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Hydrogeochemical groundwater monitoring

Results from water sampling in the Forsmark area 2022

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Abstract

The present report documents the hydrogeochemical monitoring of deep groundwaters in the Forsmark area including the Spent Nuclear Fuel Repository Project as well as the SFR Extension Project. The sampling during the 2022 campaign includes 37 borehole sections within the monitoring program.

Sampling was conducted in series of three samples collected on three different occasions during continuous pumping i.e. varying the purged volume prior to sampling. Most of the standpipes connected to the sections were cleaned before the sampling campaign, with some exceptions.

Many different parameters were analysed during the sampling in 2022. Measured values for a large group of major and minor constituents as well as trace elements and isotopes are presented in the appendices. The relative charge balance is within the acceptable limits for all samples except six. As observed in previous sampling campaigns, rather high pH values were also recorded in a couple of the monitored borehole sections in 2022. The agreement between pH measured in the field and in the lab is inferior to the results from previous years, while for the electrical conductivity (EC) values the agreement is in general very good. According to the chloride concentrations, the groundwater composition in the sampled sections has generally been stable from year to year and no significant changes have been observed during latter years.

Sammanfattning

Denna rapport dokumenterar hydrokemisk övervakning av djupt grundvatten inom Forsmarksområdet där Projekt Kärnbränsleförvaret samt Projekt SFR-Utbyggnad ingår. Provtagningen som utförts under 2022 inkluderar 37 borrhålssektioner inom övervakningsprogrammet.

Provtagningen gjordes i serier med 3 prov, tagna vid tre olika tillfällen under tiden som kontinuerlig pumpning pågick, det vill säga de omsatta volymerna innan provuttaget varierades. Med några undantag spolades de flesta vattenståndsrör som är kopplade till sektionerna innan provtagnings-kampanjen påbörjades.

Många olika parametrar analyserades under provtagningen 2022. Uppmätta värden för huvud-komponenter, mindre förekommande ämnen, spårämnen och isotoper presenteras i rapportens bilagor. Jonbalansen ligger inom acceptabla gränser för samtliga prov förutom sex. Som observerats under tidigare mätkampanjer förekom relativt höga uppmätta pH-värden i ett par borrhålssektioner även under 2022. Överenstämmelsen mellan pH uppmätt i fält och på laboratorium är sämre än tidigare år, medan den för elektrisk konduktivitet (EC) generellt är mycket bra. Med hänsyn till klorid-koncentrationerna har grundvattensammansättningarna i de provtagna sektionerna generellt varit stabila från år till år och inga signifikanta förändringar har observerats under senare år.

Contents

1 Introduction

1.1 General

This report includes results from hydrogeochemical groundwater monitoring in boreholes included in the Spent Nuclear Fuel Repository Project as well as the SFR Extension Project in the Forsmark area during the year of 2022. The long-term hydrogeochemical monitoring programme for percussion-drilled and core-drilled boreholes aims at delivering long time series of data that will provide a baseline in order to facilitate evaluation of possible future impacts on the groundwater situation from the construction and the operation of the two facilities. The extent of natural variations is important information in order to identify possible future changes in water composition. Since the two study sites overlap, each project benefit from the increased amount of information about the hydrogeochemical conditions.

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 number (AP SFK-22-010). Only data in the database 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.

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

Activity plan	**Number**	**Version**
Hydrogeokemisk övervakning i hammar- och kärnborrhål 2022	AP SFK-22-010	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för hydrogeokemisk provtagning i ytborrhål med fasta manschettinstallationer	SKB MD 425.001	3.0
Metodbeskrivning för hydrokemisk provtagning i tunnelborrhål med fasta manschettinstallationer	SKB MD 425.002	1.0
Mätsystembeskrivning (MSB) – Handhavandedel; System för hydrologisk och meteorologisk datainsamling.Vattenprovtagning och utspädningsmätning i observationshål.	SKB MD 368.010	2.0
Provtagning och provhantering	SKBdoc 1063531	17.0
Kvalitetsparametrar för kemianalyser – SKB:s kemiklasser, aktuella detektions-, rapporteringsgränser samt mätosäkerheter	SKBdoc 1494275	2.0
Provtagningstyper och felkällor	SKBdoc 1072751	6.0

The field work conducted during the 2022 campaign was entirely planned and performed by Geosigma while SKB determined which boreholes and sections were to be sampled. SKB also managed the laboratory analyses of the obtained samples, either by analysis or by distribution of samples to external laboratories. For more detailed information of the division of tasks, see Activity Plan AP SFK-22-010.

1.2 Background

The monitoring program for groundwater has been on-going since 2005 (SKB 2005) and was initiated during the site investigations for a final repository of spent nuclear fuel (SKB 2001). The program was continued after the completion of the site investigation in 2007. The current monitoring program is developed from the program in R-07-34 (SKB 2007) and since 2012 boreholes drilled during the site investigations for the SFR extension project (SKB 2008) are incorporated in the monitoring program for the Forsmark area. During the years, the program has been modified concerning sampling techniques and analytical protocol. The monitoring history is presented in Appendix 1.

1.3 Boreholes and borehole sections

A total of 37 borehole sections, representing 18 core drilled boreholes and 10 percussion drilled boreholes, were included in 2022 in the hydrogeochemical monitoring program of groundwater in the bedrock, see Figure 1-1 and Table 1-2.

Figure 1-1. *General overview of the Forsmark area and the boreholes included in the hydrogeochemical monitoring program for deep groundwater. The (telescopic) cored boreholes and the percussion boreholes within the monitoring program are marked with orange and blue filled circles, respectively.*

Table 1-2. Boreholes and borehole sections included in the monitoring programme 2022 for percussion- and core-drilled boreholes, corresponding transmissivity values and comments to sections and sampling.

Borehole [Idcode: section no.]	Section [mbl] [1]	Elevation secmid [m.b.s.l] [2]	Transmissivity [m^2/s]	Comments
KFM01A:5	109.0-130.0	115.6	1.0 E-7 [3]	
KFM01D:2	429.0-438.0	343.1	8.0 E-7 [3]	[7]
KFM01D:4	311.0-321.0	252.5	2.0 E-7 [3]	[7]
KFM02A:3	490.0-518.0	495.0	2.1 E-6 [3]	Section of interest for the Uranium project
KFM02A:5	411.0-442.0	417.8	2.5 E-6 [3]	
KFM02B:2	491.0-506.0	483.8	3.0 E-5 [4]	
KFM02B:4	410.0-431.0	407.1	2.0 E-5 [4]	
KFM03A:1	969.5-994.5	969.1	5.5 E-7 [3]	Suspected leakage to section KFM03A:2
KFM03A:4	633.5-650.0	631.1	2.4 E-6 [3]	Section of interest for the Uranium project
KFM04A:4	230.0-245.0	199.7	2.0 E-5 [3]	
KFM06A:3	738.0-748.0	622.8	1.2E-7 [3]	
KFM06A:5	341.0-362.0	298.5	3.5 E-6 [3]	
KFM06C:3	647.0-666.0	527.1	5.3 E-8 [3]	
KFM06C:5	531.0-540.0	434.9	1.1 E-6 [3]	
KFM07A:2	962.0-972.0	795.6	5.0 E-7 [3]	Not sampled 2017-2019 [6]
KFM08A:2	684.0-694.0	550.6	1.0 E-6 [3]	
KFM08A:6	265.0-280.0	127.8	1.0 E-6 [3]	
KFM08D:2	825.0-835.0	622.6	2.4 E-8 [3]	[8]
KFM08D:4	660.0-680.0	538.1	2.0 E-7 [3]	[8]
KFM10A:2	430.0-440.0	299.8	3.0 E-5 [3]	Zone A2
KFM12A:3	270.0-280.0	226.7	1.0 E-6 [3]	
HFM01:2	33.5-45.5	37.0	4.0 E-5 [5]	
HFM02:2	38.0-48.0	39.9	5.9 E-4 [5]	
HFM04:2	57.9-65.9	57.9	7.9 E-5 [5]	
HFM13:1	159.0-173.0	138.6	2.9 E-4 [5]	
HFM15:1	85.0-95.0	59.1	1.0 E-4 [5]	
HFM16:2	54.0-67.0	57.2	3.5 E-4 [5]	
HFM21:3	22.0-32.0	18.8	4.0 E-5 [5]	
HFM27:2	46.0-58.0	45.6	4.0 E-5 [5]	
HFM32:3	26.0-31.0	27.5	2.3 E-4 [5]	
HFM33:2	121.0-137.5	101.8	4.7E-4	
KFR101:1	279.5-341.8	240.2	5.8E-6 [3]	Section in bottom of borehole. Extremly low salinity. No dummy in section.
KFR104:1	333.0-454.6	306.5	6.5E-8 [3]	Section in bottom of borehole. Extremly low salinity. No dummy in section.
KFR105:1	265.0-306.8	153.6	6.1E-8 [3]	Tunnel borehole.
KFR106:1	260.0-300.1	261.0	1.0E-5 [3]	Section of interest for the Uranium project. No dummy in section.
KFR106:2	143.0-259.0	187.2	3.3E-5 [3]	Section of interest for the Uranium project. No dummy in section.
KFR01:1	44.65-62.3	94.3	-	Tunnel borehole

[1] mbl = metres borehole length
[2] m.b.s.l. = metres below sea level [RHB 70 = the national levelling system]
[3] From differential flow logging
[4] From injection tests
[5] From flow logging
[6] Due to CCC (Complete Chemical Characterization) measurements in 2017 and lifted borehole equipment in 2018-2019.
[7] Equipment lifted and reinstalled before the sampling in 2016. No changes in equipment.
[8] Equipment lifted and reinstalled in 2013-2014. PEEK (PolyEtherEtherKetone)-equipment was installed.

In order to evaluate the results of groundwater analyses and observed trends in the groundwater chemistry, it is important to have information about previous investigations in each borehole and to understand the implications of these activities on the groundwater chemistry. Investigations likely to affect subsequent water sampling include hydraulic pumping and injection tests, tracer tests, SWIW tests (*Single Well Injection and Withdrawal-tests*) and tracer dilution tests.

During the 2022 campaign, some remodelling and reconstruction works were ongoing in the area around *Barackbyn (Söderviken).* Drilling, excavation and other contract work might have affected the chemical composition and/or the hydrostatical pressure in some of the investigated borehole sections included in the campaign.

Other activities in the area during the year 2022 can be found in Sicada.

Early activities in the area for the Spent Nuclear Fuel Repository Project that may have affected, for example, the Uranine or trace metal concentrations are presented in (Nilsson 2010). After 2009 Amino-G was used as tracer instead of Uranine for dilution tests, except for in HFM15 and KFM05A where Uranine has been used as a tracer even later on, for example during the dilution tests performed in 2013 (Wass 2013).

2 Equipment

2.1 Installations in a borehole test section with connected standpipe

The monitored boreholes are divided into sections sealed off by inflated rubber packers. The groundwater pressure is measured on-line in standpipes, hydraulically connected to each section and transmitted to HMS (*Hydro Monitoring System*), i.e. SKB:s hard- and software system for processing and interim storage of hydrological, hydrogeological and meteorological data. Most of the sampled sections are so-called circulation sections and are also hydraulically connected to wider standpipes, in which the pump fits. The fixed equipment (packers, tubing, standpipes etc.) remains in the borehole from year to year. An overview of the installation equipment is seen in Figure 2-1.

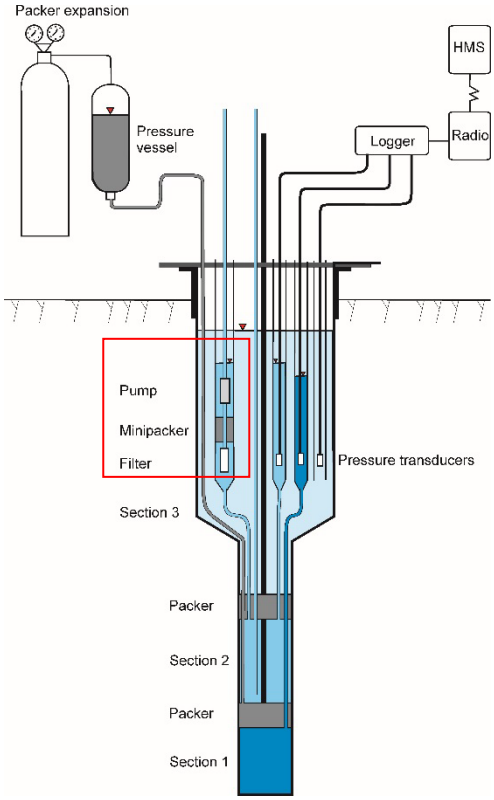

Figure 2-1. *Installations in a borehole test section with connected standpipes and monitoring equipment. The installation is permanent in the borehole, except for the pump and filter (marked with the red box), which are used in the standpipe at the pumping/sampling occasions.*

2.2 Cleaning equipment for standpipes

The cleaning is conducted using a specially designed nozzle combined with a pressure washer,

Figure 2-2. The nozzle is designed to direct the water jet in an upward direction in the standpipe in order to flush any flakes out of the standpipe. In order to lift the litter out of the standpipe more efficiently, a tube delivering nitrogen gas is mounted just above the nozzle to achieve a gas-lift pumping effect in the standpipe. A more detailed description of the cleaning equipment can be found in (Lindquist et al. 2011).

Figure 2-2. *Cleaning equipment used to clean the standpipes prior to pumping and sampling.*

2.3 Sampling equipment

Several identical pumping equipment set-ups (GEOPUMP UV45) were used to retrieve the water samples from the sampled sections, Figure 2-3. The sampling equipment is identical to what was used in previous campaigns and is further described in (Lindquist et al. 2011). When using this equipment, a mini-packer is expanded in the standpipe above the inlet to the filter and pump so that only water from the section and lowest part of the standpipe is pumped. In some sections, dissolved gas is released as pressure decreases. The gas accumulates under the mini-packer and causes pump stops. To avoid such problems, a special evacuation tube is used in some of the borehole sections, allowing the gas to evacuate. For more information about what pumping techniques were used in what sections, see Table **3-1**.

Figure 2-3. *The pumping equipment (GEOPUMP UV-45) used for pumping in wide standpipes. The equipment consists of a filter and a pump connected to the mini-packer. The small diameter plastic hose is used for expanding the packer and the plastic hose connected to the pump is the pumping hose (enclosed picture right lower corner).*

There have been problems with corrosion of the installed equipment in borehole KFM08D during the past years. In 2013 the equipment (packers etc.) was lifted and then reinstalled in 2014. The upper part of the installation was replaced by equipment in the material PEEK. Because of this, no mini-packers are used in the standpipes, instead there are O-ring sealed plugs which were removed during the sampling. To allow pumping directly from the section (and avoid contaminating water from the standpipe) a special docking unit was used, see Figure 2-4, similar to the one used in a few sections in 2015 (Lindquist and Ragvald 2015). The unit is working together with the normal pump (GEOPUMP UV45) but instead of expanding the mini-packer in the standpipe, the docking unit docks on and tightens around the top of the tube leading directly to the section (located at the bottom of the standpipe).

Figure 2-4. *The docking unit, which is used together with the pump (GEOPUMP UV-45). Instead of using the mini-packer to isolate the lower part of the standpipe with the pump, the unit is tightly fitted to the tube in the bottom of the standpipe. The photo shows the docking unit used in normally equipped boreholes. The one used in KFM08D is modified to match with the special equipment in PEEK but is very similar to the one in the photo.*

In the borehole sections lacking wide standpipes for sampling, sampling was performed in the standpipes for pressure measurements. Due to the smaller diameter of these standpipes, the sections were pumped using gas-lift pumping (with nitrogen). The function of this pump is briefly described in (Lindquist and Nilsson 2013) and the sampling equipment is also further described by (Sandström et al. 2011). Figure 2-5 shows a photo of the equipment. The sampling conditions caused by gas-lift pumping are different from the conventional pumping generally used in the hydrogeochemical monitoring programme. The more effective (intermittent) pump action might affect the borehole walls (microbe coating, mineral particles etc.), and thus might have an impact on the water composition. Especially, constituents such as hydrogen sulphide, TOC, DOC and trace metals may be affected.

In tunnel boreholes, no pumping equipment is needed due to the pressure gradient. When the valve is opened, water flows out from the section.

Figure 2-5. *The equipment used for gas-lift pumping. To the left, the tubing lowered down the standpipe (the narrower tube for sample water and the wider for gas) on a bobbin to simplify the lowering. To the upper right the control unit for the pumping/gas supply and lower right the end of the gas-lift pump.*

3 Performance

3.1 General

The sampling conducted in the 2022-campaign includes 37 borehole sections. Monitored boreholes, borehole sections and pumping technique at each sampling location are presented in Table 3-1. See Appendix 2 for more sampling information.

Table 3-1. Boreholes, borehole sections and pumping technique within the monitoring program 2022.

Borehole [Idcode:section no.]	Section [mbl]	Comments	Used pumping technique[1)]
KFM01A:5	109.0-130.0		A
KFM01D:2	429.0-438.0		A
KFM01D:4	311.0-321.0		A
KFM02A:3	490.0-518.0		A
KFM02A:5	411.0-442.0		A
KFM02B:2	491.0-506.0		A
KFM02B:4	410.0-431.0		A
KFM03A:1	969.5-994.5	Gas evacuation	A
KFM03A:4	633.5-650.0		A
KFM04A:4	230.0-245.0		A
KFM06A:3	738.0-748.0	Gas evacuation	A
KFM06A:5	341.0-362.0	Gas evacuation	A
KFM06C:3	647.0-666.0	Gas evacuation	A
KFM06C:5	531.0-540.0	Gas evacuation	A
KFM07A:2	962.0-972.0	Gas evacuation	A
KFM08A:2	684.0-694.0		A
KFM08A:6	265.0-280.0		A
KFM08D:2	825.0-835.0	Gas evacuation	D
KFM08D:4	660.0-680.0	Gas evacuation	D
KFM10A:2	430.0-440.0		A
KFM12A:3	270.0-280.0	Gas evacuation	A
HFM01:2	33.5-45.5		A
HFM02:2	38.0-48.0		A
HFM04:2	57.9-65.9		A
HFM13:1	159.0-173.0		A
HFM15:1	85.0-95.0		A
HFM16:2	54.0-67.0		A
HFM21:3	22.0-32.0		A
HFM27:2	46.0-58.0		A
HFM32:3	26.0-31.0		A
HFM33:2	121-137.5		A
KFR101:1	279.5-341.8		B
KFR104:1	333.0-454.6		B
KFR105:1	265.0-306.8		C
KFR106:1	260.0-300.1		B
KFR106:2	143.0-259.0		B
KFR01:1	44.65-62.3		C

[1)] A= UV45 pump, B= nitrogen lifting pump (in standpipe for pressure measurements), C= valve opening (no pump) and D= docking unit

3.2 Cleaning of standpipes

A special cleaning procedure was performed in most of the standpipes connected to the borehole sections prior to the sampling campaign in 2022, described in section 2.2. Some sections were not cleaned for different reasons:

- HFM32:3 since the locations of the borehole make it difficult to transport the cleaning equipment
- KFR106:1 and KFR106:2 because of the location
- KFM08D due to risk of damage on borehole equipment
- KFR105:1 and KFR01:1 (tunnel boreholes) are not connected to standpipes, so no cleaning is needed

After cleaning, the water in the standpipes was evacuated with gas (mammoth pumping) so that the standpipe filled up from underneath with section water. This was done to remove cleaning water from the standpipe and avoid cleaning water in the samples. The mammoth pumping was done twice in each standpipe. The groundwater in the standpipes and the borehole sections was then allowed to settle for a period of at least 4 weeks before the pumping and sample collection started.

3.3 Water sample treatment and analyses

The constituents included in the different SKB chemistry classes are listed in Table 3-2. Sample treatment (filtration, conservation, storage etc.) of samples, for analyses performed by SKB as well as for analyses performed by external laboratories, generally follow standard procedures. An overview of sample treatment and analysis routines/methods for major and minor constituents, organic carbon, trace metals and isotopes are given in "*Kvalitetsparametrar för kemianalyser – SKB:s kemiklasser, aktuella detektions-, rapporteringsgränser samt mätosäkerheter"*, see Table 1-1. The routines are applicable independently of sampling method or sampling object. See Appendix 3 for the results of the water composition for all the sampled boreholes and sections.

Table 3-2. Constituents analysed within the sampling series in the monitoring programme of deep groundwater in Forsmark, 2022, required volumes, pre-treatment and storage prior to analysis.

Constituent	Bottle[1)]/Volume	Preparation	Comment
pH_F, EC_F, temperature	-	-	On-line measurement in the field
pH_L, EC_L, alkalinity	500 mL	-	Analysis within 24h
Cl^-, SO_4^{2-}, Br^-, F^-	250 mL	Filtered with 0.4 µm filter	-
Na, K, Ca, Mg, SO_4-S, Si, Fe, Mn, Li, Sr, Th and U	Acid washed, 60 mL	Filtered with 0.4 µm filter, conserved with 1 mL HNO_3.	Suprapure acid is used for conservation
δ^2H, $\delta^{18}O$	100 mL	-	-
Uranine	60 mL, dark bottle		-.
HS^-	2x120 mL glass Winkler bottles	Conserved with 0.5 mL 1 M ZnAc and 0.5 mL 1M NaOH in the field. Bottle volume exchanged 2 times	
TOC	2x100 mL		Stored in freezer
DOC	2x100 mL	Filtered with 0.4 µm filter.	Stored in freezer
Archive	2x250 mL	Filtered with 0.4 µm filter	

Constituent	Bottle[1)]/Volume	Preparation	Comment
Archive	3x60 mL	Filtered with 0.4 µm filter, conserved with 1 mL HNO_3.	Suprapure acid is used for conservation
Archive	1000 mL	-	Stored in freezer
Density	100 mL		
^{3}H	500 mL	Bottle volume exchanged 3 times	
Br^- / I^-	100 mL	-	-
Fe (+II), Fe-tot	250 mL plastic Winkler bottles	Filtered with 0.4 µm filter. Conserved with 2.5 mL HCl	Analysis within 20 h Suprapure acid is used for conservation
NH_4-N, NO_2-N-N+NO_3 and PO_4-P	250 mL	Filtered with 0.4 µm filter	Do not store sample together with bottles containing HNO_3
Al, Ba, Cd, Co, Cr, Cu, Hg, Mo, Ni, P, Pb, V, Zn, (U, Th)	60 mL	Filtered with 0.4 µm filter	U and Th only included for samples in sections KFM02A:3, KFM03A:4, KFR106:1 and KFR106:2
U/Th-isotopes	1000 mL	-	Last sample in KFM02A:3, KFM03A:4, KFR106:1, KFR106:2
^{36}Cl	100-500 mL		Last sample in selected sections
^{34}S in SO_4	1000 mL		Last sample in KFM02A:3, KFM03A:1, KFM07A:2, KFM08A:2, KFM08A:6, KFM08D:4, KFM012A:3, HFM13:1, HFM15:1, HFM16:2
^{34}S	500-1000 mL		Last sample in selected sections
^{18}O in SO_4			Last sample in KFM02A:3, KFM03A:1, KFM07A:2, KFM08A:2, KFM08A:6, KFM08D:4, KFM012A:3, HFM13:1, HFM15:1, HFM16:2

Constituents determined in the different SKB chemistry classes:
Class I: Constituents in brown cells are included in class I
Class II: Constituents in brown and green cells are included in class II
Class II+: Constituents in brown, green and grey cells are included in class II+
Class III: Constituents in brown, green, grey and purple cells are included in class III
Class III+: Constituents in brown, green, grey, purple and orange cells are included in class III+
Blue cells contain additional constituents as complement to class III in some selected sections (KFR02).

[1)] Plastic bottles are used if nothing else is mentioned.

3.4 Water sampling in series and field measurements

3.4.1 General

Sampling in series was performed in all sampled borehole sections. During earlier sampling campaigns in 2011-2021, generally each series consisted of three samples distributed with respect to pumped "plug-flow volumes" (also including the volume of the tube connecting to the section). The term "plug-flow volume" refers to the theoretical volume that needs to be withdrawn in order to remove the exchangeable water present in the borehole section and achieve samples constituting close to 100% formation water (water originating directly from water bearing fractures in the surrounding rock). As the theoretical plug-flow volume may be underestimated due to laminar flow effects, 100% formation water is assumed at minimum 1.5 times the calculated plug-flow volume. The plug-flow volume varies from section to section, depending on the distribution of water-yielding fractures along the section and their hydraulic transmissivities. This concept is further described in (Nilsson 2010) and (Lindquist et al. 2011). With some exceptions 1.5, 3 and 5 plug-

flow volumes were removed before sampling in 2011-2022. Corresponding plug flow volumes for each borehole section are listed in Appendix 4.

In general, adequate water volumes according to the plug flow calculations were removed. However, in KFM08D:2 and KFR106:1, the volumes pumped before sampling were slightly less than 100 % of the plug flow volumes due to uneven flow rates. The volumes and percent formation water for each of these borehole sections are presented separately in Appendix 4.

The sampling procedure for the campaign in 2022 is described in section 3.4.2.

In order to rule out factors in the sampling procedure that could affect for example the sulphide concentrations, the discharge flow rate from each borehole section was set to the same flow rate as used during previous years. In sections with low hydraulic transmissivity, where a low flow rate must be used, all three samples in the series could not be collected during the working hours of a day. The collected samples and the removed water volumes prior to each sample are presented in Appendix 2. The discrepancy between actually removed volumes and those prescribed is partly due to practical reasons (i.e., sampling could not be performed in the middle of the night). The total removed volumes were calculated from the readings in the field protocols, where date, time and flow rates for the discharge periods and sampling occasions were noted.

Sample portions intended for analysis of major constituents and trace metals (by ICP technique), DOC, anions, iron (by spectrometry) and nutrient salts were filtered on-line in the field. Disposable 0.4 µm filters were fitted directly to the 8/6 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.

In addition to sampling of groundwater, field measurements of temperature, electrical conductivity (EC) and pH were conducted. The water from the borehole was led into a glass beaker on the ground surface 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. Measurements were conducted on flowing water. The results are given in chapter 4 and in Appendix 3.

The pumped water was, where needed, collected in tanks to prevent saline water from affecting the surroundings of the boreholes. The water was then discharged to the Baltic Sea.

The pressure in the borehole sections is continuously monitored by HMS, also during sampling. Pressure diagrams for each borehole and sampling occasion are given in Appendix 5. Possible short-circuiting, indicated by pressure responses in one or more sections other than the sampled ones, can be observed in several boreholes, see Appendix 5. However, observation of pressure propagation does not necessarily mean that water is transported between the sections. Information on flow rates, removed volumes and pressure responses are reported in Appendix 2. In the boreholes sampled from the small diameter standpipes where gas-lift pumping was used, the pressure transducers had to be lifted and the pressure in the pumped section could not be monitored during pumping.

3.4.2 Sampling in 2022

In 2022, each series consisted of three samples. Sampling was conducted in 37 borehole sections included in the monitoring program. (HFM19 was omitted due to deflated borehole packers.)

During the 2022 campaign, mainly 1.5, 3 and 5 plug-flow volumes were planned to be removed before sampling. For boreholes and sections for which the removed volume differs from 1.5, 3 and 5 plug-flow volumes, see Table 3-3. Collected samples and chemistry classes are listed in Table 3-4.

Generally, sampling was carried out successfully except for pump stops in KFM06A:3 (before the first sample), KFM01A:5 (after the first sample), KFM08D:4 (before the first sample) and HFM27 (before the first sample). In the sections where a pump stop occurred, the pumped volume prior to the next sample was measured from the new pump start, but the total pumped volume includes all pumping periods. For this and for more comments on nonconformities, see section 3.5.

Table 3-3. Sections where planned pumped volumes in sampling campaign in 2022 differ from normally used 1.5, 3 and 5 plug flow volumes.

Borehole [Idcode: section no.]	Sample 1	Sample 2	Sample 3
KFM06A:3	3 pf [1)]	+2 pf	+2 pf
KFM06C:3	115 L[2)]	+100 L	+100 L
KFM12A:3	3 sv [3)]	5 sv	7 sv
KFR01:1	3 sv	5 sv	7 sv

[1)] pf= plug flow volumes. Corresponding volume in litre for each section are found in Appendix 4.
[2)] L= Litre
[3)] sv= Section volumes including the volume of the plastic hoses. 1 sv is 23 L for KFM12A:3 and 40 L for KFR01:1

Table 3-4. Collected samples and analyses performed within the monitoring program 2022.

Borehole [Idcode: section no.]	Sample No in series	Chemistry class		
		Sample 1	Sample 2	Sample 3
KFM01A:5	100818-100820	II,b+	II,b+	III, a-d, h
KFM01D:2	100832-100834	II,b+	II,b+	III, a-d, h
KFM01D:4	100829-100831	II,b+	II,b+	III, a-d, h
KFM02A:3	100838-100840	II,b+	II,b+	III, a-d, h, f+, g+ [1)]
KFM02A:5	100835-100837	II,b+	II,b+	III, a-d, h
KFM02B:2	100844-100846	II,b+	II,b+	III, a-d, h
KFM02B:4	100841-100843	II,b+	II,b+	III, a-d, h
KFM03A:1	100850-100852	II,b+	II,b+	III, a-d, h, g+
KFM03A:4	100847-100849	II,b+	II,b+	III, a-d, h, f+ [1)]
KFM04A:4	100853-100855	II,b+	II,b+	III, a-d, h
KFM06A:3	100859-100861	II,b+	II,b+	III, a-d, h
KFM06A:5	100856-100858	II,b+	II,b+	III, a-d, h
KFM06C:3	100865-100867	II,b+	II,b+	III, a-d, h
KFM06C:5	100862-100864	II,b+	II,b+	III, a-d, h
KFM07A:2	100868-100870	II,b+	II,b+	III, a-d, h, g+
KFM08A:2	100874-100876	II,b+	II,b+	III, a-d, h, g+
KFM08A:6	100871-100873	II,b+	II,b+	III, a-d, h, g+
KFM08D:2	100880-100882	II,b+	II,b+	III, a-d, h
KFM08D:4	100877-100879	II,b+	II,b+	III, a-d, h, g+
KFM10A:2	100883-100885	II,b+	II,b+	III, a-d, h
KFM12A:3	100886-100888	II,b+	II,b+	III, a-d, h, g+
HFM01:2	100889-100891	II,b+	II,b+	III, a-d, h
HFM02:2	100892-100894	II,b+	II,b+	III, a-d, h
HFM04:2	100895-100897	II,b+	II,b+	III, a-d, h
HFM13:1	100898-100900	II,b+	II,b+	III, a-d, h, g+
HFM15:1	100901-100903	II,b+	II,b+	III, a-d, h, g+
HFM16:2	100904-100906	II,b+	II,b+	III, a-d, h, g+
HFM21:3	100907-100909	II,b+	II,b+	III, a-d, h
HFM27:2	100910-100912	II,b+	II,b+	III, a-d, h
HFM32:3	100913-100915	II,b+	II,b+	III, a-d, h
HFM33:2	100916-100918	II,b+	II,b+	III, a-d, h
KFR101:1	100919-100921	II,b+	II,b+	III, a-d, h
KFR104:1	100922-100924	II,b+	II,b+	III, a-d, h [2)]
KFR106:1	100934-100936	II,b+	II,b+	III, a-d, h, f+ [1) 2)]
KFR106:2	100931-100933	II,b+	II,b+	III, a-d, h, f+ [1) 2)]
KFR01:1	100925-100927	II,b+	II,b+	III, a-d, h [2)]
KFR105:1	100928-100930	II,b+	II,b+	III, b-d, h [2)]

1) Only U/Th isotopes from option f
2) No HS^- or Fe^{2+} analyses due to pumping technique

3.5 Nonconformities

The hydrogeochemical monitoring of deep groundwater has been conducted according to the SKB internal controlling document AP SFK SFK-22-010 with the following nonconformities.

Sampling:

- No field measurements of pH were performed when sampling KFR01 (all samples) and KFR105 (first and second sample) due to a faulty pH sensor.

Pumping procedures:

- Pump stops occurred in KFM01A:5 (between sample 1 and sample 2), KFM06A:3 (before first sample), KFM08D:4 (before first sample) and HFM27 (before first sample).
- For two sections (KFM08D:2 and KFR106:1) the pumped volumes before the sampling were lower than planned (see Appendix 2) because of lower pump flows than planned.
- For some of the sections (KFR01:1 and KFR105:1), the pumped volumes before sampling were substantially larger than planned (see Appendix 2).
- Flow rates are difficult to adjust when gas-lift pumping is used. Therefore, pumped volumes are slightly higher or lower than planned for some of the sections (i.e. KFR106:1) pumped with this method.

Analyses:

- In the first and third sample in KFR106:1 the dissolved organic carbon was significantly higher than the total organic carbon in the sample (which was also true during the 2021 campaign). The results were confirmed by both the internal and an external laboratory. The analysis of TOC and DOC of the third sample in KFM06C:3 was delayed because of transport problems. In the second sample in HFM32:3 the dissolved organic carbon was significantly higher than the total organic carbon. The sample was re-analysed with the same result.
- Samples in KFM02A:3 and KFM02A:5 were analysed twice, with concern to metals on both unfiltered and filtered water and the results from both analyses were similar.
- The relative charge balance criteria (± 5 %) were not met for six samples (second sample in HFM21:3, first and third sample in KFR101:1, and in all three samples in KFR104).
- Uranium and thorium element concentrations were not analysed in KFM02A:3, KFM03A:4, KFR106:1 and KFR106:2, which was planned.

4 Results

4.1 Water analysis and measurements

The results from analyses and field measurements are presented in Appendix 3. The first table for each year includes the major constituents Na, K, Ca, Mg, HCO_3^-, Cl^-, SO_4^{2-}, SO_4-S, Br^-, F^-, Si, Fe, Mn, Li and Sr as well as minor constituents like HS^-, NO_2^-, NO_3^-, NH_4^+, PO_4^{3-}, TOC and DOC from all sampled boreholes. Furthermore, this table contains laboratory data and field measurement data on pH, electrical conductivity (EC) and the water temperature recorded in the field.

The relative charge balance (RCB) provides an indication of the quality and uncertainty of the analyses of major constituents and, the charge balance errors were calculated for all samples. Relative errors within ± 5% are considered acceptable.

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

The relative charge balances were for all samples, except for six samples (second sample in HFM21:3, first and third sample in KFR101:1, and in all three samples in KFR104) within the acceptable limit of ± 5%.

Trace elements and the isotopes δ^2H and $\delta^{18}O$ were determined in all samples during the 2022 campaign and ^3H was determined in the last sample in each series (see Appendix 3). In 2019 (Föhlinger 2021) and 2020 (Olofsson 2022a) analyses of Ag, As, B, Nb, Rb, Zr, Sb, Cs and Nd were added in some sections. From 2021 (Olofsson 2022b) these elements were determined in the last sample in each series in all borehole sections which was also true for the 2022 campaign.

Furthermore, the uranium and thorium element concentrations were not analysed during the 2022 campaign while the isotopes (^{238}U, ^{235}U, ^{234}U, ^{232}Th and ^{230}Th) were determined in the last sample from sections KFM02A:3, KFM03A:4, KFR106:1 and KFR106:2 (see Appendix 3).

The laboratory measurements and field measurements of pH and EC are compared in Figure 4-1 and Figure 4-2 respectively.

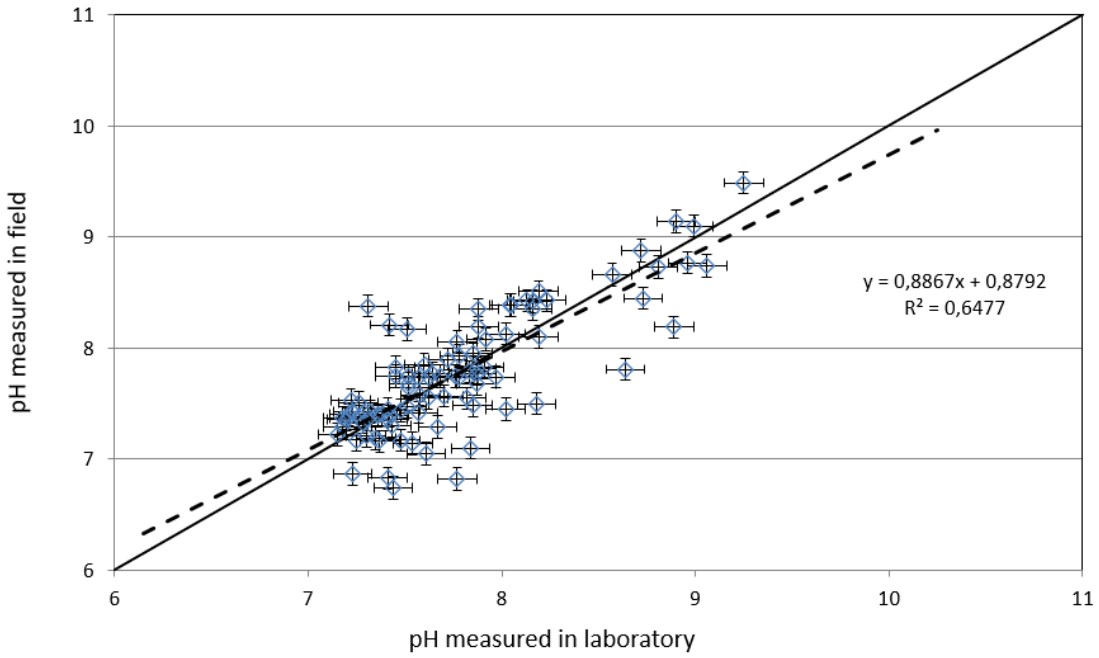

Figure 4-1. *Comparison between laboratory measurements and field measurements of pH. The laboratory measurements are performed at 25 °C and the field measurements are performed at the actual water temperature. The dashed line is the linear fit.*

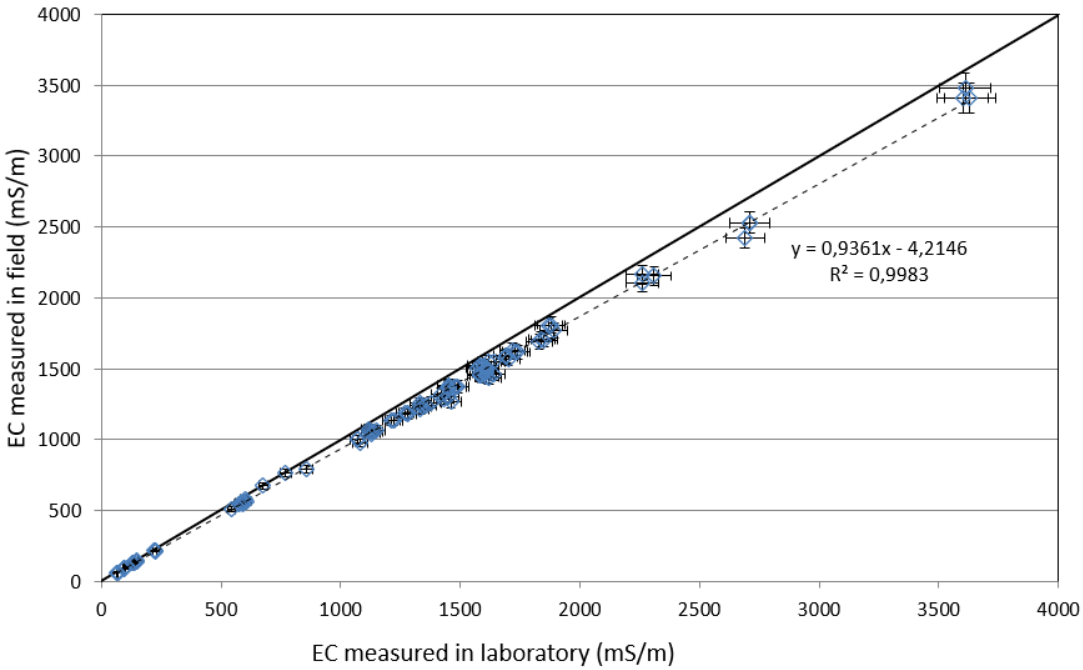

Figure 4-2. *Comparison between laboratory measurements and field measurements of EC. All values are corrected to the conductivity at 25 °C. The dashed line is the linear fit.*

The agreement between the different pH values is in general poor compared to earlier years comparisons. There are some samples where the compared pH values deviate more than others, which may be due to temperature and pressure differences and/or time delay. For some samples there are larger discrepancies between laboratory and field pH-measurements. For some of these, the field value differs compared to other pH-measurements in the same section and mistakes during field measurement is the most plausible reason. The coefficient of determination (R^2) is in the region of 0.64 which can be compared to comparisons from earlier campaigns which has been in the 0.90-range. As previously observed in some of the monitored boreholes belonging to the Spent Nuclear Fuel Repository Project, see e. g. (Ragvald 2016) and (Ragvald 2018), some high pH values were also recorded in 2022, although no pH values above 10 have been measured in the laboratory. During earlier campaigns, especially in 2019, there were several samples with pH values above 10. Diagrams of pH values during the years in sections with elevated pH values are presented in Appendix 6. The issue with elevated pH values is discussed in (Nilsson and Sandberg 2016). The earlier increase seems to have ceased or at least been less obvious and the measured pH values seem to have stabilized during the last years of sampling.

The agreement between the EC values from field and lab is quite good, but generally the results from field measurements are about 7% larger than the results from laboratory measurements, which is slightly larger than the analytical error. The dispersion between different years is small.

In the comparison between the laboratory measurements and field measurements for both EC and pH, no outliers have been removed.

For the borehole sections for which no cleaning of the stand pipes was performed prior to the sampling campaigns (see Appendix 1), the water compositions generally seem to have been quite stable through the sampling series.

4.2 Chloride

Graphs showing chloride concentrations in collected samples from hydrogeochemical monitoring 2022 together with data from hydrogeochemical monitoring earlier years are presented in Appendix 7.

When the chloride trends are analysed, it can be observed that in KFM01D:2, KFM01D:4 and KFM06C:3 there appears to be an increasing trend in chloride concentrations, however within the analytical uncertainty of the results from recent years. In KFM08D:2 and KFM08D:4, higher chloride concentrations have been measured since the measurements continued in 2015, after reinstallation in 2014.

In HFM01:2, HFM02:2, HFM15:1, KFM08A:6, KFR102A:5 and KFR104:1 there have been decreasing trends since the measurements started, which now seem to have levelled out during the latter years. In HFM27:2 there is an ongoing decreasing trend in chloride concentration.

Within each sample series (increasing plug flow volumes), the chloride concentrations were generally stable in 2022. The exceptions are KFR106:1 for which chloride concentrations increased with pumped volumes. For KFR106:1, also sodium, calcium, magnesium and sulphate concentrations increased, which has also been the case during earlier campaigns.

In 2016, the chloride concentrations were lower in KFR106:1. The lower chloride concentrations were thought to be due to smaller pumping volumes (Ragvald 2018). The values during last years in KFR106:1 vary from year to year. When comparing chloride concentrations and pumping volumes for 2014-2022, there is an indication that they might be correlated.

5 Summary and discussions

A total of 37 borehole sections included in the monitoring program were sampled during the 2022 campaign. Sampling was conducted in series of three samples collected on three different occasions during continuous pumping i.e. varying the purged volume prior to sampling. With large enough purging prior to sampling, the contribution from influenced section water present in the borehole section decreased with more representative groundwater samples as a result.

Many different parameters were analysed during the sampling in 2022 including measured values for a large group of major and minor constituents as well as trace elements and isotopes. The relative charge balance was within the acceptable limits for all analysed samples, except six of them. As observed in previous sampling campaigns for the Spent Nuclear Fuel Repository Project, high pH values were also recorded in some of the monitored borehole sections in 2022 although no pH values above 10 were measured in the laboratory. The agreement between the pH-values measured in the field and in the lab were significantly inferior compared with previous years, and the agreement between the EC-values measured in the field and in the lab seems systematically lower, around 7% from the 1:1 proportional line.

According to the analysed chloride concentrations, the groundwater compositions in the sampled sections are generally stable, although some increasing and decreasing trends (compared with 2009, when sampling series were introduced) can be discerned in some sections during the last years of sampling. A weak increasing trend (within the analytical uncertainty) might be present in KFM01D:2, and a decreasing trend is present for HFM27:2 with differences larger than the analytical error.

During the campaign a total of four pump stops occurred. Gas evacuation tubes were used in the same sections as previous years, which probably helped avoiding additional pump stops.

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Appendix 1

Overview of the monitoring program 2005-2022

Table A1-1. Overview of the monitoring program in the Forsmark area 2005-2011.

Year	Number of sections included		Sampling programme		Analyses of sulphide (HS^-)		Analyses of Uranium (U)		Cleaning	Exchange of water prior to sampling		Analytical protocol (general)
	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn		Ordinary	Series	
2005	8	10	One sample/section	One sample/section	no	yes	no	yes	no	At least 3 section volumes	-	**Spring:** Class 3 **Autumn:** Class 5
2006	15	17	One sample/section	One sample/section	no	yes	no	yes	no	At least 3 section volumes	-	**Spring:** Class 3 **Autumn**: Class 5
2007	21	28	One sample/section	Series of 3 samples in 2 sections. One sample/section in the others	no	yes	no	yes	no	At least 3 section volumes	1 tube vol., 1 section vol., 3 section vol.	**Spring:** Class 3, some class 5 **Autumn:** Mainly class 5, some class 4
2008	33	33	One sample/section	One sample/section	in class 5	yes	in class 5	in class 5	no	At least 3 section volumes	-	**Spring:** Class 5 (in 7 sections) and class 3. **Autumn:** Mainly class 5, some class 4
2009	33	33(13)	One sample/section	Series of 5 samples in 13 sections. One sample/section in the others	in class 4	All samples in series. Not in single samples.	no	All samples in series. Not in single samples.	Rinse pumping in 13 selected sections. No measure in other sections.	At least 5 section volumes	1 tube vol., 1 section vol., 2, 3, 5 section vol.	**Spring:** Class 3 and 4 (in 7 sections) **Autumn:** Class 3 for single samples. For series 4, 4+ and 5+)
2010	12	12	Series of 5 samples in 12 sections.	Series of 3 samples in 12 sections.	in all samples	last sample in each series	All samples.	In last sample in series in 4 sections.	Cleaning [1)] in all 12 sections both spring and autumn.	-	Plug flow vol. spring: (<1, 2, 3, 4, 5) autumn: (3, 4, 5-6)	**Spring:** Class 5 **Autumn:** Class 3 and 4
2011	32 [2)]	32 [2)]	Series of 3 samples from all sections	Series of 3 samples from all sections	in all samples	in all samples	Last sample in series in KFM02A:2 and KFM03A:4.	Last sample in series in KFM02A:2 and KFM03A:4.	Cleaning [1] in all sections either in spring or in autumn.	-	Plug flow volumes (1.5, 3, 5)	**Spring:** Class 4 **Autumn:** Class 4

[1)] High pressure cleaning and rinse pumping
[2)] KFM08D:2 was omitted

Table A1-2. Overview of the monitoring program in the Forsmark area 2012-2016.

Year	Number of sections included		Sampling programme		Analyses of sulphide (HS^-)		Analyses of Uranium (U)		Cleaning	Exchange of water prior to sampling series	Use of docking unit	Analytical protocol (general)
	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn				
2012	32 [3]	31 [4]	Series of 3 samples from all sections	Series of 3 samples from all sections	in all samples	no	Last sample in series in KFM02A:2 and KFM03A:4.	Last sample in series in KFM02A:2 and KFM03A:4.	Cleaning[1] in all sections in spring	Plug flow volumes (1.5, 3, 5)	-	**Spring:** Class 4 **Autumn:** Class 3
2013	31 [4]	1	Series of 3 samples from all sampled sections	Series of 3 samples from all sampled sections	in all samples	in all samples	last sample in series in KFM02A:2 and KFM03A:4.	no	Cleaning[1] in all sections in spring	Plug flow volumes (1.5, 3, 5)	-	**Spring:** Class 4 **Autumn:** Class 4
2014	24 [5]	5	Series of 3 samples from all sampled sections	Series of 3 samples from all sampled sections	in all samples	in all samples	last sample in series in KFM02A:2 and KFM03A:4.	no	Cleaning[1] in all sections except HFM32:3 either in spring or in autumn.	Plug flow volumes (1.5, 3, 5)	1 section in spring	**Spring:** Class 4 **Autumn:** Class 4
2015	27 [6]	4	Series of 3 samples from all sampled sections	Series of 3 samples from all sampled sections	in all samples	in all samples	last sample in series in KFM02A:2 and KFM03A:4.	no	Cleaning[1] or cleaning[2] in all sections except HFM32:3 and KFM08D:2 and 4 either in spring or in autumn.	Plug flow volumes (1.5, 3, 5)	KFM08D:2 and 4 (borehole equipment in PEEK)	**Spring:** Class 4 **Autumn:** Class 4
2016	23[7]	0	Series of 3 samples from all sampled sections	No sampling performed during autumn	in all samples	-	last sample in series in KFM02A:3	No	Cleaning[2] in most sections[9]	Plug flow volumes (1.5, 3, 5) in all sections except KFM06A:3, KFM06C:3 and KFM11A:2[10]	-	**Spring:** Class 4 **Autumn:** -

1) High pressure cleaning and rinse pumping
2) High pressure cleaning and gas lift pumping (2 gas blows).
3) KFM08D:2 was omitted
4) KFM08D:2 and KFM08D:4 were omitted
5) KFM01D:2, KFM01D:4, KFM07A:2, KFM08D:2 and KFM08D:4 were omitted this year.
6) KFM01D:2 and KFM01D:4 were omitted
7) KFM03A:4, KFM07A:2, KFM08A:6, KFM08A:2, KFM08D:4, KFM08D:2, KFM10A:2, KFM11A:4, HFM13:1 and HFM21:3 were omitted.
8) KFM07A:2 was omitted.
9) No cleaning in KFM03A:1, KFM11A:2, HFM01:2 and HFM32:3 due to various reasons.
10) Due to high pH values during earlier years, the plug flow volumes were increased during 2016.

Table A1-3. Overview of the monitoring program in the Forsmark area 2017-2021.

Year	Number of sections included		Sampling programme		Analyses of sulphide (HS^-)		Analyses of Uranium (U)		Cleaning	Exchange of water prior to sampling series	Use of docking unit	Analytical protocol (general)
	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn				
2017	13 [5]	0	Series of 3 or 4 samples from all sampled sections [4]	No sampling performed during autumn	In most samples, except 1st sample in series	-	No	-	Cleaning[2] in most sections[3]	Plug flow volumes (1.5, 3, 5) in all sections except some sections. [7]	KFM08D:2 and 4 (borehole equipment in PEEK)	**Spring: C**lass II, b+ and III, d-h, h **Autumn: -**
2018	22 [6]	8	Series of 3 samples from all sampled sections	Series of 3 samples from all sampled sections	in all samples	in all samples	last sample in series in KFM02A:3, KFM02A:5	-	Cleaning[2] in most sections[9]	Plug flow volumes (1.5, 3, 5) in all sections except some sections. [8]	KFM08D:2 and 4 (borehole equipment in PEEK)	**Spring: C**lass II, b+ and III, d-h, h **Autumn: C**lass II, b+ and III, d-h, h
2019	30 [8]	2	Series of 3 samples from all sampled sections	Series of 3 samples from all sampled sections	in all samples	in all samples	last sample in series in KFM02A:3, KFM02A:5	last sample in series in KFM03A:4	Cleaning[2] in most sections[9]	Plug flow volumes (1.5, 3, 5) in all sections except KFM06A:3, KFM06C:3 and KFM11A:2[10]	KFM08D:2 and 4 (borehole equipment in PEEK)	**Spring: C**lass II, b+ and III, d-h, h **Autumn: C**lass II, b+ and III, d-h, h
2020	32	0	Series of 3 samples from all sampled sections	No sampling performed during autumn	In all samples	-	Last sample in series in KFM02A:3 and KFM03A:4		Cleaning[2] in most sections[10]	Plug flow volumes (1.5, 3, 5) in all sections except KFM06A:3, KFM06C:3 and KFM11A:2[11]	KFM08D:2 and 4 (borehole equipment in PEEK)	**Spring: C**lass II, b+ and III, d-h, h **Autumn: -**
2021	33	0	Series of 3 samples from all sampled sections	No sampling performed during autumn	In all samples	-	Last sample in series in KFM02A:3, KFM03A:4 and KFM08D:4		Cleaning[2] in most sections[10]	Plug flow volumes (1.5, 3, 5) in all sections except KFM06A:3, KFM06C:3, KFM11A:2 and KFM12A:3	KFM08D:2 and 4 (borehole equipment in PEEK)	**Spring: C**lass II, b+ and III, a-d, h, f[12] **Autumn: -**

1) High pressure cleaning and rinse pumping
2) High pressure cleaning and gas lift pumping (2 gas blows).
3) No cleaning in HFM32, KFM08D due to various reasons.
4) 4 samples in: KFM06A:3 ,KFM06A:5 , KFM06C:3 , KFM06C:5 , KFM08A:2 , KFM08A:6 , KFM08D:2 , KFM08D:4 , KFM11A:2 , KFM11A:4 ,KFM12A:3. Second sample by stable pH-value.
5) KFM01A:5, KFM01D:2, KFM01D:4, KFM02A:3, KFM02A:5, KFM02B:2, KFM02B:4, KFM03A:1, KFM03A:4, HFM01:2, HFM02:2, HFM04:2, HFM13:1, HFM15:1, HFM16:2, HFM19:1, HFM21:3, HFM27:2, HFM32:3 were omitted
6) HFM32:3, HFM19:1, KFM07A:2 were omitted
7) Changed pump volume in KFM06A:5, KFM06A:3, KFM06C:5, KFM06C:3, KFM08A:6, KFM08A:2, KFM08D:4, KFM08D:2, KFM11A:4, KFM11A:2, KFM12A:3.
8) Changed pump volume in KFM06A:5, KFM06A:3, KFM06C:5, KFM06C:3, KFM08A:2, KFM08D:4, KFM08D:2, KFM11A:2
9) No cleaning in KFM08D.
10) No cleaning in HFM32:3, KFM08D, KFM02A, KFM02B, KFM04A, KFM07A
11) Changed pump volume in KFM06A:3,KFM06C:3, KFM11A:2
12) Third sample in section KFM02A:3 and KFM03A:4

Table A1-4. Overview of the monitoring program in the Forsmark area 2022.

Year	Number of sections included		Sampling programme		Analyses of sulphide (HS^-)		Analyses of Uranium (U)		Cleaning	Exchange of water prior to sampling series	Use of docking unit	Analytical protocol (general)
	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn				
2022	34	0	Series of 3 samples from all sampled sections	No sampling performed during autumn	In all samples	-	Last sample in series in KFM02A:3, KFM03A:4 and KFM08D:4		Cleaning[1)] in most sections[2)]	Plug flow volumes (1.5, 3, 5) in all sections except KFM06A:3, KFM06C:3, KFM11A:2 and KFM12A:3	KFM08D:2 and 4 (borehole equipment in PEEK)	**Spring: C**lass II, b+ and III, a-d, h, f[3)], g[4)] **Autumn: -**

1) High pressure cleaning and gas lift pumping (2 gas blows).
2) No cleaning in HFM32, HFM33 and KFM08D
3) Third sample in section KFM02A:3 and KFM03A:4
4) Third sample in section KFM02A:3, KFM03A:1, KFM07A:2, KFM08A:2, KFM08A:6, KFM08D:4, KFM12A:3, HFM13:1, HFM15:1, HFM16:2

Table A1-4. Overview of the monitoring program at the SFR-site 2012-2018.

Year	Number of sections included		Sampling programme		Analyses of sulphide (HS^-)		Analyses of Uranium (U)		Cleaning	Exchange of water prior to sampling series	Analytical protocol (general)
	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn			
2012	7	7	Series of 3 samples from all sections	Series of 3 samples from all sections	in KFR102A (2 sect.)	no	last sample in series in KFR106:1 and KFR106:2	last sample in series in KFR106:1 and KFR106:2	Cleaning [1)] in all sections in spring.	Plug flow volumes (1.5, 3, 5)	**Spring:** Class 4 **Autumn**: Class 3
2013	7	3	Series of 3 samples from sampled sections	Series of 3 samples from sampled sections	in KFR102A (2 sect.) and KFR105	no	last sample in series in KFR106:1 and KFR106:2	no	Cleaning [1)] in all sections in spring.	Plug flow volumes (1.5, 3, 5)	**Spring:** Class 4 **Autumn:** Class 3
2014	5	5	Series of 3 samples from sampled sections	Series of 3 samples from sampled sections	in KFR102A (2 sect.) and KFR105	no	no	last sample in series in KFR106:1 and KFR106:2	Cleaning [1)] in all sections in spring.	Plug flow volumes (1.5, 3, 5)	**Spring:** Class 4 **Autumn:** Class 3
2015	6	4	Series of 3 samples from sampled sections	Series of 3 samples from sampled sections	in KFR102A (2 sect.)	KFR105	last sample in series in KFR106:1 and KFR106:2	no	Cleaning[2)] in all sections except KFR105 in spring.	Plug flow volumes (1.5, 3, 5)	**Spring:** Class 4 **Autumn:** Class 3
2016	7 [3)]	0	Series of 3 samples from sampled sections	No sampling performed during autumn	in KFR102A (2 sect.) and KFR01	-	last sample in series in KFR106:1 and KFR106:2	-	Cleaning [2)] in section KFR102A:5 and KFR102A:2	Plug flow volumes (1.5, 3, 5)	**Spring:** Class 4 **Autumn:** -
2017	2[4)]	0	Series of 3 samples from all sampled sections	No sampling performed during autumn	in all samples	-	no	-	no	Plug flow volumes (1.5, 3, 5) except KFR01:1.	**Spring: C**lass II, b+ and III, d-h, h **Autumn: -**
2018	7[5)]	0	Series of 3 samples from all sampled sections	No sampling performed during autumn	In all except in KFR01	-	last sample in series in KFR106:1 and KFR106:2	-	Cleaning[2)] in all sections except KFR01, KFR106.	Plug flow volumes (1.5, 3, 5) except KFR01:1.	**Spring: C**lass II, b+ and III, d-h, h **Autumn: -**

1) High pressure cleaning and rinse pumping
2) High pressure cleaning and gas lift pumping (2 gas blows)
3) KFR01:1 was added to the monitoring program. KFR105:1 was not available during the sampling period due to hydraulic injection test.
4) KFR101:1, KFR102A.2, KFR102A:5, KFR104:1, KFR106:1, KFR106:2 were omitted.
5) KFR105:1 was omitted

Table A1-5. Overview of the monitoring program at the SFR-site 2019-2022.

Year	Number of sections included		Sampling programme		Analyses of sulphide (HS^-)		Analyses of Uranium (U)		Cleaning	Exchange of water prior to sampling series	Analytical protocol (general)
	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn			
2019	6	2	Series of 3 samples from all sampled sections	Series of 3 samples from sampled sections	in all samples	in all samples	last sample in series in KFR106:1 and KFR106:2	-	Cleaning[1)] in all sections except KFR01, KFR105 KFR106.	Plug flow volumes (1.5, 3, 5) except KFR01:1.	Spring: Class II, b+ and III, d-h, h Autumn: Class II, b+ and III, d-h, h
2020	8	0	Series of 3 samples from all sampled sections	No sampling performed during autumn	In all samples	-	last sample in series in KFR106:1, KFR106:2	-	Cleaning[1)] in all sections except KFR01, KFR105 KFR106.	Plug flow volumes (1.5, 3, 5) except KFR01:1	Spring: Class II, b+ and III, d-h, h Autumn: -
2021	8	4	Series of 3 samples from all sampled sections	Series of 3 samples from all sampled sections	In all samples	In all samples	last sample in series in KFR106:1, KFR106:2	-	Cleaning[1)] in KFR101:1, KFR102A:5, KFR102A:2, KFR104:1	Plug flow volumes (1.5, 3, 5) except KFR01:1, KFR02:2, KFR02:3, KFR02:4	Spring: Class II, b+ and III, a-h, h Autumn: Class II, b+ and III, a-h, f, h
2022	6	0	Series of 3 samples from all sampled sections	No sampling performed during autumn	In all samples	-	last sample in series in KFR106:1, KFR106:2	-	Cleaning[1)] in KFR101:1, KFR104:1	Plug flow volumes (1.5, 3, 5) except KFR01:1	Spring: Class II, b+ and III, a-d, h, f[2)] Autumn: -

1) High pressure cleaning and gas lift pumping (2 gas blows)
2) KFR106:1 and KFR106:2

Appendix 2

Sampling information

Table A2-1. Sampling information in 2022.

Idcode: section	Tube volume [L]	Section volume [L]	Length of pumping period	Medium flow rate[1] [mL/min]	Planned removed volume[2] [L]	Pumped volume[3] [L]	Sampling date	Sample no.	Responses observed in other sections in the borehole (if yes, se Appendix 4) /Comments
KFM01A:5	1.4	18	3 days 12 h 0 min	184		762	-	-	Yes
					139.5	135	2022-05-31	100818	
					279	280	2022-06-02	100819	
					465	494	2022-06-03	100820	
KFM01D:2	3.3	24.5	1 day 6 h 32 min	80		146	-	-	Yes
					24	24	2022-05-24	100832	
					48	48	2022-05-24	100833	
					80	136	2022-05-25	100834	
KFM01D:4	9	12.3	0 days 6 h 58 min	239		100	-	-	Yes
					27	28	2022-06-07	100829	
					54	54	2022-06-07	100830	
					90	91	2022-06-07	100831	
KFM02A:3	14.1	33.4	1 day 7 h 50 min	129		247	-	-	No
					63	76	2022-05-09	100838	
					126	218	2022-05-10	100839	
					210	237	2022-05-10	100840	
KFM02A:5	11.9	31.8	3 days 5 h 14 min	206		956	-	-	No
					273	317	2022-05-09	100835	
					546	591	2022-05-10	100836	
					910	943	2022-05-11	100837	
KFM02B:2	12.8	15	1 day 5 h 30 min	307		543	-	-	No
					90	120	2022-05-05	100844	
					180	187	2022-05-05	100845	
					300	534	2022-05-06	100846	

Idcode: section	Tube volume [L]	Section volume [L]	Length of pumping period	Medium flow rate[1] [mL/min]	Planned removed volume[2] [L]	Pumped volume[3] [L]	Sampling date	Sample no.	Responses observed in other sections in the borehole (if yes, se Appendix 4) /Comments
KFM02B:4	10.5	21	1 day 7 h 32 min	535		1012	-	-	No
					287	330	2022-05-05	100841	
					573	891	2022-05-06	100842	
					955	995	2022-05-06	100843	
KFM03A:1	27.7	31.5	4 days 15 h 15 min	63		422	-	-	Yes
					119	153	2022-05-16	100850	
					237	315	2022-05-18	100851	
					395	415	2022-05-19	100852	
KFM03A:4	18.2	18.6	1 day 5 h 0 min	206		358	-	-	No
					44	61	2022-05-17	100847	
					87	107	2022-05-17	100848	
					145	344	2022-05-18	100849	
KFM04A:4	6.8	18.7	0 days 7 h 27 min	188		84	-	-	No
					24	24	2022-05-11	100853	
					48	48	2022-05-11	100854	
					80	76	2022-05-11	100855	
KFM06A:3	21.1	13.6	8 days 1 h 23 min	59		364	-	-	Yes
					84	92	2022-05-09	100859	
					140	160	2022-05-10	100860	
					196	250	2022-05-11	100861	
KFM06A:5	9.9	22.4	1 day 6 h 19 min	155		281	-	-	Yes
					39	53	2022-05-03	100856	
					78	87	2022-05-03	100857	
					130	269	2022-05-04	100858	
KFM06C:3	18.5	23.5	11 days 4 h 16 min	19		313	-	-	Yes
					115	129	2022-05-09	100865	
					215	250	2022-05-13	100866	
					315	307	2022-05-16	100867	

Idcode: section	Tube volume [L]	Section volume [L]	Length of pumping period	Medium flow rate[1] [mL/min]	Planned removed volume[2] [L]	Pumped volume[3] [L]	Sampling date	Sample no.	Responses observed in other sections in the borehole (if yes, se Appendix 4) /Comments
KFM06C:5	15.3	11.1	1 day 7 h 2 min	148		275	-	-	Yes
					42	45	2022-05-04	100862	
					84	84	2022-05-04	100863	
					140	263	2022-05-05	100864	
KFM07A:2	27.4	13.9	1 day 9 h 16 min	97		194	-	-	Yes
					57	57	2022-06-13	100868	
					114	151	2022-06-14	100869	
					190	185	2022-06-14	100870	
KFM08A:2	19.6	13.9	0 days 6 h 50 min	300		123	-	-	No
					33	36	2022-05-20	100874	
					66	68	2022-05-20	100875	
					110	110	2022-05-20	100876	
KFM08A:6	7.7	16.3	3 days 6 h 8 min	279		1308	-	-	Yes
					388.5	381	2022-05-30	100871	
					777	816	2022-05-31	100872	
					1295	1295	2022-06-01	100873	
KFM08D:2	n/a	n/a	4 days 10 h 17 min	23		149	-	-	No
					49.5	40	2022-05-30	100880	
					99	78	2022-05-31	100881	
					165	140	2022-06-02	100882	
KFM08D:4	18.9	22	9 days 1 h 31 min	128		1445	-	-	Yes
					352.5	388	2022-06-10	100877	
					705	917	2022-06-13	100878	
					1175	1286	2022-06-15	100879	
KFM10A:2	12.4	13.9	2 days 12 h 25 min	204		740	-	-	Yes
					187.5	196	2022-05-17	100883	
					375	482	2022-05-18	100884	
					625	731	2022-05-19	100885	

Idcode: section	Tube volume [L]	Section volume [L]	Length of pumping period	Medium flow rate[1] [mL/min]	Planned removed volume[2] [L]	Pumped volume[3] [L]	Sampling date	Sample no.	Responses observed in other sections in the borehole (if yes, se Appendix 4) /Comments
KFM12A:3	7.9	13.6	0 days 12 h 2 min	278		201	-	-	Yes
					69	101	2022-05-12	100886	
					115	135	2022-05-12	100887	
					161	182	2022-05-12	100888	
HFM01:2	1.5	36.5	4 days 4 h 2 min	274		1645	-	-	Yes
					459	409	2022-06-07	100889	
					918	869	2022-06-08	100890	
					1530	1632	2022-06-10	100891	
HFM02:2	1.6	31.3	2 days 22 h 11 min	298		1256	-	-	No
					357	367	2022-05-30	100892	
					714	741	2022-05-31	100893	
					1190	1246	2022-06-01	100894	
HFM04:2	2.2	26.1	1 day 12 h 5 min	307		665	-	-	No
					154.5	190	2022-05-09	100895	
					309	305	2022-05-09	100896	
					515	654	2022-05-10	100897	
HFM13:1	5	45.6	8 days 13 h 28 min	214		2638	-	-	No
					772.5	899	2022-05-13	100898	
					1545	1739	2022-05-16	100899	
					2575	2624	2022-05-19	100900	
HFM15:1	2.9	31.8	2 days 18 h 0 min	192		762	-	-	No
					174	194	2022-05-16	100901	
					348	446	2022-05-17	100902	
					580	748	2022-05-18	100903	
HFM16:2	2	39	2 days 23 h 16 min	1008		4310	-	-	No (pressure increase in HFM15:2 during pumping)
					1260	1272	2022-05-03	100904	
					2520	2643	2022-05-04	100905	
					4200	4262	2022-05-05	100906	

Idcode: section	Tube volume [L]	Section volume [L]	Length of pumping period	Medium flow rate[1)] [mL/min]	Planned removed volume[2)] [L]	Pumped volume[3)] [L]	Sampling date	Sample no.	Responses observed in other sections in the borehole (if yes, se Appendix 4) /Comments
HFM21:3	1.5	30.8	2 days 12 h 1 min	235		845	-	-	No
					201	262	2022-06-14	100907	
					402	512	2022-06-15	100908	
					670	838	2022-06-16	100909	
HFM27:2	2	36.5	10 days 1 h 11 min	217		1462	-	-	No
					333	318	2022-06-13	100910	
					666	675	2022-06-14	100911	
					1110	1270	2022-06-16	100912	
HFM32:3	1.4	18	0 days 8 h 47 min	347		183	-	-	-
					44	58	2022-06-09	100913	
					87	94	2022-06-09	100914	
					145	174	2022-06-09	100915	
HFM33:2	n/a	n/a	1 day 8 h 49 min	303		597	-	-	-
					154	165	2022-06-15	100916	
					257	266	2022-06-15	100917	
					360	589	2022-06-16	100918	
KFR101:1	3.51	80.1	1 day 17 h 57 min	149		375	-	-	No
					110	108	2022-06-08	100919	
					219	326	2022-06-09	100920	
					365	369	2022-06-09	100921	
KFR104:1	9.42	199	4 days 6 h 39 min	54		331	-	-	Yes
					90	97	2022-05-31	100922	
					180	246	2022-06-02	100923	
					300	324	2022-06-03	100924	
KFR106:1	7.35	174	0 days 10 h 36 min	135		86	-	-	No
					24	23	2022-05-23	100934	
					48	43	2022-05-23	100935	
					80	73	2022-05-23	100936	

Idcode: section	Tube volume [L]	Section volume [L]	Length of pumping period	Medium flow rate[1] [mL/min]	Planned removed volume[2] [L]	Pumped volume[3] [L]	Sampling date	Sample no.	Responses observed in other sections in the borehole (if yes, se Appendix 4) /Comments
KFR106:2	4.04	490	1 day 10 h 47 min	145		302	-	-	No
					82.5	91	2022-05-23	100931	
					165	229	2022-05-24	100932	
					275	295	2022-05-24	100933	
KFR105:1	13.3	179	6 days 22 h 56 min	600		6010	-	-	
					1044	1663	2022-10-05	100928	
					2088	2540	2022-10-06	100929	
					3480	5990	2022-10-10	100930	
KFR01:1	0.8	39.6	1 day 23 h 14 min	304		862	-	-	No
					121	458	2022-10-04	100925	
					202	501	2022-10-04	100926	
					283	855	2022-10-05	100927	

1) The pumping period may contain pump stops. Medium flow rate and pumped volume is calculated from periods of actual pumping.
2) The first sample is planned to be collected after 1.5 plug flow, the second after 3 and third and last sample in each series after 5 plug flow volumes.
3) Pump stop has occurred causing restart of pumping during the pumping period for some sections. Volume written by each sample number represent volume pumped since restart in those cases, but total pumped volume include all pumping.

Appendix 3

Water Composition

Table A3-1. Water Composition – 2022.

Id code	Secup m	Seclow m	Section no.	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	Fe(II) mg/L	Mn mg/L	Li mg/L
HFM01	33.50	45.50	2	100889	2022-06-07	-0.37	420	13.1	42.8	14.0	479	366	166	59.9	1.4	2.5	5.99	0.338	-	-	0.0767	0.0133
HFM01	33.50	45.50	2	100890	2022-06-08	0.85	436	13.3	43.9	14.3	481	373	168	59.9	1.3	2.6	5.99	0.341	-	-	0.0774	0.0123
HFM01	33.50	45.50	2	100891	2022-06-10	0.44	433	13.2	43.6	14.2	482	375	169	59.3	1.3	2.5	5.94	0.344	-	-	0.0720	0.0123
HFM02	38.00	48.00	2	100892	2022-05-30	3.20	265	11.2	36.4	11.9	446	177	58	20.7	0.72	2.0	6.56	0.290	-	-	0.0752	0.0120
HFM02	38.00	48.00	2	100893	2022-05-31	2.88	263	11.2	35.9	11.7	452	173	57	20.4	0.70	2.0	6.58	0.283	-	-	0.0740	0.0120
HFM02	38.00	48.00	2	100894	2022-06-01	2.12	257	11.1	35.6	11.7	451	172	57	20.2	0.70	2.0	6.53	0.244	-	-	0.0715	0.0120
HFM04	58.00	66.00	2	100895	2022-05-09	3.44	189	7.21	30.9	8.56	418	75.0	40	14.2	0.31	1.8	6.96	0.414	-	-	0.0868	0.0102
HFM04	58.00	66.00	2	100896	2022-05-09	3.11	187	7.20	31.5	8.59	416	76.0	41	14.4	0.29	1.9	7.09	0.413	-	-	0.0874	0.0102
HFM04	58.00	66.00	2	100897	2022-05-10	3.40	188	7.11	30.7	8.36	416	74.0	40	14.2	0.31	1.8	7.00	0.359	-	-	0.0834	0.0099
HFM13	159.00	173.00	1	100898	2022-05-13	0.61	1860	25.2	1090	205	129	4930	417	157	20.0	1.3	7.29	3.72	-	-	2.19	0.0583
HFM13	159.00	173.00	1	100899	2022-05-16	0.56	1840	24.6	1100	204	132	4920	411	156	19.8	1.3	7.38	3.75	-	-	2.20	0.0582
HFM13	159.00	173.00	1	100900	2022-05-19	0.34	1760	22.9	1100	203	132	4830	410	150	19.7	1.3	7.26	3.70	-	-	2.42	0.0536
HFM15	85.00	95.00	1	100901	2022-05-16	-0.01	68.8	5.95	66.1	7.96	361	26.0	19.2	6.65	<0.2	0.88	7.07	1.09	-	-	0.194	<0.004
HFM15	85.00	95.00	1	100902	2022-05-17	2.41	72.0	6.16	69.5	8.28	359	26.0	18.6	7.04	<0.2	0.85	7.47	1.16	-	-	0.203	0.0049
HFM15	85.00	95.00	1	100903	2022-05-18	1.50	72.2	6.15	68.4	8.15	362	27.0	19.5	6.95	<0.2	0.89	7.42	1.12	-	-	0.199	0.0049
HFM16	54.00	67.00	2	100904	2022-05-03	4.91	290	6.98	31.2	7.92	465	143	80	29.0	0.63	2.5	6.62	0.431	-	-	0.0811	0.0122
HFM16	54.00	67.00	2	100905	2022-05-04	4.32	287	6.82	30.8	7.68	465	140	85	30.4	0.62	2.5	6.65	0.454	-	-	0.0810	0.0116
HFM16	54.00	67.00	2	100906	2022-05-05	3.66	283	6.72	31.0	7.66	466	140	83	30.5	0.61	2.5	6.66	0.397	-	-	0.0778	0.0120
HFM21	22.00	32.00	3	100907	2022-06-14	3.36	273	13.5	55.5	15.9	482	171	107	39.0	0.57	1.6	7.68	0.721	-	-	0.150	0.0158
HFM21	22.00	32.00	3	100908	2022-06-15	5.02	284	13.7	57.1	16.1	484	167	106	40.7	0.56	1.6	7.73	0.765	-	-	0.153	0.0161
HFM21	22.00	32.00	3	100909	2022-06-16	3.41	276	13.4	54.0	15.4	489	166	106	39.3	0.55	1.6	7.58	0.591	-	-	0.117	0.0158
HFM27	46.00	58.00	2	100910	2022-06-13	3.94	958	30.8	272	80.8	310	1670	241	90.3	5.9	1.7	6.40	1.84	-	-	0.506	0.0307
HFM27	46.00	58.00	2	100911	2022-06-14	3.98	933	30.8	288	82.7	311	1660	236	91.8	5.9	1.7	6.68	1.89	-	-	0.522	0.0298
HFM27	46.00	58.00	2	100912	2022-06-16	4.38	935	30.7	285	82.0	313	1640	234	91.1	5.8	1.7	6.72	1.68	-	-	0.491	0.0296
HFM32	26.00	31.00	3	100913	2022-06-09	1.64	2000	65.9	464	176	199	3910	363	137	13.4	1.4	5.75	4.92	-	-	0.874	0.0607
HFM32	26.00	31.00	3	100914	2022-06-09	1.41	1990	65.6	466	176	199	3920	362	136	13.4	1.4	5.73	4.95	-	-	0.877	0.0625
HFM32	26.00	31.00	3	100915	2022-06-09	1.04	1980	65.4	462	175	194	3930	362	136	13.3	1.5	5.72	4.82	-	-	0.887	0.0595
HFM33	121.00	137.50	2	100916	2022-06-15	1.23	2200	38.4	853	227	134	5040	418	155	16.8	1.3	7.33	3.62	-	-	1.77	0.0580
HFM33	121.00	137.50	2	100917	2022-06-15	1.79	2240	38.9	834	227	132	5010	418	154	16.8	1.3	7.25	3.45	-	-	1.74	0.0576
HFM33	121.00	137.50	2	100918	2022-06-16	1.30	2210	40.2	844	231	134	5040	418	157	16.7	1.3	7.35	3.56	-	-	1.95	0.0576

RCB % = Rel. charge balance error % - = Not analysed < "value" = value below reporting limit

Table A3-1. Water Composition, continued – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	RCB	Na	K	Ca	Mg	HCO_3^-	Cl^-	SO_4^{2-}	SO_4-S	Br^-	F^-	Si	Fe	Fe-tot	Fe(II)	Mn	Li
	m	m	no.	no.	date	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
KFM01A	109.00	130.00	5	100818	2022-05-31	1.10	1690	19.4	673	107	62.6	3820	209	79.2	16.1	1.6	8.50	0.240	-	-	0.528	0.0423
KFM01A	109.00	130.00	5	100819	2022-06-02	1.26	1660	18.7	679	103	64.4	3760	208	79.2	15.8	1.6	8.75	0.366	-	-	0.530	0.0418
KFM01A	109.00	130.00	5	100820	2022-06-03	0.96	1660	18.7	664	103	64.3	3760	206	78.0	15.7	1.6	8.67	0.339	-	-	0.538	0.0424
KFM01D	429.00	438.00	2	100832	2022-05-24	0.74	1740	9.37	1400	23.2	15.7	5090	76	25.9	32.0	1.4	11.1	<0.1	-	-	0.0773	0.0297
KFM01D	429.00	438.00	2	100833	2022-05-24	1.45	1760	9.22	1420	23.3	15.2	5080	78	26.8	32.0	1.3	11.1	<0.1	-	-	0.0815	0.0289
KFM01D	429.00	438.00	2	100834	2022-05-25	0.60	1750	8.35	1420	22.5	13.7	5150	82	27.3	32.0	1.3	10.5	0.009	-	-	0.0884	0.0289
KFM01D	311.00	321.00	4	100829	2022-06-07	1.06	1710	9.42	1290	26.0	10.3	4830	68	26.1	31.0	1.8	10.1	0.172	-	-	0.167	0.0308
KFM01D	311.00	321.00	4	100830	2022-06-07	1.14	1720	10.8	1200	40.2	12.2	4690	108	40.9	28.0	1.7	11.1	0.317	-	-	0.214	0.0352
KFM01D	311.00	321.00	4	100831	2022-06-07	1.11	1690	11.8	1130	46.3	14.2	4530	127	47.3	26.0	1.5	11.5	0.399	-	-	0.249	0.0365
KFM02A	490.00	518.00	3	100838	2022-05-09	0.20	2370	40.8	944	244	127	5580	484	178	19.9	1.5	7.19	1.40	-	-	2.01	0.0539
KFM02A	490.00	518.00	3	100839	2022-05-10	0.30	2370	39.6	941	245	126	5560	477	180	19.6	1.5	7.03	1.66	-	-	2.10	0.0528
KFM02A	490.00	518.00	3	100840	2022-05-10	1.25	2370	39.1	953	246	126	5470	488	180	20.0	1.5	7.04	1.62	-	-	2.18	0.0520
KFM02A	490.00	518.00	3	102508	2022-05-09	-	2310	40.1	926	244	-	-	-	175	-	-	6.98	0.808	-	-	2.06	0.0499
KFM02A	490.00	518.00	3	102509	2022-05-10	-	2470	42.4	996	258	-	-	-	201	-	-	7.47	1.00	-	-	2.12	0.0565
KFM02A	490.00	518.00	3	102510	2022-05-10	-	2360	39.5	938	248	-	-	-	179	-	-	6.47	0.364	-	-	2.15	0.0531
KFM02A	411.00	442.00	5	100835	2022-05-09	-0.19	2080	24.7	1180	210	93.6	5560	409	154	21.0	1.4	7.49	0.695	-	-	1.79	0.566
KFM02A	411.00	442.00	5	100836	2022-05-10	0.06	2090	24.6	1180	209	94.1	5540	409	155	21.0	1.4	7.49	0.710	-	-	1.82	0.532
KFM02A	411.00	442.00	5	100837	2022-05-11	0.58	2090	24.7	1190	211	93.9	5500	412	156	21.0	1.4	7.54	0.744	-	-	1.94	0.485
KFM02A	411.00	442.00	5	102511	2022-05-09	-	2040	24.2	1170	210	-	-	-	161	-	-	7.73	0.392	-	-	1.85	0.557
KFM02A	411.00	442.00	5	102512	2022-05-10	-	2130	24.6	1200	218	-	-	-	159	-	-	7.47	0.648	-	-	1.84	0.550
KFM02A	411.00	442.00	5	102513	2022-05-11	-	2200	24.9	1220	223	-	-	-	164	-	-	8.01	0.495	-	-	1.86	0.519
KFM02B	491.00	506.00	2	100844	2022-05-05	1.84	2480	42.0	956	260	124	5590	474	189	21.0	1.7	9.18	3.89	-	-	2.13	0.0644
KFM02B	491.00	506.00	2	100845	2022-05-05	0.28	2400	40.8	930	253	123	5610	473	182	21.0	1.7	8.85	4.02	-	-	2.11	0.0613
KFM02B	491.00	506.00	2	100846	2022-05-06	0.73	2370	40.3	936	253	125	5520	497	183	20.0	1.7	8.60	8.83	-	-	4.52	0.0605
KFM02B	410.00	431.00	4	100841	2022-05-05	0.78	2200	25.9	1130	225	101	5560	422	162	22.0	1.6	9.06	1.96	-	-	2.06	0.0900
KFM02B	410.00	431.00	4	100842	2022-05-06	0.68	2220	25.8	1120	224	103	5580	419	162	22.0	1.5	8.85	2.05	-	-	2.07	0.0975
KFM02B	410.00	431.00	4	100843	2022-05-06	0.76	2210	25.8	1120	224	103	5560	412	160	22.0	1.6	8.81	2.00	-	-	2.18	0.0976
KFM03A	969.50	994.50	1	100850	2022-05-16	-0.21	2450	9.62	3670	7.65	6.20	10300	48	15.8	93.0	1.5	4.96	<0.2	-	-	<0.03	<0.04
KFM03A	969.50	994.50	1	100851	2022-05-18	-0.30	2480	9.38	3690	7.91	5.70	10400	48	16.3	93.0	1.5	4.78	<0.2	-	-	<0.03	<0.04
KFM03A	969.50	994.50	1	100852	2022-05-19	-0.50	2500	7.44	3760	8.06	5.80	10600	48	16.0	91.0	1.5	4.66	0.0467	-	-	0.0342	<0.04

RCB % = Rel. charge balance error % - = Not analysed < "value" = value below reporting limit

Table A3-1. Water Composition, continued – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	RCB	Na	K	Ca	Mg	HCO_3^-	Cl^-	SO_4^{2-}	SO_4-S	Br^-	F^-	Si	Fe	Fe-tot	Fe(II)	Mn	Li
	m	m	no.	no.	date	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
KFM03A	633.50	650.00	4	100847	2022-05-17	0.47	2020	17.8	1520	57.1	18.3	5770	180	67.1	33.0	1.7	6.92	0.438	-	-	0.333	0.0311
KFM03A	633.50	650.00	4	100848	2022-05-17	0.53	1990	17.3	1530	56.1	16.7	5730	181	67.8	33.0	1.7	6.76	0.446	-	-	0.319	0.0307
KFM03A	633.50	650.00	4	100849	2022-05-18	0.60	1990	16.5	1550	55.3	15.8	5750	185	69.7	33.0	1.7	6.48	0.422	-	-	0.314	0.0319
KFM04A	230.00	245.00	4	100853	2022-05-11	1.38	2100	28.3	1400	245	102	5830	482	177	27.0	1.1	6.71	2.39	-	-	2.75	0.0601
KFM04A	230.00	245.00	4	100854	2022-05-11	-0.23	2100	28.4	1410	244	104	6050	470	177	27.0	1.1	6.76	2.27	-	-	2.80	0.0605
KFM04A	230.00	245.00	4	100855	2022-05-11	0.11	2090	28.7	1420	244	103	6010	480	177	27.0	1.1	6.81	2.08	-	-	2.89	0.0603
KFM06A	738.00	748.00	3	100859	2022-05-09	0.73	1970	10.4	2200	16.0	9.80	6800	96	34.2	51.0	1.4	6.98	<0.1	-	-	0.189	0.0420
KFM06A	738.00	748.00	3	100860	2022-05-10	0.80	1980	10.1	2250	15.0	8.50	6890	95	33.9	52.0	1.5	6.74	<0.1	-	-	0.177	0.0413
KFM06A	738.00	748.00	3	100861	2022-05-11	3.02	2100	10.4	2280	14.7	8.10	6810	95	34.4	52.0	1.5	6.74	0.114	-	-	0.168	0.0441
KFM06A	341.00	362.00	5	100856	2022-05-03	1.89	1670	12.8	1300	41.1	28.8	4720	108	36.8	30.0	1.2	6.07	0.374	-	-	0.264	0.0570
KFM06A	341.00	362.00	5	100857	2022-05-03	2.59	1660	11.9	1290	40.5	28.2	4620	109	36.4	30.0	1.3	6.03	0.389	-	-	0.264	0.0568
KFM06A	341.00	362.00	5	100858	2022-05-04	2.08	1660	9.71	1310	39.6	27.1	4700	93	35.9	31.0	1.2	5.45	0.462	-	-	0.272	0.0567
KFM06C	647.00	666.00	3	100865	2022-05-09	-0.09	1660	7.73	1760	15.4	19.9	5670	66	22.5	45.0	1.3	2.61	<0.1	-	-	<0.02	0.0356
KFM06C	647.00	666.00	3	100866	2022-05-13	1.08	1700	7.37	1810	16.7	17.4	5690	63	22.0	45.0	1.3	4.00	<0.1	-	-	0.0233	0.0364
KFM06C	647.00	666.00	3	100867	2022-05-16	1.45	1690	7.30	1820	16.2	15.5	5650	61	22.0	43.0	1.4	4.23	0.0175	-	-	0.0561	<0.04
KFM06C	531.00	540.00	5	100862	2022-05-04	0.51	1840	16.6	1300	87.2	34.9	5130	249	90.1	28.0	0.95	5.07	0.197	-	-	0.508	0.0493
KFM06C	531.00	540.00	5	100863	2022-05-04	0.26	1820	15.2	1320	86.1	43.7	5150	251	91.6	27.0	1.0	5.47	0.291	-	-	0.625	0.0498
KFM06C	531.00	540.00	5	100864	2022-05-05	0.41	1850	14.2	1310	87.7	47.7	5160	248	92.8	27.0	1.1	5.32	0.330	-	-	0.709	0.0521
KFM07A	962.00	972.00	2	100868	2022-06-13	-2.82	3370	12.9	5730	15.6	12.7	16200	94	34.4	128.0	1.6	3.47	<0.2	-	-	<0.03	0.0700
KFM07A	962.00	972.00	2	100869	2022-06-14	-2.62	3320	12.8	5640	18.6	10.2	15900	93	33.2	128.0	1.6	3.93	<0.2	-	-	0.0359	0.0695
KFM07A	962.00	972.00	2	100870	2022-06-14	-2.84	3340	12.8	5640	18.9	10.0	16000	93	34.2	127.0	1.6	4.03	0.0233	-	-	0.0452	0.0687
KFM08A	684.00	694.00	2	100874	2022-05-20	-0.03	1780	9.89	2030	9.88	14.9	6310	72	24.8	48.0	1.4	5.18	<0.1	-	-	0.0501	<0.02
KFM08A	684.00	694.00	2	100875	2022-05-20	0.91	1810	10.0	2020	9.74	12.6	6220	70	24.8	48.0	1.4	5.68	<0.1	-	-	0.0706	<0.02
KFM08A	684.00	694.00	2	100876	2022-05-20	0.94	1820	10.0	2030	9.76	11.4	6250	70	24.6	48.0	1.4	5.94	0.0795	-	-	0.109	<0.02
KFM08A	265.00	280.00	6	100871	2022-05-30	1.94	1430	13.9	881	62.8	57.5	3610	197	74.5	16.7	1.4	7.59	1.14	-	-	0.625	0.0399
KFM08A	265.00	280.00	6	100872	2022-05-31	1.83	1430	13.8	868	63.2	55.5	3600	194	73.7	16.9	1.4	7.33	1.16	-	-	0.629	0.0380
KFM08A	265.00	280.00	6	100873	2022-06-01	1.75	1420	13.5	874	63.9	63.4	3600	196	73.0	16.2	1.4	7.13	1.10	-	-	0.640	0.0384

RCB % = Rel. charge balance error % - = Not analysed < "value" = value below reporting limit

Table A3-1. Water Composition, continued – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	RCB	Na	K	Ca	Mg	HCO_3^-	Cl^-	SO_4^{2-}	SO_4-S	Br^-	F^-	Si	Fe	Fe-tot	Fe(II)	Mn	Li
	m	m	no.	no.	date	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
KFM08D	825.00	835.00	2	100880	2022-05-30	-0.24	2210	5.28	2840	2.55	11.2	8370	128	46.8	63.0	1.6	3.68	<0.1	-	-	<0.02	0.0308
KFM08D	825.00	835.00	2	100881	2022-05-31	1.42	2320	5.30	2980	1.01	36.1	8480	124	47.1	65.0	1.6	4.41	<0.1	-	-	<0.02	0.0308
KFM08D	825.00	835.00	2	100882	2022-06-02	0.47	2270	5.28	2960	2.52	12.0	8550	126	47.5	65.0	1.5	4.18	<0.004	-	-	0.00633	0.0316
KFM08D	660.00	680.00	4	100877	2022-06-10	1.95	1980	6.76	2250	7.78	7.00	6730	66	24.8	49.0	1.5	6.01	0.111	-	-	0.0839	0.0234
KFM08D	660.00	680.00	4	100878	2022-06-13	2.63	1990	6.42	2260	7.25	6.60	6670	65	24.2	49.0	1.5	5.50	<0.1	-	-	0.0830	0.0224
KFM08D	660.00	680.00	4	100879	2022-06-15	3.25	1960	6.54	2300	6.81	6.30	6610	64	23.0	50.0	1.5	5.24	0.0532	-	-	0.0836	<0.02
KFM10A	430.00	440.00	2	100883	2022-05-17	1.15	2310	31.8	1120	227	94.3	5580	547	207	19.4	1.4	7.71	2.74	-	-	1.37	0.0638
KFM10A	430.00	440.00	2	100884	2022-05-18	0.48	2270	30.7	1120	228	99.8	5600	548	207	19.4	1.4	7.57	2.95	-	-	1.46	0.0644
KFM10A	430.00	440.00	2	100885	2022-05-19	0.66	2250	29.3	1120	228	99.4	5560	552	201	19.4	1.4	7.40	3.01	-	-	1.63	0.0600
KFM12A	270.00	280.00	3	100886	2022-05-12	1.66	1150	7.76	1270	38.2	32.0	3940	61	21.3	28.0	0.89	3.91	0.131	-	-	0.483	0.0475
KFM12A	270.00	280.00	3	100887	2022-05-12	1.70	1150	7.90	1260	38.3	31.8	3920	61	21.3	28.0	0.95	3.89	0.135	-	-	0.476	0.0470
KFM12A	270.00	280.00	3	100888	2022-05-12	1.47	1130	7.75	1260	38.9	32.7	3910	59	21.5	26.0	0.93	3.92	0.186	-	-	0.505	0.0477
KFR01	44.65	62.30	1	100925	2022-10-04	4.02	1640	9.61	658	117	103	3390	344	127	11.6	1.3	4.61	0.469	-	-	0.704	0.0632
KFR01	44.65	62.30	1	100926	2022-10-04	3.45	1640	9.35	632	114	103	3390	343	123	11.6	1.4	4.51	0.452	-	-	0.679	0.0602
KFR01	44.65	62.30	1	100927	2022-10-05	2.97	1630	9.60	632	115	104	3410	350	125	11.7	1.2	4.55	0.480	0.46	0.46	0.739	0.0608
KFR101	279.50	341.76	1	100919	2022-06-08	5.50	840	4.74	401	30.3	57.2	1810	40	15.2	9.9	1.5	5.26	0.156	-	-	0.416	0.0316
KFR101	279.50	341.76	1	100920	2022-06-09	3.75	819	4.75	387	30.3	59.7	1820	42	16.3	9.9	1.6	5.29	0.322	-	-	0.453	0.0313
KFR101	279.50	341.76	1	100921	2022-06-09	5.77	853	4.43	396	31.0	59.7	1810	42	15.1	9.9	1.6	5.17	0.338	-	-	0.480	0.0283
KFR104	333.00	454.57	1	100922	2022-05-31	6.10	768	3.99	392	7.75	20.0	1640	34	13.9	9.8	1.7	4.76	<0.02	-	-	0.0199	0.0206
KFR104	333.00	454.57	1	100923	2022-06-02	7.07	818	3.99	439	9.33	21.0	1740	46	18.8	10.0	1.5	4.89	0.0231	-	-	0.0268	0.0239
KFR104	333.00	454.57	1	100924	2022-06-03	5.47	789	3.81	421	7.34	18.1	1730	45	17.0	10.1	1.5	4.77	0.0142	-	-	0.0172	0.0223
KFR105	265.00	306.80	1	100928	2022-10-05	4.00	1480	7.02	825	101	83.7	3480	261	93.1	12.5	1.4	5.02	0.764	-	-	1.61	0.0646
KFR105	265.00	306.80	1	100929	2022-10-06	3.37	1460	6.86	809	99.4	84.3	3470	260	92.0	12.4	1.3	4.95	0.737	-	-	1.59	0.0664
KFR105	265.00	306.80	1	100930	2022-10-10	3.58	1460	6.97	802	98.3	84.6	3440	258	92.0	12.3	1.5	4.99	0.745	0.72	0.71	1.66	0.0671
KFR106	260.00	300.13	1	100934	2022-05-23	2.36	964	11.0	418	53.7	123	2150	74	26.6	9.8	1.7	5.12	0.120	-	-	0.198	0.0387
KFR106	260.00	300.13	1	100935	2022-05-23	0.18	1090	12.4	503	68.1	116	2610	110	41.4	11.3	1.7	5.35	0.128	-	-	0.286	0.0415
KFR106	260.00	300.13	1	100936	2022-05-23	1.11	1160	10.2	588	74.2	86.7	2830	136	48.1	12.1	1.6	5.37	0.300	-	-	0.410	0.0416
KFR106	143.00	259.00	2	100931	2022-05-23	-0.29	1760	14.6	764	178	108	4310	308	114	14.8	1.5	5.75	1.06	-	-	1.15	0.0568
KFR106	143.00	259.00	2	100932	2022-05-24	0.34	1800	14.7	776	181	106	4340	312	116	14.8	1.5	5.73	1.13	-	-	1.18	0.0566
KFR106	143.00	259.00	2	100933	2022-05-24	0.08	1790	14.7	778	182	107	4350	313	118	14.8	1.5	5.73	1.14	-	-	1.28	0.0576

RCB % = Rel. charge balance error % - = Not analysed < "value" = value below reporting limit

Table A3-1. Water Composition, continued – 2022.

Id code	Secup	Seclow	Sec	Sample	Sampling	Sr	I^-	pH_L	pH_F	TOC	DOC	HS^-	Uranine	EC_L	EC_F	NO_2-N	NO_3-N	NO_2-N+ NO_3-N	NH_4-N	Density
	m	m	no.	no.	Date	mg/L	mg/L			mg/L	mg/L	mg/L	µg/L	mS/m	mS/m	mg/L	mg/L	mg/L	mg/L	g/mL
HFM01	33.50	45.50	2	100889	2022-06-07	0.289		7.92	8.08	11.0	10.9	0.050	1.8	223	214	-	-	-	-	-
HFM01	33.50	45.50	2	100890	2022-06-08	0.297		7.77	8.06	10.6	10.7	0.049	1.7	224	211	-	-	-	-	-
HFM01	33.50	45.50	2	100891	2022-06-10	0.295	0.0083	7.88	8.19	11.3	11.1	0.044	1.8	224	215	<0.0002	<0.0003	<0.0003	0.732	0.9980
HFM02	38.00	48.00	2	100892	2022-05-30	0.271		7.91	7.83	11.5	11.4	0.038	2.1	135	128	-	-	-	-	-
HFM02	38.00	48.00	2	100893	2022-05-31	0.269		7.85	7.48	11.0	11.3	0.037	2.1	135	128	-	-	-	-	-
HFM02	38.00	48.00	2	100894	2022-06-01	0.266	0.0129	7.78	7.93	12.1	12.1	0.035	1.8	134	126	<0.0002	<0.0003	<0.0003	0.451	0.9977
HFM04	58.00	66.00	2	100895	2022-05-09	0.269		7.68	7.75	11.3	11.1	0.056	1.6	95	89	-	-	-	-	-
HFM04	58.00	66.00	2	100896	2022-05-09	0.267		7.78	7.74	11.2	11.1	0.055	1.6	95	91	-	-	-	-	-
HFM04	58.00	66.00	2	100897	2022-05-10	0.260	0.0188	7.76	7.75	11.3	11.1	0.059	1.7	94	92	<0.0002	<0.0003	<0.0003	0.530	0.9974
HFM13	159.00	173.00	1	100898	2022-05-13	12.2		7.43	7.30	2.3	2.0	0.032	0.6	1450	1376	-	-	-	-	-
HFM13	159.00	173.00	1	100899	2022-05-16	12.1		7.41	6.83	2.2	2.0	0.039	0.7	1430	1286	-	-	-	-	-
HFM13	159.00	173.00	1	100900	2022-05-19	11.9	0.0464	7.32	7.43	2.1	2.0	0.033	0.6	1420	1320	<0.0002	<0.0003	<0.0003	1.42	1.0033
HFM15	85.00	95.00	1	100901	2022-05-16	0.298		7.23	6.87	9.4	9.3	0.100	1.2	67	62	-	-	-	-	-
HFM15	85.00	95.00	1	100902	2022-05-17	0.305		7.44	6.74	9.3	9.3	0.100	1.4	66	62	-	-	-	-	-
HFM15	85.00	95.00	1	100903	2022-05-18	0.303	0.0047	7.25	7.17	9.7	9.6	0.088	1.3	67	62	<0.0002	<0.0003	<0.0003	0.297	0.9973
HFM16	54.00	67.00	2	100904	2022-05-03	0.289		7.87	7.77	14.5	14.7	0.104	2.5	132	128	-	-	-	-	-
HFM16	54.00	67.00	2	100905	2022-05-04	0.281		7.84	7.10	14.6	14.8	0.054	2.5	132	126	-	-	-	-	-
HFM16	54.00	67.00	2	100906	2022-05-05	0.277	0.0086	7.87	7.68	14.5	14.7	0.058	2.7	132	125	<0.0002	<0.0003	<0.0003	0.679	0.9976
HFM21	22.00	32.00	3	100907	2022-06-14	0.306		7.64	7.77	9.5	9.3	0.045	1.6	148	143	-	-	-	-	-
HFM21	22.00	32.00	3	100908	2022-06-15	0.313		7.83	7.79	9.3	9.3	0.044	1.7	147	144	-	-	-	-	-
HFM21	22.00	32.00	3	100909	2022-06-16	0.294	0.0085	7.60	7.85	9.9	9.3	0.038	1.7	147	137	<0.0002	<0.0003	<0.0003	0.424	0.9978
HFM27	46.00	58.00	2	100910	2022-06-13	1.95		7.52	7.68	6.8	6.6	0.026	1.6	609	565	-	-	-	-	-
HFM27	46.00	58.00	2	100911	2022-06-14	1.94		7.57	7.74	6.5	6.4	0.028	1.4	600	583	-	-	-	-	-
HFM27	46.00	58.00	2	100912	2022-06-16	1.91	0.0451	7.51	7.47	6.5	6.7	0.028	1.7	593	563	<0.0002	<0.0003	<0.0003	1.32	0.9996
HFM32	26.00	31.00	3	100913	2022-06-09	3.45		7.18	7.37	3.7	3.5	0.131	0.7	1220	1133	-	-	-	-	-
HFM32	26.00	31.00	3	100914	2022-06-09	3.45		7.20	7.36	2.4	3.5	0.083	0.7	1220	1133	-	-	-	-	-
HFM32	26.00	31.00	3	100915	2022-06-09	3.45	0.0527	7.21	7.40	3.5	3.4	0.048	0.7	1210	1132	<0.0002	<0.0003	<0.0003	2.20	1.0022
HFM33	121.00	137.50	2	100916	2022-06-15	7.51		7.41	7.45	1.8	1.8	0.051	<0.5	1490	1374	-	-	-	-	-
HFM33	121.00	137.50	2	100917	2022-06-15	7.57		7.22	7.53	2.0	1.9	0.045	<0.5	1480	1370	-	-	-	-	-
HFM33	121.00	137.50	2	100918	2022-06-16	7.27	0.0445	7.26	7.51	2.0	2.1	0.037	<0.5	1480	1375	<0.0002	0.0003	0.0004	2.34	1.0035

pH_L; EC_L = Laboratory measurements of pH and EC
pH_F; EC_F = Field measurements of pH and EC
- = Not analysed
< "value" = value below reporting limit

Table A3-1. Water Composition, continued – 2022.

Id code	Secup	Seclow	Sec	Sample	Sampling	Sr	I^-	pH_L	pH_F	TOC	DOC	HS^-	Uranine	EC_L	EC_F	NO_2-N	NO_3-N	NO_2-N+ NO_3-N	NH_4-N	Density
	m	m	no.	no.	Date	mg/L	mg/L			mg/L	mg/L	mg/L	µg/L	mS/m	mS/m	mg/L	mg/L	mg/L	mg/L	g/mL
KFM01A	109.00	130.00	5	100818	2022-05-31	6.25	-	7.82	7.55	1.9	1.9	0.316	26	1150	1066	-	-	-	-	-
KFM01A	109.00	130.00	5	100819	2022-06-02	6.17	-	7.87	7.82	2.1	1.8	0.133	30	1120	1076	-	-	-	-	-
KFM01A	109.00	130.00	5	100820	2022-06-03	6.12	0.0627	7.72	7.90	1.8	1.7	0.123	28	1120	1058	<0.0002	<0.0003	<0.0003	0.763	1.0017
KFM01D	429.00	438.00	2	100832	2022-05-24	17.2	-	8.23	8.43	2.1	2.2	3.194	12.1	1450	1353	-	-	-	-	-
KFM01D	429.00	438.00	2	100833	2022-05-24	17.2	-	8.04	8.39	2.0	2.1	3.276	11.8	1450	1371	-	-	-	-	-
KFM01D	429.00	438.00	2	100834	2022-05-25	17.2	0.157	7.88	8.35	1.9	1.8	2.761	11.5	1450	1385	<0.0002	0.0009	0.0009	0.175	1.0032
KFM01D	311.00	321.00	4	100829	2022-06-07	15.4	-	7.31	8.38	1.2	1.2	0.333	2.8	1380	1261	-	-	-	-	-
KFM01D	311.00	321.00	4	100830	2022-06-07	13.9	-	7.42	8.21	1.7	2.0*	0.177	7.3	1360	1240	-	-	-	-	-
KFM01D	311.00	321.00	4	100831	2022-06-07	13.0	0.117	7.51	8.17	2.0	1.7	0.148	11.0	1330	1214	<0.0002	<0.0003	<0.0003	0.335	1.0025
KFM02A	490.00	518.00	3	100838	2022-05-09	9.19	-	7.28	7.33	1.9	1.8	0.153	6.7	1600	1476	-	-	-	-	-
KFM02A	490.00	518.00	3	100839	2022-05-10	9.21	-	7.30	7.21	1.7	1.8	0.133	6.6	1600	1517	-	-	-	-	-
KFM02A	490.00	518.00	3	100840	2022-05-10	9.22	0.0800	7.18	7.29	1.7	1.7	0.127	6.5	1600	1523	<0.0002	<0.0003	<0.0003	2.60	1.0041
KFM02A	490.00	518.00	3	102508	2022-05-09	9.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KFM02A	490.00	518.00	3	102509	2022-05-10	9.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KFM02A	490.00	518.00	3	102510	2022-05-10	9.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KFM02A	411.00	442.00	5	100835	2022-05-09	13.0	-	7.23	7.43	1.3	1.3	0.246	37	1580	1510	-	-	-	-	-
KFM02A	411.00	442.00	5	100836	2022-05-10	12.9	-	7.42	7.39	1.3	1.4	0.179	34	1570	1501	-	-	-	-	-
KFM02A	411.00	442.00	5	100837	2022-05-11	12.9	0.116	7.38	7.40	1.3	1.2	0.154	30	1580	1453	<0.0002	0.0015	0.0017	1.68	1.0041
KFM02A	411.00	442.00	5	102511	2022-05-09	12.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KFM02A	411.00	442.00	5	102512	2022-05-10	13.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KFM02A	411.00	442.00	5	102513	2022-05-11	13.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KFM02B	491.00	506.00	2	100844	2022-05-05	8.97	-	7.37	7.16	1.7	1.7	0.095	1.6	1610	1490	-	-	-	-	-
KFM02B	491.00	506.00	2	100845	2022-05-05	8.74	-	7.15	7.22	1.7	1.6	0.083	1.7	1620	1433	-	-	-	-	-
KFM02B	491.00	506.00	2	100846	2022-05-06	8.71	0.643	7.36	7.39	1.5	1.6	0.073	1.9	1610	1502	<0.0002	0.0005	0.0006	2.74	1.0041
KFM02B	410.00	431.00	4	100841	2022-05-05	12.1	-	7.31	7.36	1.3	1.5	0.079	3.6	1590	1455	-	-	-	-	-
KFM02B	410.00	431.00	4	100842	2022-05-06	12.0	-	7.41	7.36	1.3	1.3	0.070	3.9	1600	1470	-	-	-	-	-
KFM02B	410.00	431.00	4	100843	2022-05-06	12.0	0.125	7.48	7.44	1.4	1.4	0.065	4.0	1600	1479	<0.0002	0.0018	0.0018	1.91	1.0040
KFM03A	969.50	994.50	1	100850	2022-05-16	46.3	-	7.77	6.82	0.3	<0.3	0.151	<0.5	2690	2420	-	-	-	-	-
KFM03A	969.50	994.50	1	100851	2022-05-18	47.0	-	8.02	8.13	0.3	<0.3	0.086	<0.5	2710	2530	-	-	-	-	-
KFM03A	969.50	994.50	1	100852	2022-05-19	47.6	0.309	8.13	8.43	<0.3	<0.3	0.070	<0.5	2710	2530	<0.0002	<0.0003	<0.0003	0.0103	1.0095

pH_L; EC_L = Laboratory measurements of pH and EC
pH_F; EC_F = Field measurements of pH and EC
* possibly affected sample (DOC > TOC)

- = Not analysed
< "value" = value below reporting limit

Table A3-1. Water Composition, continued – 2022.

Id code	Secup	Seclow	Sec	Sample	Sampling	Sr	I^-	pH_L	pH_F	TOC	DOC	HS^-	Uranine	EC_L	EC_F	NO_2-N	NO_3-N	NO_2-N+ NO_3-N	NH_4-N	Density
	m	m	no.	no.	Date	mg/L	mg/L			mg/L	mg/L	mg/L	µg/L	mS/m	mS/m	mg/L	mg/L	mg/L	mg/L	g/mL
KFM03A	633.50	650.00	4	100847	2022-05-17	19.6	-	7.54	7.14	0.8	0.8	0.277	2.6	1610	1446	-	-	-	-	-
KFM03A	633.50	650.00	4	100848	2022-05-17	19.7	-	7.35	7.19	0.8	0.8	0.136	2.5	1610	1467	-	-	-	-	-
KFM03A	633.50	650.00	4	100849	2022-05-18	19.7	0.153	7.45	7.83	0.7	0.6	0.129	2.2	1610	1491	<0.0002	<0.0003	<0.0003	0.149	1.0040
KFM04A	230.00	245.00	4	100853	2022-05-11	16.2	-	7.29	7.43	1.4	1.4	0.183	3.3	1690	1582	-	-	-	-	-
KFM04A	230.00	245.00	4	100854	2022-05-11	16.3	-	7.21	7.37	1.6	1.5	0.120	2.5	1700	1568	-	-	-	-	-
KFM04A	230.00	245.00	4	100855	2022-05-11	16.4	0.0632	7.26	7.38	1.4	1.4	0.107	2.4	1690	1590	<0.0002	0.0021	0.0021	1.51	1.0047
KFM06A	738.00	748.00	3	100859	2022-05-09	27.4	-	8.16	8.42	0.9	1.0	0.190	23	1870	1803	-	-	-	-	-
KFM06A	738.00	748.00	3	100860	2022-05-10	27.8	-	8.16	8.35	0.8	1.0*	0.181	21	1880	1809	-	-	-	-	-
KFM06A	738.00	748.00	3	100861	2022-05-11	28.8	0.179	8.05	8.39	0.8	0.8	0.231	20	1890	1767	<0.0002	0.0008	0.0008	0.125	1.0054
KFM06A	341.00	362.00	5	100856	2022-05-03	16.5	-	8.02	7.45	1.5	1.4	0.195	15	1340	1228	-	-	-	-	-
KFM06A	341.00	362.00	5	100857	2022-05-03	16.7	-	7.85	7.95	1.3	1.3	0.154	14.8	1330	1258	-	-	-	-	-
KFM06A	341.00	362.00	5	100858	2022-05-04	16.7	0.148	7.70	7.57	1.1	1.0	0.088	13.9	1330	1242	<0.0002	<0.0003	<0.0003	0.161	1.0026
KFM06C	647.00	666.00	3	100865	2022-05-09	22.7	-	9.25	9.49	1.5	1.4	1.564	9.2	1580	1524	-	-	-	-	-
KFM06C	647.00	666.00	3	100866	2022-05-13	23.5	-	8.96	8.77	0.9	0.8	0.403	8.9	1580	1457	-	-	-	-	-
KFM06C	647.00	666.00	3	100867	2022-05-16	23.6	0.172	8.64	7.81	0.6	0.7	0.336	8.7	1580	1448	<0.0002	0.0003	0.0004	0.0897	1.0039
KFM06C	531.00	540.00	5	100862	2022-05-04	15.1	-	7.97	7.74	1.8	1.7	0.314	44	1450	1372	-	-	-	-	-
KFM06C	531.00	540.00	5	100863	2022-05-04	15.2	-	7.67	7.29	1.4	1.5	0.178	42	1450	1300	-	-	-	-	-
KFM06C	531.00	540.00	5	100864	2022-05-05	15.4	0.129	7.61	7.05	1.4	1.4	0.118	43	1460	1264	<0.0002	0.0009	0.0009	0.424	1.0033
KFM07A	962.00	972.00	2	100868	2022-06-13	70.7	-	9.06	8.74	1.5	1.3	0.205	1.0	3630	3410	-	-	-	-	-
KFM07A	962.00	972.00	2	100869	2022-06-14	69.6	-	8.81	8.73	1.5	1.1	0.315	1.2	3600	3410	-	-	-	-	-
KFM07A	962.00	972.00	2	100870	2022-06-14	69.0	0.406	8.73	8.45	1.5	1.1	0.358	1.1	3610	3480	<0.0002	0.0013	0.0013	0.0067	1.0145
KFM08A	684.00	694.00	2	100874	2022-05-20	25.4	-	8.99	9.10	0.7	0.6	0.120	9.6	1730	1620	-	-	-	-	-
KFM08A	684.00	694.00	2	100875	2022-05-20	25.2	-	8.72	8.88	0.6	0.7	0.081	9.9	1740	1616	-	-	-	-	-
KFM08A	684.00	694.00	2	100876	2022-05-20	25.2	0.220	8.57	8.66	0.6	0.6	0.072	10	1720	1632	<0.0002	<0.0003	<0.0003	0.0641	1.0046
KFM08A	265.00	280.00	6	100871	2022-05-30	11.0	-	7.48	7.17	1.5	1.3	0.123	5.1	1080	975	-	-	-	-	-
KFM08A	265.00	280.00	6	100872	2022-05-31	10.9	-	7.57	7.42	1.4	1.5	0.097	5.2	1070	999	-	-	-	-	-
KFM08A	265.00	280.00	6	100873	2022-06-01	10.8	0.0617	7.62	7.74	1.3	1.3	0.074	5.2	1070	1003	<0.0002	0.0027	0.0027	0.316	1.0015

pH_L; EC_L = Laboratory measurements of pH and EC
pH_F; EC_F = Field measurements of pH and EC
* possibly affected sample (DOC > TOC)

- = Not analysed
< "value" = value below reporting limit

Table A3-1. Water Composition, continued – 2022.

Id code	Secup	Seclow	Sec	Sample	Sampling	Sr	I^-	pH_L	pH_F	TOC	DOC	HS^-	Uranine	EC_L	EC_F	NO_2-N	NO_3-N	NO_2-N+ NO_3-N	NH_4-N	Density
	m	m	no.	no.	Date	mg/L	mg/L			mg/L	mg/L	mg/L	µg/L	mS/m	mS/m	mg/L	mg/L	mg/L	mg/L	g/mL
KFM08D	825.00	835.00	2	100880	2022-05-30	33.5	-	8.89	8.19	1.3	1.6*	0.026	0.6	2260	2106	-	-	-	-	-
KFM08D	825.00	835.00	2	100881	2022-05-31	35.0	-	>10	10.44	1.3	1.1	<0.019	0.7	2310	2154	-	-	-	-	-
KFM08D	825.00	835.00	2	100882	2022-06-02	34.6	0.247	8.90	9.14	0.5	0.4	<0.019	0.5	2260	2165	<0.0002	0.0019	0.0019	0.0111	1.0074
KFM08D	660.00	680.00	4	100877	2022-06-10	27.7	-	8.19	8.51	0.5	0.6	0.039	20	1830	1689	-	-	-	-	-
KFM08D	660.00	680.00	4	100878	2022-06-13	28.0	-	8.18	7.50	0.4	0.4	0.036	18	1850	1703	-	-	-	-	-
KFM08D	660.00	680.00	4	100879	2022-06-15	27.6	0.209	8.19	8.10	0.4	0.4	<0.019	18	1840	1706	<0.0002	<0.0003	<0.0003	0.0606	1.0052
KFM10A	430.00	440.00	2	100883	2022-05-17	12.1	-	7.36	7.40	1.4	1.5	0.124	1.0	1640	1458	-	-	-	-	-
KFM10A	430.00	440.00	2	100884	2022-05-18	12.2	-	7.52	7.75	1.4	1.5	0.117	0.9	1640	1546	-	-	-	-	-
KFM10A	430.00	440.00	2	100885	2022-05-19	12.0	0.0357	7.45	7.75	1.5	1.4	0.111	0.8	1620	1551	<0.0002	<0.0003	<0.0003	1.27	1.0044
KFM12A	270.00	280.00	3	100886	2022-05-12	20.0	-	7.62	7.55	0.8	0.9	0.117	1.3	1130	1042	-	-	-	-	-
KFM12A	270.00	280.00	3	100887	2022-05-12	20.0	-	7.52	7.65	0.8	0.7	0.123	1.3	1140	1058	-	-	-	-	-
KFM12A	270.00	280.00	3	100888	2022-05-12	20.0	0.111	7.58	7.58	1.1	0.8	0.106	1.3	1130	1055	<0.0002	0.0006	0.0007	0.0419	1.0018
KFR01	44.65	62.30	1	100925	2022-10-04	9.42	-	7.33	-	1.3	1.3	<0.019	<0.5	1040	952	-	-	-	-	-
KFR01	44.65	62.30	1	100926	2022-10-04	9.26	-	7.38	-	1.3	1.3	<0.019	<0.5	1040	966	-	-	-	-	-
KFR01	44.65	62.30	1	100927	2022-10-05	9.13	0.0302	7.37	-	1.5	1.4	<0.019	<0.5	1040	970	<0.0002	<0.0003	<0.0003	0.221	1.0014
KFR101	279.50	341.76	1	100919	2022-06-08	6.60	-	7.80	8.27	1.2	0.9	0.927	<0.5	592	550	-	-	-	-	-
KFR101	279.50	341.76	1	100920	2022-06-09	6.42	-	7.45	8.09	0.9	0.9	0.431	<0.5	591	548	-	-	-	-	-
KFR101	279.50	341.76	1	100921	2022-06-09	6.64	0.1060	7.70	8.08	1.0	0.8	0.415	<0.5	595	560	<0.0002	0.0075	0.0075	0.0621	0.9992
KFR104	333.00	454.57	1	100922	2022-05-31	6.68	-	8.63	8.44	1.3	1.2	0.989	0.7	542	507	-	-	-	-	-
KFR104	333.00	454.57	1	100923	2022-06-02	7.44	-	8.43	8.22	1.0	1.0	0.681	1.1	573	542	-	-	-	-	-
KFR104	333.00	454.57	1	100924	2022-06-03	7.13	0.0891	8.44	8.59	0.8	0.8	0.486	1.0	578	553	<0.0002	<0.0003	<0.0003	0.0099	0.9991
KFR105	265.00	306.80	1	100928	2022-10-05	12.4	-	7.52	-	0.8	0.9	<0.019	<0.5	1050	978	-	-	-	-	-
KFR105	265.00	306.80	1	100929	2022-10-06	12.2	-	7.48	-	0.8	0.7	<0.019	<0.5	1050	967	-	-	-	-	-
KFR105	265.00	306.80	1	100930	2022-10-10	12.1	0.0364	7.57	7.62	0.9	0.7	<0.019	<0.5	1030	968	<0.0002	0.0004	0.0005	0.0100	1.0013
KFR106	260.00	300.13	1	100934	2022-05-23	6.66	-	7.87	7.91	5.6	6.2*	1.902	0.7	677	673	-	-	-	-	-
KFR106	260.00	300.13	1	100935	2022-05-23	7.81	-	7.83	7.95	6.0	4.9	2.898	0.9	769	765	-	-	-	-	-
KFR106	260.00	300.13	1	100936	2022-05-23	9.26	0.0797	7.80	7.85	2.9	3.6*	2.815	1.1	856	791	<0.0002	0.0010	0.0011	0.102	1.0004
KFR106	143.00	259.00	2	100931	2022-05-23	9.84	-	7.50	7.61	3.0	1.5	0.543	0.6	1270	1189	-	-	-	-	-
KFR106	143.00	259.00	2	100932	2022-05-24	10.0	-	7.55	7.63	1.4	1.3	0.455	0.6	1280	1189	-	-	-	-	-
KFR106	143.00	259.00	2	100933	2022-05-24	10.0	0.0486	7.52	7.59	1.3	1.2	0.419	0.6	1280	1177	<0.0002	<0.0003	<0.0003	0.201	1.0025

pH_L; EC_L = Laboratory measurements of pH and EC
pH_F; EC_F = Field measurements of pH and EC
* possibly affected sample (DOC > TOC)

- = Not analysed
< "value" = value below reporting limit
> "value" = value above reporting limit

Table A3-1. Water Composition, continued – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	PO_4-P	PO_4-P^2	Temp_F
	m	m	no.	no.	Date	mg/L	mg/L	
HFM01	33.50	45.50	2	100889	2022-06-07	-	-	8.5
HFM01	33.50	45.50	2	100890	2022-06-08	-	-	9.4
HFM01	33.50	45.50	2	100891	2022-06-10	0.0557	0.0815	8.6
HFM02	38.00	48.00	2	100892	2022-05-30	-	-	9.8
HFM02	38.00	48.00	2	100893	2022-05-31	-	-	8.3
HFM02	38.00	48.00	2	100894	2022-06-01	0.0343	0.0425	10.8
HFM04	58.00	66.00	2	100895	2022-05-09	-	-	8.2
HFM04	58.00	66.00	2	100896	2022-05-09	-	-	10.2
HFM04	58.00	66.00	2	100897	2022-05-10	0.0122	0.0188	8.8
HFM13	159.00	173.00	1	100898	2022-05-13	-	-	11.8
HFM13	159.00	173.00	1	100899	2022-05-16	-	-	10.0
HFM13	159.00	173.00	1	100900	2022-05-19	<0.0005	<0.0005	9.8
HFM15	85.00	95.00	1	100901	2022-05-16	-	-	9.2
HFM15	85.00	95.00	1	100902	2022-05-17	-	-	7.9
HFM15	85.00	95.00	1	100903	2022-05-18	0.0008	0.0063	11.9
HFM16	54.00	67.00	2	100904	2022-05-03	-	-	7.1
HFM16	54.00	67.00	2	100905	2022-05-04	-	-	7.4
HFM16	54.00	67.00	2	100906	2022-05-05	0.0501	0.0673	8.6
HFM21	22.00	32.00	3	100907	2022-06-14	-	-	14.6
HFM21	22.00	32.00	3	100908	2022-06-15	-	-	14.3
HFM21	22.00	32.00	3	100909	2022-06-16	0.0068	0.0185	15.5
HFM27	46.00	58.00	2	100910	2022-06-13	-	-	13.7
HFM27	46.00	58.00	2	100911	2022-06-14	-	-	12.9
HFM27	46.00	58.00	2	100912	2022-06-16	<0.0005	0.0140	12.6
HFM32	26.00	31.00	3	100913	2022-06-09	-	-	15.1
HFM32	26.00	31.00	3	100914	2022-06-09	-	-	15.2
HFM32	26.00	31.00	3	100915	2022-06-09	<0.0005	0.0083	12.6
HFM33	121.00	137.50	2	100916	2022-06-15	-	-	13.5
HFM33	121.00	137.50	2	100917	2022-06-15	-	-	16.8
HFM33	121.00	137.50	2	100918	2022-06-16	<0.0005	0.0019	13.1

PO_4-P^2 = P after hydrolysis - = Not analysed < "value" = value below reporting limit

Table A3-1. Water Composition, continued – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	PO_4-P	PO_4-P^2	Temp_F
	m	m	no.	no.	Date	mg/L	mg/L	
KFM01A	109.00	130.00	5	100818	2022-05-31	-	-	10.1
KFM01A	109.00	130.00	5	100819	2022-06-02	-	-	10.9
KFM01A	109.00	130.00	5	100820	2022-06-03	<0.0005	<0.0005	14.0
KFM01D	429.00	438.00	2	100832	2022-05-24	-	-	18.3
KFM01D	429.00	438.00	2	100833	2022-05-24	-	-	15.9
KFM01D	429.00	438.00	2	100834	2022-05-25	0.0005	0.0011	16.1
KFM01D	311.00	321.00	4	100829	2022-06-07	-	-	12.9
KFM01D	311.00	321.00	4	100830	2022-06-07	-	-	13.5
KFM01D	311.00	321.00	4	100831	2022-06-07	0.0014	0.0033	13.9
KFM02A	490.00	518.00	3	100838	2022-05-09	-	-	14.3
KFM02A	490.00	518.00	3	100839	2022-05-10	-	-	11.0
KFM02A	490.00	518.00	3	100840	2022-05-10	<0.0005	<0.0005	13.0
KFM02A	490.00	518.00	3	102508	2022-05-09	-	-	-
KFM02A	490.00	518.00	3	102509	2022-05-10	-	-	-
KFM02A	490.00	518.00	3	102510	2022-05-10	-	-	-
KFM02A	411.00	442.00	5	100835	2022-05-09	-	-	10.0
KFM02A	411.00	442.00	5	100836	2022-05-10	-	-	10.5
KFM02A	411.00	442.00	5	100837	2022-05-11	<0.0005	<0.0005	14.5
KFM02A	411.00	442.00	5	102511	2022-05-09	-	-	-
KFM02A	411.00	442.00	5	102512	2022-05-10	-	-	-
KFM02A	411.00	442.00	5	102513	2022-05-11	-	-	-
KFM02B	491.00	506.00	2	100844	2022-05-05	-	-	9.9
KFM02B	491.00	506.00	2	100845	2022-05-05	-	-	12.5
KFM02B	491.00	506.00	2	100846	2022-05-06	<0.0005	<0.0005	8.3
KFM02B	410.00	431.00	4	100841	2022-05-05	-	-	11.5
KFM02B	410.00	431.00	4	100842	2022-05-06	-	-	8.0
KFM02B	410.00	431.00	4	100843	2022-05-06	<0.0005	<0.0005	9.0
KFM03A	969.50	994.50	1	100850	2022-05-16	-	-	10.0
KFM03A	969.50	994.50	1	100851	2022-05-18	-	-	12.8
KFM03A	969.50	994.50	1	100852	2022-05-19	<0.0005	0.0009	13.2

PO_4-P^2 = P after hydrolysis - = Not analysed < "value" = value below reporting limit

Table A3-1. Water Composition, continued – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	PO_4-P	PO_4-P^2	Temp_F
	m	m	no.	no.	Date	mg/L	mg/L	
KFM03A	633.50	650.00	4	100847	2022-05-17	-	-	10.2
KFM03A	633.50	650.00	4	100848	2022-05-17	-	-	11.6
KFM03A	633.50	650.00	4	100849	2022-05-18	<0.0005	<0.0005	11.9
KFM04A	230.00	245.00	4	100853	2022-05-11	-	-	10.0
KFM04A	230.00	245.00	4	100854	2022-05-11	-	-	11.6
KFM04A	230.00	245.00	4	100855	2022-05-11	<0.0005	0.0009	11.1
KFM06A	738.00	748.00	3	100859	2022-05-09	-	-	15.9
KFM06A	738.00	748.00	3	100860	2022-05-10	-	-	12.8
KFM06A	738.00	748.00	3	100861	2022-05-11	<0.0005	<0.0005	13.0
KFM06A	341.00	362.00	5	100856	2022-05-03	-	-	8.5
KFM06A	341.00	362.00	5	100857	2022-05-03	-	-	10.1
KFM06A	341.00	362.00	5	100858	2022-05-04	<0.0005	<0.0005	8.6
KFM06C	647.00	666.00	3	100865	2022-05-09	-	-	16.7
KFM06C	647.00	666.00	3	100866	2022-05-13	-	-	14.7
KFM06C	647.00	666.00	3	100867	2022-05-16	0.0008	0.0010	13.0
KFM06C	531.00	540.00	5	100862	2022-05-04	-	-	7.8
KFM06C	531.00	540.00	5	100863	2022-05-04	-	-	10.0
KFM06C	531.00	540.00	5	100864	2022-05-05	<0.0005	<0.0005	12.4
KFM07A	962.00	972.00	2	100868	2022-06-13	-	-	15.2
KFM07A	962.00	972.00	2	100869	2022-06-14	-	-	14.0
KFM07A	962.00	972.00	2	100870	2022-06-14	<0.0005	0.0009	18.3
KFM08A	684.00	694.00	2	100874	2022-05-20	-	-	9.0
KFM08A	684.00	694.00	2	100875	2022-05-20	-	-	9.4
KFM08A	684.00	694.00	2	100876	2022-05-20	<0.0005	0.0006	10.1
KFM08A	265.00	280.00	6	100871	2022-05-30	-	-	10.2
KFM08A	265.00	280.00	6	100872	2022-05-31	-	-	9.5
KFM08A	265.00	280.00	6	100873	2022-06-01	<0.0005	0.0008	13.8

PO_4-P^2 = P after hydrolysis - = Not analysed < "value" = value below reporting limit

Table A3-1. Water Composition, continued – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	PO_4-P	PO_4-P[2]	Temp_F
	m	m	no.	no.	Date	mg/L	mg/L	
KFM08D	825.00	835.00	2	100880	2022-05-30	-	-	15.0
KFM08D	825.00	835.00	2	100881	2022-05-31	-	-	10.8
KFM08D	825.00	835.00	2	100882	2022-06-02	0.0006	0.0009	11.8
KFM08D	660.00	680.00	4	100877	2022-06-10	-	-	15.6
KFM08D	660.00	680.00	4	100878	2022-06-13	-	-	14.4
KFM08D	660.00	680.00	4	100879	2022-06-15	<0.0005	0.0008	13.7
KFM10A	430.00	440.00	2	100883	2022-05-17	-	-	10.3
KFM10A	430.00	440.00	2	100884	2022-05-18	-	-	12.5
KFM10A	430.00	440.00	2	100885	2022-05-19	<0.0005	0.0022	9.9
KFM12A	270.00	280.00	3	100886	2022-05-12	-	-	9.5
KFM12A	270.00	280.00	3	100887	2022-05-12	-	-	10.0
KFM12A	270.00	280.00	3	100888	2022-05-12	<0.0005	<0.0005	9.5
KFR01	44.65	62.30	1	100925	2022-10-04	-	-	9.8
KFR01	44.65	62.30	1	100926	2022-10-04	-	-	9.5
KFR01	44.65	62.30	1	100927	2022-10-05	<0.0005	<0.0005	9.5
KFR101	279.50	341.76	1	100919	2022-06-08	-	-	10.7
KFR101	279.50	341.76	1	100920	2022-06-09	-	-	12.6
KFR101	279.50	341.76	1	100921	2022-06-09	<0.0005	0.0011	13.2
KFR104	333.00	454.57	1	100922	2022-05-31	-	-	11.7
KFR104	333.00	454.57	1	100923	2022-06-02	-	-	11.1
KFR104	333.00	454.57	1	100924	2022-06-03	0.0018	0.0025	19.1
KFR105	265.00	306.80	1	100928	2022-10-05	-	-	9.5
KFR105	265.00	306.80	1	100929	2022-10-06	-	-	9.5
KFR105	265.00	306.80	1	100930	2022-10-10	<0.0005	<0.0005	9.8
KFR106	260.00	300.13	1	100934	2022-05-23	-	-	8.6
KFR106	260.00	300.13	1	100935	2022-05-23	-	-	8.7
KFR106	260.00	300.13	1	100936	2022-05-23	<0.0005	0.0011	10.4
KFR106	143.00	259.00	2	100931	2022-05-23	-	-	11.0
KFR106	143.00	259.00	2	100932	2022-05-24	-	-	8.9
KFR106	143.00	259.00	2	100933	2022-05-24	<0.0005	<0.0005	10.1

$PO4-P^2$ = P after hydrolysis - = Not analysed < "value" = value below reporting limit

Table A3-2. Trace elements – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	Ag	Al	As	B	Ba	Cd	Cr	Cu	Co	Hg	Ni	Mo	Nb
	m	m	no.	no.	date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
HFM01	33.50	45.50	2	100891	2022-06-10	<0.05	3.01	0.220	378	20.5	<0.003	0.209	<0.1	0.0356	<0.002	0.240	11.4	0.0253
HFM02	38.00	48.00	2	100894	2022-06-01	<0.05	2.81	0.127	239	24.9	0.0061	0.111	0.208	0.0275	<0.002	0.223	8.11	0.0293
HFM04	57.90	65.90	2	100897	2022-05-10	<0.05	3.64	0.139	201	38.7	0.0039	0.440	<0.1	0.0422	<0.002	0.387	3.25	0.0779
HFM13	159.00	175.60	1	100900	2022-05-19	<0.50	2.38	<0.5	524	81.0	<0.05	0.414	<0.5	<0.05	<0.002	<0.5	3.73	0.0304
HFM15	85.00	99.50	1	100903	2022-05-18	<0.05	15.9	0.209	73.0	32.0	0.0103	0.625	<0.1	0.0368	<0.002	0.443	10.6	0.0359
HFM16	54.00	67.00	2	100906	2022-05-05	<0.05	4.52	0.609	316	24.7	<0.007	0.138	<0.1	0.0453	<0.002	0.184	25.2	0.0228
HFM21	22.00	32.00	3	100909	2022-06-16	<0.05	2.96	0.105	209	30.0	0.0088	0.134	<0.1	0.0312	<0.002	0.112	7.48	0.0302
HFM27	46.00	58.00	2	100912	2022-06-16	<0.3	4.61	<0.5	368	29.8	<0.02	0.176	<0.2	0.0261	<0.002	<0.2	9.34	0.0210
HFM32	26.00	31.00	3	100915	2022-06-09	<0.3	2.44	1.23	635	60.4	<0.02	0.286	<0.2	0.0586	<0.002	0.293	11.3	0.0095
HFM33	121.00	137.50	2	100918	2022-06-16	<0.5	2.30	<0.5	622	76.7	<0.05	0.428	<0.5	<0.05	<0.002	<0.5	4.68	<0.01
KFM01A	109.00	130.00	5	100820	2022-06-03	<0.3	2.56	<0.5	747	84.9	<0.02	0.0951	<0.2	0.0365	<0.002	<0.2	27.2	0.0085
KFM01D	429.00	438.00	2	100834	2022-05-25	<0.5	4.51	<0.5	618	611	<0.05	0.412	<0.5	<0.05	0.0027	0.701	0.518	0.0294
KFM01D	311.00	321.00	4	100831	2022-06-07	<0.3	4.80	<0.5	658	446	<0.02	0.192	<0.2	0.0273	<0.002	<0.2	5.74	0.0166
KFM02A	490.00	518.00	3	100840	2022-05-10	<0.5	2.60	<0.5	600	89.9	<0.05	0.416	<0.5	0.0927	<0.002	0.580	89.5	0.0247
KFM02A	490.00	518.00	3	102510	2022-05-10	<0.5	1.48	<0.5	615	92.1	<0.05	0.184	<0.5	0.0966	<0.002	<0.5	86.6	0.0225
KFM02A	411.00	442.00	5	100837	2022-05-11	<0.5	3.82	<0.5	665	82.7	<0.05	0.411	<0.5	0.123	<0.002	<0.5	17.2	0.0221
KFM02A	411.00	442.00	5	102513	2022-05-11	<0.5	2.08	<0.5	712	82.9	<0.05	0.166	0.752	0.0702	<0.002	<0.5	13.8	0.0144
KFM02B	491.00	506.00	2	100846	2022-05-06	<0.5	3.51	<0.5	611	195	<0.05	0.496	<0.5	0.191	<0.0020	0.593	11.7	0.0322
KFM02B	410.00	431.00	4	100843	2022-05-06	<0.5	2.82	<0.5	665	86.0	<0.05	0.104	<0.5	0.0596	<0.002	<0.5	8.00	0.0356
KFM03A	969.50	994.50	1	100852	2022-05-19	<0.5	14.2	<0.5	893	1000	<0.05	1.900	<0.5	<0.05	<0.002	0.654	9.09	0.0830
KFM03A	633.50	650.00	4	100849	2022-05-18	<0.5	5.04	<0.5	1020	154	<0.05	0.239	<0.5	<0.05	<0.002	<0.5	26.2	0.0266
KFM04A	230.00	245.00	4	100855	2022-05-11	<0.5	1.96	<0.5	558	101	<0.05	0.307	<0.5	2.0000	<0.002	0.746	84.8	0.0311
KFM06A	738.00	748.00	3	100861	2022-05-11	<0.5	0.94	0.625	787	384	<0.1	0.406	<0.5	<0.05	<0.002	<0.5	318	0.0447
KFM06A	341.00	362.00	5	100858	2022-05-04	<0.3	1.97	7.27	964	223	<0.05	0.158	<0.2	0.262	<0.002	0.529	166	0.0257
KFM06C	647.00	666.00	3	100867	2022-05-16	<0.5	1.60	1.18	884	362	<0.05	0.139	<0.5	<0.05	<0.002	0.640	32.0	0.0307
KFM06C	531.00	540.00	5	100864	2022-05-05	<0.5	1.84	<0.5	1010	98.4	<0.05	0.990	<0.5	<0.05	<0.002	1.48	46.6	0.0346
KFM07A	962.00	972.00	2	100870	2022-06-14	<0.5	2.55	<0.5	734	570	<0.05	0.610	<0.5	<0.05	<0.002	0.588	5.84	0.0386
KFM08A	684.00	694.00	2	100876	2022-05-20	<0.5	<0.7	2.48	693	378	<0.05	0.500	<0.5	<0.05	<0.002	0.523	33.2	0.0433
KFM08A	265.00	280.00	6	100873	2022-06-01	<0.3	6.63	<0.5	885	377	<0.02	0.155	<0.2	0.0234	<0.002	<0.2	8.94	0.0126

< "value" = result less than reporting limit

Table A3-2. Trace elements, continued – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	Ag	Al	As	B	Ba	Cd	Cr	Cu	Co	Hg	Ni	Mo	Nb
	m	m	no.	no.	date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
KFM08D	825.00	835.00	2	100882	2022-06-02	<0.5	2.52	<0.5	698	223	<0.05	<0.1	<0.5	<0.05	<0.002	1.16	34.0	0.0334
KFM08D	660.00	680.00	4	100879	2022-06-15	<0.5	13.0	0.824	694	570	<0.05	0.573	0.535	<0.05	<0.002	1.79	34.8	0.0164
KFM10A	430.00	440.00	2	100885	2022-05-19	<0.5	4.80	<0.5	677	71.8	<0.05	0.221	<0.5	<0.05	<0.002	<0.5	3.18	0.0249
KFM12A	270.00	280.00	3	100888	2022-05-12	<0.3	5.45	4.63	780	549	<0.02	1.44	<0.2	0.158	<0.002	0.861	9.29	0.0429
KFR01	44.65	62.30	1	100927	2022-10-05	<0.3	2.23	<0.5	724	53.8	<0.02	<0.04	<0.2	<0.02	<0.002	<0.2	4.23	0.0128
KFR101	279.50	341.76	1	100921	2022-06-09	<0.3	3.20	<0.5	908	574	<0.02	0.214	<0.2	0.0265	<0.002	0.367	3.52	<0.005
KFR104	333.00	454.57	1	100924	2022-06-03	<0.3	3.68	<0.5	912	246	<0.02	0.144	0.203	<0.02	<0.002	0.238	12.1	0.0061
KFR105	265.00	306.80	1	100930	2022-10-10	<0.3	2.42	<0.5	892	107	<0.02	<0.04	<0.2	<0.02	<0.002	<0.2	2.17	0.0117
KFR106	260.00	300.13	1	100936	2022-05-23	<0.3	9.07	<0.5	771	320	0.0634	0.958	<0.2	0.0370	<0.002	1.10	5.62	0.0156
KFR106	143.00	259.00	2	100933	2022-05-24	<0.3	7.19	<0.5	782	72.4	<0.02	<0.04	<0.2	0.0542	<0.002	1.14	5.42	0.0174

< "value" = result less than reporting limit

Table A3-2. Trace elements, continued – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	U	Th	Rb	Zr	Sb	Cs	Pb	Pd	Se	Sn	V	Zn
	m	m	no.	no.	date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
HFM01	33.50	45.50	2	100891	2022-06-10			7.48	8.31	0.0295	0.220	0.0254	0.0247	<0.3	<0.05	1.24	1.08
HFM02	38.00	48.00	2	100894	2022-06-01			5.89	8.32	0.0114	0.182	<0.01	0.0670	<0.3	<0.05	1.32	0.975
HFM04	57.90	65.90	2	100897	2022-05-10			8.48	7.99	0.0109	0.224	0.0246	0.0536	<0.3	<0.05	1.11	0.299
HFM13	159.00	175.60	1	100900	2022-05-19			49.0	0.294	<0.1	2.00	<0.3	<0.01	4.02	<0.5	0.223	14.1
HFM15	85.00	99.50	1	100903	2022-05-18			7.26	16.9	0.0254	64.8	0.0306	0.136	<0.3	<0.05	1.23	5.54
HFM16	54.00	67.00	2	100906	2022-05-05			6.03	6.16	0.0540	0.0673	0.0148	0.0227	<0.3	<0.05	1.80	1.03
HFM21	22.00	32.00	3	100909	2022-06-16			8.18	5.85	0.0110	0.161	0.0119	0.0170	<0.3	<0.05	0.935	<0.2
HFM27	46.00	58.00	2	100912	2022-06-16			19.8	3.41	<0.1	0.916	<0.1	0.00849	<2	<0.3	0.537	<0.8
HFM32	26.00	31.00	3	100915	2022-06-09			37.4	0.593	<0.1	0.951	<0.1	0.00687	<2	<0.3	0.452	<0.8
HFM33	121.00	137.50	2	100918	2022-06-16			54.8	<0.2	<0.1	1.83	<0.3	<0.01	<2	<0.5	0.238	<2
KFM01A	109.00	130.00	5	100820	2022-06-03			48.5	<0.1	<0.1	0.854	<0.1	<0.008	<2	<0.3	0.264	<0.8
KFM01D	429.00	438.00	2	100834	2022-05-25			40.0	<0.2	<0.1	2.74	<0.3	<0.01	<2	<0.5	0.314	<2
KFM01D	311.00	321.00	4	100831	2022-06-07			41.8	<0.1	<0.1	0.538	<0.1	<0.005	3.28	<0.3	0.437	<0.8
KFM02A	490.00	518.00	3	100840	2022-05-10			64.3	<0.2	<0.1	1.70	<0.3	<0.03	<2	<0.5	0.258	3.40
KFM02A	490.00	518.00	3	102510	2022-05-10			65.3	<0.2	<0.1	1.65	<0.3	<0.03	<2	<0.5	<0.05	<2
KFM02A	411.00	442.00	5	100837	2022-05-11	-	-	382	<0.2	<0.1	94.9	<0.3	0.0165	<2	<0.5	0.249	16.8
KFM02A	411.00	442.00	5	102513	2022-05-11			380	<0.2	<0.1	90.9	<0.3	<0.01	<2	<0.5	<0.05	<2
KFM02B	491.00	506.00	2	100846	2022-05-06			116	<0.2	<0.1	3.42	<0.3	0.0231	<2	<0.5	0.622	<2
KFM02B	410.00	431.00	4	100843	2022-05-06			64.8	<0.2	<0.1	3.96	<0.3	0.0459	<2	<0.5	0.259	4.02
KFM03A	969.50	994.50	1	100852	2022-05-19			32.0	<0.2	<0.1	0.628	0.492	<0.01	6.05	<0.5	0.222	4.32
KFM03A	633.50	650.00	4	100849	2022-05-18	-	-	38.0	<0.2	<0.1	2.67	<0.3	<0.01	<2	<0.5	0.269	<2
KFM04A	230.00	245.00	4	100855	2022-05-11			41.8	<0.2	<0.1	1.43	<0.3	<0.02	<2	<0.5	0.158	<2
KFM06A	738.00	748.00	3	100861	2022-05-11			28.3	<0.2	<0.1	0.531	<0.3	<0.1	<2	<0.5	0.334	2.91
KFM06A	341.00	362.00	5	100858	2022-05-04			21.8	<0.1	1.34	0.266	<0.1	<0.05	<2	<0.3	0.289	1.16
KFM06C	647.00	666.00	3	100867	2022-05-16			17.8	<0.2	0.281	0.954	<0.3	<0.01	<2	<0.5	0.385	3.78
KFM06C	531.00	540.00	5	100864	2022-05-05			28.5	<0.2	<0.1	0.792	<0.3	0.0320	<2	<0.5	0.308	2.77
KFM07A	962.00	972.00	2	100870	2022-06-14			39.2	<0.2	0.134	0.778	<0.3	<0.01	4.66	<0.5	0.255	<2
KFM08A	684.00	694.00	2	100876	2022-05-20			28.5	<0.2	<0.1	0.508	<0.3	<0.01	<2	<0.5	0.357	<2
KFM08A	265.00	280.00	6	100873	2022-06-01			30.1	<0.1	<0.1	0.306	<0.1	<0.005	<2	<0.3	0.334	22.3

- = Planned but not analysed < "value" = result less than reporting limit

Table A3-2. Trace elements, continued – 2022.

Id code	Secup m	Seclow m	Section no.	Sample no.	Sampling date	U µg/L	Th µg/L	Rb µg/L	Zr µg/L	Sb µg/L	Cs µg/L	Pb µg/L	Pd µg/L	Se µg/L	Sn µg/L	V µg/L	Zn µg/L
KFM08D	825.00	835.00	2	100882	2022-06-02			14.9	<0.2	0.318	0.298	<0.3	<0.01	5.80	<0.5	0.416	3.54
KFM08D	660.00	680.00	4	100879	2022-06-15			17.9	<0.2	<0.1	0.269	<0.3	<0.01	<2	<0.5	0.252	2.07
KFM10A	430.00	440.00	2	100885	2022-05-19			61.1	0.209	<0.1	0.920	<0.3	<0.01	5.92	<0.5	0.164	<2
KFM12A	270.00	280.00	3	100888	2022-05-12			13.4	<0.1	0.462	0.289	0.224	<0.005	<2	<0.3	0.365	0.914
KFR01	44.65	62.30	1	100927	2022-10-05			13.8	<0.1	<0.1	0.367	<0.1	<0.005	8.65	<0.3	0.141	2.28
KFR101	279.50	341.76	1	100921	2022-06-09			10.9	<0.1	<0.1	0.277	<0.1	<0.005	<2	<0.3	0.236	1.10
KFR104	333.00	454.57	1	100924	2022-06-03			7.22	<0.1	<0.1	0.139	<0.1	<0.005	<2	<0.3	0.309	<0.8
KFR105	265.00	306.80	1	100930	2022-10-10			12.2	<0.1	<0.1	0.319	<0.1	<0.005	9.84	<0.3	0.321	1.85
KFR106	260.00	300.13	1	100936	2022-05-23	-	-	16.2	<0.1	0.157	0.358	0.125	<0.005	<2	<0.3	0.334	1.81
KFR106	143.00	259.00	2	100933	2022-05-24	-	-	25.3	<0.1	<0.1	0.720	0.261	<0.005	<2	<0.3	0.288	0.933

- = Planned but not analysed < "value" = result less than reporting limit

Table A3-3. Isotopes I (H-, O- and C-isotopes), continued – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	$\delta^{2}H$	^{3}H	$\delta^{18}O$	$\delta^{34}S\text{-}SO_4$	$\delta^{18}O\text{-}SO_4$
	m	m	no.	no.	date	‰ dev SMOW	TU	‰ dev SMOW	‰ dev CDT	‰ dev SMOW
HFM01	33.50	45.50	2	100889	2022-06-07	-75.5	-	-10.21	-	-
HFM01	33.50	45.50	2	100890	2022-06-08	-75.3	-	-10.32	-	-
HFM01	33.50	45.50	2	100891	2022-06-10	-76.2	3.0	-10.30	-	-
HFM02	38.00	48.00	2	100892	2022-05-30	-82.2	-	-11.49	-	-
HFM02	38.00	48.00	2	100893	2022-05-31	-82.5	-	-11.53	-	-
HFM02	38.00	48.00	2	100894	2022-06-01	-81.5	3.6	-11.44	-	-
HFM04	58.00	66.00	2	100895	2022-05-09	-83.0	-	-11.66	-	-
HFM04	58.00	66.00	2	100896	2022-05-09	-83.3	-	-11.67	-	-
HFM04	58.00	66.00	2	100897	2022-05-10	-82.7	3.3	-11.66	-	-
HFM13	159.00	173.00	1	100898	2022-05-13	-71.7	-	-9.68	-	-
HFM13	159.00	173.00	1	100899	2022-05-16	-71.8	-	-9.54	-	-
HFM13	159.00	173.00	1	100900	2022-05-19	-71.2	<0.8	-9.60	27.6	13.6
HFM15	85.00	95.00	1	100901	2022-05-16	-81.4	-	-11.50	-	-
HFM15	85.00	95.00	1	100902	2022-05-17	-81.4	-	-11.52	-	-
HFM15	85.00	95.00	1	100903	2022-05-18	-80.5	6.0	-11.38	13.0	8.8
HFM16	54.00	67.00	2	100904	2022-05-03	-80.0	-	-11.02	-	-
HFM16	54.00	67.00	2	100905	2022-05-04	-79.8	-	-10.86	-	-
HFM16	54.00	67.00	2	100906	2022-05-05	-80.9	3.0	-11.12	14.1	10.7
HFM21	22.00	32.00	3	100907	2022-06-14	-81.4	-	-11.27	-	-
HFM21	22.00	32.00	3	100908	2022-06-15	-81.3	-	-11.16	-	-
HFM21	22.00	32.00	3	100909	2022-06-16	-81.5	3.5	-11.28	-	-
HFM27	46.00	58.00	2	100910	2022-06-13	-74.5	-	-10.06	-	-
HFM27	46.00	58.00	2	100911	2022-06-14	-75.8	-	-10.27	-	-
HFM27	46.00	58.00	2	100912	2022-06-16	-74.7	1.8	-10.21	-	-
HFM32	26.00	31.00	3	100913	2022-06-09	-66.4	-	-8.59	-	-
HFM32	26.00	31.00	3	100914	2022-06-09	-66.5	-	-8.87	-	-
HFM32	26.00	31.00	3	100915	2022-06-09	-66.6	<0.8	-8.54	-	-
HFM33	121.00	137.50	2	100916	2022-06-15	-67.0	-	-8.74	-	-
HFM33	121.00	137.50	2	100917	2022-06-15	-67.0	-	-8.82	-	-
HFM33	121.00	137.50	2	100918	2022-06-16	-66.5	1.0	-8.66	-	-

- = Not analysed < "value" = result less than reporting limit

Table A3-3. Isotopes I (H-, O- and C-isotopes), continued – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	$\delta^{2}H$	^{3}H	$\delta^{18}O$	$\delta^{34}S\text{-}SO_4$	$\delta^{18}O\text{-}SO_4$
	m	m	no.	no.	date	‰ dev SMOW	TU	‰ dev SMOW	‰ dev CDT	‰ dev SMOW
KFM01A	109.00	130.00	5	100818	2022-05-31	-89.3	-	-11.98	-	-
KFM01A	109.00	130.00	5	100819	2022-06-02	-90.6	-	-12.04	-	-
KFM01A	109.00	130.00	5	100820	2022-06-03	-89.6	1.0	-12.03	-	-
KFM01D	429.00	438.00	2	100832	2022-05-24	-72.8	-	-10.80	-	-
KFM01D	429.00	438.00	2	100833	2022-05-24	-73.0	-	-10.76	-	-
KFM01D	429.00	438.00	2	100834	2022-05-25	-74.2	<0.8	-10.87	-	-
KFM01D	311.00	321.00	4	100829	2022-06-07	-77.9	-	-11.25	-	-
KFM01D	311.00	321.00	4	100830	2022-06-07	-76.8	-	-11.01	-	-
KFM01D	311.00	321.00	4	100831	2022-06-07	-76.9	<0.8	-10.75	-	-
KFM02A	490.00	518.00	3	100838	2022-05-09	-66.1	-	-8.85	-	-
KFM02A	490.00	518.00	3	100839	2022-05-10	-66.1	-	-8.81	-	-
KFM02A	490.00	518.00	3	100840	2022-05-10	-66.4	<0.8	-8.89	27.3	13.5
KFM02A	490.00	518.00	3	102508	2022-05-09	-	-	-	-	-
KFM02A	490.00	518.00	3	102509	2022-05-10	-	-	-	-	-
KFM02A	490.00	518.00	3	102510	2022-05-10	-	-	-	-	-
KFM02A	411.00	442.00	5	100835	2022-05-09	-75.4	-	-9.98	-	-
KFM02A	411.00	442.00	5	100836	2022-05-10	-75.5	-	-10.11	-	-
KFM02A	411.00	442.00	5	100837	2022-05-11	-75.5	<0.8	-10.09	-	-
KFM02A	411.00	442.00	5	102511	2022-05-09	-	-	-	-	-
KFM02A	411.00	442.00	5	102512	2022-05-10	-	-	-	-	-
KFM02A	411.00	442.00	5	102513	2022-05-11	-	-	-	-	-
KFM02B	491.00	506.00	2	100844	2022-05-05	-65.0	-	-8.55	-	-
KFM02B	491.00	506.00	2	100845	2022-05-05	-65.0	-	-8.64	-	-
KFM02B	491.00	506.00	2	100846	2022-05-06	-65.4	<0.8	-8.78	-	-
KFM02B	410.00	431.00	4	100841	2022-05-05	-72.6	-	-9.80	-	-
KFM02B	410.00	431.00	4	100842	2022-05-06	-72.4	-	-9.91	-	-
KFM02B	410.00	431.00	4	100843	2022-05-06	-72.3	<0.8	-9.57	-	-
KFM03A	969.50	994.50	1	100850	2022-05-16	-95.8	-	-13.66	-	-
KFM03A	969.50	994.50	1	100851	2022-05-18	-96.3	-	-13.64	-	-
KFM03A	969.50	994.50	1	100852	2022-05-19	-96.6	<0.8	-13.58	33.3	10.7

- = Not analysed < "value" = result less than reporting limit

Table A3-3. Isotopes I (H-, O- and C-isotopes), continued – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	$\delta^{2}H$	^{3}H	$\delta^{18}O$	$\delta^{34}S\text{-}SO_4$	$\delta^{18}O\text{-}SO_4$
	m	m	no.	no.	date	‰ dev SMOW	TU	‰ dev SMOW	‰ dev CDT	‰ dev SMOW
KFM03A	633.50	650.00	4	100847	2022-05-17	-84.1	-	-11.63	-	-
KFM03A	633.50	650.00	4	100848	2022-05-17	-84.2	-	-11.64	-	-
KFM03A	633.50	650.00	4	100849	2022-05-18	-84.3	<0.8	-11.60	-	-
KFM04A	230.00	245.00	4	100853	2022-05-11	-70.2	-	-9.31	-	-
KFM04A	230.00	245.00	4	100854	2022-05-11	-68.7	-	-9.00	-	-
KFM04A	230.00	245.00	4	100855	2022-05-11	-70.2	<0.8	-9.44	-	-
KFM06A	738.00	748.00	3	100859	2022-05-09	-82.0	-	-12.01	-	-
KFM06A	738.00	748.00	3	100860	2022-05-10	-81.2	-	-11.78	-	-
KFM06A	738.00	748.00	3	100861	2022-05-11	-81.6	1.8	-11.85	-	-
KFM06A	341.00	362.00	5	100856	2022-05-03	-89.3	-	-12.48	-	-
KFM06A	341.00	362.00	5	100857	2022-05-03	-88.9	-	-12.24	-	-
KFM06A	341.00	362.00	5	100858	2022-05-04	-89.7	0.9	-12.51	-	-
KFM06C	647.00	666.00	3	100865	2022-05-09	-93.4	-	-12.96	-	-
KFM06C	647.00	666.00	3	100866	2022-05-13	-92.8	-	-12.82	-	-
KFM06C	647.00	666.00	3	100867	2022-05-16	-93.5	<0.8	-12.98	-	-
KFM06C	531.00	540.00	5	100862	2022-05-04	-82.0	-	-11.09	-	-
KFM06C	531.00	540.00	5	100863	2022-05-04	-82.6	-	-11.16	-	-
KFM06C	531.00	540.00	5	100864	2022-05-05	-82.0	0.8	-11.21	-	-
KFM07A	962.00	972.00	2	100868	2022-06-13	-86.9	-	-13.06	-	-
KFM07A	962.00	972.00	2	100869	2022-06-14	-87.7	-	-13.13	-	-
KFM07A	962.00	972.00	2	100870	2022-06-14	-87.5	<0.8	-13.07	28.2	10.4
KFM08A	684.00	694.00	2	100874	2022-05-20	-91.9	-	-13.08	-	-
KFM08A	684.00	694.00	2	100875	2022-05-20	-90.9	-	-13.00	-	-
KFM08A	684.00	694.00	2	100876	2022-05-20	-90.2	<0.8	-12.96	34.0	13.4
KFM08A	265.00	280.00	6	100871	2022-05-30	-101.4	-	-13.52	-	-
KFM08A	265.00	280.00	6	100872	2022-05-31	-100.5	-	-13.60	-	-
KFM08A	265.00	280.00	6	100873	2022-06-01	-100.1	<0.8	-13.45	27.6	10.9

- = Not analysed < "value" = result less than reporting limit

Table A3-3. Isotopes I (H-, O- and C-isotopes), continued – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	$\delta^{2}H$	^{3}H	$\delta^{18}O$	$\delta^{34}S\text{-}SO_4$	$\delta^{18}O\text{-}SO_4$
	m	m	no.	no.	date	‰ dev SMOW	TU	‰ dev SMOW	‰ dev CDT	‰ dev SMOW
KFM08D	825.00	835.00	2	100880	2022-05-30	-82.0	-	-11.96	-	-
KFM08D	825.00	835.00	2	100881	2022-05-31	-81.9	-	-11.90	-	-
KFM08D	825.00	835.00	2	100882	2022-06-02	-80.8	<0.8	-12.08	-	-
KFM08D	660.00	680.00	4	100877	2022-06-10	-83.6	-	-12.05	-	-
KFM08D	660.00	680.00	4	100878	2022-06-13	-83.8	-	-12.01	-	-
KFM08D	660.00	680.00	4	100879	2022-06-15	-83.9	<0.8	-12.10	39.0	13.3
KFM10A	430.00	440.00	2	100883	2022-05-17	-64.7	-	-8.51	-	-
KFM10A	430.00	440.00	2	100884	2022-05-18	-64.1	-	-8.52	-	-
KFM10A	430.00	440.00	2	100885	2022-05-19	-64.4	<0.8	-8.53	-	-
KFM12A	270.00	280.00	3	100886	2022-05-12	-111.8	-	-15.10	-	-
KFM12A	270.00	280.00	3	100887	2022-05-12	-112.6	-	-15.25	-	-
KFM12A	270.00	280.00	3	100888	2022-05-12	-112.9	<0.8	-15.36	34.6	13.3
KFR01	44.65	62.30	1	100925	2022-10-04	-78.0	-	-10.26	-	-
KFR01	44.65	62.30	1	100926	2022-10-04	-78.1	-	-10.39	-	-
KFR01	44.65	62.30	1	100927	2022-10-05	-77.8	-	-10.35	-	-
KFR101	279.50	341.76	1	100919	2022-06-08	-112.4	-	-15.10	-	-
KFR101	279.50	341.76	1	100920	2022-06-09	-112.1	-	-15.16	-	-
KFR101	279.50	341.76	1	100921	2022-06-09	-111.8	<0.8	-15.16	-	-
KFR104	333.00	454.57	1	100922	2022-05-31	-107.1	-	-14.43	-	-
KFR104	333.00	454.57	1	100923	2022-06-02	-107.0	-	-14.35	-	-
KFR104	333.00	454.57	1	100924	2022-06-03	-107.3	<0.8	-14.36	-	-
KFR105	265.00	306.80	1	100928	2022-10-05	-101.9	-	-13.58	-	-
KFR105	265.00	306.80	1	100929	2022-10-06	-101.9	-	-13.57	-	-
KFR105	265.00	306.80	1	100930	2022-10-10	-101.5	-	-13.51	-	-
KFR106	260.00	300.13	1	100934	2022-05-23	-113.3	-	-15.22	-	-
KFR106	260.00	300.13	1	100935	2022-05-23	-109.4	-	-14.74	-	-
KFR106	260.00	300.13	1	100936	2022-05-23	-109.0	1.3	-14.50	-	-
KFR106	143.00	259.00	2	100931	2022-05-23	-82.7	-	-10.92	-	-
KFR106	143.00	259.00	2	100932	2022-05-24	-82.7	-	-10.99	-	-
KFR106	143.00	259.00	2	100933	2022-05-24	-82.4	<0.8	-10.86	-	-

- = Not analysed < "value" = result less than reporting limit

Table A3-4. Isotopes II (U- and Th-isotopes) – 2022.

Id code	Secup	Seclow	Section	Sample	Sampling	^{238}U	^{235}U	^{234}U	^{232}Th	^{230}Th
	m	m	no.	no.	date	mBq/kg	mBq/kg	mBq/kg	mBq/kg	mBq/kg
KFM02A	490.00	518.00	3	100840	2022-05-10	1.47	0.06	2.99	0.00032	0.00041
KFRM03A	633.50	650.00	4	100849	2022-05-18	0.17	0.01	0.27	0.00044	0.00052
KFR106	260.00	300.10	1	100936	2022-05-23	0.16	0.01	0.33	0.00013	0.00058
KFR106	143.00	259.00	2	100933	2022-05-24	0.29	0.01	0.88	0.00005	0.00032

Appendix 4

Plug flow volumes

Table A4-1. Plug flow volumes.

Borehole Idcode: section	Plug flow volume [L]
KFM01A:5	93
KFM01D:2	16
KFM01D:4	18
KFM02A:3	42
KFM02A:5	182
KFM02B:2	60
KFM02B:4	191
KFM03A:1	79
KFM03A:4	29
KFM04A:4	16
KFM06A:3	28
KFM06A:5	26
KFM06C:3 [2)]	43
KFM06C:5 [2)]	28
KFM07A:2	38
KFM08A:2	22
KFM08A:6	259
KFM08D:2	33
KFM08D:4	235
KFM10A:2	125
KFM11A:2 [2)]	46
KFM11A:4	21
KFM12A:3 [2)]	23
HFM01:2	306
HFM02:2	238
HFM04:2	103
HFM13:1	515
HFM15:1	116
HFM16:2	840
HFM19:1	203
HFM21:3	134
HFM27:2	222
HFM32:3	29
KFR101:1 [1)]	73
KFR102A:2 [1)]	194
KFR102A:5	52
KFR104:1 [1)]	60
KFR105:1 [1)]	696
KFR106:2 [1)]	55
KFR01:1 [2)]	40
KFR02:2	42
KFR02:3	87
KFR02:4	86

[1)] Used plug flow volumes smaller than 100% formation waters, se table A6-2.
[2)] Section volume

Table A4-2. Plug flow volumes special.

Idcode: section	Used plug flow volume	Percent formation water	Volume needed for 100 % formation water
	[L]	[%]	[L]
KFR101:1	73	99	17881
KFR102A:2	194	100	986
KFR104:1	60	83	491
KFR105:1	696	99	2433
KFR106:2	55	89	1450

Appendix 5

Pressure registrations during pumping and sampling, HMS system

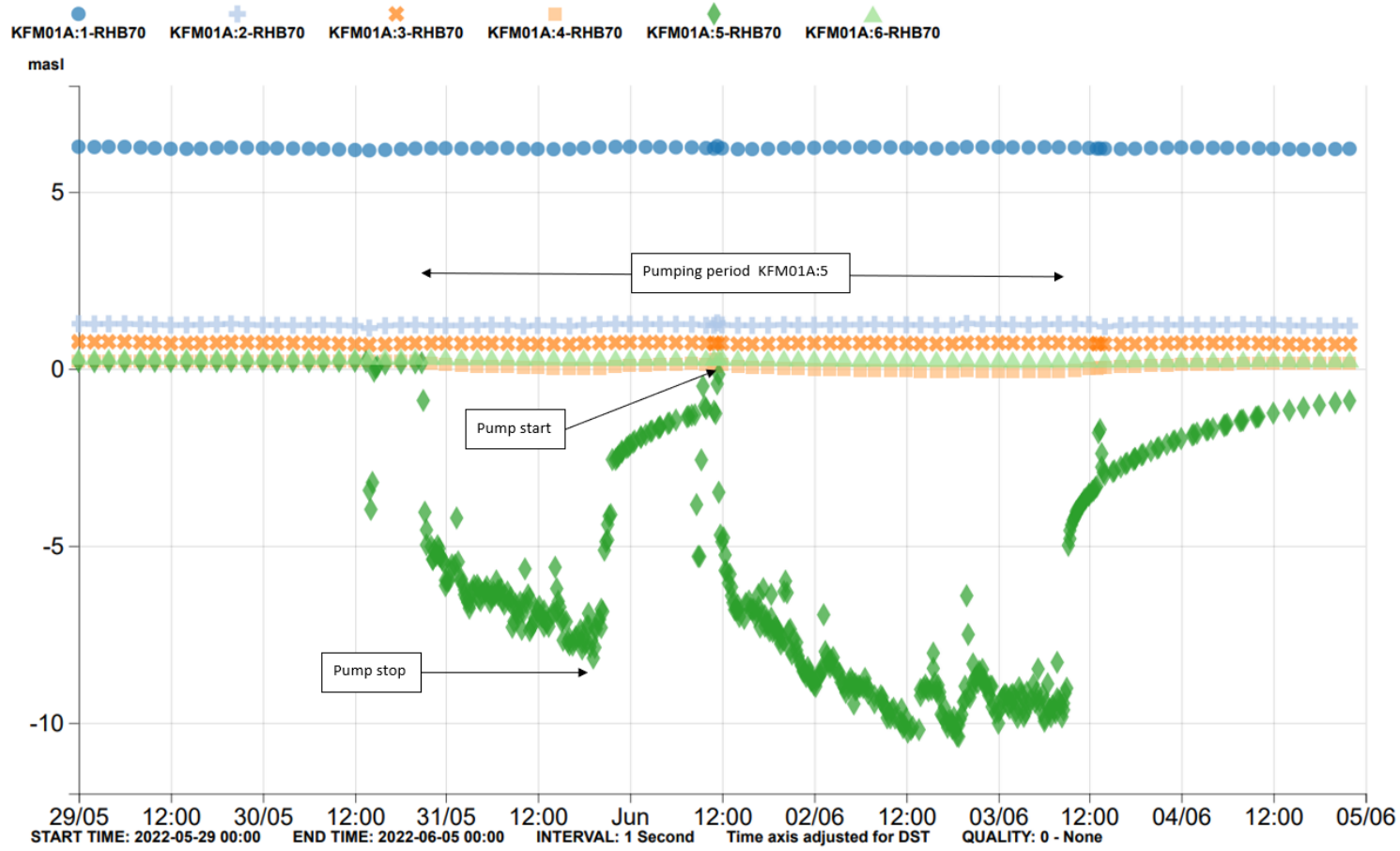

Figure A5-1. *Pumping and drawdown in KFM01A:5 in May and June 2022. A small response was observed in 4. During the pump period a pump stop occurred.*

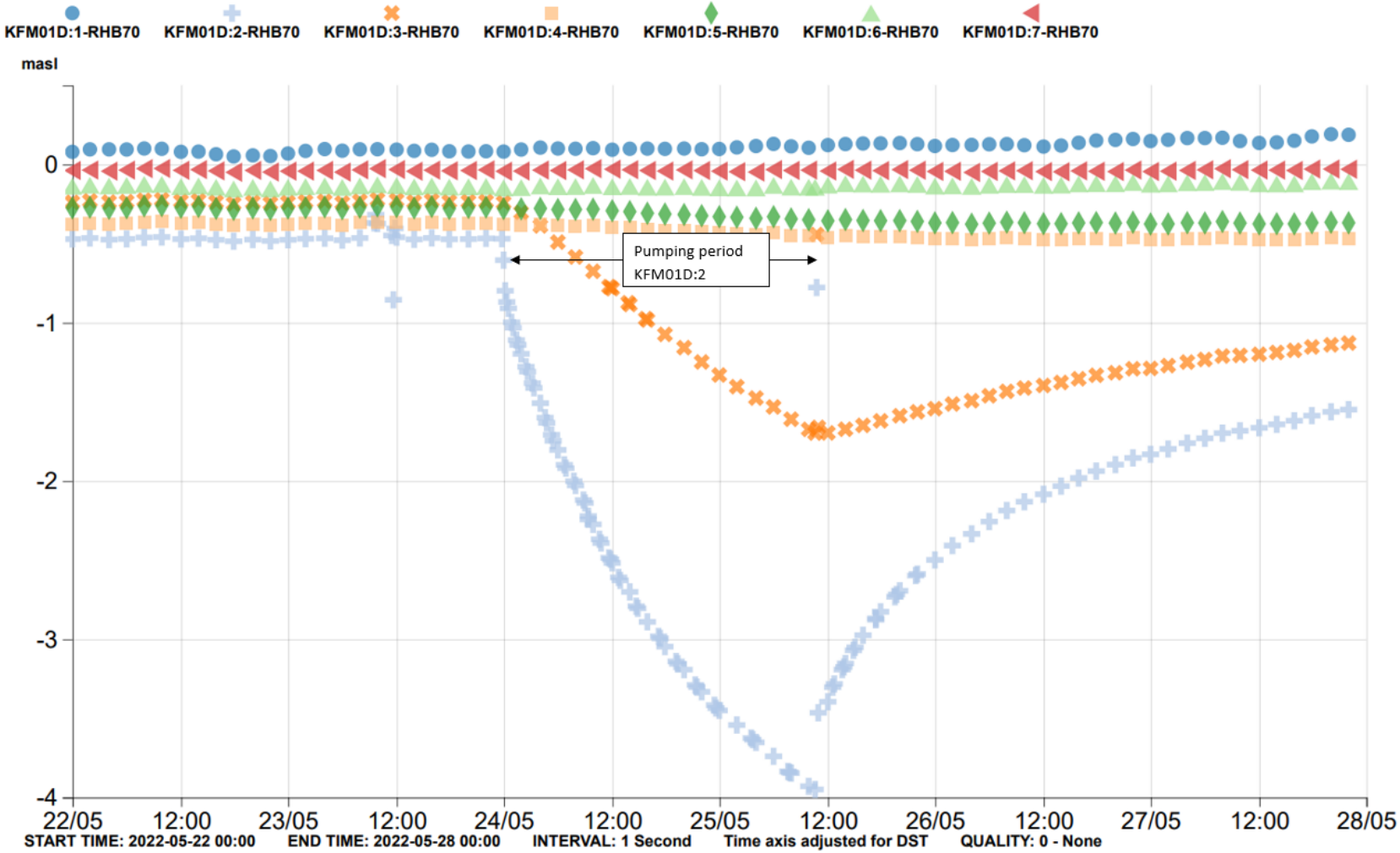

Figure A5-2. *Pumping and drawdown in KFM01D:2 in May 2022. Sections KFM01D:3, KFM01D:4 and KFM01D:5 were affected by the pumping in KFM01D:2.*

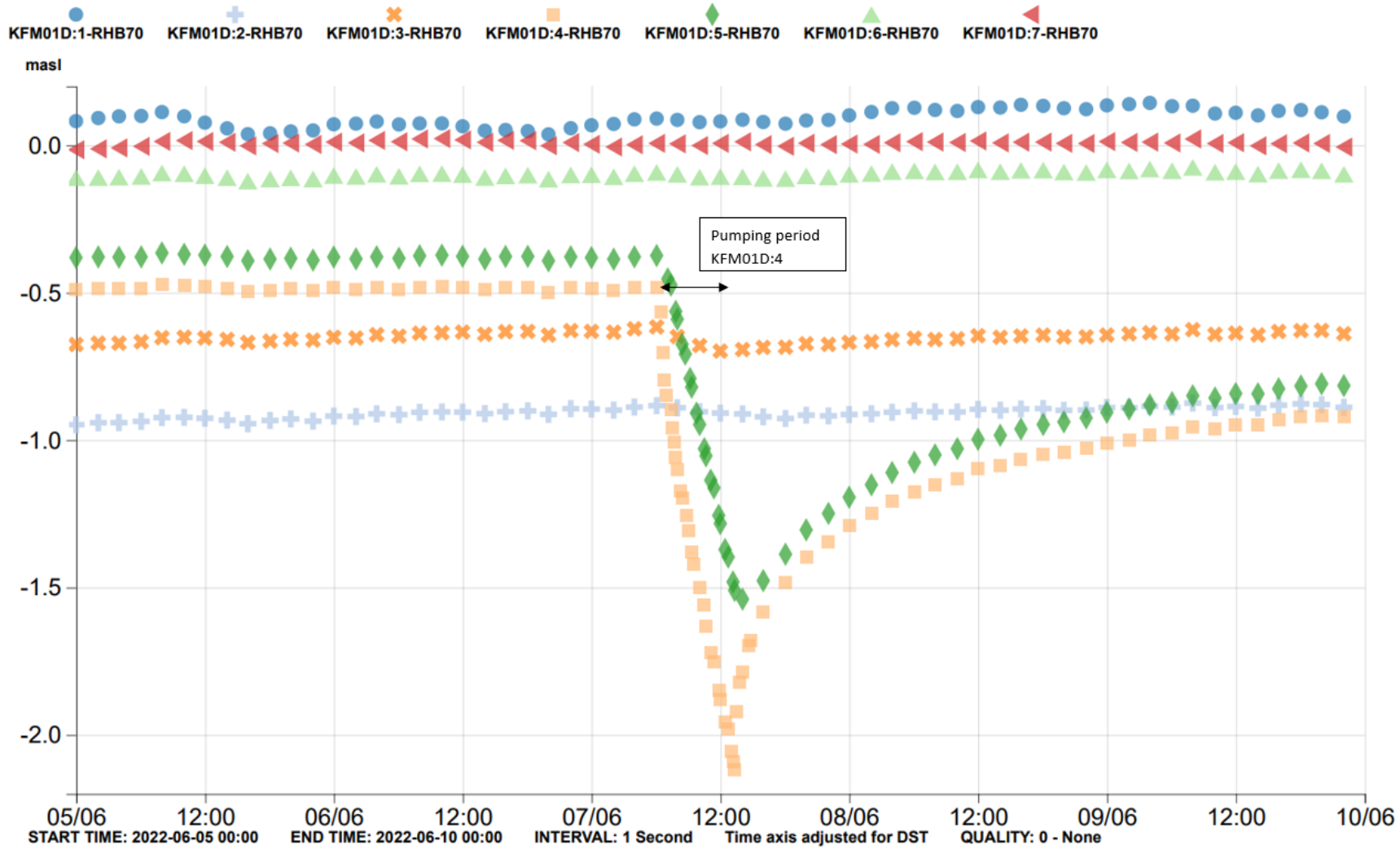

Figure A5-3. *Pumping and drawdown in KFM01D:4 in June 2022. Sections KFM01D:3 and KFM01D:5 were affected by the pumping in KFM01D:4.*

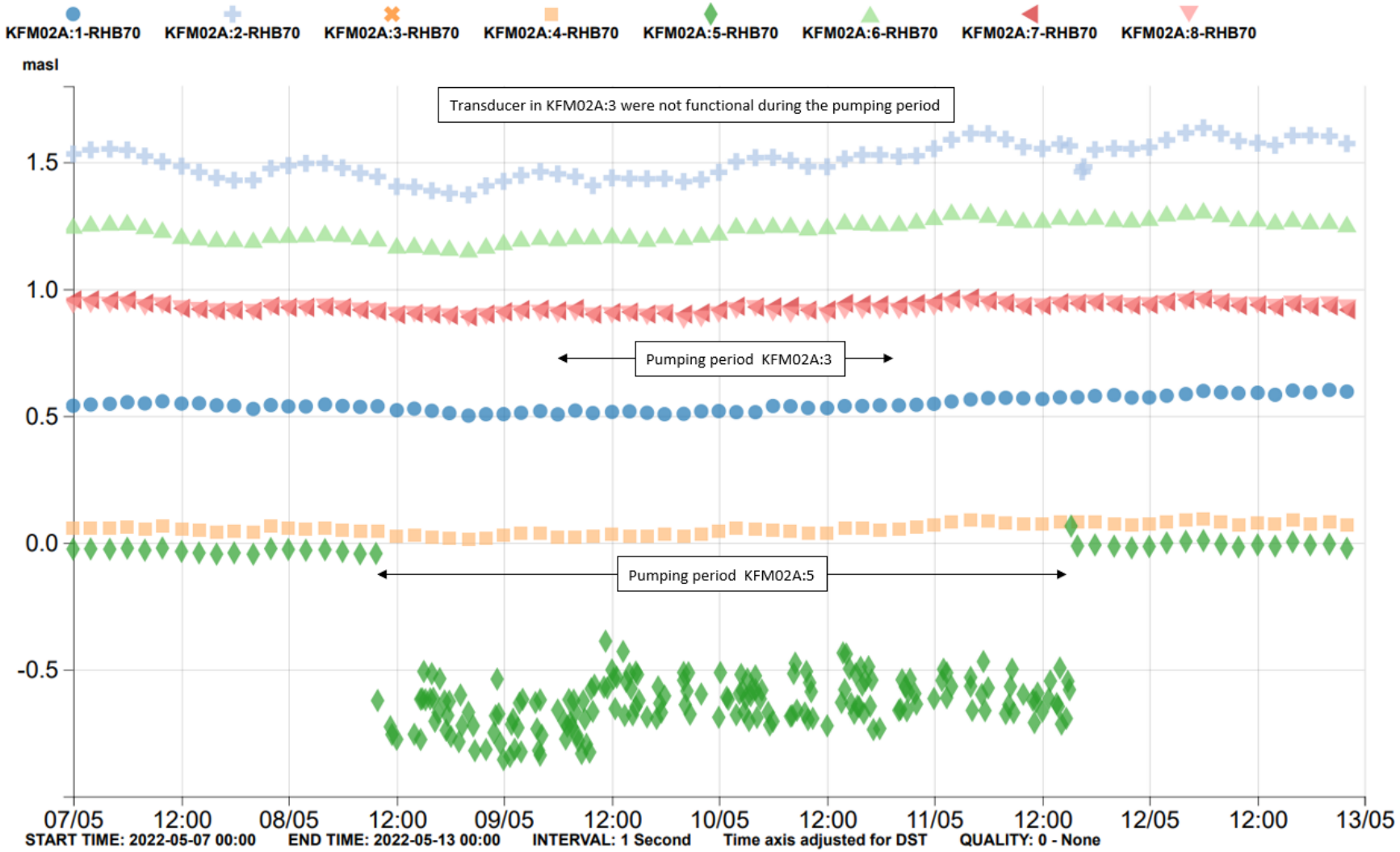

Figure A5-4. *Pumping and drawdown in KFM02A:3 and KFM02A:5 in May 2022. No other sections were affected.*

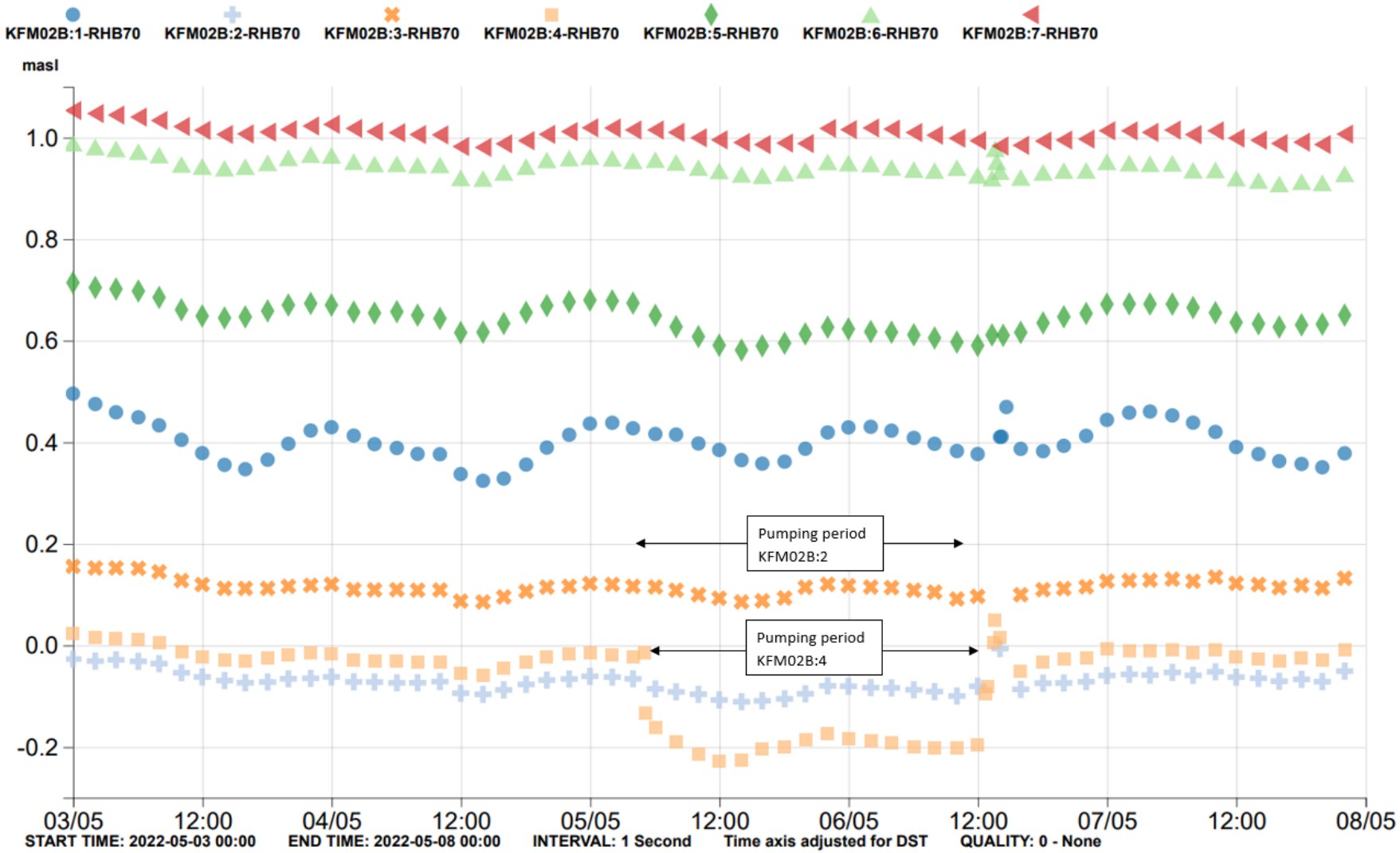

Figure A5-5. *Pumping and drawdown in KFM02B:2 and KFM02B:4 in June 2022. No (?) sections were affected. However, in KFM02A:5 there is a response to the pumping in KFM02B:4 (not shown in this graph).*

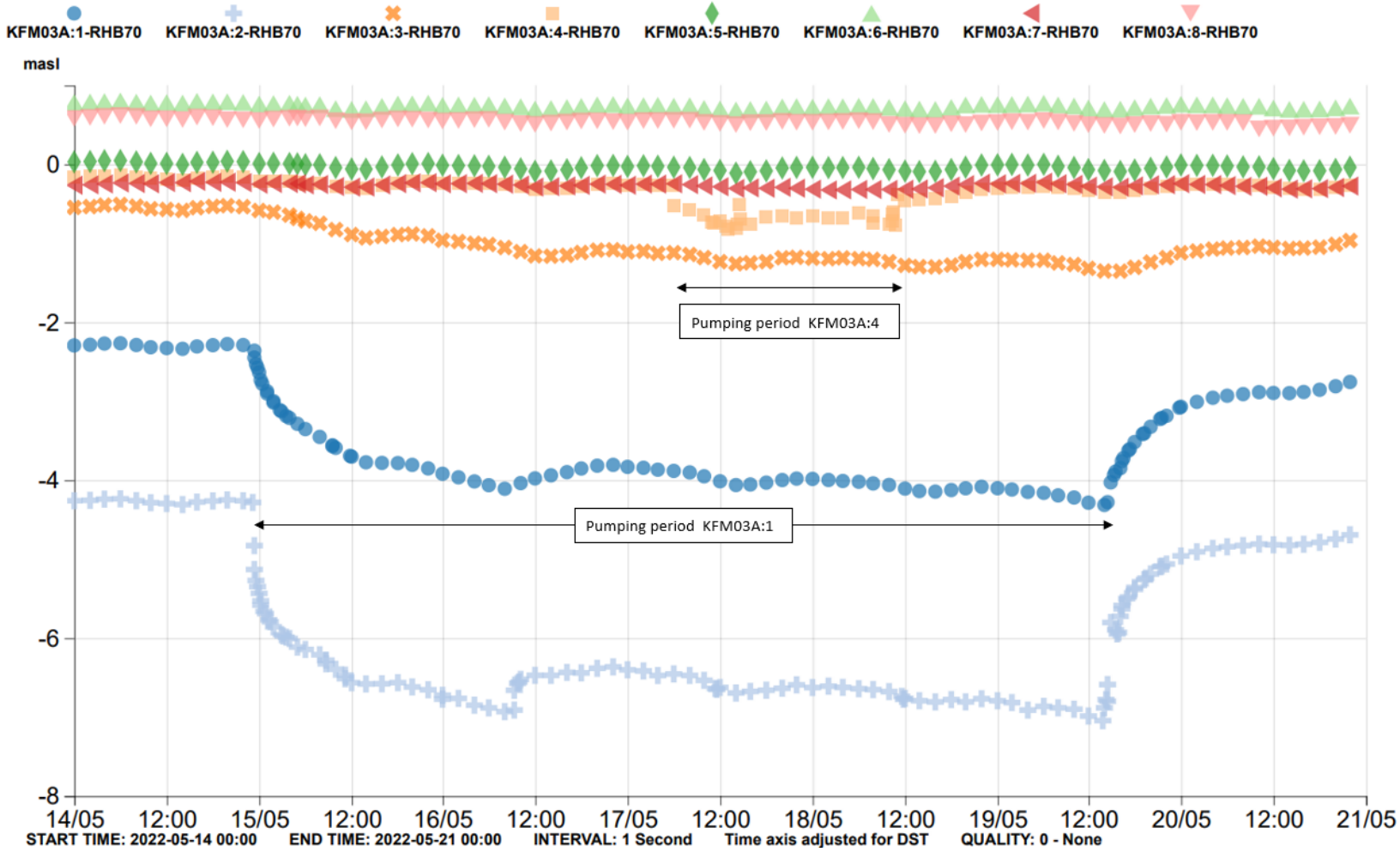

Figure A5-6. *Pumping and drawdown in KFM03A:1 and KFM03A:4 in May 2022. The pressure response observed in KFM03A:2 during pumping in KFM03A:1 may be caused by a leaking connection in the equipment between sections KFM03A:1 and KFM03A:2 rather than a connected fracture system. A response to the pumping in KFM03A:1 was also seen in KFM03A:3.*

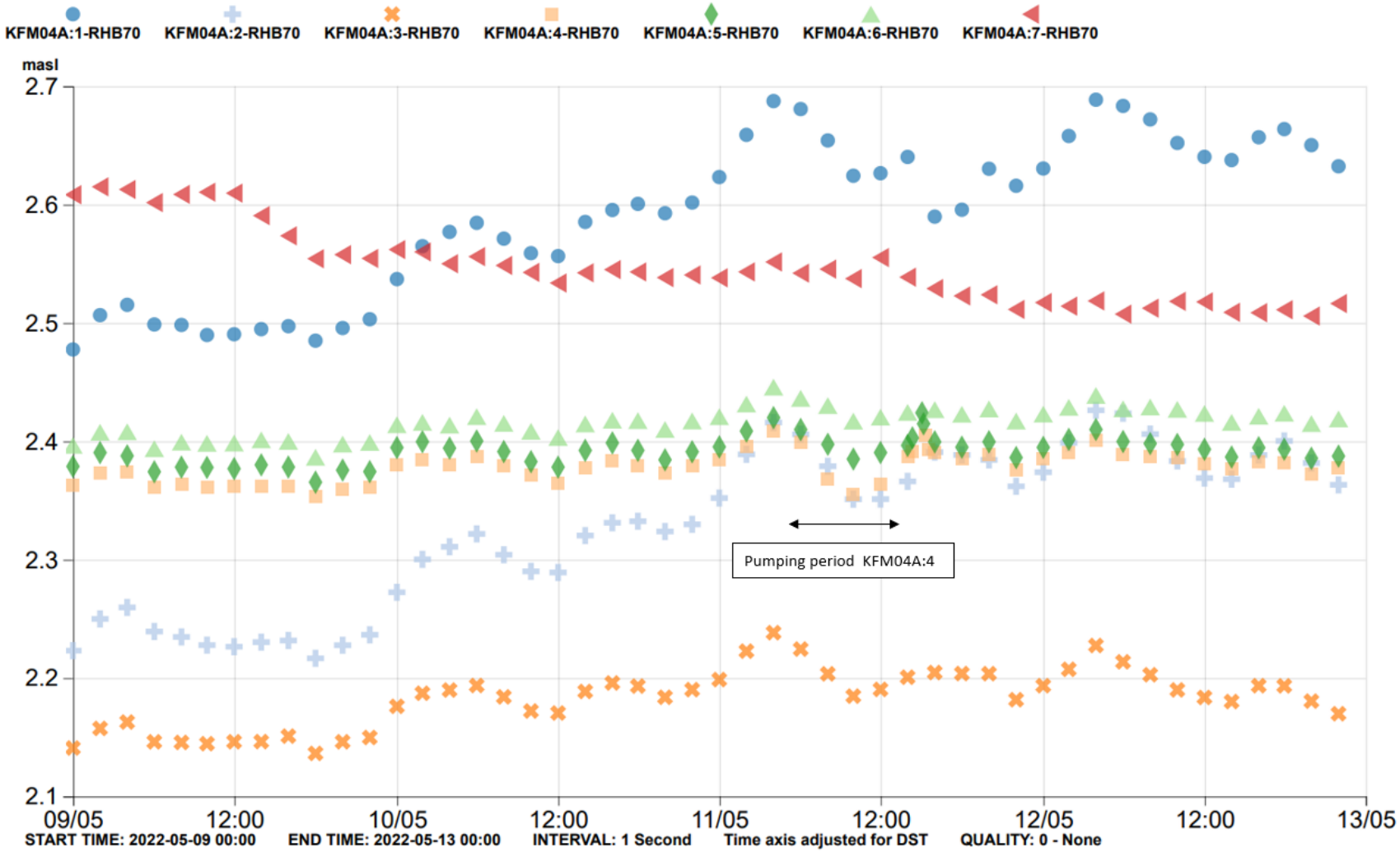

Figure A5-7. *Pumping and drawdown in KFM04A:4 in May 2022. No (?) sections were significantly affected by the pumping.*

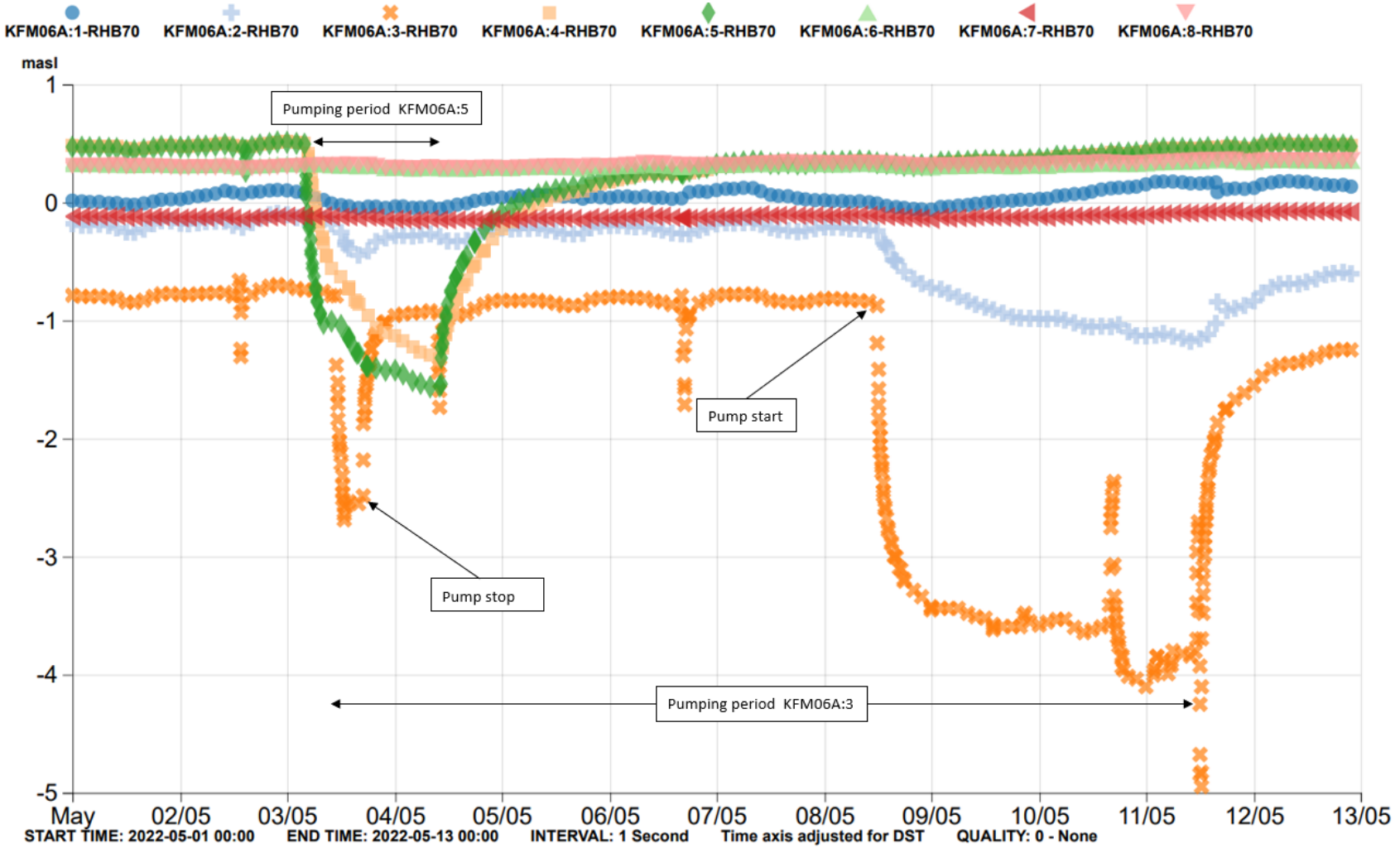

Figure A5-8. *Pumping and drawdown in KFM06A:3 and KFM06A:5 in May 2022. Section KFM06A:2 was affected by the pumping in KFM06A:3. KFM06A:4 was affected by the pumping in section KFM06A:5. During the pumping period for KFM06A:3 a pump stop occurred.*

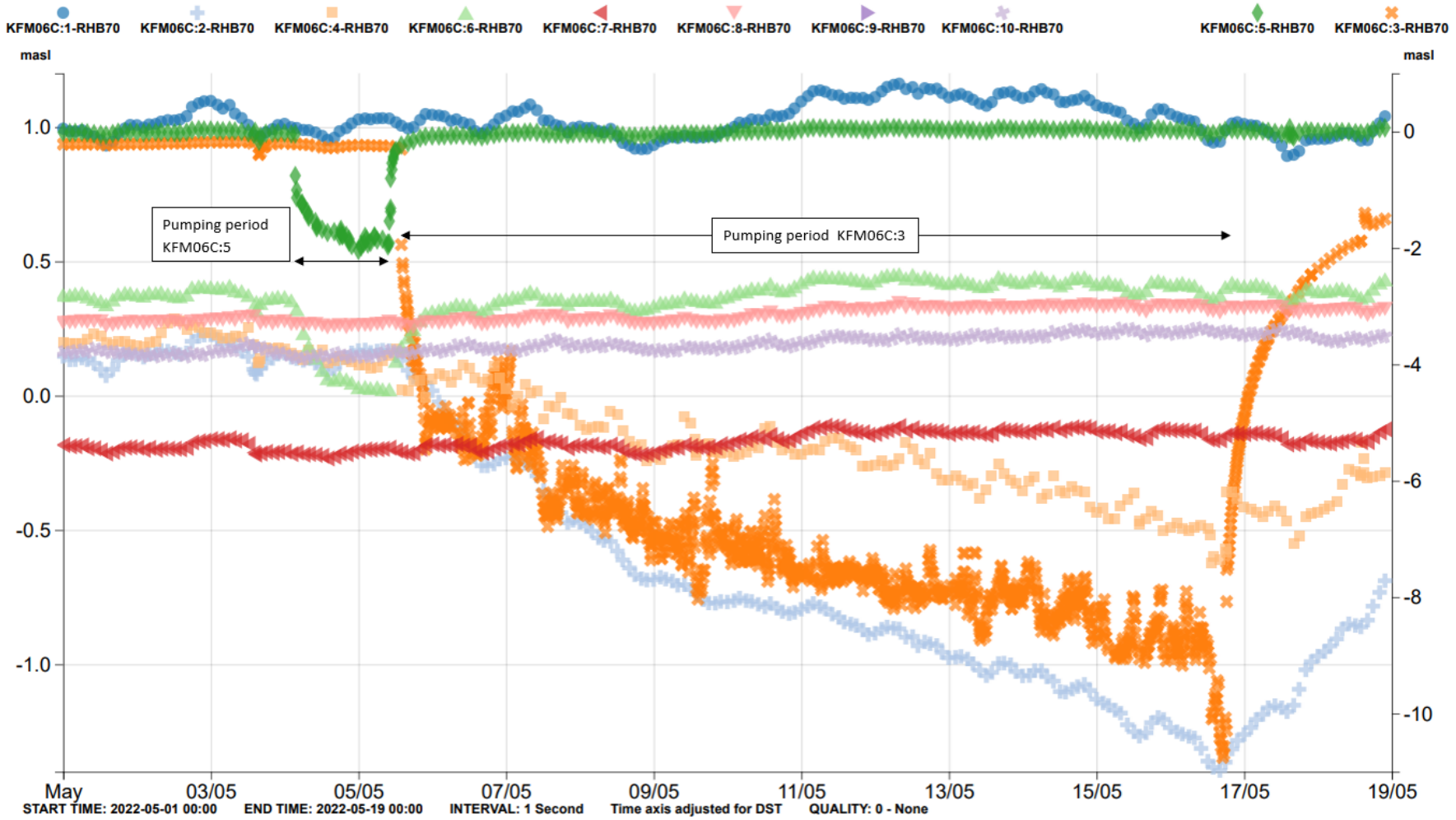

Figure A5-9. *Pumping and drawdown in KFM06C:3 and KFM06C:5 in May 2022. Sections KFM06C:2 and KFM06C:4 were affected by the pumping in section KFM06C:3. The pumping in section KFM06C:5 caused a response in KFM06C:6.*

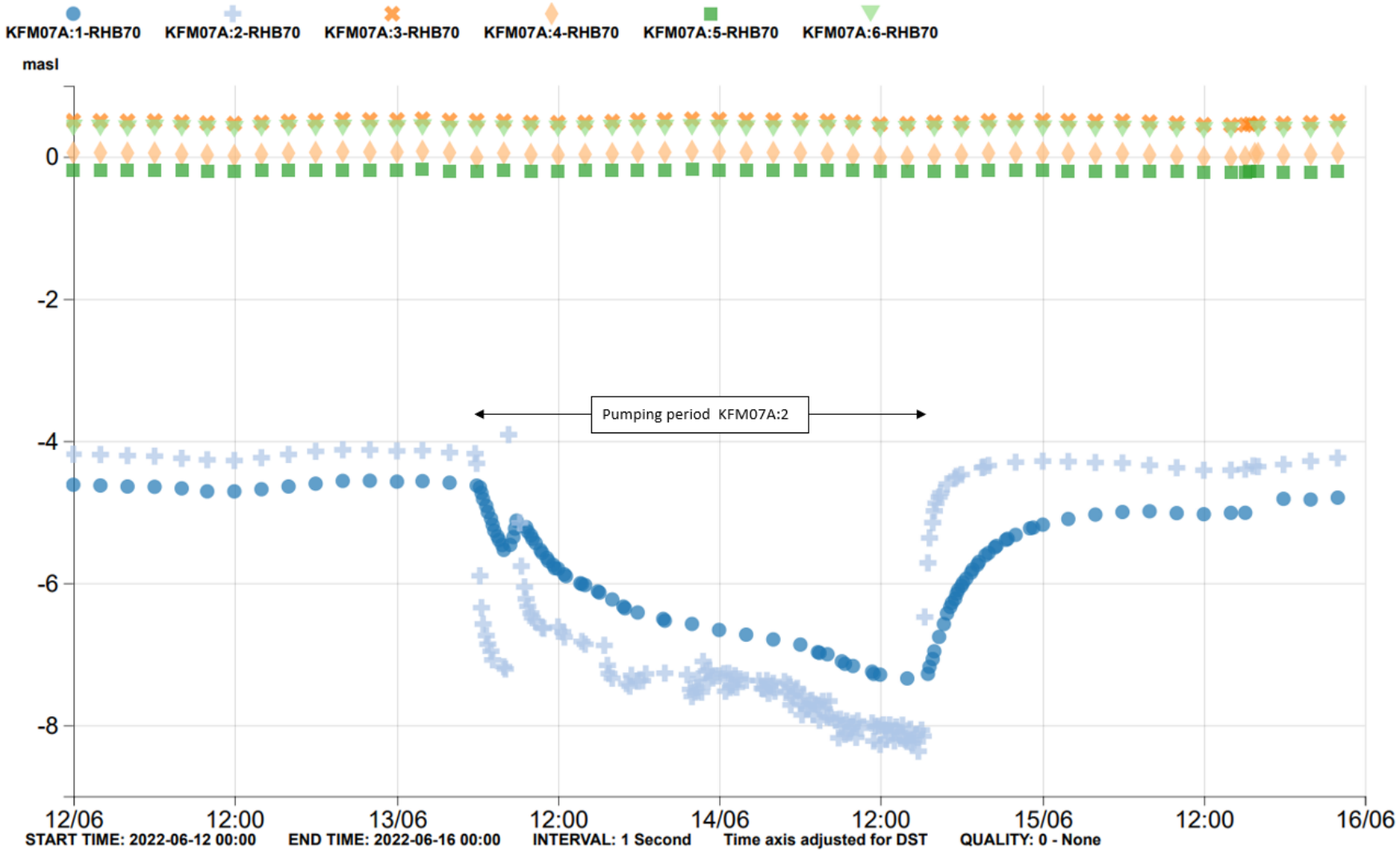

Figure A5-10. *Detailed plot of pumping and drawdown in KFM07A:2 in June 2022. The pumping in section KFM07A:2 caused a response in KFM07A:1.*

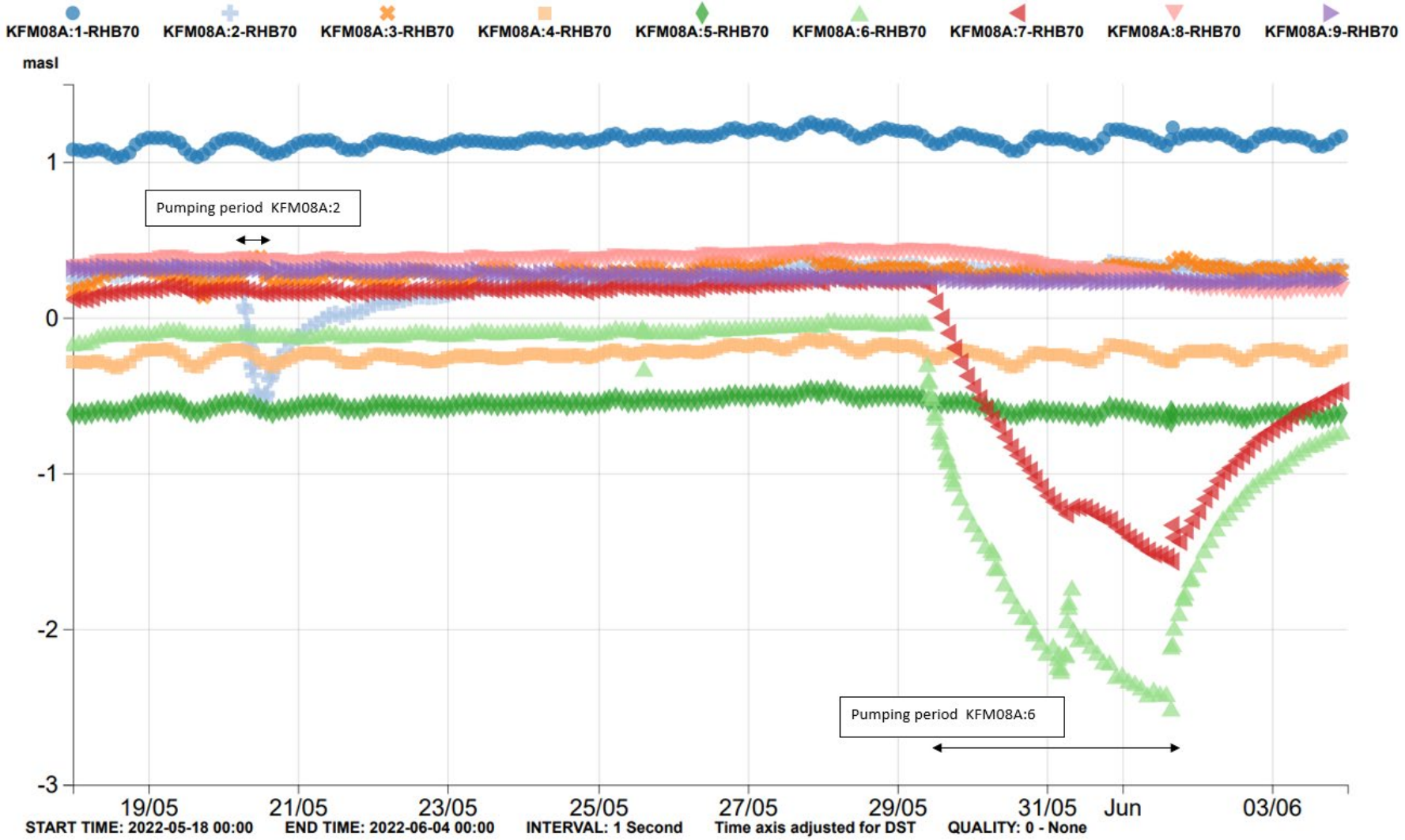

Figure A5-11. *Detailed plot of pumping and drawdown in KFM08A:2 and KFM08A:6 in May and June 2022. The pumping in section KFM08A:2 caused an inverted (increase in pressure) response in KFM08A:3. Pumping in section KFM08A:6 caused responses in KFM08A:7 and KFM08A:8.*

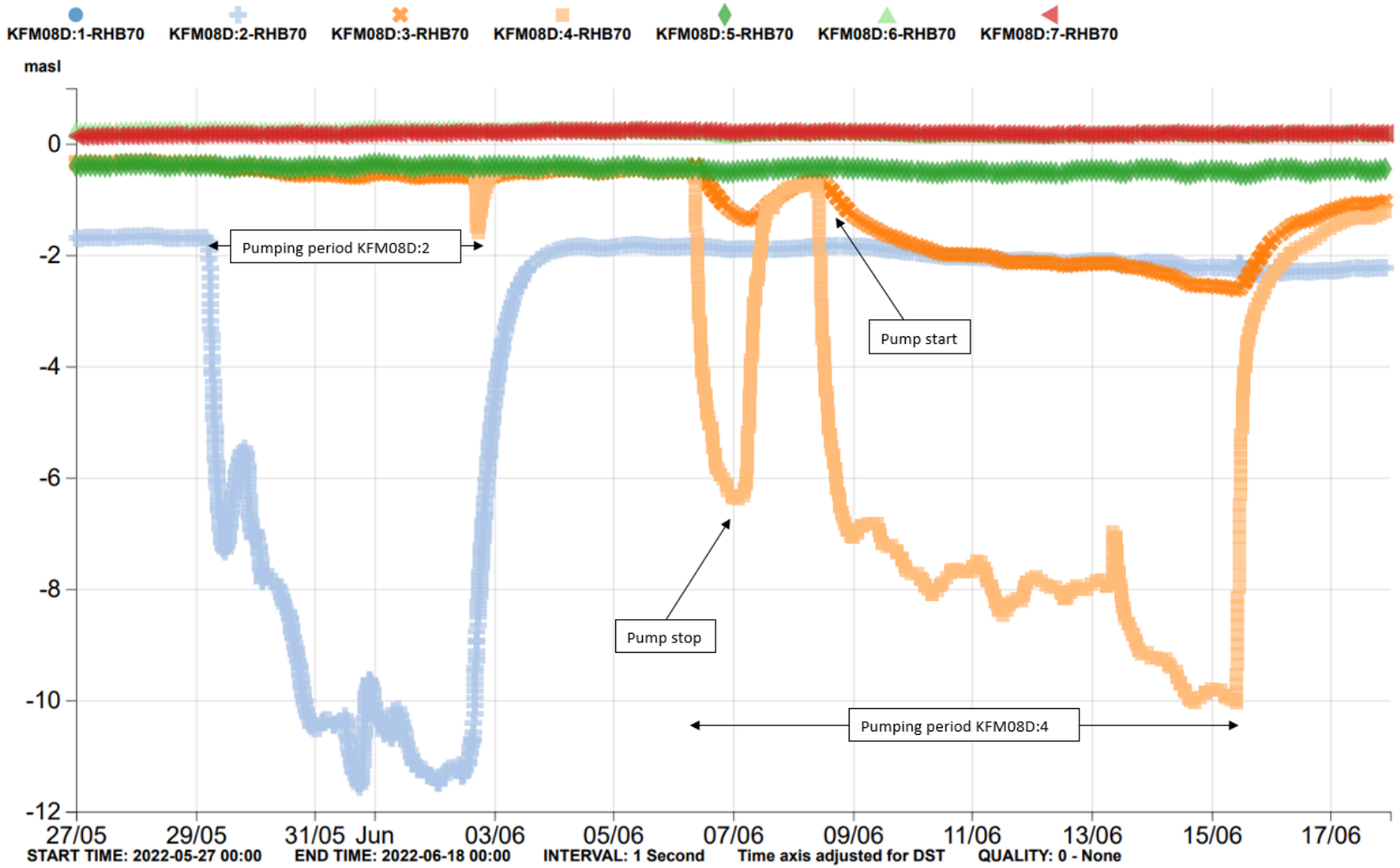

Figure A5-12. *Detailed plot of pumping and drawdown in KFM08D:2 and KFM08D:4 in May and June 2022. Pumping in KFM08D:2 caused a small response in KFM08D:3. The pumping in section KFM08D:4 causes a response in KFM08D:3 and KFM08D:2. The pumping rate in both sections had to be adjusted several times which could be seen in the graph.*

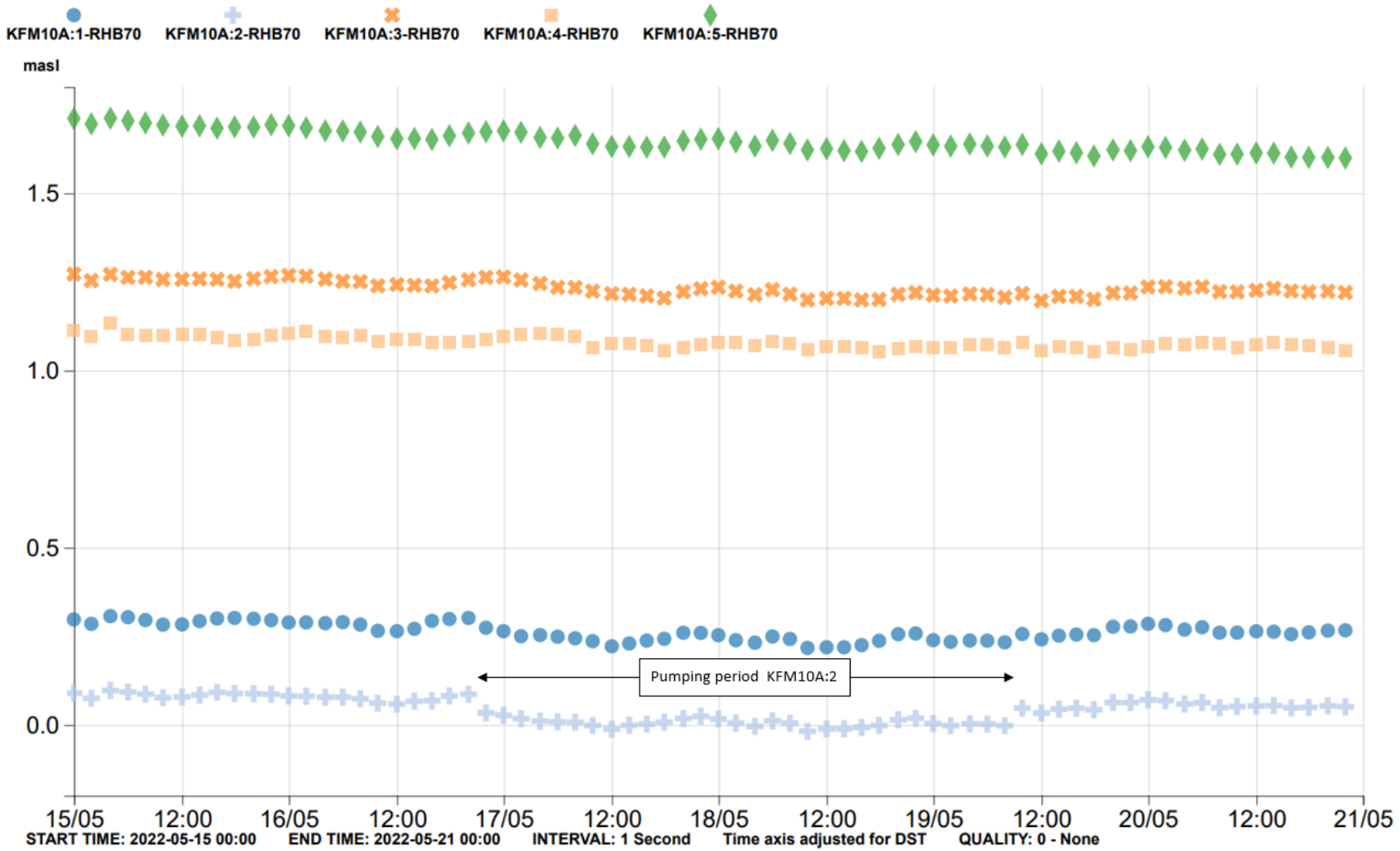

Figure A5-13. *Detailed plot of pumping and drawdown in KFM10A:2 in May 2022. No (?) sections were significantly affected by the pumping.*

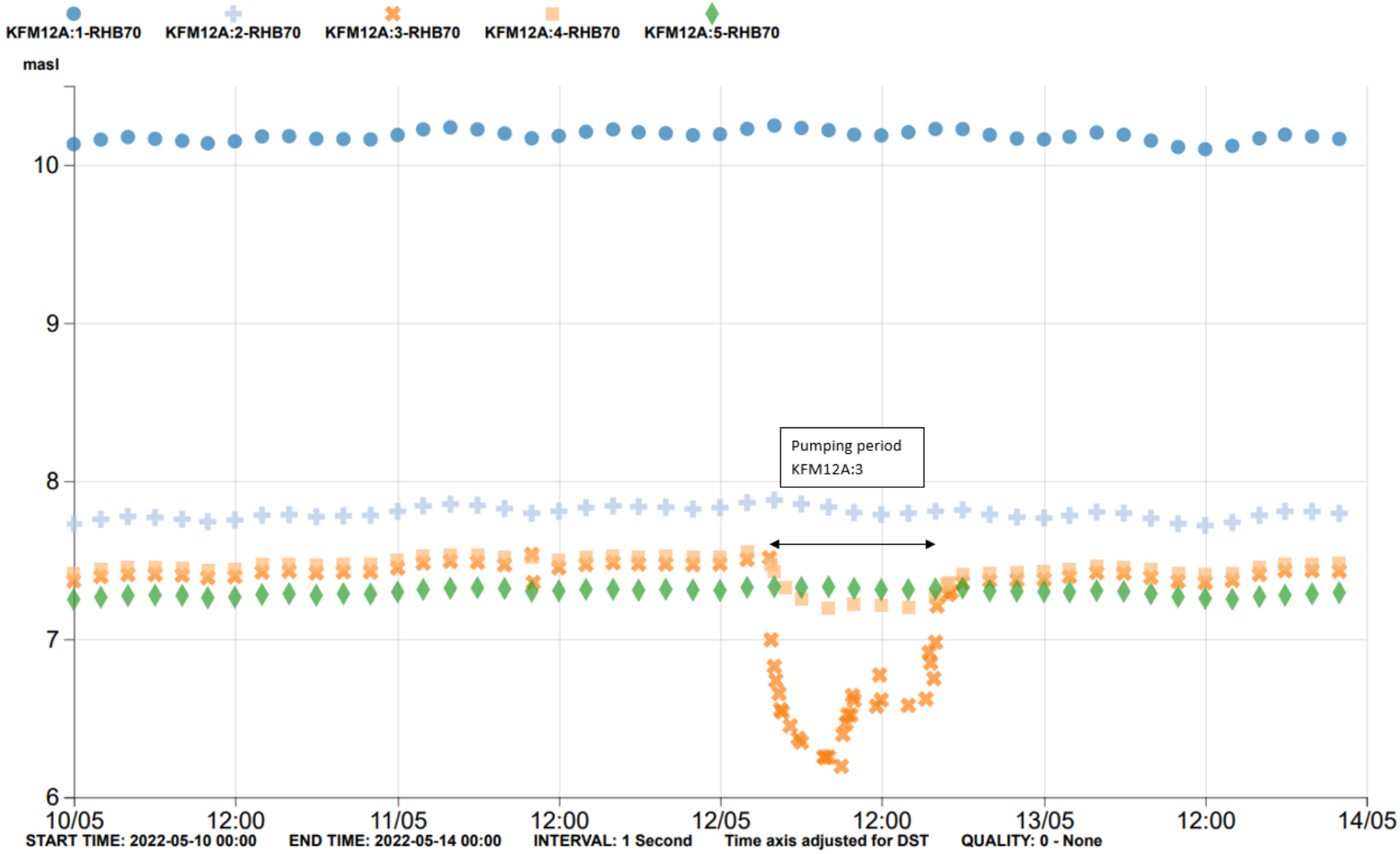

Figure A5-14. *Pumping and drawdown in KFM12A:3 in May 2022. The pumping in section KFM12A:3 caused a response in KFM12A:4.*

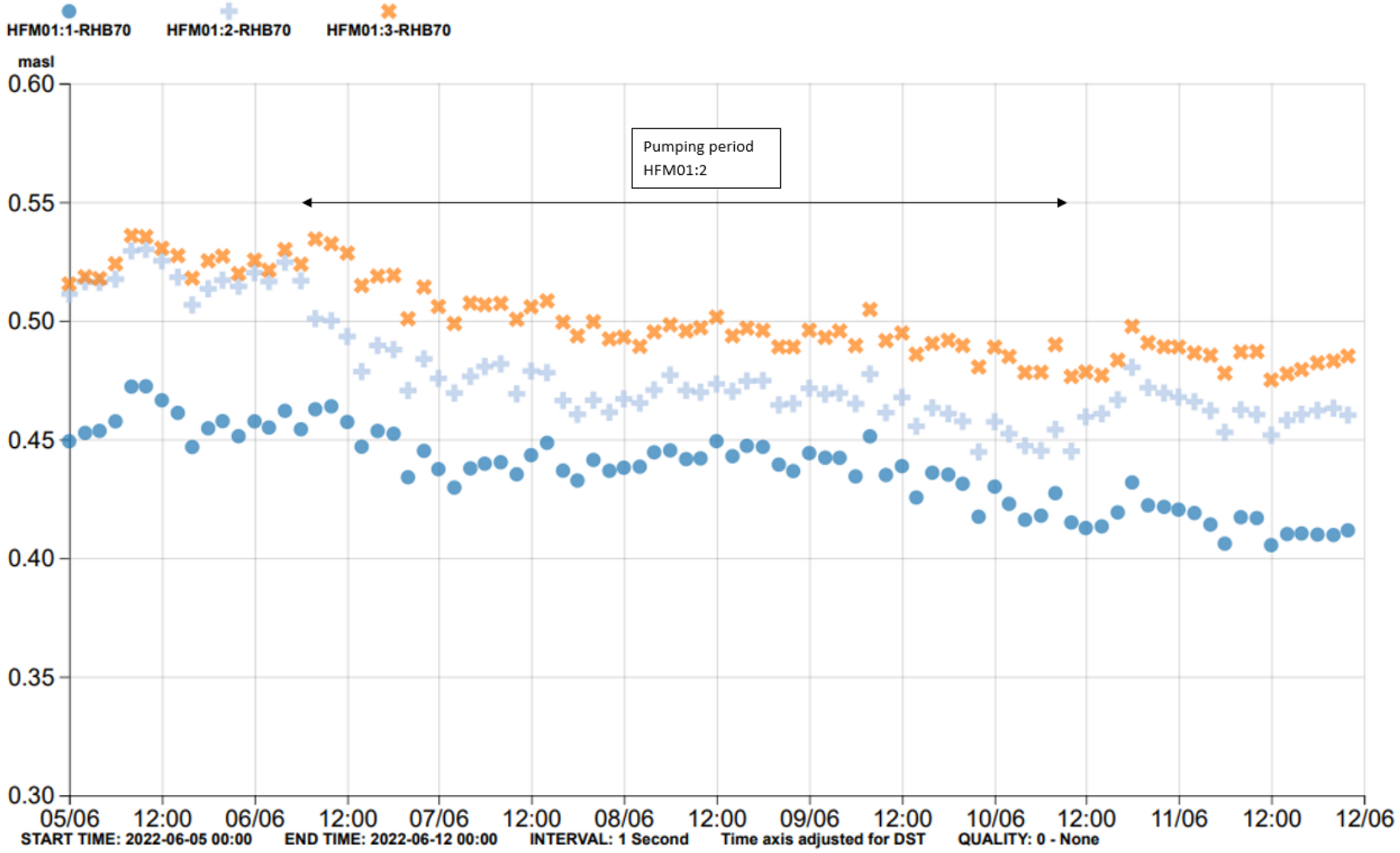

Figure A5-15. *Pumping and drawdown in HFM01:2 in June 2022. No (?) sections were significantly affected by the pumping.*

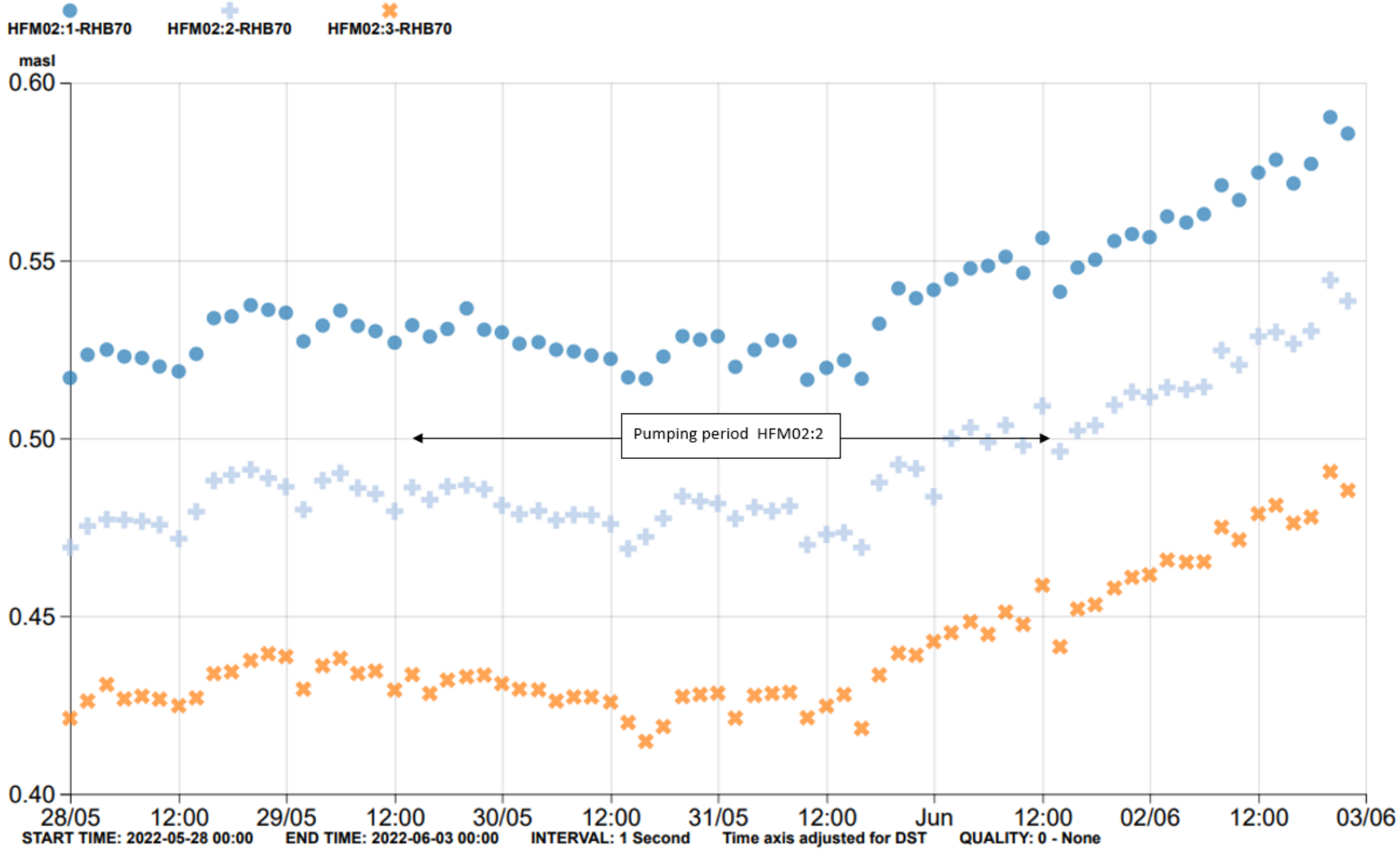

Figure A5-16. *Pumping in HFM02:2 in May and June 2022. No significant drawdown was observed in any of the borehole sections.*

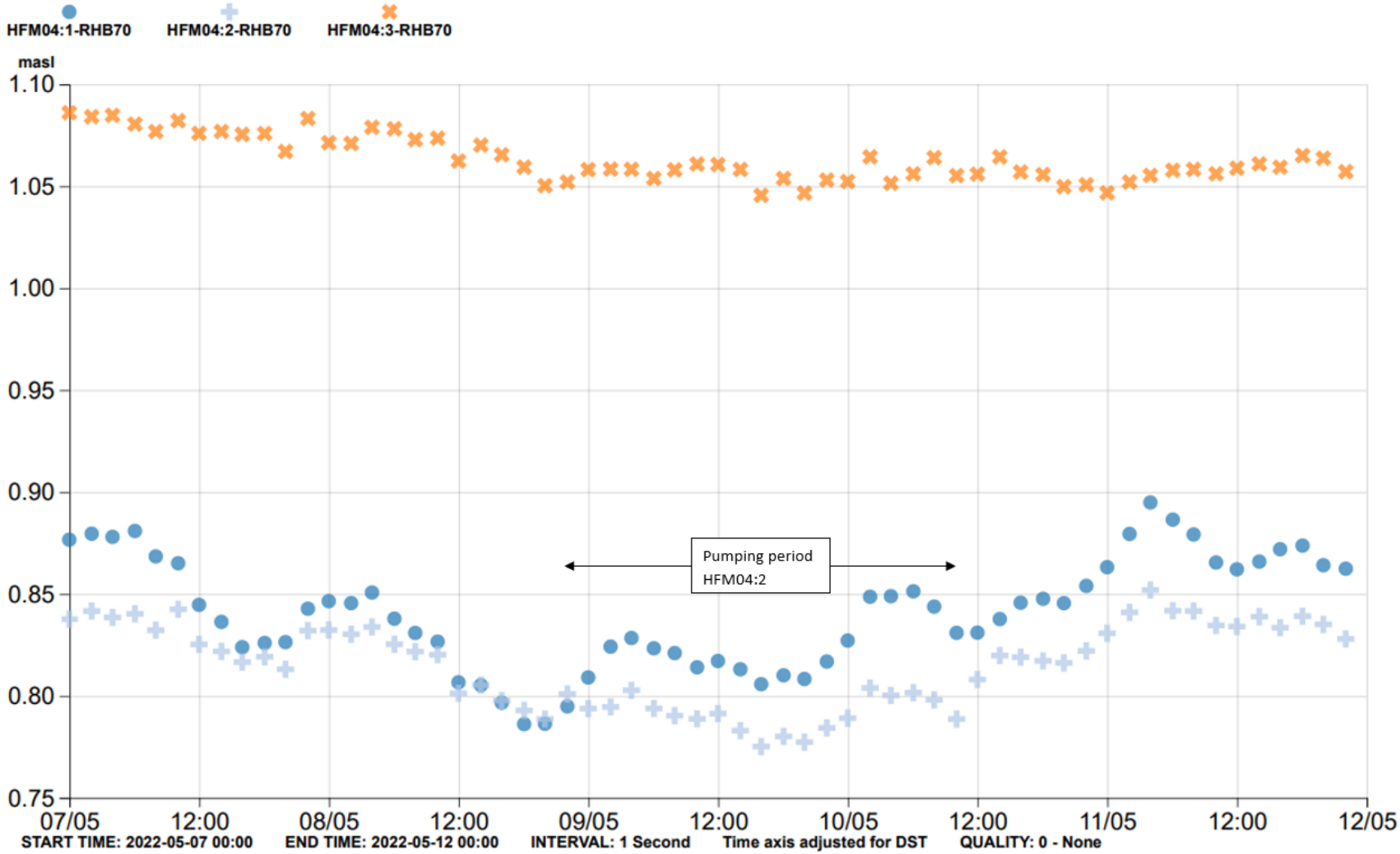

Figure A5-17. *Pumping in HFM04:2 in May 2022. No significant drawdown was observed in any of the borehole sections.*

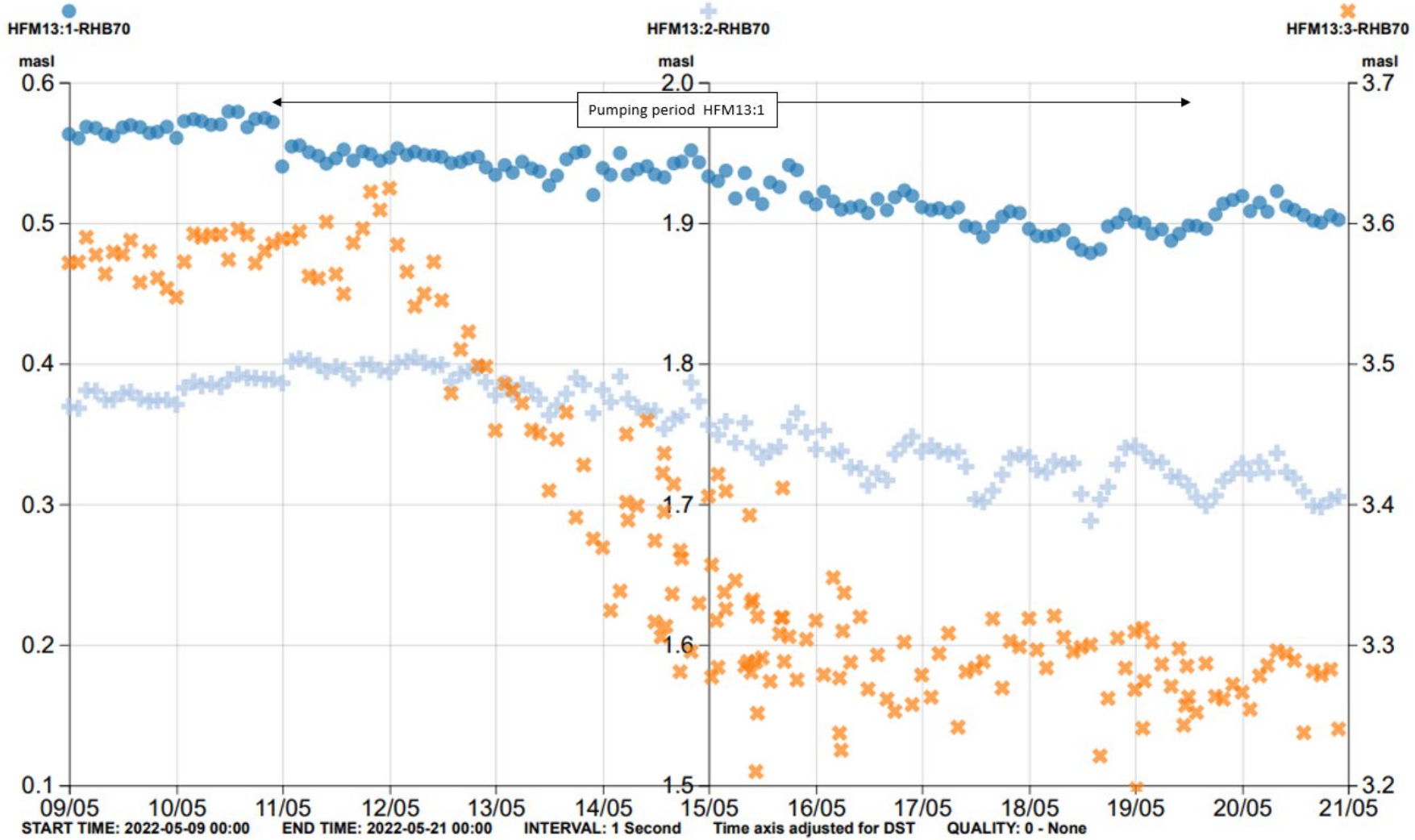

Figure A5-18. *Pumping in HFM13:1 in May 2022. No (?) sections were significantly affected by the pumping. Note the different scales for the respective borehole sections.*

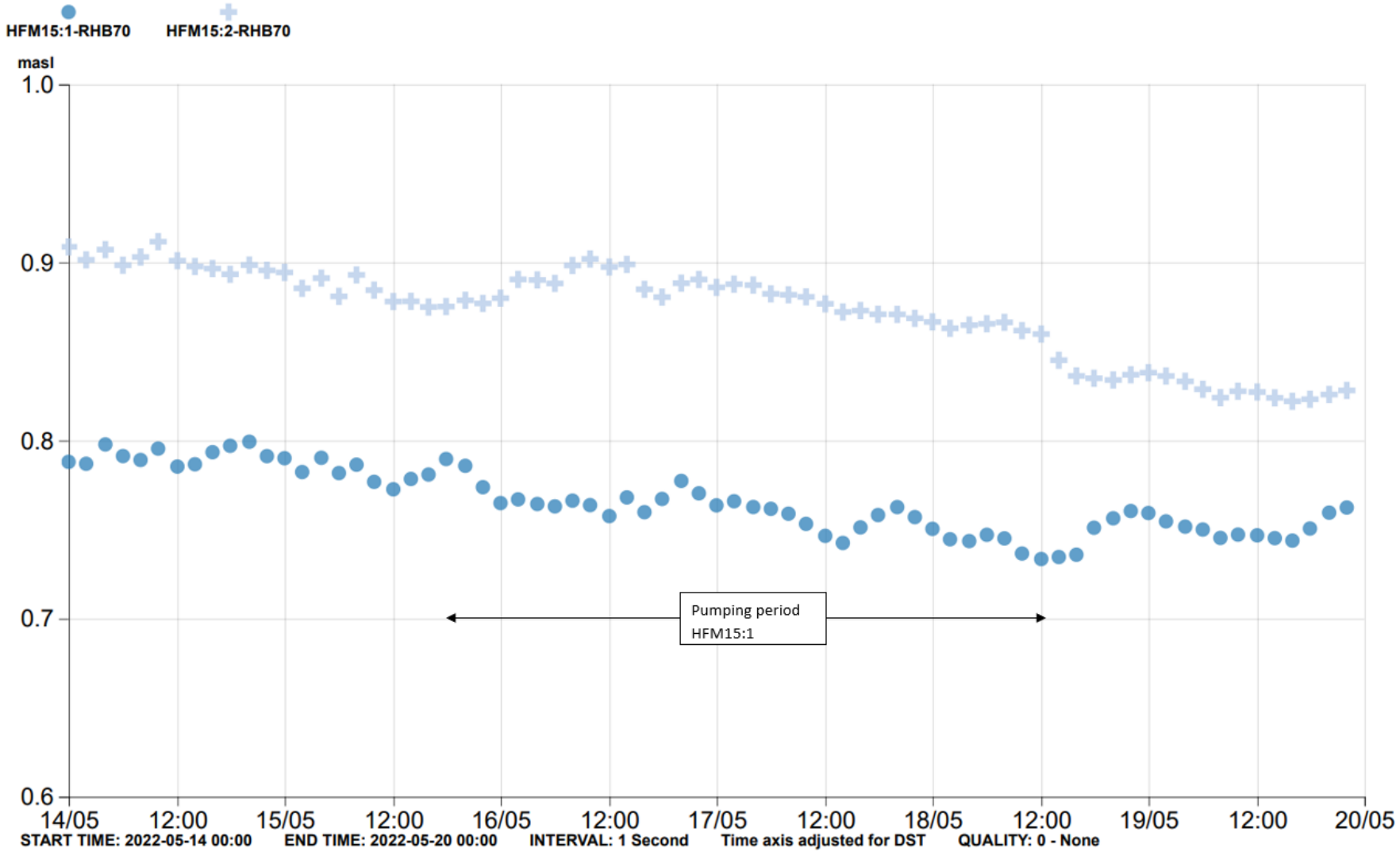

Figure A5-19. *Pumping in HFM15:1 during May 2022. No significant drawdown was observed in any of the borehole sections.*

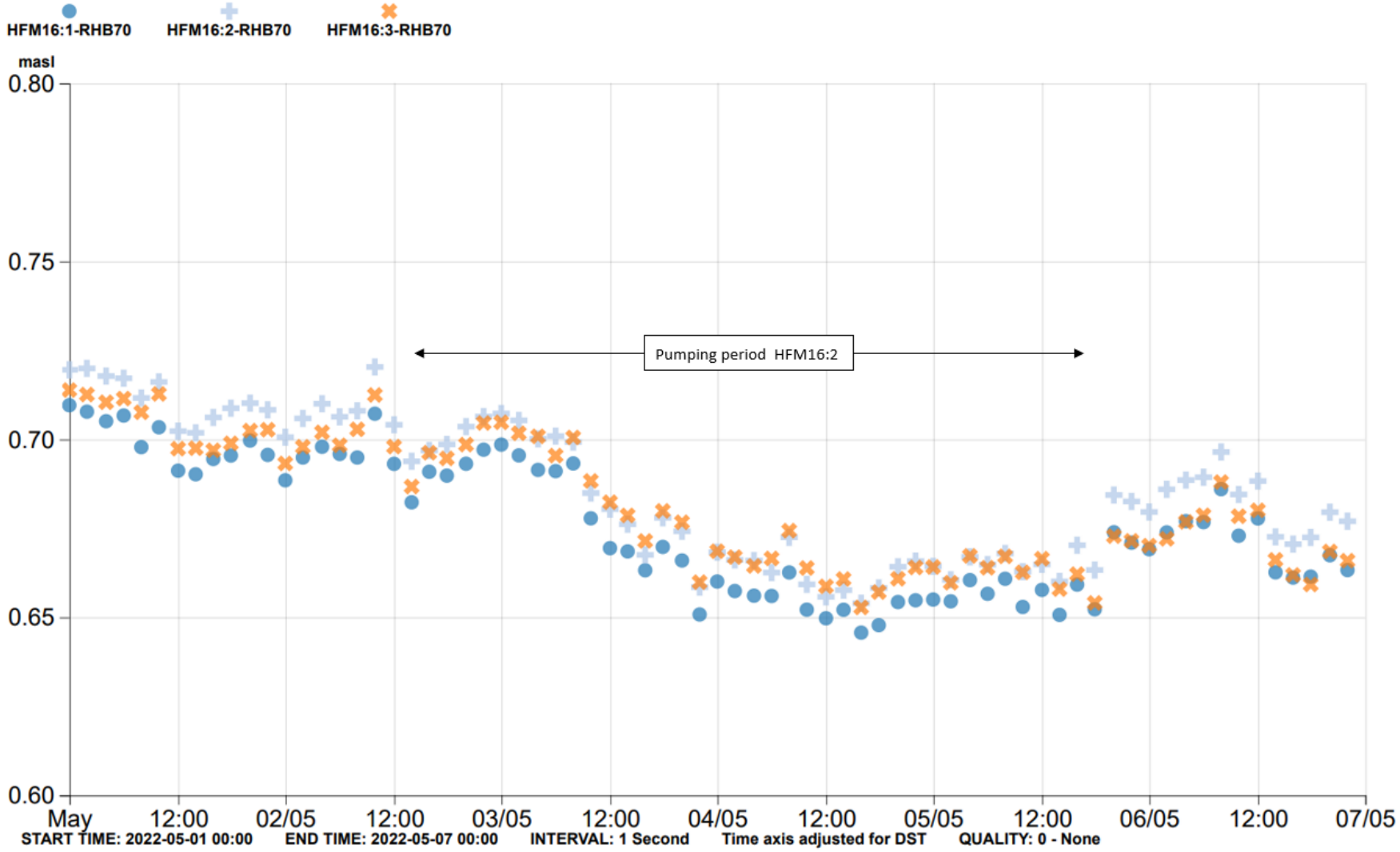

Figure A5-20. *Pumping in HFM16:2 in May 2022. No significant drawdown was observed in any of the borehole sections.*

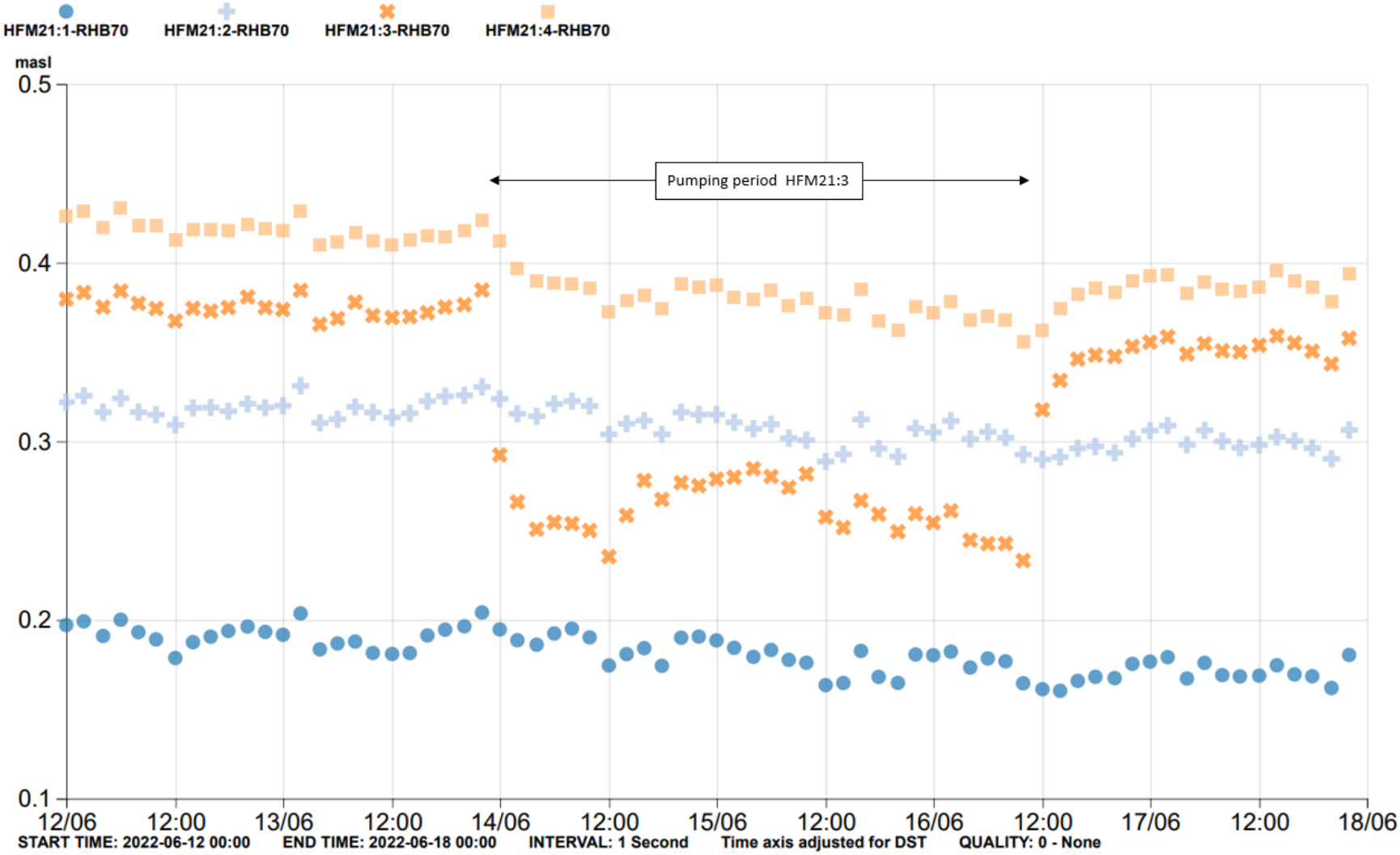

Figure A5-21. *Pumping in HFM21:3 in June 2022. A small drawdown was observed in HFM21:4.*

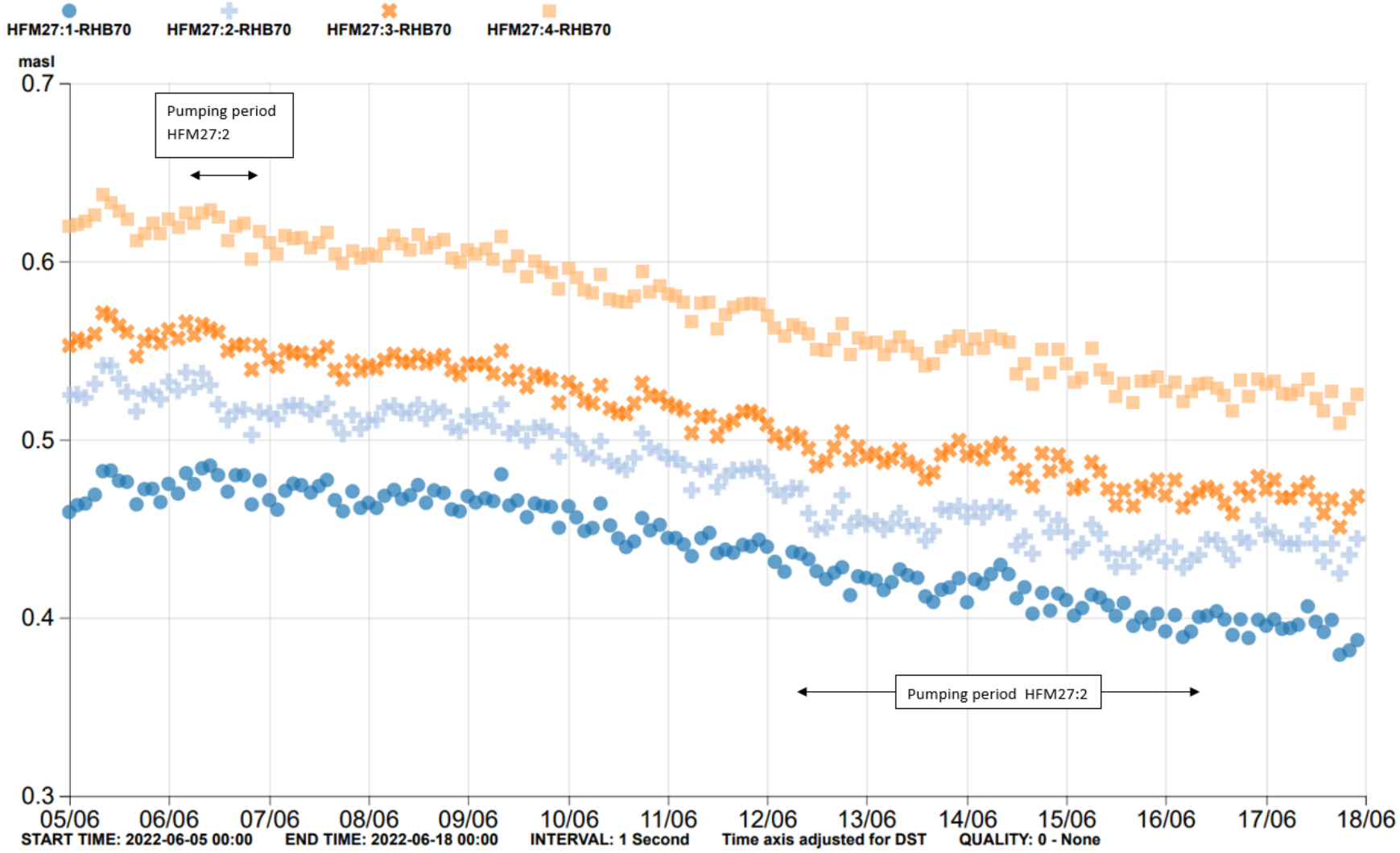

Figure A5-22. *Pumping in HFM27:2 in June 2022. No significant drawdown was observed in any of the borehole sections.*

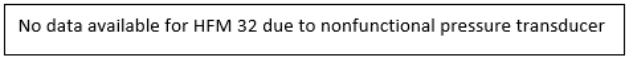

Figure A5-23. *No data is available for the pumping period in HFM32:3 due to non-functional pressure transducers.*

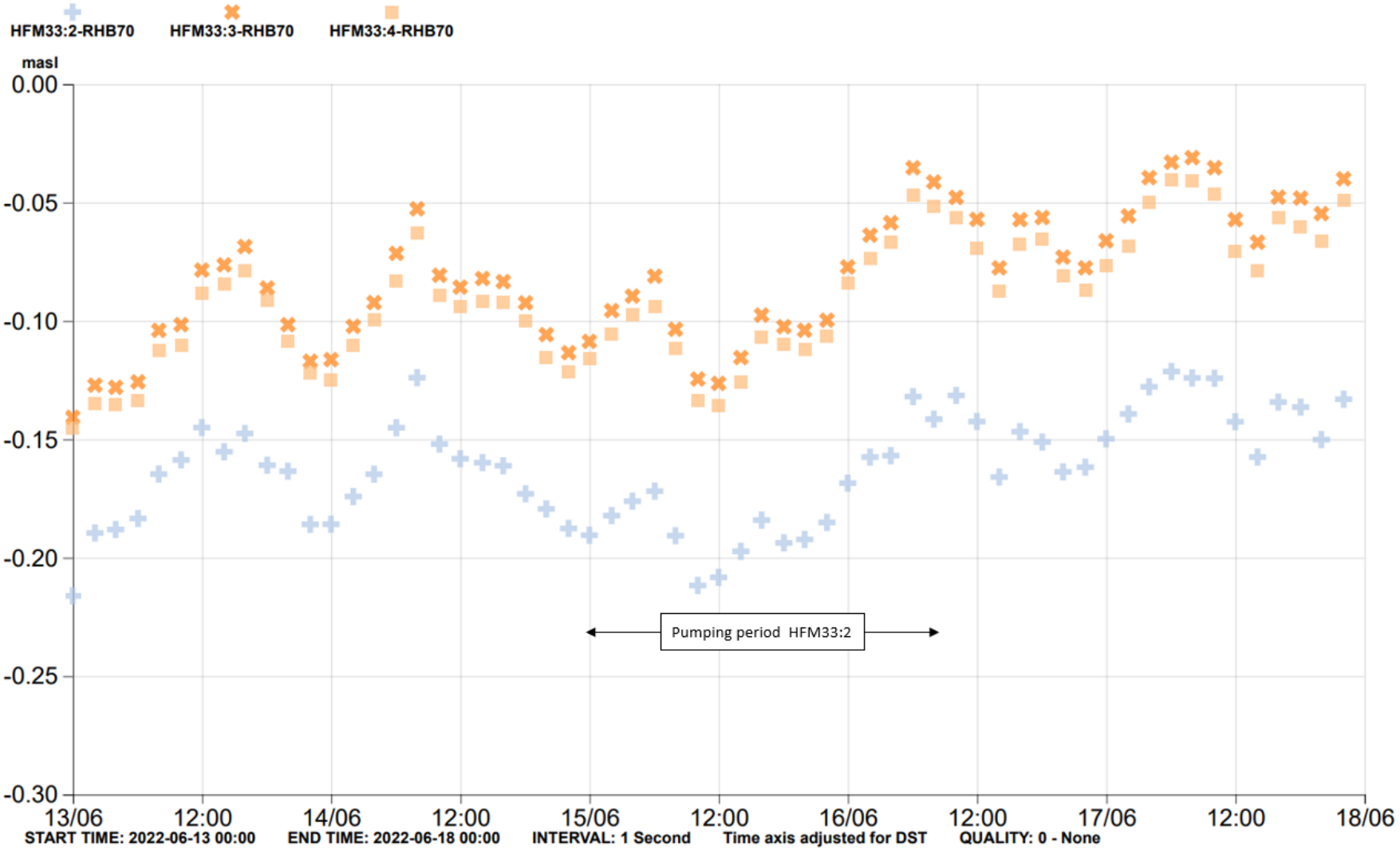

Figure A5-24*. Pumping in HFM33:2 in June 2022. No significant responses were observed.*

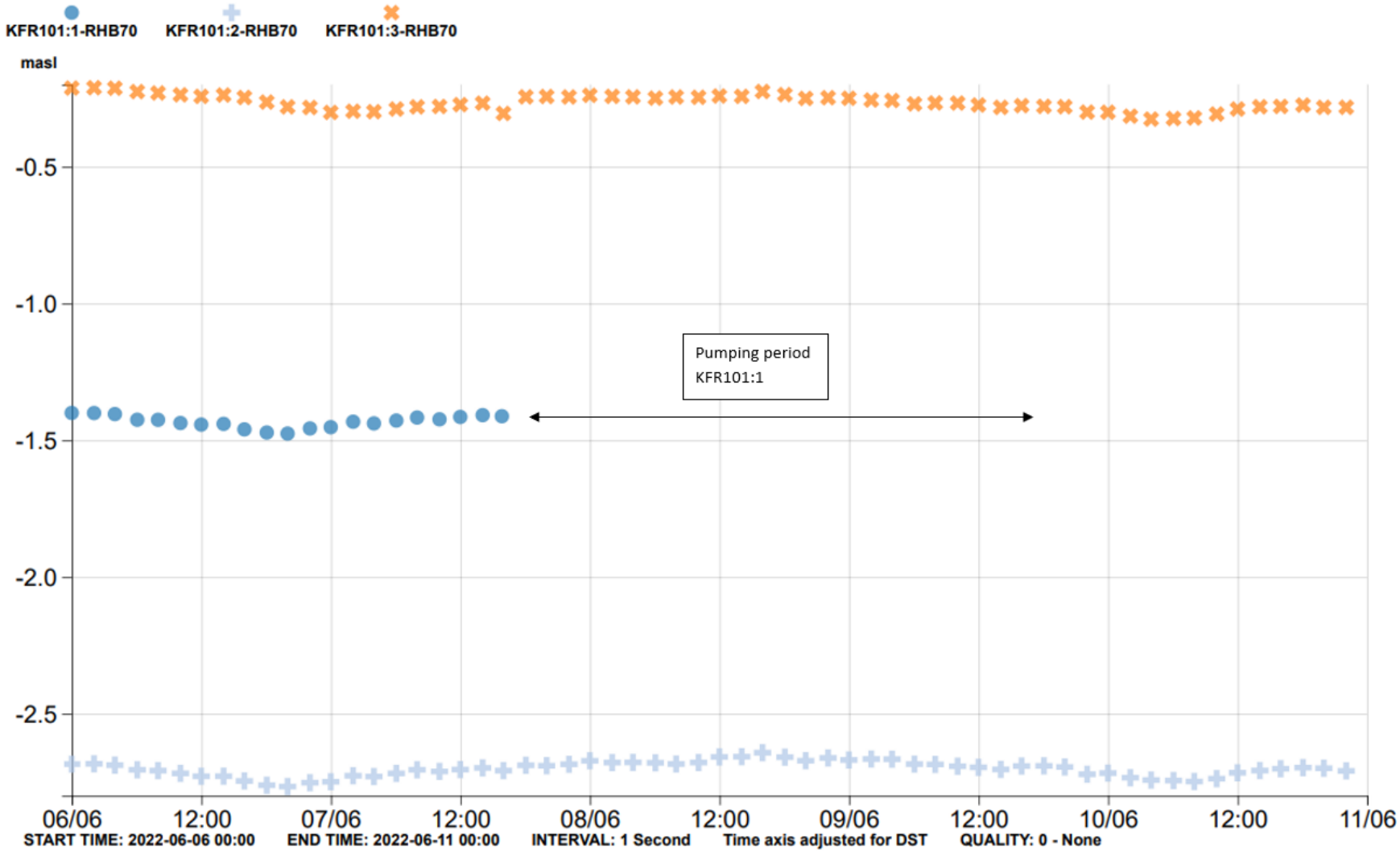

Figure A5-25. *Pumping in KFR101:1 in June 2022. The pressure transducer in KFR101:1 was removed during the pumping. No significant drawdown was noted in any other section.*

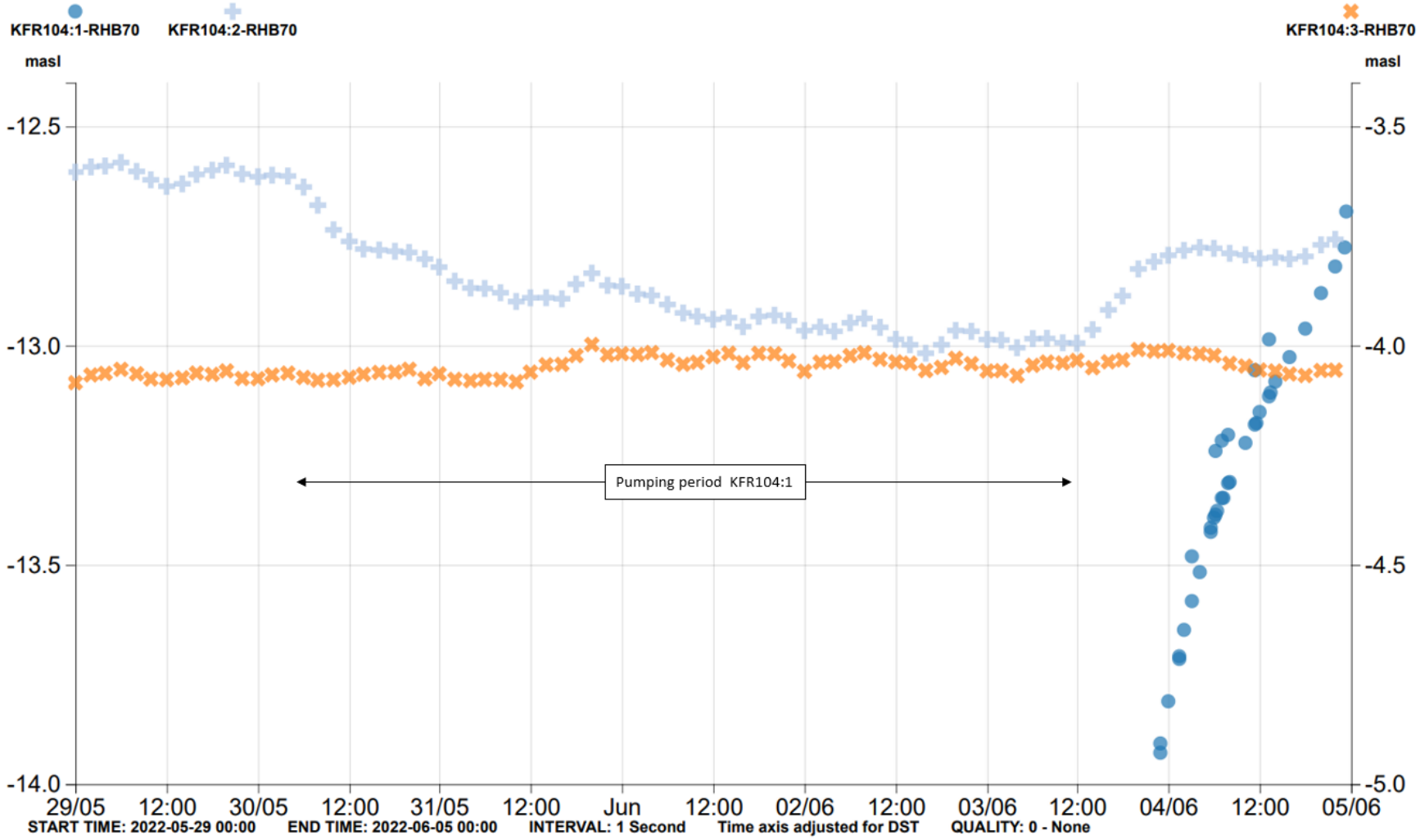

Figure A5-26. *Pumping in KFR104:1 in May and June 2022. The pressure transducer in KFR104:1 was removed during the pumping. A response can be seen in section KFR104:2. Note the different scales for the respective borehole sections.*

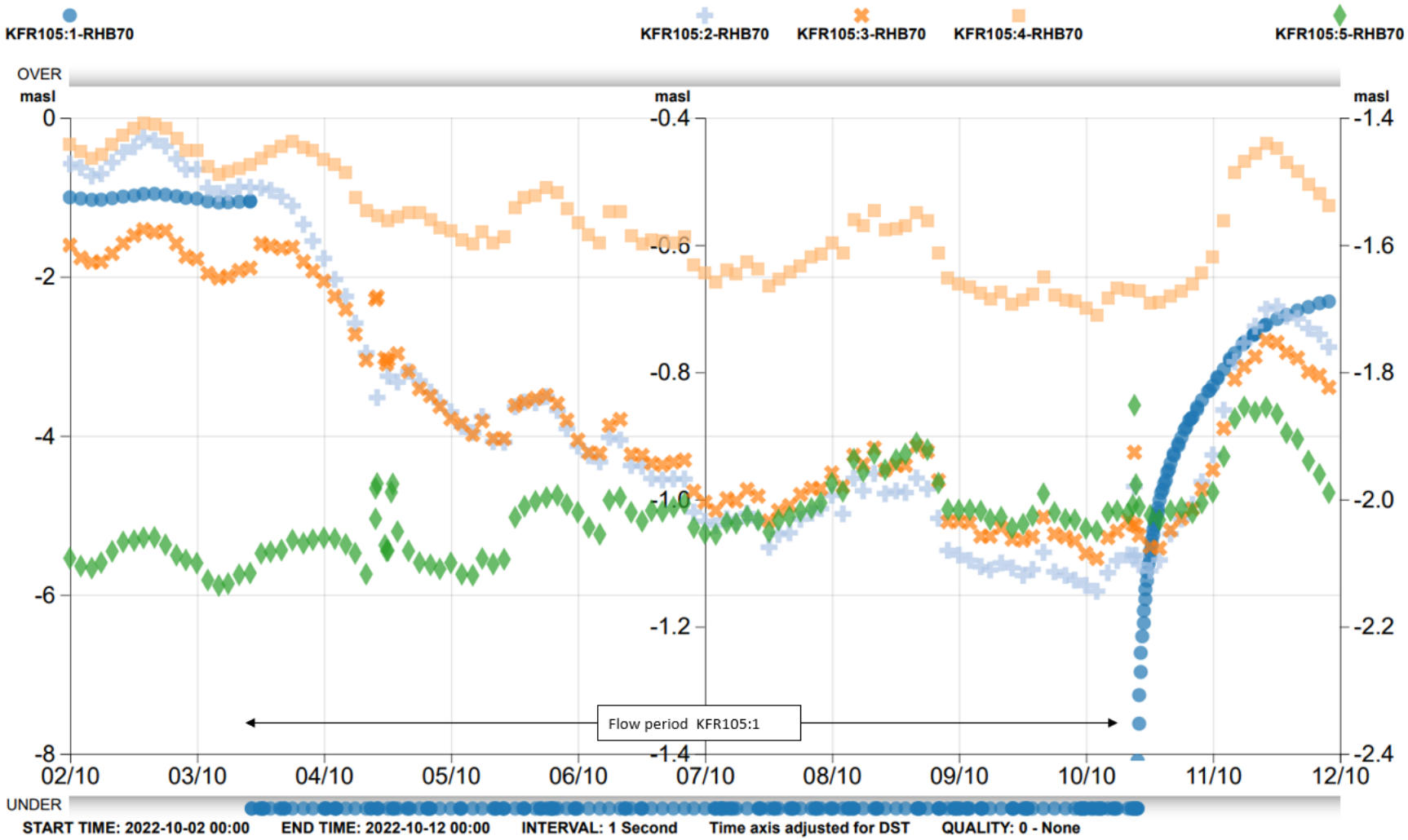

Figure A5-27. *Flow period in KFR105:1 in October 2022. The efflux in KFR105:1 caused responses in KFR105:2, KFR105:3 and KFR105:4. Note the different scales for the respective borehole sections.*

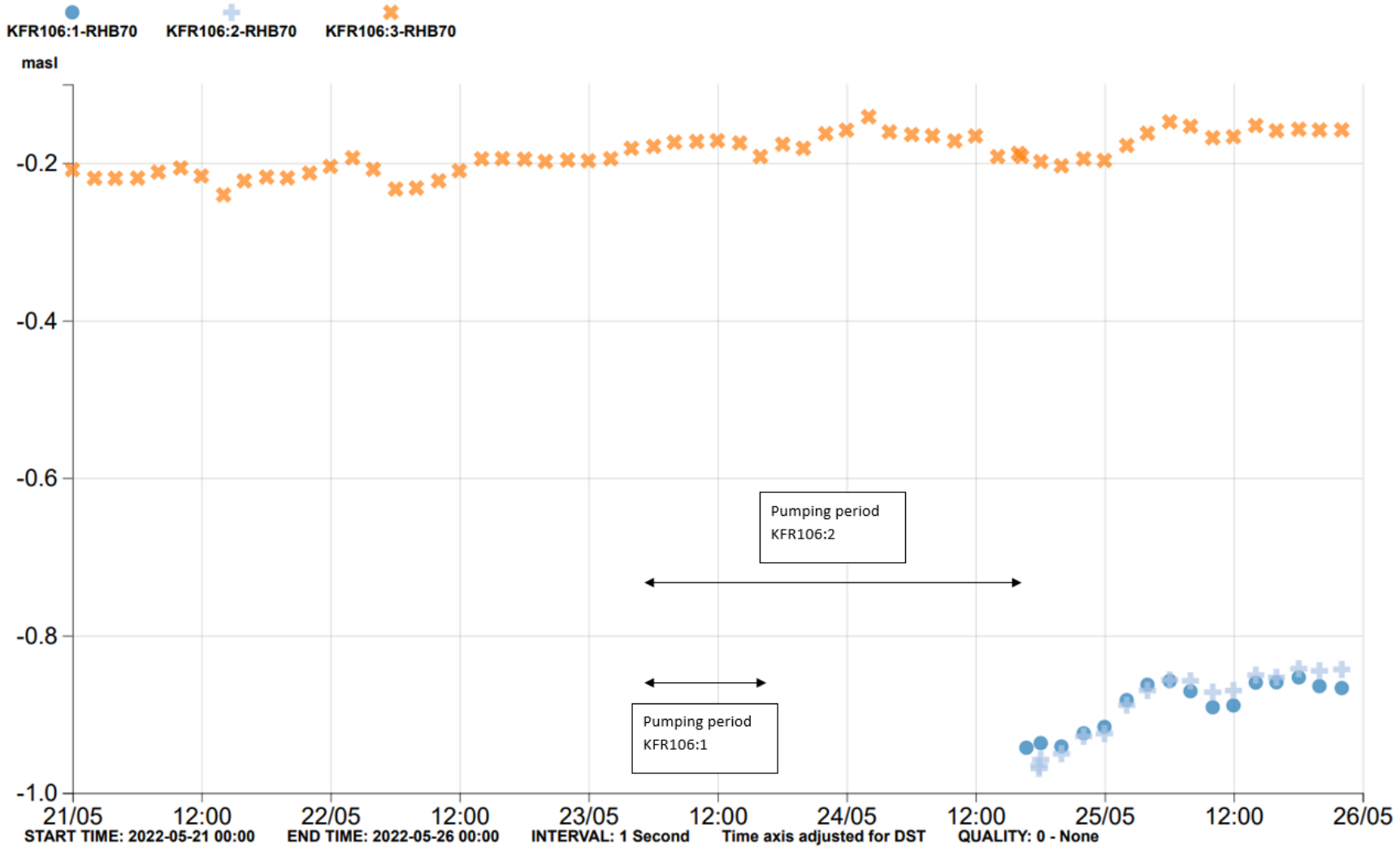

Figure A5-28. *Pumping in KFR106:1 and KFR106:2 in May 2022. The pressure transducers in the pumped sections were removed during the pumping. KFR106:3 was not affected.*

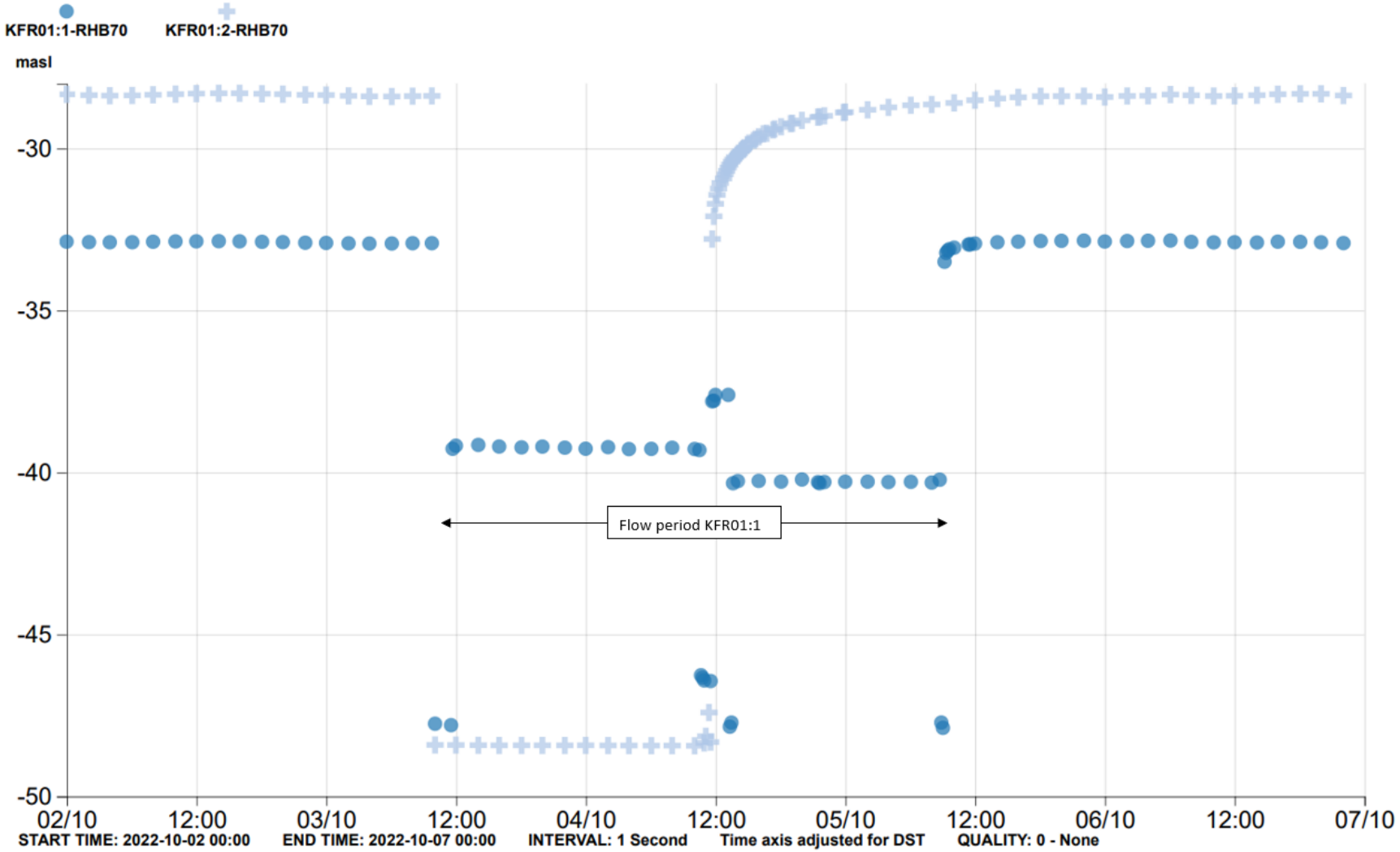

Figure A5-29. *Flow period in KFR01:1 in October 2022. The response in KFR01:2 was affected due to the valve to the section being open 3/10-4/10 in another sampling campaign.*

Appendix 6

pH trends in some of the core drilled boreholes

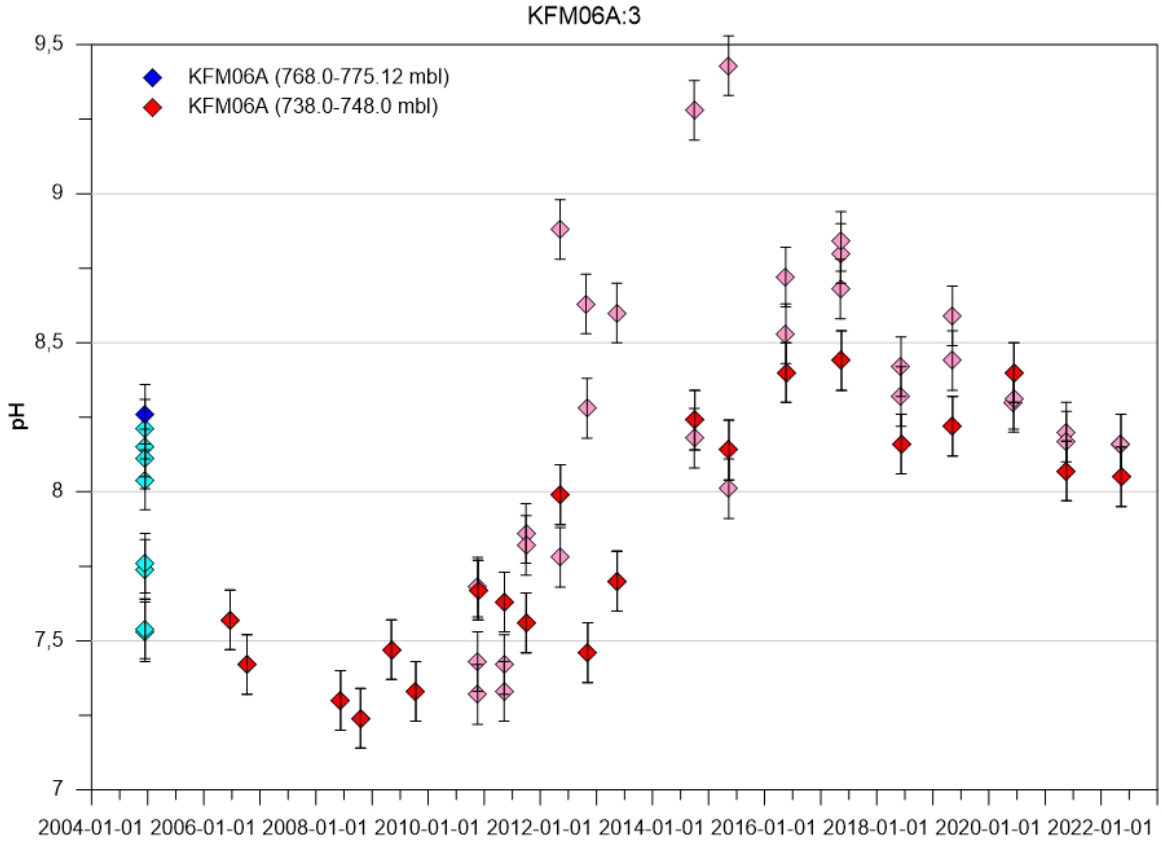

Figure A6-1. *Comparison between initial pH-values from complete chemical characterisation during PLU (Forsmark site investigation; blue diamonds) and later measurements in the ongoing monitoring programme (red diamonds) for KFM06A:3. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 which are from field measurements.*

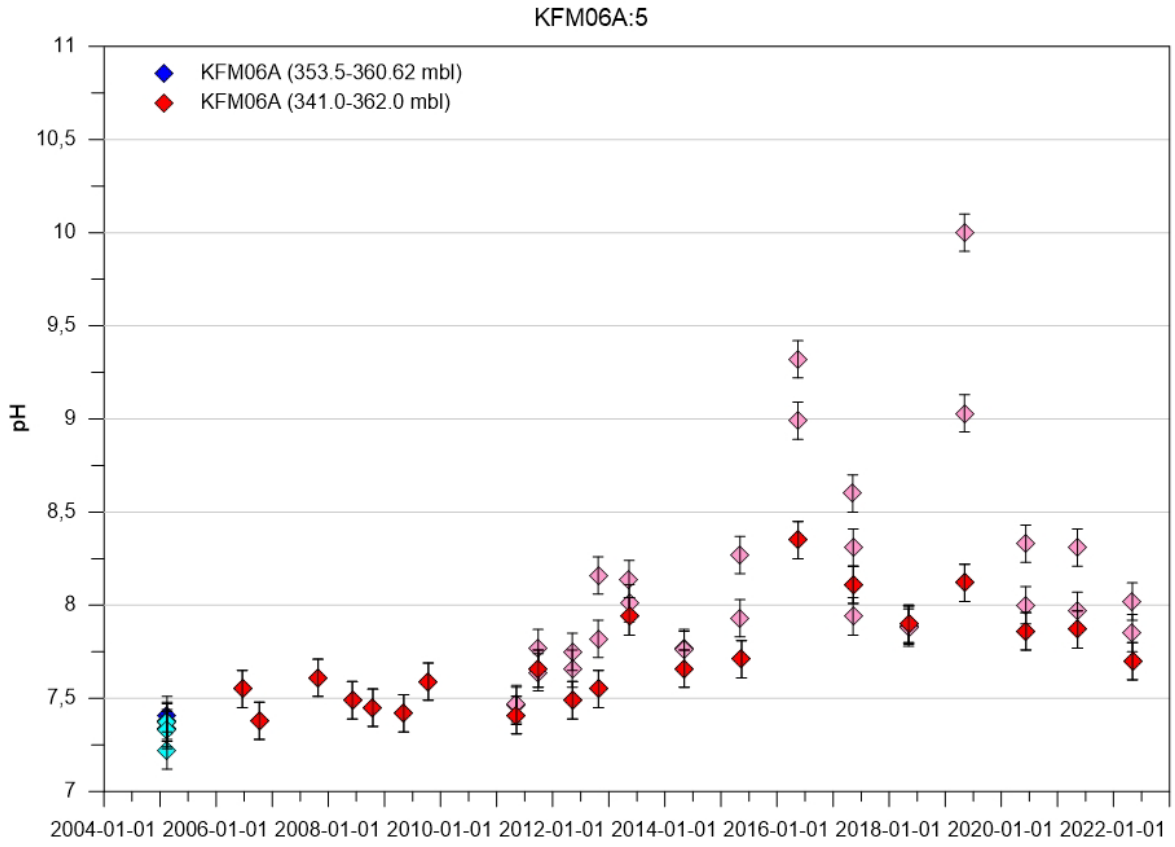

Figure A6-2. *Comparison between initial pH-values from complete chemical characterisation during PLU (blue diamonds) and later measurements in the ongoing monitoring programme (red diamonds) for KFM06A:5. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 which are from field measurements.*

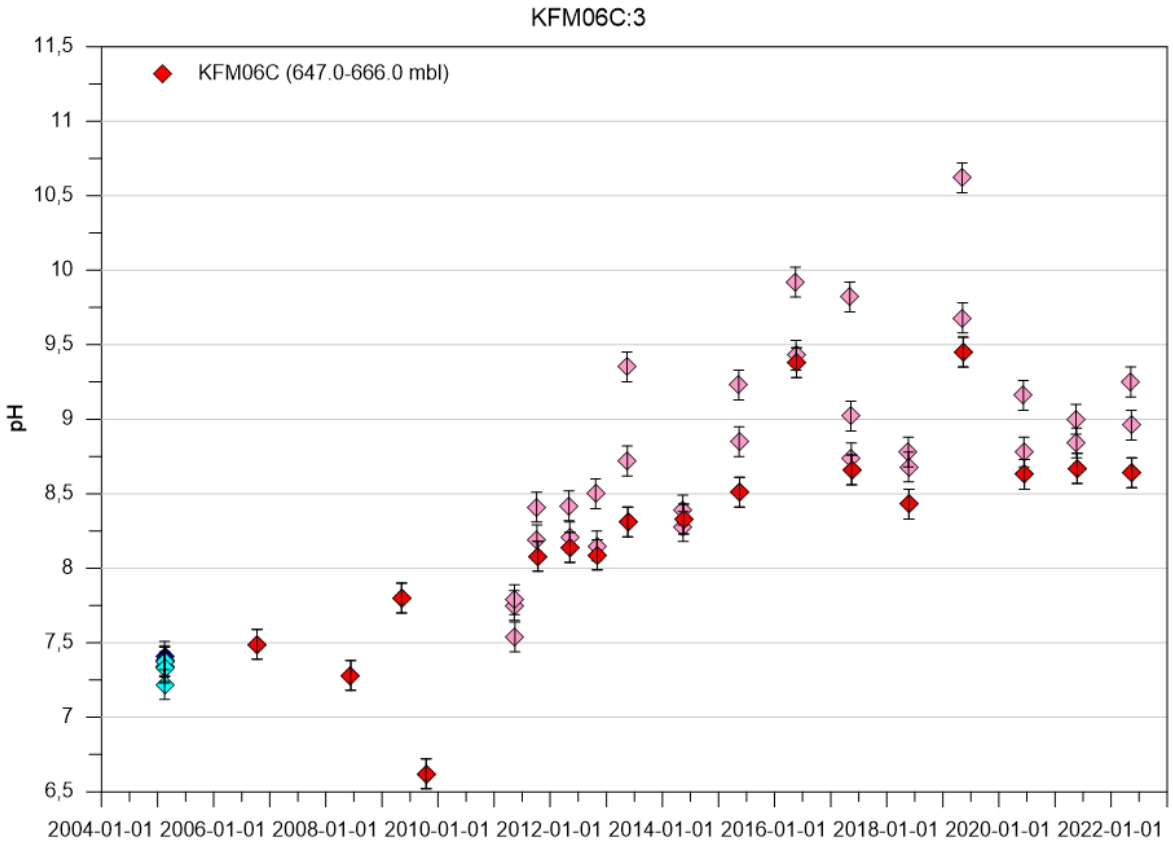

Figure A6-3. *Measurements of pH-values from the ongoing monitoring programme (red diamonds) for KFM06C:3. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 and the last sample from 2015 which are from field measurements.*

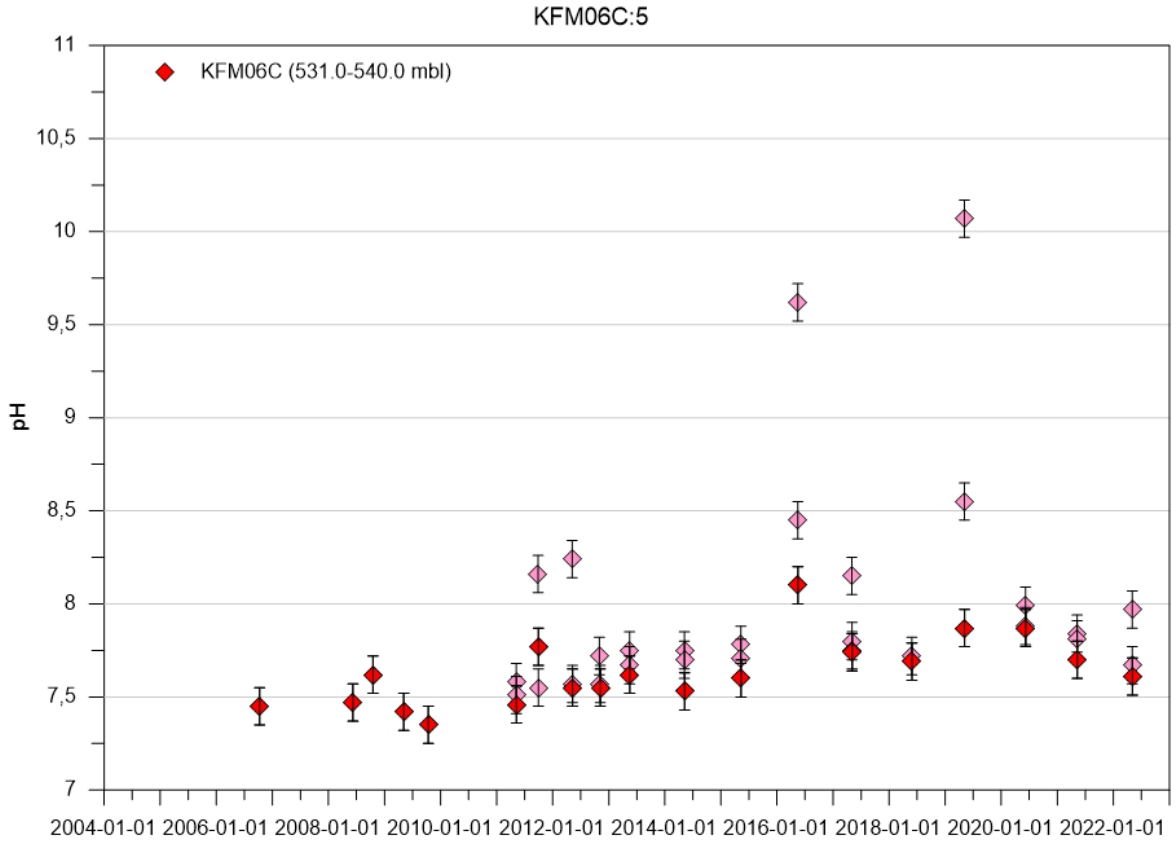

Figure A6-4. *Measurements of pH-values from the ongoing monitoring programme (red diamonds) for KFM06C:5. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 which are from field measurements.*

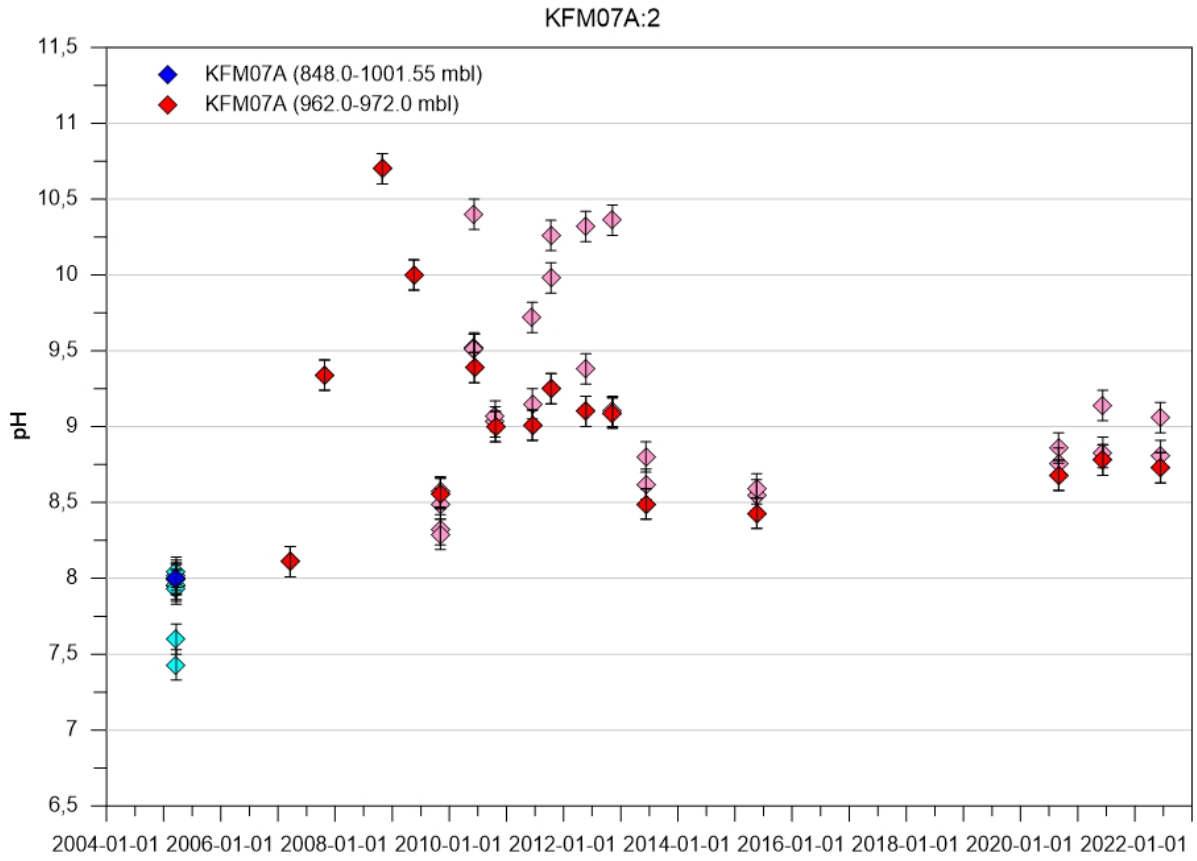

Figure A6-5. *Comparison between initial pH-values from complete chemical characterisation during PLU (blue diamonds) and later measurements in the ongoing monitoring programme (red diamonds) for KFM07A:2. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 which are from field measurements.*

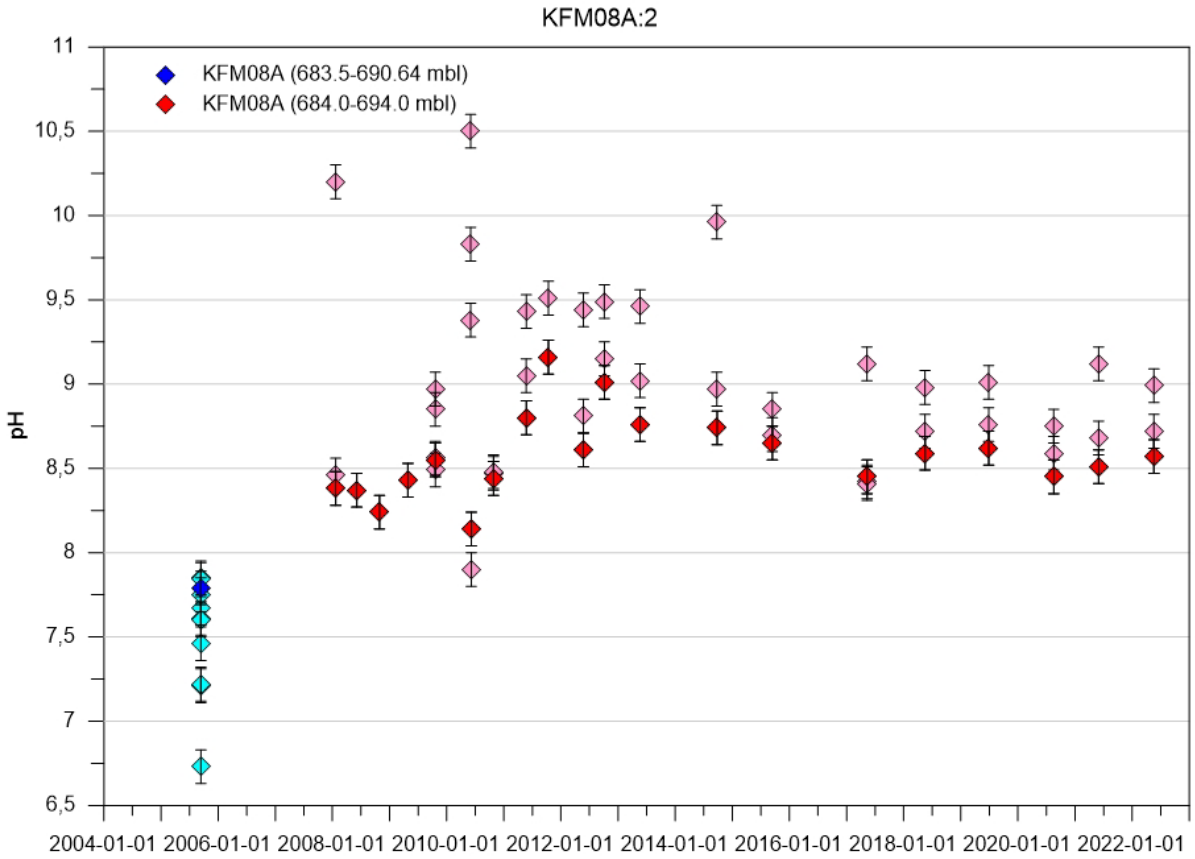

Figure A6-6. *Comparison between initial pH-values from complete chemical characterisation during PLU (blue diamonds) and later measurements in the ongoing monitoring programme (red diamonds) for KFM08A:2. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 which are from field measurements.*

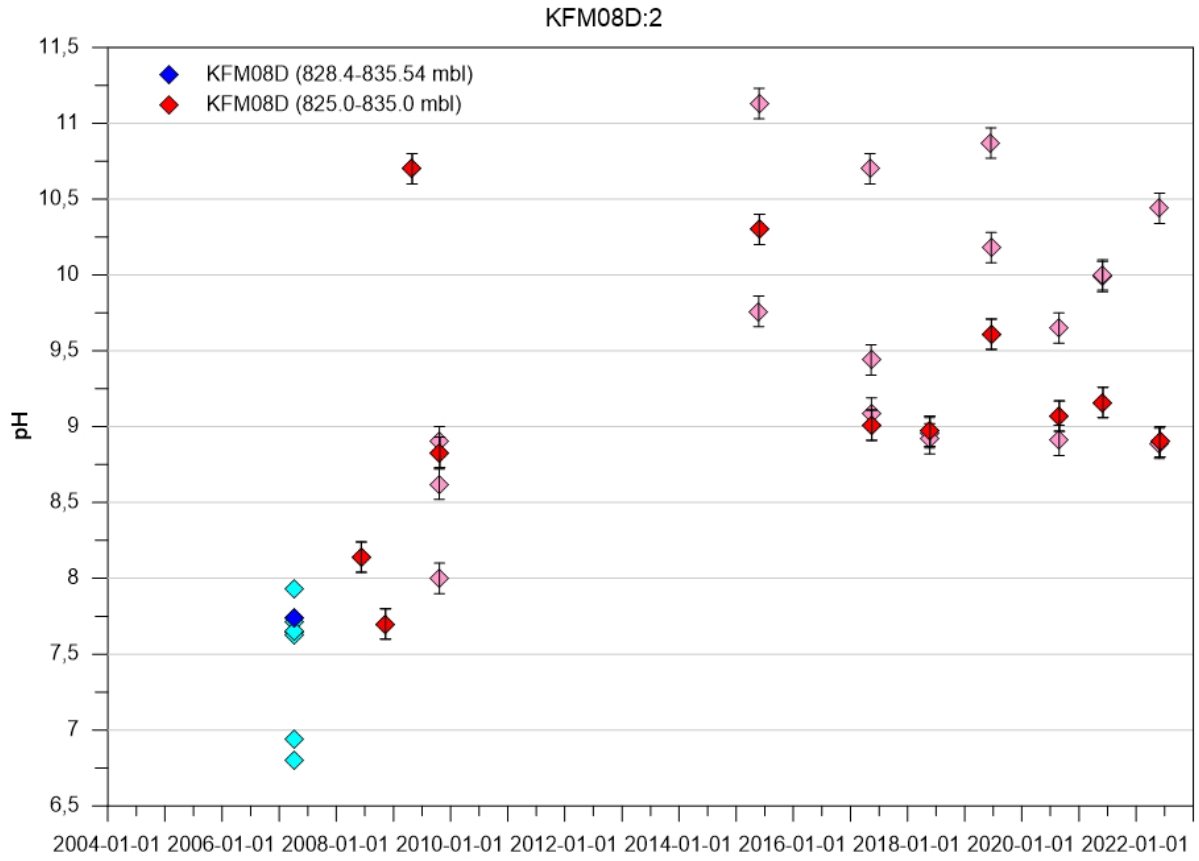

Figure A6-7. *Comparison between initial pH-values from complete chemical characterisation during PLU (blue diamonds) and later measurements in the ongoing monitoring programme (red diamonds) for KFM08D:2. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C. This section has been omitted from the monitoring program for many years due to corrosion problems. After reinstallation of borehole equipment it was sampled again from 2015 and onwards.*

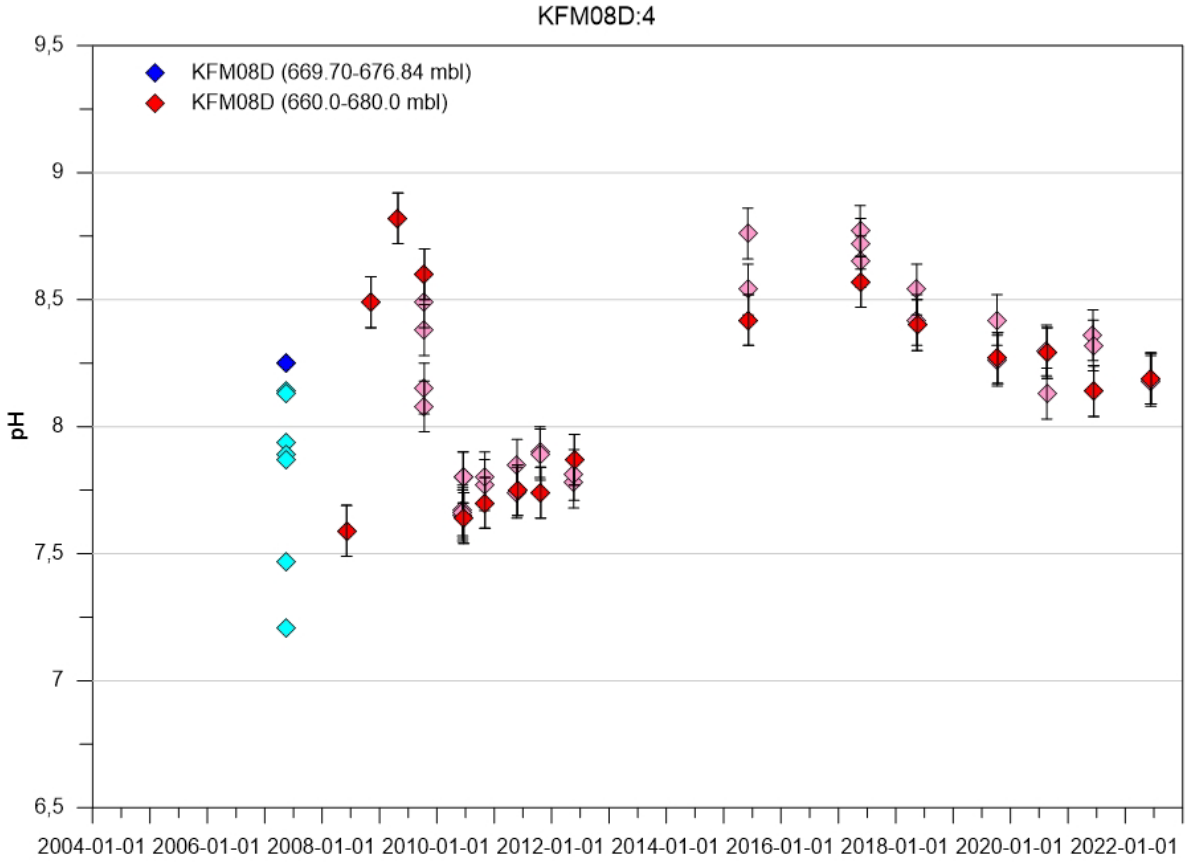

Figure A6-8. *Comparison between initial pH-values from complete chemical characterisation during PLU (blue diamonds) and later measurements in the ongoing monitoring programme (red diamonds) for KFM08D:4. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C. This section has been omitted from the monitoring program for 2013-2014 due to corrosion problems. After reinstallation of borehole equipment it was sampled again from 2015 and onwards.*

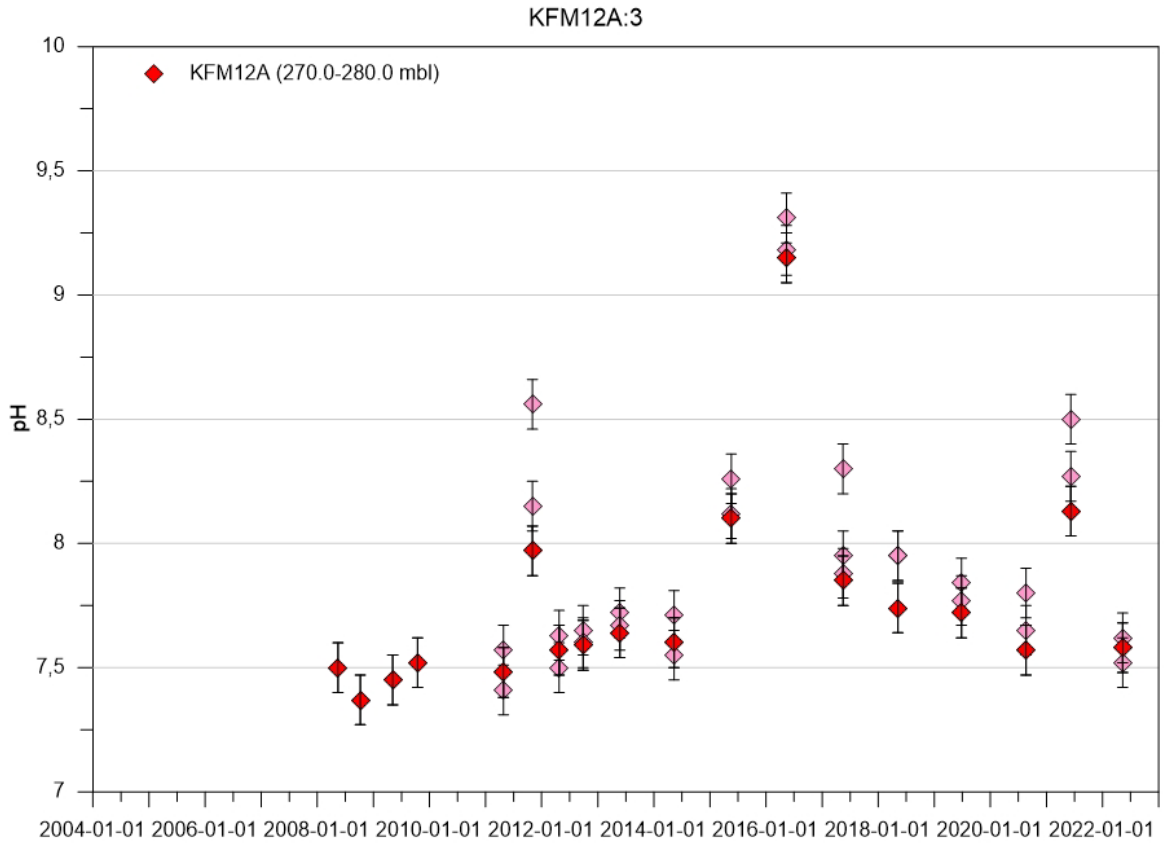

Figure A6-9. *Measurements of pH-values from the ongoing monitoring programme (red diamonds) for KFM12A:3. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 and 2015 which are from field measurements.*

Appendix 7

Chloride trends in some of the core drilled boreholes

Figure A7-1 to Figure A7-8 present chloride concentrations in collected samples from hydrogeochemical monitoring 2022 together with data from hydrogeochemical monitoring earlier years. The analytical uncertainty (± 5%) is shown as error bars in the diagrams. For some of the core drilled boreholes, data from the initial complete chemical characterisation (CCC) in corresponding borehole sections (Lindquist et al. 2011, SKB Database Sicada) are also presented. The CCC data are shown as dots on the y-axes (not corresponding to date on the x-axis). In the cases of sample series (after October 2009 and onwards), the value from the last sample in the series is presented in the diagrams. For boreholes included in the SFR Extension Project, the hydrogeochemical monitoring program started in 2012, but the diagrams of chloride concentrations (Figure A7-6 f), Figure A7-7 and Figure A7-8 c) also include data from earlier studies. Results from KFR02:2, KFR02:3 and KFR02:4, shown in Figures A7-7 and A7-8 do not include data from earlier studies. Results from HFM19:1, seen in Figure A7-5 f), not sampled during the 2021-2022 campaign, is included in the presentation.

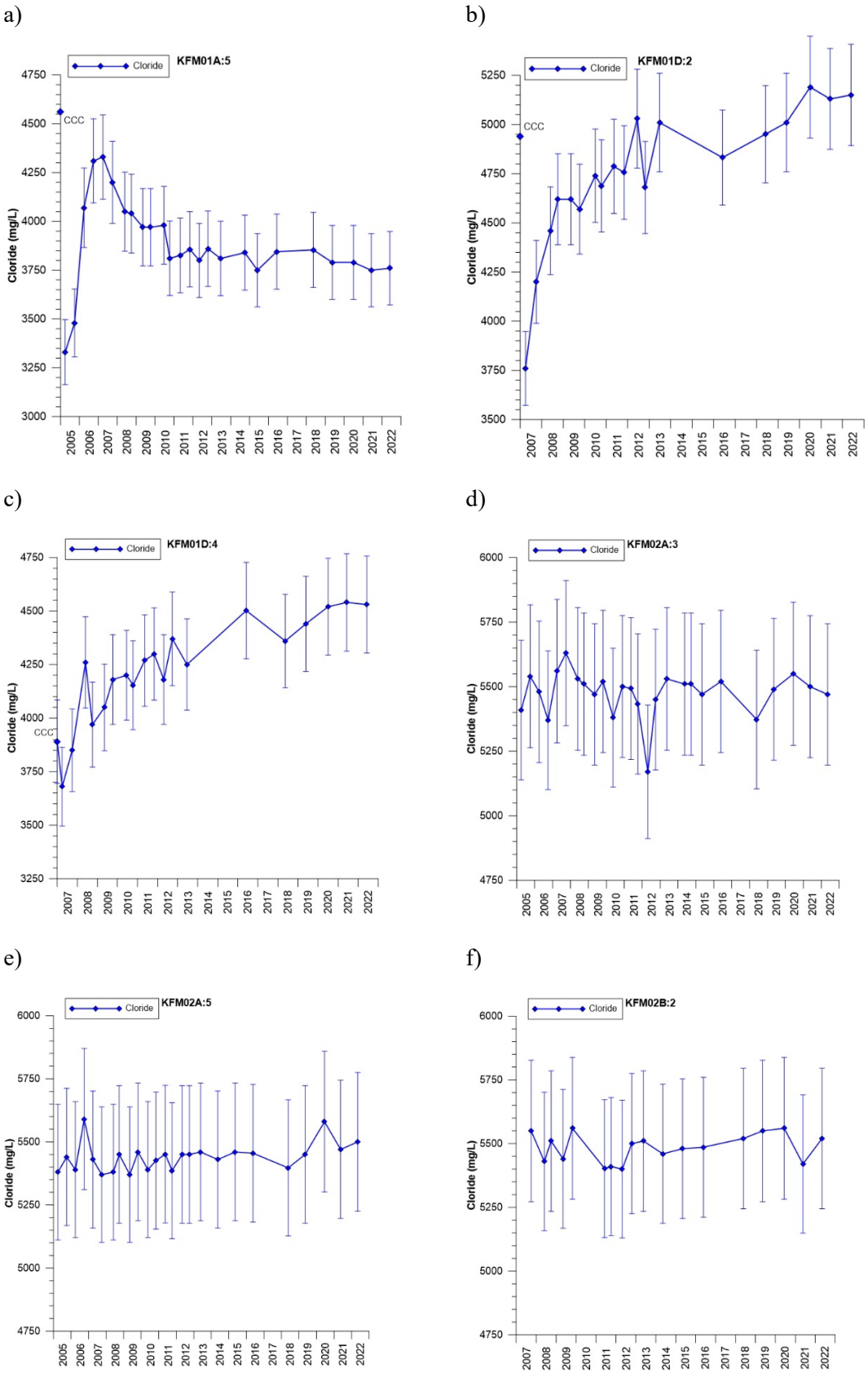

***Figure A7-1**. Chloride concentrations in collected samples from hydrogeochemical monitoring 2005 to 2022 and from the initial complete chemical characterisation (CCC). The data points for CCC are placed on the y-axes with no correlation to date on x-axis.*

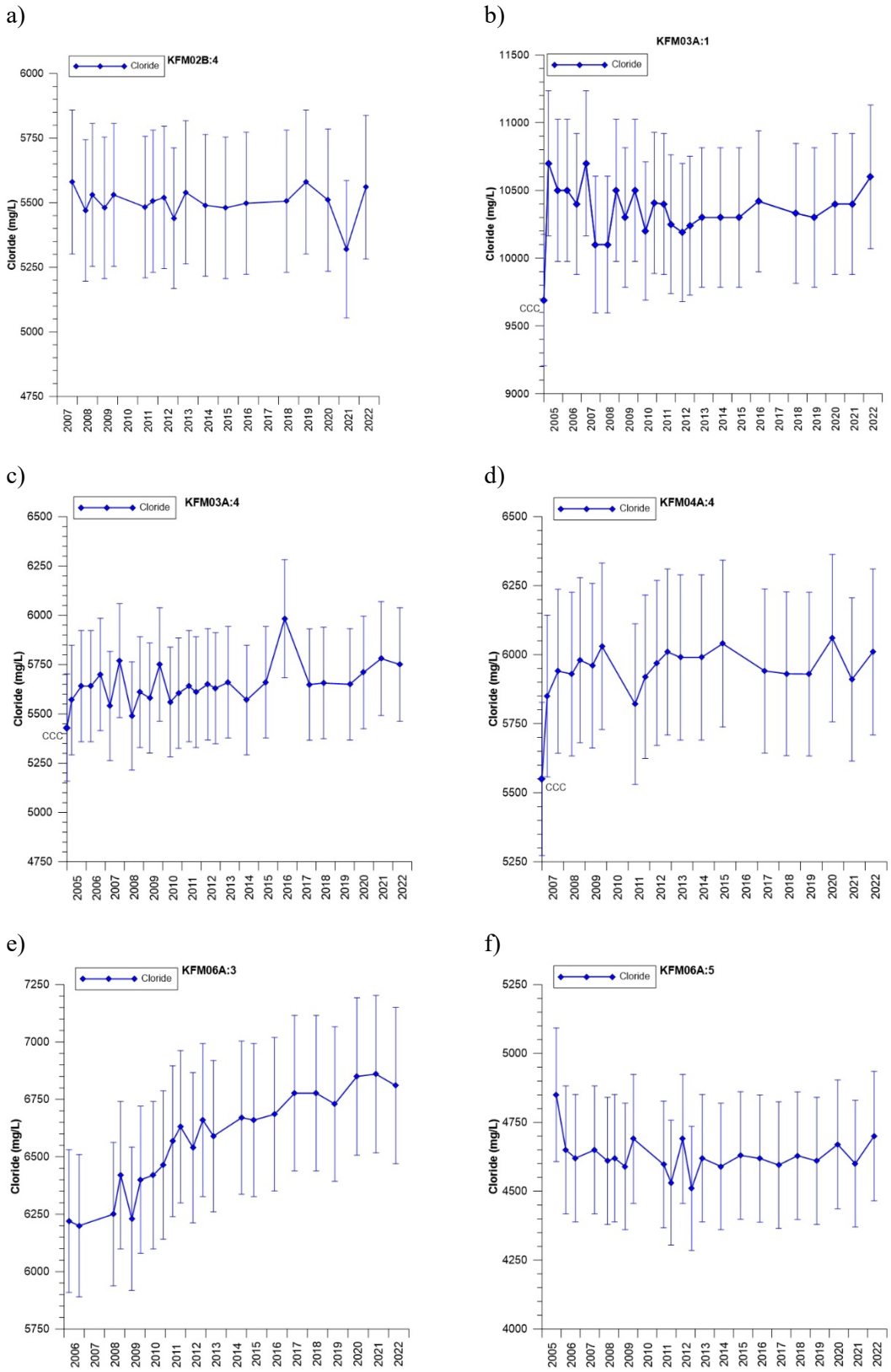

Figure A7-2. *Chloride concentrations in collected samples from hydrogeochemical monitoring 2005 to 2022 and from the initial complete chemical characterisation (CCC). The points for CCC are placed on the y-axes with no correlation to date on x-axis.*

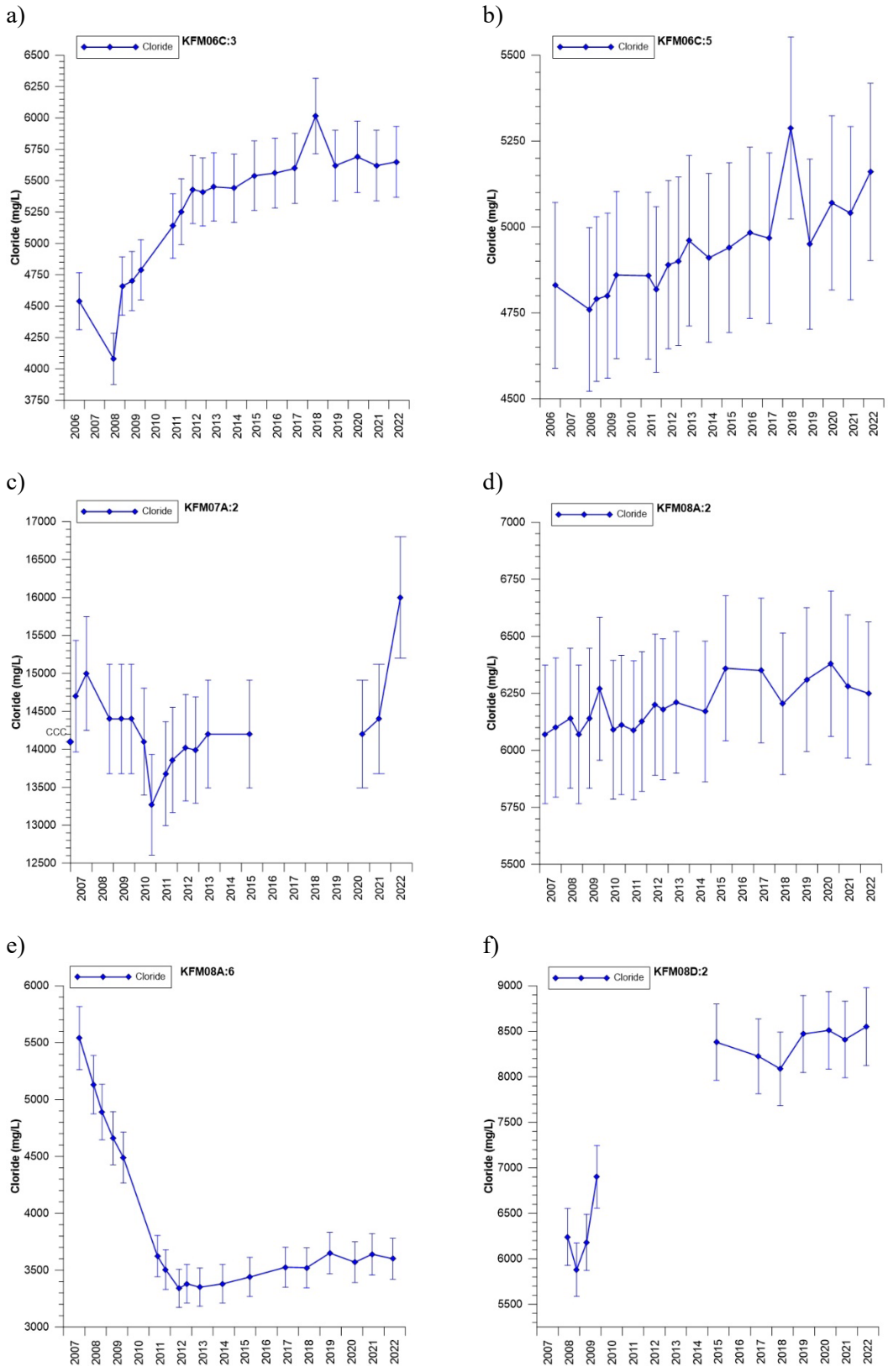

Figure A7-3. *Chloride concentrations in collected samples from hydrogeochemical monitoring 2006 to 2022 and from the initial complete chemical characterisation (CCC). The points for CCC are placed on the y-axes with no correlation to date on x-axis.*

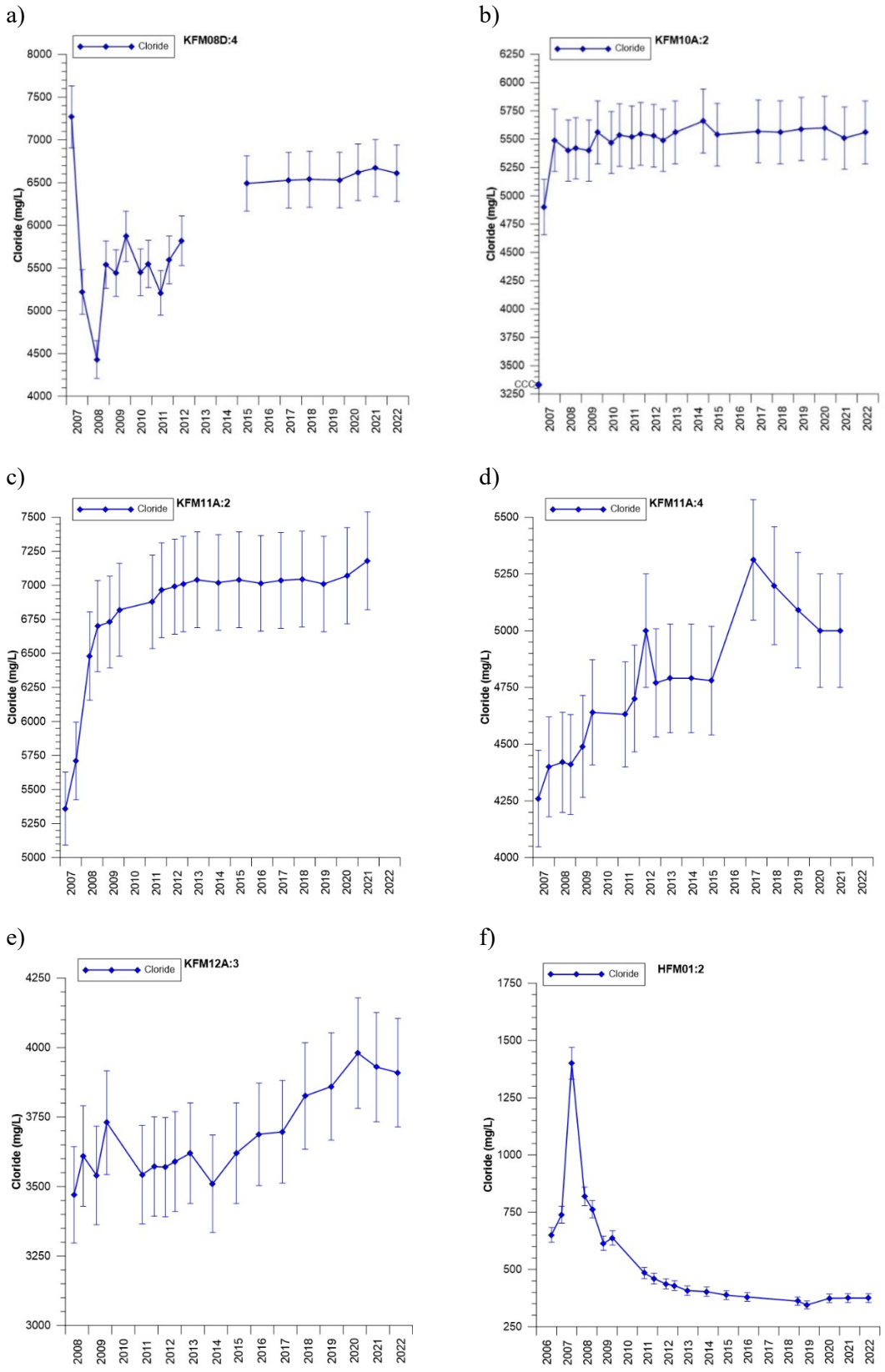

Figure A7-4*. Chloride concentrations in collected samples from hydrogeochemical monitoring 2006 to 2022.*

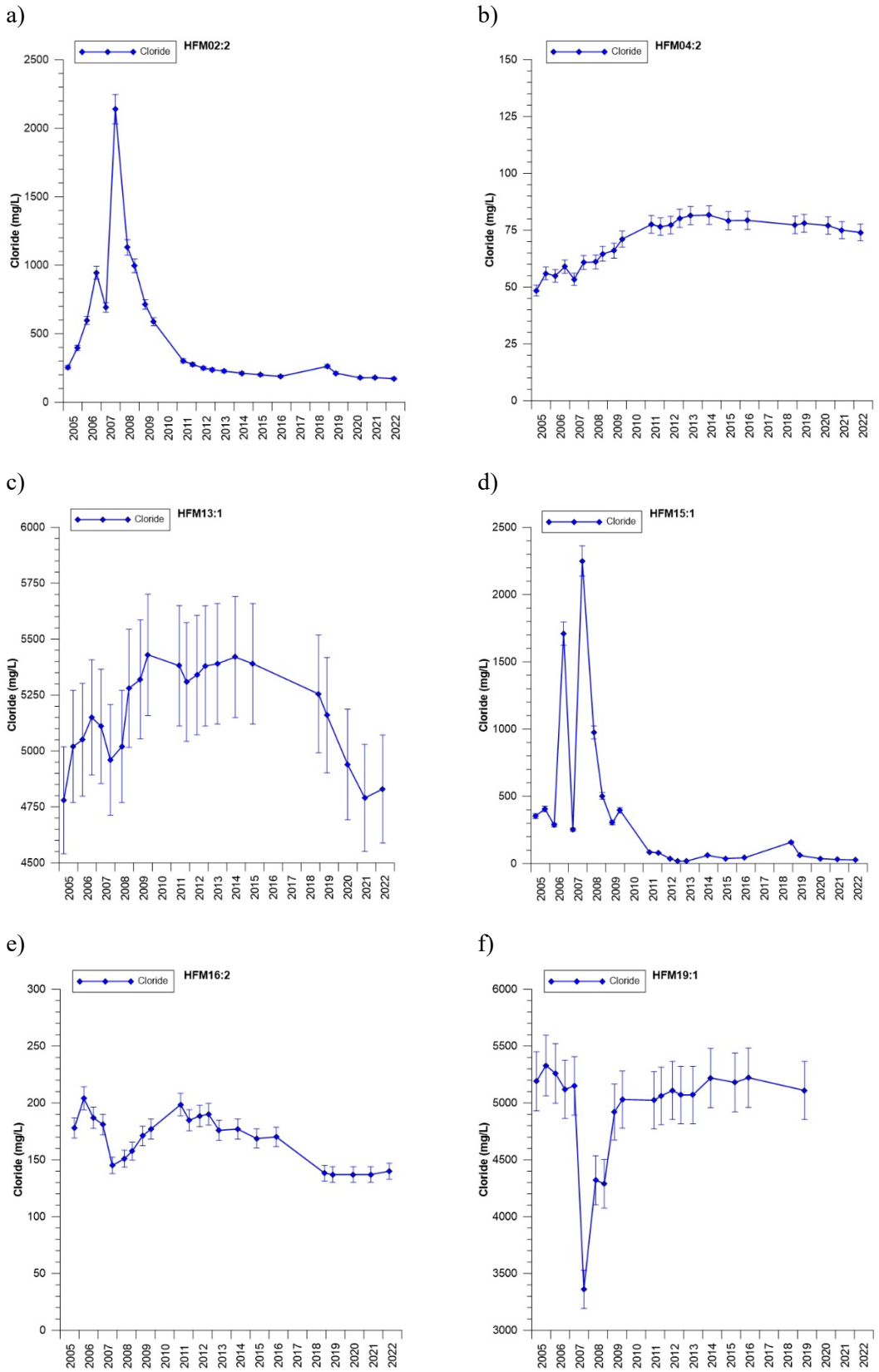

Figure A7-5. *Chloride concentrations in collected samples from hydrogeochemical monitoring 2005 to 2022.*

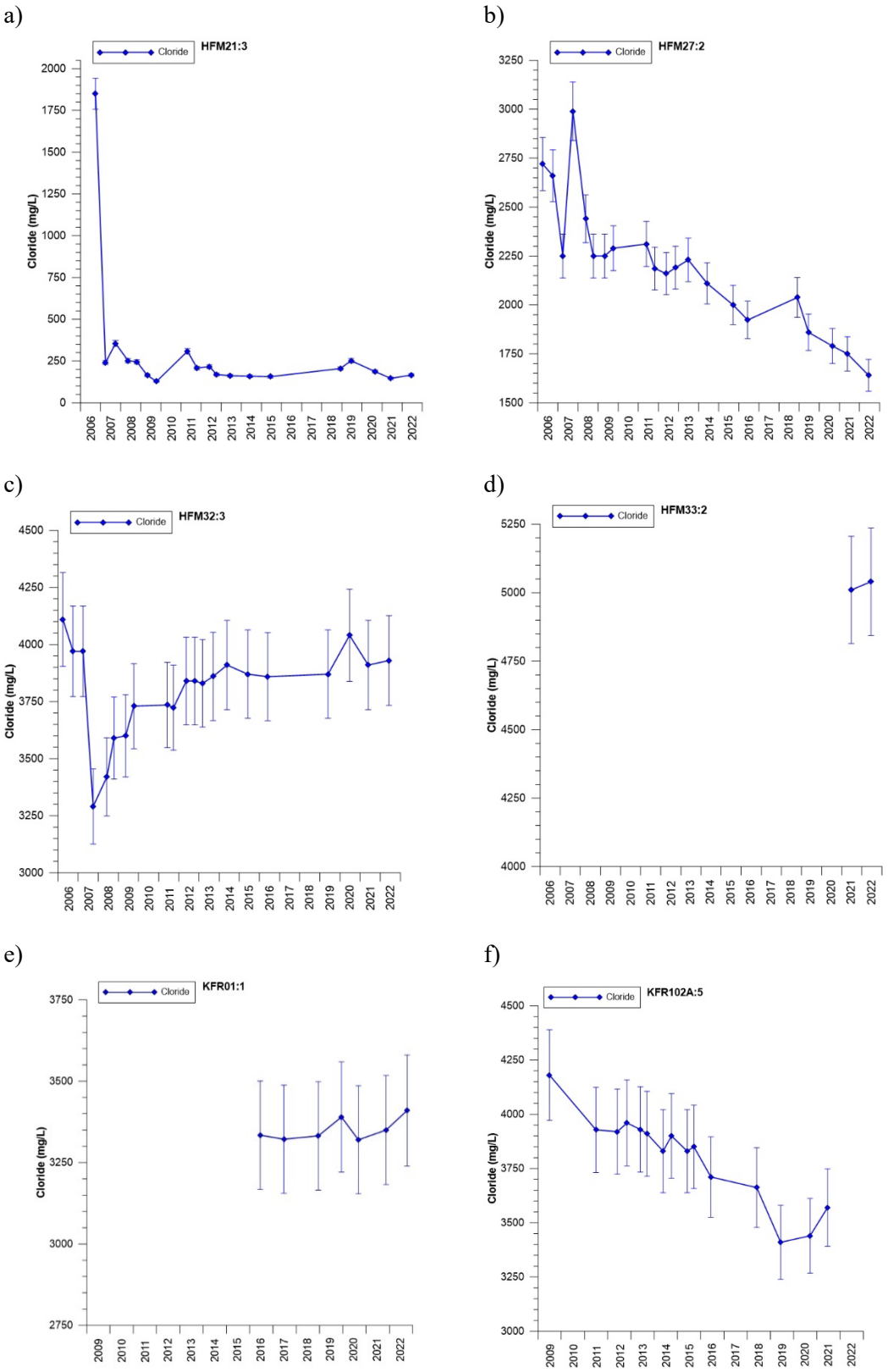

Figure A7-6. *Chloride concentrations in collected samples from hydrogeochemical monitoring 2005 to 2022.*

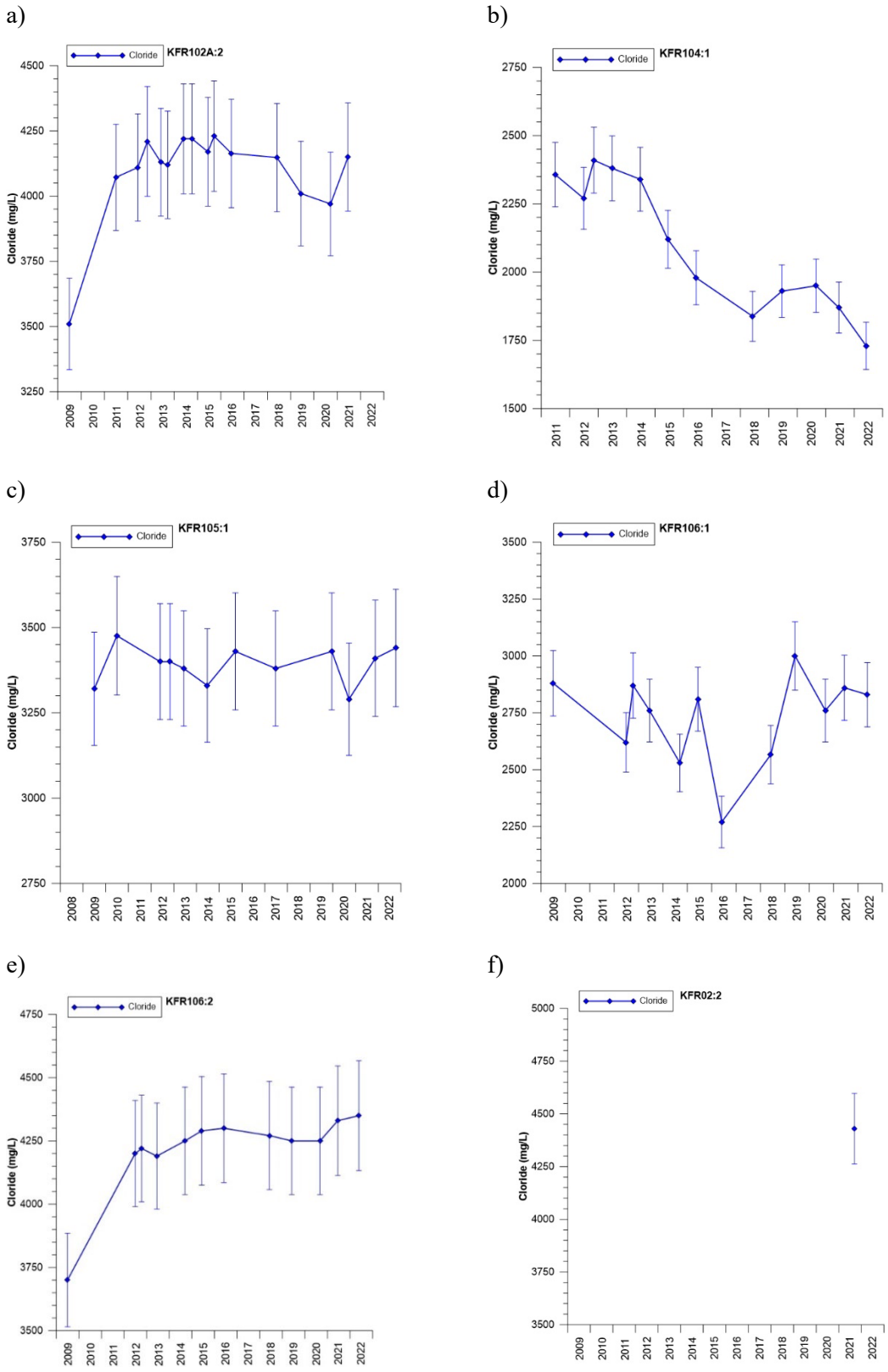

Figure A7-7. *Chloride concentrations in collected samples from hydrogeochemical monitoring 2009 to 2022.*

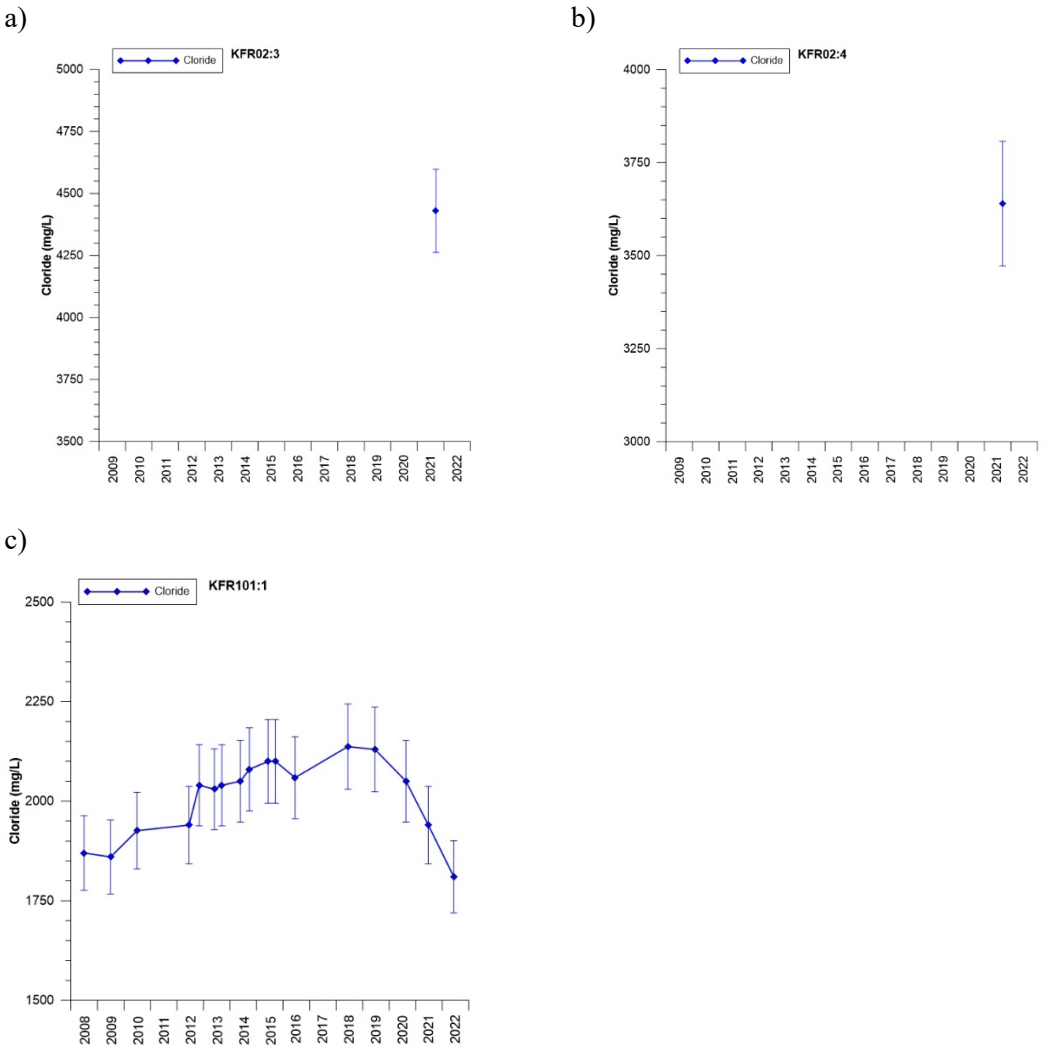

Figure A7-8. *Chloride concentrations in collected samples from hydrogeochemical monitoring 2008 to 2022.*