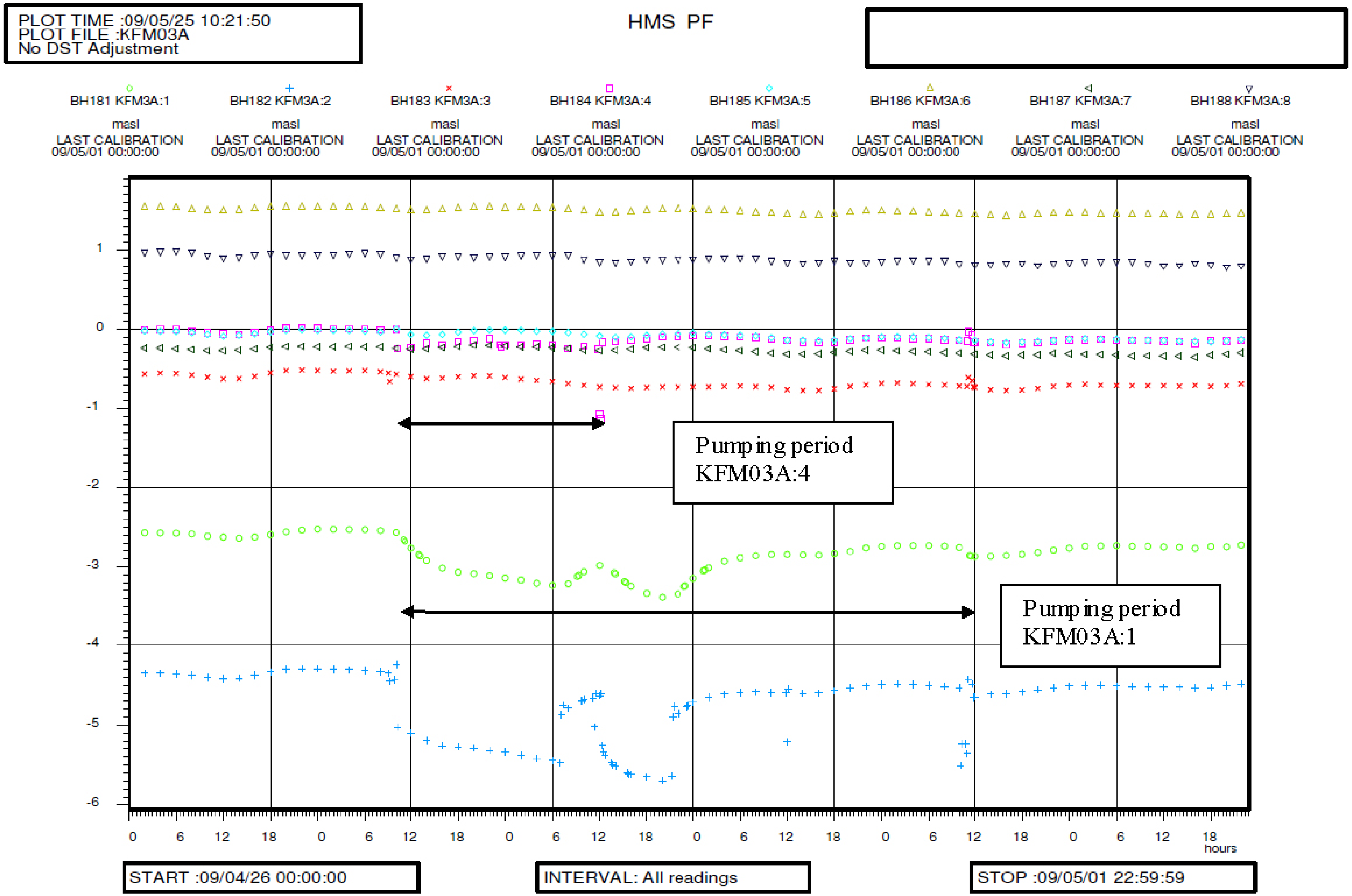


Figure A1-29. *Pumping in KFM03A:1 and KFM03A:4 in April 2009. The pumping was started simultaneously in both sections. The pressure response observed in section KFM03A:2 may be caused by a leaking connection in the equipment between sections KFM03A:1 and KFM03A:2 rather than by a connected fracture system. A small response is also seen in KFM03A:3.*

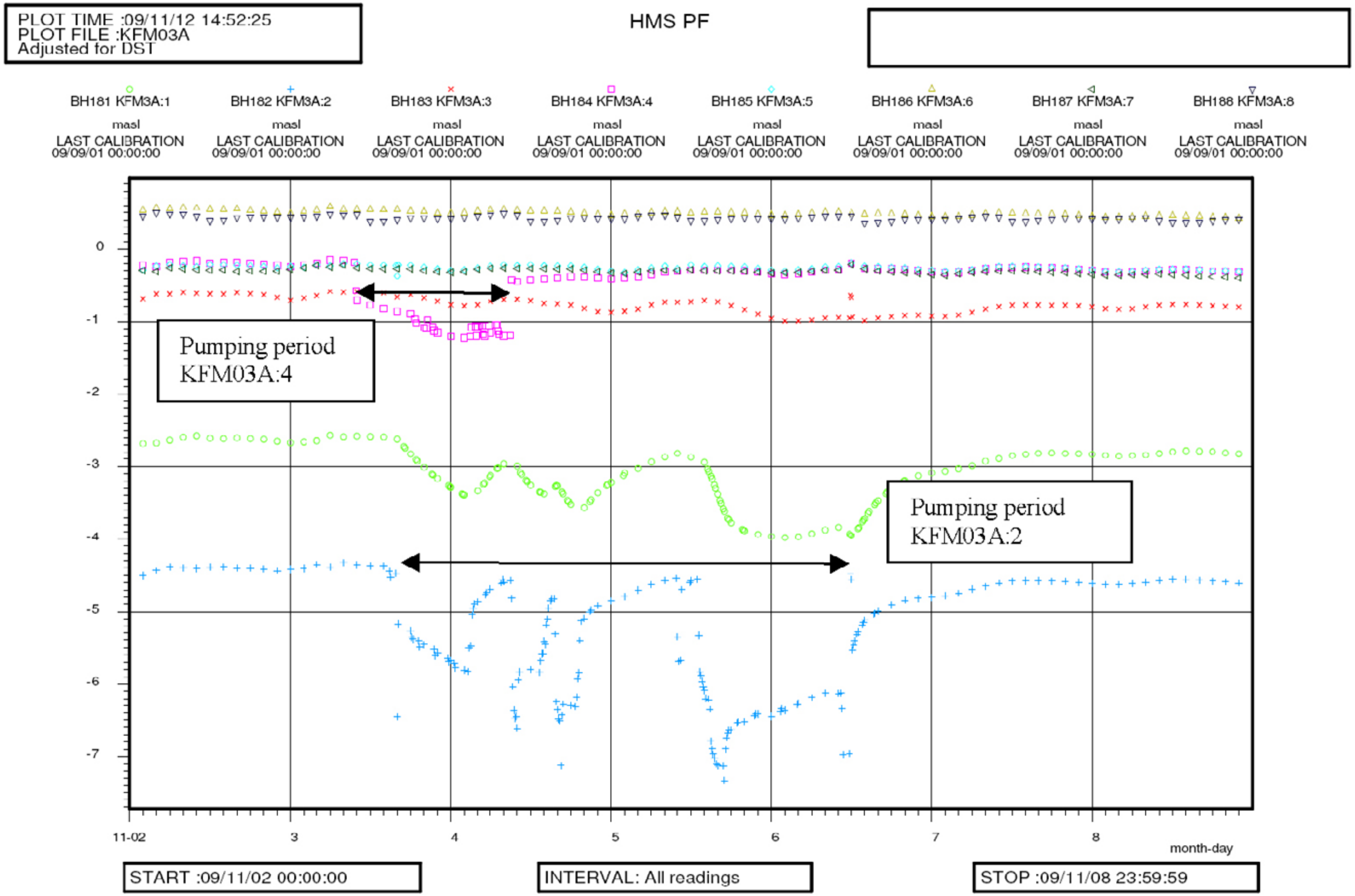


Figure A1-30. *Pumping and drawdown in KFM03A:1 in November 2009. The pressure response observed in section KFM03A:2 may be caused by a leaking connection in the equipment between sections KFM03A:1 and KFM03A:2 rather than by a connected fracture system. A small response is also seen in KFM03A:3.*

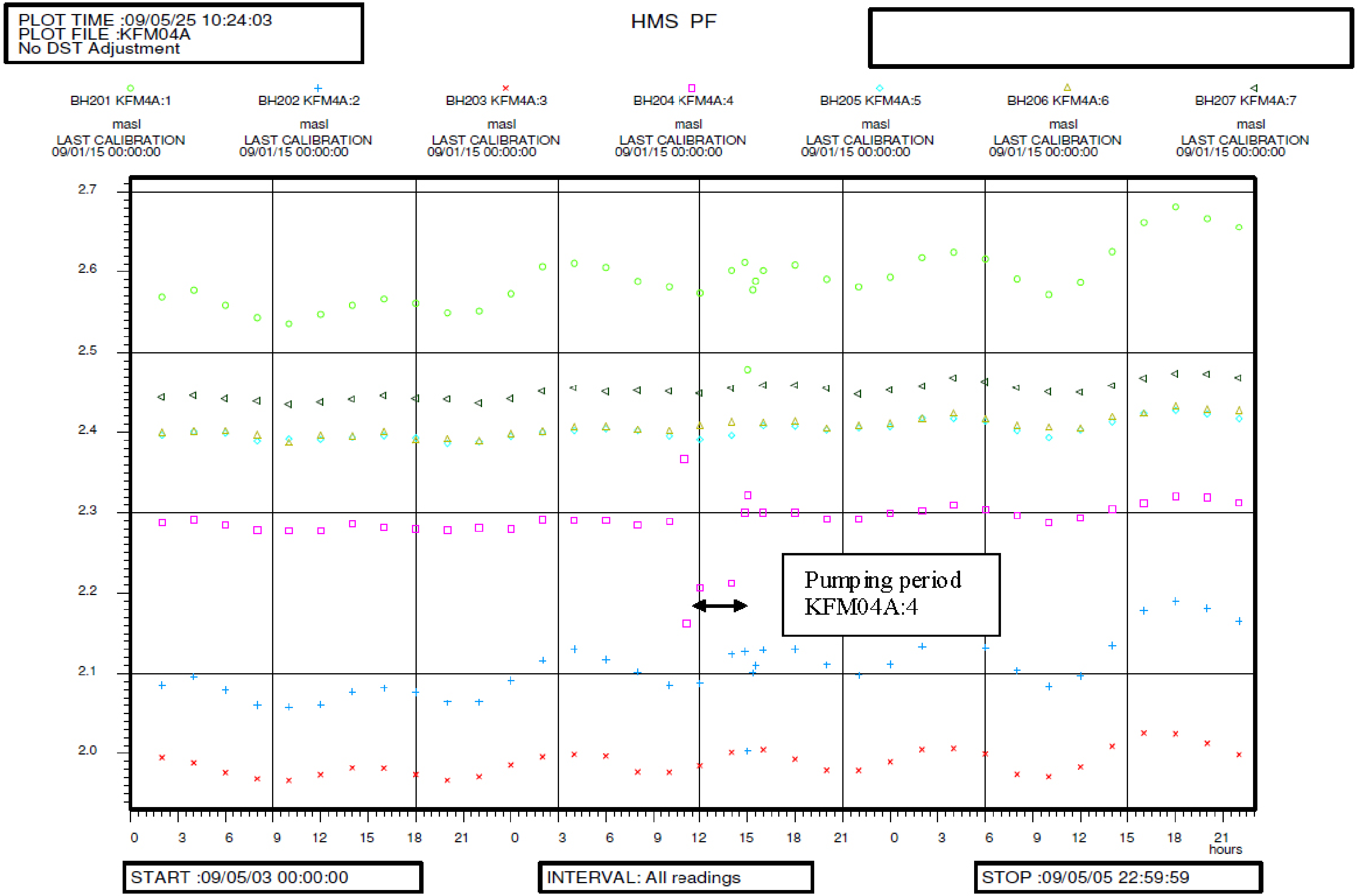


Figure A1‑31. *Pumping and drawdown in KFM04A:4 in May 2009. None of the sections seems affected by the pumping.*

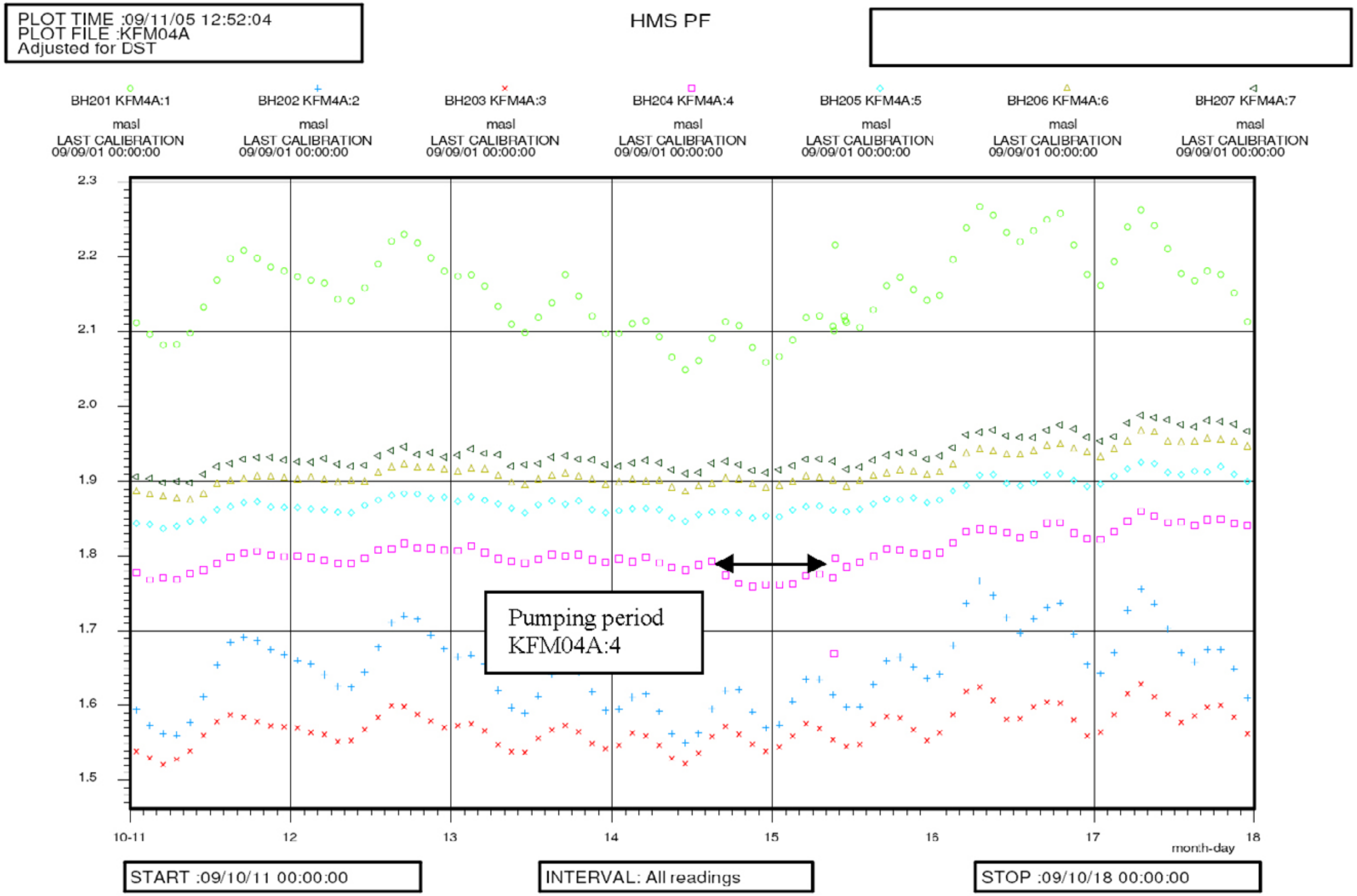
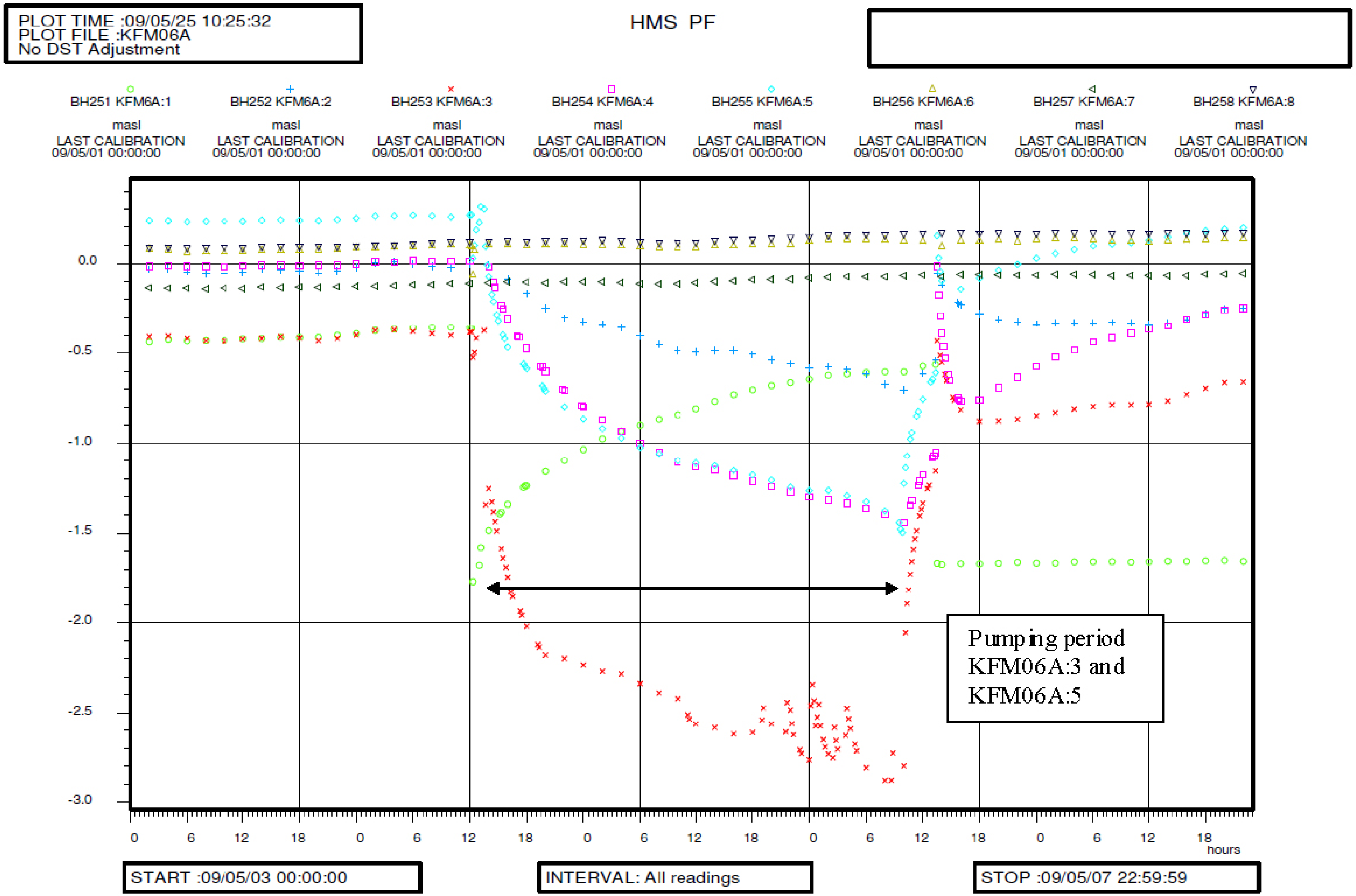


Figure A1-32. *Pumping and drawdown in KFM04A:4 in October 2009. None of the sections seems affected by the pumping.*



Pumping period
KFM06A:3 and
KFM06A:5

Figure A1-33. *Pumping and drawdown in KFM06A:3 and KFM06A:5 in May 2009. Sections KFM06A:2 and :4 are affected by the pumping.*

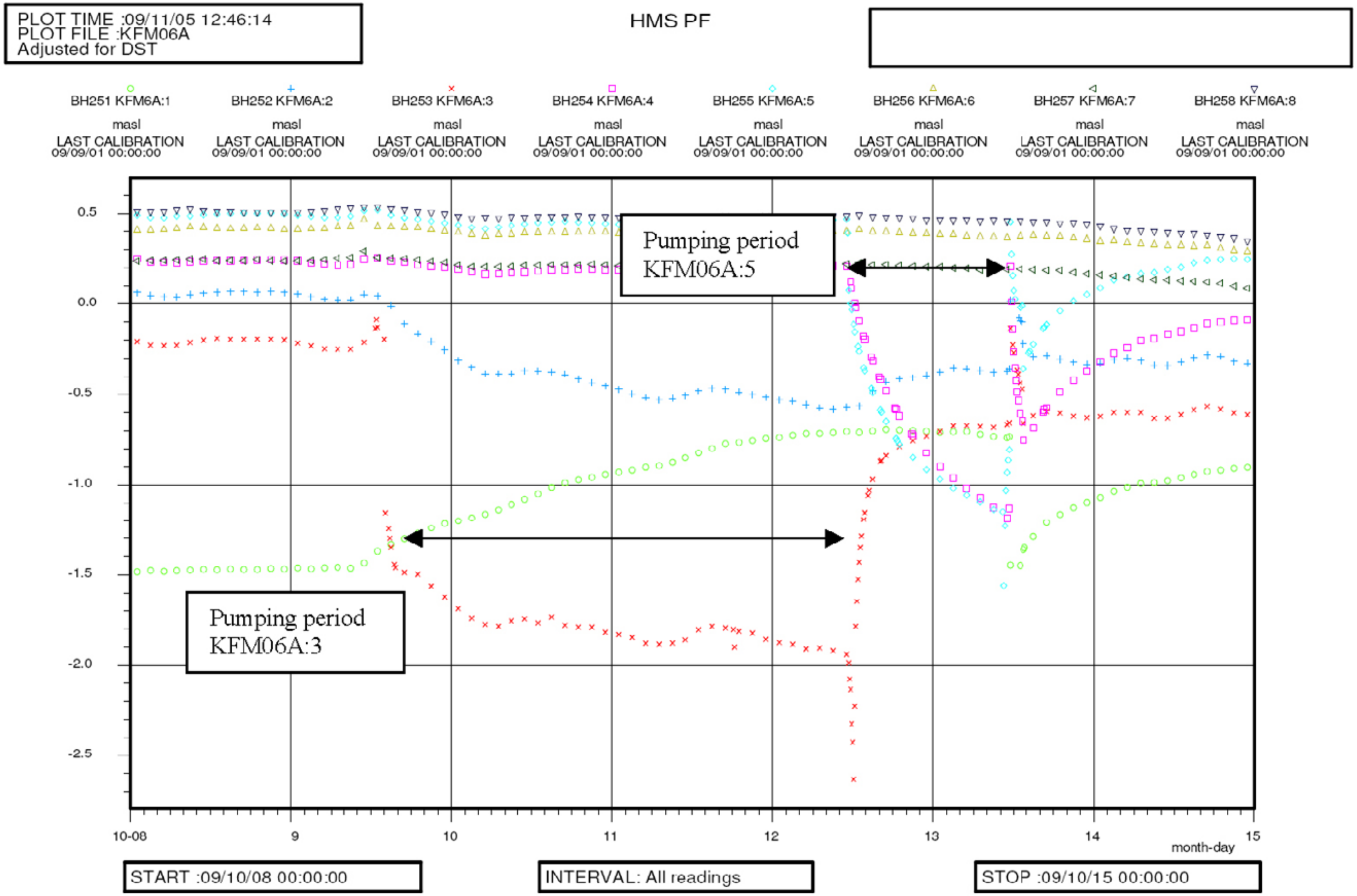


Figure A1-34. Pumping and drawdown in KFM06A:3 and KFM06A:5 in October 2009. Section KFM06A:2 is probably affected by the pumping in both sections. KFM06A:4 is affected by the pumping in section KFM06A:5.

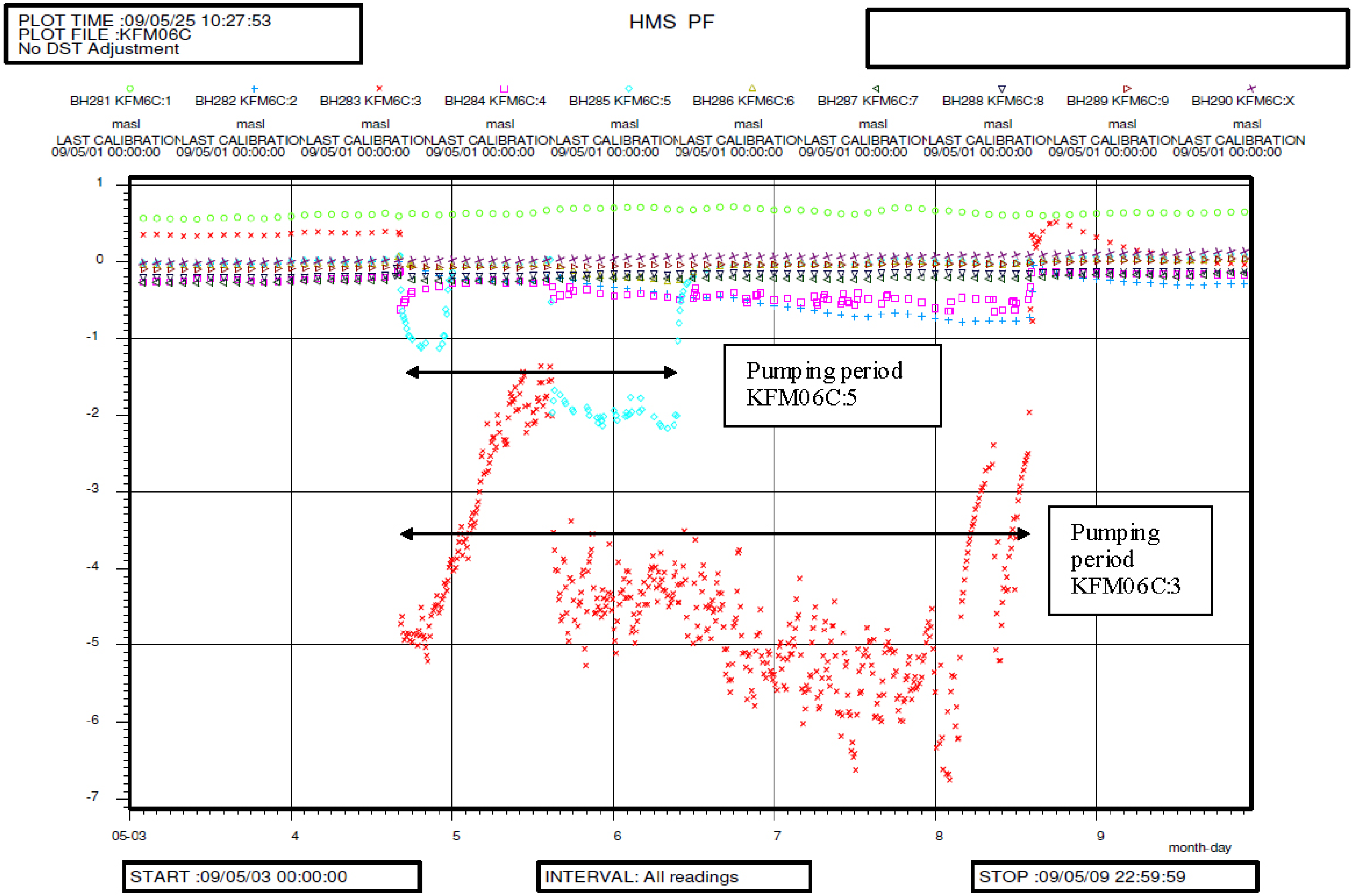


Figure A1-35. *Pumping and drawdown in KFM06C:3 and KFM06C:5 in May 2009. Section KFM06C:4 is affected by the pumping in section :3.*

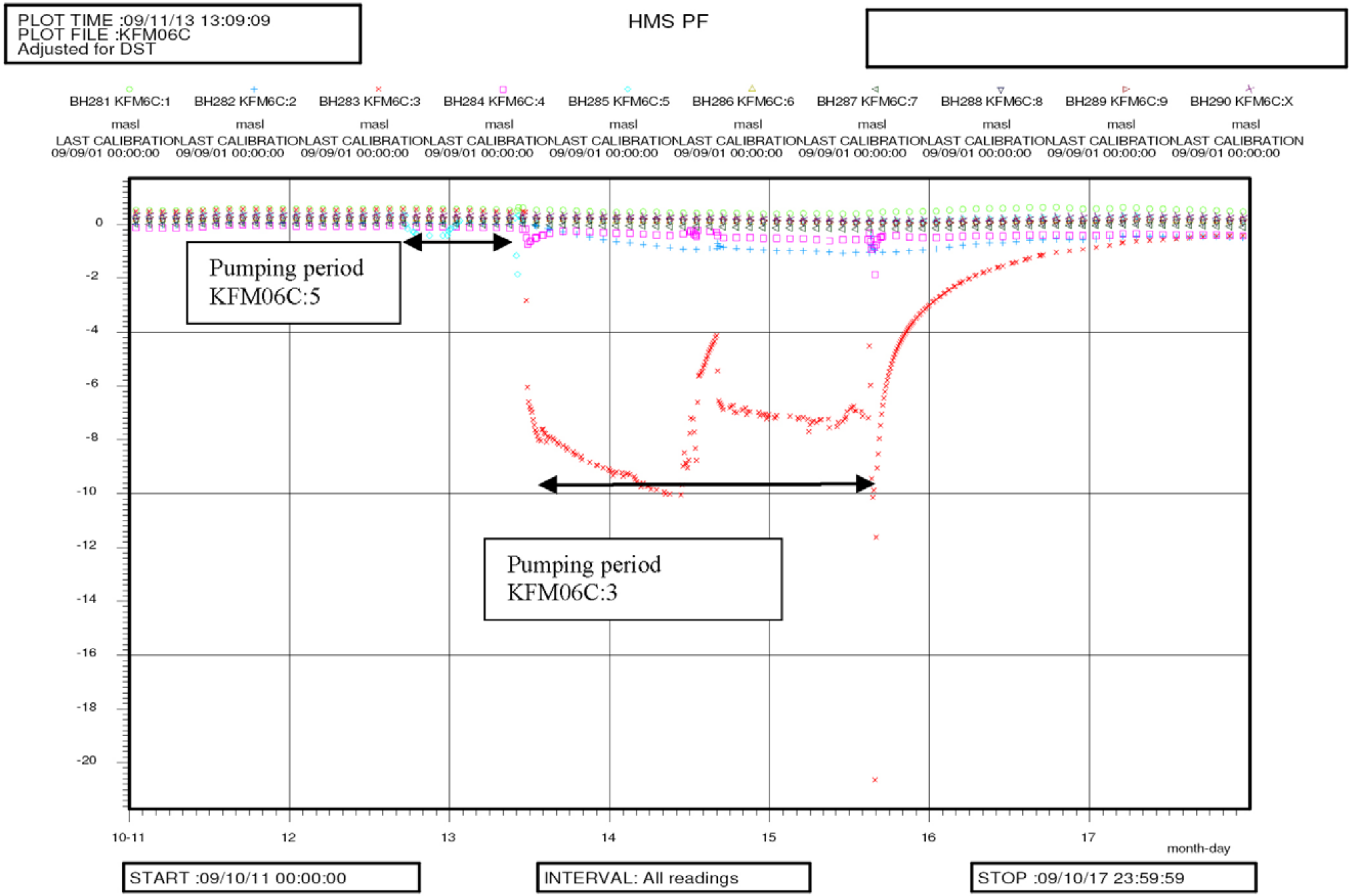


***Figure A1-36.** Pumping and drawdown in KFM06C:3 and KFM06C:5 in October 2009. Section KFM06C:4 is affected by the pumping in section :3.*

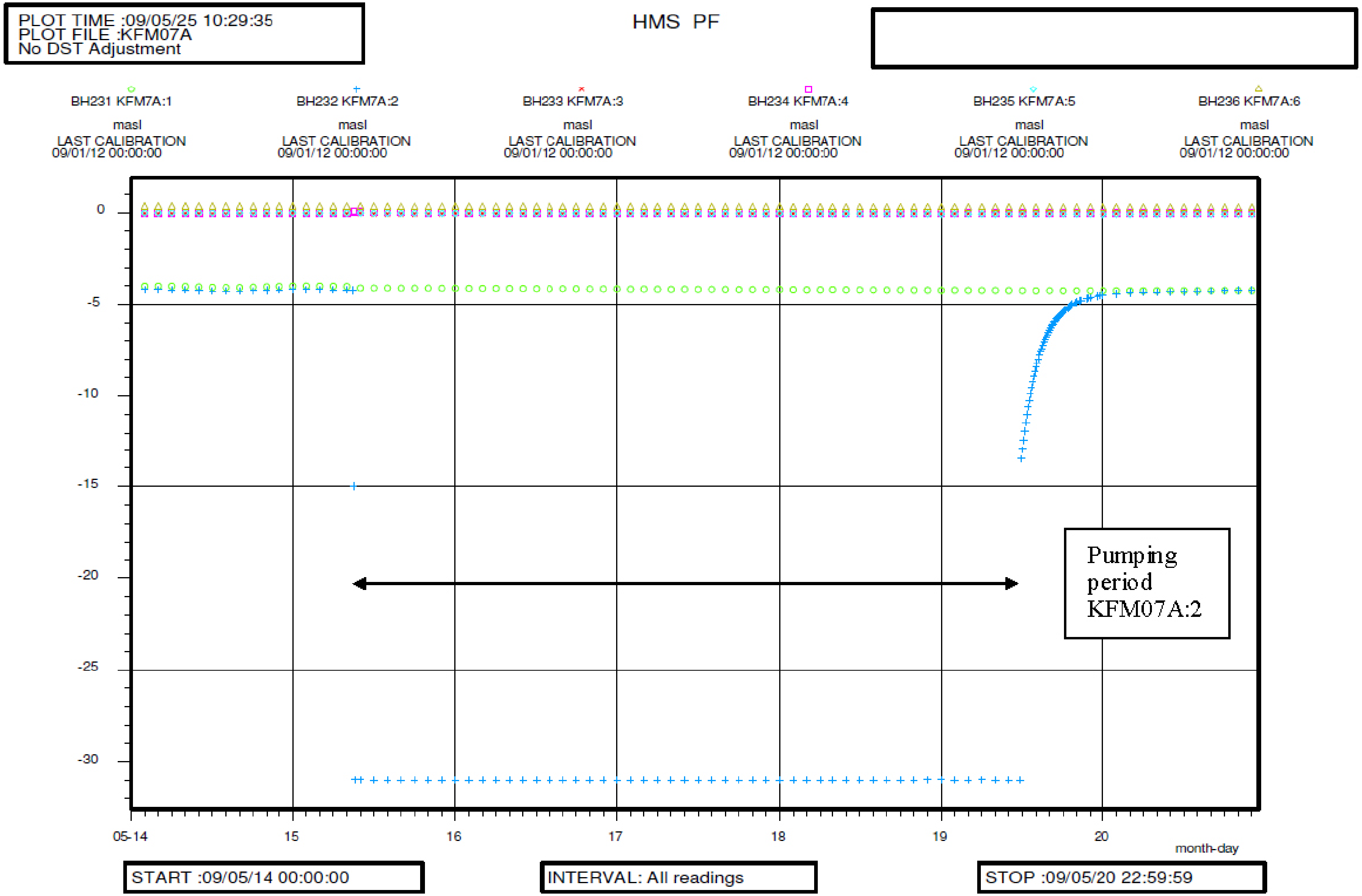


Figure A1-37. Pumping and drawdown in KFM07A:2 in May 2009. None of the other sections are affected by the pumping.

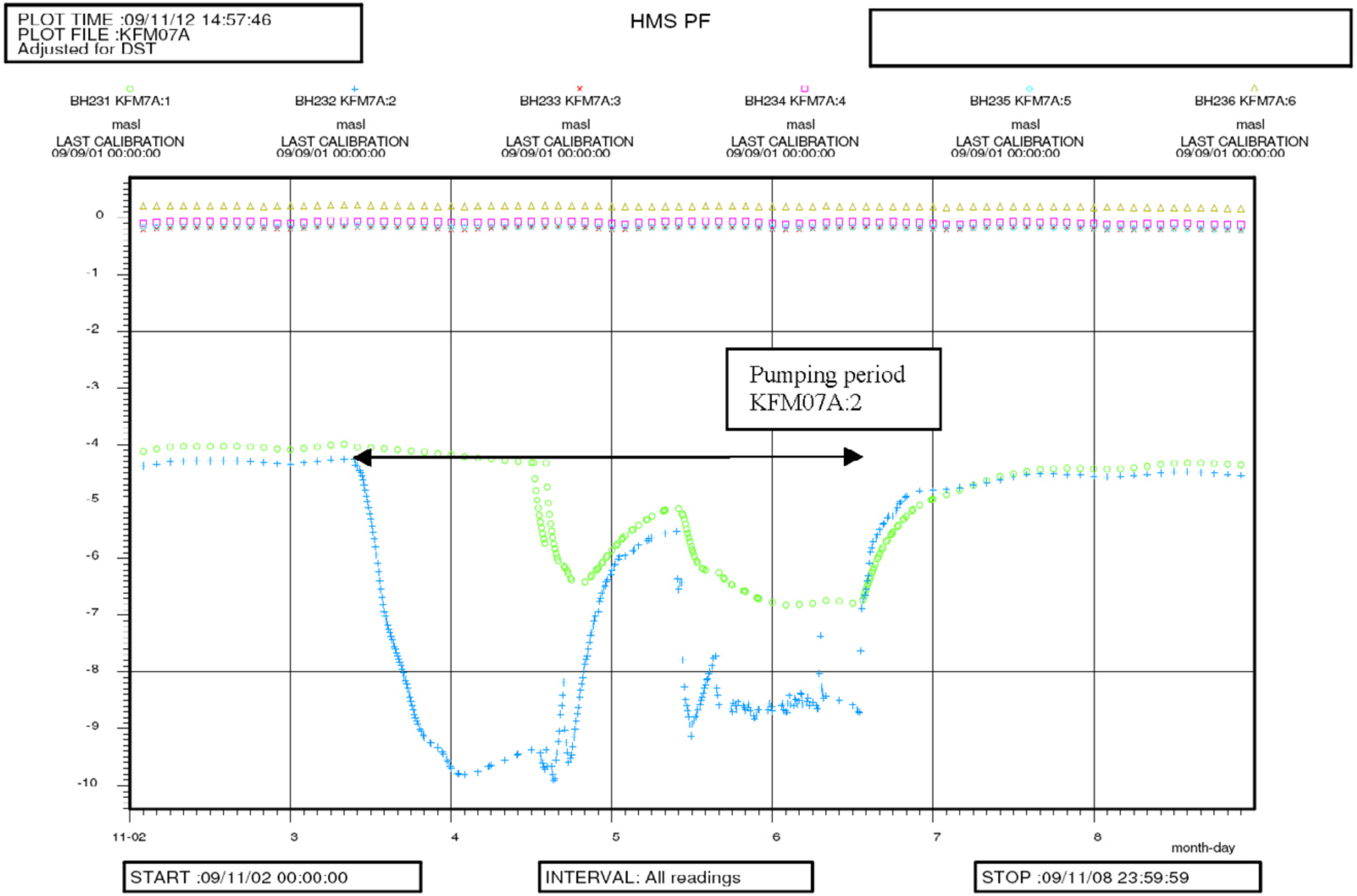


***Figure A1-38.** Pumping and drawdown in KFM07A:2 in November 2009. KFM07A:1 is affected by the pumping, but this may be due to connection between connection hoses rather than a short-cut between the sections. During the first day of pumping, the packers were deflated and it is at the time of packer re-inflation that the response in KFM07A:1 appears.*

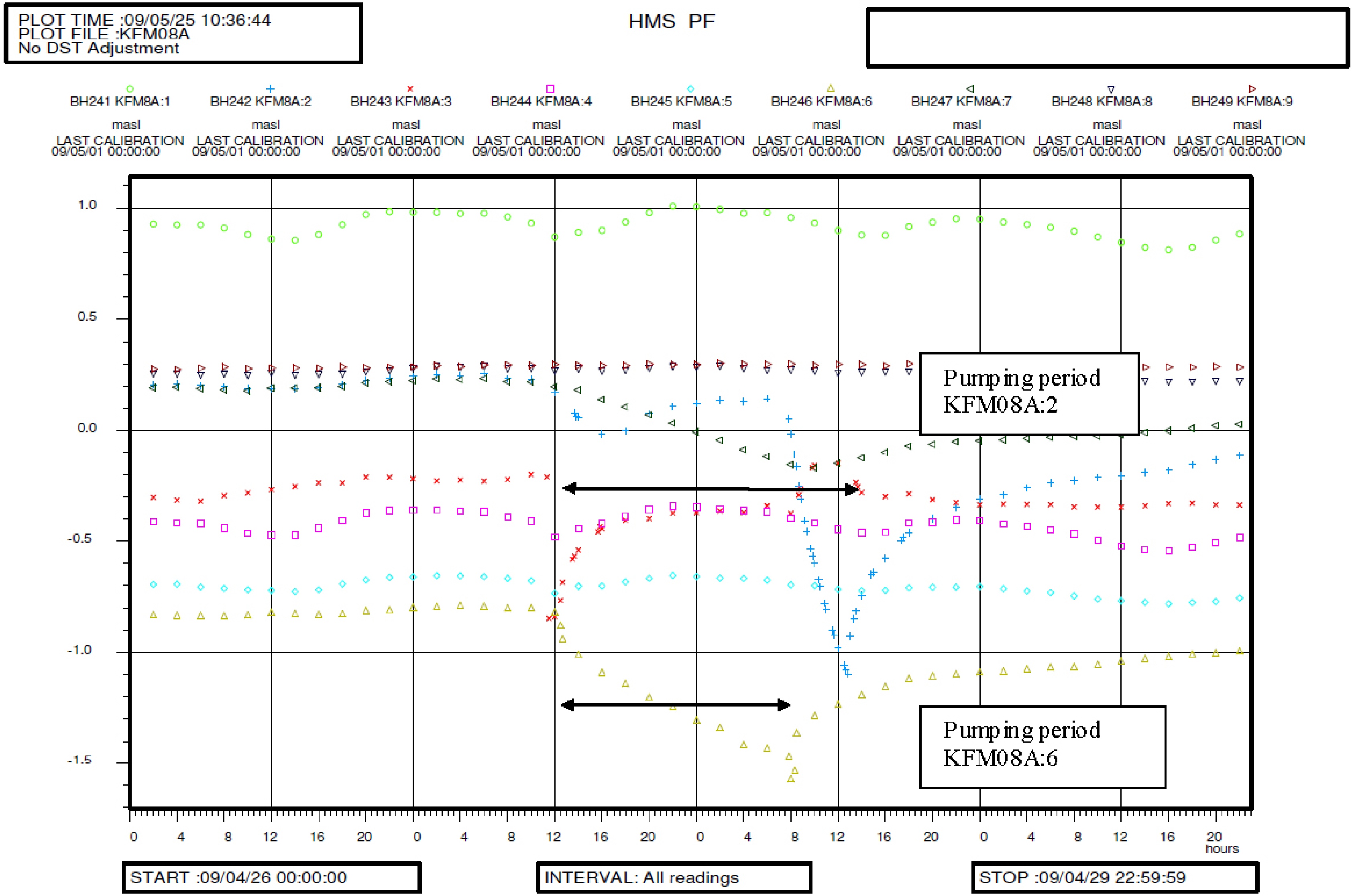


***Figure A1-39.** Pumping and drawdown in KFM08A:2 and KFM08A:6 in April and May 2009. A pressure response from the pumping in section KFM08A:6 is seen in section KFM08A:3 and :7.*

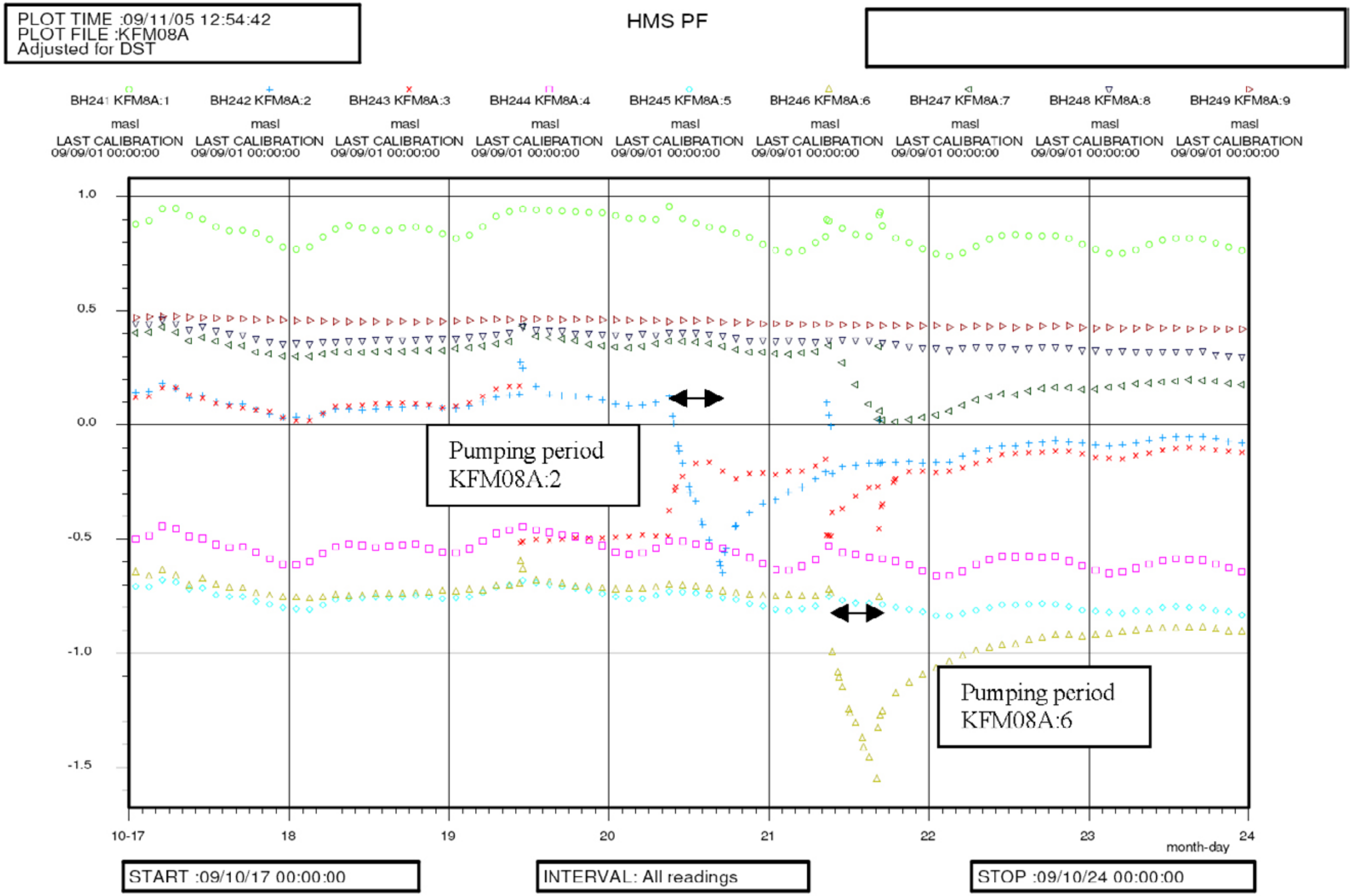


Figure A1-40. *Pumping and drawdown in KFM08A:2 and KFM08A:6 in October 2009. Pressure response from the pumping in section KFM08A:6 is seen in sections KFM08A:3 and :7.*

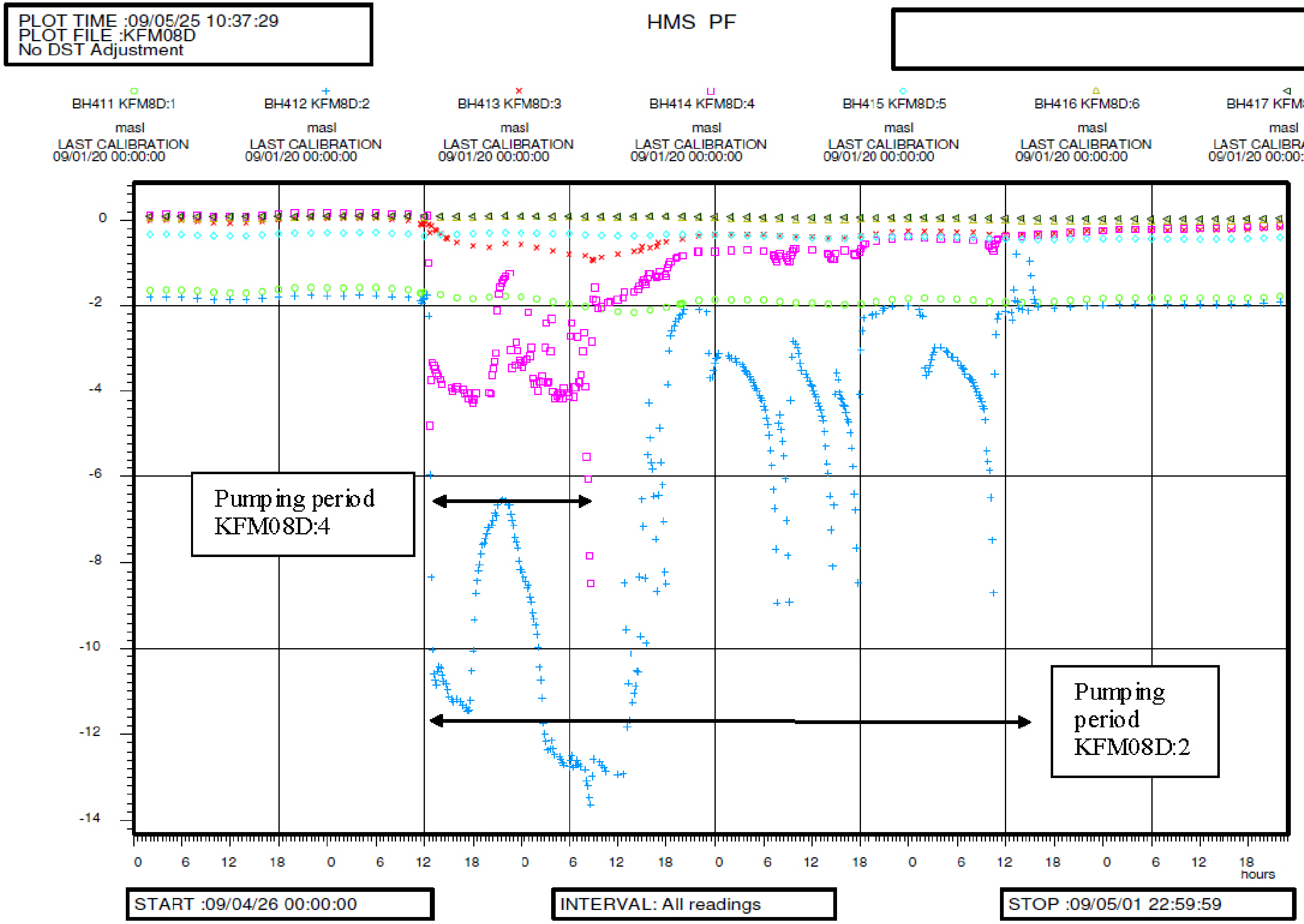


Figure A1-41. Pumping and drawdown in KFM08D:2 and KFM08D:4 in April 2009. Effects from pumping in section KFM08D:4 are seen in section KFM08D:3 and a possible response in KFM08D:1 is observed as well.

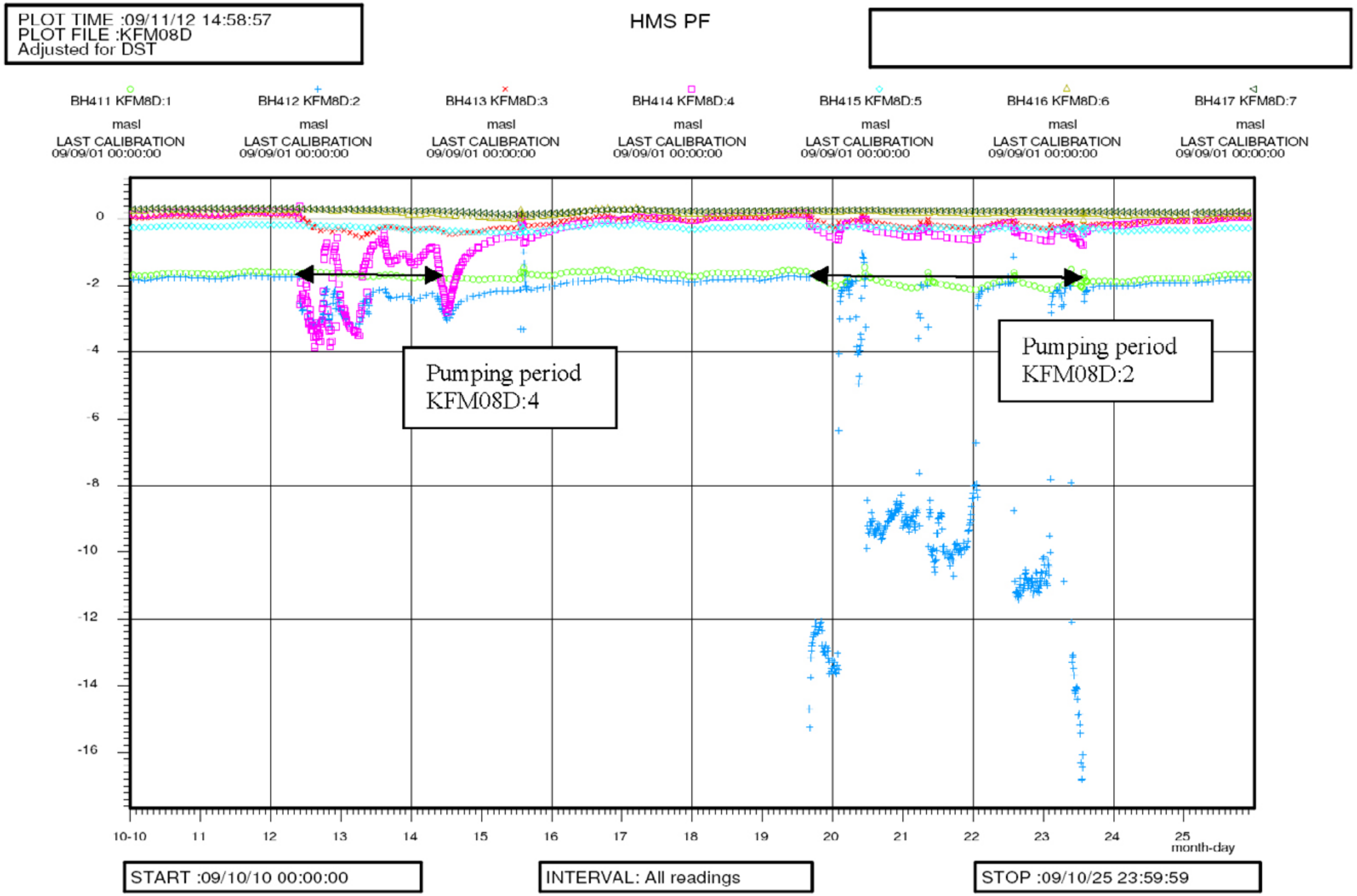


Figure A1-42. *Pumping and drawdown in KFM08D:2 and KFM08D:4 in October–November 2008. Effects from pumping in section KFM08D:4 are seen in section KFM08D:2 and in KFM08D:3 as well. The pumping in KFM08D:2 gives responses in KFM08D:3 and KFM08D:4as well as a small response in KFM08D:1.*

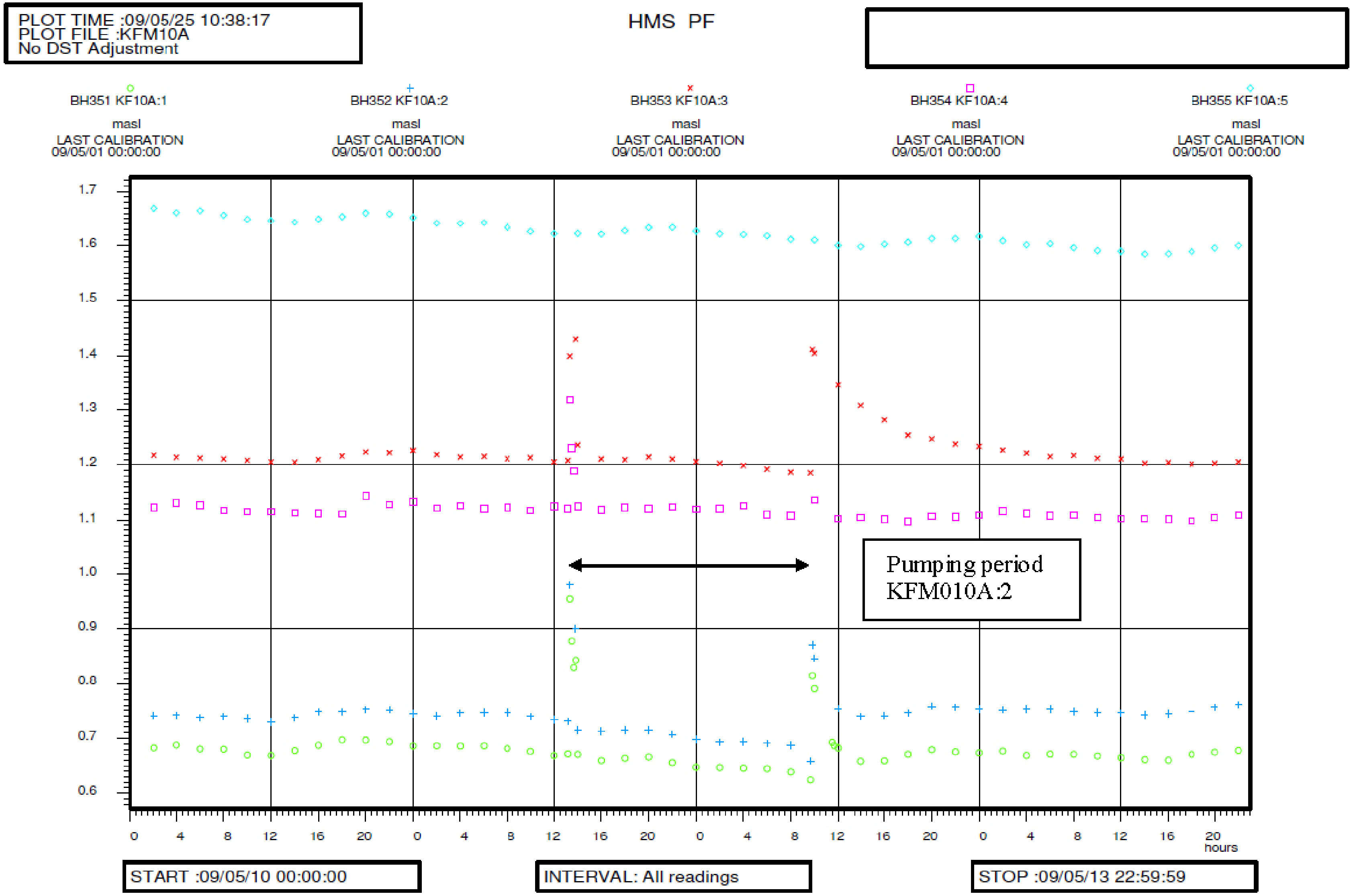


Figure A1-43. *Pumping and drawdown in KFM10A:2 in May 2009. Some pressure responses are observed in section KFM10A:1.*

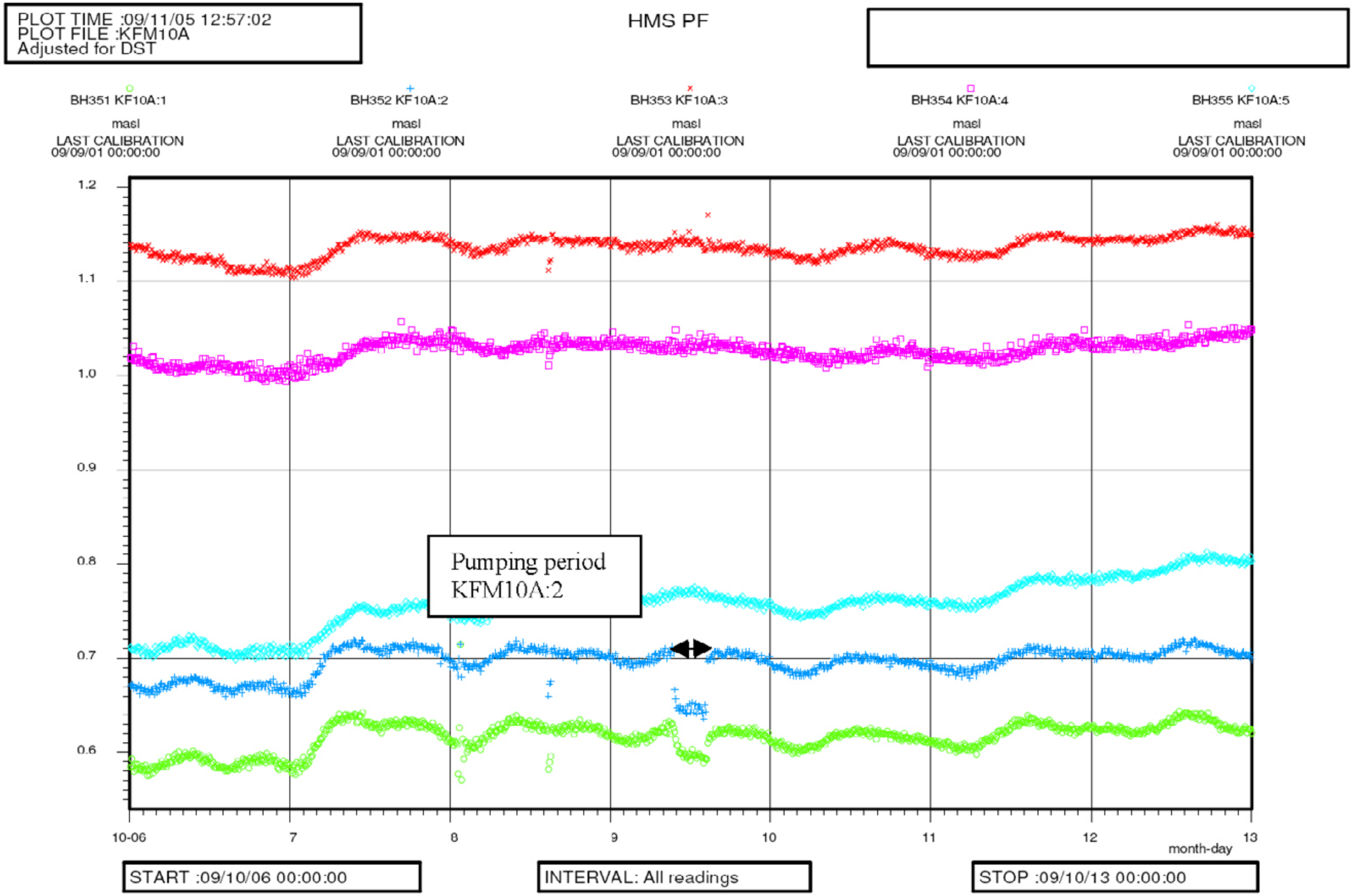


Figure A1-44. *Pumping and drawdown in KFM10A:2 in October 2009. Some pressure responses are observed in section KFM10A:1.*

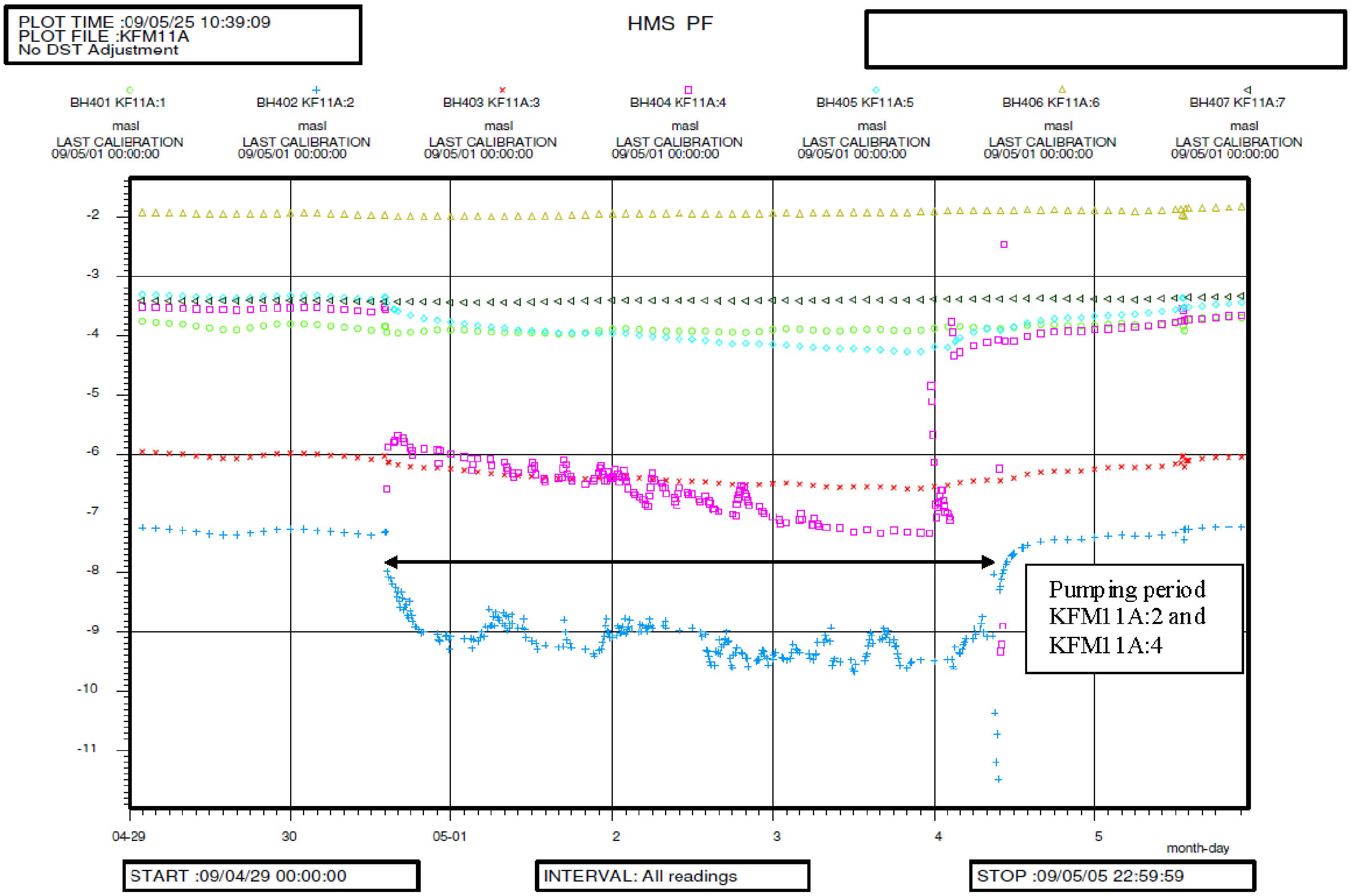


Figure A1-45. *Pumping and drawdown in KFM11A:2 and KFM11A:4 in April and May 2009. Pumping was performed in both sections simultaneously. Some pressure responses are seen in sections KFM11A:3 and KFM11A:5.*

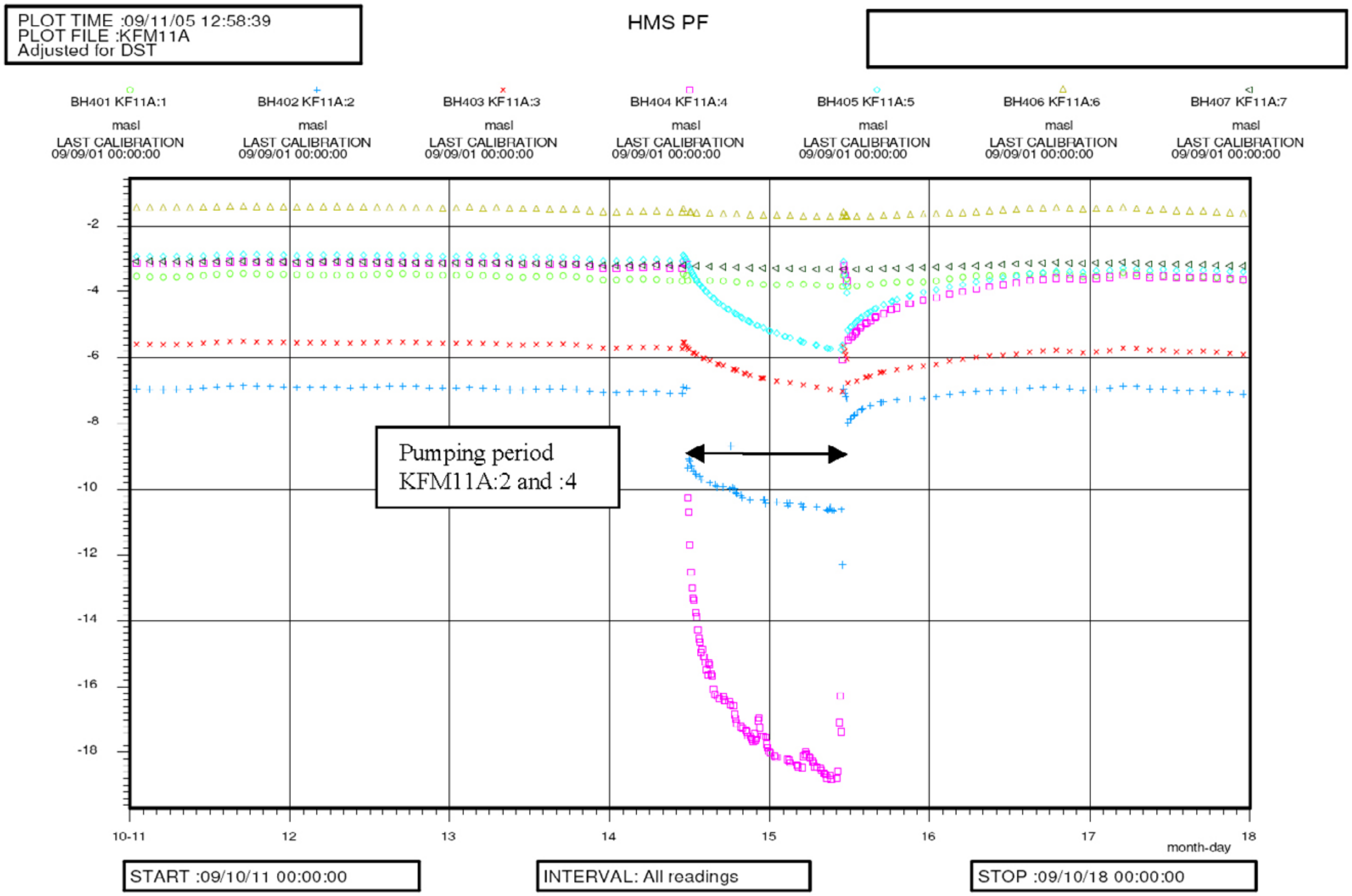


Figure A1-46. *Pumping and drawdown in KFM11A:2 and KFM11A:4 in October 2009. Pumping was performed in both sections simultaneously. Pressure responses are seen in sections KFM11A:3 and KFM11A:5 as well as some small response in KFM11A:1.*

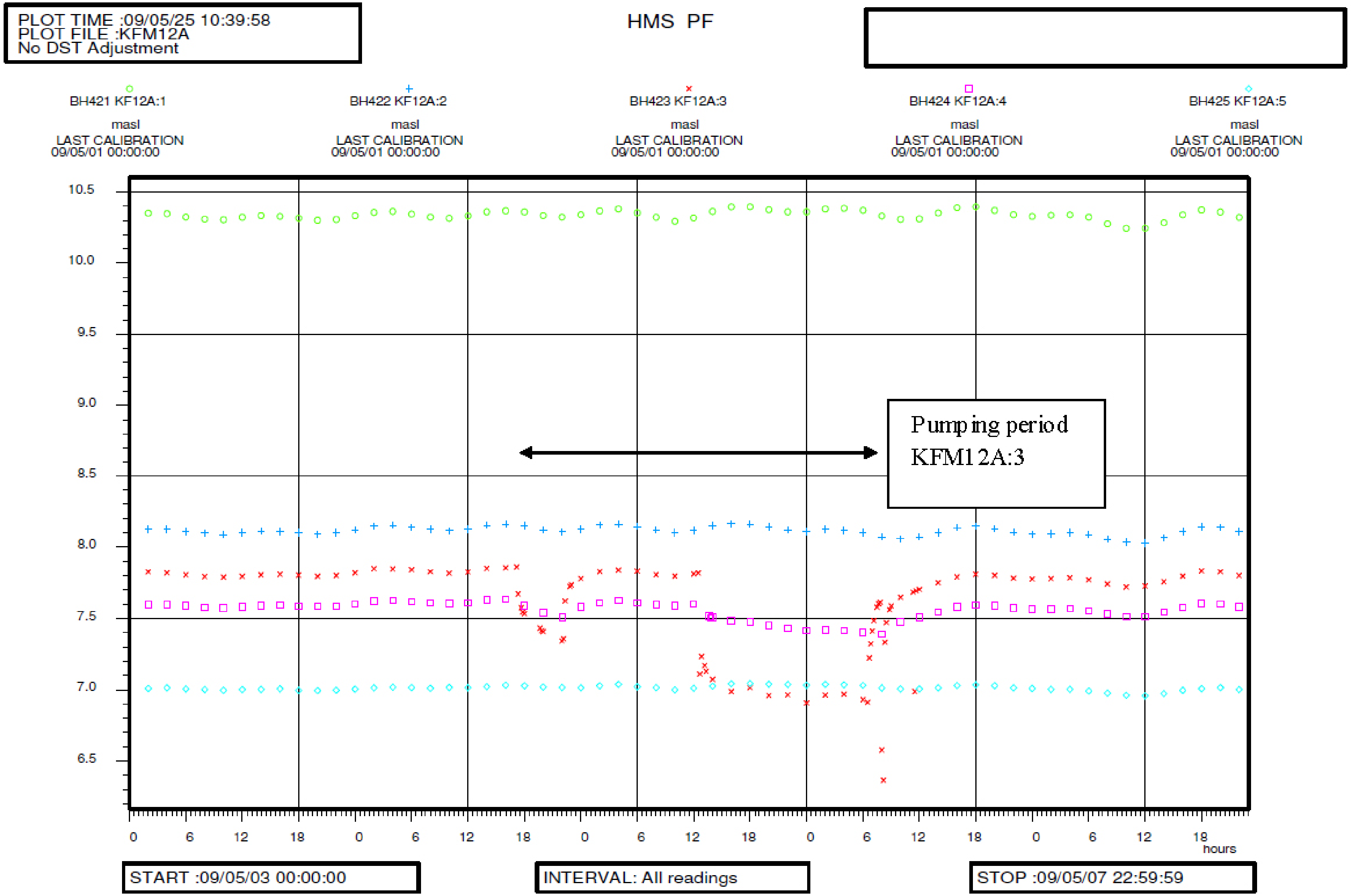


Figure A1-47. *Pumping and drawdown in KFM12A:3 in May 2009. Some pressure responses might be seen in section KFM12A:4.*

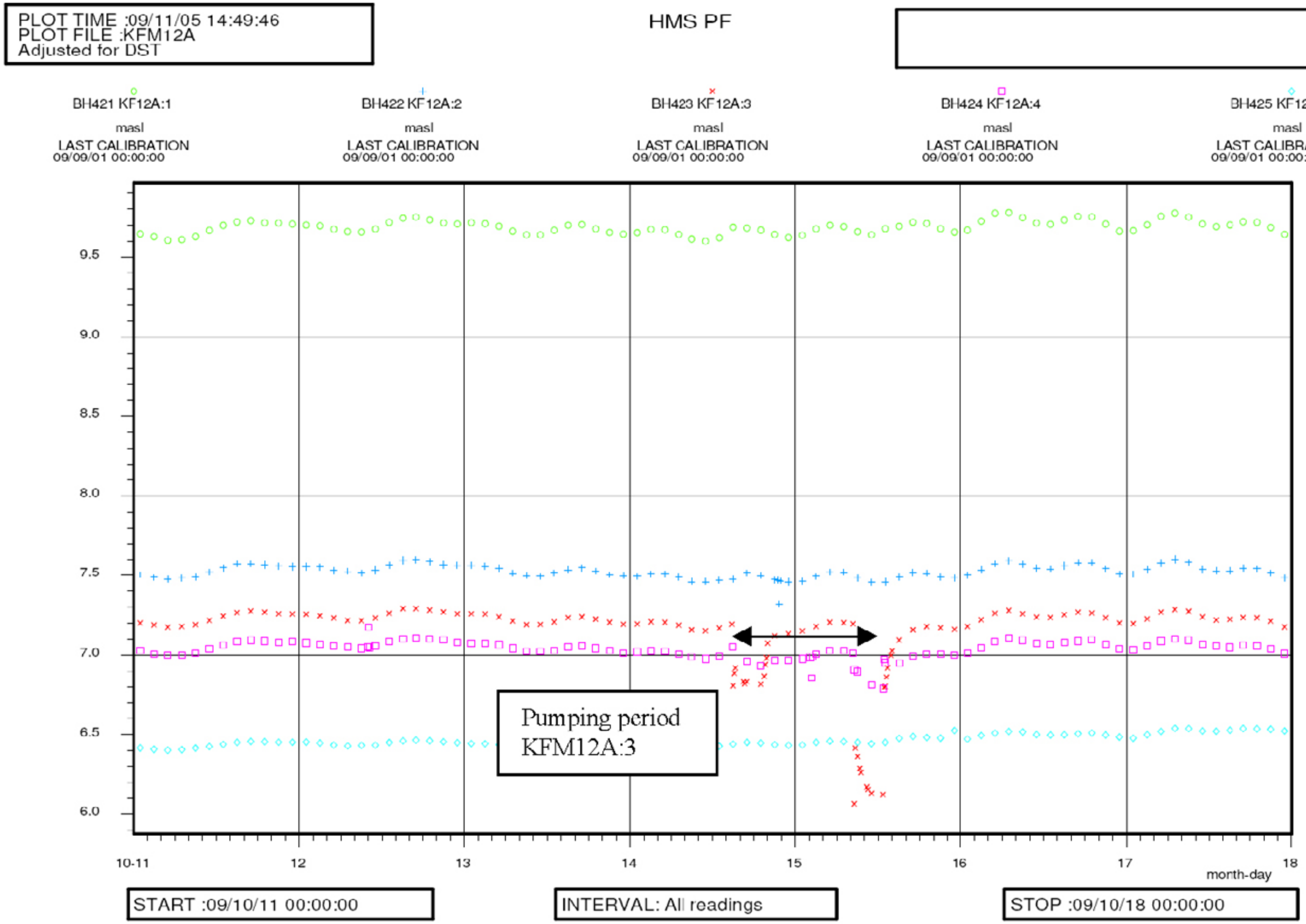


Figure A1-48. *Pumping and drawdown in KFM12A:3 in October 2009. Some pressure responses are seen in section KFM12A:4.*

Appendix 2

Sampling information groundwater

Spring 2009

Idcode:section	Volume in tubes [dm³]	Volume in section [dm³]	Pumped time	Flow rate [mL/min]	Respons in other sections in borehole
HFM01:2	0.1	30	20 h 32 min	185	No
HFM02:2	0.2	25	43 h 33 min	125	No
HFM04:2	0.8	20	18 h 51 min	300	No
HFM13:1	3.6	35	20 h 59 min	222.5	No
HFM15:1	1.5	25	21 h 50 min	500	No
HFM16:2	0.7	32.5	45 h 9 min	180	No
HFM19:1	3.9	35	22 h 11 min	215	No
HFM21:3	0.1	25	46 h 57 min	205	No
HFM27:2	0.5	30	46 h 28 min	235	No
HFM32:3	0.1	12.5	3 h 28 min	750	No
KFM01A:5	2.0	21	65 h 20 min	135	Some in KFM01A:4
KFM01D:4	7.7	10	64 h 26 min	145	In section 3, 5 and a small in 7
KFM01D:2	11.0	9	64 h 3 min	80	In section 3, 5 and a small in 7
KFM01D:2	11.0	9	3 h 9 min	132.5	See above
KFM02A:5	10.5	31	42 h 40 min	137.5	Some effect on section 2
KFM02A:3	12.7	28	42 h 40 min	105	Some effect on section 2
KFM02B:4	10.5	21	42 h 32 min	125	Some effect on section 5
KFM02B:2	12.8	15	42 h 32 min	100	Some effect on section 5
KFM03A:4	16.9	16.5	26h 16 min	90	Yes, section 2
KFM03A:1	26.3	25	30h 59 min	70	Yes, section 2
KFM04A:4	5.4	15	3 h 13 min	660	No
KFM06A:5	8.5	21	44 h 18 min	110	In section 1, 3 and 5
KFM06A:3	19.7	10	44 h 23 min	47.5	In section 1, 3 and 5
KFM06C:5	13.9	9	24 h 39 min	157	In section 2 and 4
KFM06C:3	17.2	19	70 h 29 min	28	In section 2 and 4
KFM07A:2	27.5	14.9	96 h 9 min	150	No
KFM08A:6	6.4	15	19 h 53 min	110	In section 3 and 7
KFM08A:2	18.2	10	8 h 47 min	104	In section 3 and 7
KFM08D:4	17.5	20	20 h 12 min	110	In section 1 and 3
KFM08D:2	22.2	10	74 h 25 min	20	In section 1
KFM10A:2	11.0	10	19 h 51 min	140	Yes, some in section 1
KFM11A:4	11.5	10	81 h 36 min	60	In section 3 and 5
KFM11A:2	18.4	20	91 h 28 min	120	In section 3 and 5
KFM12A:3	10.2	20.2	24 h 15 min	233	In section 4

Autumn 2009

Idcode:section	Volume in tubes [dm³]	Volume in section [dm³]	Pumped time	Flow rate [mL/min]	Respons in other sections in borehole
HFM01:2	1.23	36.33	22 h 23 min	285	No
HFM02:2	1.36	24.82	21 h 41 min	240	No
HFM04:2	1.92	22.74	22 h 31 min	360	No
HFM13:1	4.78	28.64	19 h 20 min	220	No
HFM15:1	2.69	29.41	20 h 56 min	220	No
HFM16:2	1.81	38.92	6 h 29 min	900	No
HFM19:1	5.03	33.51	17 h 45 min	300	No
HFM21:3	0.90	28.56	17 h 44 min	210	No
HFM27:2	1.58	36.08	21 h 40 min	205	No
HFM32:3	1.02	17.14	4 h 41 min	260	No
KFM01A:5	3.36	25.23	7 h 23 min	257	Some in KFM01A:4
KFM01D:2	12.41	12.58	5 h 36 min	205	In section 3
KFM01D:4	9.08	12.03	4 h 55 min	240	In section 5
KFM02A:3	14.14	36.59	9 h 4 min	300	Some in section 5
KFM02A:5	11.90	35.29	9 h 42 min	300	No
KFM02B:2	14.17	19.20	4 h 35 min	440	No
KFM02B:4	11.88	22.43	4 h 53 min	500	No
KFM03A:1	27.69	34.33	67 h 48 min	85	Yes, section 2
KFM03A:4	18.19	20.37	23 h 25 min	300	No
KFM04A:4	6.79	20.34	18 h 14 min	165	No
KFM06A:3	21.15	14.98	70 h 14 min	45	In section 2 and 4
KFM06A:5	9.92	25.40	23 h 30 min	150	In section 4
KFM06C:3	18.58	25.62	52 h 57 min	25	In section 4
KFM06C:5	15.30	11.95	16 h 49 min	138	No
KFM07A:2	27.48	14.93	73 h 27 min	100	Yes some in section 1
KFM08A:2	19.62	14.93	8 h 0 min	205	No
KFM08A:6	7.78	17.90	6 h 58 min	240	In section 3 and 7
KFM08D:2	23.61	15.25	93 h 25 min	26	Yes, section 3, 4 and some in 1
KFM08D:4	18.94	24.86	50 h 20 min	85	Yes, section 2 and 3
KFM10A:2	12.44	13.68	4 h 50 min	285	Yes, section 1
KFM11A:2	19.79	28.08	23 h 20 min	180	Yes, section 5, 3 and some in section 1
KFM11A:4	12.89	13.60	23 h 3 min	180	Yes, section 5, 3 and some in section 1
KFM12A:3	7.92	14.98	21 h 33 min	263	Yes in section 4

Pumping periods in sections with pump failures

ID Code	Pump start	Pump stop	Duration (min)	Flow rate (mL/min)
KFM03A:1	2009-11-03 15:59	2009-11-04 03:00	661	0.05
	2009-11-04 09:13	2009-11-04 13:20	247	0.08
	2009-11-04 15:36	2009-11-04 18:40	184	0.1
	2009-11-05 10:00	2009-11-05 10:45	45	0.09
	2009-11-05 13:09	2009-11-05 14:46	97	0.11
	2009-11-05 14:46	2009-11-05 16:45	119	0.15
	2009-11-05 16:45	2009-11-06 10:30	1,065	0.095
KFM06C:5	2009-10-12 17:23	2009-10-12 23:45	382	0.135
	2009-10-13 09:50	2009-10-13 09:57	7	0.35
KFM06C:3	2009-10-13 10:59	2009-10-14 11:00	1,441	0.025
	2009-10-14 16:00	2009-10-15 14:52	1,372	0.025
	2009-10-15 15:02	2009-10-15 15:10	8	0.05
KFM07A:1	2009-11-03 11:45[1)]	2009-11-03 23:35	710	0.11
	2009-11-03 23:35	2009-11-04 11:24	709	0.1
	2009-11-04 11:30	2009-11-04 14:30	180	0.13
	2009-11-04 14:30	2009-11-04 17:30	180	0.12
	2009-11-04 17:30	2009-11-05 09:30	960	0.08
	2009-11-05 09:30	2009-11-05 10:39	69	0.11
KFM08D:2	2009-10-19 16:06	2009-10-20 02:00	590	0.03
	2009-10-20 08:00	2009-10-20 10:00	120	0.03
	2009-10-20 11:30	2009-10-21 06:00	1,110	0.023
	2009-10-21 08:40	2009-10-22 01:35	1,015	0.025
	2009-10-22 13:55	2009-10-23 02:30	755	0.025
	2009-10-23 09:25	2009-10-23 13:31	246	0.038
KFM08D:4	2009-10-12 09:53	2009-10-12 20:22	629	0.1
	2009-10-12 22:39	2009-10-13 07:20	521	0.07
	2009-10-13 07:20	2009-10-13 09:20	120	0.05
	2009-10-13 14:25	2009-10-13 20:00	335	0.1
	2009-10-14 08:16	2009-10-14 08:45	29	0.13
	2009-10-14 08:45	2009-10-14 11:08	143	0.06
KFM12A:3	2009-10-14 15:13	2009-10-14 19:00	227	0.17
	2009-10-15 08:28	2009-10-15 12:33	245	0.35

[1)] Fictive start time to account for the fact that the packer was not expanded during the first part of the pumping and that a portion of the pumped water originated from the standpipe and not from the section. The real starting time was 2009-11-03 09:40.

Appendix 4

Sampling, analytical methods and data handling

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 120×2	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)
Dissolved organic Carbon, dissolved inorganic Carbon	DOC, DIC	Plastic	250 25	Yes	Frozen, transported in isolated bag	UV oxidation, IR	Short transportation time
Total organic Carbon	TOC	Plastic	250 25	No	Frozen, transported in isolated bag	UV oxidation, IR	Short transportation time
Environmental isotopes	^2H, ^{18}O	Plastic	100	No	– –	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.
Tritium,	^{3}H (enhanced.)	Plastic (dry bottle)	500	No	–	LSC	Not critical (month)
Chlorine-37	Chlorine-37	Plastic	100	No	–	MS	
Carbon isotopes	^{13}C, ^{14}C	Glass (brown)	100×2	No	–	(A)MS	A few days
Sulphur isotopes	^{34}S	Plastic	500–1,000	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_2H_2, C_2H_4, C_2H_6, C_3H_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
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
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	1,000	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

Component group	Component/element	Sample container (material)	Volume (mL)	Filtering	Preparation/ Conservation*	Analysis method	Analysis within – or delivery time to lab.
Chlorophyll	Chlorophyll a, c and pheopigment	Plastic	1,000–2,000	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	5,000	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
INAA	Instrumental Neutron Activation Analysis
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.

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^- Cl^-	Mohr-titration IC	≥ 70 0.5–70	mg/L	5% 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^- F^-	IC Potentiometric	DL 0.2, RL 0.5 DL 0.1, RL 0.2	mg/L	13% 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% (50–1,200 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	0.7	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%
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]

Component	**Method**[1]	**Reporting limits (RL), detection limits (DL) or range**[2]	**Unit**	**Measurement uncertainty**[3]
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]
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[7]	0.9 (one standard deviation)
δ^{18}O	MS	0.1	‰ SMOW[7]	0.1 (one standard dev.)
^{3}H	LSC	0.8	TU[8]	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 dev.)
^{87}Sr/^{86}Sr	TIMS	–	No unit (ratio)[14]	0.00002
^{10}B/^{11}B	ICP SFMS	–	No unit (ratio)[14]	–
^{234}U, ^{235}U, ^{238}U, ^{232}Th, ^{30}Th	Alfa spectr.	0.0001	Bq/L[15]	≤5% (Counting statistics uncertainty)
^{222}Rn, ^{226}Ra	LSS	0.015	Bq/L	≤5% (Count. stat. uncert.)

[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, 1,440 mS/m and 3,810 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 deviation[16] 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 deviation[16] from SMOC (Standard Mean Oceanic Chloride).

[11] Per mille deviation[16] from PDB (the standard PeeDee Belemnite).

[12] The following relation is valid between pmC (percent modern carbon) and Carbon-14 age: pmC = $100 \times e^{((1950-y-1.03t)/8274)}$.
where y = the year of the C-14 measurement and t = C-14 age.

[13] Per mille deviation[16] 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/kg^{238}U, 1 ppm Th = 3.93 Bq/kg^{232}Th.

[16] Isotopes are often reported as per mill deviation from a standard. The deviation is calculated as: $\delta yI = 1{,}000 \times (K_{sample} - K_{standard}) / K_{standard}$, where K = the isotope ratio and ^{y}I = ^{2}H, ^{18}O, ^{37}Cl, ^{13}C or ^{34}S etc.

[17] SKB estimation from duplicate analyses by the contracted laboratory.

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%).

$$rel.error(\%) = 100 \times \frac{\sum cation(equivalents) - \sum anions(equivalents)}{\sum cation(equivalents) + \sum anion(equivalents)}$$

- 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 A4-1.

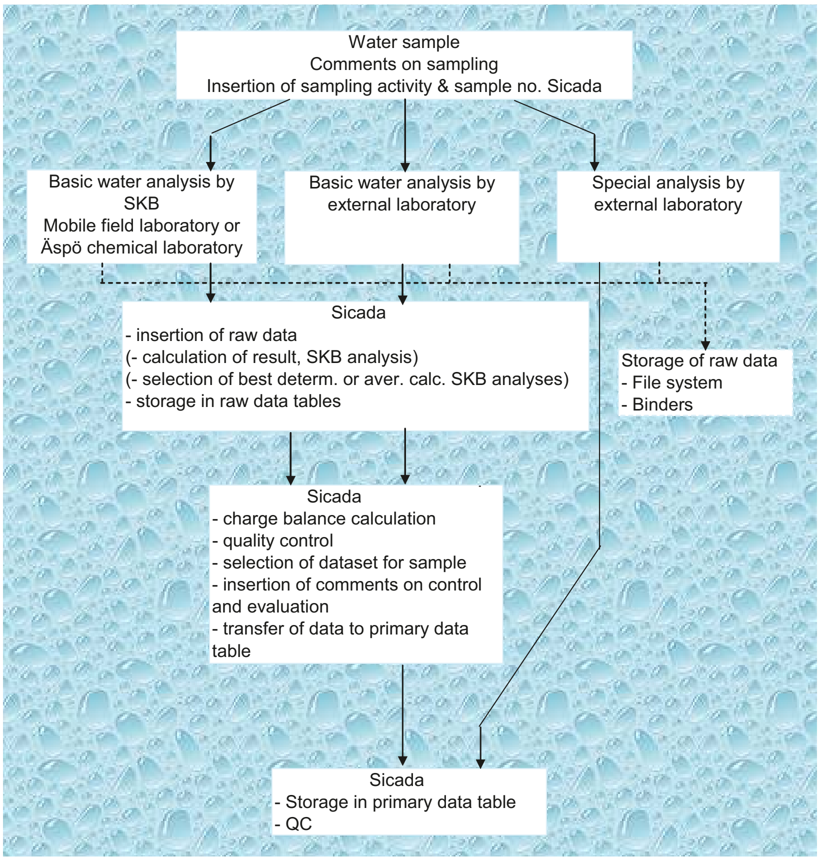


***Figure A4-1.** Overview of data management for hydrochemical data.*

Appendix 5

Water composition, groundwater

Table A5-1. Water composition.

Id code	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	SO$_4$-S mg/L	Br$^-$ mg/L	F$^-$ mg/L	Si mg/L	Fe mg/L	Fe-tot mg/L	FeII mg/L	Mn mg/L	Li mg/L	Sr mg/L	I$^-$ mg/L	pH_L
HFM01	33.50	45.50	16282	2009-04-28	1.80	538	17.1	78.3	24.6	445	614	172	63.4	2.26	2.39	6.83	–	–	–	–	0.0150	0.484		7.78
HFM01	33.50	45.50	16522	2009-10-07	–4.88	466	13.9	77.9	23.1	449	638	168	57.9	2.49	2.47	6.42	–	–	–	–	0.0153	0.413	–	7.78
HFM02	38.00	48.00	16285	2009-04-30	–0.65	463	18.8	111	34.8	394	714	116	43.2	2.51	1.75	7.35	–	–	–	–	0.0192	0.732	–	7.65
HFM02	38.00	48.00	16521	2009-10-07	0.14	376	14.4	90.4	27.4	281	587	107	34.3	2.33	1.94	6.82	–	–	–	–	0.0158	0.517	–	7.68
HFM04	57.90	65.90	16295	2009-05-06	0.21	161	6.57	31.4	8.08	390	66.0	46.0	16.1	0.231	2.02	7.68	–	–	–	–	0.0088	0.241	–	7.71
HFM04	58.00	66.00	16548	2009-10-14	–2.77	155	6.62	29.7	7.87	394	71.1	46.3	15.8	0.326	2.01	7.51	–	–	–	–	0.0078	0.210	–	7.77
HFM13	159.00	175.60	16303	2009-05-12	–1.08	1,790	23.0	1,260	224	119	5,320	471	179	21.9	1.33	8.57	–	–	–	–	0.0622	13.4	–	7.29
HFM13	159.00	173.00	16533	2009-10-08	–2.58	1,780	22.4	1,230	216	116	5,430	470	166	21.8	1.20	8.01	–	–	–	–	0.0559	12.0	–	7.22
HFM15	85.00	99.50	16308	2009-05-12	–1.10	265	11.8	86.9	18.1	495	304	56.5	20.8	1.22	1.02	9.92	–	–	–	–	0.0139	0.490	–	7.16
HFM15	85.00	95.00	16534	2009-10-08	–3.84	291	10.8	93.7	19.6	490	396	73.3	23.8	1.53	1.18	9.06	–	–	–	–	0.0126	0.482	–	7.25
HFM16	54.00	67.00	16283	2009-05-06	–0.85	272	6.63	31.8	7.95	447	171	97.4	35.2	0.598	2.57	6.85	–	–	–	–	0.0104	0.263	–	7.80
HFM16	54.00	67.00	16539	2009-10-12	–4.05	250	5.52	31.2	7.48	441	177	96.1	31.1	0.625	2.60	6.33	–	–	–	–	0.0106	0.230	–	7.91
HFM19	168.00	185.20	16310	2009-05-12	–2.33	1,880	48.5	862	236	194	4,920	457	165	17.7	1.34	7.25	–	–	–	–	0.0612	7.60	–	7.02
HFM19	168.00	182.00	16536	2009-10-09	–2.88	1,860	45.5	908	229	138	5,030	x	171	12.4	1.25	6.95	–	–	–	–	0.0601	6.65	–	7.22
HFM21	22.00	32.00	16290	2009-04-30	2.94	252	12.4	64.7	17.0	486	164	94.2	37.0	0.585	1.81	8.39	–	–	–	–	0.0143	0.383	–	7.70
HFM21	22.00	32.00	16540	2009-10-14	–2.13	231	11.0	40.1	11.3	497	128	90.5	31.7	0.506	1.90	7.81	–	–	–	–	0.0127	0.225	–	7.79
HFM27	46.00	58.00	16286	2009-04-30	–0.39	1,080	34.3	363	104	288	2,250	293	109	7.75	1.42	6.98	–	–	–	–	0.0350	2.48	–	7.46
HFM27	46.00	58.00	16520	2009-10-07	–5.66	971	30.0	370	103	413	2,290	308	109	8.45	1.99	6.68	–	–	–	–	0.0348	2.19	–	7.41
HFM32	26.00	31.00	16309	2009-05-12	–0.99	1,700	66.2	447	161	219	3,600	334	130	12.8	1.47	6.68	–	–	–	–	0.0636	3.08	–	7.20
HFM32	26.00	31.00	16535	2009-10-08	–4.78	1,630	53.8	425	151	214	3,730	341	122	13.6	2.00	6.17	–	–	–	–	0.0576	2.71	–	7.26
KFM01A	109.00	130.00	16304	2009-05-11	–1.58	1,620	22.0	718	125	99.8	3,970	302	115	15.0	1.60	10.5	0.362	–	–	0.620	0.0459	6.29	–	7.65
KFM01A	109.00	130.00	16505	2009-10-06	–2.42	1,540	19.1	726	123	133	3,900	x	115	15.2	1.35	10.0	0.170	–	–	0.597	0.0437	5.69	–	7.05
KFM01A	109.00	130.00	16506	2009-10-06	–3.30	1,540	19.1	726	122	96.0	4,000	308	112	15.8	1.47	9.72	0.252	–	–	0.586	0.0438	5.77	–	7.62
KFM01A	109.00	130.00	16507	2009-10-06	–1.38	1,600	20.9	749	127	96.0	4,000	310	108	15.8	1.47	9.78	0.356	0.358	0.363	0.703	0.0428	5.50	0.0675	7.67
KFM01A	109.00	130.00	16508	2009-10-06	–2.57	1,550	19.1	745	123	95.4	3,990	302	113	15.5	1.38	9.96	0.366	–	–	0.598	0.0434	5.68	–	7.73
KFM01A	109.00	130.00	16512	2009-10-06	–3.13	1,530	19.0	729	120	95.3	3,970	306	111	16.1	2.06	9.97	0.488	0.491	0.486	0.737	0.0416	5.82	0.0752	7.73
KFM01D	311.00	321.00	16306	2009-05-11	–1.16	1,490	19.1	921	67.5	42.0	4,050	183	72.5	21.4	1.59	14.7	1.59	–	–	0.543	0.0390	9.87	–	7.32
KFM01D	311.00	321.00	16523	2009-10-08	0.23	1,440	14.5	1,140	45.2	34.4	4,220	160	52.9	24.2	2.06	12.6	0.226	–	–	0.421	0.0316	10.9	–	6.90
KFM01D	311.00	321.00	16524	2009-10-08	1.07	1,460	14.1	1,170	46.3	20.9	4,270	104	39.0	29.2	1.50	13.5	1.10	–	–	0.440	0.0306	11.6	–	7.07
KFM01D	311.00	321.00	16525	2009-10-08	–0.29	1,510	15.9	1,070	52.8	19.3	4,290	125	49.2	29.0	1.52	13.9	1.47	1.40	1.34	0.570	0.0317	10.4	0.189	7.06
KFM01D	311.00	321.00	16526	2009-10-08	–2.27	1,500	15.0	1,000	55.4	22.9	4,310	142	57.2	26.7	1.53	13.8	1.30	–	–	0.444	0.0318	10.2	–	7.10
KFM01D	311.00	321.00	16527	2009-10-08	–2.47	1,480	16.5	943	56.7	29.8	4,180	167	63.4	22.9	1.49	14.3	1.45	1.40	1.34	0.488	0.0347	9.43	0.137	7.24
KFM01D	429.00	438.00	16305	2009-05-11	–0.50	1,590	14.5	1,190	40.2	48.6	4,620	104	37.3	27.7	1.26	15.8	0.0595	–	–	0.210	0.0327	13.7	–	7.66
KFM01D	429.00	438.00	16313	2009-05-19	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM01D	429.00	438.00	16314	2009-05-19	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM01D	429.00	438.00	16312	2009-05-19	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM01D	429.00	438.00	16315	2009-05-19	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Id code	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	SO$_4$-S mg/L	Br$^-$ mg/L	F$^-$ mg/L	Si mg/L	Fe mg/L	Fe-tot mg/L	FeII mg/L	Mn mg/L	Li mg/L	Sr mg/L	I$^-$ mg/L	pH_L
KFM01D	429.00	438.00	16509	2009-10-07	–0.89	1,470	10.8	1,280	30.9	39.8	4,600	101	39.3	29.8	1.15	14.5	0.0906	–	–	0.162	0.0311	13.1	–	6.91
KFM01D	429.00	438.00	16510	2009-10-07	–2.49	1,440	11.6	1,240	33.5	38.8	4,640	101	39.1	30.0	1.23	14.7	0.0926	–	–	0.167	0.0305	12.8	–	7.54
KFM01D	429.00	438.00	16518	2009-10-07	–3.10	1,420	11.6	1,220	34.3	40.7	4,620	105	43.5	29.6	1.23	15.1	0.114	0.099	0.101	0.202	0.0324	12.7	0.162	7.71
KFM01D	429.00	438.00	16511	2009-10-07	–1.44	1,460	11.8	1,250	34.8	40.4	4,590	104	41.1	29.9	1.22	15.4	0.0979	–	–	0.171	0.0294	13.3	–	7.73
KFM01D	429.00	438.00	16519	2009-10-07	–1.56	1,450	11.5	1,250	33.7	39.6	4,570	104	46.8	28.2	1.30	14.7	0.139	0.112	0.120	0.190	0.0313	12.8	0.170	7.76
KFM02A	411.00	442.00	16301	2009-05-08	–0.64	1,900	24.0	1,200	210	106	5,370	407	155	22.2	1.45	8.79	0.639	–	–	1.75	2.80	12.5	–	7.36
KFM02A	411.00	442.00	16573	2009-10-27	–2.20	1,870	21.9	1,190	202	107	5,480	404	142	22.6	1.26	9.07	0.127	–	–	1.79	1.37	11.0	–	7.27
KFM02A	411.00	442.00	16574	2009-10-27	–2.95	1,820	22.2	1,190	199	108	5,480	409	144	22.9	1.24	8.13	0.597	–	–	1.76	2.69	11.2	–	7.35
KFM02A	411.00	442.00	16575	2009-10-27	–3.37	1,780	21.3	1,190	198	105	5,470	411	140	22.3	1.23	8.14	0.600	0.645	0.615	1.92	2.52	10.8	0.113	7.36
KFM02A	411.00	442.00	16576	2009-10-27	–1.76	1,850	22.2	1,200	200	103	5,400	401	150	22.4	1.32	8.32	0.307	–	–	1.78	2.64	11.3	–	7.37
KFM02A	411.00	442.00	16577	2009-10-27	–2.42	1,830	21.4	1,210	199	101	5,460	412	150	22.6	1.25	8.35	0.537	0.586	0.578	1.92	2.41	10.9	0.116	7.37
KFM02A	490.00	518.00	16299	2009-05-08	–1.85	2,160	39.1	946	244	130	5,470	500	190	20.0	1.58	7.73	2.37	–	–	2.17	0.0548	8.92	–	7.23
KFM02A	490.00	518.00	16568	2009-10-26	–3.30	2,080	35.5	970	235	132	5,560	498	175	20.8	1.47	7.67	2.07	–	–	2.11	0.0472	7.91	–	7.21
KFM02A	490.00	518.00	16569	2009-10-26	–0.92	2,220	37.9	996	251	135	5,570	504	185	21.3	2.16	7.99	3.19	–	–	2.23	0.0503	8.23	–	7.29
KFM02A	490.00	518.00	16570	2009-10-26	–3.31	2,060	35.2	983	234	130	5,570	459	168	18.3	1.47	7.07	2.59	2.44	2.47	2.06	0.0447	7.73	0.124	7.25
KFM02A	490.00	518.00	16571	2009-10-26	–2.36	2,120	35.3	981	238	129	5,550	503	172	20.9	1.45	7.10	2.18	–	–	2.07	0.0484	7.99	–	7.22
KFM02A	490.00	518.00	16572	2009-10-26	–1.67	2,140	36.2	989	241	127	5,520	485	176	18.6	1.44	7.21	1.96	2.03	2.04	2.12	0.0508	8.13	0.116	7.19
KFM02B	410.00	431.00	16302	2009-05-08	–0.82	2,060	30.8	1,100	232	116	5,480	448	170	20.8	1.65	10.2	2.09	–	–	2.08	0.150	11.1	–	7.51
KFM02B	410.00	431.00	16584	2009-10-26	–2.02	2,000	28.0	1,100	223	110	5,530	438	155	21.0	1.60	9.75	–	–	–	–	0.132	9.79	–	7.40
KFM02B	491.00	506.00	16300	2009-05-08	–1.30	2,230	43.1	893	249	131	5,440	493	189	19.4	1.71	9.53	3.94			2.04	0.0623	8.69	–	7.37
KFM02B	491.00	506.00	16583	2009-10-26	–2.99	2,120	38.6	949	238	128	5,560	479	175	19.5	1.72	9.02	–	–	–	–	0.0546	7.40	–	7.24
KFM03A	633.50	650.00	16279	2009-04-28	–0.72	1,790	19.7	1,530	67.1	28.1	5,580	190	75.5	26.3	1.60	8.26	–	–	–	–	0.0324	18.8	–	7.29
KFM03A	633.50	650.00	16605	2009-11-03	–2.24	1,740	16.9	1,520	62.7	23.6	5,660	195	66.3	34.8	2.08	7.68	0.299	–	–	0.385	0.0309	16.5	–	6.89
KFM03A	633.50	650.00	16606	2009-11-03	–1.75	1,780	18.3	1,510	67.7	27.8	5,660	187	68.0	34.9	2.10	8.04	0.751	–	–	0.421	0.0308	17.2	–	7.44
KFM03A	633.50	650.00	16607	2009-11-03	–1.29	1,800	18.4	1,550	66.1	18.9	5,710	195	69.0	34.8	2.09	7.69	0.672	0.736	0.723	0.425	0.0301	17.3	0.149	7.46
KFM03A	633.50	650.00	16608	2009-11-03	–2.12	1,750	17.7	1,550	64.5	25.2	5,720	196	67.5	34.9	2.09	7.57	0.698	–	–	0.391	0.0311	16.8	–	7.51
KFM03A	633.50	650.00	16609	2009-11-03	–2.87	1,740	16.7	1,530	62.8	22.6	5,750	197	68.2	35.1	2.13	7.40	0.650	0.673	0.663	0.414	0.0296	16.4	0.145	7.48
KFM03A	969.00	1,001.19	16582	2009-11-06	–1.21	2,180	9.76	3,900	9.80	6.44	10,500	44.0	17.5	101	1.41	5.96	0.269	0.285	0.275	0.0381	0.0274	46.2	0.449	7.89
KFM03A	969.50	1,001.19	16289	2009-04-30	–1.10	2,110	10.1	3,860	11.1	16.5	10,300	23.1	13.1	101	1.33	6.95	–	–	–	–	0.0332	45.3	–	6.67
KFM03A	969.50	1,001.19	16578	2009-11-04	–0.59	2,200	9.71	3,900	9.61	12.0	10,400	40.9	16.5	98.0	1.32	6.38	0.204	–	–	0.0424	0.0307	46.5	–	6.80
KFM03A	969.50	1,001.19	16579	2009-11-04	–1.07	2,160	9.72	3,880	9.78	11.6	10,400	44.0	16.8	99.0	1.39	6.45	0.252	–	–	0.0462	0.0302	45.9	–	6.83
KFM03A	969.50	1,001.19	16580	2009-11-05	–0.98	2,170	10.4	3,880	9.79	8.06	10,400	45.3	17.4	99.7	1.38	6.35	0.358	0.365	0.356	0.0507	0.0285	46.3	0.407	7.22
KFM03A	969.50	1,001.19	16581	2009-11-05	–0.79	2,200	9.94	3,930	9.95	7.44	10,500	42.2	17.2	94.0	1.29	6.18	0.335	–	–	0.0475	0.0333	46.7	–	7.39
KFM04A	230.00	245.00	16288	2009-05-04	–1.05	1,900	26.7	1,480	246	103	5,960	486	182	27.5	1.22	7.38	–	–	–	–	0.0666	16.6	–	7.13
KFM04A	230.00	245.00	16542	2009-10-15	–3.28	1,800	22.8	1,460	229	101	6,030	484	166	28.6	1.14	6.87	–	–	–	–	0.0565	14.0	–	7.23
KFM06A	341.00	362.00	16296	2009-05-06	–0.49	1,470	12.1	1,270	53.0	40.2	4,590	128	49.1	29.0	1.29	6.58	–	–	–	–	0.0548	15.2	–	7.42
KFM06A	341.00	362.00	16537	2009-10-13	–2.23	1,440	13.1	1,260	53.0	42.8	4,690	131	48.9	28.8	1.34	6.77	–	–	–	–	0.0544	14.0	–	7.59
KFM06A	738.00	748.00	16293	2009-05-06	–0.50	1,690	12.2	2,020	28.2	18.7	6,230	112	42.0	44.0	1.36	7.81	–	–	–	–	0.0419	24.5	–	7.47
KFM06A	738.00	748.00	16538	2009-10-12	–2.36	1,680	11.4	1,980	30.3	16.7	6,400	x	39.3	20.7	1.29	7.72	–	–	–	–	0.0406	20.6	–	7.33
KFM06C	531.00	540.00	16294	2009-05-06	–0.30	1,640	16.0	1,250	93.6	67.7	4,800	257	98.1	24.6	1.13	5.97	–	–	–	–	0.0496	13.7	–	7.42
KFM06C	531.00	540.00	16541	2009-10-13	–2.22	1,580	19.5	1,200	97.4	64.3	4,860	224	82.1	24.1	1.05	5.86	–	–	–	–	0.0480	11.7	–	7.35
KFM06C	647.00	666.00	16298	2009-05-08	–0.48	1,430	12.9	1,370	52.5	77.2	4,700	104	41.4	32.1	1.15	8.34	–	–	–	–	0.0371	16.2	–	7.80

Id code	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	SO_4-S mg/L	Br^- mg/L	F^- mg/L	Si mg/L	Fe mg/L	Fe-tot mg/L	FeII mg/L	Mn mg/L	Li mg/L	Sr mg/L	I^- mg/L	pH_L
KFM06C	647.00	666.00	16552	2009-10-15	–2.64	1,500	14.3	1,180	85.8	120	4,790	x	25.8	13.4	1.67	6.20	–	–	–	–	0.0400	10.7	–	6.62
KFM07A	962.00	972.00	16561	2009-11-04	–0.11	2,930	13.5	5,410	24.2	18.4	14,100	103	38.0	137	1.37	4.89	<0.1	–	–	0.136	0.0747	67.2		8.57
KFM07A	962.00	972.00	16610	2009-11-04	–0.64	3,010	14.4	5,480	24.2	18.6	14,500	109	39.3	139	1.33	4.79	<0.1	–	–	0.131	0.0715	70.7		8.32
KFM07A	962.00	972.00	16611	2009-11-04	–0.21	2,990	15.2	5,510	24.7	16.4	14,400	109	39.6	139	1.35	4.89	0.0835	0.076	0.074	0.144	0.0739	68.2	0.503	8.49
KFM07A	962.00	972.00	16612	2009-11-04	–0.25	3,000	14.8	5,440	24.7	15.9	14,300	109	40.0	139	1.32	4.96	<0.1	–	–	0.142	0.0739	69.0		8.29
KFM07A	962.00	972.00	16613	2009-11-05	–0.50	3,050	15.0	5,410	25.0	17.4	14,400	108	40.2	137	1.24	4.99	0.0761	0.077	0.064	0.127	0.0736	71.4	0.516	8.56
KFM07A	963.00	972.00	16311	2009-05-19	–0.17	3,030	15.8	5,500	18.1	41.0	14,400	117	40.5	133	1.49	3.08	–	–	–	–	0.0750	69.8	–	10.0
KFM08A	265.00	280.00	16280	2009-04-28	–0.27	1,400	18.2	1,380	45.0	84.0	4,660	69.8	27.4	32.9	1.24	7.45	–	–	–	–	0.0272	16.4	–	7.61
KFM08A	265.00	280.00	16553	2009-10-21	0.19	1,390	17.4	1,270	40.9	79.7	4,410	76.8	22.2	32.1	1.25	7.14	0.169	–	–	0.394	0.0253	14.0		7.75
KFM08A	265.00	280.00	16554	2009-10-21	1.03	1,440	20.0	1,300	45.0	88.6	4,460	71.4	26.7	32.6	1.27	7.69	1.05	–	–	0.474	0.0283	15.9		7.77
KFM08A	265.00	280.00	16555	2009-10-21	–2.09	1,350	17.9	1,290	44.3	82.8	4,590	80.0	27.6	34.6	1.30	7.39	1.37	1.34	1.32	0.576	0.0268	14.9	0.237	7.59
KFM08A	265.00	280.00	16556	2009-10-21	–2.91	1,340	17.1	1,250	43.6	84.3	4,570	79.8	28.0	33.5	1.28	7.46	1.34	–	–	0.550	0.0263	14.3		7.59
KFM08A	265.00	280.00	16557	2009-10-21	–3.29	1,290	17.7	1,230	44.4	85.0	4,490	81.1	28.6	32.7	1.13	7.77	1.35	1.31	1.32	0.590	0.0277	14.3	0.219	7.59
KFM08A	684.00	694.00	16281	2009-04-28	–0.75	1,620	13.8	2,020	16.1	14.8	6,140	84.2	32.7	47.0	1.13	5.80	–	–	–	–	0.0220	24.7	–	8.43
KFM08A	684.00	694.00	16563	2009-10-20	–1.28	1,560	11.1	2,070	11.7	12.9	6,190	87.4	29.7	50.6	1.30	2.57	<0.1	–	–	0.034	0.0223	22.4	–	8.85
KFM08A	684.00	694.00	16564	2009-10-20	–3.09	1,510	10.8	2,040	13.4	14.5	6,290	83.7	29.3	48.4	1.32	3.63	<0.1	–	–	0.102	0.0217	22.2	–	8.97
KFM08A	684.00	694.00	16565	2009-10-20	–1.09	1,560	11.3	2,090	14.3	16.7	6,210	81.7	29.5	47.7	1.26	4.59	0.213	0.203	0.197	0.150	<0.02	21.8	0.319	8.49
KFM08A	684.00	694.00	16566	2009-10-20	–3.62	1,560	11.7	1,990	14.5	15.5	6,350	90.8	28.9	50.5	1.24	4.73	0.220	–	–	0.139	0.0228	22.1	–	8.56
KFM08A	684.00	694.00	16567	2009-10-20	–2.76	1,540	11.3	2,020	15.3	14.2	6,270	95.7	28.4	49.4	1.33	5.21	0.302	0.311	0.301	0.162	0.0206	21.4	0.323	8.55
KFM08D	660.00	680.00	16284	2009-04-28	–2.50	1,580	15.8	1,560	34.7	25.1	5,440	133	56.7	38.8	0.97	5.68	–	–	–	–	0.0315	18.0	–	8.82
KFM08D	660.00	680.00	16543	2009-10-12	–1.70	1,580	10.6	1,850	21.5	12.4	5,870	116	44.6	43.0	1.14	6.78	0.0322	–	–	0.116	0.0270	18.8	–	8.49
KFM08D	660.00	680.00	16544	2009-10-12	–2.54	1,530	10.7	1,810	22.0	14.5	5,820	101	44.1	38.8	1.09	7.16	0.0988	–	–	0.131	0.0254	19.0	–	8.38
KFM08D	660.00	680.00	16545	2009-10-12	–1.26	1,630	11.5	1,790	24.0	16.3	5,800	106	41.2	45.6	1.05	7.18	0.138	0.118	0.110	0.167	0.0271	18.0	0.250	8.15
KFM08D	660.00	680.00	16546	2009-10-13	–2.24	1,630	11.5	1,780	22.7	14.1	5,900	x	40.5	41.2	1.11	7.05	<0.1	–	–	0.163	0.0263	18.6	–	8.08
KFM08D	660.00	680.00	16547	2009-10-14	–2.99	1,590	11.9	1,760	18.9	17.7	5,870	123	42.6	41.4	0.99	5.30	0.0644	0.042	0.037	0.126	0.0291	18.7	0.241	8.60
KFM08D	825.00	835.00	16291	2009-04-30	–0.58	1,720	12.3	2,020	13.1	80.1	6,180	141	53.8	45.7	1.00	0.89	–	–	–	–	0.0279	23.5	–	10.7
KFM08D	825.00	835.00	16558	2009-10-20	0.21	1,830	9.29	2,310	14.5	19.4	6,810	123	46.4	55.3	1.21	6.10	<0.1	–	–	0.0231	0.0341	25.8	–	8.62
KFM08D	825.00	835.00	16559	2009-10-21	0.86	1,860	10.0	2,350	14.9	15.5	6,840	121	46.3	54.7	1.16	6.33	<0.1	–	–	0.0528	0.0300	25.9	–	8.90
KFM08D	825.00	835.00	16560	2009-10-21	–0.57	1,840	9.54	2,300	15.0	15.8	6,920	121	46.9	53.3	1.22	6.62	0.0154	0.015	0.010	0.0809	0.0324	25.9	0.263	8.00
KFM08D	825.00	835.00	16562	2009-10-23	–0.50	1,820	9.34	2,310	14.9	13.6	6,900	119	46.0	54.4	1.16	6.56	0.0198	0.019	0.012	0.1060	0.0297	25.4	0.268	8.83
KFM10A	430.00	440.00	16307	2009-05-12	–0.90	2,040	32.8	1,120	219	96.1	5,400	522	200	20.2	1.47	7.99	–	–	–	–	0.0656	11.3	–	7.47
KFM10A	430.00	440.00	16528	2009-10-09	–1.48	2,010	29.9	1,060	211	72.9	5,340	511	181	20.1	1.96	5.62	12.5	–	–	1.50	0.0538	9.51	–	7.07
KFM10A	430.00	440.00	16529	2009-10-09	–3.03	2,020	30.0	1,080	213	76.3	5,570	530	186	20.7	1.99	6.98	8.50	–	–	1.44	0.0631	9.63	–	7.04
KFM10A	430.00	440.00	16530	2009-10-09	–1.38	2,080	31.2	1,090	215	93.9	5,480	515	192	23.5	1.31	7.58	7.45	7.01	6.99	1.73	0.0589	9.89	0.0609	7.26
KFM10A	430.00	440.00	16531	2009-10-09	–1.91	2,040	30.5	1,100	213	96.3	5,480	524	193	19.2	1.40	7.82	6.74	–	–	1.47	0.0600	9.75	–	7.29
KFM10A	430.00	440.00	16532	2009-10-09	–2.40	2,050	30.3	1,100	214	102	5,560	527	193	23.1	1.37	7.99	6.71	5.02	5.09	1.47	0.0610	9.70	0.0581	7.40
KFM11A	446.00	456.00	16287	2009-05-04	0.40	1,350	6.28	1,450	28.1	8.81	4,490	241	93.2	21.7	1.15	5.12	–	–	–	–	0.0536	20.3	–	7.73
KFM11A	446.00	456.00	16550	2009-10-15	–1.54	1,290	5.86	1,480	28.4	8.74	4,640	254	90.5	23.7	1.22	5.02	–	–	–	–	0.0537	19.2	–	7.80
KFM11A	690.00	710.00	16292	2009-05-04	–0.31	1,870	12.0	2,150	31.6	13.7	6,730	109	42.1	50.8	1.24	6.40	–	–	–	–	0.0506	28.9	–	7.73
KFM11A	690.00	710.00	16549	2009-10-15	0.20	1,930	13.2	2,180	36.5	15.7	6,820	105	39.9	51.7	3.17	6.72	–	–	–	–	0.0571	28.1	–	7.62
KFM12A	270.00	280.00	16297	2009-05-06	0.83	984	7.60	1,160	43.5	54.2	3,540	87.2	32.5	24.1	0.94	4.85	–	–	–	–	0.0436	17.1	–	7.45
KFM12A	270.00	280.00	16551	2009-10-15	–1.69	937	8.14	1,200	41.2	50.5	3,730	77.9	29.2	25.0	0.85	4.93	–	–	–	–	0.0439	16.9	–	7.52

Id code	Secup m	Seclow m	Sample no.	Sampling date	pH_F	TOC mg/L	DOC 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	PO_4-P_hlysis mg/L	P mg/L	Temp_F °C
HFM01	33.50	45.50	16282	2009-04-28	7.73					2.05	297	303								8.4
HFM01	33.50	45.50	16522	2009-10-07	7.55	–	–	–	–	1.40	295	307	–	–	–	–	–	–	–	8.2
HFM02	38.00	48.00	16285	2009-04-30	7.65	–	–	–	–	1.50	300	303	–	–	–	–	–	–	–	12.0
HFM02	38.00	48.00	16521	2009-10-07	7.51	–	–	–	–	0.75	261	267	–	–	–	–	–	–	–	10.8
HFM04	57.90	65.90	16295	2009-05-06	7.67	–	–	–	–	0.55	89.4	86	–	–	–	–	–	–	–	7.9
HFM04	58.00	66.00	16548	2009-10-14	7.81	–	–	–	–	0.75	90.2	88	–	–	–	–	–	–	–	7.3
HFM13	159.00	175.60	16303	2009-05-12	7.39	–	–	–	–	1.60	1,540	1,536	–	–	–	–	–	–	–	7.5
HFM13	159.00	173.00	16533	2009-10-08	7.17	–	–	–	–	0.70	1,540	1,536	–	–	–	–	–	–	–	7.9
HFM15	85.00	99.50	16308	2009-05-12	7.70	–	–	–	–	1.75	176	175	–	–	–	–	–	–	–	7.3
HFM15	85.00	95.00	16534	2009-10-08	7.07	–	–	–	–	1.40	207	211	–	–	–	–	–	–	–	7.9
HFM16	54.00	67.00	16283	2009-05-06	7.63	–	–	–	–	1.25	142	133	–	–	–	–	–	–	–	8.4
HFM16	54.00	67.00	16539	2009-10-12	–	–	–	–	–	1.15	142	–	–	–	–	–	–	–	–	–
HFM19	168.00	185.20	16310	2009-05-12	7.22	–	–	–	–	1.35	1,440	1,358	–	–	–	–	–	–	–	8.5
HFM19	168.00	182.00	16536	2009-10-09	7.08	–	–	–	–	0.75	1,450	1,459	–	–	–	–	–	–	–	8.0
HFM21	22.00	32.00	16290	2009-04-30	7.48	–	–	–	–	1.85	142	149	–	–	–	–	–	–	–	9.1
HFM21	22.00	32.00	16540	2009-10-14	7.75	–	–	–	–	1.00	132	124	–	–	–	–	–	–	–	7.5
HFM27	46.00	58.00	16286	2009-04-30	7.33	–	–	–	–	1.35	749	732	–	–	–	–	–	–	–	9.7
HFM27	46.00	58.00	16520	2009-10-07	7.21	–	–	–	–	0.75	761	1,384	–	–	–	–	–	–	–	9.6
HFM32	26.00	31.00	16309	2009-05-12	7.27	–	–	–	–	0.65	1,110	1,114	–	–	–	–	–	–	–	11.1
HFM32	26.00	31.00	16535	2009-10-08	6.58	–	–	–	–	0.50	1,120	1,125	–	–	–	–	–	–	–	10.8
KFM01A	109.00	130.00	16304	2009-05-11	7.81	–	–	0.356	–	52.8	1,180	1,181	–	–	–	–	–	–	–	7.1
KFM01A	109.00	130.00	16505	2009-10-06	7.16	8.7	5.7	3.11	25.2	50.3	1,180	1,280	0.711	0.0005	0.0017	0.0021	<0.0005	0.0010	–	8.6
KFM01A	109.00	130.00	16506	2009-10-06	7.39	2.9	2.7	0.667	23.7	47.3	1,210	1,269	0.889	0.0016	0.0044	0.0061	<0.0005	0.0024	–	9.3
KFM01A	109.00	130.00	16507	2009-10-06	7.67	2.5	2.5	0.474	23.6	47.3	1,210	1,271	0.901	0.0005	0.0015	0.0020	<0.0005	0.0010	<0.005	9.1
KFM01A	109.00	130.00	16508	2009-10-06	7.71	2.8	2.5	0.405	22.9	45.7	1,200	1,269	0.899	0.0003	0.0078	0.0081	<0.0005	0.0011	–	9.3
KFM01A	109.00	130.00	16512	2009-10-06	7.71	2.5	2.1	0.313	22.9	45.8	1,200	1,269	0.888	<0.0002	0.0042	0.0043	<0.0005	0.0011	<0.005	9.3
KFM01D	311.00	321.00	16306	2009-05-11	7.72	–	–	0.279	11.2	22.4	1,190	1,188	–	–	–	–	–	–	–	8.4
KFM01D	311.00	321.00	16523	2009-10-08	6.81	3.8	8.1	2.45	8.80	17.6	1,220	1,296	0.347	0.0009	0.0169	0.0178	0.0020	0.0038	–	8.4
KFM01D	311.00	321.00	16524	2009-10-08	7.28	3.5	1.8	1.04	2.75	5.50	1,320	1,323	0.409	<0.0002	0.0026	0.0027	<0.0005	0.0081	–	9.5
KFM01D	311.00	321.00	16525	2009-10-08	7.47	2.1	2.1	0.228	3.53	7.05	1,300	1,285	0.440	<0.0002	0.120	0.121	<0.0005	0.0088	0.0155	10.0
KFM01D	311.00	321.00	16526	2009-10-08	7.58	2.3	2.8	0.163	5.57	11.1	1,270	1,245	0.451	0.0002	0.0133	0.0135	<0.0005	0.0088	–	9.7
KFM01D	311.00	321.00	16527	2009-10-08	7.57	2.7	3.0	0.136	9.15	18.3	1,220	1,218	0.460	<0.0002	0.0439	0.0441	<0.0005	0.0086	0.0165	9.6
KFM01D	429.00	438.00	16305	2009-05-11	7.67	–	–	0.337	9.63	19.3	1,320	1,314	–	–	–	–	–	–	–	7.7
KFM01D	429.00	438.00	16313	2009-05-19	–	–	–	2.47	–	–	–	–	–	–	–	–	–	–	–	–
KFM01D	429.00	438.00	16314	2009-05-19	–	–	–	2.47	–	–	–	–	–	–	–	–	–	–	–	–
KFM01D	429.00	438.00	16312	2009-05-19	–	–	–	2.57	–	–	–	–	–	–	–	–	–	–	–	–
KFM01D	429.00	438.00	16315	2009-05-19	–	–	–	2.80	–	–	–	–	–	–	–	–	–	–	–	–

Id code	Secup m	Seclow m	Sample no.	Sampling date	pH_F	TOC mg/L	DOC 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	PO_4-P_hlysis mg/L	P mg/L	Temp_F °C
KFM01D	429.00	438.00	16509	2009-10-07	6.91	3.7	6.8	5.98	8.93	17.9	1,330	1,409	0.204	0.0003	0.0005	0.0007	0.0010	0.0023	–	12.6
KFM01D	429.00	438.00	16510	2009-10-07	7.47	3.4	3.4	3.30	9.60	19.2	1,330	1,384	0.274	0.0002	0.143	0.143	<0.0005	0.0018	–	12.4
KFM01D	429.00	438.00	16518	2009-10-07	7.49	3.4	3.2	2.97	9.85	19.7	1,330	1,384	0.283	<0.0002	0.0021	0.0022	<0.0005	0.0018	0.00869	11.2
KFM01D	429.00	438.00	16511	2009-10-07	7.45	2.9	3.1	3.20	9.50	19.0	1,320	1,384	0.276	0.0002	0.0210	0.0213	<0.0005	0.0017	–	12.6
KFM01D	429.00	438.00	16519	2009-10-07	7.61	2.9	2.9	3.85	9.55	19.1	1,330	1,385	0.272	<0.0002	0.0006	0.0007	0.0022	0.0036	0.00770	11.2
KFM02A	411.00	442.00	16301	2009-05-08	7.28	–	–	0.533	x	183	1,560	1,733	–	–	–	–	–	–	–	7.3
KFM02A	411.00	442.00	16573	2009-10-27	7.96	2.2	2.0	0.462	x	110	1,570	1,424	1.62	<0.0002	0.0009	0.0009	<0.0005	<0.0005	–	8.7
KFM02A	411.00	442.00	16574	2009-10-27	7.57	1.8	2.0	1.13	x	170	1,550	1,453	1.64	<0.0002	<0.0003	<0.0003	<0.0005	<0.0005	–	7.4
KFM02A	411.00	442.00	16575	2009-10-27	7.54	1.8	1.9	0.831	x	192	1,550	1,460	1.62	<0.0002	<0.0003	<0.0003	<0.0005	<0.0005	<0.04	7.1
KFM02A	411.00	442.00	16576	2009-10-27	7.73	1.6	2.1	0.576	x	180	1,540	1,431	1.63	<0.0002	<0.0003	<0.0003	<0.0005	<0.0005	–	7.8
KFM02A	411.00	442.00	16577	2009-10-27	7.56	1.6	1.8	0.323	x	175	1,550	1,457	1.64	<0.0002	0.0026	0.0026	<0.0005	<0.0005	<0.04	7.2
KFM02A	490.00	518.00	16299	2009-05-08	7.13	–	–	0.159	3.27	7.30	1,600	1,637	–	–	–	–	–	–	–	8.5
KFM02A	490.00	518.00	16568	2009-10-26	7.39	2.5	2.4	0.682	3.59	8.00	1,600	1,484	2.57	0.0004	0.0397	0.0401	<0.0005	<0.0005	–	8.0
KFM02A	490.00	518.00	16569	2009-10-26	7.52	2.3	2.4	0.351	3.95	8.80	1,590	1,479	2.54	<0.0002	0.0095	0.0095	<0.0005	0.0005	–	8.2
KFM02A	490.00	518.00	16570	2009-10-26	7.44	2.2	1.8	0.146	4.10	8.20	1,590	1,487	2.60	<0.0002	0.0025	0.0026	<0.0005	<0.0005	<0.04	8.2
KFM02A	490.00	518.00	16571	2009-10-26	7.43	2.0	1.9	0.126	3.50	7.80	1,600	1,489	2.61	<0.0002	0.0045	0.0045	<0.0005	<0.0005	–	8.2
KFM02A	490.00	518.00	16572	2009-10-26	7.40	1.9	2.0	0.115	3.34	7.35	1,590	1,482	2.60	<0.0002	0.0004	0.0004	<0.0005	<0.0005	<0.04	8.0
KFM02B	410.00	431.00	16302	2009-05-08	7.47	–	–	0.062	4.18	8.35	1,580	1,541	–	–	–	–	–	–	–	12.5
KFM02B	410.00	431.00	16584	2009-10-26	7.68	–	–	–	4.28	8.55	1,580	1,472	–	–	–	–	–	–	–	7.9
KFM02B	491.00	506.00	16300	2009-05-08	7.35	–	–	0.042	2.60	5.20	1,590	1,587	–	–	–	–	–	–	–	15.6
KFM02B	491.00	506.00	16583	2009-10-26	7.58	–	–	–	2.90	5.80	1,590	1,479	–	–	–	–	–	–	–	8.1
KFM03A	633.50	650.00	16279	2009-04-28	7.34	–	–	–	4.05	8.10	1,580	1,591	–	–	–	–	–	–	–	10.0
KFM03A	633.50	650.00	16605	2009-11-03	7.12	1.3	1.7	0.865	2.95	5.90	1,590	1,591	0.246	<0.0002	0.0006	0.0006	<0.0005	<0.0005	–	7.8
KFM03A	633.50	650.00	16606	2009-11-03	7.63	1.3	1.4	0.766	3.00	6.00	1,590	1,592	0.280	<0.0002	<0.0003	<0.0003	<0.0005	<0.0005	–	7.5
KFM03A	633.50	650.00	16607	2009-11-03	7.68	1.3	1.7	0.205	2.93	5.85	1,590	1,590	0.266	<0.0002	0.0004	0.0004	<0.0005	0.0008	<0.04	7.2
KFM03A	633.50	650.00	16608	2009-11-03	7.65	1.5	2.0	0.173	2.85	5.70	1,580	1,656	0.257	<0.0002	0.0068	0.0068	<0.0005	0.0010	–	7.2
KFM03A	633.50	650.00	16609	2009-11-03	7.61	1.4	1.3	0.158	2.93	5.89	1,590	1,558	0.241	<0.0002	0.0006	0.0006	<0.0005	0.0007	<0.04	6.6
KFM03A	969.00	1,001.19	16582	2009-11-06	7.66	<1	<1	0.109	0.45	0.90	2,670	2,710	0.0377	<0.0002	0.0019	0.0019	<0.0005	0.0012	<0.04	8.2
KFM03A	969.50	1,001.19	16289	2009-04-30	6.01	–	–	–	0.72	1.45	2,670	2,650	–	–	–	–	–	–	–	9.7
KFM03A	969.50	1,001.19	16578	2009-11-04	7.03	5.8	1.8	2.06	0.75	1.50	2,670	2,650	0.0376	<0.0002	0.0350	0.0351	0.0013	0.0026	–	5.8
KFM03A	969.50	1,001.19	16579	2009-11-04	7.62	5.1	1.8	1.00	0.78	1.55	2,680	2,650	0.0108	0.0008	0.0151	0.0160	<0.0005	0.0006	–	6.0
KFM03A	969.50	1,001.19	16580	2009-11-05	7.76	<1	<1	0.675	0.55	1.10	2,660	2,720	0.0805	<0.0002	0.0075	0.0076	<0.0005	0.0019	<0.04	4.1
KFM03A	969.50	1,001.19	16581	2009-11-05	7.76	<1	<1	0.222	0.48	0.95	2,690	2,680	0.0602	<0.0002	0.0162	0.0162	<0.0005	0.0029	–	4.1
KFM04A	230.00	245.00	16288	2009-05-04	7.26	–	–	–	0.60	1.20	1,700	1,683	–	–	–	–	–	–	–	7.5
KFM04A	230.00	245.00	16542	2009-10-15	7.17	–	–	–	0.83	1.65	1,700	1,632	–	–	–	–	–	–	–	7.3
KFM06A	341.00	362.00	16296	2009-05-06	7.56	–	–	–	9.35	18.7	1,320	1,450	–	–	–	–	–	–	–	9.1
KFM06A	341.00	362.00	16537	2009-10-13	7.50	–	–	–	9.65	19.3	1,320	1,319	–	–	–	–	–	–	–	7.5
KFM06A	738.00	748.00	16293	2009-05-06	7.63	–	–	–	20.7	41.3	1,730	1,750	–	–	–	–	–	–	–	12.7
KFM06A	738.00	748.00	16538	2009-10-12	7.20	–	–	–	19.8	39.7	1,730	1,734	–	–	–	–	–	–	–	7.7
KFM06C	531.00	540.00	16294	2009-05-06	7.36	–	–	–	25.8	51.6	1,380	1,415	–	–	–	–	–	–	–	10.5
KFM06C	531.00	540.00	16541	2009-10-13	7.39	–	–	–	27.1	54.3	1,380	1,373	–	–	–	–	–	–	–	6.7
KFM06C	647.00	666.00	16298	2009-05-08	–	–	–	–	25.5	51.0	1,350	–	–	–	–	–	–	–	–	–

Id code	Secup m	Seclow m	Sample no.	Sampling date	pH_F	TOC mg/L	DOC 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	PO_4-P_hlysis mg/L	P mg/L	Temp_F °C
KFM06C	647.00	666.00	16552	2009-10-15	7.10	–	–	–	23.1	46.2	1,330	1,291	–	–	–	–	–	–	–	8.2
KFM07A	962.00	972.00	16561	2009-11-04	9.09	1.2	1.6	0.044	1.53	3.05	3,570	3,370	0.0110	<0.0002	0.0063	0.0064	0.0012	0.0018	–	4.4
KFM07A	962.00	972.00	16610	2009-11-04	9.08	4.1	2.8	0.024	1.83	3.65	3,610	3,310	0.0076	0.0008	0.196	0.197	<0.0005	0.0005	–	4.1
KFM07A	962.00	972.00	16611	2009-11-04	8.89	1.1	2.3	0.034	1.70	3.40	3,600	3,390	0.0027	0.0003	0.0280	0.0283	<0.0005	0.0008	<0.04	3.4
KFM07A	962.00	972.00	16612	2009-11-04	9.05	<1	<1	0.037	1.60	3.20	3,600	3,320	0.0033	0.0006	0.0603	0.0609	<0.0005	<0.0005	–	4.9
KFM07A	962.00	972.00	16613	2009-11-05	9.24	4.3	2.6	0.029	1.75	3.50	3,600	3,320	0.0060	0.0002	0.0170	0.0172	<0.0005	0.0010	<0.04	3.7
KFM07A	963.00	972.00	16311	2009-05-19	10.36	–	–	–	1.40	2.80	3,600	3,630	–	–	–	–	–	–	–	11.8
KFM08A	265.00	280.00	16280	2009-04-28	7.71	–	–	–	20.3	40.50	1,330	1,331	–	–	–	–	–	–	–	8.1
KFM08A	265.00	280.00	16553	2009-10-21	7.82	4.0	4.1	3.84	20.1	40.2	1,260	1,265	0.402	0.0109	0.522	0.533	0.0010	0.0017	–	7.9
KFM08A	265.00	280.00	16554	2009-10-21	7.86	3.3	3.3	1.26	20.5	41.0	1,270	1,263	0.543	0.0017	0.342	0.344	<0.0005	0.0023	–	7.6
KFM08A	265.00	280.00	16555	2009-10-21	7.83	2.6	2.5	0.272	19.5	39.0	1,310	1,315	0.483	0.0004	0.0320	0.0324	<0.0005	0.0024	<0.005	8.4
KFM08A	265.00	280.00	16556	2009-10-21	7.78	2.7	2.5	0.179	20.0	39.9	1,300	1,288	0.457	0.0003	0.238	0.238	<0.0005	0.0026		8.3
KFM08A	265.00	280.00	16557	2009-10-21	7.81	2.5	2.5	0.138	19.9	39.8	1,290	1,278	0.426	<0.0002	0.241	0.241	<0.0005	0.0025	0.00559	8.6
KFM08A	684.00	694.00	16281	2009-04-28	8.65	–	–	–	6.55	13.1	1,690	1,709	–	–	–	–	–	–	–	8.9
KFM08A	684.00	694.00	16563	2009-10-20	9.69	1.8	1.7	0.058	4.98	9.95	1,730	1,743	0.0909	<0.0002	0.0545	0.0545	<0.0005	0.0009	–	7.5
KFM08A	684.00	694.00	16564	2009-10-20	9.06	1.5	1.0	0.044	5.18	10.4	1,730	1,711	0.0836	<0.0002	0.594	0.594	<0.0005	0.0005	–	8.9
KFM08A	684.00	694.00	16565	2009-10-20	8.85	1.1	1.0	0.027	5.38	10.8	1,720	1,704	0.0894	<0.0002	0.0233	0.0233	<0.0005	0.0005	<0.04	9.1
KFM08A	684.00	694.00	16566	2009-10-20	8.90	1.2	1.1	0.026	5.63	11.3	1,720	1,747	0.0903	<0.0002	0.751	0.751	<0.0005	0.0006	–	9.1
KFM08A	684.00	694.00	16567	2009-10-20	8.77	1.2	<1	0.024	6.00	12.0	1,720	1,782	0.0995	<0.0002	0.0023	0.0023	<0.0005	0.0006	<0.04	7.5
KFM08D	660.00	680.00	16284	2009-04-28	8.42	–	–	–	26.6	53.3	1,540	1,428	–	–	–	–	–	–	–	11.1
KFM08D	660.00	680.00	16543	2009-10-12	8.57	2.9	2.7	0.940	27.4	54.8	1,620	1,603	0.151	0.0025	0.0149	0.0173	<0.0005	<0.0005	–	7.7
KFM08D	660.00	680.00	16544	2009-10-12	8.51	2.0	2.0	0.482	27.9	55.9	1,610	1,602	0.165	0.0003	0.0008	0.0010	<0.0005	<0.0005	–	7.2
KFM08D	660.00	680.00	16545	2009-10-12	8.45	1.9	1.7	0.408	28.0	56.0	1,610	1,614	0.167	<0.0002	0.0014	0.0014	<0.0005	<0.0005	<0.04	7.5
KFM08D	660.00	680.00	16546	2009-10-13	8.35	1.4	1.5	0.340	28.0	56.1	1,610	1,605	0.178	<0.0002	0.0269	0.0269	<0.0005	<0.0005	–	7.4
KFM08D	660.00	680.00	16547	2009-10-14	9.02	5.7	6.4	0.625	28.0	56.0	1,610	1,604	0.190	<0.0002	0.0010	0.0012	<0.0005	0.0006	<0.04	7.2
KFM08D	825.00	835.00	16291	2009-04-30	–	–	–	–	1.90	3.80	1,750	–	–	–	–	–	–	–	–	–
KFM08D	825.00	835.00	16558	2009-10-20	9.55	2.1	1.7	0.548	15.3	30.6	1,900	1,747	0.108	<0.0002	0.0072	0.0073	0.0006	0.0013	–	7.5
KFM08D	825.00	835.00	16559	2009-10-21	9.44	3.3	2.9	0.462	15.2	30.4	1,900	1,743	0.107	<0.0002	0.0376	0.0376	<0.0005	0.0012	–	9.6
KFM08D	825.00	835.00	16560	2009-10-21	9.24	1.5	1.4	0.391	15.7	31.4	1,900	1,704	0.114	0.0002	0.0205	0.0207	0.0006	0.0006	<0.04	9.7
KFM08D	825.00	835.00	16562	2009-10-23	9.03	1.9	2.3	0.459	15.8	31.5	1,910	1,724	0.106	<0.0002	0.0005	0.0006	<0.0005	0.0007	<0.04	9.1
KFM10A	430.00	440.00	16307	2009-05-12	7.95	–	–	–	1.10	2.20	1,580	1,572	–	–	–	–	–	–	–	8.6
KFM10A	430.00	440.00	16528	2009-10-09	7.86	2.4	2.4	0.032	1.03	2.05	1,560	1,577	1.29	0.0006	0.0063	0.0069	<0.0005	0.0019	–	7.7
KFM10A	430.00	440.00	16529	2009-10-09	7.78	2.4	2.4	0.042	0.90	1.80	1,580	1,577	1.32	<0.0002	0.136	0.136	<0.0005	0.0031	–	7.7
KFM10A	430.00	440.00	16530	2009-10-09	7.75	2.3	2.5	0.047	0.90	1.80	1,570	1,581	1.32	<0.0002	0.504	0.504	<0.0005	0.0032	<0.04	7.7
KFM10A	430.00	440.00	16531	2009-10-09	7.70	2.1	3.2	0.055	0.80	1.60	1,570	1,578	1.32	<0.0002	0.261	0.261	<0.0005	0.0034	–	7.8
KFM10A	430.00	440.00	16532	2009-10-09	7.69	2.8	2.6	0.066	0.90	1.80	1,570	1,579	1.31	<0.0002	0.0285	0.0287	<0.0005	0.0039	<0.04	8.3
KFM11A	446.00	456.00	16287	2009-05-04	8.11	–	–	–	3.53	6.00	1,320	1,316	–	–	–	–	–	–	–	9.0
KFM11A	446.00	456.00	16550	2009-10-15	8.36	–	–	–	3.32	5.65	1,330	1,305	–	–	–	–	–	–	–	7.9
KFM11A	690.00	710.00	16292	2009-05-04	8.21	–	–	–	0.79	1.35	1,860	1,843	–	–	–	–	–	–	–	8.1
KFM11A	690.00	710.00	16549	2009-10-15	8.26	–	–	–	0.68	1.15	1,850	1,818	–	–	–	–	–	–	–	7.9
KFM12A	270.00	280.00	16297	2009-05-06	7.48	–	–	–	4.50	9.00	1,050	1,048	–	–	–	–	–	–	–	7.0
KFM12A	270.00	280.00	16551	2009-10-15	7.64	–	–	–	3.65	7.30	1,060	1,022	–	–	–	–	–	–	–	9.9

pH_F; EC_F = Field measurements of pH and EC.
< “value” = Value below reporting limit.
RCB % = Rel. charge balance error %.
x = No result due to analytical problem.

Table A5-2. Trace elements.

Id code	Secup m	Seclow m	Sample no.	Sampling date	Al µg/L	As µg/L	B µg/L	Ba µg/L	Cd µg/L	Cu µg/L	Cr µg/L	Co µg/L	Hg µg/L	Ni µg/L	V µg/L	U µg/L	Th µg/L	Sc µg/L	Rb µg/L	Y µg/L	Zr µg/L	Zn µg/L	In µg/L	Sb µg/L
KFM01A	109.00	130.00	16505	2009-10-06	–	–	–	–	–	–	–	–	–	–	–	4.06	–	–	–	–	–	–	–	–
KFM01A	109.00	130.00	16506	2009-10-06	–	–	–	–	–	–	–	–	–	–	–	3.56	–	–	–	–	–	–	–	–
KFM01A	109.00	130.00	16507	2009-10-06	40.0	<0.5	783	124	<0.02	<0.2	0.656	0.0314	<0.002	0.609	0.0689	3.19	<0.2	<0.4	52.1	14.9	0.192	<0.8	<0.2	<0.1
KFM01A	109.00	130.00	16508	2009-10-06	–	–	–	–	–	–	–	–	–	–	–	3.03	–	–	–	–	–	–	–	–
KFM01A	109.00	130.00	16512	2009-10-06	19.0	<0.5	791	129	<0.02	<0.2	1.40	0.0456	<0.002	0.885	0.0595	2.97	<0.2	<0.4	50.3	14.7	0.149	<0.8	<0.2	<0.1
KFM01D	311.00	321.00	16523	2009-10-08	–	–	–	–	–	–	–	–	–	–	–	0.459	–	–	–	–	–	–	–	–
KFM01D	311.00	321.00	16524	2009-10-08	–	–	–	–	–	–	–	–	–	–	–	0.225	–	–	–	–	–	–	–	–
KFM01D	311.00	321.00	16525	2009-10-08	3.14	<0.5	687	453	<0.02	<0.2	0.624	0.0317	<0.002	1.500	0.1750	0.316	<0.2	<0.4	41.7	1.29	0.396	<0.8	<0.2	<0.1
KFM01D	311.00	321.00	16526	2009-10-08	–	–	–	–	–	–	–	–	–	–	–	0.396	–	–	–	–	–	–	–	–
KFM01D	311.00	321.00	16527	2009-10-08	3.15	<0.5	740	454	<0.02	<0.2	0.505	0.0260	<0.002	0.649	0.1550	0.611	<0.2	<0.4	42.9	1.33	0.452	<0.8	<0.2	<0.1
KFM01D	429.00	438.00	16509	2009-10-07	–	–	–	–	–	–	–	–	–	–	–	0.869	–	–	–	–	–	–	–	–
KFM01D	429.00	438.00	16510	2009-10-07	–	–	–	–	–	–	–	–	–	–	–	0.847	–	–	–	–	–	–	–	–
KFM01D	429.00	438.00	16518	2009-10-07	2.94	<0.5	721	603	<0.02	<0.2	2.19	0.0856	<0.002	0.852	0.1730	0.830	<0.2	<0.4	69.1	6.39	0.300	<0.8	<0.2	<0.1
KFM01D	429.00	438.00	16511	2009-10-07	–	–	–	–	–	–	–	–	–	–	–	0.804	–	–	–	–	–	–	–	–
KFM01D	429.00	438.00	16519	2009-10-07	2.88	<0.5	726	621	<0.02	<0.2	6.42	0.175	<0.002	2.540	0.1610	0.862	<0.2	<0.4	73.5	6.31	0.241	<0.8	<0.2	<0.1
KFM02A	411.00	442.00	16573	2009-10-27	–	–	–	–	–	–	–	–	–	–	–	27.6	–	–	–	–	–	–	–	–
KFM02A	411.00	442.00	16574	2009-10-27	–	–	–	–	–	–	–	–	–	–	–	42.2	–	–	–	–	–	–	–	–
KFM02A	411.00	442.00	16575	2009-10-27	4.98	<1	632	113	<0.05	1.66	<0.1	0.400	<0.002	0.522	0.209	41.8	<0.2	<0.5	1160	4.83	<0.3	5.80	<0.5	0.245
KFM02A	411.00	442.00	16576	2009-10-27	–	–	–	–	–	–	–	–	–	–	–	43.5	–	–	–	–	–	–	–	–
KFM02A	411.00	442.00	16577	2009-10-27	3.16	<1	634	113	0.0649	1.80	<0.1	0.4210	<0.002	0.564	0.140	38.1	<0.2	<0.5	1150	4.75	<0.3	3.05	<0.5	0.270
KFM02A	490.00	518.00	16568	2009-10-26	–	–	–	–	–	–	–	–	–	–	–	175	–	–	–	–	–	–	–	–
KFM02A	490.00	518.00	16569	2009-10-26	–	–	–	–	–	–	–	–	–	–	–	172	–	–	–	–	–	–	–	–
KFM02A	490.00	518.00	16570	2009-10-26	4.78	<1	614	94.4	<0.05	<0.5	<0.1	0.589	<0.002	0.840	0.204	153	<0.2	<0.5	61.7	3.76	<0.3	2.66	<0.5	0.206
KFM02A	490.00	518.00	16571	2009-10-26	–	–	–	–	–	–	–	–	–	–	–	147	–	–	–	–	–	–	–	–
KFM02A	490.00	518.00	16572	2009-10-26	5.47	<1	629	84.7	<0.05	<0.5	<0.1	0.443	<0.002	0.665	0.133	172	<0.2	<0.5	61.9	3.38	<0.3	2.34	<0.5	0.191
KFM03A	633.50	650.00	16605	2009-11-03	–	–	–	–	–	–	–	–	–	–	–	15.4	–	–	–	–	–	–	–	–
KFM03A	633.50	650.00	16606	2009-11-03	–	–	–	–	–	–	–	–	–	–	–	16.8	–	–	–	–	–	–	–	–
KFM03A	633.50	650.00	16607	2009-11-03	4.06	<1	1060	171	<0.05	<0.5	1.98	0.0894	<0.002	1.42	<0.05	34.4	<0.2	<0.5	42.0	0.494	<0.3	<2	<0.5	0.174
KFM03A	633.50	650.00	16608	2009-11-03	–	–	–	–	–	–	–	–	–	–	–	38.6	–	–	–	–	–	–	–	–
KFM03A	633.50	650.00	16609	2009-11-03	3.33	<1	1040	166	<0.05	<0.5	0.270	<0.05	<0.002	0.640	0.112	38.9	<0.2	<0.5	40.7	0.463	<0.3	<2	<0.5	0.214
KFM03A	969.00	994.50	16582	2009-11-06	14.60	<1	932	1030	<0.05	<0.5	0.188	<0.05	<0.002	0.523	0.0589	0.161	<0.2	0.6190	32.4	0.454	<0.3	4.44	<0.5	0.536
KFM03A	969.50	994.50	16578	2009-11-04	–	–	–	–	–	–	–	–	–	–	–	0.332	–	–	–	–	–	–	–	–
KFM03A	969.50	994.50	16579	2009-11-04	–	–	–	–	–	–	–	–	–	–	–	0.275	–	–	–	–	–	–	–	–
KFM03A	969.50	994.50	16580	2009-11-05	13.80	<1	921	1040	<0.05	<0.5	0.297	<0.05	<0.002	0.890	0.144	0.292	<0.2	0.6620	34.9	0.565	<0.3	2.42	<0.5	0.449
KFM03A	969.50	994.50	16581	2009-11-05	–	–	–	–	–	–	–	–	–	–	–	0.189	–	–	–	–	–	–	–	–
KFM07A	962.00	972.00	16561	2009-11-04	–	–	–	–	–	–	–	–	–	–	–	0.0559	–	–	–	–	–	–	–	–
KFM07A	962.00	972.00	16610	2009-11-04	–	–	–	–	–	–	–	–	–	–	–	0.117	–	–	–	–	–	–	–	–

Id code	Secup m	Seclow m	Sample no.	Sampling date	Al µg/L	As µg/L	B µg/L	Ba µg/L	Cd µg/L	Cu µg/L	Cr µg/L	Co µg/L	Hg µg/L	Ni µg/L	V µg/L	U µg/L	Th µg/L	Sc µg/L	Rb µg/L	Y µg/L	Zr µg/L	Zn µg/L	In µg/L	Sb µg/L
KFM07A	962.00	972.00	16611	2009-11-04	1.95	<1	802	578	<0.05	<0.5	2.06	0.2040	0.0035	12.1	0.1560	0.139	<0.2	1.0100	40.2	0.516	<0.3	5.38	<0.5	0.822
KFM07A	962.00	972.00	16612	2009-11-04	–	–	–	–	–	–	–	–	–	–	–	0.0627	–	–	–	–	–	–	–	–
KFM07A	962.00	972.00	16613	2009-11-05	4.83	<1	803	526	<0.05	0.9280	3.33	0.2910	0.0037	14.5	0.0865	0.0582	<0.2	1.0900	39.6	0.502	<0.3	6.05	<0.5	0.917
KFM08A	265.00	280.00	16553	2009-10-21	–	–	–	–	–	–	–	–	–	–	–	8.33	–	–	–	–	–	–	–	–
KFM08A	265.00	280.00	16554	2009-10-21	–	–	–	–	–	–	–	–	–	–	–	19.7	–	–	–	–	–	–	–	–
KFM08A	265.00	280.00	16555	2009-10-21	3.91	<1	831	697	<0.02	<0.2	0.977	0.0375	<0.002	1.24	0.3740	18.4	<0.2	<0.4	35.1	0.804	<0.1	2.89	<0.2	0.255
KFM08A	265.00	280.00	16556	2009-10-21	–	–	–	–	–	–	–	–	–	–	–	18.8	–	–	–	–	–	–	–	–
KFM08A	265.00	280.00	16557	2009-10-21	3.70	<0.5	845	718	<0.02	<0.2	0.523	0.0487	<0.002	0.991	0.3390	16.9	<0.2	<0.4	34.0	0.814	<0.1	1.57	<0.2	0.243
KFM08A	684.00	694.00	16563	2009-10-20	–	–	–	–	–	–	–	–	–	–	–	0.0274	–	–	–	–	–	–	–	–
KFM08A	684.00	694.00	16564	2009-10-20	–	–	–	–	–	–	–	–	–	–	–	0.185	–	–	–	–	–	–	–	–
KFM08A	684.00	694.00	16565	2009-10-20	1.35	2.2	723	371	<0.05	<0.5	<0.1	0.0856	<0.002	0.775	<0.05	0.433	<0.2	<0.5	32.4	0.194	<0.3	5.62	<0.5	0.323
KFM08A	684.00	694.00	16566	2009-10-20	–	–	–	–	–	–	–	–	–	–	–	0.490	–	–	–	–	–	–	–	–
KFM08A	684.00	694.00	16567	2009-10-20	1.39	2.2	731	362	<0.05	<0.5	<0.1	<0.05	<0.002	0.753	0.0751	0.739	<0.2	<0.5	31.2	0.173	<0.3	3.48	<0.5	0.275
KFM08D	660.00	680.00	16543	2009-10-12	–	–	–	–	–	–	–	–	–	–	–	0.0548	–	–	–	–	–	–	–	–
KFM08D	660.00	680.00	16544	2009-10-12	–	–	–	–	–	–	–	–	–	–	–	1.50	–	–	–	–	–	–	–	–
KFM08D	660.00	680.00	16545	2009-10-12	<0.7	<1	721	413	<0.05	<0.5	1.51	<0.05	<0.002	1.39	0.218	1.44	<0.2	<0.5	25.6	0.140	<0.3	<2	<0.5	0.178
KFM08D	660.00	680.00	16546	2009-10-13	–	–	–	–	–	–	–	–	–	–	–	1.87	–	–	–	–	–	–	–	–
KFM08D	660.00	680.00	16547	2009-10-14	18.6	1.1	714	440	<0.05	<0.5	<0.1	0.0598	<0.002	2.53	0.161	1.15	<0.2	<0.5	25.1	0.181	<0.3	9.16	<0.5	0.812
KFM08D	825.00	835.00	16558	2009-10-20	–	–	–	–	–	–	–	–	–	–	–	0.0474	–	–	–	–	–	–	–	–
KFM08D	825.00	835.00	16559	2009-10-21	–	–	–	–	–	–	–	–	–	–	–	0.0691	–	–	–	–	–	–	–	–
KFM08D	825.00	835.00	16560	2009-10-21	<0.7	<1	734	346	<0.05	<0.5	<0.1	0.0722	<0.002	0.894	0.219	0.0606	<0.2	<0.5	20.5	0.179	<0.3	3.07	<0.5	0.590
KFM08D	825.00	835.00	16562	2009-10-23	0.908	<1	726	344	<0.05	<0.5	<0.1	0.0674	<0.002	0.810	0.0911	0.0536	<0.2	<0.5	20.9	0.181	<0.3	2.59	<0.5	0.423
KFM10A	430.00	440.00	16528	2009-10-09	–	–	–	–	–	–	–	–	–	–	–	1.25	–	–	–	–	–	–	–	–
KFM10A	430.00	440.00	16529	2009-10-09	–	–	–	–	–	–	–	–	–	–	–	3.93	–	–	–	–	–	–	–	–
KFM10A	430.00	440.00	16530	2009-10-09	<0.7	<1	756	94.7	<0.05	<0.5	0.378	<0.05	<0.002	0.980	0.0933	4.35	<0.2	<0.5	56.5	7.86	0.462	<2	<0.5	<0.1
KFM10A	430.00	440.00	16531	2009-10-09	–	–	–	–	–	–	–	–	–	–	–	4.81	–	–	–	–	–	–	–	–
KFM10A	430.00	440.00	16532	2009-10-09	<0.7	<1	765	92.0	<0.05	<0.5	0.234	<0.05	<0.002	<0.5	0.180	4.71	<0.2	<0.5	59.7	9.67	0.433	<2	<0.5	0.106

Id code	Secup m	Seclow m	Sample no.	Sampling date	Cs µg/L	La µg/L	Hf µg/L	Tl µg/L	Ce µg/L	Pr µg/L	Nd µg/L	Sm µg/L	Eu µg/L	Gd µg/L	Tb µg/L	Dy µg/L	Ho µg/L	Er µg/L	Tm µg/L	Yb µg/L	Mo µg/L	Pb µg/L	Lu µg/L
KFM01A	109.00	130.00	16505	2009-10-06	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM01A	109.00	130.00	16506	2009-10-06	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM01A	109.00	130.00	16507	2009-10-06	0.717	1.10	<0.02	<0.05	1.64	0.223	1.180	0.376	0.0419	0.814	0.131	0.947	0.268	0.825	0.0837	0.442	20.0	<0.1	0.0739
KFM01A	109.00	130.00	16508	2009-10-06	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM01A	109.00	130.00	16512	2009-10-06	0.705	1.07	<0.02	<0.05	1.59	0.218	1.110	0.405	0.0340	0.855	0.124	0.943	0.271	0.837	0.0873	0.431	20.1	<0.1	0.0726
KFM01D	311.00	321.00	16523	2009-10-08	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM01D	311.00	321.00	16524	2009-10-08	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM01D	311.00	321.00	16525	2009-10-08	0.435	1.38	<0.02	<0.05	1.57	0.155	0.675	0.113	<0.02	0.142	<0.02	0.0891	0.0206	0.0638	<0.02	0.0476	4.64	<0.1	<0.02
KFM01D	311.00	321.00	16526	2009-10-08	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM01D	311.00	321.00	16527	2009-10-08	0.463	1.27	<0.02	<0.05	1.48	0.150	0.629	0.136	<0.02	0.146	<0.02	0.0904	0.0232	0.0549	<0.02	0.0580	3.86	<0.1	<0.02
KFM01D	429.00	438.00	16509	2009-10-07	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM01D	429.00	438.00	16510	2009-10-07	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM01D	429.00	438.00	16518	2009-10-07	6.90	1.98	<0.02	<0.05	2.49	0.320	1.63	0.382	<0.02	0.538	0.0588	0.366	0.0962	0.258	0.0261	0.134	0.33	<0.1	<0.02
KFM01D	429.00	438.00	16511	2009-10-07	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM01D	429.00	438.00	16519	2009-10-07	6.97	1.99	<0.02	<0.05	2.53	0.305	1.66	0.382	<0.02	0.566	0.0617	0.364	0.0976	0.248	0.0275	0.137	0.55	<0.1	0.0215
KFM02A	411.00	442.00	16573	2009-10-27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM02A	411.00	442.00	16574	2009-10-27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM02A	411.00	442.00	16575	2009-10-27	360	0.667	<0.05	<0.1	1.03	0.110	0.503	0.139	<0.05	0.287	<0.05	0.316	0.0902	0.272	<0.05	0.150	27.2	<0.3	<0.05
KFM02A	411.00	442.00	16576	2009-10-27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM02A	411.00	442.00	16577	2009-10-27	319	0.654	<0.05	<0.1	0.873	0.0937	0.445	0.113	<0.05	0.280	<0.05	0.323	0.0799	0.253	<0.05	0.181	25.4	<0.3	<0.05
KFM02A	490.00	518.00	16568	2009-10-26	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM02A	490.00	518.00	16569	2009-10-26	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM02A	490.00	518.00	16570	2009-10-26	1.79	1.41	<0.05	<0.1	2.12	0.165	0.738	0.119	<0.05	0.283	<0.05	0.254	0.0642	0.170	<0.05	0.123	107.0	<0.3	<0.05
KFM02A	490.00	518.00	16571	2009-10-26	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM02A	490.00	518.00	16572	2009-10-26	1.85	1.37	<0.05	<0.1	1.88	0.154	0.715	0.113	<0.05	0.241	<0.05	0.218	<0.05	0.159	<0.05	0.094	80.8	<0.3	<0.05
KFM03A	633.50	650.00	16605	2009-11-03	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM03A	633.50	650.00	16606	2009-11-03	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM03A	633.50	650.00	16607	2009-11-03	6.65	0.422	<0.05	<0.1	0.474	<0.05	0.214	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	41.9	<0.3	<0.05
KFM03A	633.50	650.00	16608	2009-11-03	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM03A	633.50	650.00	16609	2009-11-03	6.59	0.429	<0.05	<0.1	0.425	<0.05	0.147	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	37.8	<0.3	<0.05
KFM03A	969.00	994.50	16582	2009-11-06	0.641	0.452	<0.05	<0.1	0.410	<0.05	0.119	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	10.1	<0.3	<0.05
KFM03A	969.50	994.50	16578	2009-11-04	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM03A	969.50	994.50	16579	2009-11-04	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM03A	969.50	994.50	16580	2009-11-05	0.699	0.686	<0.05	<0.1	0.685	0.0606	0.221	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	9.94	<0.3	<0.05
KFM03A	969.50	994.50	16581	2009-11-05	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM07A	962.00	972.00	16561	2009-11-04	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM07A	962.00	972.00	16610	2009-11-04	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Id code	Secup m	Seclow m	Sample no.	Sampling date	Cs µg/L	La µg/L	Hf µg/L	Tl µg/L	Ce µg/L	Pr µg/L	Nd µg/L	Sm µg/L	Eu µg/L	Gd µg/L	Tb µg/L	Dy µg/L	Ho µg/L	Er µg/L	Tm µg/L	Yb µg/L	Mo µg/L	Pb µg/L	Lu µg/L
KFM07A	962.00	972.00	16611	2009-11-04	0.959	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	20.7	<0.3	<0.05
KFM07A	962.00	972.00	16612	2009-11-04	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM07A	962.00	972.00	16613	2009-11-05	1.03	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	19.7	<0.3	<0.05
KFM08A	265.00	280.00	16553	2009-10-21	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM08A	265.00	280.00	16554	2009-10-21	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM08A	265.00	280.00	16555	2009-10-21	0.353	0.102	<0.02	<0.05	0.132	<0.02	0.0612	<0.02	<0.02	0.0381	<0.02	0.0337	<0.02	0.0382	<0.02	0.0366	11.5	<0.1	<0.02
KFM08A	265.00	280.00	16556	2009-10-21	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM08A	265.00	280.00	16557	2009-10-21	0.366	0.112	<0.02	<0.05	0.131	<0.02	0.0773	<0.02	<0.02	0.0383	<0.02	0.0341	<0.02	0.0363	<0.02	0.0302	13.6	<0.1	<0.02
KFM08A	684.00	694.00	16563	2009-10-20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM08A	684.00	694.00	16564	2009-10-20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM08A	684.00	694.00	16565	2009-10-20	0.593	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	30.7	<0.3	<0.05
KFM08A	684.00	694.00	16566	2009-10-20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM08A	684.00	694.00	16567	2009-10-20	0.551	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	33.1	<0.3	<0.05
KFM08D	660.00	680.00	16543	2009-10-12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM08D	660.00	680.00	16544	2009-10-12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM08D	660.00	680.00	16545	2009-10-12	0.287	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	32.8	<0.3	<0.05
KFM08D	660.00	680.00	16546	2009-10-13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM08D	660.00	680.00	16547	2009-10-14	0.374	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	42.1	<0.3	<0.05
KFM08D	825.00	835.00	16558	2009-10-20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM08D	825.00	835.00	16559	2009-10-21	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM08D	825.00	835.00	16560	2009-10-21	0.324	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	35.0	<0.3	<0.05
KFM08D	825.00	835.00	16562	2009-10-23	0.299	<0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	34.3	<0.3	<0.05
KFM10A	430.00	440.00	16528	2009-10-09	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM10A	430.00	440.00	16529	2009-10-09	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM10A	430.00	440.00	16530	2009-10-09	0.959	0.212	<0.05	<0.1	0.317	0.057	0.584	0.659	0.0883	1.97	0.381	2.59	2.03	1.36	0.110	0.379	3.11	<0.3	0.0544
KFM10A	430.00	440.00	16531	2009-10-09	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KFM10A	430.00	440.00	16532	2009-10-09	0.890	0.263	<0.05	<0.1	0.398	0.074	0.721	0.800	0.111	2.51	0.450	3.08	2.64	1.73	0.129	0.517	2.92	<0.3	0.0663

Table A5-3. Isotopes I (H-, B-, S-, C-, Sr-, and Cl-isotopes).

Id code	Secup m	Seclow m	Sample no.	Sampling date	δ^{2}H dev SMOW	^{3}H TU	δ^{18}O dev SMOW	^{10}B/^{11}B no unit	δ^{34}S dev CDT	δ^{13}C dev PDB	^{87}Sr/^{86}Sr no unit	^{14}C pmC	δ^{37}Cl dev SMOC
HFM01	33.50	45.50	16282	2009-04-28	–76.5	5.40	–10.90	–	–	–	–	–	–
HFM01	33.50	45.50	16522	2009-10-07	–73.9	4.40	–10.50	–	–	–	–	–	–
HFM02	38.00	48.00	16285	2009-04-30	–80.5	7.00	–11.60	–	–	–	–	–	–
HFM02	38.00	48.00	16521	2009-10-07	–78.5	5.10	–11.20	–	–	–	–	–	–
HFM04	58.00	66.00	16295	2009-05-06	–82.1	8.00	–11.50	–	–	–	–	–	–
HFM04	58.00	66.00	16548	2009-10-14	–85.0	7.50	–12.30	–	–	–	–	–	–
HFM13	159.00	173.00	16303	2009-05-12	–70.7	2.10	–9.30	–	–	–	–	–	–
HFM13	159.00	173.00	16533	2009-10-08	–71.1	0.90	–9.70	–	–	–	–	–	–
HFM15	85.00	95.00	16308	2009-05-12	–85.7	10.3	–12.00	–	–	–	–	–	–
HFM15	85.00	95.00	16534	2009-10-08	–86.4	7.90	–12.00	–	–	–	–	–	–
HFM16	54.00	67.00	16283	2009-05-06	–80.7	5.40	–11.50	–	–	–	–	–	–
HFM16	54.00	67.00	16539	2009-10-12	–82.7	4.80	–11.00	–	–	–	–	–	–
HFM19	168.00	182.00	16310	2009-05-12	–67.7	1.50	–9.00	–	–	–	–	–	–
HFM19	168.00	182.00	16536	2009-10-09	–70.8	1.00	–9.00	–	–	–	–	–	–
HFM21	22.00	32.00	16290	2009-04-30	–78.3	10.6	–11.30	–	–	–	–	–	–
HFM21	22.00	32.00	16540	2009-10-14	–80.1	8.10	–11.90	–	–	–	–	–	–
HFM27	46.00	58.00	16286	2009-04-30	–71.8	2.40	–10.20	–	–	–	–	–	–
HFM27	46.00	58.00	16520	2009-10-07	–71.1	1.70	–10.00	–	–	–	–	–	–
HFM32	26.00	31.00	16309	2009-05-12	–68.0	2.20	–8.90	–	–	–	–	–	–
HFM32	26.00	31.00	16535	2009-10-08	–68.2	2.10	–9.10	–	–	–	–	–	–
KFM01A	109.00	130.00	16304	2009-05-11	–84.5	1.50	–11.30	–	–	–	–	–	–
KFM01A	109.00	130.00	16505	2009-10-06	–78.5	1.30	–10.70	–	–	–	–	–	–
KFM01A	109.00	130.00	16506	2009-10-06	–80.8	1.30	–11.00	–	–	–	–	–	–
KFM01A	109.00	130.00	16507	2009-10-06	–78.5	1.00	–11.20	0.2367	25.6	–9.36	0.720394	23.46	–0.34
KFM01A	109.00	130.00	16508	2009-10-06	–78.8	1.60	–11.00	–	–	–	–	–	–
KFM01A	109.00	130.00	16512	2009-10-06	–81.0	1.40	–10.80	0.2372	25.5	–9.29	0.720359	22.70	–0.16
KFM01D	311.00	321.00	16306	2009-05-11	–74.3	2.00	–10.50	–	–	–	–	–	–
KFM01D	311.00	321.00	16523	2009-10-08	–75.2	1.70	–10.70	–	–	–	–	–	–
KFM01D	311.00	321.00	16524	2009-10-08	–76.2	1.20	–11.10	–	–	–	–	–	–
KFM01D	311.00	321.00	16525	2009-10-08	–77.6	<0.8	–11.00	0.2366	29.3	–	0.720630	–	–0.39
KFM01D	311.00	321.00	16526	2009-10-08	–78.8	<0.8	–10.10	–	–	–	–	–	–
KFM01D	311.00	321.00	16527	2009-10-08	–78.5	1.00	–10.60	0.2369	23.4	–15.34	0.720656	40.41	–0.44
KFM01D	429.00	438.00	16305	2009-05-11	–75.4	1.00	–10.80	–	–	–	–	–	–
KFM01D	429.00	438.00	16509	2009-10-07	–69.3	1.30	–10.60	–	–	–	–	–	–
KFM01D	429.00	438.00	16510	2009-10-07	–69.9	1.80	–10.60	–	–	–	–	–	–
KFM01D	429.00	438.00	16518	2009-10-07	–79.3	1.60	–11.00	0.2369	43.3	–	0.720306	–	–0.34
KFM01D	429.00	438.00	16511	2009-10-07	–70.0	1.80	–10.70	–	–	–	–	–	–
KFM01D	429.00	438.00	16519	2009-10-07	–73.6	1.60	–10.60	0.2370	41.7	–18.69	0.720307	50.99	–0.37
KFM02A	411.00	442.00	16301	2009-05-08	–77.6	2.10	–10.50	–	–	–	–	–	–
KFM02A	411.00	442.00	16573	2009-10-27	–72.0	1.20	–10.20	–	–	–	–	–	–
KFM02A	411.00	442.00	16574	2009-10-27	–76.4	1.60	–10.50	–	–	–	–	–	–
KFM02A	411.00	442.00	16575	2009-10-27	–74.6	2.20	–10.40	0.2379	21.8	–6.19	0.715926	14.98	–0.52
KFM02A	411.00	442.00	16576	2009-10-27	–77.1	2.10	–11.50	–	–	–	–	–	–
KFM02A	411.00	442.00	16577	2009-10-27	–77.5	1.70	–11.00	0.2374	23.0	–5.97	0.715599	14.01	–0.24
KFM02A	490.00	518.00	16299	2009-05-08	–66.5	1.30	–9.00	–	–	–	–	–	–
KFM02A	490.00	518.00	16568	2009-10-26	–65.5	<0.8	–9.20	–	–	–	–	–	–
KFM02A	490.00	518.00	16569	2009-10-26	–63.9	1.10	–9.00	–	–	–	–	–	–
KFM02A	490.00	518.00	16570	2009-10-26	–64.7	<0.8	–8.90	0.2374	24.7	–5.67	0.718302	17.04	–0.65
KFM02A	490.00	518.00	16571	2009-10-26	–64.9	<0.8	–8.90	–	–	–	–	–	–
KFM02A	490.00	518.00	16572	2009-10-26	–64.6	<0.8	–8.80	0.2370	24.2	–5.91	0.718329	17.63	–0.47
KFM02B	410.00	431.00	16302	2009-05-08	–70.9	0.90	–9.60	–	–	–	–	–	–
KFM02B	410.00	431.00	16584	2009-10-26	–68.0	1.00	–10.00	–	–	–	–	–	–
KFM02B	491.00	506.00	16300	2009-05-08	–64.7	1.50	–8.90	–	–	–	–	–	–
KFM02B	491.00	506.00	16583	2009-10-26	–63.5	<0.8	–9.30	–	–	–	–	–	–
KFM03A	633.50	650.00	16279	2009-04-28	–85.2	1.10	–12.00	–	–	–	–	–	–
KFM03A	633.50	650.00	16605	2009-11-03	–83.9	1.20	–11.70	–	–	–	–	–	–
KFM03A	633.50	650.00	16606	2009-11-03	–84.0	1.00	–12.30	–	–	–	–	–	–
KFM03A	633.50	650.00	16607	2009-11-03	–86.1	<0.8	–12.50	0.2363	26.6	–	0.717451	–	0.24
KFM03A	633.50	650.00	16608	2009-11-03	–83.9	<0.8	–12.50	–	–	–	–	–	–
KFM03A	633.50	650.00	16609	2009-11-03	–83.2	<0.8	–12.50	0.2366	25.9	–12.70	0.717506	57.60	0.15
KFM03A	969.00	994.50	16582	2009-11-06	–96.7	<0.8	–14.50	0.2385	31.2	–16.00	0.717793	62.98	–0.65
KFM03A	969.50	994.50	16289	2009-04-30	–98.0	0.90	–14.00	–	–	–	–	–	–
KFM03A	969.50	994.50	16578	2009-11-04	–99.8	<0.8	–14.60	–	–	–	–	–	–

Id code	Secup m	Seclow m	Sample no.	Sampling date	δ^{2}H dev SMOW	^{3}H TU	δ^{18}O dev SMOW	^{10}B/^{11}B no unit	δ^{34}S dev CDT	δ^{13}C dev PDB	^{87}Sr/^{86}Sr no unit	^{14}C pmC	δ^{37}Cl dev SMOC
KFM03A	969.50	994.50	16579	2009-11-04	–99.0	1.50	–14.50	–	–	–	–	–	–
KFM03A	969.50	994.50	16580	2009-11-05	–98.6	1.00	–14.60	0.2381	32.5	x	0.717746	x	x
KFM03A	969.50	994.50	16581	2009-11-05	–98.3	1.00	–14.40	–	–	–	–	–	–
KFM04A	230.00	245.00	16288	2009-05-04	–72.0	2.50	–9.90	–	–	–	–	–	–
KFM04A	230.00	245.00	16542	2009-10-15	–70.6	1.50	–10.20	–	–	–	–	–	–
KFM06A	341.00	362.00	16296	2009-05-06	–88.1	1.60	–12.10	–	–	–	–	–	–
KFM06A	341.00	362.00	16537	2009-10-13	–91.6	1.00	–13.20	–	–	–	–	–	–
KFM06A	738.00	748.00	16293	2009-05-06	–80.7	3.30	–11.70	–	–	–	–	–	–
KFM06A	738.00	748.00	16538	2009-10-12	–83.7	1.40	–11.80	–	–	–	–	–	–
KFM07A	962.00	972.00	16561	2009-11-04	–91.5	<0.8	–14.00	–	–	–	–	–	–
KFM07A	962.00	972.00	16610	2009-11-04	–89.0	<0.8	–13.70	–	–	–	–	–	–
KFM07A	962.00	972.00	16611	2009-11-04	–84.6	<0.8	–13.30	0.2381	24.8	–	0.717783	–	0.10
KFM07A	962.00	972.00	16612	2009-11-04	–88.3	<0.8	–13.70	–	–	–	–	–	–
KFM07A	962.00	972.00	16613	2009-11-05	–86.0	<0.8	–13.60	0.2387	24.0	–19.60	0.717518	79.75	0.01
KFM07A	963.00	972.00	16311	2009-05-19	–85.3	<0.8	–13.20	–	–	–	–	–	–
KFM08A	265.00	280.00	16280	2009-04-28	–93.5	2.00	–13.40	–	–	–	–	–	–
KFM08A	265.00	280.00	16553	2009-10-21	–95.7	1.20	–14.10	–	–	–	–	–	–
KFM08A	265.00	280.00	16554	2009-10-21	–96.4	1.40	–13.90	–	–	–	–	–	–
KFM08A	265.00	280.00	16555	2009-10-21	–95.8	1.50	–14.00	0.2370	37.5	–15.23	0.718282	52.31	–0.43
KFM08A	265.00	280.00	16556	2009-10-21	–98.8	1.40	–14.10	–	–	–	–	–	–
KFM08A	265.00	280.00	16557	2009-10-21	–94.8	1.50	–14.00	0.2374	36.4	–14.82	0.718270	52.12	–0.27
KFM08A	684.00	694.00	16281	2009-04-28	–91.4	0.90	–13.40	–	–	–	–	–	–
KFM08A	684.00	694.00	16563	2009-10-20	–90.2	1.00	–13.30	–	–	–	–	–	–
KFM08A	684.00	694.00	16564	2009-10-20	–91.6	<0.8	–13.60	–	–	–	–	–	–
KFM08A	684.00	694.00	16565	2009-10-20	–91.6	<0.8	–13.60	0.2375	30.1	–	0.718064	–	–0.44
KFM08A	684.00	694.00	16566	2009-10-20	–90.3	<0.8	–13.60	–	–	–	–	–	–
KFM08A	684.00	694.00	16567	2009-10-20	–89.6	<0.8	–13.50	0.2371	30.2	–13.80	0.718130	47.93	–0.89
KFM08D	660.00	680.00	16284	2009-04-28	–81.1	1.90	–11.80	–	–	–	–	–	–
KFM08D	660.00	680.00	16543	2009-10-12	–85.5	1.70	–11.50	–	–	–	–	–	–
KFM08D	660.00	680.00	16544	2009-10-12	–85.1	1.10	–11.50	–	–	–	–	–	–
KFM08D	660.00	680.00	16545	2009-10-12	–84.7	1.10	–11.60	0.2385	30.1	–	0.718818	–	–0.79
KFM08D	660.00	680.00	16546	2009-10-13	–84.7	1.60	–11.60	–	–	–	–	–	–
KFM08D	660.00	680.00	16547	2009-10-14	–81.0	1.40	–12.30	0.2381	28.3	–17.90	0.718197	46.63	–0.63
KFM08D	825.00	835.00	16291	2009-04-30	–78.1	1.50	–11.60	–	–	–	–	–	–
KFM08D	825.00	835.00	16558	2009-10-20	–82.4	1.70	–12.60	–	–	–	–	–	–
KFM08D	825.00	835.00	16559	2009-10-21	–84.0	<0.8	–13.20	–	–	–	–	–	–
KFM08D	825.00	835.00	16560	2009-10-21	–81.5	1.40	–12.80	0.2371	29.9	–	0.717762	–	0.23
KFM08D	825.00	835.00	16562	2009-10-23	–83.3	1.00	–12.40	0.2376	29.0	–17.70	0.717734	61.55	0.08
KFM10A	430.00	440.00	16307	2009-05-12	–68.2	<0.8	–9.20	–	–	–	–	–	–
KFM10A	430.00	440.00	16528	2009-10-09	–67.2	1.50	–8.80	–	–	–	–	–	–
KFM10A	430.00	440.00	16529	2009-10-09	–67.1	0.80	–8.60	–	–	–	–	–	–
KFM10A	430.00	440.00	16530	2009-10-09	–65.7	1.00	–8.70	0.2377	23.1	–6.68	0.718687	20.15	–1.06
KFM10A	430.00	440.00	16531	2009-10-09	–72.3	1.00	–10.10	–	–	–	–	–	–
KFM10A	430.00	440.00	16532	2009-10-09	–71.0	0.90	–9.70	0.2382	28.3	–6.64	0.718750	20.16	–0.90
KFM11A	446.00	456.00	16287	2009-05-04	–90.0	2.00	–12.40	–	–	–	–	–	–
KFM11A	446.00	456.00	16550	2009-10-15	–69.1	1.20	–13.30	–	–	–	–	–	–
KFM11A	690.00	710.00	16292	2009-05-04	–83.7	1.60	–12.20	–	–	–	–	–	–
KFM11A	690.00	710.00	16549	2009-10-15	–87.3	1.40	–12.50	–	–	–	–	–	–
KFM12A	270.00	280.00	16297	2009-05-06	–110.3	1.00	–15.00	–	–	–	–	–	–
KFM12A	270.00	280.00	16551	2009-10-15	–112.3	1.20	–16.00	–	–	–	–	–	–

< “value” = Result less than reporting limit.
x = No result due to analytical problem.

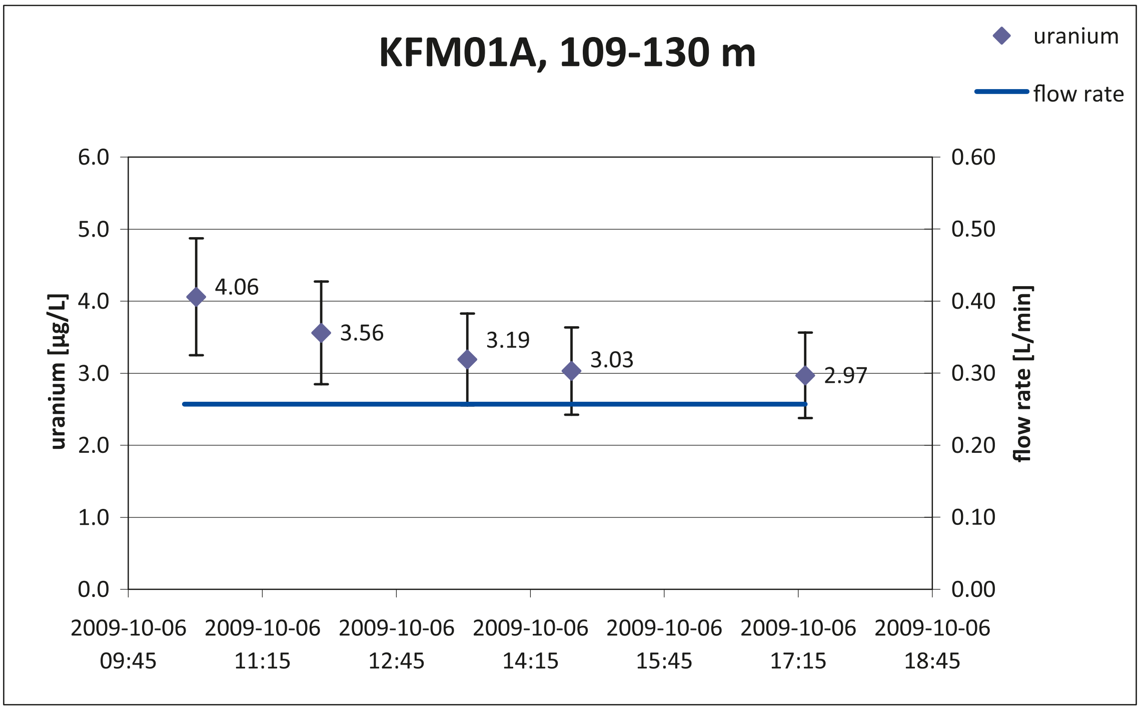
Table A5-4. Isotopes II (U-, Th-, Ra- and Rn-isotopes).

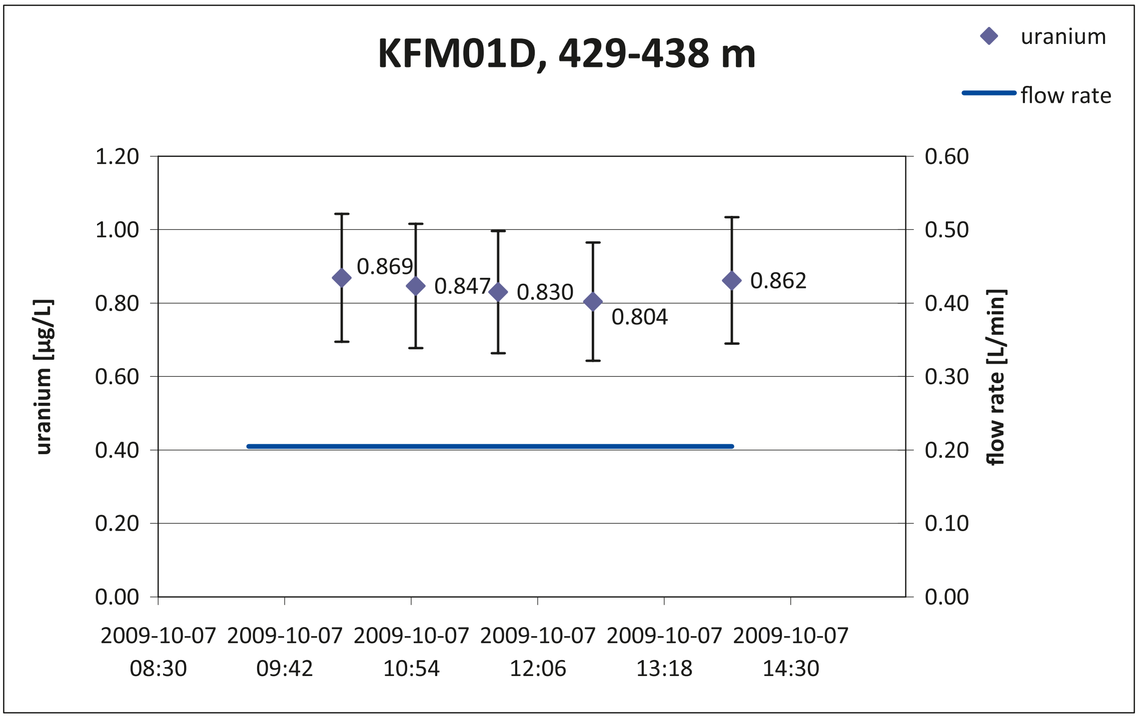
Id code	Secup m	Seclow m	Sample no.	Sampling date	^{238}U mBq/L	^{235}U mBq/L	^{234}U mBq/L	^{232}Th mBq/L	^{230}Th mBq/L	^{226}Ra Bq/L	^{222}Rn Bq/L At time of analysis	^{222}Rn Bq/L At time of collection
KFM01A	109.00	130.00	16512	2009-10-06	36.0	1.60	91.0	0.44	0.84	1.63	326	601
KFM01D	311.00	321.00	16527	2009-10-08	7.0	0.40	22.0	0.31	1.20	1.91	333	471
KFM01D	429.00	438.00	16519	2009-10-07	10.0	0.50	30.0	0.23	0.85	4.17	592	959
KFM02A	411.00	442.00	16575	2009-10-27	497	15.8	1,646	0.58	1.38	2.06	416	841
KFM02A	411.00	442.00	16577	2009-10-27	165	16.1	1,517	0.55	0.92	2.02	440	885
KFM02A	490.00	518.00	16570	2009-10-26	1,736	43.3	3,559	0.26	0.72	3.70	701	1,574
KFM02A	490.00	518.00	16572	2009-10-26	1,894	48.7	3,802	0.39	0.79	3.83	1,212	2,719
KFM03A	633.50	650.00	16607	2009-11-03	379	14.3	574	0.53	0.82	18.4	1,789	10,100
KFM03A	633.50	650.00	16609	2009-11-03	470	16.1	712	0.42	0.69	22.1	1,812	10,380
KFM03A	969.00	994.50	16582	2009-11-06	0.20	0.13	0.46	0.23	0.25	9.60	19.8	75.4
KFM03A	969.50	994.50	16580	2009-11-05	0.14	0.04	0.35	0.42	0.63	8.80	11.0	74.5
KFM07A	962.00	972.00	16613	2009-11-05	0.50	0.01	1.6	0.34	0.39	13.2	13.0	55.5
KFM08A	684.00	694.00	16567	2009-10-20	9.2	0.34	18.1	0.33	0.77	5.26	246	457
KFM08D	825.00	835.00	16562	2009-10-23	1.7	0.15	5.1	0.38	0.70	8.86	104	292
KFM10A	430.00	440.00	16532	2009-10-09	54.0	2.10	151	0.52	1.08	1.87	121	270

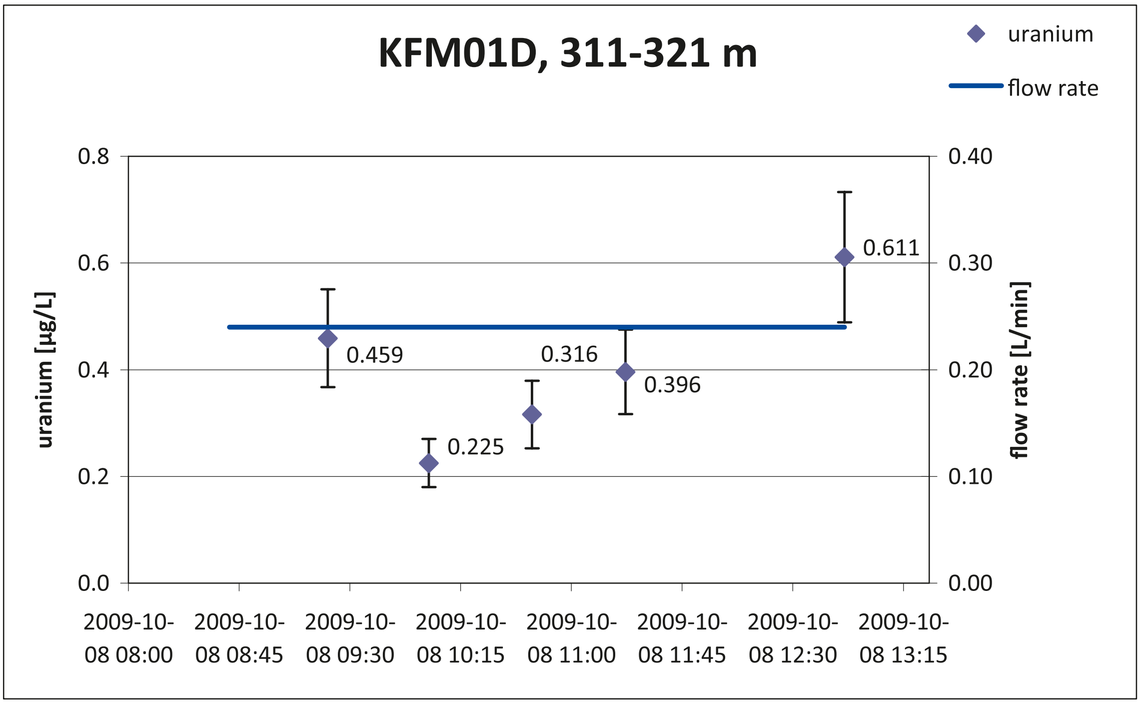
Appendix 6

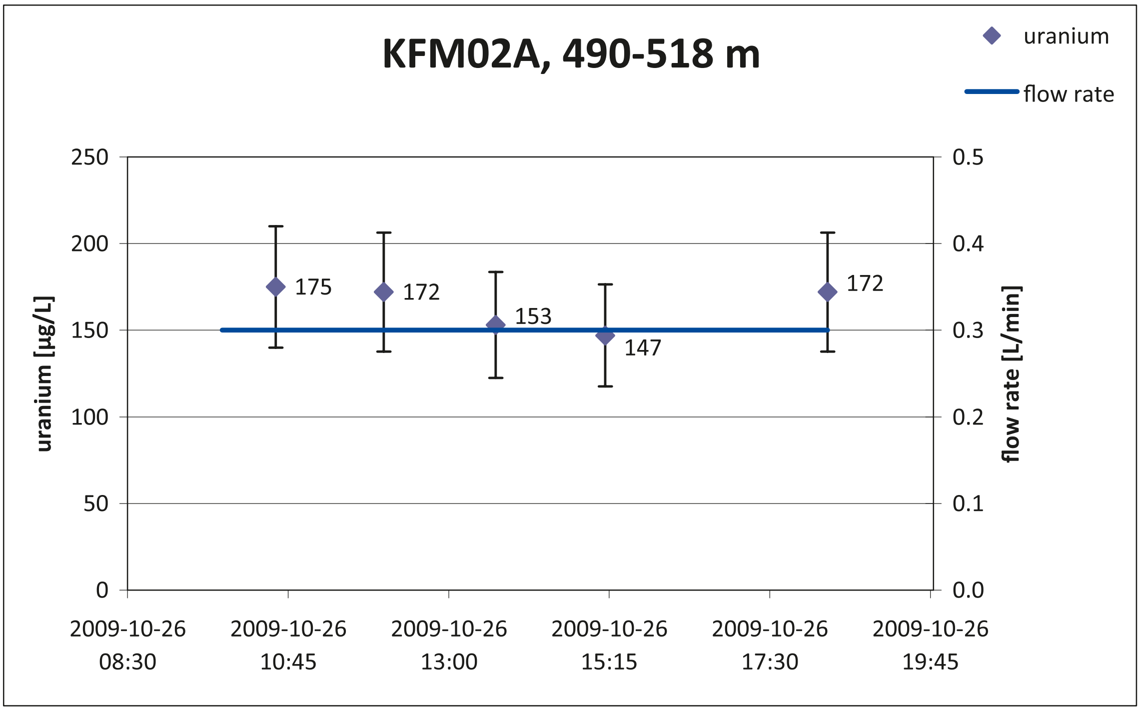
Uranium and sulphide concentration trends in sample series from October 2009

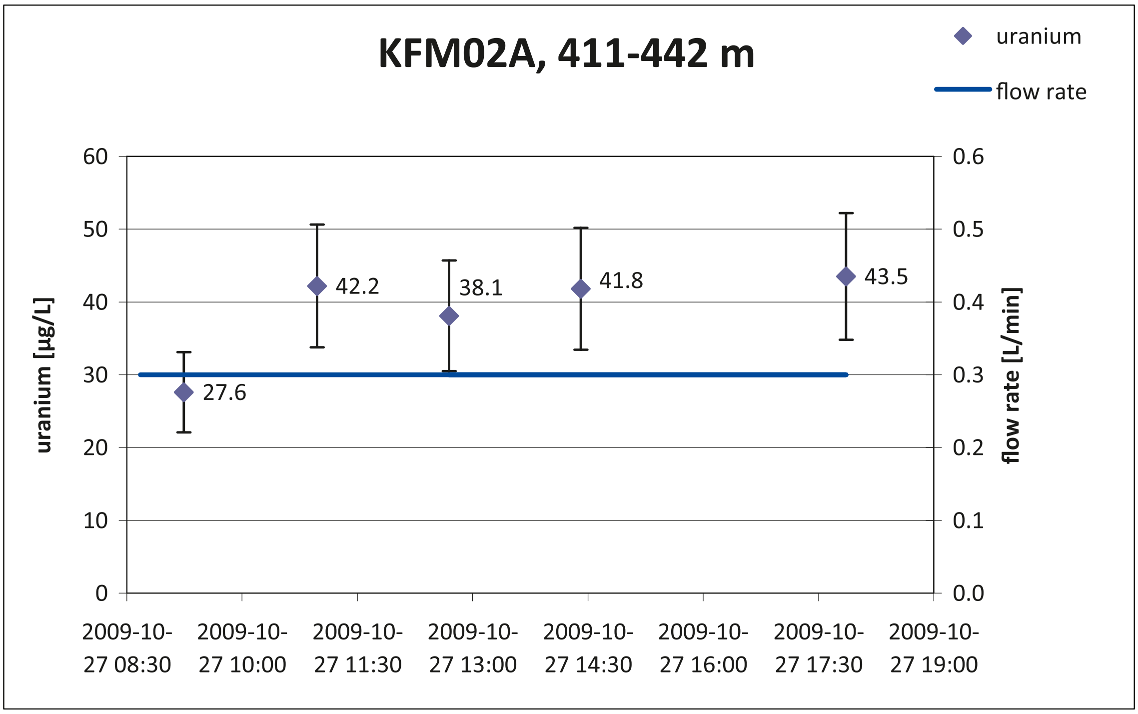
Uranium

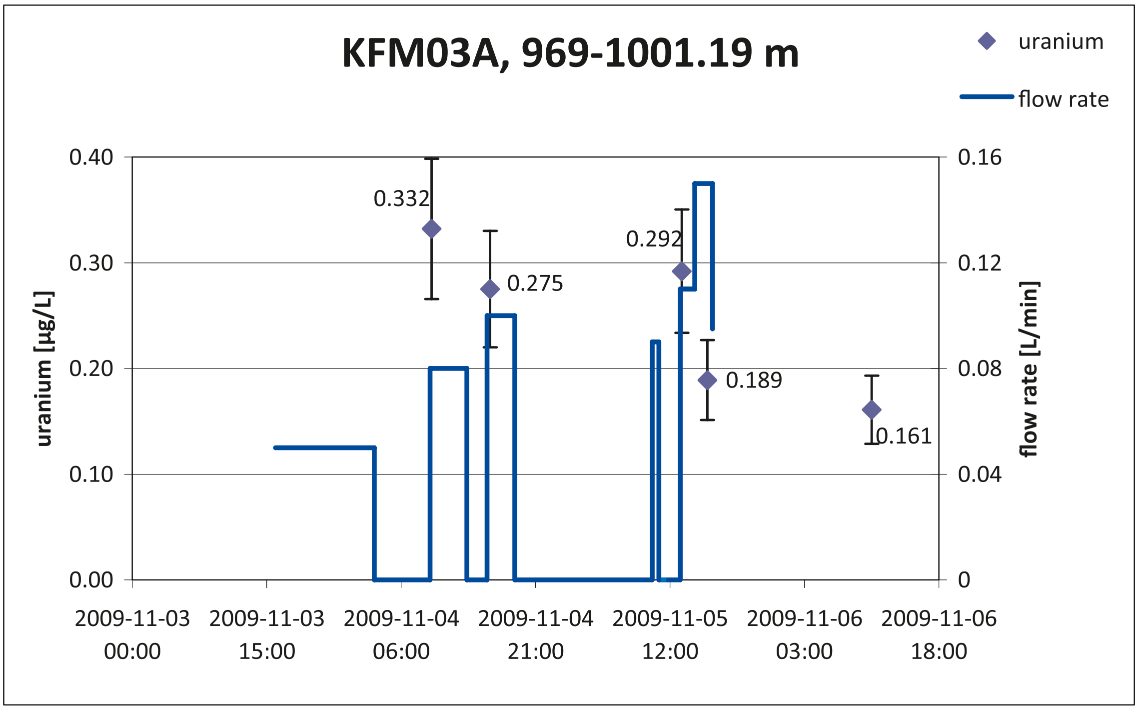


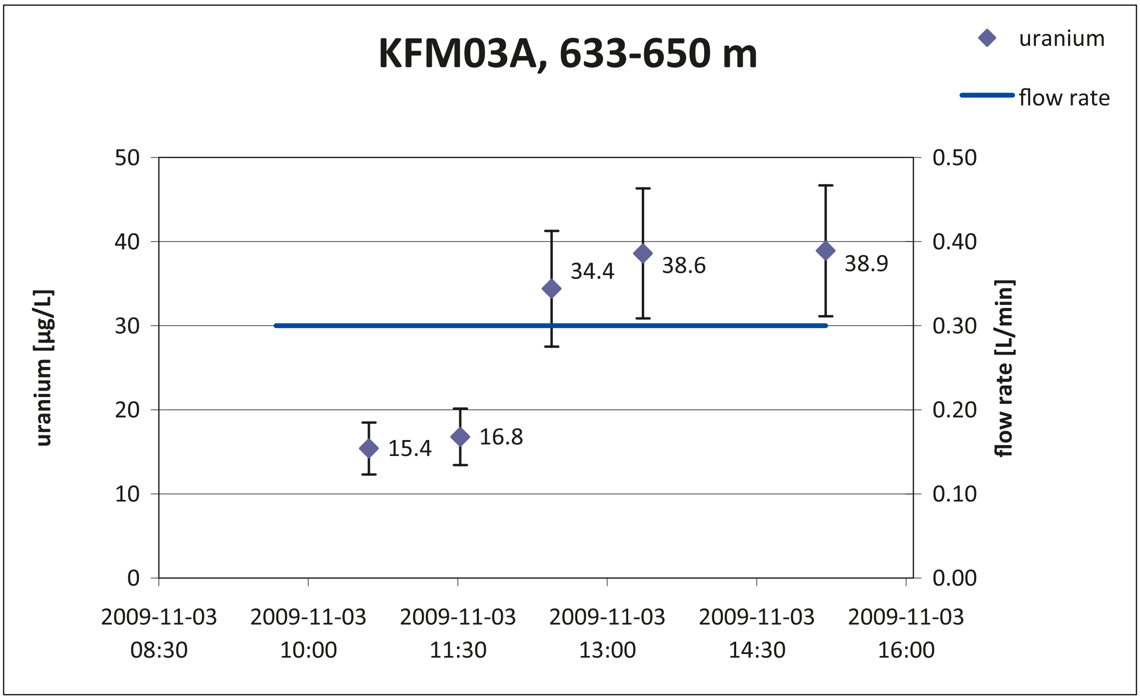


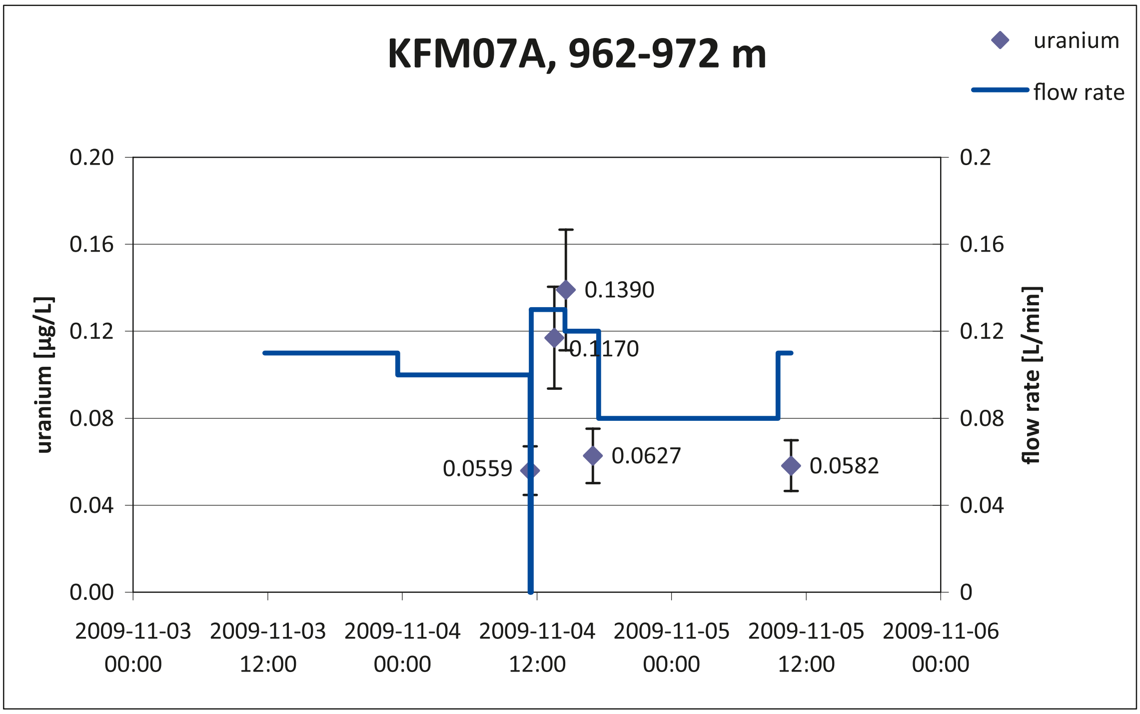

KFM01D, 311-321 m
uranium
flow rate
uranium [µg/L]
flow rate [L/min]
0.8
0.6
0.4
0.2
0.0
0.40
0.30
0.20
0.10
0.00
0.459
0.225
0.316
0.396
0.611
2009-10-08 08:00
2009-10-08 08:45
2009-10-08 09:30
2009-10-08 10:15
2009-10-08 11:00
2009-10-08 11:45
2009-10-08 12:30
2009-10-08 13:15

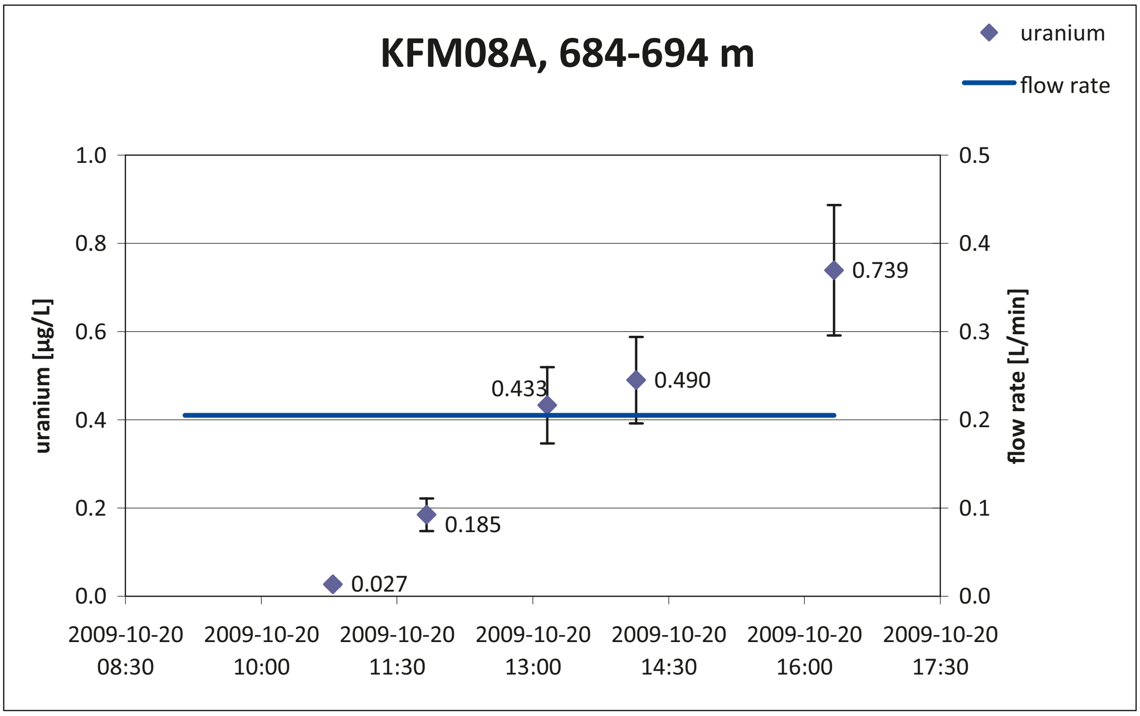

KFM02A, 490-518 m
uranium
flow rate
uranium [µg/L]
flow rate [L/min]
250
200
150
100
50
0
0.5
0.4
0.3
0.2
0.1
0.0
175
172
153
147
172
2009-10-26 08:30
2009-10-26 10:45
2009-10-26 13:00
2009-10-26 15:15
2009-10-26 17:30
2009-10-26 19:45

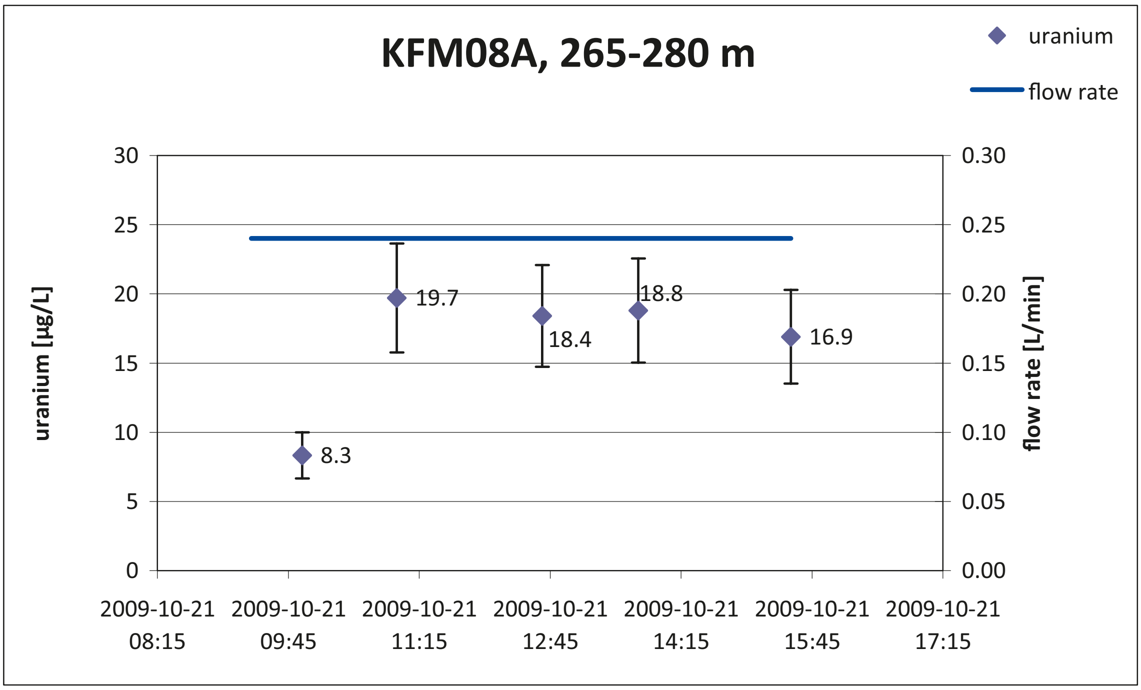

KFM02A, 411-442 m
uranium
flow rate
uranium [µg/L]
flow rate [L/min]
60
50
40
30
20
10
0
0.6
0.5
0.4
0.3
0.2
0.1
0.0
27.6
42.2
38.1
41.8
43.5
2009-10-27 08:30
2009-10-27 10:00
2009-10-27 11:30
2009-10-27 13:00
2009-10-27 14:30
2009-10-27 16:00
2009-10-27 17:30
2009-10-27 19:00

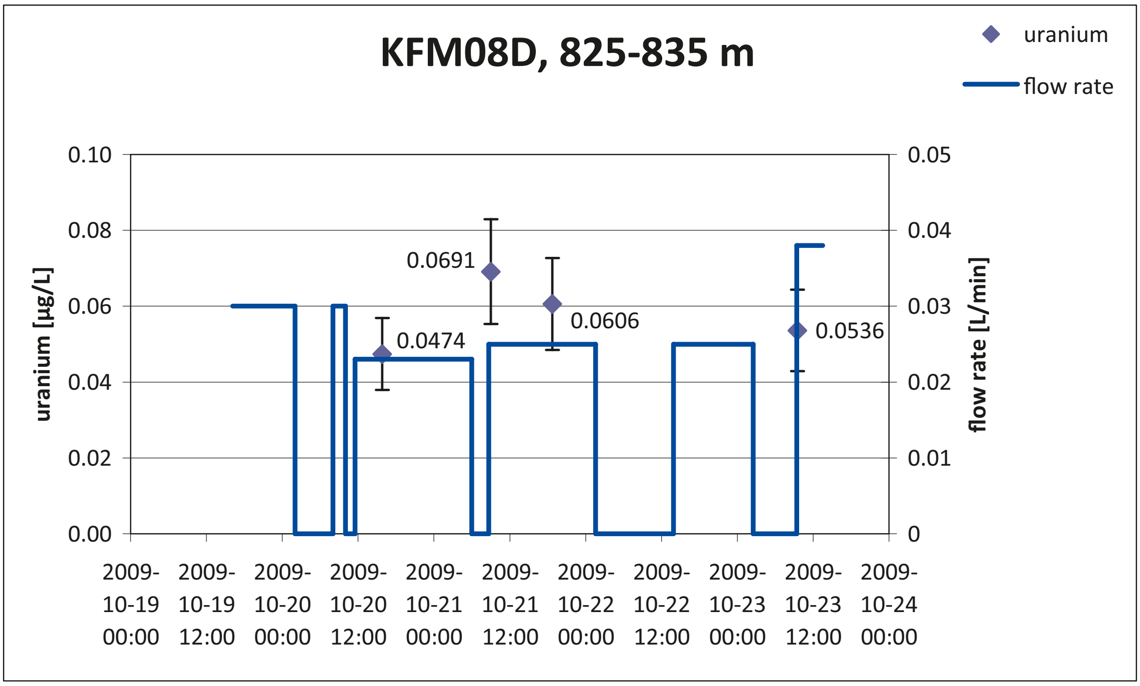

KFM03A, 969-1001.19 m
uranium
flow rate
uranium [µg/L]
flow rate [L/min]
0.40
0.30
0.20
0.10
0.00
0.16
0.12
0.08
0.04
0
0.332
0.275
0.292
0.189
0.161
2009-11-03 00:00
2009-11-03 15:00
2009-11-04 06:00
2009-11-04 21:00
2009-11-05 12:00
2009-11-06 03:00
2009-11-06 18:00

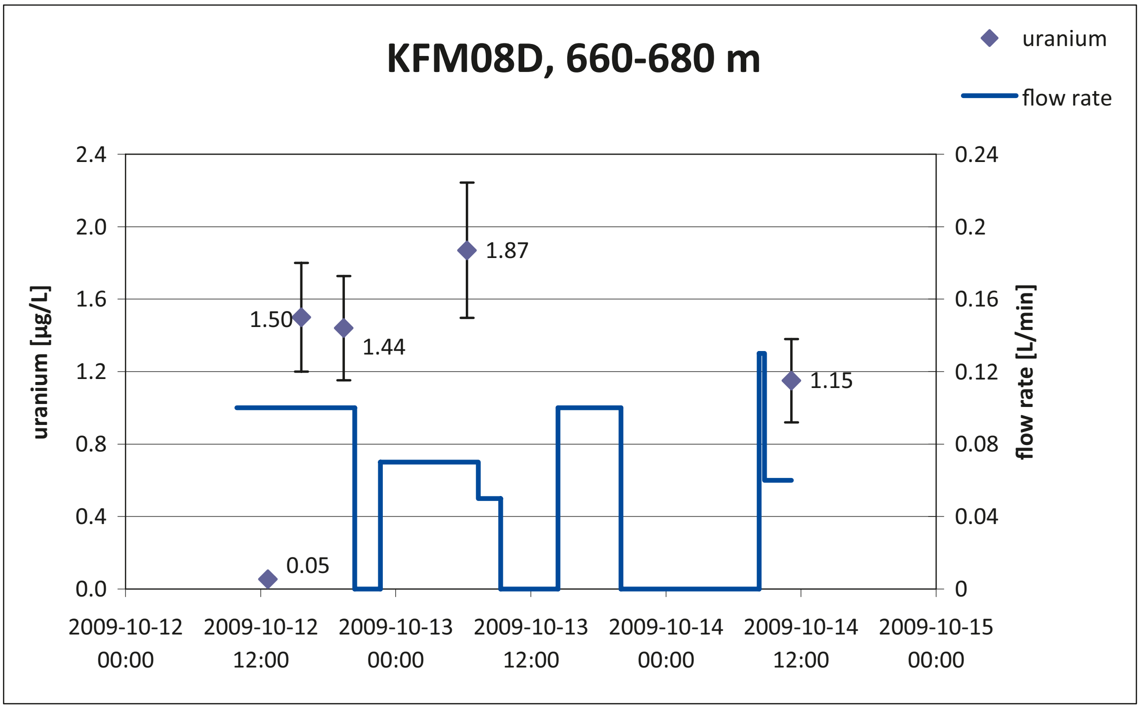

KFM03A, 633-650 m
uranium
flow rate
uranium [µg/L]
flow rate [L/min]
50
40
30
20
10
0
0.50
0.40
0.30
0.20
0.10
0.00
15.4
16.8
34.4
38.6
38.9
2009-11-03 08:30
2009-11-03 10:00
2009-11-03 11:30
2009-11-03 13:00
2009-11-03 14:30
2009-11-03 16:00

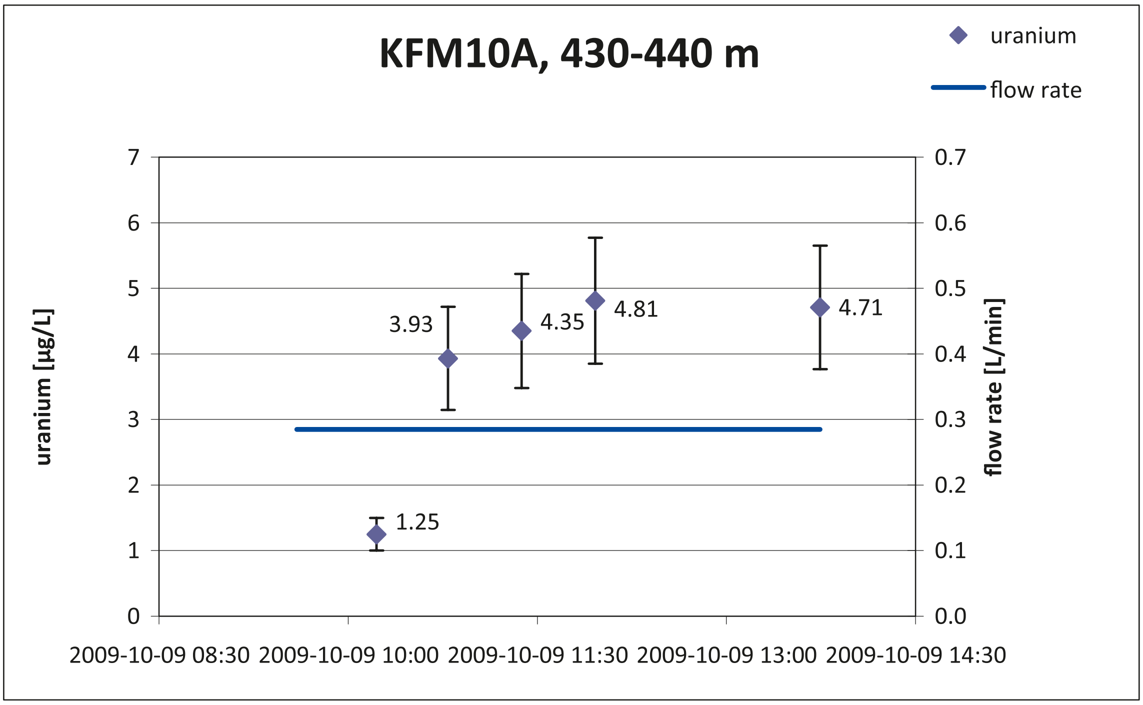

KFM07A, 962-972 m
uranium
flow rate
uranium [µg/L]
flow rate [L/min]
0.20
0.16
0.12
0.08
0.04
0.00
0.2
0.16
0.12
0.08
0.04
0
0.1390
0.1170
0.0559
0.0627
0.0582
2009-11-03 00:00
2009-11-03 12:00
2009-11-04 00:00
2009-11-04 12:00
2009-11-05 00:00
2009-11-05 12:00
2009-11-06 00:00


KFM08A, 684-694 m
uranium
flow rate
uranium [µg/L]
flow rate [L/min]
1.0
0.8
0.6
0.4
0.2
0.0
0.5
0.4
0.3
0.2
0.1
0.0
0.027
0.185
0.433
0.490
0.739
2009-10-20 08:30
2009-10-20 10:00
2009-10-20 11:30
2009-10-20 13:00
2009-10-20 14:30
2009-10-20 16:00
2009-10-20 17:30

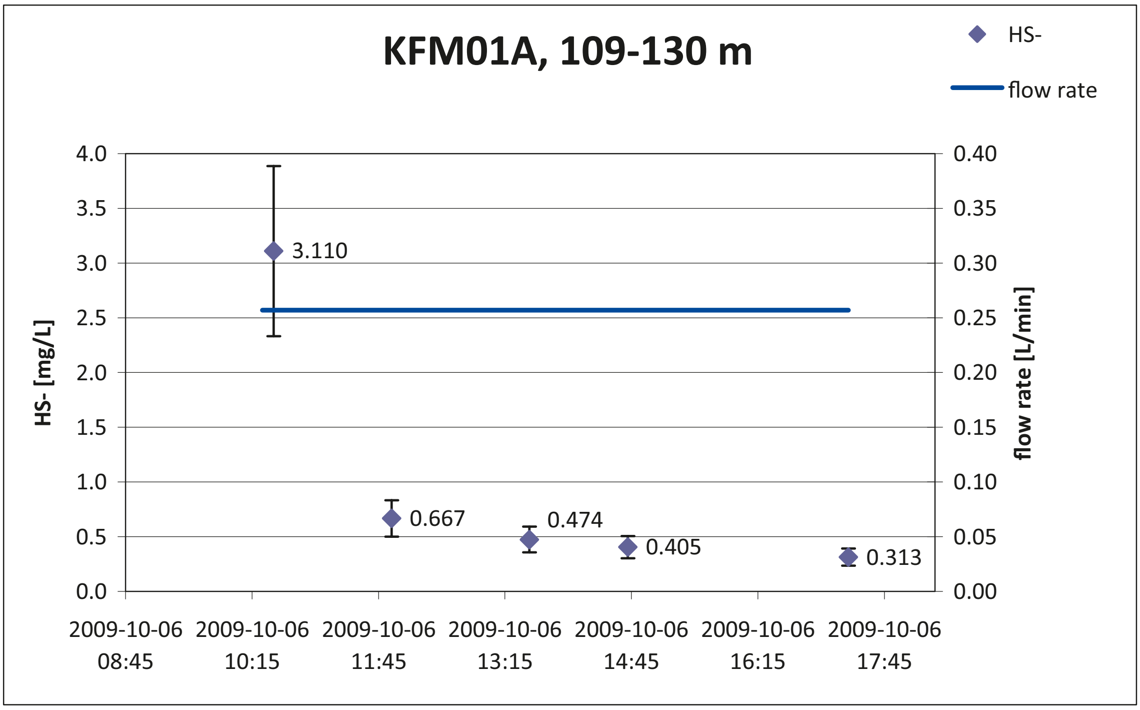

KFM08A, 265-280 m
uranium
flow rate
uranium [µg/L]
flow rate [L/min]
30
25
20
15
10
5
0
0.30
0.25
0.20
0.15
0.10
0.05
0.00
8.3
19.7
18.4
18.8
16.9
2009-10-21 08:15
2009-10-21 09:45
2009-10-21 11:15
2009-10-21 12:45
2009-10-21 14:15
2009-10-21 15:45
2009-10-21 17:15

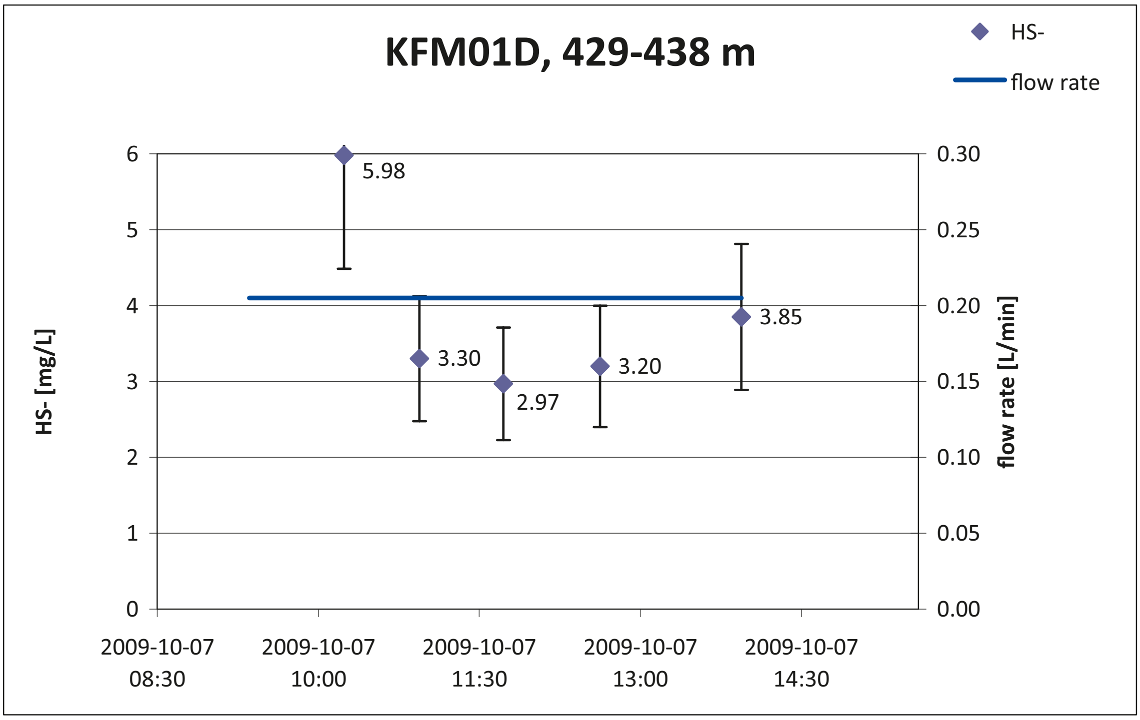

KFM08D, 825-835 m
uranium
flow rate
uranium [µg/L]
flow rate [L/min]
0.10
0.08
0.06
0.04
0.02
0.00
0.05
0.04
0.03
0.02
0.01
0
0.0691
0.0606
0.0474
0.0536
2009-10-19 00:00
2009-10-19 12:00
2009-10-20 00:00
2009-10-20 12:00
2009-10-21 00:00
2009-10-21 12:00
2009-10-22 00:00
2009-10-22 12:00
2009-10-23 00:00
2009-10-23 12:00
2009-10-24 00:00

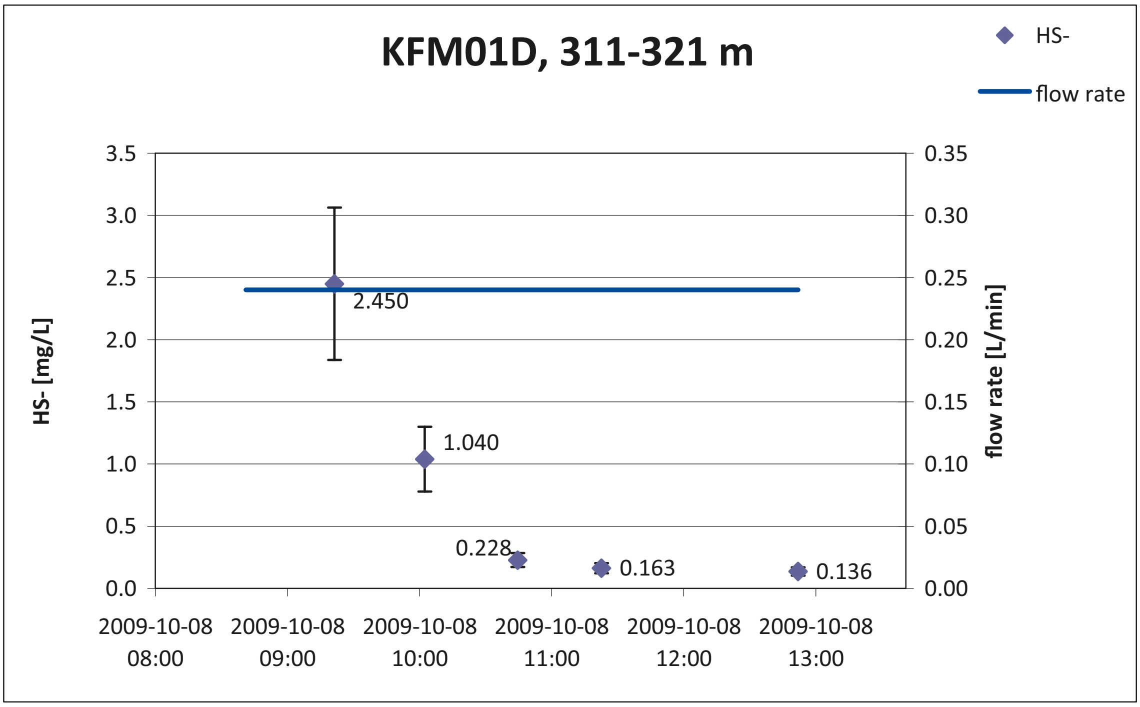

KFM08D, 660-680 m
uranium
flow rate
uranium [µg/L]
flow rate [L/min]
2.4
2.0
1.6
1.2
0.8
0.4
0.0
0.24
0.2
0.16
0.12
0.08
0.04
0
1.50
1.44
1.87
1.15
0.05
2009-10-12 00:00
2009-10-12 12:00
2009-10-13 00:00
2009-10-13 12:00
2009-10-14 00:00
2009-10-14 12:00
2009-10-15 00:00

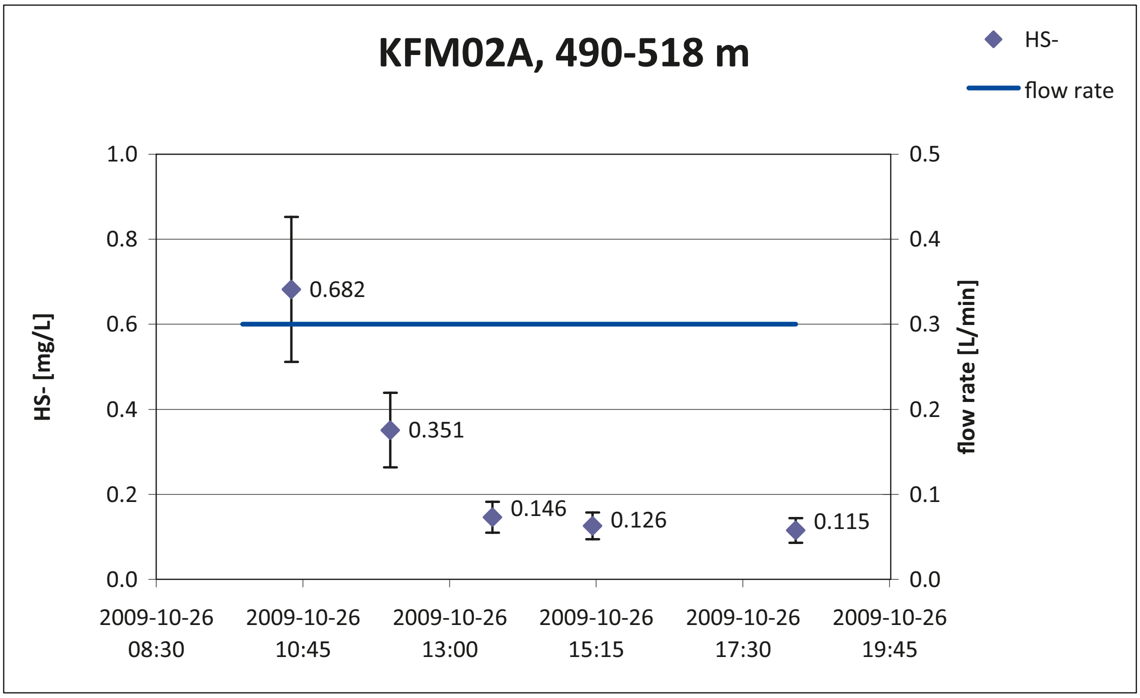

KFM10A, 430-440 m
uranium
flow rate
uranium [µg/L]
flow rate [L/min]
7
6
5
4
3
2
1
0
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3.93
4.35
4.81
4.71
1.25
2009-10-09 08:30
2009-10-09 10:00
2009-10-09 11:30
2009-10-09 13:00
2009-10-09 14:30

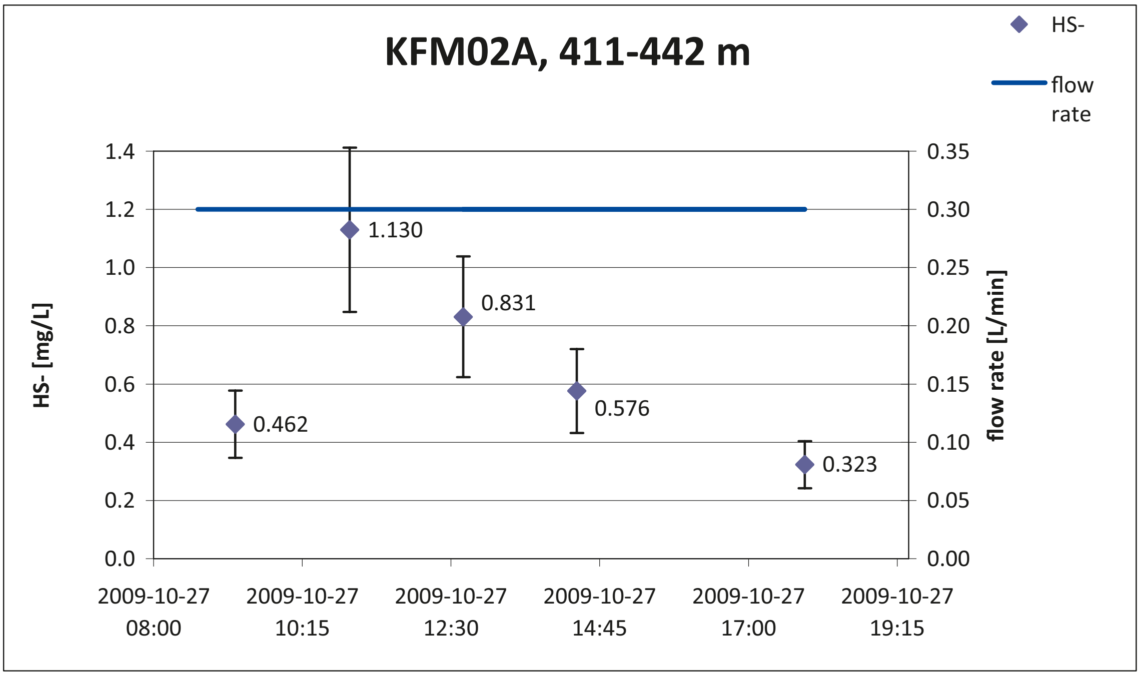
Sulphide

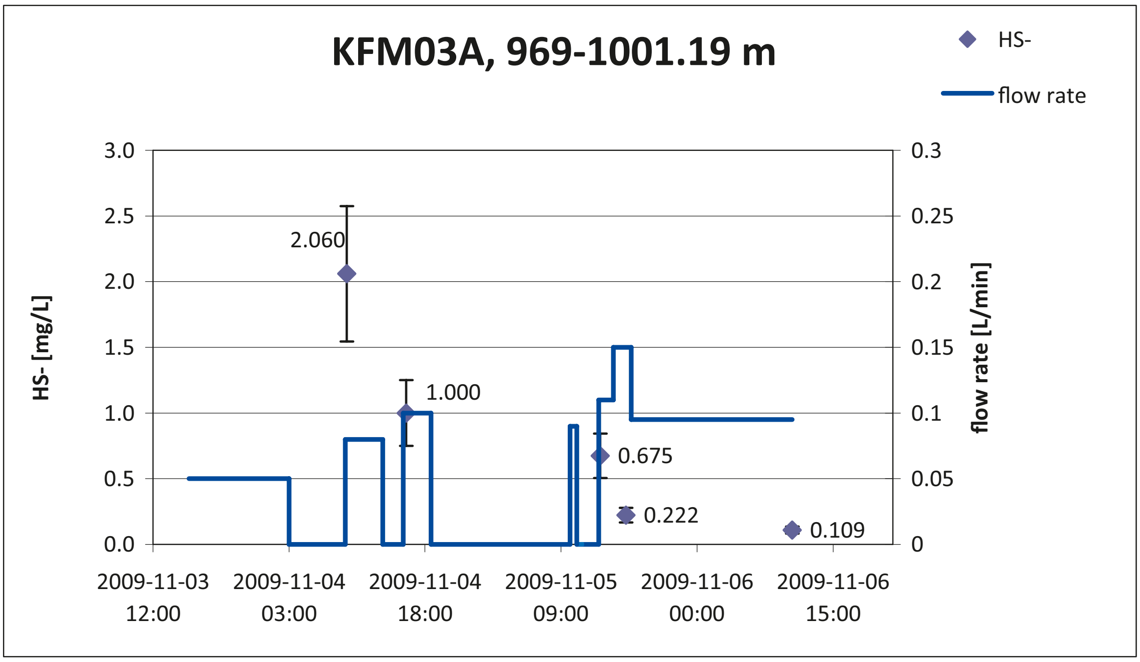

KFM01A, 109-130 m
HS-
flow rate
HS- [mg/L]
flow rate [L/min]
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
3.110
0.667
0.474
0.405
0.313
2009-10-06 08:45
2009-10-06 10:15
2009-10-06 11:45
2009-10-06 13:15
2009-10-06 14:45
2009-10-06 16:15
2009-10-06 17:45

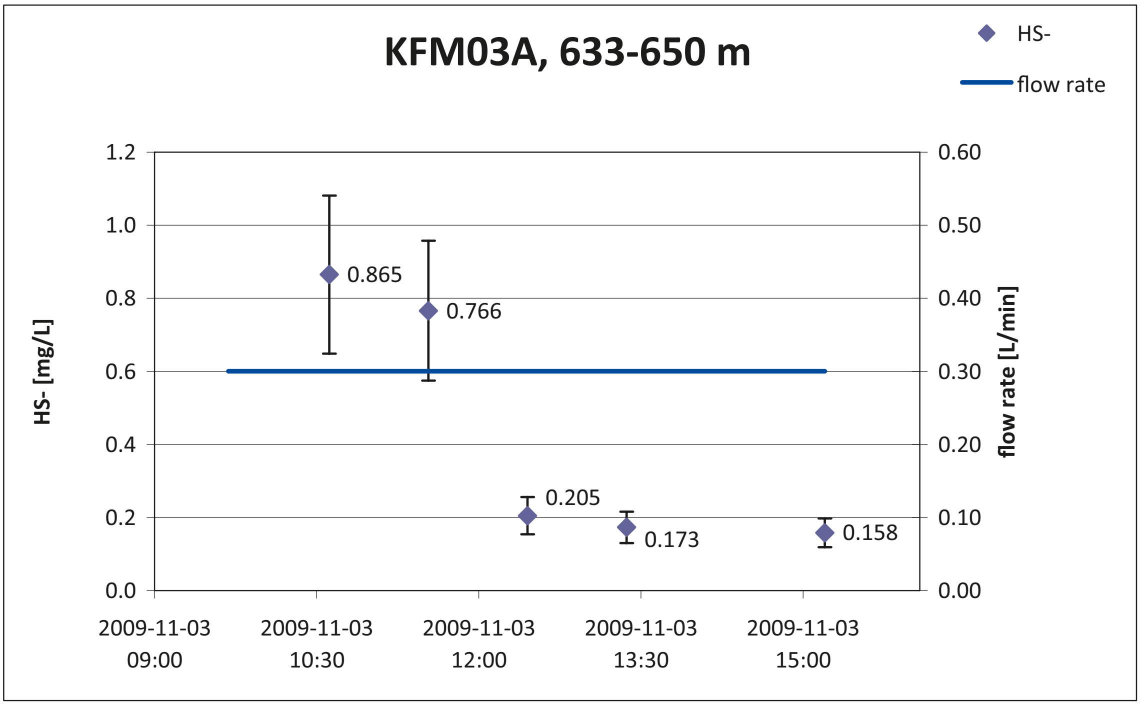

KFM01D, 429-438 m
HS-
flow rate
HS- [mg/L]
flow rate [L/min]
6
5
4
3
2
1
0
0.30
0.25
0.20
0.15
0.10
0.05
0.00
5.98
3.30
2.97
3.20
3.85
2009-10-07 08:30
2009-10-07 10:00
2009-10-07 11:30
2009-10-07 13:00
2009-10-07 14:30

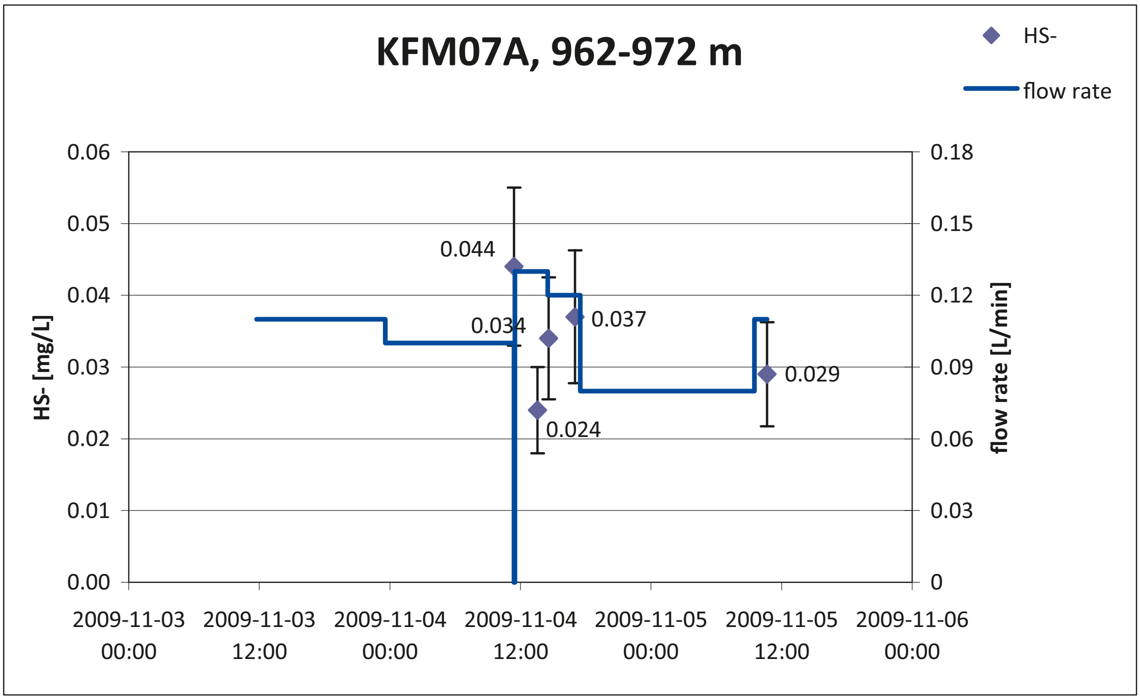

KFM01D, 311-321 m
HS-
flow rate
HS- [mg/L]
flow rate [L/min]
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2.450
1.040
0.228
0.163
0.136
2009-10-08 08:00
2009-10-08 09:00
2009-10-08 10:00
2009-10-08 11:00
2009-10-08 12:00
2009-10-08 13:00

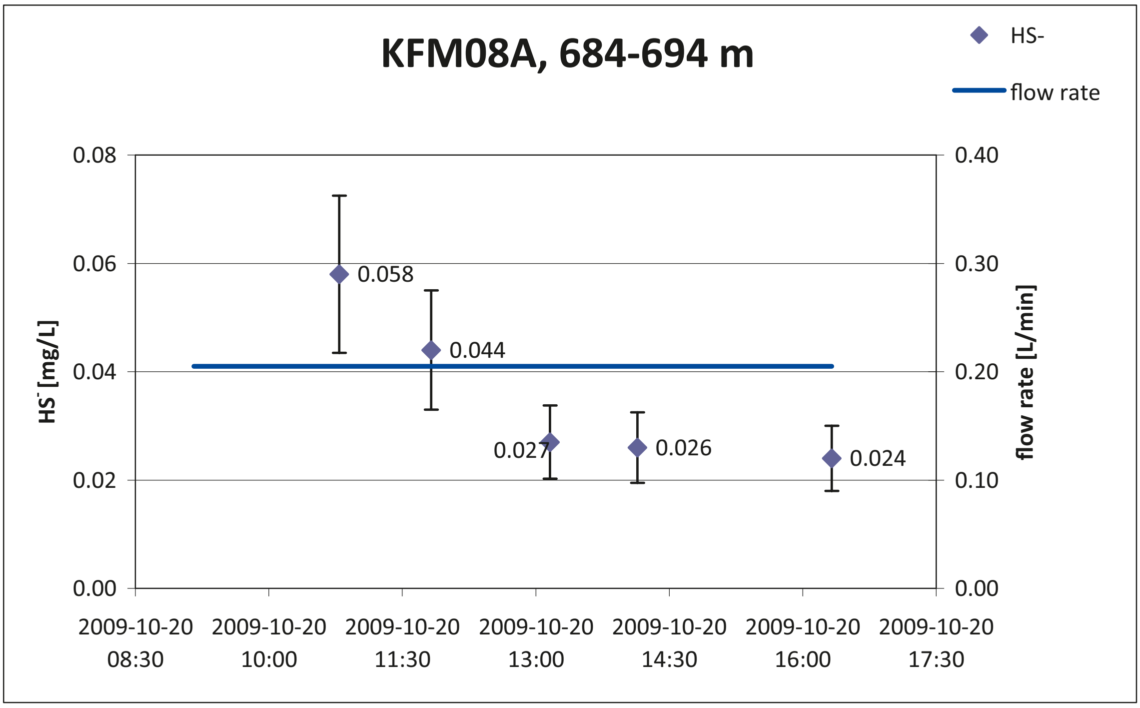

KFM02A, 490-518 m
HS-
flow rate
HS- [mg/L]
flow rate [L/min]
1.0
0.8
0.6
0.4
0.2
0.0
0.5
0.4
0.3
0.2
0.1
0.0
0.682
0.351
0.146
0.126
0.115
2009-10-26 08:30
2009-10-26 10:45
2009-10-26 13:00
2009-10-26 15:15
2009-10-26 17:30
2009-10-26 19:45

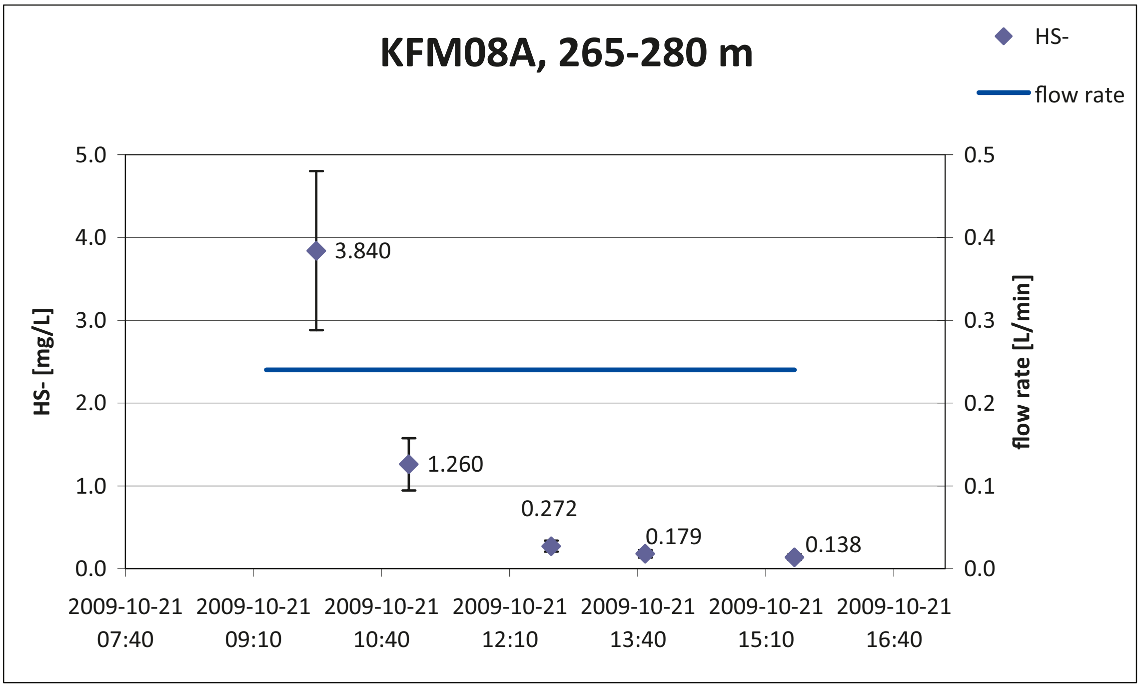

KFM02A, 411-442 m
HS-
flow rate
HS- [mg/L]
flow rate [L/min]
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1.130
0.831
0.576
0.462
0.323
2009-10-27 08:00
2009-10-27 10:15
2009-10-27 12:30
2009-10-27 14:45
2009-10-27 17:00
2009-10-27 19:15

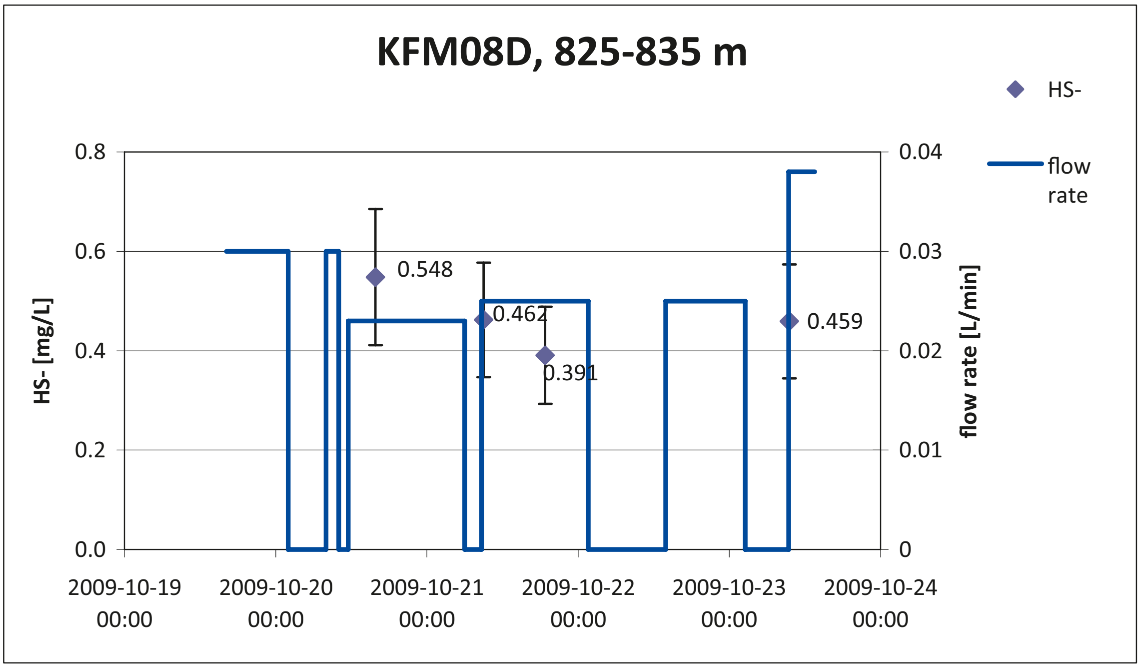

KFM03A, 969-1001.19 m
HS-
flow rate
HS- [mg/L]
flow rate [L/min]
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.3
0.25
0.2
0.15
0.1
0.05
0
2.060
1.000
0.675
0.222
0.109
2009-11-03 12:00
2009-11-04 03:00
2009-11-04 18:00
2009-11-05 09:00
2009-11-06 00:00
2009-11-06 15:00

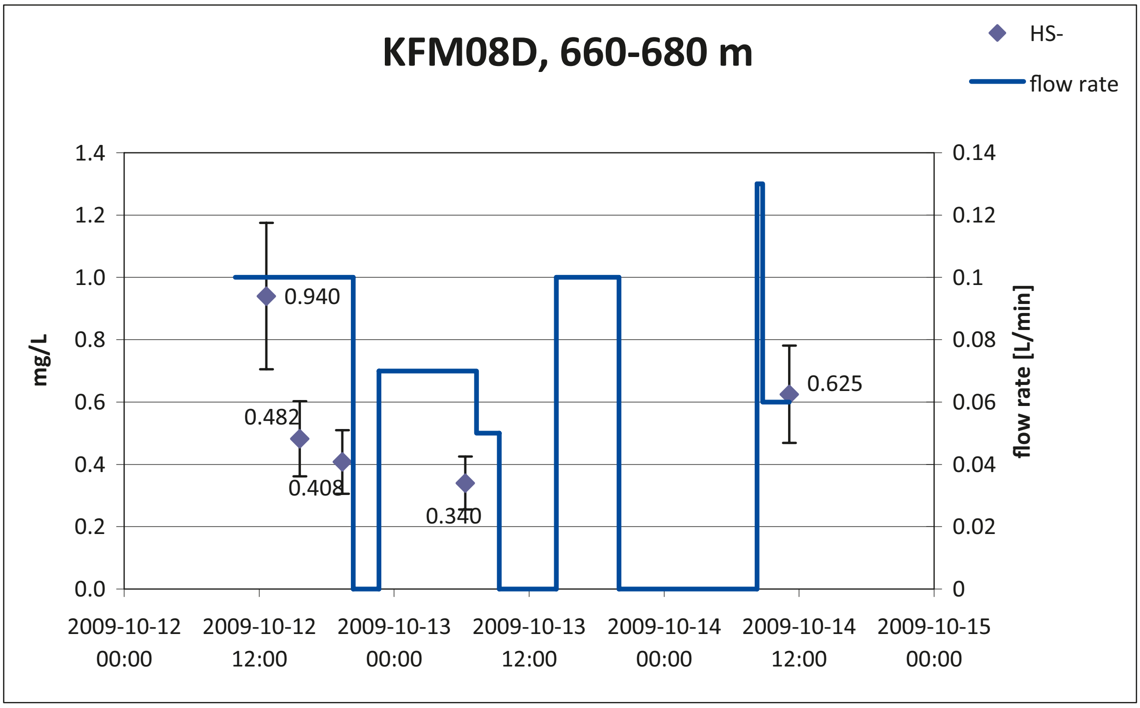

KFM03A, 633-650 m
HS-
flow rate
HS- [mg/L]
flow rate [L/min]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.865
0.766
0.205
0.173
0.158
2009-11-03 09:00
2009-11-03 10:30
2009-11-03 12:00
2009-11-03 13:30
2009-11-03 15:00

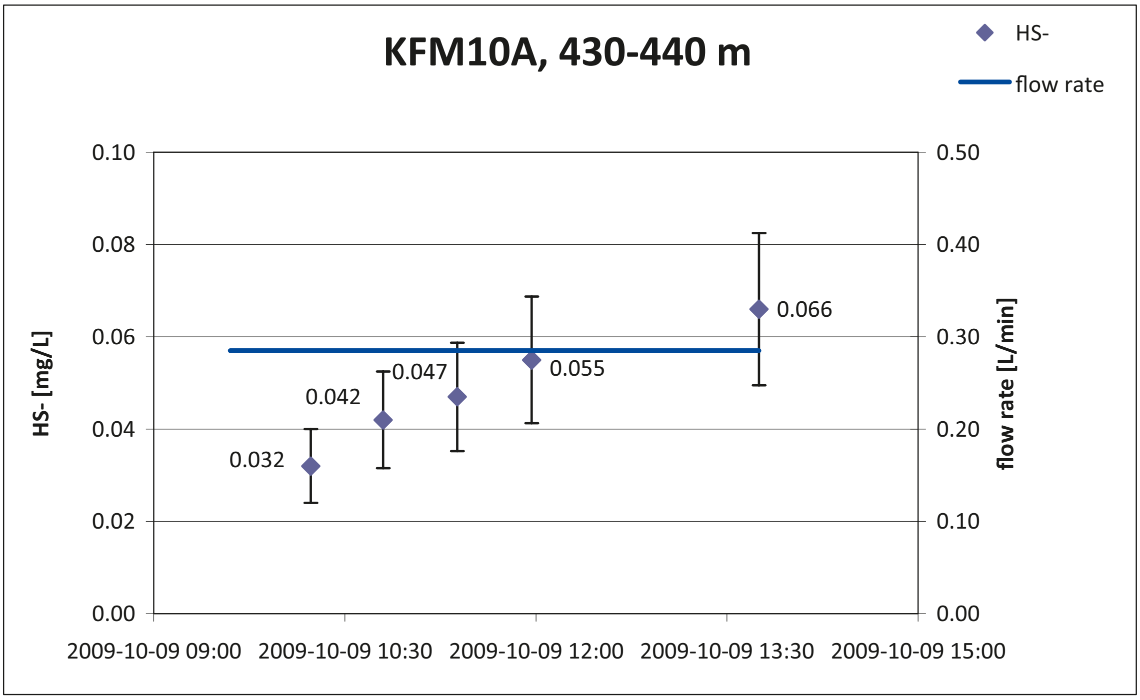

KFM07A, 962-972 m
HS-
flow rate
HS- [mg/L]
flow rate [L/min]
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.18
0.15
0.12
0.09
0.06
0.03
0
0.044
0.034
0.037
0.024
0.029
2009-11-03 00:00
2009-11-03 12:00
2009-11-04 00:00
2009-11-04 12:00
2009-11-05 00:00
2009-11-05 12:00
2009-11-06 00:00


KFM08A, 684-694 m
HS-
flow rate
HS- [mg/L]
flow rate [L/min]
0.08
0.06
0.04
0.02
0.00
0.40
0.30
0.20
0.10
0.00
0.058
0.044
0.027
0.026
0.024
2009-10-20 08:30
2009-10-20 10:00
2009-10-20 11:30
2009-10-20 13:00
2009-10-20 14:30
2009-10-20 16:00
2009-10-20 17:30


KFM08A, 265-280 m
HS-
flow rate
HS- [mg/L]
flow rate [L/min]
5.0
4.0
3.0
2.0
1.0
0.0
0.5
0.4
0.3
0.2
0.1
0.0
3.840
1.260
0.272
0.179
0.138
2009-10-21 07:40
2009-10-21 09:10
2009-10-21 10:40
2009-10-21 12:10
2009-10-21 13:40
2009-10-21 15:10
2009-10-21 16:40


KFM08D, 825-835 m
HS-
flow rate
HS- [mg/L]
flow rate [L/min]
0.8
0.6
0.4
0.2
0.0
0.04
0.03
0.02
0.01
0
0.548
0.462
0.391
0.459
2009-10-19 00:00
2009-10-20 00:00
2009-10-21 00:00
2009-10-22 00:00
2009-10-23 00:00
2009-10-24 00:00


KFM08D, 660-680 m
HS-
flow rate
mg/L
flow rate [L/min]
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.940
0.482
0.408
0.340
0.625
2009-10-12 00:00
2009-10-12 12:00
2009-10-13 00:00
2009-10-13 12:00
2009-10-14 00:00
2009-10-14 12:00
2009-10-15 00:00


KFM10A, 430-440 m
HS-
flow rate
HS- [mg/L]
flow rate [L/min]
0.10
0.08
0.06
0.04
0.02
0.00
0.50
0.40
0.30
0.20
0.10
0.00
0.032
0.042
0.047
0.055
0.066
2009-10-09 09:00
2009-10-09 10:30
2009-10-09 12:00
2009-10-09 13:30
2009-10-09 15:00

Appendix 7

Diagrams showing accumulated flow distribution and sulphide concentrations in sample series

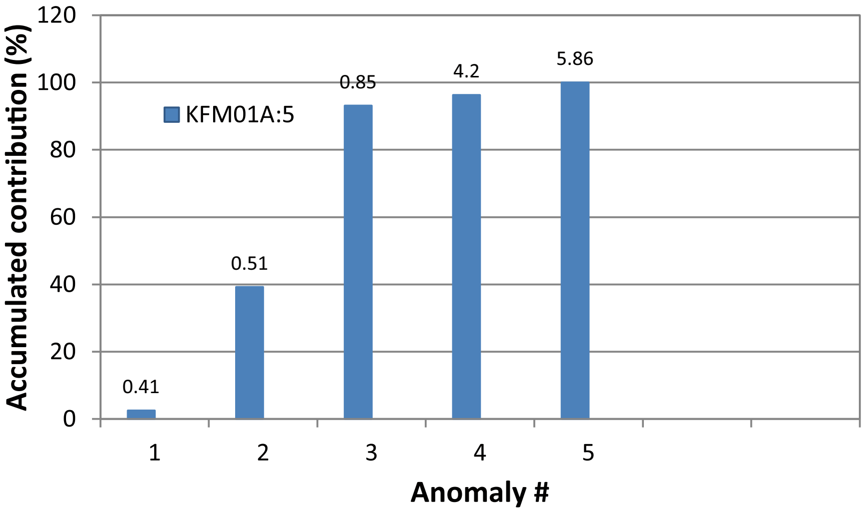


Figure A7-1. *Accumulated flow distribution of flow anomalies in section KFM01A:5, numbered from the uppermost anomaly and downwards. The numbers above bars indicate the estimated travel time (h) from the anomalies to top of section.*

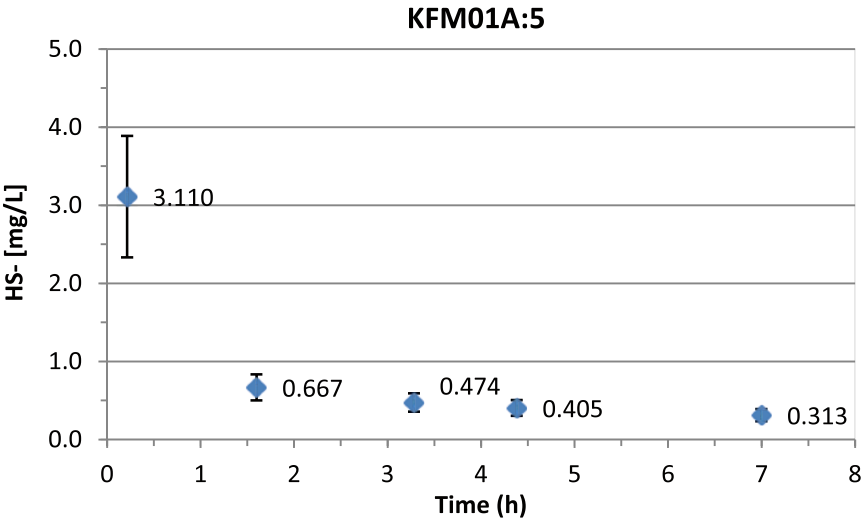


Figure A7-2. *Sulphide concentration in samples taken in borehole section KFM01A:5. Time after start of pumping is reduced with the estimated travel time from top of section to ground surface.*

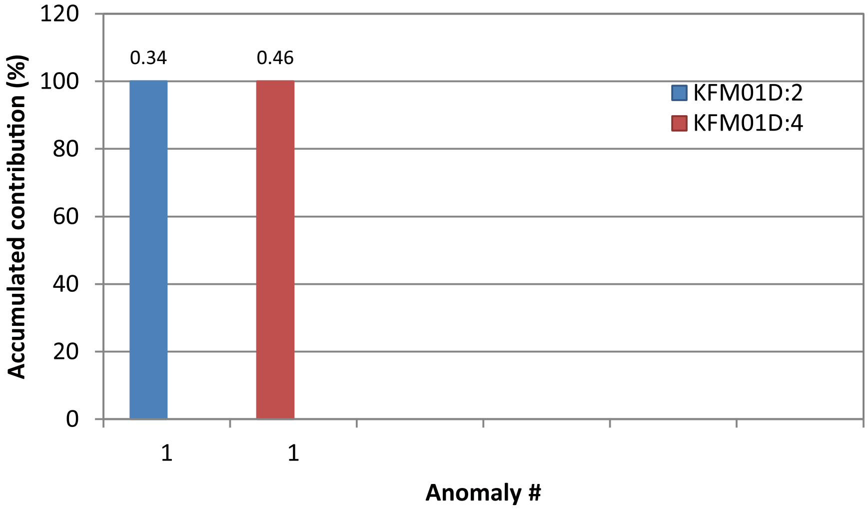


Figure A7-3. Flow anomalies in sections KFM01D:2 and KFM01D:4. In both sections only one significant flow anomaly was detected during the PFL logging. The numbers above bars indicate the estimated travel time (h) from the anomalies to top of section.

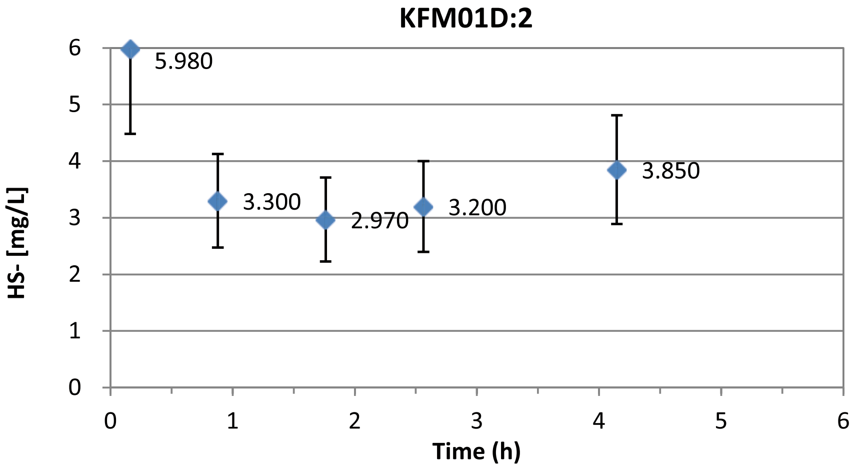


Figure A7-4. Sulphide concentration in samples taken in borehole section KFM01D:2. Time after start of pumping is reduced with the estimated travel time from top of section to ground surface.

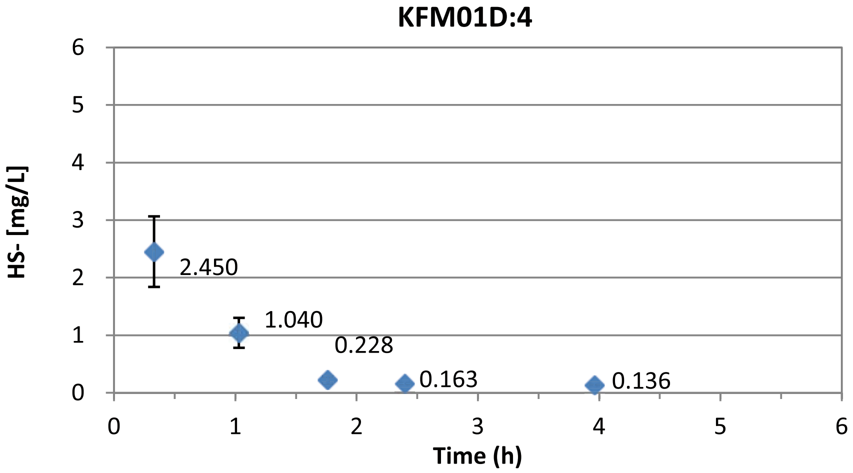


Figure A7-5. Sulphide concentration in samples taken in borehole section KFM01D:4. Time after start of pumping is reduced with the estimated travel time from top of section to ground surface.

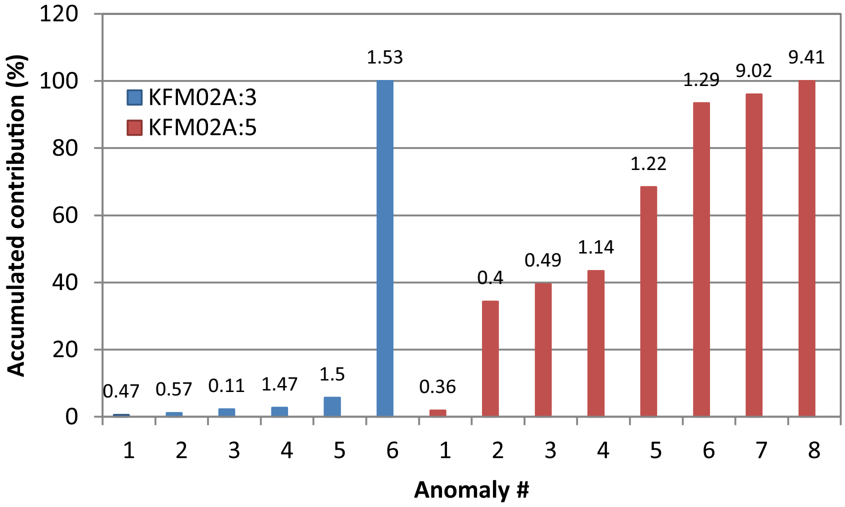


Figure A7-6. *Accumulated flow distribution of flow anomalies in sections KFM02A:3 and KFM02A:5, numbered from the uppermost anomaly and downwards. The numbers above bars indicate the estimated travel time (h) from the anomalies to top of section.*

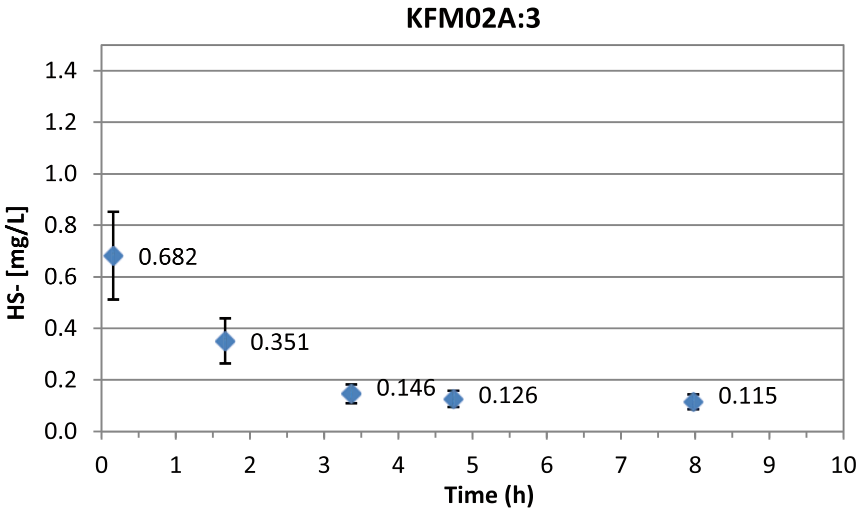


Figure A7-7. *Sulphide concentration in samples taken in borehole section KFM02A:3. Time after start of pumping is reduced with the estimated travel time from top of section to ground surface.*

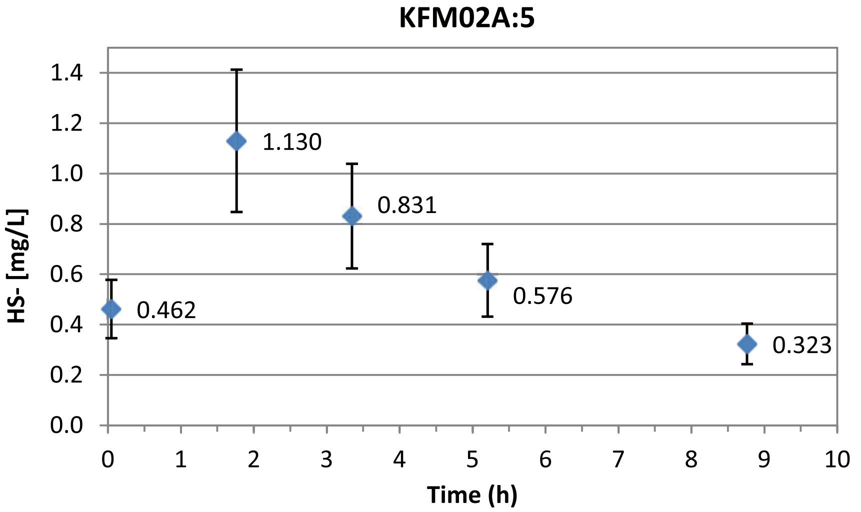


Figure A7-8. *Sulphide concentration in samples taken in borehole section KFM02A:5. Time after start of pumping is reduced with the estimated travel time from top of section to ground surface.*

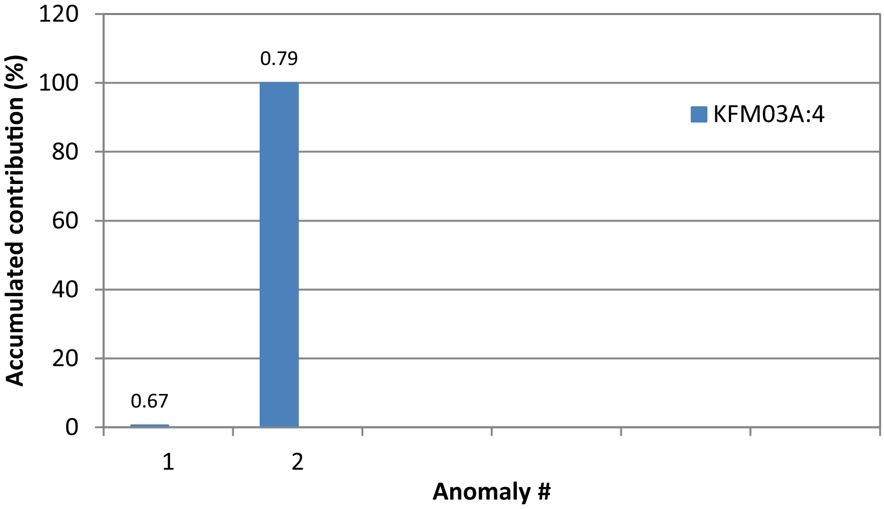


Figure A7-9. *Accumulated flow distribution of flow anomalies in section KFM03A:4, numbered from the uppermost anomaly and downwards. The dominating anomaly 2 contributes to more than 99% of the total flow. The numbers above bars indicate the estimated travel time (h) from the anomalies to top of section.*

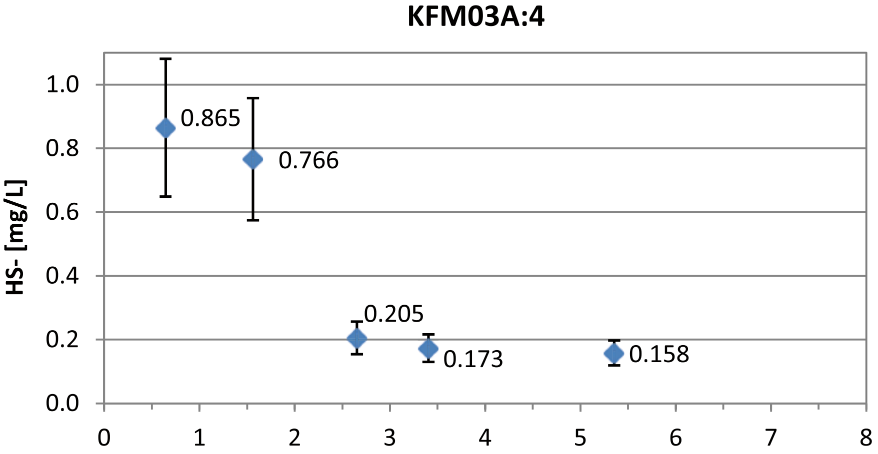


Figure A7-10. *Sulphide concentration in samples taken in borehole section KFM03A:4. Time after start of pumping is reduced with the estimated travel time from top of section to ground surface.*

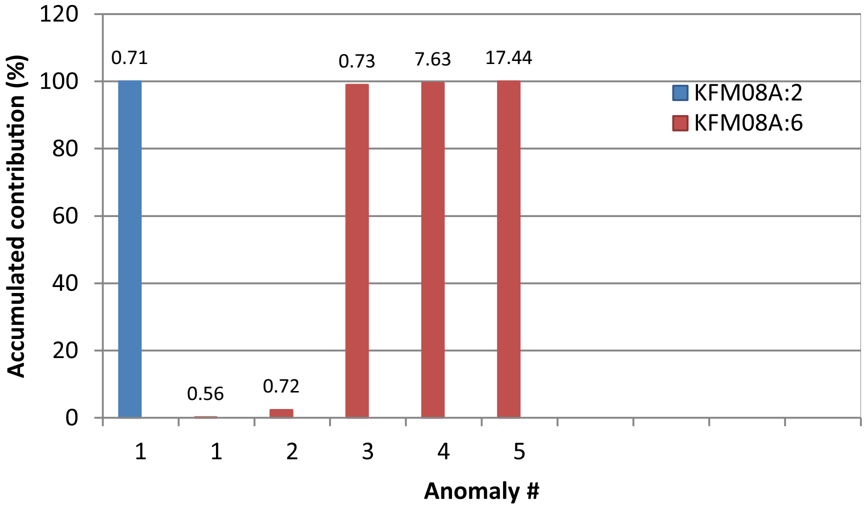


Figure A7-11. *Accumulated flow distribution of flow anomalies in sections KFM08A:2 and KFM08A:6, numbered from the uppermost anomaly and downwards. Anomalies 1–3 in section 6 contribute to c. 99 % of the total flow. The numbers above bars indicate the estimated travel time (h) from the anomalies to top of section.*

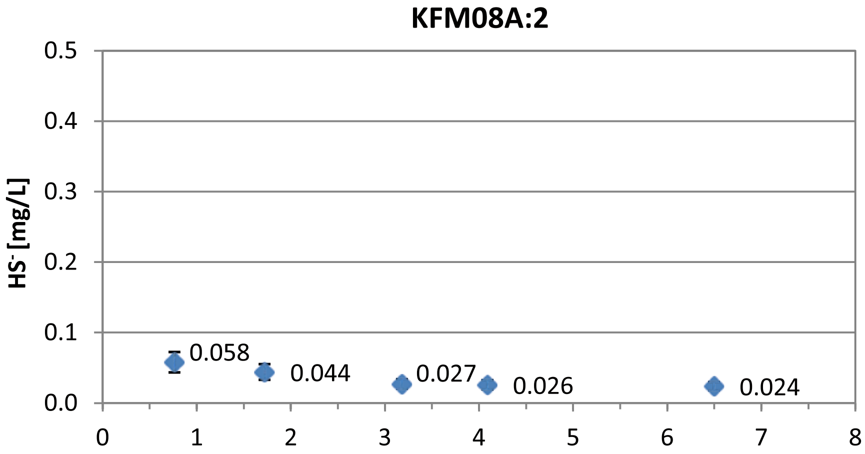


Figure A7-12. *Sulphide concentration in samples taken in borehole section KFM08A:2. Time after start of pumping is reduced with the estimated travel time from top of section to ground surface.*

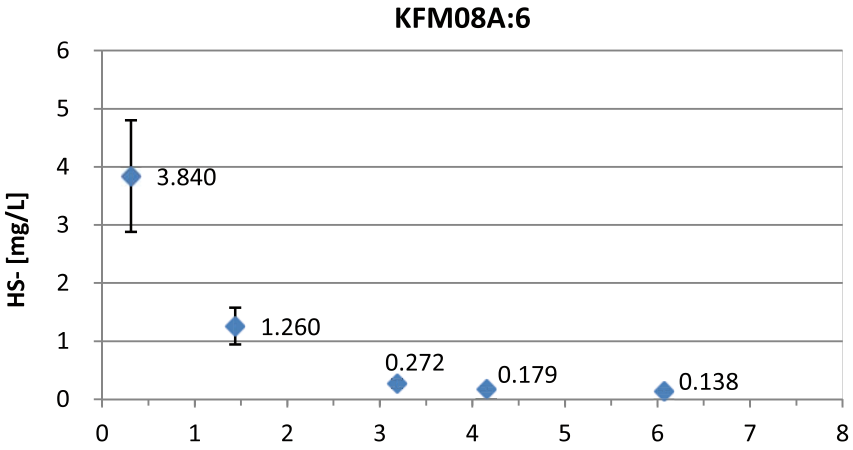


Figure A7-13. *Sulphide concentration in samples taken in borehole section KFM08A:6. Time after start of pumping is reduced with the estimated travel time from top of section to ground surface.*

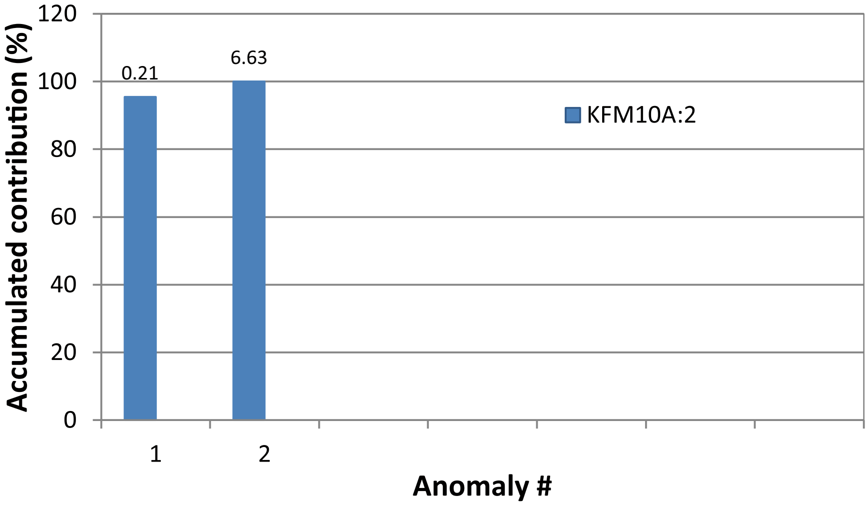


Figure A7-14. *Accumulated flow distribution of flow anomalies in section KFM10A:2, numbered from the uppermost anomaly and downwards. The dominating anomaly 1 contributes to c. 95% of the total flow. The numbers above bars indicate the estimated travel time (h) from the anomalies to top of section.*

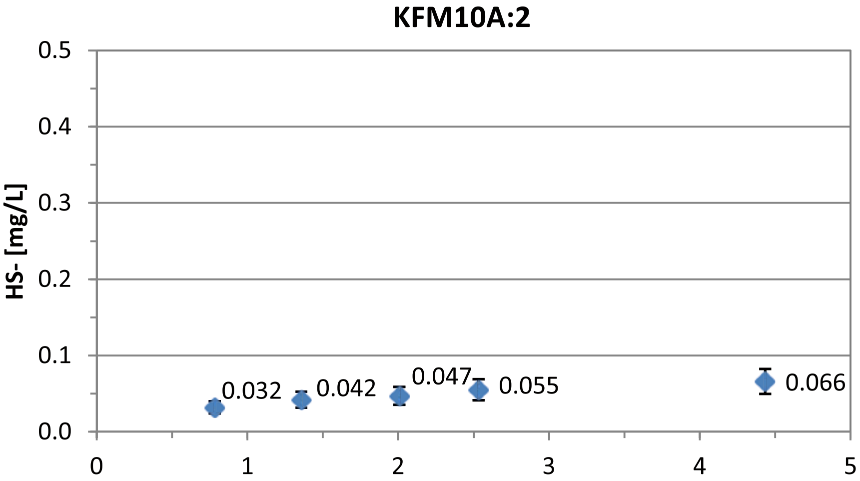


Figure A7-15. *Sulphide concentration in samples taken in borehole section KFM10A:2. Time after start of pumping is reduced with the estimated travel time from top of section to ground surface.*

Appendix 8

Field measurements, near surface groundwater

Table A8-1. Field measurements.

Idcode	Start_date yyyy/mm/dd hh:mm	Stop_date yyyy/mm/dd hh:mm	Water temp. (°C)	pH	EC (mS/m)	Salinity (%)	ORP (mV)	O_2 diss. (mg/L)	Oxygen (%)
SFM0001	2009-01-13 13:35	2009-01-13 14:43	6.3	7.08	108.6	0.54	–122.00	0.44	3.6
SFM0001	2009-04-14 13:40	2009-04-14 18:50	4.7	6.95	125.5	0.62	–132.00	0.52	4.1
SFM0001	2009-08-11 17:00	2009-08-11 17:45	7.7	7.24	199.8	1.02	–117.00	1.16	9.8
SFM0001	2009-10-06 16:12	2009-10-06 16:45	8.4	7.14	211.6	1.09	–170.00	1.46	12.6
SFM0023	2009-01-16 08:45	2009-01-16 09:15	7.7	7.36	961.8	5.40	–194.00	0.51	4.4
SFM0023	2009-04-17 07:30	2009-04-17 08:20	7.7	7.40	993.9	5.59	–221.00	0.32	2.8
SFM0023	2009-08-14 10:55	2009-08-14 12:00	15.1	7.25	998.2	5.65	–249.00	3.17	32.6
SFM0023	2009-10-09 08:00	2009-10-09 08:30	12.7	7.23	992.0	5.61	–211.00	1.51	14.7
SFM0032	2009-01-13 17:45	2009-01-13 18:15	4.8	7.00	73.5	0.36	–100.00	0.49	3.8
SFM0032	2009-04-15 10:20	2009-04-15 10:45	3.2	6.93	74.6	0.36	–106.00	0.32	2.4
SFM0032	2009-08-11 20:38	2009-08-11 21:30	11.7	6.96	70.8	0.37	–148.00	1.30	12.1
SFM0032	2009-10-06 18:10	2009-10-06 18:30	10.0	6.83	71.5	0.35	–145.00	0.62	5.5
SFM0037	2009-01-14 10:44	2009-01-14 11:21	3.3	6.85	76.8	0.37	–149.00	0.63	4.7
SFM0037	2009-04-15 14:36	2009-04-15 15:00	2.7	6.82	76.5	0.37	–124.00	0.37	2.7
SFM0037	2009-08-12 20:38	2009-08-12 21:30	12.5	6.83	102.1	0.51	–173.00	1.03	9.7
SFM0037	2009-10-07 15:14	2009-10-07 15:40	9.6	6.86	143.6	0.72	–94.00	0.74	6.5
SFM0049	2009-01-13 20:23	2009-01-13 21:08	2.4	6.62	46.0	0.22	–89.00	0.64	4.7
SFM0049	2009-04-14 18:35	2009-04-14 19:00	1.6	6.51	33.0	0.16	–117.00	0.37	2.7
SFM0049	2009-08-11 12:15	2009-08-11 13:05	15.0	6.64	37.8	0.18	–161.00	1.08	10.7
SFM0049	2009-10-06 19:20	2009-10-06 19:40	11.2	6.55	40.8	0.20	–123.00	0.56	5.1

Appendix 9

Compilation of water analysis data, near surface groundwaters

Table A9-1. Water composition.

Idcode	Secup m	Seclow m	Date yyyy-mm-dd	Sample No.	RCB %	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	HCO_3 mg/L	Cl mg/L	SO_4 mg/L	SO_4-S mg/L	Br mg/l	F^- mg/L	Si mg/L	Fe mg/L	Fe(tot) mg/L	Fe(+II) mg/L	Mn mg/L
SFM0001	3.80	4.80	2009-01-13	16174	1.32	117.0	11.30	78.7	22.5	335.0	129.0	76.1	28.30	0.56	0.69	7.97	1.750	1.810	1.800	0.171
SFM0001	3.80	4.80	2009-04-14	16252	–0.70	138.0	12.00	90.3	26.3	386.0	168.0	96.4	33.00	0.68	0.62	8.24	–	–	–	–
SFM0001	3.80	4.80	2009-08-11	16350	–1.52	293.0	19.30	90.2	38.8	505.0	336.0	168.0	61.80	1.25	0.83	8.70	2.100	2.120	2.120	0.194
SFM0001	3.80	4.80	2009-10-06	16500	–2.24	294.0	17.60	92.9	40.9	520.0	346.0	177.0	62.10	1.27	0.83	8.31	–	–	–	–
SFM0023	3.32	4.32	2009-01-16	16178	–4.49	1,340.0	53.60	423.0	140.0	199.0	3,220.0	285.0	108.00	11.90	0.87	4.55	–	–	–	–
SFM0023	3.32	4.32	2009-04-17	16256	–1.78	1,400.0	58.60	442.0	146.0	182.0	3,190.0	283.0	110.00	12.60	1.01	6.37	–	–	–	–
SFM0023	3.32	4.32	2009-08-14	16348	–6.33	1,280.0	60.20	434.0	137.0	155.0	3,290.0	293.0	110.00	12.20	0.81	4.43	–	–	–	–
SFM0023	3.32	4.32	2009-10-09	16504	–4.26	1,330.0	59.20	412.0	137.0	203.0	3,170.0	284.0	103.00	12.10	0.84	3.97	–	–	–	–
SFM0032	1.94	2.94	2009-01-13	16175	1.39	28.8	5.52	121.0	9.9	348.0	42.2	48.3	18.20	0.29	0.67	6.66	1.370	1.290	1.240	0.175
SFM0032	1.94	2.94	2009-04-15	16254	1.79	31.1	5.88	121.0	10.5	349.0	37.5	51.5	20.80	0.28	0.64	7.20	–	–	–	–
SFM0032	1.94	2.94	2009-08-11	16351	–0.79	28.4	6.55	119.0	10.6	374.0	40.3	42.0	18.00	0.27	0.73	9.29	2.070	2.050	2.050	0.267
SFM0032	1.94	2.94	2009-10-06	16501	3.44	23.1	4.89	119.0	9.5	310.0	26.6	77.4	23.40	0.18	0.70	9.74	–	–	–	–
SFM0037	1.10	2.10	2009-01-14	16177	–2.33	33.5	5.00	120.0	14.9	419.0	38.7	48.2	21.10	0.28	0.57	7.15	2.090	2.120	2.110	0.192
SFM0037	1.10	2.10	2009-04-15	16255	0.09	29.3	5.03	120.0	13.9	361.0	28.4	77.2	28.30	0.24	0.66	5.89	–	–	–	–
SFM0037	1.10	2.10	2009-08-12	16352	–1.66	76.4	6.59	126.0	19.4	453.0	78.5	100.0	35.20	0.46	0.73	9.39	2.710	2.850	2.840	0.340
SFM0037	1.10	2.10	2009-10-07	16503	–3.84	119.0	9.21	143.0	29.1	516.0	173.0	134.0	44.10	0.64	0.84	8.36	–	–	–	–
SFM0049	2.90	3.90	2009-01-13	16176	1.48	12.2	3.03	77.3	6.5	261.0	20.0	0.5	0.83	0.10	0.29	7.01	1.200	1.430	1.420	0.161
SFM0049	2.90	3.90	2009-04-14	16253	5.49	11.3	3.23	63.6	5.3	208.0	10.0	0.6	0.70	0.07	0.33	6.29	–	–	–	–
SFM0049	2.90	3.90	2009-08-11	16349	1.35	11.8	2.79	62.5	4.8	208.0	16.1	0.6	2.64	0.07	0.44	5.83	1.500	1.550	1.520	0.169
SFM0049	2.90	3.90	2009-10-06	16502	1.24	12.7	2.03	68.4	5.1	226.0	17.5	2.2	1.81	0.06	0.39	4.37	–	–	–	–
SFM0051	4.32	4.48	2009-01-13	16179	0.79	12.6	4.37	113.0	7.4	361.0	19.6	21.6	8.06	0.15	0.59	8.07	5.700	5.770	5.630	0.236
SFM0051	4.32	4.48	2009-04-14	16257	2.28	12.0	4.58	114.0	7.8	354.0	19.7	19.8	7.43	0.19	0.57	8.92	5.500	5.370	5.360	0.221
SFM0051	4.32	4.48	2009-08-10	16347	–0.46	10.4	4.63	111.0	7.5	353.0	19.5	17.8	6.81	0.20	0.62	8.28	5.720	–	–	0.226
SFM0051	4.32	4.48	2009-10-05	16399	0.87	10.3	4.00	110.0	7.1	351.0	19.5	18.4	6.29	0.16	0.62	9.50	6.010	6.030	5.960	0.259

Idcode	Secup m	Seclow m	Date yyyy-mm-dd	Sample No.	Li mg/L	Sr mg/L	pH (lab)	EC (lab) mS/m	HS$^-$ mg/L	I$^-$ mg/L
SFM0001	3.80	4.80	2009-01-13	16174	0.010	0.236	7.32	106.0	0.136	0.0108
SFM0001	3.80	4.80	2009-04-14	16252	0.012	0.275	7.08	126.0	–	–
SFM0001	3.80	4.80	2009-08-11	16350	0.018	0.358	7.29	212.0	0.079	0.0144
SFM0001	3.80	4.80	2009-10-06	16500	0.018	0.350	7.26	222.0	–	–
SFM0023	3.32	4.32	2009-01-16	16178	0.052	2.860	6.78	986.0	0.025	0.0476
SFM0023	3.32	4.32	2009-04-17	16256	0.051	3.230	6.72	989.0	–	–
SFM0023	3.32	4.32	2009-08-14	16348	0.058	2.970	6.68	994.0	–	0.0711
SFM0023	3.32	4.32	2009-10-09	16504	0.053	2.670	6.55	973.0	–	–
SFM0032	1.94	2.94	2009-01-13	16175	0.007	0.205	7.23	74.3	0.032	0.0058
SFM0032	1.94	2.94	2009-04-15	16254	0.007	0.228	7.13	75.7	–	–
SFM0032	1.94	2.94	2009-08-11	16351	0.007	0.223	7.02	76.2	0.406	0.0096
SFM0032	1.94	2.94	2009-10-06	16501	0.007	0.202	6.97	70.5	–	–
SFM0037	1.10	2.10	2009-01-14	16177	0.006	0.204	6.95	78.0	1.330	0.0147
SFM0037	1.10	2.10	2009-04-15	16255	0.008	0.203	6.99	77.0	–	–
SFM0037	1.10	2.10	2009-08-12	16352	0.012	0.247	6.93	107.0	0.180	0.0123
SFM0037	1.10	2.10	2009-10-07	16503	0.014	0.343	6.98	147.0	–	–
SFM0049	2.90	3.90	2009-01-13	16176	<0.004	0.099	6.95	47.1	0.202	0.0118
SFM0049	2.90	3.90	2009-04-14	16253	<0.004	0.086	6.69	34.1	–	–
SFM0049	2.90	3.90	2009-08-11	16349	0.002	0.085	6.84	38.4	0.336	0.0060
SFM0049	2.90	3.90	2009-10-06	16502	<0.004	0.085	6.75	41.8	–	–
SFM0051	4.32	4.48	2009-01-13	16179	0.005	0.158	7.39	62.8	–	0.0065
SFM0051	4.32	4.48	2009-04-14	16257	0.006	0.170	7.52	62.6	–	0.0078
SFM0051	4.32	4.48	2009-08-10	16347	0.007	0.162	7.60	63.1	–	0.0100
SFM0051	4.32	4.48	2009-10-05	16399	0.005	0.147	7.45	62.1	–	0.0090

< “value” = Result below detection or reporting limit.
RCB % = Relative charge balance error %.
EC = Electrical Conductivity.

SICADA: water_composition

Table A9-2. Drinking water.

Id code		PFM000001	PFM000009	PFM006382
Date	yyyy/mm/dd	2009-10-08	2009-10-08	2009-11-03
Kbact	no/100mL	190	<1	3
Microbes	no/100mL	25,000	7,400	3,200
Ecoli	no/100mL	<1	<1	<1
Temp.	°C_Field	5.0	5.0	–
Smell	_Lab	Chemical smell	No smell	No smell
Colour	(number)	140	87	97
pH_L	_Lab	7.3	7.2	7.4
Temp_pH	(°C)	25	25	25
Alk	mg/L	760	40	390
EC_L	mS/m_Lab	140	1,300	150
Ca	mg/L	190	1,100	140
Cl	mg/L	61.0	4,600.0	210.0
COD	mg/L	15.0	22.0	21.0
Cu	mg/L	<0.02	<0.02	<0.02
F	mg/L	0.6	<0.2	0.7
Fe	mg/L	8.6	7.8	1.9
Hardness	_German	32	193	24
K	mg/L	44	23	8
Mg	mg/L	25	170	17
Mn	mg/L	0.49	0.78	0.06
Na	mg/L	32	1,300	92
NH_4_N	mg/L	5.000	1.200	<0.01
NH_4	mg/L	6.40	1.50	<0.01
NO_3_N	mg/L	<0.1	<0.1	<0.1
NO_3	mg/L	<0.44	<0.44	<0.44
NO_2_N	mg/L	<0.002	<0.002	<0.002
NO_2	mg/L	<0.01	<0.01	<0.01
PO_4_P	mg/L	<0.005	<0.005	<0.005
PO_4	mg/L	<0.02	<0.02	<0.02
SO_4	mg/L	70	160	83

Explanations:

Kbact	Number of coliform bacteria.
Ecoli	Number of escherichia coli bacteria at 35°C.
Sediment	Ocular inspection of sediment.
EC_L	Electric conductivity.

Table A9-3. Surface water supplements.

Id code	Secup m	Seclow m	Date yyyy/mm/dd	Sample No.	NH_4-N mg/L	NO_2-N mg/L	NO_3-N+NO_2-N mg/L	NO_3-N mg/L	N-tot mg/L	P-tot mg/L	PO_4-P mg/L	SiO_4-Si mg/L	TOC mg/L	DOC mg/L	DIC mg/L
SFM0001	3.80	4.80	2009-01-13	16174	0.147	0.0009	0.0009	<0.0003	1.570	0.0376	0.0286	7.09	45.0	44.0	65.8
SFM0001	3.80	4.80	2009-04-14	16252	0.165	0.0004	0.0004	<0.0003	1.340	0.0366	0.0301	6.95	37.0	37.2	71.1
SFM0001	3.80	4.80	2009-08-11	16350	0.250	0.0003	0.0003	<0.0003	1.130	0.0491	0.0444	7.43	27.3	27.5	97.9
SFM0001	3.80	4.80	2009-10-06	16500	0.267	0.0004	0.0007	<0.0003	1.130	0.0519	0.0452	8.03	26.6	26.9	99.4
SFM0023	3.32	4.32	2009-01-16	16178	2.450	0.0009	0.0016	0.0007	2.430	0.0024	0.0021	2.95	3.6	3.5	18.8
SFM0023	3.32	4.32	2009-04-17	16256	2.570	0.0003	0.0051	0.0049	2.460	0.0045	<0.0005	3.52	15.1	3.4	20.0
SFM0023	3.32	4.32	2009-08-14	16348	2.000	0.0008	0.0021	0.0013	2.530	0.0039	0.0012	2.71	3.0	4.9	20.0
SFM0023	3.32	4.32	2009-10-09	16504	2.470	<0.0002	0.0006	0.0006	2.570	0.0010	<0.0005	2.51	3.5	4.4	20.0
SFM0032	1.94	2.94	2009-01-13	16175	0.067	0.0008	0.0010	<0.0003	0.537	0.0099	0.0051	5.94	17.2	17.2	68.1
SFM0032	1.94	2.94	2009-04-15	16254	0.075	0.0003	0.0004	<0.0003	0.533	0.0109	0.0065	5.71	16.1	16.4	61.4
SFM0032	1.94	2.94	2009-08-11	16351	0.032	0.0002	0.0003	<0.0003	0.656	0.0157	0.0054	7.88	21.1	22.5	75.5
SFM0032	1.94	2.94	2009-10-06	16501	0.029	0.0006	0.0008	<0.0003	0.751	0.0130	0.0064	8.81	22.5	22.5	61.8
SFM0037	1.10	2.10	2009-01-14	16177	0.034	0.0007	0.0008	<0.0003	1.250	0.1590	0.0062	6.36	40.3	41.2	74.8
SFM0037	1.10	2.10	2009-04-15	16255	0.001	0.0002	0.0004	<0.0003	0.841	0.0391	0.0046	4.98	27.3	27.6	63.4
SFM0037	1.10	2.10	2009-08-12	16352	0.379	0.0004	0.0005	<0.0003	1.570	0.2230	0.0444	8.17	32.9	32.9	77.5
SFM0037	1.10	2.10	2009-10-07	16503	0.059	0.0004	0.0014	0.0010	0.891	0.0771	0.0075	7.91	23.9	24.6	87.3
SFM0049	2.90	3.90	2009-01-13	16176	0.083	0.0005	<0.0003	<0.0003	0.761	0.0145	0.0064	6.68	24.9	24.4	54.3
SFM0049	2.90	3.90	2009-04-14	16253	0.218	0.0007	0.0007	<0.0003	0.869	0.0254	0.0061	4.81	24.5	24.3	34.4
SFM0049	2.90	3.90	2009-08-11	16349	0.164	0.0002	0.0003	<0.0003	0.865	0.0197	0.0125	5.09	24.6	24.7	48.6
SFM0049	2.90	3.90	2009-10-06	16502	0.196	0.0002	0.0005	0.0003	0.754	0.0165	0.0148	4.17	22.1	21.9	49.1

< “value” = Below reporting limit.
x = No result due to analytical problems.

SICADA: biochemistry_supplements

Table A9-4. Isotopes I.

Id code	Secup m	Seclow m	Date yyyy-mm-dd	Sample No.	$^{10}B/^{11}B$	δ D (‰ SMOW)	Tritium (TU)	$\delta^{18}O$ (‰ SMOW)
SFM0001	3.80	4.80	2009-01-13	16174	–	–81.1	9.70	–11.80
SFM0001	3.80	4.80	2009-04-14	16252	–	–79.9	9.50	–11.90
SFM0001	3.80	4.80	2009-08-11	16350	0.2378	–76.4	9.90	–10.60
SFM0001	3.80	4.80	2009-10-06	16500	–	–72.3	9.00	–11.40
SFM0023	3.32	4.32	2009-01-16	16178	–	–62.1	4.30	–8.30
SFM0023	3.32	4.32	2009-04-17	16256	–	–64.2	2.60	–8.50
SFM0023	3.32	4.32	2009-08-14	16348	0.2387	–66.3	3.70	–8.40
SFM0023	3.32	4.32	2009-10-09	16504	–	–60.1	3.20	–8.50
SFM0032	1.94	2.94	2009-01-13	16175	–	–81.2	10.00	–12.00
SFM0032	1.94	2.94	2009-04-15	16254	–	–81.7	8.40	–12.20
SFM0032	1.94	2.94	2009-08-11	16351	0.2428	–82.2	11.40	–11.60
SFM0032	1.94	2.94	2009-10-06	16501	–	–72.6	10.30	–10.90
SFM0037	1.10	2.10	2009-01-14	16177	–	–82.5	10.70	–12.30
SFM0037	1.10	2.10	2009-04-15	16255	–	–84.4	9.60	–12.40
SFM0037	1.10	2.10	2009-08-12	16352	0.2412	–74.5	12.10	–9.90
SFM0037	1.10	2.10	2009-10-07	16503	–	–65.2	10.10	–10.30
SFM0049	2.90	3.90	2009-01-13	16176	–	–81.2	10.40	–12.00
SFM0049	2.90	3.90	2009-04-14	16253	–	–81.3	10.20	–11.80
SFM0049	2.90	3.90	2009-08-11	16349	0.2407	–68.4	13.70	–8.70
SFM0049	2.90	3.90	2009-10-06	16502	–	–65.9	12.50	–9.50
SFM0051	4.32	4.48	2009-01-13	16179	0.2450	–81.4	10.90	–11.70
SFM0051	4.32	4.48	2009-04-14	16257	–	–77.8	9.40	–11.80
SFM0051	4.32	4.48	2009-08-10	16347	0.2460	–84.2	10.40	–11.80
SFM0051	4.32	4.48	2009-10-07	16399	0.2457	–79.0	10.10	–12.40

A: Results to be reported

SICADA: Isotopes_1

Table A9-5. Trace metals I.

Idcode	Secup m	Seclow m	Date yyyy/mm/dd	Sample No.	Al µg/L	As µg/L	Cd µg/L	Cr µg/L	Cu µg/L	Co µg/L	Hg µg/L	Ni µg/L	Zn µg/L	Pb µg/L	V µg/L	Mo µg/L	Ba µg/L	B µg/L
SFM0001	3.80	4.80	2009-01-13	16174	77.3	–	0.008	0.663	0.604	0.174	<0.002	1.800	0.737	0.127	3.140	1.180	31.4	–
SFM0001	3.80	4.80	2009-08-11	16350	21.8	–	<0.002	0.240	<0.1	0.138	<0.002	0.582	0.221	0.034	2.500	1.990	54.8	–
SFM0032	1.94	2.94	2009-01-13	16175	16.2	–	0.004	0.148	0.278	0.109	<0.002	0.782	0.680	0.035	1.290	2.560	56.5	–
SFM0032	1.94	2.94	2009-08-11	16351	24.8	–	<0.002	0.302	0.139	0.142	<0.002	0.566	<0.2	0.015	1.990	4.390	57.8	–
SFM0037	1.10	2.10	2009-01-14	16177	53.5	–	<0.002	0.507	0.432	0.149	0.004	1.660	0.451	0.022	2.280	0.216	52.5	–
SFM0037	1.10	2.10	2009-08-12	16352	42.0	–	<0.002	0.687	0.303	0.195	<0.002	1.780	0.465	0.052	3.640	1.910	72.7	–
SFM0049	2.90	3.90	2009-01-13	16176	36.1	–	<0.002	0.212	<0.1	0.134	<0.002	0.517	<0.2	0.139	0.744	<0.05	30.3	–
SFM0049	2.90	3.90	2009-08-11	16349	34.9	–	<0.002	0.260	<0.1	0.065	0.002	0.309	<0.2	0.084	1.120	<0.05	21.7	–
SFM0051	4.32	4.48	2009-01-13	16179	62.3	–	0.007	0.908	0.689	0.080	<0.002	0.944	1.900	0.101	2.460	0.917	76.9	–
SFM0051	4.32	4.48	2009-04-14	16257	62.5	2.020	0.016	0.576	1.560	0.057	<0.002	0.784	3.160	0.110	2.280	0.934	74.1	24.8
SFM0051	4.32	4.48	2009-08-10	16347	52.6	1.380	0.017	2.390	16.700	0.138	<0.002	3.990	11.000	1.040	2.260	0.990	79.8	22.1
SFM0051	4.32	4.48	2009-10-05	16399	46.5	–	<0.002	1.190	0.291	0.060	<0.002	0.976	1.600	0.079	2.430	0.915	82.5	–

< "value" = Below reporting limit.

SICADA: trace_elements_1

Table A9-6. Trace metals II.

Idcode	Secup m	Seclow m	Date yyyy/mm/dd	Sample No.	U µg/L	Th µg/L	Sc µg/L	Rb µg/L	Y µg/L	Zr µg/L	In µg/L	Sb µg/L	Cs µg/L	La µg/L	Hf µg/L	Tl µg/L	Ce µg/L	Pr µg/L	Nd µg/L	Sm µg/L
SFM0001	3.80	4.80	2009-01-13	16174	4.9300	0.4480	0.1720	2.380	5.840	7.050	–	0.0741	0.0723	4.530	0.1220	<0.01	11.300	1.0900	4.620	0.9150
SFM0001	3.80	4.80	2009-08-11	16350	4.7800	0.2180	0.1290	3.750	2.600	7.180	–	0.0625	<0.03	2.010	0.1260	<0.01	4.950	0.4400	1.900	0.3730
SFM0032	1.94	2.94	2009-01-13	16175	9.2700	0.0837	0.0696	1.950	1.640	3.820	–	0.0368	<0.03	0.784	0.0651	<0.01	1.110	0.1780	0.749	0.1530
SFM0032	1.94	2.94	2009-08-11	16351	5.6600	0.1220	0.0748	1.960	3.460	3.450	–	0.0445	<0.03	3.020	0.0696	<0.01	3.810	0.5940	2.530	0.4680
SFM0037	1.10	2.10	2009-01-14	16177	7.9100	0.3040	0.1370	2.410	4.410	3.910	–	0.1100	<0.03	2.190	0.0974	<0.01	3.710	0.5420	2.350	0.5160
SFM0037	1.10	2.10	2009-08-12	16352	9.4900	0.4440	0.2070	5.140	4.570	4.750	–	0.1280	<0.03	3.780	0.1320	<0.01	6.550	0.8220	3.460	0.7060
SFM0049	2.90	3.90	2009-01-13	16176	0.3050	0.0935	0.0515	3.170	0.976	0.382	–	0.0507	<0.03	1.590	0.0102	<0.01	2.950	0.3380	1.350	0.2400
SFM0049	2.90	3.90	2009-08-11	16349	0.2030	0.1600	0.0869	4.180	1.110	0.378	–	0.0366	<0.03	1.810	0.0164	<0.01	3.380	0.3780	1.480	0.2900
SFM0051	4.32	4.48	2009-01-13	16179	0.8120	0.0687	0.0571	1.350	0.667	6.080	–	0.0909	0.1180	0.270	0.0700	<0.01	0.527	0.0699	0.288	0.0646
SFM0051	4.32	4.48	2009-04-14	16257	0.8930	0.0576	0.0541	1.150	0.664	5.230	<0.05	0.5170	<0.03	0.260	0.0730	<0.01	0.500	0.0596	0.272	0.0699
SFM0051	4.32	4.48	2009-08-10	16347	1.0100	0.0850	<0.05	1.160	0.791	4.580	<0.05	0.0768	<0.03	0.335	0.0694	<0.01	0.632	0.0821	0.377	0.0851
SFM0051	4.32	4.48	2009-10-05	16399	0.9340	0.0996	0.0673	1.120	0.736	5.410	–	0.1250	<0.03	0.287	0.0834	<0.01	0.541	0.0705	0.306	0.0660

Idcode	Secup m	Seclow m	Date yyyy/mm/dd	Sample No.	Eu µg/L	Gd µg/L	Tb µg/L	Dy µg/L	Ho µg/L	Er µg/L	Tm µg/L	Yb µg/L	Lu µg/L
SFM0001	3.80	4.80	2009-01-13	16174	0.1040	0.9170	0.1340	0.8840	0.1900	0.5540	0.0785	0.5230	0.0812
SFM0001	3.80	4.80	2009-08-11	16350	0.0480	0.4040	0.0621	0.3760	0.0786	0.2440	0.0312	0.2350	0.0401
SFM0032	1.94	2.94	2009-01-13	16175	0.0074	0.1750	0.0265	0.2000	0.0456	0.1500	0.0226	0.1530	0.0267
SFM0032	1.94	2.94	2009-08-11	16351	0.0643	0.4950	0.0648	0.3970	0.0900	0.2940	0.0352	0.2560	0.0473
SFM0037	1.10	2.10	2009-01-14	16177	0.0516	0.5590	0.0874	0.6160	0.1390	0.4470	0.0655	0.4450	0.0693
SFM0037	1.10	2.10	2009-08-12	16352	0.0858	0.7490	0.1120	0.6740	0.1400	0.4660	0.0597	0.4500	0.0737
SFM0049	2.90	3.90	2009-01-13	16176	0.0266	0.2030	0.0274	0.1710	0.0337	0.0975	0.0130	0.0861	0.0130
SFM0049	2.90	3.90	2009-08-11	16349	0.0375	0.2570	0.0374	0.2010	0.0369	0.1190	0.0143	0.0977	0.0156
SFM0051	4.32	4.48	2009-01-13	16179	<0.005	0.0784	0.0112	0.0844	0.0209	0.0739	0.0120	0.0975	0.0202
SFM0051	4.32	4.48	2009-04-14	16257	0.1070	0.0700	0.0118	0.0812	0.0224	0.0808	0.0661	1.4900	0.5410
SFM0051	4.32	4.48	2009-08-10	16347	0.0222	0.0962	0.0154	0.1090	0.0247	0.0976	0.0176	0.2360	0.0706
SFM0051	4.32	4.48	2009-10-05	16399	0.0057	0.0882	0.0131	0.0957	0.0245	0.0839	0.0130	0.1150	0.0257

< “value” = Below reporting limit.

SICADA: trace_elements_2

Appendix 10

Field measurements, surface waters

Idcode	Start date yyyy/mm/dd hh:mm	Stop date yyyy/mm/dd hh:mm	Measured depth (m)	Water depth (m)	Sno	Temp. (°C)	pH	EC (mS/m)	Salinity (per mill)	Turb* (NTU)	Light (µmol/m^{2}s)	O_2 diss. (mg/l)	Chloro-phyll (ug/l)	ORP (mV)	Atm. Pres-sure (hPa)
PFM000062	2009-01-13 08:00	2009-01-13 20:00	0.5		16192	–0.2	7.95	898.5	4.87	–0.3	25.6	17.06	0.0	113	994.6
PFM000062	2009-01-13 08:00	2009-01-13 20:00	1.0			–0.2	7.96	901.2	4.89	–0.2	16.8	17.95	0.7	114	995.1
PFM000062	2009-01-13 08:00	2009-01-13 20:00	2.0			–0.2	7.96	904.5	4.91	–0.3	6.0	17.38	0.0	114	995.8
PFM000062	2009-01-13 08:00	2009-01-13 20:00	3.0			–0.2	7.96	907.6	4.93	–0.1	2.1	17.45	1.2	115	996.6
PFM000062	2009-02-09 09:30	2009-02-09 21:00	0.6	4.00	16197	–0.5	7.93	943.0	5.12	–0.4	40.3	14.42	0.6	284	997.6
PFM000062	2009-02-09 09:30	2009-02-09 21:00	1.0	4.00		–0.5	7.91	942.9	5.12	–0.5	19.5	14.38	0.2	285	997.6
PFM000062	2009-02-09 09:30	2009-02-09 21:00	2.0	4.00		–0.5	7.89	950.5	5.17	–0.4	12.0	14.35	0.0	285	997.8
PFM000062	2009-02-09 09:30	2009-02-09 21:00	3.0	4.00		–0.5	7.89	947.6	5.15	–0.5	9.6	14.34	0.4	284	998.2
PFM000062	2009-03-09 09:00	2009-03-09 21:00	0.5	4.00	16213	0.3	7.76	940.3	5.13	–0.8	121.8	15.60	0.4	424	1,000.3
PFM000062	2009-03-09 09:00	2009-03-09 21:00	1.0	4.00		0.4	7.78	940.7	5.13	–0.8	88.3	15.51	0.1	428	1,000.2
PFM000062	2009-03-09 09:00	2009-03-09 21:00	2.0	4.00		0.4	7.80	941.0	5.14	–0.8	47.9	15.50	1.3	418	1,000.1
PFM000062	2009-03-09 09:00	2009-03-09 21:00	3.0	4.00		0.4	7.81	941.3	5.14	–0.9	29.5	15.44	1.5	424	1,000.2
PFM000062	2009-04-14 08:00	2009-04-14 19:00	0.5	3.70	16244	3.5	8.27	897.5	4.96	0.0	370.7	16.07	2.3	356	1,010.6
PFM000062	2009-04-14 08:00	2009-04-14 19:00	1.0	3.70		3.4	8.28	898.1	4.96	0.0	286.3	15.46	1.7	355	1,011.0
PFM000062	2009-04-14 08:00	2009-04-14 19:00	2.0	3.70		3.4	8.30	898.5	4.96	0.0	150.3	15.52	3.0	353	1,011.6
PFM000062	2009-04-14 08:00	2009-04-14 19:00	3.0	3.70		3.4	8.30	898.6	4.96	–0.9	77.3	15.53	4.2	352	1,011.9
PFM000062	2009-05-11 08:30	2009-05-11 21:00	0.5	3.90	16258	5.7	8.02	895.2	4.98	–0.3	917.1	13.64	1.5	230	1,020.0
PFM000062	2009-05-11 08:30	2009-05-11 21:00	1.0	3.90		5.7	8.03	895.1	4.98	–0.2	627.5	13.63	0.7	235	1,020.0
PFM000062	2009-05-11 08:30	2009-05-11 21:00	2.0	3.90		5.6	8.04	895.7	4.98	–0.2	321.8	13.64	0.8	240	1,019.9
PFM000062	2009-05-11 08:30	2009-05-11 21:00	3.0	3.90		5.6	8.04	895.7	4.98	–0.2	152.0	13.65	1.2	244	1,019.9
PFM000062	2009-06-15 09:00	2009-06-15 21:00	0.5	4.00	16317	11.3	7.92	872.7	4.89	0.7	344.3	11.56	1.4	116	1,001.3
PFM000062	2009-06-15 09:00	2009-06-15 21:00	1.0	4.00		11.3	7.92	873.2	4.89	0.7	263.1	11.56	1.9	118	1,001.2
PFM000062	2009-06-15 09:00	2009-06-15 21:00	2.0	4.00		11.3	7.93	873.2	4.89	0.8	111.0	11.55	1.9	120	1,001.2
PFM000062	2009-06-15 09:00	2009-06-15 21:00	3.0	4.00		11.3	7.93	874.0	4.90	0.9	59.5	11.53	2.1	123	1,001.2
PFM000062	2009-08-10 09:00	2009-08-10 21:00	0.5	3.90	16343	12.0	7.48	892.9	5.01	–0.7	811.0	9.68	1.2	61	1,018.6
PFM000062	2009-08-10 09:00	2009-08-10 21:00	1.0	3.90		12.0	7.51	893.1	5.01	–0.8	516.1	9.49	0.2	61	1,018.7
PFM000062	2009-08-10 09:00	2009-08-10 21:00	2.0	3.90		11.8	7.51	894.7	5.02	–0.7	310.0	9.33	1.9	61	1,018.9
PFM000062	2009-08-10 09:00	2009-08-10 21:00	3.0	3.90		11.7	7.51	895.4	5.03	–0.7	183.8	9.21	1.5	60	1,018.9
PFM000062	2009-09-01 07:30	2009-09-01 15:00	0.5	3.80	16385	10.2	7.58	916.4	5.15	–0.9	250.8	10.03	1.0	101	1,011.6

Idcode	Start date yyyy/mm/dd hh:mm	Stop date yyyy/mm/dd hh:mm	Measured depth (m)	Water depth (m)	Sno	Temp. (°C)	pH	EC (mS/m)	Salinity (per mill)	Turb* (NTU)	Light (µmol/m²s)	O_2 diss. (mg/l)	Chloro-phyll (ug/l)	ORP (mV)	Atm. Pres-sure (hPa)
PFM000062	2009-09-01 07:30	2009-09-01 15:00	1.0	3.80		10.1	7.59	916.5	5.15	–0.8	186.7	9.98	0.2	100	1,011.6
PFM000062	2009-09-01 07:30	2009-09-01 15:00	2.0	3.80		10.1	7.59	916.7	5.15	–0.8	126.8	9.99	0.4	100	1,011.6
PFM000062	2009-09-01 07:30	2009-09-01 15:00	3.0	3.80		10.0	7.59	916.9	5.15	–0.8	81.1	10.00	–0.7	99	1,011.6
PFM000062	2009-10-05 09:00	2009-10-05 21:00	0.5	4.00	16391	8.6	7.97	861.5	4.81	0.6	257.6	10.84	0.4	294	1,000.0
PFM000062	2009-10-05 09:00	2009-10-05 21:00	1.0	4.00		8.7	7.98	861.8	4.81	0.4	208.9	10.82	1.6	293	999.9
PFM000062	2009-10-05 09:00	2009-10-05 21:00	2.0	4.00		8.6	7.99	862.3	4.81	0.3	74.0	10.80	1.4	291	1,000.1
PFM000062	2009-10-05 09:00	2009-10-05 21:00	3.0	4.00		8.6	7.99	863.9	4.82	0.2	41.4	10.77	1.3	290	1,000.0
PFM000062	2009-11-02 09:30	2009-11-02 18:30	0.5	3.80	16589	5.8	7.74	900.2	5.01	–0.7	128.8	12.28	3.0	319	1,009.6
PFM000062	2009-11-02 09:30	2009-11-02 18:30	1.0	3.80		5.8	7.81	900.2	5.01	–0.6	99.4	12.25	3.4	317	1,009.8
PFM000062	2009-11-02 09:30	2009-11-02 18:30	2.0	3.80		5.8	7.86	900.3	5.01	–0.7	53.5	12.23	2.8	315	1,009.6
PFM000062	2009-11-02 09:30	2009-11-02 18:30	3.1	3.80		5.8	7.88	900.5	5.01	–0.7	24.6	12.22	3.4	315	1,009.8
PFM000062	2009-11-30 09:00	2009-11-30 17:30	0.5	4.10	16615	4.4	7.75	913.0	5.06	–0.9	17.2	11.98	1.4	200	997.5
PFM000062	2009-11-30 09:00	2009-11-30 17:30	1.0	4.10		4.4	7.77	913.1	5.06	–0.9	13.4	11.96	0.9	201	997.5
PFM000062	2009-11-30 09:00	2009-11-30 17:30	2.0	4.10		4.4	7.79	913.2	5.06	–1.0	8.2	11.95	0.4	200	997.5
PFM000062	2009-11-30 09:00	2009-11-30 17:30	3.0	4.10		4.4	7.80	913.3	5.07	–0.9	5.2	11.93	1.2	199	997.5
PFM000066	2009-01-13 08:00	2009-01-13 20:00	0.3		16193	–0.2	7.19	41.4	0.20			4.28		81	996.0
PFM000066	2009-02-09 09:30	2009-02-09 21:00	0.2	0.20	16201	–0.5	7.01	48.1	0.23			1.28		104	998.9
PFM000066	2009-03-09 09:00	2009-03-09 21:00	0.2	0.20	16220	–0.5	7.00	52.7	0.25			4.10		87	1,000.4
PFM000066	2009-04-14 08:00	2009-04-14 19:00	0.4	0.40	16250	6.1	7.14	25.2	0.12			5.29		113	1,017.5
PFM000066	2009-05-11 08:30	2009-05-11 21:00	0.3	0.25	16262	10.9	7.52	37.3	0.18			8.12		140	1,019.2
PFM000066	2009-06-15 09:00	2009-06-15 21:00	0.4	0.35	16323	10.2	7.34	30.4	0.15			6.01		62	1,004.1
PFM000066	2009-08-11 07:00	2009-08-11 16:00	0.2	0.15	16342	16.8	7.49	36.0	0.17			5.71		–16	1,008.4
PFM000066	2009-09-01 07:30	2009-09-01 15:00	0.2	0.25	16386	15.4	7.52	35.8	0.17			6.54		–15	1,012.3
PFM000066	2009-10-06 08:00	2009-10-06 16:00	0.3	0.15	16397	3.1	7.60	35.3	0.17			8.03		150	1,013.0
PFM000066	2009-11-03 07:30	2009-11-03 15:30	0.2	0.20	16595	4.5	7.68	35.2	0.17			8.94		255	1,007.9
PFM000066	2009-12-01 07:30	2009-12-01 18:00	0.3	0.30	16622	3.2	7.38	33.6	0.16			8.02		163	1,002.4
PFM000068	2009-01-13 08:00	2009-01-13 20:00	0.5		16189	–0.1	7.14	34.9	0.16			6.27		145	994.0
PFM000068	2009-02-09 09:30	2009-02-09 21:00	0.5	0.50	16200	–0.5	7.05	46.4	0.22			4.20		112	998.5
PFM000068	2009-03-09 09:00	2009-03-09 21:00	0.4	0.50	16217	–0.5	7.06	48.9	0.23			6.88		42	1,000.7
PFM000068	2009-04-14 08:00	2009-04-14 19:00	0.6	0.60	16248	5.5	7.21	24.8	0.12			8.32		138	1,018.1
PFM000068	2009-05-11 08:30	2009-05-11 21:00	0.6	0.50	16265	8.7	7.41	37.8	0.18			8.17		94	1,019.2
PFM000068	2009-06-15 09:00	2009-06-15 21:00	0.7	0.70	16322	9.5	7.15	24.9	0.12			7.38		73	1,004.6
PFM000068	2009-08-11 07:00	2009-08-11 16:00	0.4	0.40	16340	14.7	7.38	41.2	0.20			6.32		223	1,011.7

Idcode	Start date yyyy/mm/dd hh:mm	Stop date yyyy/mm/dd hh:mm	Measured depth (m)	Water depth (m)	Sno	Temp. (°C)	pH	EC (mS/m)	Salinity (per mill)	Turb* (NTU)	Light (µmol/m²s)	O_2 diss. (mg/l)	Chloro-phyll (ug/l)	ORP (mV)	Atm. Pres-sure (hPa)
PFM000068	2009-08-31 09:30	2009-08-31 19:30	0.4	0.40	16384	12.9	7.49	40.9	0.20			7.17		87	1,010.5
PFM000068	2009-10-05 09:00	2009-10-05 21:00	0.4	0.45	16395	5.1	7.54	51.7	0.25			4.97		150	1,004.3
PFM000068	2009-11-02 09:30	2009-11-02 18:30	0.4	0.40	16593	4.5	7.47	42.9	0.21			6.74		264	1,006.7
PFM000068	2009-11-30 09:00	2009-11-30 17:30	0.6	0.50	16619	3.7	7.26	33.3	0.16			8.32		215	995.9
PFM000069	2009-01-13 08:00	2009-01-13 20:00	0.2		16191	0.0	7.24	51.1	0.24			4.48		67	996.2
PFM000069	2009-02-09 09:30	2009-02-09 21:00	0.2	0.20	16199	–0.5	6.98	58.5	0.28			1.48		166	998.7
PFM000069	2009-03-09 09:00	2009-03-09 21:00	0.2	0.20	16219	–0.6	6.88	59.7	0.28			2.35		65	1,001.3
PFM000069	2009-04-14 08:00	2009-04-14 19:00	0.3	0.40	16249	5.3	7.08	27.7	0.13			6.04		118	1,018.5
PFM000069	2009-05-11 08:30	2009-05-11 21:00	0.2	0.20	16263	9.0	7.30	39.5	0.19			7.06		109	1,019.4
PFM000069	2009-06-15 09:00	2009-06-15 21:00	0.3	0.30	16321	9.4	7.11	35.8	0.17			5.54		88	1,004.3
PFM000069	2009-08-11 07:00	2009-08-11 16:00	0.2	0.15	16341	14.5	7.33	42.0	0.20			6.88		155	1,010.9
PFM000069	2009-08-31 09:30	2009-08-31 19:30	0.3	0.25	16383	12.7	7.46	42.3	0.20			7.88		126	1,010.2
PFM000069	2009-10-05 09:00	2009-10-05 21:00	0.3	0.10	16394	4.8	7.73	53.6	0.26			8.78		206	1,003.9
PFM000069	2009-11-02 09:30	2009-11-02 18:30	0.2	0.10	16592	4.6	7.50	45.8	0.22			8.17		265	1,006.7
PFM000069	2009-11-30 09:00	2009-11-30 17:30	0.2	0.20	16618	4.0	7.21	41.8	0.20			6.81		217	996.1
PFM000070	2009-01-12 09:00	2009-01-12 19:00	0.2		16188	0.3	7.80	2.7	0.01			14.59		95	993.2
PFM000070	2009-02-09 09:30	2009-02-09 21:00	0.2	0.20	16198	–0.5	7.39	37.9	0.18			2.69		412	997.5
PFM000070	2009-03-09 09:00	2009-03-09 21:00	0.3	0.30	16218	–0.3	7.39	39.3	0.19			4.72		108	1,000.5
PFM000070	2009-04-14 08:00	2009-04-14 19:00	0.2	0.30	16247	9.8	7.35	30.5	0.15			7.38		177	1,018.0
PFM000070	2009-05-11 08:30	2009-05-11 21:00	0.3	0.20	16261	13.1	7.44	29.6	0.14			6.90		206	1,019.2
PFM000070	2009-06-15 09:00	2009-06-15 21:00	0.2	0.25	16320	12.3	7.69	24.5	0.12			9.45		99	1,003.0
PFM000070	2009-08-10 09:00	2009-08-10 21:00	0.2	0.25	16339	19.0	7.11	26.2	0.12			4.89		215	1,014.6
PFM000070	2009-08-31 09:30	2009-08-31 19:30	0.3	0.25	16382	15.0	7.23	25.5	0.12			6.26		153	1,009.6
PFM000070	2009-10-06 08:00	2009-10-06 16:00	0.2	0.10	16396	3.2	7.41	31.9	0.15			6.42		164	1,012.6
PFM000070	2009-11-02 09:30	2009-11-02 18:30	0.2	0.10	16591	4.7	7.38	32.0	0.15			8.03		225	1,006.5
PFM000070	2009-11-30 09:00	2009-11-30 17:30	0.3	0.30	16617	3.9	7.73	27.4	0.13			10.35		207	995.6
PFM000074	2009-01-13 08:00	2009-01-13 20:00	0.5		16190	0.2	7.09	46.0	0.22	–1.4	7.9	2.75	11.0	5	994.9
PFM000074	2009-02-10 08:00	2009-02-10 15:30	0.5	0.90	16212	0.3	6.89	67.0	0.32	–1.1	11.2	3.14	14.9	91	1,001.3
PFM000074	2009-03-10 08:00	2009-03-10 17:00	0.5	0.80	16230	–0.3	7.02	55.3	0.26	0.9	5.3	3.19	19.5	60	998.2
PFM000074	2009-04-15 08:00	2009-04-15 18:00	0.5	1.20	16251	4.1	7.30	27.2	0.13	–1.2	91.7	7.08	6.5	82	1,024.7
PFM000074	2009-05-12 08:30	2009-05-12 12:00	0.5	0.80	16264	10.1	7.52	40.7	0.20	–1.2	262.0	8.26	7.1	225	1,023.9
PFM000074	2009-06-16 07:30	2009-06-16 15:00	0.5	0.80	16324	11.8	7.38	33.6	0.16	–0.3	109.7	7.95	7.8	104	1,012.6
PFM000074	2009-08-11 07:00	2009-08-11 16:00	0.5	0.90	16346	18.9	7.38	42.8	0.21	–0.2	19.0	7.89	10.0	38	1,010.2

Idcode	Start date yyyy/mm/dd hh:mm	Stop date yyyy/mm/dd hh:mm	Measured depth (m)	Water depth (m)	Sno	Temp. (°C)	pH	EC (mS/m)	Salinity (per mill)	Turb* (NTU)	Light (µmol/m²s)	O_2 diss. (mg/l)	Chloro-phyll (ug/l)	ORP (mV)	Atm. Pres-sure (hPa)
PFM000074	2009-08-31 09:30	2009-08-31 19:30	0.5	0.70	16380	15.6	7.55	41.8	0.20	–0.7	218.2	9.44	8.2	69	1,010.0
PFM000074	2009-10-06 08:00	2009-10-06 16:00	0.5	0.60	16398	6.1	8.07	41.3	0.20	–1.3	125.2	12.53	5.5	120	1,013.3
PFM000074	2009-11-03 07:30	2009-11-03 15:30	0.5	0.80	16596	4.1	7.82	43.8	0.21	–0.4	28.1	11.82	7.8	255	1,008.6
PFM000074	2009-12-01 07:30	2009-12-01 18:00	0.5	0.90	16621	3.6	7.26	38.6	0.18	–1.6	28.1	5.52	8.3	170	1,002.4
PFM000097	2009-01-13 08:00	2009-01-13 20:00	0.5		16171	0.8	7.14	45.4	0.22	4.3	3.7	3.29	17.2	–36	995.5
PFM000097	2009-02-10 08:00	2009-02-10 15:30	0.5	0.90	16114	1.7	6.77	114.7	0.56	6.1	9.1	1.97	30.4	55	1,001.5
PFM000097	2009-03-09 09:00	2009-03-09 21:00	0.5	0.70	16231	1.2	6.89	140.0	0.69	2.6	5.9	1.51	24.3	–92	1,001.0
PFM000097	2009-04-15 08:00	2009-04-15 18:00	0.5	1.00		7.8	7.41	35.7	0.17	–0.6	63.7	9.02	5.5	264	1,024.9
PFM000097	2009-05-12 08:30	2009-05-12 12:00	0.5	0.80		10.5	8.37	38.6	0.19	–0.4	292.8	12.05	6.5	187	1,023.7
PFM000097	2009-06-16 07:30	2009-06-16 15:00	0.5	0.80		11.2	7.99	34.3	0.17	–1.1	912.1	10.97	5.2	110	1,011.8
PFM000097	2009-08-11 07:00	2009-08-11 16:00	0.5	0.90		19.5	7.84	36.2	0.17	0.4	345.2	8.17	4.6	12	1,011.1
PFM000097	2009-09-01 07:30	2009-09-01 15:00	0.5	0.80		16.4	8.38	39.8	0.19	–0.9	83.9	10.77	3.1	41	1,012.6
PFM000097	2009-10-06 08:00	2009-10-06 16:00	0.5	0.70		8.2	7.49	643.9	3.52	–0.9	233.3	10.15	1.9	211	1,013.2
PFM000097	2009-11-03 07:30	2009-11-03 15:30	0.5	0.65		4.2	8.12	239.4	1.23	0.3	75.5	13.19	5.6	256	1,008.9
PFM000097	2009-12-01 07:30	2009-12-01 18:00	0.5	0.80		3.3	7.87	63.0	0.30	–1.3	9.4	12.00	4.0	202	1,002.0
PFM000107	2009-01-12 09:00	2009-01-12 19:00	0.5		16184	0.7	7.25	41.4	0.20	–1.3	2.6	3.57	12.5	228	994.0
PFM000107	2009-01-12 09:00	2009-01-12 19:00	1.0		16186	2.4	7.27	45.2	0.22	–0.8	0.0	1.74	11.4	82	994.1
PFM000107	2009-02-09 09:30	2009-02-09 21:00	0.5	1.80	16195	0.7	7.07	46.3	0.22	–0.4	20.1	2.06	10.6	96	996.2
PFM000107	2009-02-09 09:30	2009-02-09 21:00	1.0	1.80	16196	2.7	7.10	45.7	0.22	–0.2	1.5	1.67	13.5	38	996.4
PFM000107	2009-03-09 09:00	2009-03-09 21:00	0.5	1.80	16215	0.4	7.10	55.3	0.26	–0.9	18.5	1.96	13.8	61	1,000.6
PFM000107	2009-03-09 09:00	2009-03-09 21:00	1.0	1.80	16216	2.3	7.08	54.9	0.26	–0.7	3.4	1.43	14.6	22	1,000.6
PFM000107	2009-04-13 13:00	2009-04-13 19:00	0.5	1.70	16246	8.4	7.17	35.3	0.17	0.0	66.2	6.85	6.7	382	1,014.8
PFM000107	2009-04-13 13:00	2009-04-13 19:00	1.0	1.70		8.4	7.17	35.3	0.17	0.0	17.2	6.64	7.4	380	1,015.0
PFM000107	2009-05-11 08:30	2009-05-11 21:00	0.5	1.80	16259	12.3	8.38	36.6	0.18	–0.7	352.5	11.54	5.9	154	1,019.9
PFM000107	2009-05-11 08:30	2009-05-11 21:00	1.0	1.80		12.3	8.38	36.4	0.18	–0.7	166.5	11.57	6.1	153	1,019.9
PFM000107	2009-06-15 09:00	2009-06-15 21:00	0.5	1.70	16318	11.6	8.41	33.7	0.16	–0.9	284.2	11.69	6.0	123	1,002.9
PFM000107	2009-06-15 09:00	2009-06-15 21:00	1.0	1.70		11.6	8.41	33.6	0.16	–0.9	152.6	11.70	4.6	122	1,002.9
PFM000107	2009-08-10 09:00	2009-08-10 21:00	0.5	1.70	16344	22.5	8.72	33.6	0.16	–0.6	413.0	11.68	4.7	82	1,017.9
PFM000107	2009-08-10 09:00	2009-08-10 21:00	1.0	1.70		22.4	8.71	33.5	0.16	–0.7	208.9	11.60	4.5	78	1,018.0
PFM000107	2009-08-31 09:30	2009-08-31 19:30	0.5	1.70	16379	15.5	8.49	32.1	0.15	–0.7	581.9	10.29	3.0	210	1,009.7
PFM000107	2009-08-31 09:30	2009-08-31 19:30	1.0	1.70		15.5	8.50	32.1	0.15	–0.7	206.9	10.31	2.6	211	1,009.7
PFM000107	2009-10-05 09:00	2009-10-05 21:00	0.5	1.70	16393	6.7	8.76	33.3	0.16	–1.3	61.0	12.95	2.3	193	1,003.3
PFM000107	2009-10-05 09:00	2009-10-05 21:00	1.0	1.70		6.6	8.76	33.3	0.16	–1.3	34.3	12.93	1.7	198	1,003.2

Idcode	Start date yyyy/mm/dd hh:mm	Stop date yyyy/mm/dd hh:mm	Measured depth (m)	Water depth (m)	Sno	Temp. (°C)	pH	EC (mS/m)	Salinity (per mill)	Turb* (NTU)	Light (µmol/m²s)	O_2 diss. (mg/l)	Chloro-phyll (ug/l)	ORP (mV)	Atm. Pres-sure (hPa)
PFM000107	2009-11-02 09:30	2009-11-02 18:30	0.5	1.70	16590	4.2	8.36	37.5	0.18	–0.9	34.4	13.14	4.2	247	1,008.0
PFM000107	2009-11-02 09:30	2009-11-02 18:30	1.0	1.70		4.2	8.35	37.0	0.18	–0.9	21.2	13.14	4.3	253	1,008.0
PFM000107	2009-11-30 09:00	2009-11-30 17:30	0.5	1.70	16616	3.2	8.17	38.3	0.18	–1.4	11.1	12.15	4.2	146	996.5
PFM000107	2009-11-30 09:00	2009-11-30 17:30	1.0	1.70		3.2	8.15	38.1	0.18	–1.4	6.5	12.16	3.2	151	996.7
PFM000117	2009-01-12 09:00	2009-01-12 19:00	0.5		16185	0.9	7.46	31.5	0.15	–1.5	–0.9	7.53	7.6	106	993.2
PFM000117	2009-01-12 09:00	2009-01-12 19:00	1.0			2.4	7.43	31.7	0.15	–1.6	–1.1	3.86	7.5	98	993.3
PFM000117	2009-01-12 09:00	2009-01-12 19:00	1.5		16187	3.2	7.41	34.4	0.16	–1.5	–1.1	1.31	11.0	80	993.1
PFM000117	2009-02-10 08:00	2009-02-10 15:30	0.5	2.00	16202	0.5	7.30	34.2	0.16	–1.3	16.1	3.19	8.2	298	1,000.9
PFM000117	2009-02-10 08:00	2009-02-10 15:30	1.0	2.00		1.9	7.29	33.5	0.16	–1.3	3.8	2.33	8.2	301	1,000.9
PFM000117	2009-02-10 08:00	2009-02-10 15:30	1.5	2.00	16211	3.6	7.27	35.4	0.17	–1.2	1.2	1.42	14.3	162	1,001.0
PFM000117	2009-03-10 08:00	2009-03-10 17:00	0.5	2.00	16221	0.4	7.27	35.1	0.17	–0.9	8.0	1.87	10.5	277	997.7
PFM000117	2009-03-10 08:00	2009-03-10 17:00	1.0	2.00		1.6	7.24	35.5	0.17	–1.1	3.0	1.47	10.6	261	997.7
PFM000117	2009-03-10 08:00	2009-03-10 17:00	1.5	2.00	16229	2.9	7.17	37.2	0.18	–1.1	1.4	1.37	15.0	169	997.9
PFM000117	2009-04-14 08:00	2009-04-14 19:00	0.5	2.30	16245	7.8	7.36	31.9	0.15	–1.0	568.0	8.26	6.0	200	1,018.1
PFM000117	2009-04-14 08:00	2009-04-14 19:00	1.0	2.30		7.5	7.35	31.7	0.15	–1.0	89.6	8.18	7.0	200	1,018.1
PFM000117	2009-04-14 08:00	2009-04-14 19:00	1.5	2.30		6.2	7.22	42.4	0.20	–0.7	60.5	5.83	8.5	202	1,018.0
PFM000117	2009-05-11 08:30	2009-05-11 21:00	0.5	2.10	16260	13.1	8.43	29.8	0.14	–0.8	313.7	12.69	6.0	203	1,019.3
PFM000117	2009-05-11 08:30	2009-05-11 21:00	1.0	2.10		13.0	8.42	29.8	0.14	–0.8	141.3	12.19	5.4	208	1,019.3
PFM000117	2009-05-11 08:30	2009-05-11 21:00	1.5	2.10		12.9	8.41	29.8	0.14	–0.8	90.9	12.13	5.2	211	1,019.3
PFM000117	2009-06-15 09:00	2009-06-15 21:00	0.5	2.30	16319	12.4	8.37	25.3	0.12	–1.1	147.7	11.26	5.0	116	1,002.7
PFM000117	2009-06-15 09:00	2009-06-15 21:00	1.0	2.30		12.4	8.37	25.3	0.12	–1.0	82.4	11.24	4.2	115	1,002.7
PFM000117	2009-06-15 09:00	2009-06-15 21:00	1.5	2.30		12.4	8.38	25.3	0.12	–1.1	48.9	11.25	3.6	115	1,002.7
PFM000117	2009-08-10 09:00	2009-08-10 21:00	0.5	2.20	16345	22.9	8.58	23.0	0.11	–0.8	268.6	11.10	4.6	264	1,015.9
PFM000117	2009-08-10 09:00	2009-08-10 21:00	1.0	2.20		22.9	8.58	23.0	0.11	–0.5	160.5	11.08	3.9	268	1,015.9
PFM000117	2009-08-10 09:00	2009-08-10 21:00	1.5	2.20		22.9	8.58	23.0	0.11	–1.0	94.2	11.04	5.2	272	1,015.9
PFM000117	2009-08-31 09:30	2009-08-31 19:30	0.5	2.10	16381	16.8	8.55	22.6	0.11	–0.8	279.7	10.44	2.7	19	1,009.8
PFM000117	2009-08-31 09:30	2009-08-31 19:30	1.0	2.10		16.8	8.55	22.5	0.11	–0.6	121.5	10.47	2.6	19	1,009.8
PFM000117	2009-08-31 09:30	2009-08-31 19:30	1.5	2.10		16.8	8.55	22.5	0.11	–0.8	99.0	10.54	2.3	20	1,009.9
PFM000117	2009-10-05 09:00	2009-10-05 21:00	0.5	2.20	16392	7.1	8.53	26.0	0.12	–1.0	336.9	11.94	3.0	220	1,002.0
PFM000117	2009-10-05 09:00	2009-10-05 21:00	1.0	2.20		7.1	8.53	26.1	0.12	–1.0	325.0	11.87	1.9	222	1,002.1
PFM000117	2009-10-05 09:00	2009-10-05 21:00	1.5	2.20		7.1	8.53	26.0	0.12	–1.0	135.6	11.88	2.6	223	1,002.2
PFM000117	2009-11-03 07:30	2009-11-03 15:30	0.5	2.20	16594	3.9	8.19	25.3	0.12	–1.1	87.9	12.74	4.1	247	1,007.8
PFM000117	2009-11-03 07:30	2009-11-03 15:30	1.0	2.20		3.9	8.19	25.3	0.12	–1.1	61.9	12.72	4.5	251	1,007.7

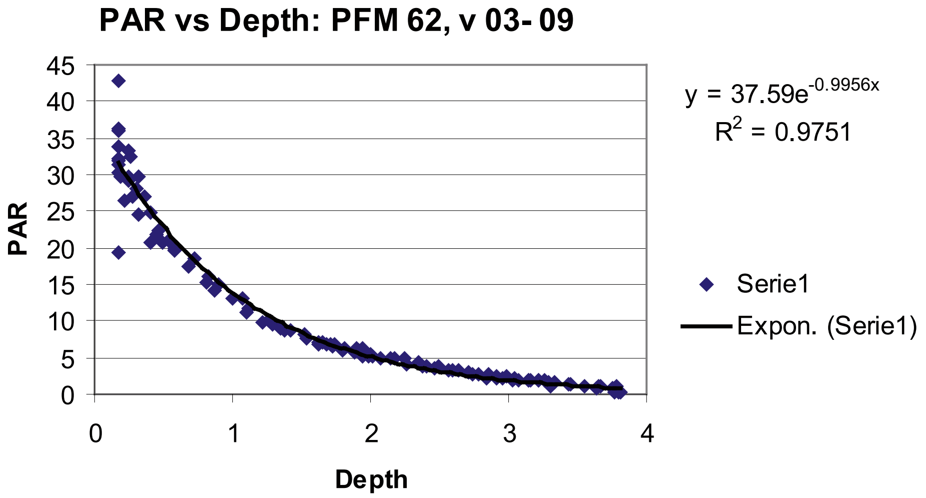
Idcode	Start date yyyy/mm/dd hh:mm	Stop date yyyy/mm/dd hh:mm	Measured depth (m)	Water depth (m)	Sno	Temp. (°C)	pH	EC (mS/m)	Salinity (per mill)	Turb* (NTU)	Light (µmol/m^{2}s)	O_2 diss. (mg/l)	Chloro-phyll (ug/l)	ORP (mV)	Atm. Pres-sure (hPa)
PFM000117	2009-11-03 07:30	2009-11-03 15:30	1.5	2.20		3.9	8.18	25.3	0.12	–1.1	40.8	12.70	5.1	255	1,007.8
PFM000117	2009-12-01 07:30	2009-12-01 18:00	0.5	2.40	16620	3.4	8.03	26.2	0.12	–1.2	4.3	11.86	4.0	225	1,000.2
PFM000117	2009-12-01 07:30	2009-12-01 18:00	1.0	2.40		3.4	8.03	26.2	0.12	–1.2	2.4	11.80	3.7	232	1,000.2
PFM000117	2009-12-01 07:30	2009-12-01 18:00	1.5	2.40		3.4	8.04	26.2	0.12	–1.2	1.2	11.81	3.4	235	1,000.3
PFM102269	2009-01-13 08:00	2009-01-13 20:00	0.5		16170	11.0	7.91	874.2	4.90	–0.3	0.5	14.34	0.2	121	996.1
PFM102269	2009-02-09 09:30	2009-02-09 21:00	0.5		16194	11.0	7.80	913.7	5.13	0.3	1.1	13.03	1.5	430	996.3
PFM102269	2009-03-09 09:00	2009-03-09 21:00	0.5		16222	11.0	7.86	904.5	5.08	–1.0	12.2	14.07	1.3	82	1,001.4
PFM102269	2009-04-14 08:00	2009-04-14 19:00	0.5		16243	12.0	8.25	879.1	4.93	–0.8	452.3	15.23	2.2	276	1,019.2
PFM102269	2009-05-12 08:30	2009-05-12 12:00	0.5		16266	17.2	8.07	877.8	4.92	–0.5	794.9	12.13	1.1	196	1,025.1
PFM102269	2009-06-16 07:30	2009-06-16 15:00	0.5		16316	21.5	7.82	874.2	4.89	–0.1	446.0	9.82	1.1	166	1,012.4
PFM102269	2009-08-11 07:00	2009-08-11 16:00	0.5		16338	20.2	8.10	874.0	4.89	–1.4	102.9	9.70	0.6	12	1,008.6
PFM102269	2009-09-01 07:30	2009-09-01 15:00	0.5		16378	11.8	7.72	907.0	5.10	–0.9	157.9	10.40	–0.7	71	1,011.9
PFM102269	2009-10-06 08:00	2009-10-06 16:00	0.5		16390	18.8	7.98	859.4	4.81	–0.2	135.3	10.19	–0.1	111	1,013.0
PFM102269	2009-11-02 09:30	2009-11-02 18:30	0.5		16597	16.2	7.83	887.4	4.98	–0.9	3.3	11.18	3.1	259	1,007.6
PFM102269	2009-12-01 07:30	2009-12-01 18:00	0.5		16614	14.6	7.66	894.0	5.02	–1.1	34.1	10.84	0.7	162	1,004.8

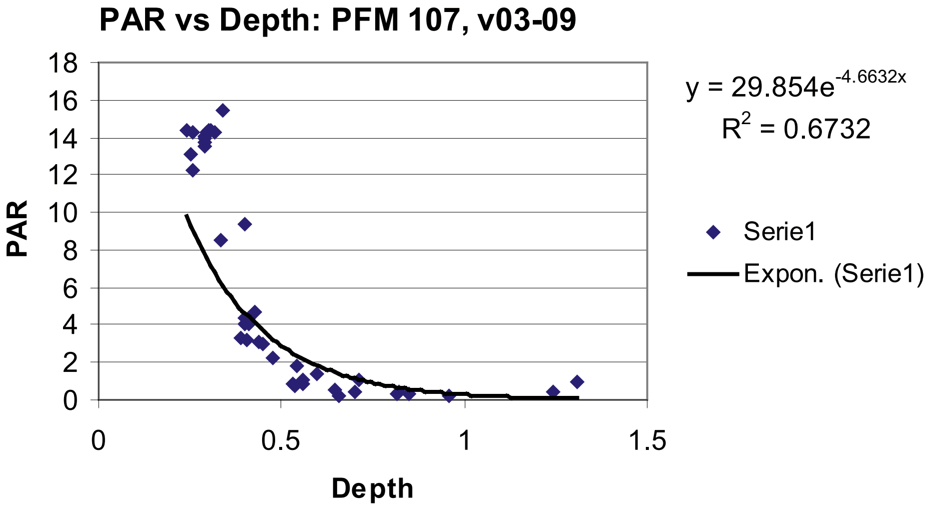
Sno = Corresponding water sample no.
EC = Electrical conductivity.
NTU = Nephelometric Turbidiy Unit.
ORP = Oxidising Reducing Potential.
* Measurements with low reliability.

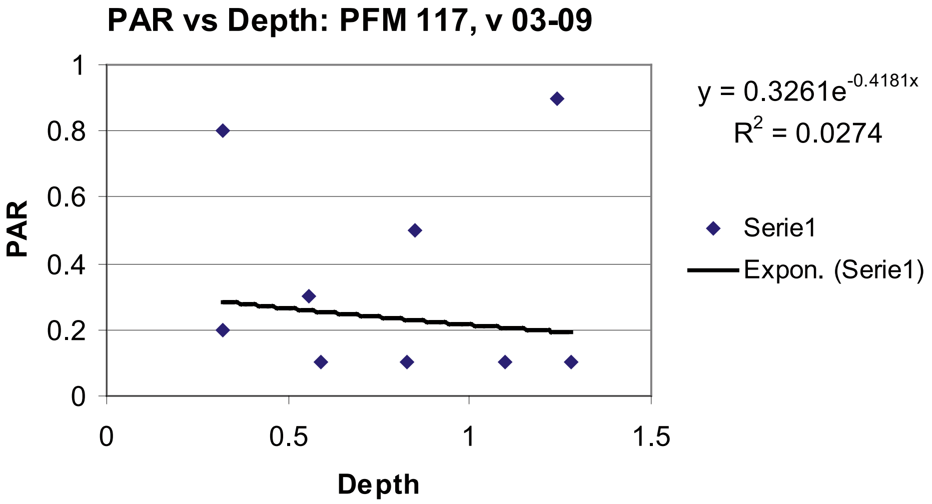
Appendix 11

PAR-profile logs

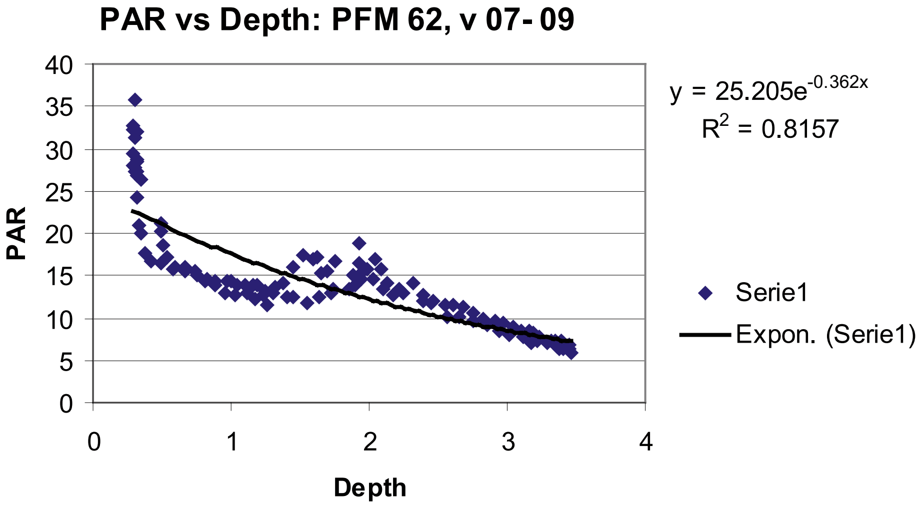
Week 3, 2009

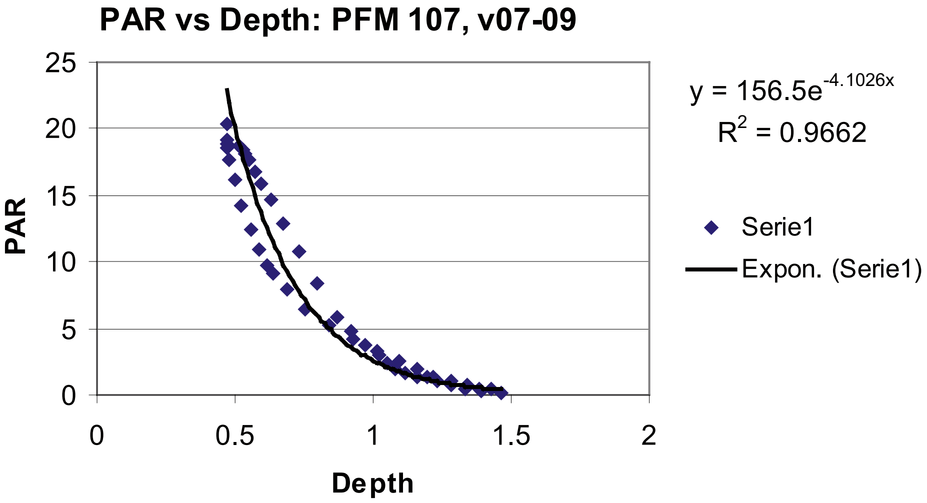


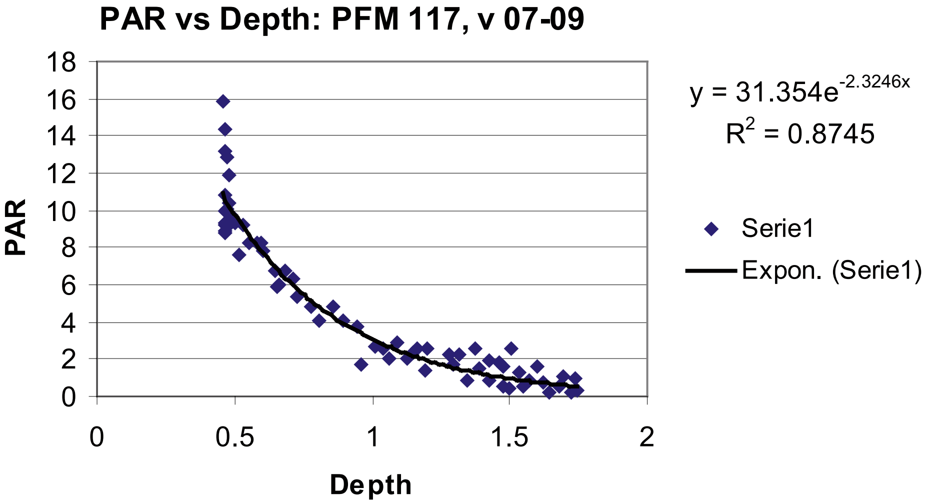




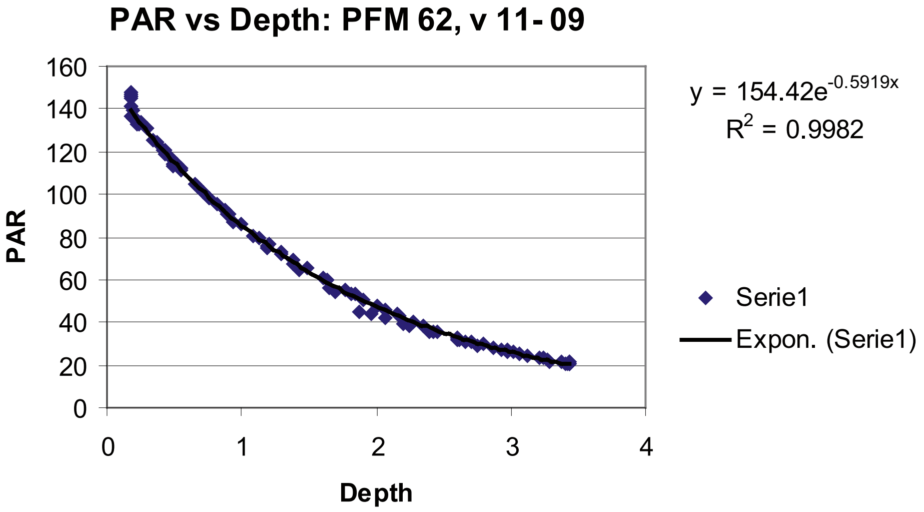
Week 7, 2009

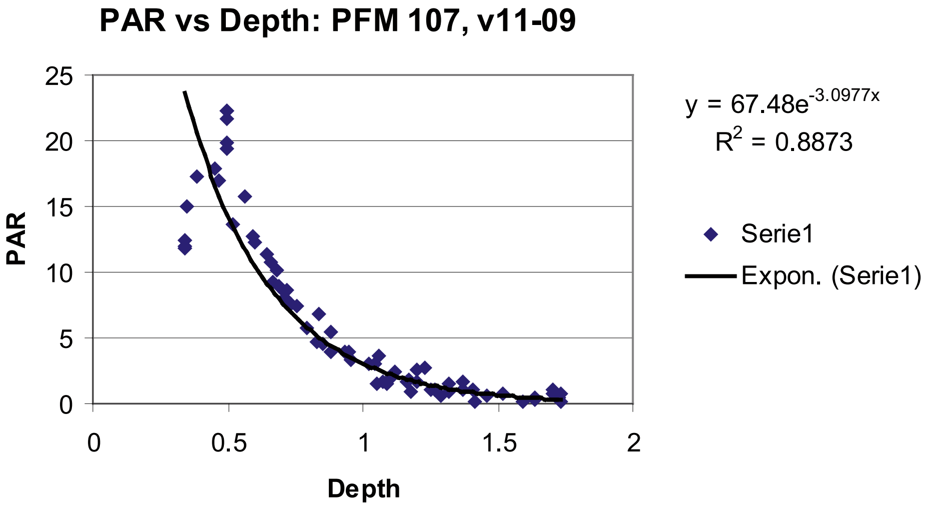

PAR vs Depth: PFM 62, v 07- 09

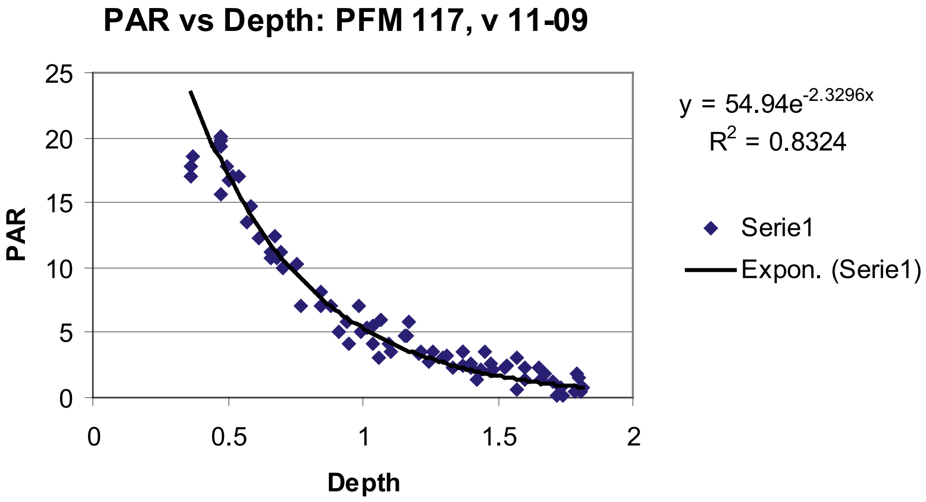

PAR vs Depth: PFM 107, v07-09


PAR vs Depth: PFM 117, v 07-09

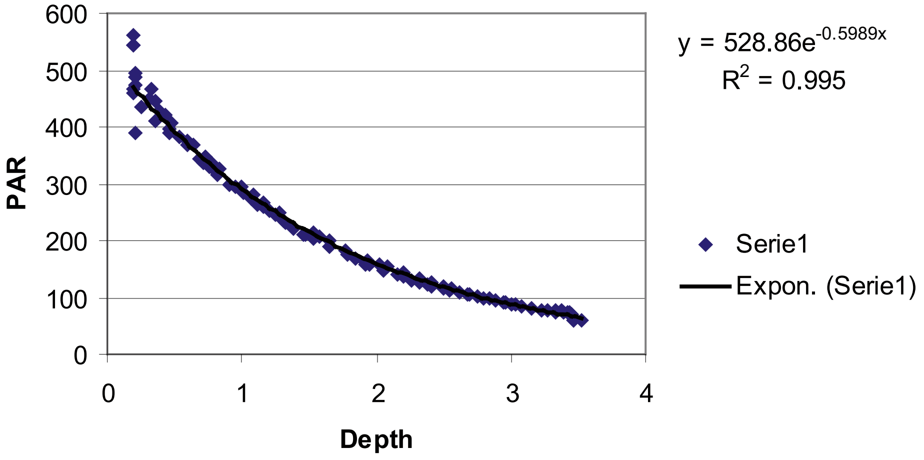
Week 11, 2009

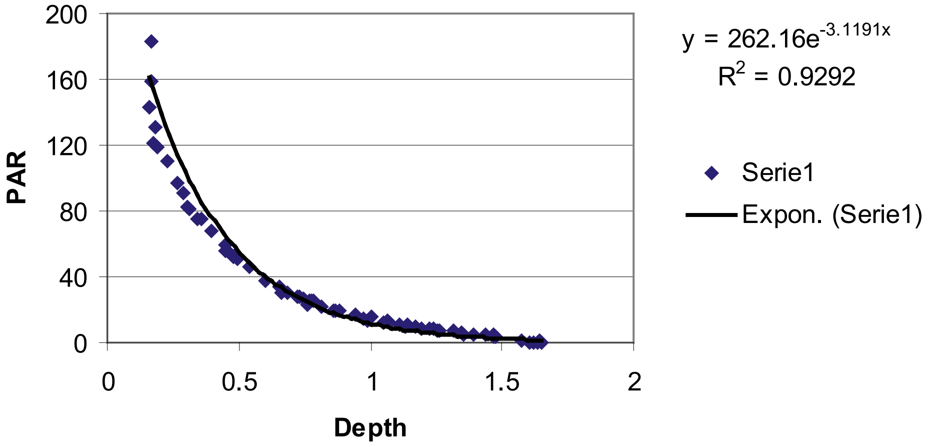

PAR vs Depth: PFM 62, v 11- 09

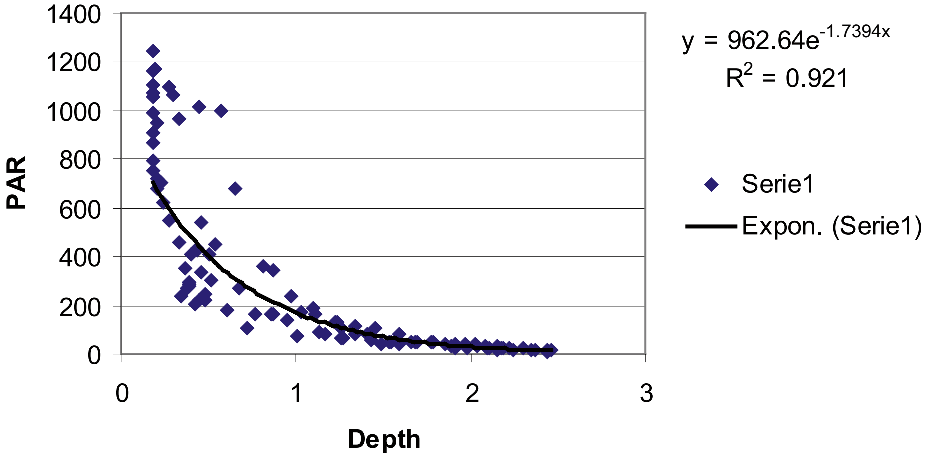

PAR vs Depth: PFM 107, v11-09


PAR vs Depth: PFM 117, v 11-09

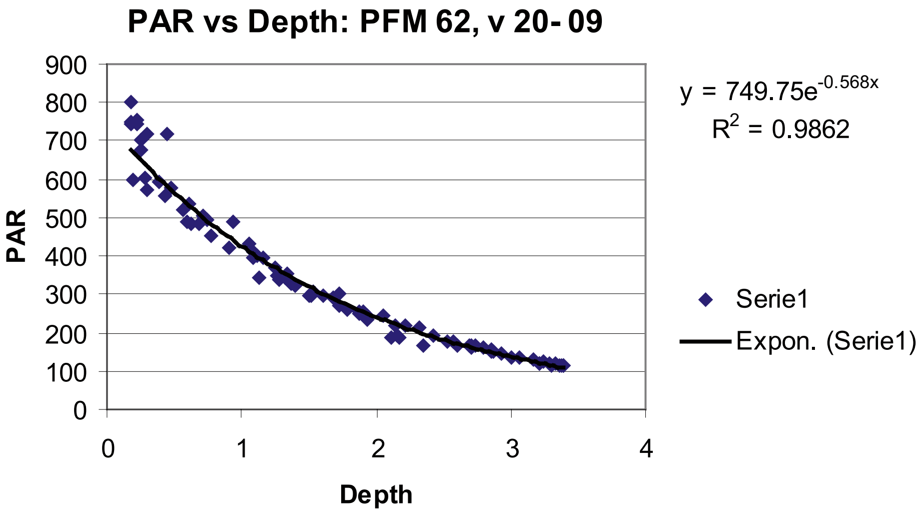
Week 16, 2009

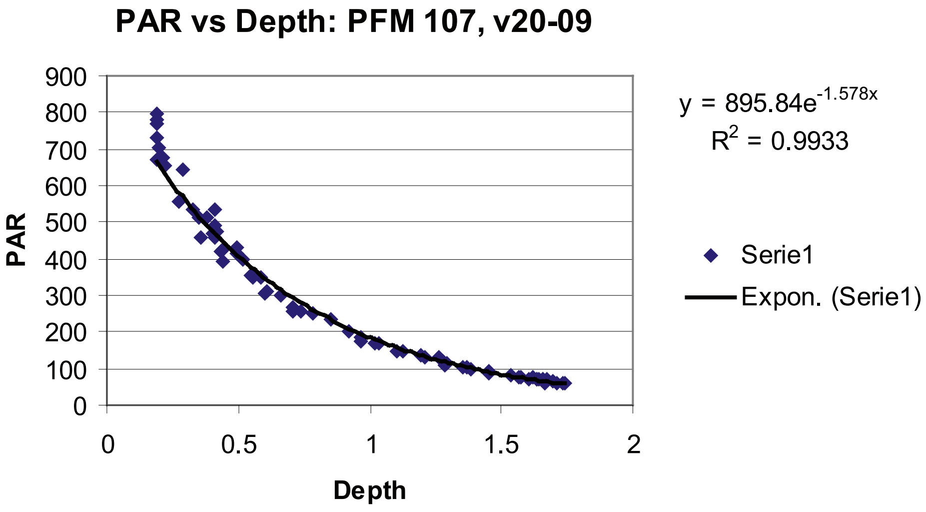

PAR vs Depth: PFM 62, v 16- 09

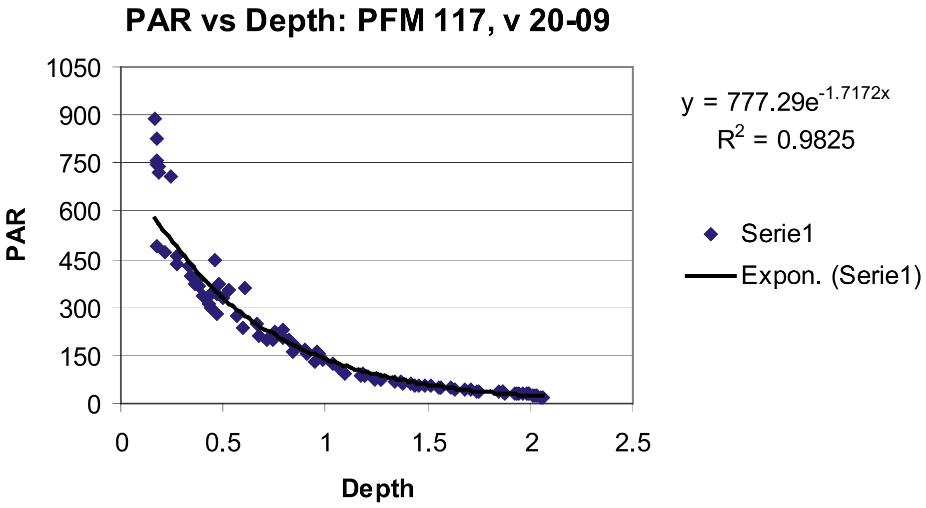

PAR vs Depth: PFM 107, v16-09


PAR vs Depth: PFM 117, v 16-09

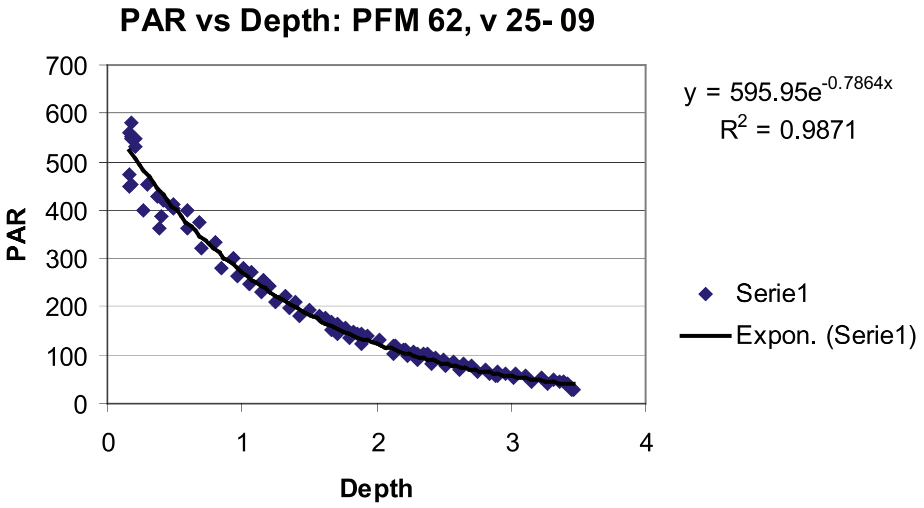
Week 20, 2009

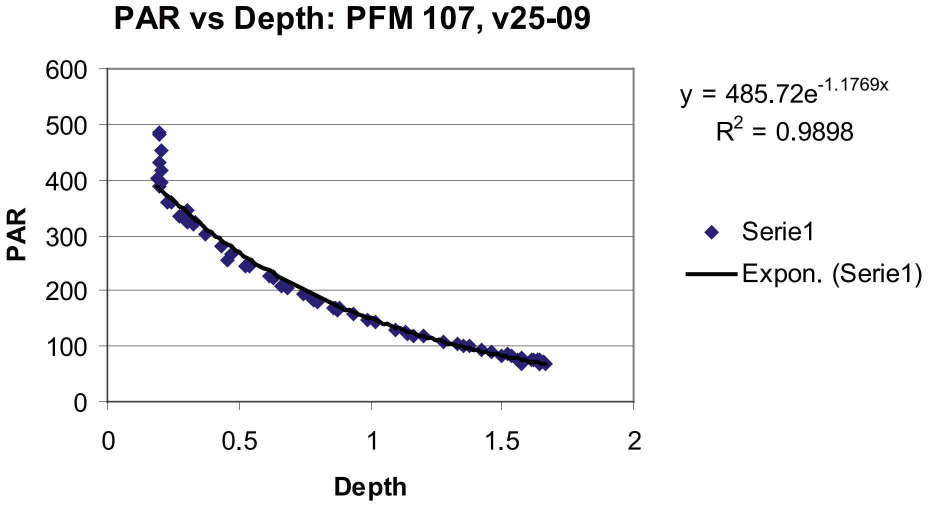

PAR vs Depth: PFM 62, v 20- 09
y = 749.75e$^{-0.568x}$
R^2 = 0.9862
PAR
900
800
700
600
500
400
300
200
100
0
0
1
2
3
4
Depth
Serie1
Expon. (Serie1)

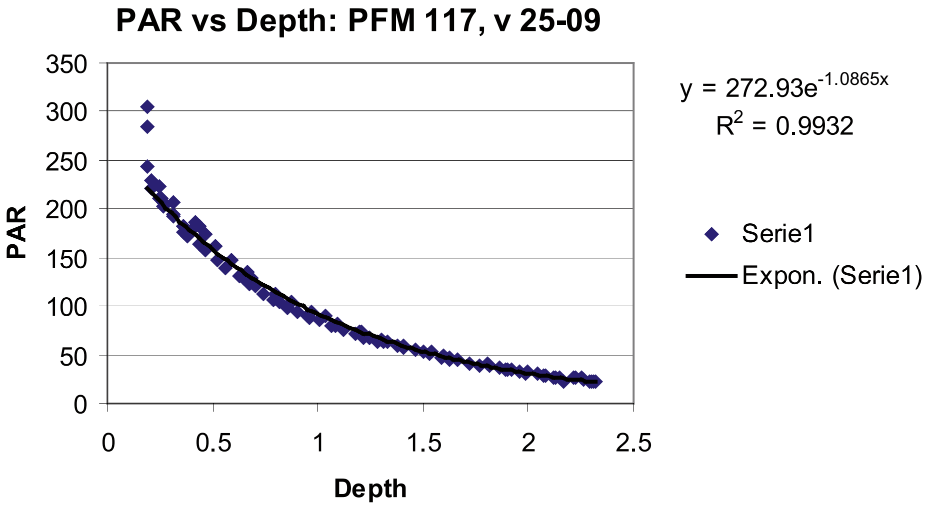

PAR vs Depth: PFM 107, v20-09
y = 895.84e$^{-1.578x}$
R^2 = 0.9933
PAR
900
800
700
600
500
400
300
200
100
0
0
0.5
1
1.5
2
Depth
Serie1
Expon. (Serie1)


PAR vs Depth: PFM 117, v 20-09
y = 777.29e$^{-1.7172x}$
R^2 = 0.9825
PAR
1050
900
750
600
450
300
150
0
0
0.5
1
1.5
2
2.5
Depth
Serie1
Expon. (Serie1)

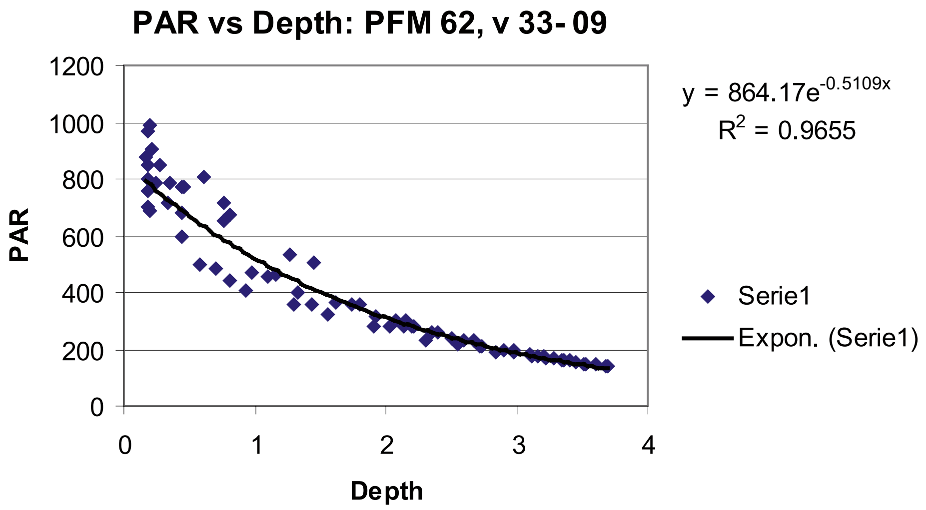
Week 25, 2009

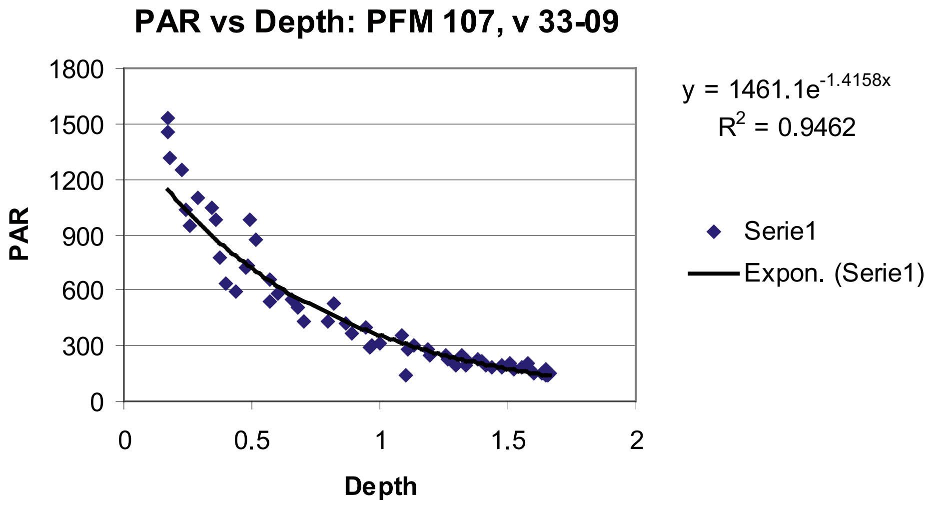

PAR vs Depth: PFM 62, v 25- 09

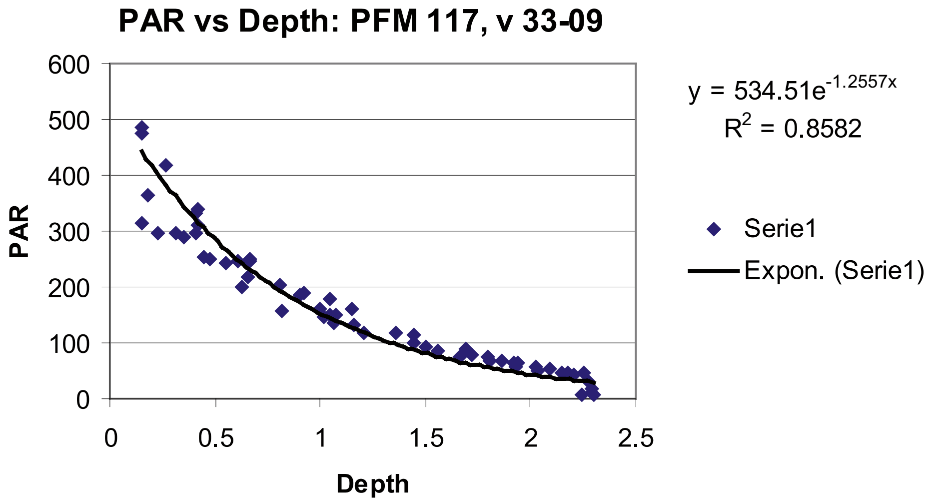

PAR vs Depth: PFM 107, v25-09


PAR vs Depth: PFM 117, v 25-09

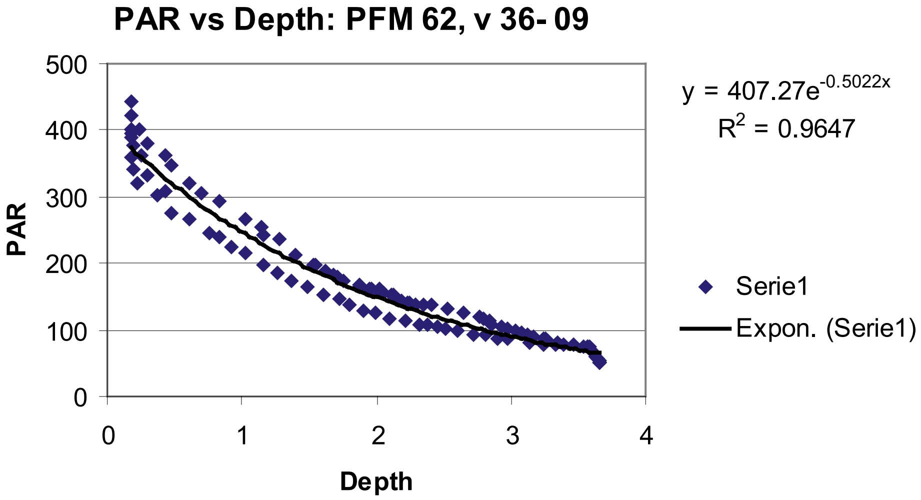
Week 33, 2009

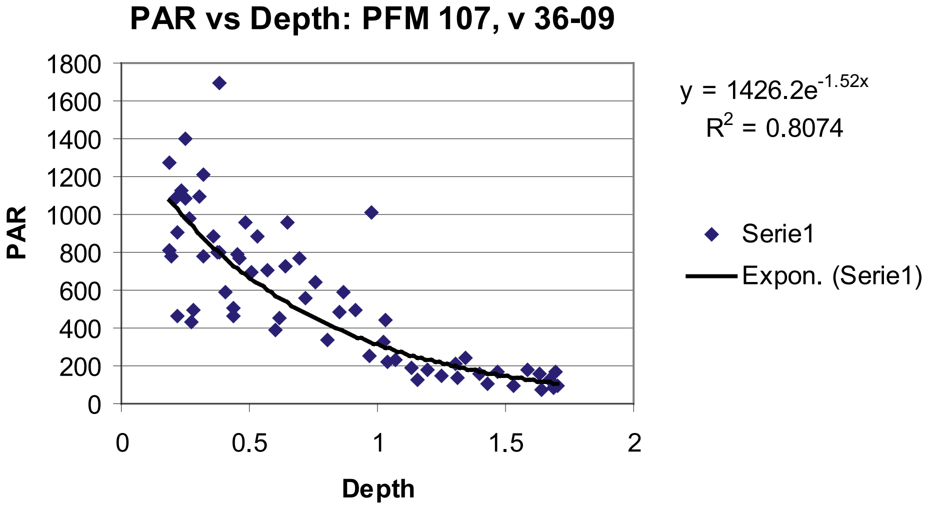

PAR vs Depth: PFM 62, v 33- 09
PAR
Depth
1200
1000
800
600
400
200
0
0
1
2
3
4
y = 864.17e^-0.5109x
R^2 = 0.9655
Serie1
Expon. (Serie1)

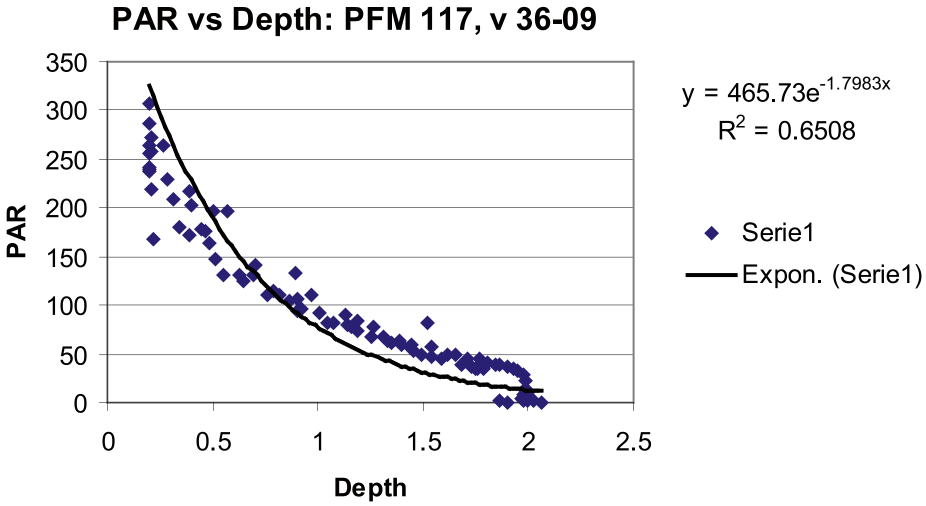

PAR vs Depth: PFM 107, v 33-09
PAR
Depth
1800
1500
1200
900
600
300
0
0
0.5
1
1.5
2
y = 1461.1e^-1.4158x
R^2 = 0.9462
Serie1
Expon. (Serie1)


PAR vs Depth: PFM 117, v 33-09
PAR
Depth
600
500
400
300
200
100
0
0
0.5
1
1.5
2
2.5
y = 534.51e^-1.2557x
R^2 = 0.8582
Serie1
Expon. (Serie1)

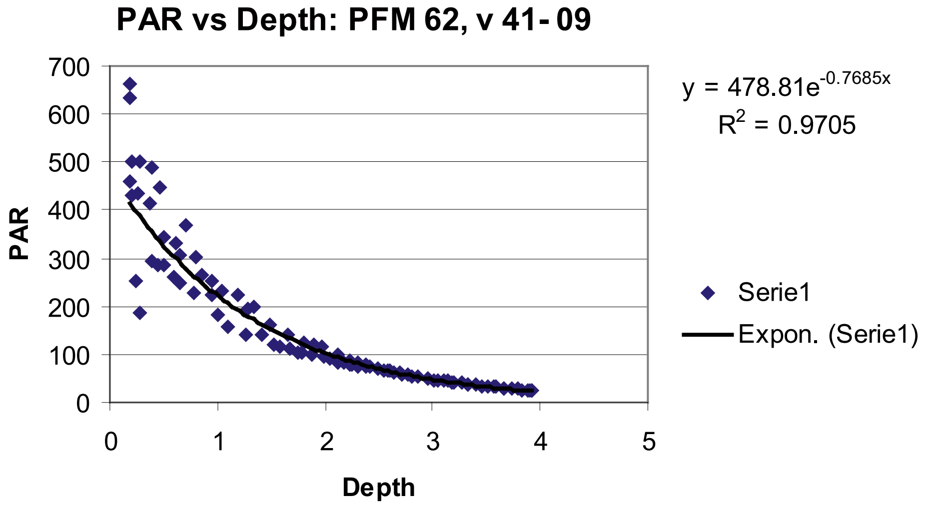
Week 36, 2009

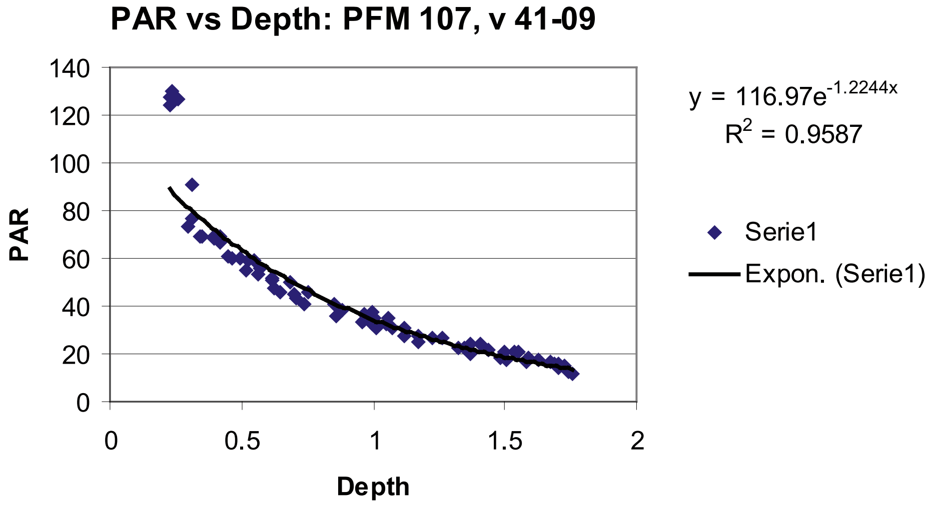

PAR vs Depth: PFM 62, v 36- 09
500
400
300
200
100
0
PAR
0
1
2
3
4
Depth
$y = 407.27e^{-0.5022x}$
$R^2 = 0.9647$
Serie1
Expon. (Serie1)

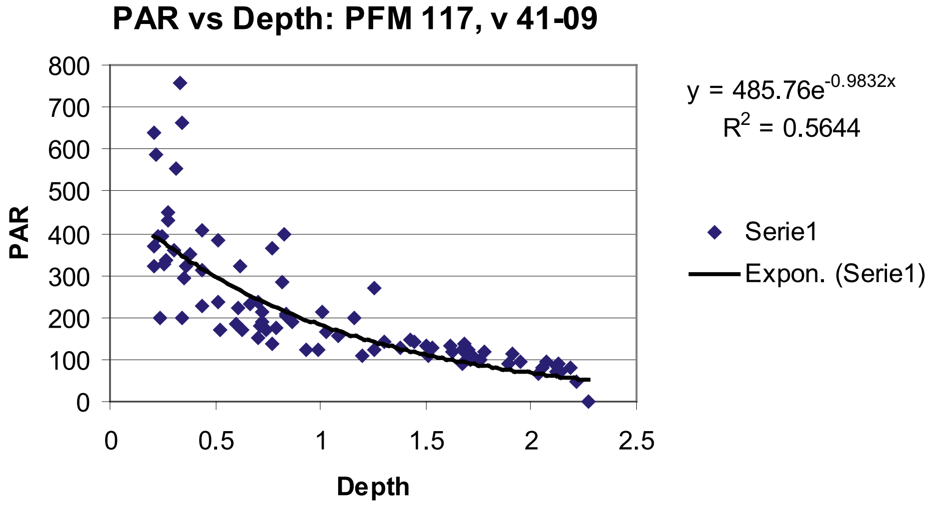

PAR vs Depth: PFM 107, v 36-09
1800
1600
1400
1200
1000
800
600
400
200
0
PAR
0
0.5
1
1.5
2
Depth
$y = 1426.2e^{-1.52x}$
$R^2 = 0.8074$
Serie1
Expon. (Serie1)


PAR vs Depth: PFM 117, v 36-09
350
300
250
200
150
100
50
0
PAR
0
0.5
1
1.5
2
2.5
Depth
$y = 465.73e^{-1.7983x}$
$R^2 = 0.6508$
Serie1
Expon. (Serie1)

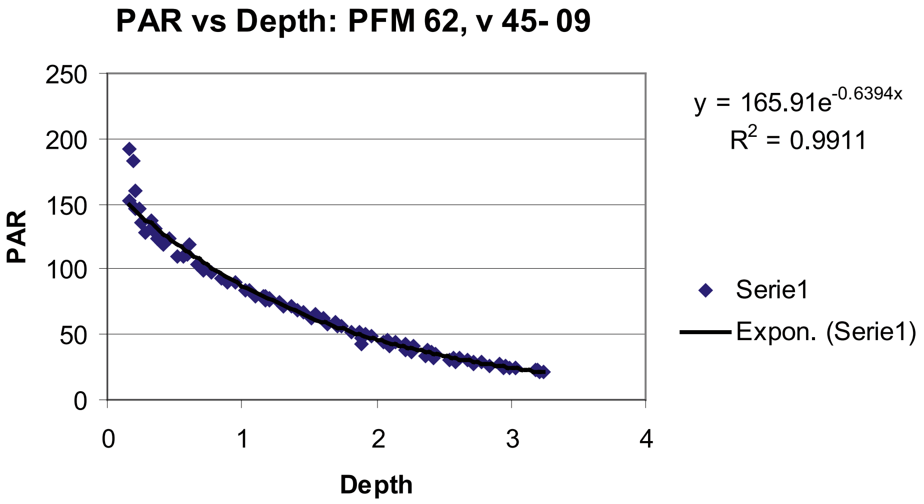
Week 41, 2009

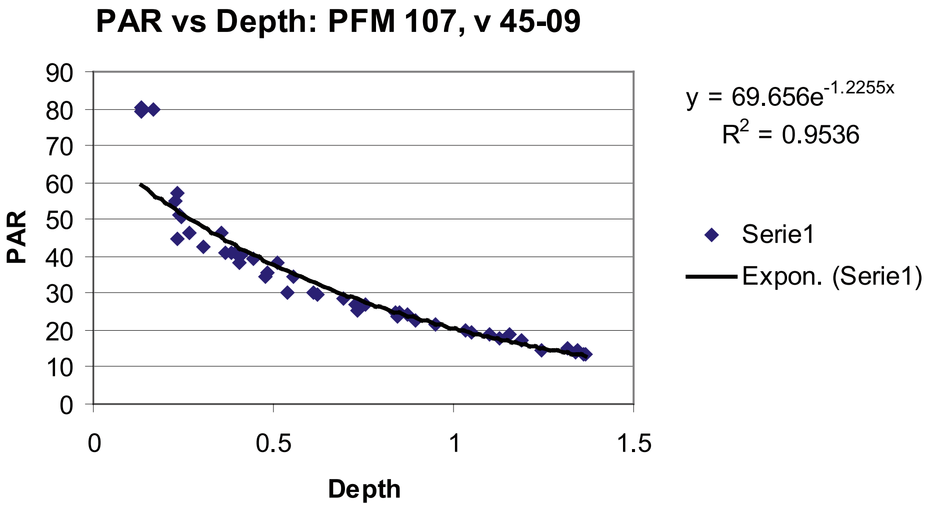

PAR vs Depth: PFM 62, v 41- 09
700
600
500
400
300
200
100
0
PAR
0
1
2
3
4
5
Depth
$y = 478.81e^{-0.7685x}$
$R^2 = 0.9705$
Serie1
Expon. (Serie1)

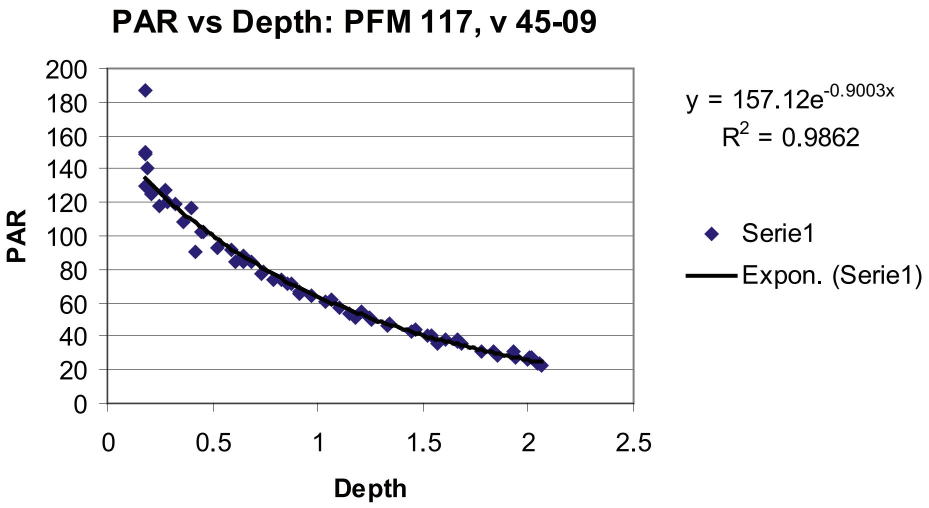

PAR vs Depth: PFM 107, v 41-09
140
120
100
80
60
40
20
0
PAR
0
0.5
1
1.5
2
Depth
$y = 116.97e^{-1.2244x}$
$R^2 = 0.9587$
Serie1
Expon. (Serie1)


PAR vs Depth: PFM 117, v 41-09
800
700
600
500
400
300
200
100
0
PAR
0
0.5
1
1.5
2
2.5
Depth
$y = 485.76e^{-0.9832x}$
$R^2 = 0.5644$
Serie1
Expon. (Serie1)

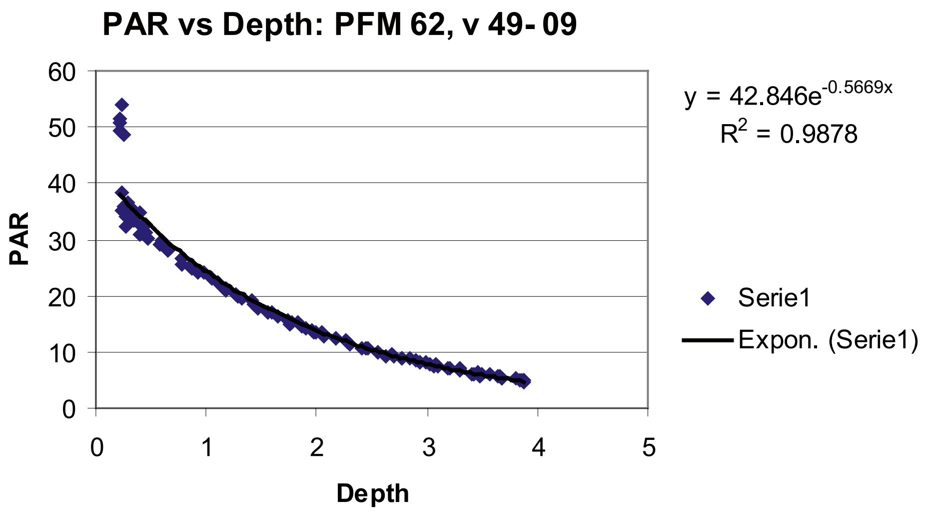
Week 45, 2009

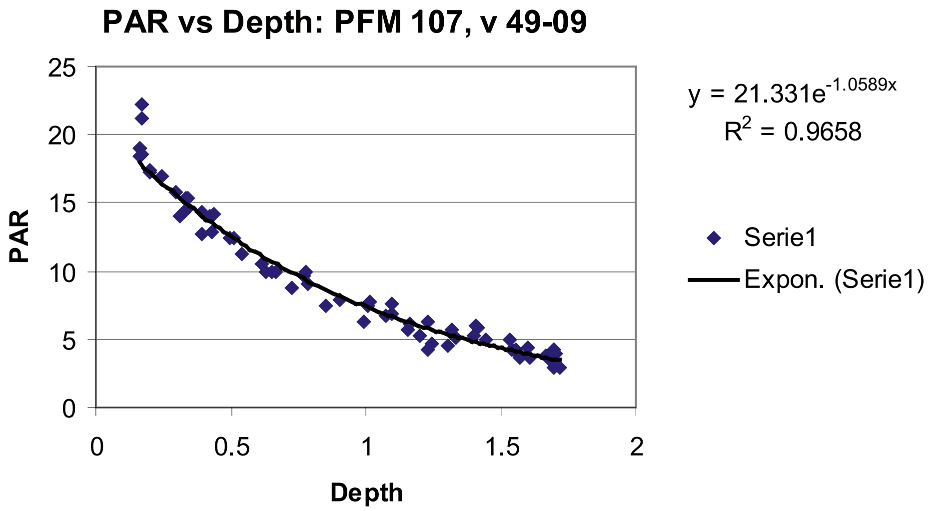

PAR vs Depth: PFM 62, v 45- 09
250
200
150
100
50
0
PAR
0
1
2
3
4
Depth
y = 165.91e$^{-0.6394x}$
R^2 = 0.9911
Serie1
Expon. (Serie1)

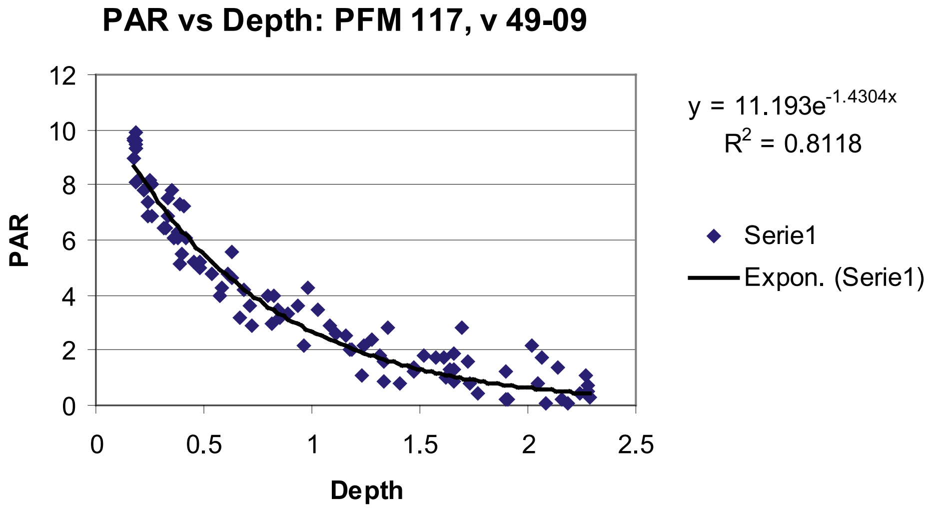

PAR vs Depth: PFM 107, v 45-09
90
80
70
60
50
40
30
20
10
0
PAR
0
0.5
1
1.5
Depth
y = 69.656e$^{-1.2255x}$
R^2 = 0.9536
Serie1
Expon. (Serie1)


PAR vs Depth: PFM 117, v 45-09
200
180
160
140
120
100
80
60
40
20
0
PAR
0
0.5
1
1.5
2
2.5
Depth
y = 157.12e$^{-0.9003x}$
R^2 = 0.9862
Serie1
Expon. (Serie1)

Week 49, 2009


PAR vs Depth: PFM 62, v 49- 09


PAR vs Depth: PFM 107, v 49-09


PAR vs Depth: PFM 117, v 49-09

Water flow measurements

Idcode	Start date	Stop date	Simple flow rate (m^3/s)	Code
PFM000062	2009-01-13 08:00	2009-01-13 20:00		N
PFM000062	2009-02-09 09:30	2009-02-09 21:00		N
PFM000062	2009-03-09 09:00	2009-03-09 21:00		N
PFM000062	2009-04-14 08:00	2009-04-14 19:00		N
PFM000062	2009-05-11 08:30	2009-05-11 21:00		N
PFM000062	2009-06-15 09:00	2009-06-15 21:00		N
PFM000062	2009-08-10 09:00	2009-08-10 21:00		N
PFM000062	2009-09-01 07:30	2009-09-01 15:00		N
PFM000062	2009-10-05 09:00	2009-10-05 21:00		N
PFM000062	2009-11-02 09:30	2009-11-02 18:30		N
PFM000062	2009-11-30 09:00	2009-11-30 17:30		N
PFM000066	2009-01-13 08:00	2009-01-13 20:00		C
PFM000066	2009-02-09 09:30	2009-02-09 21:00		C
PFM000066	2009-03-09 09:00	2009-03-09 21:00		C
PFM000066	2009-04-14 08:00	2009-04-14 19:00	0.10	L
PFM000066	2009-05-11 08:30	2009-05-11 21:00	0.03	L
PFM000066	2009-06-15 09:00	2009-06-15 21:00	0.04	L
PFM000066	2009-08-11 07:00	2009-08-11 16:00		F
PFM000066	2009-09-01 07:30	2009-09-01 15:00		F
PFM000066	2009-10-06 08:00	2009-10-06 16:00		F
PFM000066	2009-11-03 07:30	2009-11-03 15:30		F
PFM000066	2009-12-01 07:30	2009-12-01 18:00	0.04	L
PFM000068	2009-01-13 08:00	2009-01-13 20:00		C
PFM000068	2009-02-09 09:30	2009-02-09 21:00		C
PFM000068	2009-03-09 09:00	2009-03-09 21:00		C
PFM000068	2009-04-14 08:00	2009-04-14 19:00	0.12	L
PFM000068	2009-05-11 08:30	2009-05-11 21:00	0.02	L
PFM000068	2009-06-15 09:00	2009-06-15 21:00	0.10	L
PFM000068	2009-08-11 07:00	2009-08-11 16:00		B
PFM000068	2009-08-31 09:30	2009-08-31 19:30		F
PFM000068	2009-10-05 09:00	2009-10-05 21:00		F
PFM000068	2009-11-02 09:30	2009-11-02 18:30		F
PFM000068	2009-11-30 09:00	2009-11-30 17:30	0.08	L
PFM000069	2009-01-13 08:00	2009-01-13 20:00	0.05	L
PFM000069	2009-02-09 09:30	2009-02-09 21:00		C
PFM000069	2009-03-09 09:00	2009-03-09 21:00		C
PFM000069	2009-04-14 08:00	2009-04-14 19:00	0.11	L
PFM000069	2009-05-11 08:30	2009-05-11 21:00	0.03	L
PFM000069	2009-06-15 09:00	2009-06-15 21:00	0.04	L
PFM000069	2009-08-11 07:00	2009-08-11 16:00	0.02	L
PFM000069	2009-08-31 09:30	2009-08-31 19:30	0.02	L
PFM000069	2009-10-05 09:00	2009-10-05 21:00		F
PFM000069	2009-11-02 09:30	2009-11-02 18:30		F
PFM000069	2009-11-30 09:00	2009-11-30 17:30	0.03	L
PFM000070	2009-01-12 09:00	2009-01-12 19:00	0.06	L
PFM000070	2009-02-09 09:30	2009-02-09 21:00		C
PFM000070	2009-03-09 09:00	2009-03-09 21:00		C
PFM000070	2009-04-14 08:00	2009-04-14 19:00	0.06	L
PFM000070	2009-05-11 08:30	2009-05-11 21:00		F
PFM000070	2009-06-15 09:00	2009-06-15 21:00	0.03	L

Idcode	Start date	Stop date	Simple flow rate (m^3/s)	Code
PFM000070	2009-08-10 09:00	2009-08-10 21:00		B
PFM000070	2009-08-31 09:30	2009-08-31 19:30		B
PFM000070	2009-10-06 08:00	2009-10-06 16:00		F
PFM000070	2009-11-02 09:30	2009-11-02 18:30		F
PFM000070	2009-11-30 09:00	2009-11-30 17:30	0.03	L
PFM000074	2009-01-13 08:00	2009-01-13 20:00		N
PFM000074	2009-02-10 08:00	2009-02-10 15:30		N
PFM000074	2009-03-10 08:00	2009-03-10 17:00		N
PFM000074	2009-04-15 08:00	2009-04-15 18:00		N
PFM000074	2009-05-12 08:30	2009-05-12 12:00		N
PFM000074	2009-06-16 07:30	2009-06-16 15:00		N
PFM000074	2009-08-11 07:00	2009-08-11 16:00		N
PFM000074	2009-08-31 09:30	2009-08-31 19:30		N
PFM000074	2009-10-06 08:00	2009-10-06 16:00		N
PFM000074	2009-11-03 07:30	2009-11-03 15:30		N
PFM000074	2009-12-01 07:30	2009-12-01 18:00		N
PFM000097	2009-01-13 08:00	2009-01-13 20:00		N
PFM000097	2009-02-10 08:00	2009-02-10 15:30		N
PFM000097	2009-03-09 09:00	2009-03-09 21:00		N
PFM000097	2009-04-15 08:00	2009-04-15 18:00		N
PFM000097	2009-05-12 08:30	2009-05-12 12:00		N
PFM000097	2009-06-16 07:30	2009-06-16 15:00		N
PFM000097	2009-08-11 07:00	2009-08-11 16:00		N
PFM000097	2009-09-01 07:30	2009-09-01 15:00		N
PFM000097	2009-10-06 08:00	2009-10-06 16:00		N
PFM000097	2009-11-03 07:30	2009-11-03 15:30		N
PFM000097	2009-12-01 07:30	2009-12-01 18:00		N
PFM000107	2009-01-12 09:00	2009-01-12 19:00		N
PFM000107	2009-02-09 09:30	2009-02-09 21:00		N
PFM000107	2009-03-09 09:00	2009-03-09 21:00		N
PFM000107	2009-04-13 13:00	2009-04-13 19:00		N
PFM000107	2009-05-11 08:30	2009-05-11 21:00		N
PFM000107	2009-06-15 09:00	2009-06-15 21:00		N
PFM000107	2009-08-10 09:00	2009-08-10 21:00		N
PFM000107	2009-08-31 09:30	2009-08-31 19:30		N
PFM000107	2009-10-05 09:00	2009-10-05 21:00		N
PFM000107	2009-11-02 09:30	2009-11-02 18:30		N
PFM000107	2009-11-30 09:00	2009-11-30 17:30		N
PFM000117	2009-01-12 09:00	2009-01-12 19:00		N
PFM000117	2009-02-10 08:00	2009-02-10 15:30		N
PFM000117	2009-03-10 08:00	2009-03-10 17:00		N
PFM000117	2009-04-14 08:00	2009-04-14 19:00		N
PFM000117	2009-05-11 08:30	2009-05-11 21:00		N
PFM000117	2009-06-15 09:00	2009-06-15 21:00		N
PFM000117	2009-08-10 09:00	2009-08-10 21:00		N
PFM000117	2009-08-31 09:30	2009-08-31 19:30		N
PFM000117	2009-10-05 09:00	2009-10-05 21:00		N
PFM000117	2009-11-03 07:30	2009-11-03 15:30		N
PFM000117	2009-12-01 07:30	2009-12-01 18:00		N
PFM102269	2009-01-13 08:00	2009-01-13 20:00		N
PFM102269	2009-02-09 09:30	2009-02-09 21:00		N
PFM102269	2009-03-09 09:00	2009-03-09 21:00		N
PFM102269	2009-04-14 08:00	2009-04-14 19:00		N
PFM102269	2009-05-12 08:30	2009-05-12 12:00		N

Idcode	Start date	Stop date	Simple flow rate (m^3/s)	Code
PFM102269	2009-06-16 07:30	2009-06-16 15:00		N
PFM102269	2009-08-11 07:00	2009-08-11 16:00		K
PFM102269	2009-09-01 07:30	2009-09-01 15:00		N
PFM102269	2009-10-06 08:00	2009-10-06 16:00		N
PFM102269	2009-11-02 09:30	2009-11-02 18:30		N
PFM102269	2009-12-01 07:30	2009-12-01 18:00		N

Simple flow rate = based on simple “floating bottle” method.

Code	Code description
A	Blocked flow; no measurement
B	Too much water vegetation, no measurement
C	Water completely frosen, no measurement
D	Too much ice, no measurement
E	Flow rate too high, no measurement
F	Flow rate too low, no measurement
G	Dry conditions, no measurements
H	Measurement not possible, estimated value
I	Measurement not possible, see protocol
K	Comment missing
L	Flow rate value available
M	Low water level
N	Lake, Sea, no measurement
O	Too much wind, no measurement
P	Stationary water

Appendix 13

Compilation of water analysis data, surface waters

Table A13-1. Water composition.

Idcode	Sample no.	Depth (m)	Sampling date (yyyy/mm/dd)	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)	SO_4-S (mg/L)	Br (mg/L)	F^- (mg/L)	Si (mg/L)	Fe (mg/L)	Mn (mg/L)
PFM000062	16192	0.51	2009-01-13	<4.94	1,430.0	53.40	71.8	170.00	79.20	2,820.0	382.00	138.00	9.730	0.32	0.97	0.0113	0.00317
PFM000062	16197	0.56	2009-02-09	<3.21	1,500.0	55.90	75.8	181.00	80.60	2,850.0	379.00	147.00	9.530	0.34	0.92	–	–
PFM000062	16213	0.50	2009-03-09	<1.25	1,570.0	59.40	83.6	191.00	80.40	2,860.0	399.00	158.00	9.660	0.36	1.03	–	–
PFM000062	16244	0.50	2009-04-14	0.66	1,590.0	58.40	75.5	182.00	78.70	2,750.0	403.00	148.00	9.710	0.42	0.40	0.0072	0.00496
PFM000062	16258	0.50	2009-05-11	<1.83	1,510.0	60.00	74.4	183.00	79.40	2,780.0	359.00	150.00	9.250	0.35	0.34	–	–
PFM000062	16317	0.50	2009-06-15	<0.92	1,510.0	61.10	74.8	184.00	75.50	2,730.0	392.00	150.00	9.050	0.30	0.25	–	–
PFM000062	16343	0.50	2009-08-10	<4.08	1,460.0	60.60	73.0	179.00	76.90	2,840.0	388.00	145.00	9.330	0.33	0.59	0.0053	0.00902
PFM000062	16385	0.50	2009-09-01	<3.43	1,470.0	54.60	78.6	182.00	78.60	2,810.0	395.00	153.00	9.870	0.29	0.65	–	–
PFM000062	16391	0.50	2009-10-05	<4.73	1,370.0	49.50	73.0	173.00	75.40	2,720.0	376.00	136.00	8.750	0.33	0.62	0.0032	0.00122
PFM000062	16589	0.50	2009-11-02	<0.84	1,600.0	63.10	78.1	184.00	78.30	2,890.0	384.00	142.00	9.350	0.32	0.70	–	–
PFM000062	16615	0.50	2009-11-30	<2.84	1,490.0	55.00	75.1	179.00	79.70	2,800.0	401.00	148.00	9.470	0.31	0.78	–	–
PFM000066	16193	0.30	2009-01-13	3.29	4.7	2.39	77.7	3.75	238.00	4.8	4.35	1.93	0.062	0.29	6.47	0.3070	0.13800
PFM000066	16201	0.20	2009-02-09	1.83	7.0	2.77	91.7	4.58	289.00	7.8	5.76	2.61	0.084	0.28	7.67	–	–
PFM000066	16220	0.20	2009-03-09	1.07	7.2	3.12	96.5	4.85	312.00	8.0	4.79	2.13	0.110	0.33	8.28	–	–
PFM000066	16250	0.37	2009-04-14	3.16	3.6	2.11	48.4	2.50	151.00	3.0	3.02	1.42	0.040	0.24	4.20	0.1070	0.01500
PFM000066	16262	0.25	2009-05-11	3.25	5.5	2.80	72.4	3.64	226.00	4.8	3.76	1.66	0.064	0.29	3.68	–	–
PFM000066	16323	0.35	2009-06-15	4.59	4.7	2.06	60.2	3.09	180.00	3.5	5.13	2.29	0.053	0.25	3.94	–	–
PFM000066	16342	0.15	2009-08-11	2.15	5.2	1.43	67.6	3.35	215.00	4.0	2.85	1.56	0.066	0.28	5.56	0.2350	0.02470
PFM000066	16386	0.18	2009-09-01	6.40	5.3	1.26	72.0	3.37	208.00	3.9	3.46	1.57	0.066	0.31	6.30	–	–
PFM000066	16397	0.28	2009-10-06	2.96	5.6	1.61	66.8	3.46	208.00	4.8	4.70	1.88	0.063	0.29	6.83	0.1450	0.02180
PFM000066	16595	0.17	2009-11-03	2.46	5.5	1.76	63.5	3.38	197.00	4.8	6.38	2.76	0.059	0.30	7.07	–	–
PFM000066	16622	0.30	2009-12-01	<1.75	5.0	2.19	58.7	3.10	191.00	5.7	9.86	4.38	0.072	0.28	6.35	–	–
PFM000068	16189	0.48	2009-01-13	3.64	9.4	2.27	58.4	4.27	174.00	14.8	7.34	3.05	0.105	0.29	6.07	0.6080	0.12300
PFM000068	16200	0.47	2009-02-09	1.81	12.0	2.55	74.1	5.16	228.00	19.0	9.93	4.03	0.124	0.33	6.85	–	–
PFM000068	16217	0.43	2009-03-09	1.31	15.8	2.73	77.2	5.82	242.00	25.2	10.50	4.19	0.196	0.32	7.64	–	–
PFM000068	16248	0.58	2009-04-14	2.76	6.8	1.86	41.2	2.99	124.00	10.4	7.28	2.67	0.051	0.22	3.91	0.1570	0.01870
PFM000068	16265	0.56	2009-05-11	3.03	14.6	2.59	60.1	4.94	183.00	21.4	9.00	3.90	0.127	0.35	5.27	–	–
PFM000068	16322	0.70	2009-06-16	6.91	9.6	1.86	42.2	3.44	110.00	13.6	10.50	4.54	0.095	0.29	4.26	–	–
PFM000068	16340	0.39	2009-08-11	1.92	18.4	1.02	61.4	5.40	189.00	30.6	6.89	3.06	0.171	0.38	5.38	0.3660	0.03500
PFM000068	16384	0.41	2009-08-31	3.94	19.2	0.93	63.7	5.67	185.00	32.1	7.44	3.26	0.168	0.40	6.01	–	–
PFM000068	16395	0.42	2009-10-05	1.09	30.5	2.98	65.3	7.48	204.00	54.8	9.98	4.09	0.256	0.38	7.75	0.4470	0.08750
PFM000068	16593	0.37	2009-11-02	0.55	19.0	1.75	58.7	5.70	185.00	32.6	10.10	4.04	0.141	0.35	7.39	–	–
PFM000068	16619	0.55	2009-11-30	0.15	11.0	2.15	50.8	4.01	149.00	17.9	15.30	6.79	0.116	0.32	5.58	–	–
PFM000069	16191	0.18	2009-01-13	4.98	15.5	3.12	81.3	6.14	231.00	25.5	11.50	4.69	0.159	0.36	8.62	0.8290	0.18700
PFM000069	16199	0.20	2009-02-09	3.35	18.0	2.96	90.5	6.73	266.00	29.7	12.50	5.21	0.192	0.38	8.60	–	–

Idcode	Sample no.	Depth (m)	Sampling date (yyyy/mm/dd)	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)	SO$_4$-S (mg/L)	Br (mg/L)	F$^-$ (mg/L)	Si (mg/L)	Fe (mg/L)	Mn (mg/L)
PFM000069	16219	0.18	2009-03-09	1.61	23.2	3.00	89.3	7.30	278.00	39.7	10.80	3.99	0.288	0.40	9.38	–	–
PFM000069	16249	0.30	2009-04-14	3.17	8.9	1.95	44.3	3.35	130.00	13.3	9.71	3.62	0.066	0.24	4.17	0.1000	0.00752
PFM000069	16263	0.18	2009-05-11	2.49	16.6	2.75	59.7	5.22	184.00	24.9	10.30	4.14	0.146	0.37	5.56	–	–
PFM000069	16321	0.28	2009-06-15	3.03	18.0	2.25	51.2	4.93	142.00	30.3	14.70	6.05	0.159	0.32	4.86	–	–
PFM000069	16341	0.24	2009-08-11	1.94	20.1	1.02	61.9	5.71	191.00	33.0	7.26	3.31	0.194	0.39	5.58	0.1880	0.00799
PFM000069	16383	0.25	2009-08-31	3.75	21.1	0.82	64.3	5.95	188.00	35.4	7.34	3.23	0.169	0.37	5.87	–	–
PFM000069	16394	0.26	2009-10-05	0.57	31.5	3.32	66.0	7.92	208.00	57.4	12.00	4.64	0.282	0.38	7.55	0.1420	0.01870
PFM000069	16592	0.17	2009-11-02	0.18	21.4	1.23	59.8	6.05	190.00	38.1	8.50	3.52	0.165	0.37	7.81	–	–
PFM000069	16618	0.16	2009-11-30	–0.76	15.9	1.91	59.6	4.97	178.00	28.9	16.00	6.98	0.150	0.33	7.17	–	–
PFM000070	16188	0.15	2009-01-12	4.90	0.7	<0.4	5.6	0.34	16.60	0.8	0.86	0.21	<0.02	<0.2	0.47	0.0208	0.01160
PFM000070	16198	0.20	2009-02-09	2.21	6.3	2.13	61.5	3.33	191.00	7.1	6.23	2.71	0.056	0.26	5.19	–	–
PFM000070	16218	0.26	2009-03-09	2.06	7.4	2.48	63.2	3.64	199.00	8.1	7.14	2.81	0.062	0.28	5.47	–	–
PFM000070	16247	0.21	2009-04-14	4.39	5.9	2.08	56.2	3.03	170.00	5.5	4.91	2.10	0.045	0.26	4.45	0.1040	0.08640
PFM000070	16261	0.25	2009-05-11	3.67	6.5	2.02	53.7	3.09	167.00	5.8	4.26	1.94	0.045	0.28	2.67	–	–
PFM000070	16320	0.22	2009-06-15	6.12	6.3	1.90	45.3	2.90	133.00	6.1	4.58	2.13	0.042	0.23	1.10	–	–
PFM000070	16339	0.24	2009-08-10	3.87	6.3	1.24	46.9	2.95	146.00	6.2	3.57	1.52	0.063	0.27	3.84	0.1400	0.15600
PFM000070	16382	0.28	2009-08-31	5.40	6.3	1.23	47.4	2.91	142.00	6.2	3.44	1.52	0.047	0.29	3.88	–	–
PFM000070	16396	0.24	2009-10-06	3.08	6.7	1.52	49.8	3.17	158.00	6.6	4.20	1.67	0.045	0.27	4.67	0.1180	0.08720
PFM000070	16591	0.17	2009-11-02	0.89	6.3	1.78	40.3	2.68	132.00	7.1	5.11	2.06	0.035	0.28	4.04	–	–
PFM000070	16617	0.31	2009-11-30	3.90	6.5	2.03	46.6	3.05	145.00	6.3	4.16	1.94	0.065	0.29	2.31	–	–
PFM000074	16190	0.50	2009-01-13	3.24	5.8	2.61	79.8	4.01	243.00	7.3	5.26	2.26	0.066	0.28	6.86	0.1720	0.07090
PFM000074	16212	0.50	2009-02-10	–3.92	18.0	2.66	87.8	4.95	306.00	31.6	5.76	2.82	0.103	0.32	8.36	–	–
PFM000074	16230	0.50	2009-03-10	2.62	8.9	3.21	98.8	5.16	307.00	11.3	5.26	2.55	0.116	0.31	8.59	–	–
PFM000074	16251	0.50	2009-04-15	4.15	4.6	2.12	49.8	2.67	150.00	5.8	3.55	1.47	0.044	0.21	4.23	0.0717	0.01570
PFM000074	16264	0.51	2009-05-12	3.72	11.3	3.03	74.0	4.16	227.00	15.0	3.72	1.81	0.069	0.33	4.21	–	–
PFM000074	16324	0.51	2009-06-16	5.43	8.5	2.10	59.6	3.29	176.00	8.9	5.46	2.25	0.068	0.26	4.50	–	–
PFM000074	16346	0.50	2009-08-11	2.40	12.5	1.36	76.4	4.19	238.00	17.1	3.36	1.82	0.076	0.34	6.37	0.0793	0.02490
PFM000074	16380	0.48	2009-08-31	5.15	11.4	1.42	79.8	4.17	232.00	16.0	3.48	1.76	0.085	0.35	7.04	–	–
PFM000074	16398	0.46	2009-10-06	1.48	13.4	1.37	70.6	4.20	224.00	20.0	3.78	1.65	0.076	0.34	8.56	0.0239	0.00475
PFM000074	16596	0.51	2009-11-03	0.11	12.9	2.22	73.7	4.05	233.00	21.0	7.73	3.06	0.075	0.32	7.46	–	–
PFM000074	16621	0.50	2009-12-01	3.20	8.3	2.74	65.9	3.57	192.00	11.3	10.70	4.54	0.073	0.29	6.68	–	–
PFM000107	16184	0.50	2009-01-12	4.22	13.9	3.14	65.1	5.30	187.00	22.2	12.10	4.96	0.121	0.33	6.39	0.3450	0.08830
PFM000107	16186	1.00	2009-01-12	2.31	12.7	2.98	68.4	5.13	204.00	21.8	11.70	4.66	0.125	0.34	6.70	0.4940	0.15800
PFM000107	16195	0.50	2009-02-09	2.03	13.6	2.89	75.8	5.60	231.00	22.3	10.40	4.48	0.150	0.34	7.24	–	–
PFM000107	16196	1.00	2009-02-09	3.09	16.1	3.49	85.7	6.03	257.00	26.5	9.03	4.04	0.165	0.31	7.50	–	–
PFM000107	16215	0.50	2009-03-09	3.29	16.5	3.39	87.8	6.41	264.00	25.4	10.50	4.60	0.181	0.34	8.39	–	–
PFM000107	16216	1.00	2009-03-09	1.92	18.3	3.48	90.9	6.65	285.00	29.1	9.79	3.70	0.214	0.36	8.48	–	–
PFM000107	16246	0.51	2009-04-13	4.19	14.8	2.74	54.1	4.80	163.00	22.6	7.54	2.93	0.137	0.26	4.76	0.2690	0.10400
PFM000107	16259	0.51	2009-05-11	3.65	17.6	2.79	52.0	5.32	159.00	25.9	9.45	3.90	0.138	0.30	1.90	–	–

Idcode	Sample no.	Depth (m)	Sampling date (yyyy/mm/dd)	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)	SO_4-S (mg/L)	Br (mg/L)	F^- (mg/L)	Si (mg/L)	Fe (mg/L)	Mn (mg/L)
PFM000107	16318	0.50	2009-06-15	1.21	19.7	2.78	39.7	5.39	127.00	32.8	9.52	4.01	0.158	0.28	0.39	–	–
PFM000107	16344	0.51	2009-08-10	2.78	18.9	2.43	40.1	5.40	123.00	30.2	10.40	4.23	0.171	0.33	1.27	0.0826	0.00758
PFM000107	16379	0.51	2009-08-31	3.71	20.1	2.21	38.8	5.56	115.00	32.9	9.95	4.10	0.160	0.32	0.86	–	–
PFM000107	16393	0.50	2009-10-05	1.61	22.3	2.28	36.0	5.61	114.00	37.6	9.99	3.75	0.169	0.35	0.14	0.0392	0.00193
PFM000107	16590	0.51	2009-11-02	0.02	23.3	2.79	37.5	5.74	124.00	40.1	10.00	3.92	0.167	0.35	0.12	–	–
PFM000107	16616	0.50	2009-11-30	2.93	22.3	2.73	42.5	5.71	131.00	35.4	10.10	4.15	0.220	0.33	0.64	–	–
PFM000117	16185	0.50	2009-01-12	x	x	x	x	x	129.00	5.5	4.99	x	0.037	0.21	x	x	x
PFM000117	16187	1.50	2009-01-12	4.04	6.5	2.35	65.2	3.31	194.00	6.9	6.54	2.95	0.047	0.27	5.05	0.1210	0.19100
PFM000117	16202	0.50	2009-02-10	–2.97	6.5	2.05	55.7	3.21	192.00	7.7	7.18	3.29	0.054	0.27	5.21	–	–
PFM000117	16211	1.50	2009-02-10	–4.90	5.8	1.95	57.9	2.97	205.00	7.5	6.86	3.32	0.054	0.26	5.73	–	–
PFM000117	16221	0.50	2009-03-10	2.37	7.5	2.55	63.5	3.68	199.00	7.9	7.31	2.97	0.064	0.30	5.47	–	–
PFM000117	16229	1.51	2009-03-10	3.74	7.0	2.47	72.1	3.74	219.00	7.3	5.13	2.44	0.072	0.29	6.10	–	–
PFM000117	16245	0.52	2009-04-14	4.05	5.9	2.09	55.6	3.01	170.00	5.4	5.23	2.03	0.053	0.23	4.46	0.2850	0.10800
PFM000117	16260	0.50	2009-05-11	4.36	6.4	2.06	55.8	3.14	170.00	5.7	4.97	2.05	0.047	0.29	2.28	–	–
PFM000117	16319	0.50	2009-06-15	1.74	6.0	1.93	43.0	2.83	139.00	6.1	4.50	2.17	0.038	0.23	0.87	–	–
PFM000117	16345	0.51	2009-08-10	4.33	6.2	1.97	39.0	3.01	122.00	6.0	4.52	1.97	0.035	0.26	1.70	0.0119	0.00196
PFM000117	16381	0.50	2009-08-31	6.13	6.2	1.75	40.7	3.03	121.00	6.3	4.70	1.94	0.040	0.29	2.02	–	–
PFM000117	16392	0.50	2009-10-05	3.39	6.5	1.78	40.6	2.93	129.00	6.5	4.30	1.79	0.044	0.28	2.05	0.0089	0.00124
PFM000117	16594	0.51	2009-11-03	2.21	6.6	2.16	42.8	3.00	140.00	6.6	4.03	1.77	0.039	0.29	2.13	–	–
PFM000117	16620	0.50	2009-12-01	1.19	6.2	1.88	44.3	2.88	145.00	6.3	4.30	2.09	0.054	0.29	2.33	–	–
PFM102269	16170	0.51	2009-01-13	–	–	–	–	–	79.40	2,770.0	363.00	–	9.100	0.33	–	–	–
PFM102269	16194	0.51	2009-02-09	–	–	–	–	–	80.30	2,850.0	403.00	–	x	0.35	–	–	–
PFM102269	16222	0.50	2009-03-09	–	–	–	–	–	80.90	2,860.0	409.00	–	9.990	0.32	–	–	–
PFM102269	16243	0.50	2009-04-14	–	–	–	–	–	78.80	2,780.0	388.00	–	9.260	0.36	–	–	–
PFM102269	16266	0.50	2009-05-12	–	–	–	–	–	79.30	2,760.0	371.00	–	9.190	0.36	–	–	–
PFM102269	16316	0.51	2009-06-16	–	–	–	–	–	75.50	2,730.0	392.00	–	9.310	0.31	–	–	–
PFM102269	16338	0.51	2009-08-11	–	–	–	–	–	78.00	2,820.0	387.00	–	9.100	0.31	–	–	–
PFM102269	16378	0.50	2009-09-01	–	–	–	–	–	79.40	2,800.0	390.00	–	8.810	0.30	–	–	–
PFM102269	16390	0.50	2009-10-06	–	–	–	–	–	75.50	2,750.0	370.00	–	8.600	0.33	–	–	–
PFM102269	16597	0.51	2009-11-02	–	–	–	–	–	77.60	2,860.0	383.00	–	9.330	0.32	–	–	–
PFM102269	16614	0.51	2009-12-01	–	–	–	–	–	79.60	2,810.0	396.00	–	9.460	0.32	–	–	–

Idcode	Sample no.	Depth (m)	Sampling date (yyyy/mm/dd)	Li (mg/L)	Sr (mg/L)	I^- (mg/L)	pH_L	pH_F	Temp_F (°C)	EC_L (mS/m)
PFM000062	16192	0.51	2009-01-13	0.0234	1.000	<0.02	7.63	–0.2	7.95	880.0
PFM000062	16197	0.56	2009-02-09	0.0254	1.130	–	7.75	–0.5	7.93	907.0
PFM000062	16213	0.50	2009-03-09	0.0261	1.150	–	7.78	0.3	7.76	911.0
PFM000062	16244	0.50	2009-04-14	0.0249	1.200	<0.02	8.08	3.5	8.27	892.0
PFM000062	16258	0.50	2009-05-11	0.0266	1.210	–	7.86	5.7	8.02	892.0
PFM000062	16317	0.50	2009-06-15	0.0282	1.190	–	7.85	11.3	7.92	879.0
PFM000062	16343	0.50	2009-08-10	0.0260	1.180	<0.02	7.61	12.0	7.48	892.0
PFM000062	16385	0.50	2009-09-01	0.0257	1.090	–	7.61	10.2	7.58	913.0
PFM000062	16391	0.50	2009-10-05	0.0244	0.992	0.0204	7.85	8.6	7.97	870.0
PFM000062	16589	0.50	2009-11-02	0.0287	1.170	–	7.82	5.8	7.74	898.0
PFM000062	16615	0.50	2009-11-30	0.0291	1.090	–	7.75	4.4	7.75	906.0
PFM000066	16193	0.30	2009-01-13	<0.004	0.075	0.0113	7.22	–0.2	7.19	39.4
PFM000066	16201	0.20	2009-02-09	<0.004	0.092	–	7.16	–0.5	7.01	48.3
PFM000066	16220	0.20	2009-03-09	<0.004	0.099	–	6.94	–0.5	7.00	51.4
PFM000066	16250	0.37	2009-04-14	<0.004	0.052	0.0068	7.12	6.1	7.14	25.9
PFM000066	16262	0.25	2009-05-11	<0.004	0.080	–	7.55	10.9	7.52	37.3
PFM000066	16323	0.35	2009-06-15	<0.004	0.067	–	7.41	10.2	7.34	30.9
PFM000066	16342	0.15	2009-08-11	<0.004	0.077	–	7.64	16.8	7.49	35.6
PFM000066	16386	0.18	2009-09-01	<0.004	0.077	–	7.55	15.4	7.52	35.2
PFM000066	16397	0.28	2009-10-06	<0.004	0.071	0.0074	7.47	3.1	7.60	35.3
PFM000066	16595	0.17	2009-11-03	<0.004	0.077	–	7.58	4.5	7.68	34.2
PFM000066	16622	0.30	2009-12-01	<0.004	0.063	–	7.47	3.2	7.38	34.0
PFM000068	16189	0.48	2009-01-13	<0.004	0.077	0.0120	7.21	–0.1	7.14	34.5
PFM000068	16200	0.47	2009-02-09	<0.004	0.095	–	7.28	–0.5	7.05	43.9
PFM000068	16217	0.43	2009-03-09	<0.004	0.108	–	7.12	–0.5	7.06	48.2
PFM000068	16248	0.58	2009-04-14	<0.004	0.057	0.0052	7.19	5.5	7.21	25.1
PFM000068	16265	0.56	2009-05-11	<0.004	0.093	–	7.44	8.7	7.41	38.7
PFM000068	16322	0.70	2009-06-16	<0.004	0.071	–	7.22	9.5	7.15	25.3
PFM000068	16340	0.39	2009-08-11	<0.004	0.102	–	7.54	14.7	7.38	41.7
PFM000068	16384	0.41	2009-08-31	<0.004	0.102	–	7.55	12.9	7.49	41.5
PFM000068	16395	0.42	2009-10-05	<0.004	0.106	0.0121	7.41	5.1	7.54	52.7
PFM000068	16593	0.37	2009-11-02	<0.004	0.104	–	7.47	4.5	7.47	41.9
PFM000068	16619	0.55	2009-11-30	<0.004	0.075	–	7.34	3.7	7.26	33.7
PFM000069	16191	0.18	2009-01-13	<0.004	0.105	0.0165	7.09	0.0	7.24	47.7
PFM000069	16199	0.20	2009-02-09	<0.004	0.120	–	7.11	–0.5	6.98	52.9

Idcode	Sample no.	Depth (m)	Sampling date (yyyy/mm/dd)	Li (mg/L)	Sr (mg/L)	I^- (mg/L)	pH_L	pH_F	Temp_F (°C)	EC_L (mS/m)
PFM000069	16219	0.18	2009-03-09	0.0044	0.128	–	6.84	–0.6	6.88	57.6
PFM000069	16249	0.30	2009-04-14	<0.004	0.062	0.0054	7.06	5.3	7.08	28.6
PFM000069	16263	0.18	2009-05-11	<0.004	0.095	–	7.29	9.0	7.30	39.7
PFM000069	16321	0.28	2009-06-15	<0.004	0.087	–	7.16	9.4	7.11	36.2
PFM000069	16341	0.24	2009-08-11	<0.004	0.104	–	7.49	14.5	7.33	42.7
PFM000069	16383	0.25	2009-08-31	<0.004	0.104	–	7.58	12.7	7.46	43.2
PFM000069	16394	0.26	2009-10-05	0.0043	0.112	0.0120	7.61	4.8	7.73	54.2
PFM000069	16592	0.17	2009-11-02	<0.004	0.105	–	7.50	4.6	7.50	44.3
PFM000069	16618	0.16	2009-11-30	<0.004	0.091	–	7.24	4.0	7.21	41.5
PFM000070	16188	0.15	2009-01-12	<0.004	0.006	–0.0050	7.20	0.3	7.80	3.6
PFM000070	16198	0.20	2009-02-09	<0.004	0.063	–	7.55	–0.5	7.39	34.3
PFM000070	16218	0.26	2009-03-09	<0.004	0.070	–	7.25	–0.3	7.39	35.8
PFM000070	16247	0.21	2009-04-14	<0.004	0.058	0.0075	7.37	9.8	7.35	30.4
PFM000070	16261	0.25	2009-05-11	<0.004	0.060	–	7.39	13.1	7.44	29.6
PFM000070	16320	0.22	2009-06-15	<0.004	0.052	–	7.74	12.3	7.69	25.0
PFM000070	16339	0.24	2009-08-10	<0.004	0.057	–	7.31	19.0	7.11	26.4
PFM000070	16382	0.28	2009-08-31	<0.004	0.053	–	7.24	15.0	7.23	25.8
PFM000070	16396	0.24	2009-10-06	<0.004	0.053	0.0073	7.06	3.2	7.41	28.6
PFM000070	16591	0.17	2009-11-02	<0.004	0.046	–	7.34	4.7	7.38	25.2
PFM000070	16617	0.31	2009-11-30	<0.004	0.054	–	7.79	3.9	7.73	26.5
PFM000074	16190	0.50	2009-01-13	<0.004	0.081	0.0111	7.29	0.2	7.09	41.2
PFM000074	16212	0.50	2009-02-10	<0.004	0.096	–	7.16	0.3	6.89	58.1
PFM000074	16230	0.50	2009-03-10	<0.004	0.106	–	7.13	–0.3	7.02	51.7
PFM000074	16251	0.50	2009-04-15	0.0011	0.055	0.0058	7.39	4.1	7.30	27.1
PFM000074	16264	0.51	2009-05-12	<0.004	0.089	–	7.51	10.1	7.52	40.8
PFM000074	16324	0.51	2009-06-16	<0.004	0.073	–	7.37	11.8	7.38	33.1
PFM000074	16346	0.50	2009-08-11	0.0019	0.097	0.0187	7.58	18.9	7.38	43.6
PFM000074	16380	0.48	2009-08-31	<0.004	0.093	–	7.63	15.6	7.55	42.9
PFM000074	16398	0.46	2009-10-06	0.0021	0.084	0.0129	7.96	6.1	8.07	42.2
PFM000074	16596	0.51	2009-11-03	<0.004	0.092	–	7.77	4.1	7.82	44.1
PFM000074	16621	0.50	2009-12-01	<0.004	0.074	–	7.36	3.6	7.26	36.5
PFM000107	16184	0.50	2009-01-12	<0.004	0.091	0.0089	7.28	0.7	7.25	40.6
PFM000107	16186	1.00	2009-01-12	<0.004	0.093	0.0101	7.33	2.4	7.27	42.2
PFM000107	16195	0.50	2009-02-09	<0.004	0.101	–	7.40	0.7	7.07	45.5
PFM000107	16196	1.00	2009-02-09	<0.004	0.116	–	7.46	2.7	7.10	50.4
PFM000107	16215	0.50	2009-03-09	<0.004	0.121	–	7.16	0.4	7.10	51.5
PFM000107	16216	1.00	2009-03-09	<0.004	0.129	–	7.13	2.3	7.08	55.7
PFM000107	16246	0.51	2009-04-13	0.0021	0.085	0.0080	7.17	8.4	7.17	36.1
PFM000107	16259	0.51	2009-05-11	<0.004	0.092	–	8.20	12.3	8.38	36.0

Idcode	Sample no.	Depth (m)	Sampling date (yyyy/mm/dd)	Li (mg/L)	Sr (mg/L)	I^- (mg/L)	pH_L	pH_F	Temp_F (°C)	EC_L (mS/m)
PFM000107	16318	0.50	2009-06-15	<0.004	0.086	–	8.26	11.6	8.41	33.8
PFM000107	16344	0.51	2009-08-10	0.0028	0.090	0.0119	8.63	22.5	8.72	32.4
PFM000107	16379	0.51	2009-08-31	<0.004	0.087	–	8.38	15.5	8.49	33.2
PFM000107	16393	0.50	2009-10-05	0.0026	0.082	0.0108	8.53	6.7	8.76	33.8
PFM000107	16590	0.51	2009-11-02	<0.004	0.091	–	8.12	4.2	8.36	35.7
PFM000107	16616	0.50	2009-11-30	<0.004	0.089	–	7.97	3.2	8.17	35.7
PFM000117	16185	0.50	2009-01-12	x	x	<0.005	7.63	0.9	7.46	34.1
PFM000117	16187	1.50	2009-01-12	<0.004	0.065	0.0064	7.59	3.2	7.41	34.3
PFM000117	16202	0.50	2009-02-10	<0.004	0.060	–	7.46	0.5	7.30	34.3
PFM000117	16211	1.50	2009-02-10	<0.004	0.056	–	7.41	3.6	7.27	36.9
PFM000117	16221	0.50	2009-03-10	<0.004	0.070	–	7.26	0.4	7.27	35.8
PFM000117	16229	1.51	2009-03-10	<0.004	0.072	–	7.12	2.9	7.17	38.3
PFM000117	16245	0.52	2009-04-14	0.0023	0.058	0.0076	7.36	7.8	7.36	30.4
PFM000117	16260	0.50	2009-05-11	<0.004	0.059	–	8.28	13.1	8.43	29.9
PFM000117	16319	0.50	2009-06-15	<0.004	0.050	–	8.21	12.4	8.37	25.7
PFM000117	16345	0.51	2009-08-10	0.0013	0.053	0.0072	8.52	22.9	8.58	22.8
PFM000117	16381	0.50	2009-08-31	<0.004	0.052	–	8.46	16.8	8.55	23.1
PFM000117	16392	0.50	2009-10-05	0.0013	0.049	0.0078	8.31	7.1	8.53	24.4
PFM000117	16594	0.51	2009-11-03	<0.004	0.055	–	8.08	3.9	8.19	25.7
PFM000117	16620	0.50	2009-12-01	<0.004	0.051	–	8.01	3.4	8.03	26.3
PFM102269	16170	0.51	2009-01-13	–	–	–	7.70	11.0	7.91	872.0
PFM102269	16194	0.51	2009-02-09	–	–	–	7.69	11.0	7.80	900.0
PFM102269	16222	0.50	2009-03-09	–	–	–	7.77	11.0	7.86	909.0
PFM102269	16243	0.50	2009-04-14	–	–	–	8.05	12.0	8.25	888.0
PFM102269	16266	0.50	2009-05-12	–	–	–	7.94	17.2	8.07	885.0
PFM102269	16316	0.51	2009-06-16	–	–	–	7.89	21.5	7.82	879.0
PFM102269	16338	0.51	2009-08-11	–	–	–	7.80	20.2	8.10	886.0
PFM102269	16378	0.50	2009-09-01	–	–	–	7.69	11.8	7.72	915.0
PFM102269	16390	0.50	2009-10-06	–	–	–	7.86	18.8	7.98	864.0
PFM102269	16597	0.51	2009-11-02	–	–	–	7.81	16.2	7.83	893.0
PFM102269	16614	0.51	2009-12-01	–	–	–	7.79	14.6	7.66	899.0

RCB = Relative Charge Balance error.
pH_L = lab. pH.
pH_F = field pH.
Temp_F = water temperature in the field.
EC = Electrical Conductivity.

< “value” = Below detection limit
x = No result due to analytical problems

Table A13-2. Surface water suppliments.

Idcode	Sample no.	Sampling date (yyyy/mm/dd)	Depth (m)	NH_4_N (mg/L)	NO_2_N (mg/L)	NO_3_N+NO_2_N (mg/L)	N TOT (mg/L)	P TOT (mg/L)	PO_4_P (mg/L)	POP (mg/L)	PON (mg/L)	SIO_2_SI (mg/L)	Chl. C (ug/L)	Chl. A (ug/L)	Pheop. (ug/L)	POC (mg/L)	TOC (mg/L)	DOC (mg/L)	DIC (mg/L)	Abs. coeff. (1/m)
PFM000062	16192	2009-01-13	0.51	0.0029	0.0027	0.0889	0.3140	0.0183	0.0096	0.0045	0.0239	0.8730	0.200	1.00	0.30	0.22	4.50	4.40	13.60	0.38
PFM000062	16197	2009-02-09	0.56	0.0027	–	0.0765	0.2940	0.0176	0.0091	0.0024	0.0121	0.7960	0.200	1.30	0.20	0.08	4.20	4.20	15.50	0.36
PFM000062	16213	2009-03-09	0.50	0.0031	–	0.0671	0.2950	0.0145	0.0080	0.0034	0.0189	0.7840	0.200	1.50	0.20	0.14	4.30	4.10	14.10	0.26
PFM000062	16244	2009-04-14	0.50	0.0138	0.0003	0.0004	0.2500	0.0108	–0.0005	0.0076	x	0.3270	0.700	2.80	0.60	x	4.40	4.30	13.20	0.32
PFM000062	16258	2009-05-11	0.50	0.0014	–	0.0008	0.2430	0.0111	0.0005	0.0082	0.0442	0.2480	0.300	2.00	0.50	0.33	3.90	3.90	13.90	0.22
PFM000062	16317	2009-06-15	0.50	0.0018	–	0.0008	0.2660	0.0225	0.0011	0.0068	0.0364	0.1550	xx	xx	xx	0.24	4.00	4.00	10.60	0.26
PFM000062	16343	2009-08-10	0.50	0.0007	–0.0002	–0.0003	0.2390	0.0102	–0.0005	0.0052	0.0402	0.4690	0.300	2.20	1.20	0.29	3.90	4.00	14.70	0.26
PFM000062	16385	2009-09-01	0.50	0.0015	–	0.0035	0.2230	0.0099	0.0012	0.0045	0.0290	0.5260	0.200	1.80	0.50	0.20	3.70	3.50	14.60	0.22
PFM000062	16391	2009-10-05	0.50	0.0009	0.0002	0.0004	0.2520	0.0133	–0.0005	0.0055	0.0724	0.5380	0.300	2.70	0.80	0.52	4.10	4.10	11.70	0.32
PFM000062	16589	2009-11-02	0.50	0.0057	–	0.0056	0.2380	0.0106	0.0013	0.0033	0.0412	0.5680	0.300	2.80	0.80	0.42	3.90	4.10	12.70	0.24
PFM000062	16615	2009-11-30	0.50	0.0019	–	0.0415	0.2590	0.0131	0.0052	0.0032	0.0201	0.6780	0.200	1.40	0.30	0.16	4.00	3.90	14.70	0.19
PFM000066	16193	2009-01-13	0.30	0.0533	0.0006	0.0053	0.8100	0.0125	0.0010	0.0066	0.0393	6.0000	–	–	–	0.29	21.60	20.10	43.40	3.36
PFM000066	16201	2009-02-09	0.20	0.1160	–	0.0011	0.9850	0.0109	0.0010	0.0033	0.0224	6.9200	–	–	–	0.17	36.80	34.40	57.50	3.60
PFM000066	16220	2009-03-09	0.20	0.2210	–	0.0025	1.1500	0.0134	0.0015	0.0056	0.0386	7.6400	–	–	–	0.30	37.00	35.50	52.50	3.96
PFM000066	16250	2009-04-14	0.37	0.0086	0.0004	0.0043	0.5680	0.0136	–0.0005	0.0058	0.0394	3.5400	–	–	–	0.24	12.80	12.90	28.30	2.18
PFM000066	16262	2009-05-11	0.25	0.0188	–	0.0029	0.7800	0.0117	0.0017	0.0063	0.0421	3.1700	–	–	–	0.29	18.80	18.90	37.70	2.80
PFM000066	16323	2009-06-15	0.35	0.0191	–	0.0078	0.8650	0.0196	0.0020	0.0103	0.0552	3.3300	–	–	–	0.41	19.10	19.20	35.60	3.30
PFM000066	16342	2009-08-11	0.15	0.0242	0.0039	0.0476	1.1100	0.0317	0.0052	0.0140	0.0643	4.9200	–	–	–	0.64	25.50	25.60	37.20	4.16
PFM000066	16386	2009-09-01	0.18	0.0245	–	0.0287	1.0200	0.0150	0.0033	0.0046	0.0287	5.6200	–	–	–	0.27	24.30	23.00	36.00	3.62
PFM000066	16397	2009-10-06	0.28	0.0012	0.0011	0.0204	0.9680	0.0208	–0.0005	0.0093	0.0738	6.5800	–	–	–	0.86	22.70	22.60	35.40	2.98
PFM000066	16595	2009-11-03	0.17	0.0290	–	0.0151	0.9590	0.0109	0.0018	0.0056	0.0260	6.1400	–	–	–	0.25	22.50	22.60	37.60	2.64
PFM000066	16622	2009-12-01	0.30	0.0103	–	0.0134	0.8100	0.0085	0.0007	0.0051	0.0692	5.6600	–	–	–	0.86	20.20	19.90	33.10	2.80
PFM000068	16189	2009-01-13	0.48	0.0964	0.0017	0.0399	1.1000	0.0137	–0.0005	0.0063	0.0418	5.6400	–	–	–	0.34	28.10	27.80	33.80	4.80
PFM000068	16200	2009-02-09	0.47	0.2080	–	0.0362	1.3000	0.0124	0.0005	0.0036	0.0336	6.4500	–	–	–	0.27	31.00	30.80	47.40	4.50
PFM000068	16217	2009-03-09	0.43	0.2940	–	0.0189	1.3100	0.0124	0.0011	0.0052	0.0371	6.8900	–	–	–	0.30	29.70	27.70	44.70	4.06
PFM000068	16248	2009-04-14	0.58	0.0253	0.0009	0.0256	0.7080	0.0131	–0.0005	0.0058	0.0337	3.3700	–	–	–	0.24	15.60	15.70	21.80	2.84
PFM000068	16265	2009-05-11	0.56	0.0380	–	0.0062	0.8580	0.0153	0.0017	0.0053	0.0404	4.4900	–	–	–	0.34	20.40	20.40	31.60	3.70
PFM000068	16322	2009-06-16	0.70	0.0132	–	0.0441	1.1700	0.0266	0.0022	0.0116	0.0787	3.4900	–	–	–	0.63	30.50	28.60	21.20	6.46
PFM000068	16340	2009-08-11	0.39	0.0371	0.0027	0.0144	1.0300	0.0167	0.0026	0.0041	0.0313	4.8000	–	–	–	0.31	25.60	25.10	33.50	5.13
PFM000068	16384	2009-08-31	0.41	0.0288	–	0.0235	1.0300	0.0168	0.0041	0.0036	0.0244	5.3200	–	–	–	0.22	24.00	24.20	32.30	4.66
PFM000068	16395	2009-10-05	0.42	0.0163	0.0011	0.0131	1.0300	0.0228	0.0014	0.0077	0.0421	7.3200	–	–	–	0.38	24.90	24.70	30.80	4.62
PFM000068	16593	2009-11-02	0.37	0.0269	–	0.0075	0.9030	0.0132	0.0022	0.0041	0.0356	6.4800	–	–	–	0.29	22.40	22.40	36.10	3.74
PFM000068	16619	2009-11-30	0.55	0.0258	–	0.0788	0.9600	0.0103	0.0012	0.0033	0.0256	4.7900	–	–	–	0.27	21.30	21.00	30.20	3.12

Idcode	Sample no.	Sampling date (yyyy/mm/dd)	Depth (m)	NH_4_N (mg/L)	NO_2_N (mg/L)	NO_3_N+NO_2_N (mg/L)	N TOT (mg/L)	P TOT (mg/L)	PO_4_P (mg/L)	POP (mg/L)	PON (mg/L)	SIO_2_SI (mg/L)	Chl. C (ug/L)	Chl. A (ug/L)	Pheop. (ug/L)	POC (mg/L)	TOC (mg/L)	DOC (mg/L)	DIC (mg/L)	Abs. coeff. (1/m)
PFM000069	16191	2009-01-13	0.18	0.0191	0.0005	0.0017	1.1400	0.0167	0.0006	0.0071	0.0480	7.8300	–	–	–	0.37	36.30	36.40	44.30	6.42
PFM000069	16199	2009-02-09	0.20	0.0235	–	0.0021	1.0500	0.0162	–0.0005	0.0058	0.0442	7.5300	–	–	–	0.31	37.70	36.30	52.00	5.16
PFM000069	16219	2009-03-09	0.18	0.0688	–	0.0018	1.0100	0.0149	0.0005	0.0070	0.0572	8.3900	–	–	–	0.46	35.40	32.70	52.10	4.66
PFM000069	16249	2009-04-14	0.30	0.0014	0.0002	0.0054	0.5490	0.0124	–0.0005	0.0047	0.0311	3.6100	–	–	–	0.19	13.80	13.60	24.90	2.40
PFM000069	16263	2009-05-11	0.18	0.0147	–	0.0021	0.7640	0.0122	0.0014	0.0047	0.0325	4.7700	–	–	–	0.26	19.20	19.30	32.10	3.32
PFM000069	16321	2009-06-15	0.28	0.0178	–	0.0747	0.9940	0.0199	0.0021	0.0097	0.0657	4.1400	–	–	–	0.50	22.80	22.60	28.00	4.40
PFM000069	16341	2009-08-11	0.24	0.0181	0.0010	0.0076	0.9970	0.0133	0.0011	0.0029	0.0211	4.8300	–	–	–	0.22	25.80	25.90	34.60	4.92
PFM000069	16383	2009-08-31	0.25	0.0183	–	0.0130	1.0000	0.0137	0.0030	0.0027	0.0181	5.3500	–	–	–	0.16	24.20	24.20	33.60	4.64
PFM000069	16394	2009-10-05	0.26	0.0059	0.0022	0.0275	1.0600	0.0174	–0.0005	0.0038	0.0349	7.2000	–	–	–	0.34	24.80	24.70	31.50	4.12
PFM000069	16592	2009-11-02	0.17	0.0391	–	0.0120	0.9450	0.0133	0.0026	0.0048	0.0264	7.0000	–	–	–	0.20	23.00	23.00	36.30	3.63
PFM000069	16618	2009-11-30	0.16	0.0115	–	0.0151	0.7850	0.0112	0.0017	0.0031	0.0190	6.2800	–	–	–	0.17	20.10	19.90	35.40	3.08
PFM000070	16188	2009-01-12	0.15	0.0590	0.0023	0.0308	0.2510	0.0036	–0.0005	0.0027	0.0316	0.3680	–	–	–	0.39	3.20	2.90	3.50	0.44
PFM000070	16198	2009-02-09	0.20	0.5530	–	0.0214	1.7700	0.0109	0.0006	0.0045	0.0357	4.8200	–	–	–	0.38	29.00	29.80	38.20	3.78
PFM000070	16218	2009-03-09	0.26	0.6550	–	0.0043	1.8800	0.0138	0.0008	0.0070	0.0601	4.9400	–	–	–	0.56	29.30	28.60	37.00	3.72
PFM000070	16247	2009-04-14	0.21	0.3480	0.0011	0.0176	1.3000	0.0121	–0.0005	0.0053	0.0515	3.8000	–	–	–	0.37	21.10	21.00	29.20	3.16
PFM000070	16261	2009-05-11	0.25	0.1010	–	0.0110	1.0600	0.0149	0.0021	0.0061	0.0895	2.3300	–	–	–	0.95	21.00	21.20	26.70	2.66
PFM000070	16320	2009-06-15	0.22	0.0104	–	0.0047	1.0600	0.0119	0.0019	0.0049	0.0541	0.9390	–	–	–	0.40	22.00	22.10	23.90	2.46
PFM000070	16339	2009-08-10	0.24	0.1400	0.0004	0.0042	1.1300	0.0108	–0.0005	0.0055	0.0474	3.3900	–	–	–	0.39	22.10	21.70	24.40	2.78
PFM000070	16382	2009-08-31	0.28	0.1000	–	0.0077	1.0000	0.0084	0.0011	0.0036	0.0361	3.4700	–	–	–	0.31	21.10	20.80	26.30	2.68
PFM000070	16396	2009-10-06	0.24	0.0568	0.0005	0.0057	0.9200	0.0108	–0.0005	0.0046	0.0471	4.4800	–	–	–	0.36	20.80	20.90	28.60	2.48
PFM000070	16591	2009-11-02	0.17	0.1230	–	0.0628	0.9130	0.0060	0.0011	0.0026	0.0501	3.6600	–	–	–	0.48	18.20	18.00	24.90	1.85
PFM000070	16617	2009-11-30	0.31	0.3280	–	0.0322	1.4200	0.0071	–0.0005	0.0039	0.0504	2.0800	–	–	–	0.46	20.20	20.30	26.30	1.25
PFM000074	16190	2009-01-13	0.50	0.0403	0.0012	0.0313	0.8180	0.0086	–0.0005	0.0025	0.0161	6.3300	0.600	0.30	0.80	0.13	21.60	21.40	45.90	3.04
PFM000074	16212	2009-02-10	0.50	0.1590	–	0.0094	1.0200	0.0108	–0.0005	0.0037	0.0292	7.4800	0.300	2.20	2.00	0.22	39.30	36.00	56.50	3.18
PFM000074	16230	2009-03-10	0.50	0.1460	–	0.0210	1.0100	0.0095	0.0011	0.0037	0.0362	7.4500	–0.200	5.30	0.80	0.28	31.80	28.30	49.40	3.12
PFM000074	16251	2009-04-15	0.50	0.0056	0.0009	0.0234	0.5670	0.0108	–0.0005	0.0044	0.0269	3.4800	–0.200	0.20	–0.20	0.20	12.70	12.60	28.70	2.02
PFM000074	16264	2009-05-12	0.51	0.0098	–	0.0005	0.8030	0.0113	0.0009	0.0035	0.0425	3.5900	–0.200	1.60	0.50	0.30	18.90	18.60	38.80	2.90
PFM000074	16324	2009-06-16	0.51	0.0085	–	0.0012	0.7940	0.0119	0.0009	0.0045	0.0380	3.9600	xx	xx	xx	0.29	19.00	18.90	34.10	3.34
PFM000074	16346	2009-08-11	0.50	0.0088	0.0002	0.0007	1.0300	0.0096	–0.0005	0.0038	0.0458	5.5800	–0.200	3.00	2.20	0.34	30.00	29.50	37.80	3.80
PFM000074	16380	2009-08-31	0.48	0.0140	–	0.0009	0.9530	0.0082	0.0008	0.0026	0.0370	6.3700	0.500	2.20	3.10	0.27	23.50	22.90	39.40	3.32
PFM000074	16398	2009-10-06	0.46	0.0171	0.0002	0.0014	0.9400	0.0064	–0.0005	0.0038	0.0385	8.3100	0.400	3.30	0.40	0.29	22.20	21.60	33.50	2.51
PFM000074	16596	2009-11-03	0.51	0.0283	–	0.0019	0.8400	0.0068	0.0012	0.0029	0.0320	6.5500	0.200	1.80	0.50	0.29	21.80	21.20	40.20	2.52
PFM000074	16621	2009-12-01	0.50	0.0090	–	0.0210	0.7740	0.0068	–0.0005	0.0026	0.0265	5.9200	–0.200	0.40	–0.20	0.32	19.30	19.00	34.30	2.61
PFM000097	16171	2009-01-13	0.50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
PFM000097	16214	2009-02-10	0.50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Idcode	Sample no.	Sampling date (yyyy/mm/dd)	Depth (m)	NH_4_N (mg/L)	NO_2_N (mg/L)	NO_3_N+NO_2_N (mg/L)	N TOT (mg/L)	P TOT (mg/L)	PO_4_P (mg/L)	POP (mg/L)	PON (mg/L)	SIO_2_SI (mg/L)	Chl. C (ug/L)	Chl. A (ug/L)	Pheop. (ug/L)	POC (mg/L)	TOC (mg/L)	DOC (mg/L)	DIC (mg/L)	Abs. coeff. (1/m)
PFM000097	16231	2009-03-09	0.51	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
PFM000107	16184	2009-01-12	0.50	0.1150	0.0016	0.0427	1.3800	0.0128	–0.0005	0.0040	0.0369	5.7600	0.600	0.70	0.50	0.32	34.00	34.20	37.30	6.28
PFM000107	16186	2009-01-12	1.00	0.1510	0.0014	0.0240	1.4200	0.0169	0.0002	0.0064	0.0599	6.2700	0.400	0.40	0.50	0.53	34.10	33.50	40.50	5.86
PFM000107	16195	2009-02-09	0.50	0.1930	–	0.0288	1.4100	0.0133	–0.0005	0.0039	0.0447	6.5300	0.200	0.30	–0.20	0.37	35.00	33.10	47.20	5.48
PFM000107	16196	2009-02-09	1.00	0.4810	–	0.0009	1.8100	0.0156	–0.0005	0.0081	0.0649	6.9400	–0.200	0.30	0.30	0.48	37.50	37.80	48.90	6.66
PFM000107	16215	2009-03-09	0.50	0.3430	–	0.0013	1.5500	0.0161	0.0006	0.0084	0.0595	7.2700	–0.200	0.70	0.20	0.39	37.60	38.60	50.40	4.76
PFM000107	16216	2009-03-09	1.00	0.4840	–	0.0010	1.7400	0.0156	0.0006	0.0072	0.0496	7.5500	–0.200	0.50	0.20	0.34	35.60	34.80	52.70	5.34
PFM000107	16246	2009-04-13	0.51	0.3010	0.0010	0.0184	1.1200	0.0135	–0.0005	0.0058	0.0348	4.0500	0.800	2.20	1.10	0.29	19.60	19.30	29.20	3.68
PFM000107	16259	2009-05-11	0.51	0.0153	–	0.0009	0.9090	0.0160	0.0026	0.0077	0.0829	1.6200	0.600	4.20	0.60	0.55	18.50	18.10	27.40	2.54
PFM000107	16318	2009-06-15	0.50	0.0047	–	0.0015	0.9590	0.0199	0.0017	0.0054	0.0650	0.3470	0.700	3.20	1.10	0.50	18.20	18.50	22.80	1.60
PFM000107	16344	2009-08-10	0.51	0.0087	–0.0002	0.0006	1.1300	0.0167	0.0005	0.0063	0.0815	1.1900	0.500	2.70	0.80	0.70	21.50	21.40	18.70	2.01
PFM000107	16379	2009-08-31	0.51	0.0149	–	0.0006	1.1200	0.0145	0.0010	0.0057	0.0616	0.7470	0.600	2.00	2.90	0.56	20.80	20.90	18.60	1.62
PFM000107	16393	2009-10-05	0.50	0.0044	<0.0002	0.0008	1.1200	0.0118	<0.0005	0.0026	0.0360	0.1190	<0.2	0.90	0.20	0.30	20.50	20.40	17.30	1.28
PFM000107	16590	2009-11-02	0.51	0.0313	–	0.0018	1.0800	0.0134	0.0016	0.0063	0.0541	0.1140	0.200	1.70	0.60	0.45	19.30	19.50	22.70	1.16
PFM000107	16616	2009-11-30	0.50	0.0321	–	0.0142	0.9830	0.0099	0.0008	0.0028	0.0250	0.5520	0.200	1.40	0.20	0.21	18.70	18.30	23.20	1.32
PFM000117	16185	2009-01-12	0.50	0.1630	0.0019	0.0477	1.2800	0.0092	0.0016	0.0038	0.0435	1.4600	0.400	0.80	0.70	0.47	18.20	9.40	11.00	2.40
PFM000117	16187	2009-01-12	1.50	0.9240	0.0005	0.0010	2.1000	0.0104	<0.0005	0.0047	0.0572	4.5100	0.500	0.80	0.90	0.49	28.00	28.10	33.50	3.52
PFM000117	16202	2009-02-10	0.50	0.5820	–	0.0228	1.8400	0.0175	0.0010	0.0037	0.0297	4.6500	x	x	x	0.24	28.60	28.70	39.00	3.38
PFM000117	16211	2009-02-10	1.50	0.8310	–	0.0014	2.2200	0.0116	0.0006	0.0049	0.0504	5.0500	0.200	0.80	0.50	0.38	35.10	34.40	40.10	4.72
PFM000117	16221	2009-03-10	0.50	0.6610	–	0.0010	1.8600	0.0114	0.0007	0.0054	0.0519	4.8700	<0.2	0.50	<0.2	0.40	28.90	28.30	35.30	3.58
PFM000117	16229	2009-03-10	1.51	0.6950	–	0.0009	1.9300	0.0116	0.0011	0.0050	0.0481	5.4700	<0.2	0.50	0.20	0.36	33.40	32.50	38.60	4.74
PFM000117	16245	2009-04-14	0.52	0.4240	0.0007	0.0168	1.3700	0.0118	<0.0005	0.0063	0.0600	3.8500	0.400	1.70	0.80	0.46	20.90	21.40	26.80	3.06
PFM000117	16260	2009-05-11	0.50	0.0215	–	0.0034	1.0300	0.0125	0.0015	0.0050	0.0748	1.9700	0.400	2.50	0.80	0.52	20.90	21.40	26.80	2.64
PFM000117	16319	2009-06-15	0.50	0.0102	–	0.0033	1.0600	0.0112	0.0021	0.0048	0.0708	0.7550	1.000	5.40	1.90	0.48	20.60	20.60	24.50	1.78
PFM000117	16345	2009-08-10	0.51	0.0109	<0.0002	0.0007	1.1700	0.0080	<0.0005	0.0030	0.0618	1.4900	0.500	2.50	0.80	0.58	22.60	21.90	18.60	1.72
PFM000117	16381	2009-08-31	0.50	0.0127	–	0.0010	1.1700	0.0066	0.0006	0.0030	0.0585	1.8000	0.700	2.20	1.80	0.52	22.00	22.00	18.90	1.50
PFM000117	16392	2009-10-05	0.50	0.0462	0.0002	0.0018	1.2100	0.0059	<0.0005	0.0026	0.0446	1.9400	0.400	1.70	0.50	0.41	21.70	20.90	21.90	1.22
PFM000117	16594	2009-11-03	0.51	0.1960	–	0.0064	1.3300	0.0068	0.0022	0.0024	0.0272	1.8900	0.300	2.70	0.40	0.25	21.40	21.30	26.10	1.22
PFM000117	16620	2009-12-01	0.50	0.3450	–	0.0192	1.4600	0.0077	0.0006	0.0038	0.0431	2.0400	0.300	2.20	0.60	0.46	20.30	20.60	23.60	1.28

Pheop. = Pheopigment.
Abs. Coeff. = Absorption Coefficient 436 nm (colour).
Chl. A = Chlorophyll a.
Chl. C = Chlorophyll c.
x = No result due to analytical problems.
xx = No result due to sampling problems.

Table A13-3. Isotopes I (H-, B-, S- and C-isotopes).

Idcode	Sample no.	Sampling date (yyyy/mm/dd)	Depth (m)	^{14}C pmC	δ^{13}C ‰ PDB	δ^{34}S ‰ CDT	δ^{37}Cl ‰ SMOC	^{86}Sr/^{87}Sr	δ^{2}H ‰ SMOW	^{3}H TU	δ^{18}O ‰ SMOW
PFM000062	16192	2009-01-13	0.51	–	–	–	–	–	–57.2	11.40	–8.00
PFM000062	16244	2009-04-14	0.50	–	–	–	–	–	–60.1	10.20	–8.20
PFM000062	16343	2009-08-10	0.50	103.32	–2.32	20.5	–0.04	0.7095	–61.9	8.30	–7.90
PFM000062	16391	2009-10-05	0.50	–	–	–	–	–	–62.9	10.40	–8.20
PFM000066	16193	2009-01-13	0.30	–	–	–	–	–	–79.4	11.50	–12.20
PFM000066	16250	2009-04-14	0.37	–	–	–	–	–	–79.9	9.60	–12.10
PFM000066	16342	2009-08-11	0.15	–	–	–	–	–	–71.7	10.40	–9.50
PFM000066	16397	2009-10-06	0.28	–	–	–	–	–	–66.8	10.20	–8.60
PFM000068	16189	2009-01-13	0.48	–	–	–	–	–	–77.3	8.60	–11.20
PFM000068	16248	2009-04-14	0.58	–	–	–	–	–	–80.2	10.20	–11.40
PFM000068	16340	2009-08-11	0.39	–	–	–	–	–	–74.7	11.40	–10.00
PFM000068	16395	2009-10-05	0.42	–	–	–	–	–	–74.7	11.30	–9.80
PFM000069	16191	2009-01-13	0.18	–	–	–	–	–	–85.0	10.70	–12.50
PFM000069	16249	2009-04-14	0.30	–	–	–	–	–	–81.2	10.00	–12.10
PFM000069	16341	2009-08-11	0.24	–	–	–	–	–	–75.8	11.90	–10.30
PFM000069	16394	2009-10-05	0.26	–	–	–	–	–	–75.3	10.80	–9.90
PFM000070	16188	2009-01-12	0.15	–	–	–	–	–	–69.4	9.30	–10.30
PFM000070	16247	2009-04-14	0.21	–	–	–	–	–	–75.9	10.10	–10.40
PFM000070	16339	2009-08-10	0.24	–	–	–	–	–	–61.6	10.70	–7.20
PFM000070	16396	2009-10-06	0.24	–	–	–	–	–	–61.8	11.00	–7.00
PFM000074	16190	2009-01-13	0.50	–	–	–	–	–	–85.1	10.10	–12.40
PFM000074	16251	2009-04-15	0.50	–	–	–	–	–	–80.5	9.70	–11.90
PFM000074	16346	2009-08-11	0.50	114.26	–8.30	2.8	0.30	0.7228	–71.9	12.00	–9.60
PFM000074	16398	2009-10-06	0.46	–	–	–	–	–	–66.8	10.30	–8.80
PFM000107	16184	2009-01-12	0.50	–	–	–	–	–	–83.4	10.30	–11.70
PFM000107	16186	2009-01-12	1.00	–	–	–	–	–	–79.6	10.00	–11.30
PFM000107	16246	2009-04-13	0.51	–	–	–	–	–	–78.6	9.60	–11.10
PFM000107	16344	2009-08-10	0.51	108.07	–3.51	4.1	0.04	0.7218	–58.6	13.40	–6.60
PFM000107	16393	2009-10-05	0.50	–	–	–	–	–	–50.2	10.00	–5.20
PFM000117	16185	2009-01-12	0.50	–	–	–	–	–	–71.5	9.10	–9.60
PFM000117	16187	2009-01-12	1.50	–	–	–	–	–	–66.3	11.80	–9.00
PFM000117	16245	2009-04-14	0.52	–	–	–	–	–	–74.0	11.10	–10.40
PFM000117	16345	2009-08-10	0.51	106.90	–2.37	x	0.97	0.7243	–59.3	12.40	–7.10
PFM000117	16392	2009-10-05	0.50	–	–	–	–	–	–54.0	9.90	–5.90
PFM102269	16170	2009-01-13	0.51	–	–	–	–	–	–	10.40	–
PFM102269	16194	2009-02-09	0.51	–	–	–	–	–	–	10.90	–
PFM102269	16222	2009-03-09	0.50	–	–	–	–	–	–	10.20	–
PFM102269	16243	2009-04-14	0.50	–	–	–	–	–	–	8.10	–
PFM102269	16266	2009-05-12	0.50	–	–	–	–	–	–	10.30	–
PFM102269	16316	2009-06-16	0.51	–	–	–	–	–	–	10.00	–
PFM102269	16338	2009-08-11	0.51	–	–	–	–	–	–	74.20	–
PFM102269	16378	2009-09-01	0.50	–	–	–	–	–	–	11.80	–
PFM102269	16390	2009-10-06	0.50	–	–	–	–	–	–	10.90	–
PFM102269	16597	2009-11-02	0.51	–	–	–	–	–	–	10.40	–
PFM102269	16614	2009-12-01	0.51	–	–	–	–	–	–	8.40	–

x = No result due to sampling problems.

Table A13-4. Trace elements.

Idcode	Sample no.	Sampling date (yyyy/mm/dd)	Depth (m)	Al (ug/L)	Cd (ug/L)	Cr (ug/L)	Cu (ug/L)	Co (ug/L)	Hg (ug/L)	Ni (ug/L)	Zn (ug/L)	Pb (ug/L)	V (ug/L)	Mo (ug/L)	Ba (ug/L)
PFM000062	16192	2009-01-13	0.51	8.91	<0.02	0.238	1.060	0.049	<0.002	1.060	1.670	<0.1	0.108	1.410	15.3
PFM000062	16244	2009-04-14	0.50	25.80	0.022	0.069	0.759	0.047	<0.002	0.759	1.100	<0.1	0.099	1.510	15.8
PFM000062	16343	2009-08-10	0.50	1.18	<0.02	0.099	0.710	0.021	<0.002	0.811	2.470	<0.1	0.163	1.430	16.6
PFM000062	16391	2009-10-05	0.50	0.54	<0.02	0.072	0.618	0.025	<0.002	0.829	3.210	<0.1	0.106	1.450	16.5
PFM000074	16190	2009-01-13	0.50	18.40	<0.002	0.217	1.170	0.119	0.003	0.778	1.920	0.031	0.211	0.339	26.8
PFM000074	16251	2009-04-15	0.50	12.20	0.005	0.131	1.030	0.051	<0.002	0.633	1.090	0.018	0.270	0.541	19.7
PFM000074	16346	2009-08-11	0.50	4.32	<0.002	0.089	0.233	0.056	<0.002	0.465	1.630	0.036	0.176	0.274	33.4
PFM000074	16398	2009-10-06	0.46	2.18	<0.002	0.079	0.166	0.040	<0.002	0.270	0.581	0.026	0.149	0.299	28.3
PFM000107	16184	2009-01-12	0.50	49.50	0.006	0.378	2.010	0.158	0.005	1.210	3.700	0.102	0.317	0.663	25.0
PFM000107	16186	2009-01-12	1.00	47.70	0.011	0.319	1.540	0.281	0.006	1.040	3.570	0.134	0.352	0.539	27.2
PFM000107	16246	2009-04-13	0.51	23.90	0.006	0.224	0.464	0.119	0.003	0.661	0.597	0.105	0.291	0.298	22.4
PFM000107	16344	2009-08-10	0.51	9.32	<0.002	0.126	0.626	0.079	<0.002	0.507	1.070	0.184	0.387	0.792	17.2
PFM000107	16393	2009-10-05	0.50	4.78	<0.002	0.089	0.483	0.068	<0.002	0.406	0.677	0.124	0.214	0.622	14.6
PFM000117	16185	2009-01-12	0.50	x	x	x	x	x	x	x	x	x	x	x	x
PFM000117	16187	2009-01-12	1.50	76.00	0.010	0.259	0.678	0.069	<0.002	0.522	2.560	0.134	0.229	0.222	28.2
PFM000117	16245	2009-04-14	0.52	25.50	0.004	0.221	0.445	0.110	<0.002	0.701	0.692	0.103	0.323	0.304	23.1
PFM000117	16345	2009-08-10	0.51	3.83	<0.002	0.092	0.484	0.044	<0.002	0.271	1.340	<0.01	0.217	0.264	12.8
PFM000117	16392	2009-10-05	0.50	1.41	<0.002	0.047	0.296	0.048	<0.002	0.207	0.841	<0.01	0.166	0.193	14.0

Idcode	Sample no.	Sampling date (yyyy/mm/dd)	Depth (m)	U (ug/L)	Th (ug/L)	Sc (ug/L)	Rb (ug/L)	Y (ug/L)	Zr (ug/L)	Sb (ug/L)	Cs (ug/L)	La (ug/L)	Hf (ug/L)	Tl (ug/L)	Ce (ug/L)
PFM000062	16343	2009-08-10	0.50	0.562	<0.2	<0.4	18.300	0.029	0.164	<0.1	<0.1	<0.02	<0.02	<0.05	<0.02
PFM000074	16346	2009-08-11	0.50	1.280	<0.02	<0.05	1.600	0.130	0.187	0.051	<0.03	0.042	<0.005	<0.01	0.044
PFM000107	16344	2009-08-10	0.51	2.300	<0.02	<0.05	2.900	0.103	0.281	0.099	0.042	0.077	0.006	<0.01	0.101
PFM000117	16345	2009-08-10	0.51	1.170	<0.02	<0.05	2.220	0.056	0.211	0.091	<0.03	0.011	<0.005	<0.01	0.010

Idcode	Sample no.	Sampling date (yyyy/mm/dd)	Depth (m)	Pr (ug/L)	Nd (ug/L)	Sm (ug/L)	Eu (ug/L)	Gd (ug/L)	Tb (ug/L)	Dy (ug/L)	Ho (ug/L)	Er (ug/L)	Tm (ug/L)	Yb (ug/L)	Lu (ug/L)
PFM000062	16343	2009-08-10	0.50	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
PFM000074	16346	2009-08-11	0.50	0.013	0.062	0.014	<0.005	0.017	<0.005	0.017	<0.005	0.015	<0.004	0.015	<0.005
PFM000107	16344	2009-08-10	0.51	0.017	0.073	0.017	<0.005	0.014	<0.005	0.016	<0.005	0.011	<0.004	0.013	<0.005
PFM000117	16345	2009-08-10	0.51	<0.005	0.020	<0.005	<0.005	0.006	<0.005	0.008	<0.005	0.006	<0.004	0.009	<0.005

< “value” = below reporting limit.
x = No result due to analytical problems.

Table A13-5. Isotopes II (U-, Th-, Ra- and Rn-isotopes).

Idcode	Sample no.	Sampling date (yyyy/mm/dd)	Depth (m)	^{238}U mBq/kg	^{234}U mBq/kg	Th^{230} mBq/kg	Ra^{226} Bq/l
PFM000062	16317	2009-06-15	0.50	6.37	7.55	0.0040	0.0031
PFM000062	16343	2009-08-10	0.50	7.00	10.00	0.6300	–
PFM000068	16322	2009-06-16	0.70	21.84	23.90	1.0769	0.0044
PFM000074	16346	2009-08-11	0.50	13.00	14.00	0.5300	–
PFM000107	16318	2009-06-15	0.50	28.53	32.31	0.0096	0.0058
PFM000107	16344	2009-08-10	0.51	26.00	29.00	0.4600	–
PFM000117	16319	2009-06-15	0.50	12.31	13.16	0.0603	0.0038
PFM000117	16345	2009-08-10	0.51	14.00	15.00	0.8300	–