P-03-28

Forsmark site investigation

Difference flow logging of borehole KFM01A

Pekka Rouhiainen, Jari Pöllänen
PRG-Tec Oy

May 2003

Svensk Kärnbränslehantering AB
Swedish Nuclear Fuel
and Waste Management Co
Box 5864
SE-102 40 Stockholm Sweden
Tel 08-459 84 00
+46 8 459 84 00
Fax 08-661 57 19
+46 8 661 57 19

ISSN 1651-4416
SKB P-03-28

Forsmark site investigation

Difference flow logging of borehole KFM01A

Pekka Rouhiainen, Jari Pöllänen
PRG-Tec Oy

May 2003

Keywords: Forsmark, hydrogeology, hydraulic tests, difference flow measurements.

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

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

Abstract

Difference flow logging is a swift method for determination of hydraulic conductivity and hydraulic head in fractures and fracture zones in cored boreholes. This report presents the main principles of the method as well as results of measurements carried out in borehole KFM01A at Forsmark, Sweden, in November 2002, using the Posiva Flow Log. The primary aim of the measurements was to determine the depth and flow rate of flow yielding fractures in borehole KFM01A prior to groundwater sampling.

The flow rate into or out of a 5 m long test section was measured between 100–1000 m borehole length during natural (un-pumped) as well as pumped conditions. The flow measurements were repeated at the location of the detected flow anomalies using a 1 m long test section, successively transferred with an overlapping of 0.1 m.

Depth calibration was made based on depth marks milled into the borehole wall at accurately determined positions along the borehole. The depth marks were detected by caliper measurements and by single point resistance measurements using sensors connected to the flow meter electronics.

The electric conductivity (EC) of the borehole water was also measured. The EC-measurements were used to study the occurence of saline water in the borehole during natural as well as pumped conditions.

Sammanfattning

Differensflödesloggning är en metod för snabb bestämning av hydraulisk konduktivitet och trycknivå i grundvattenförande sprickor och sprickzoner i kärnborrhål. Föreliggande rapport beskriver huvudprinciperna för differensflödesloggning samt resultat från mätningar med Posiva flödeslogg under november 2002 i kärnborrhål KFM01A i Forsmark. Huvudsyftet med mätningarna var att bestämma djupet till och flödets storlek hos flödande sprickor i KFM01A inför vattenprovtagning.

Inledningsvis mättes flödet till/från en 5 m lång testsektion sekventiellt i borrhålsintervallet 100–1000 m, dels under naturliga flödesförhållanden, dels vid pumpning. Därefter upprepades mätningarna med s k överlappande mätningar på de nivåer där flödesanomalier påträffats. De överlappande mätningarna utfördes med en 1 m lång testsektion och med steglängden 0.1 m.

Djupkalibrering gjordes mot kända markeringar i borrhålet, vilka detekterades med calipermätning och en-punkts resistivitetsmätning. Även borrhålsvattnets elektriska konduktivitet (EC) uppmättes. Syftet med EC-mätningarna var att undersöka salthaltsfördelningen under såväl naturliga förhållanden som vid pumpning.

Contents

1 Introduction

Difference flow logging was carried out in borehole KFM01A at Forsmark, Sweden, during November 18–30, 2002. Borehole KFM01A, which is the first deep cored borehole drilled within the frame of the on-going site investigation in the Forsmark area, is a so called telescopic borehole of SKB chemical type. The borehole is sub-vertical, c 1000 m deep and cased to c 100 m depth. The borehole diameter is c 76 mm in the interval 100–1000 m. The location of the borehole is shown in Figure 1-1.

The field work was conducted by PRG-Tec Oy. The Posiva Flow Log/Difference Flow method has previously been employed in Posiva's site characterisation programme in Finland as well as at the Äspö Hard Rock Laboratory at Simpevarp, Sweden. The commissions at the latter site included measurements in the 1700 m deep cored borehole KLX02 at Laxemar /Ludvigson et al, 2002/.

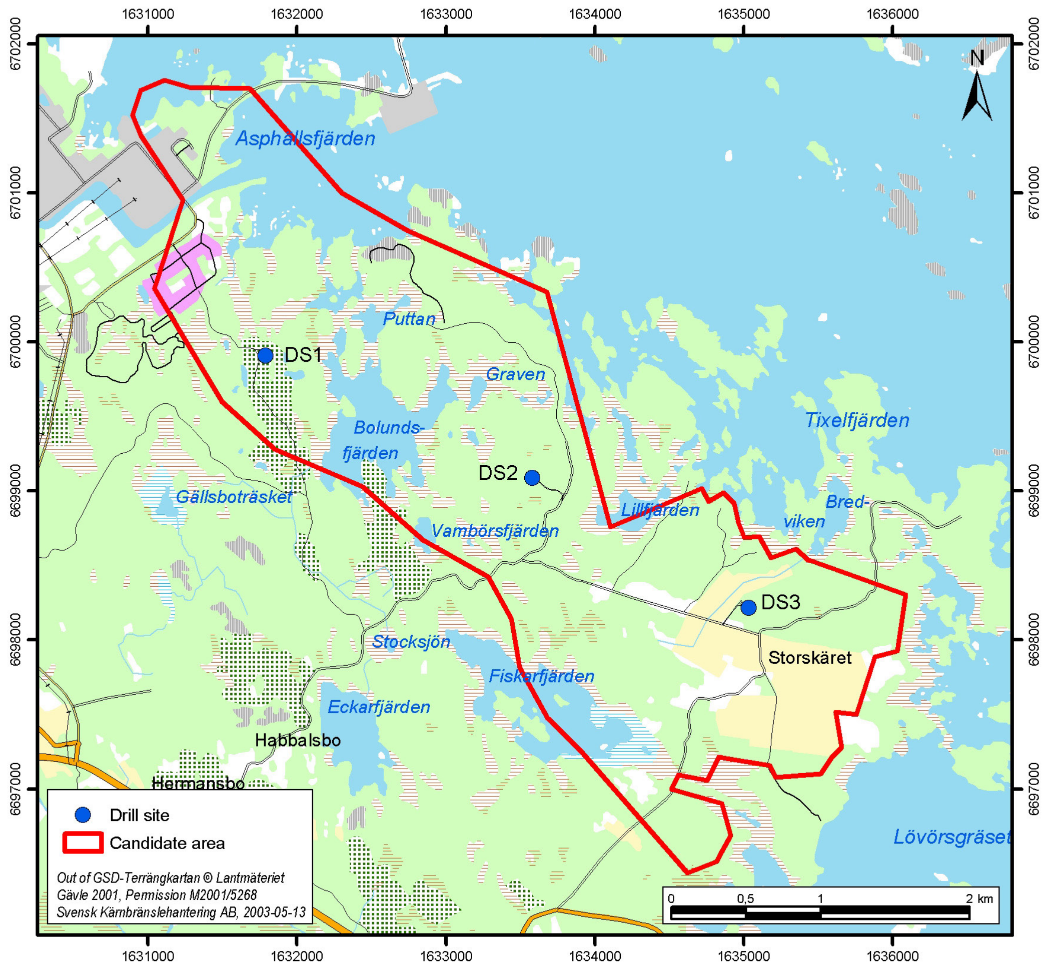


Figure 1-1. The investigation area at Forsmark including the candidate area selected for more detailed investigations. The drillsites for the earliest drilled deep cored boreholes are marked with blue dots. Borehole KFM01A is situated at drillsite DS1.

2 Objective and scope

The objective of the difference flow logging was, firstly, to identify water-conductive sections/fractures suitable for subsequent hydro-geochemical characterisation. Secondly, the measurements aimed at a hydrogeological characterisation, including the prevailing water flow balance in the borehole and the hydraulic properties (transmissivity and undisturbed hydraulic head) of the tested sections. Based on the results of these investigations, a more detailed characterisation of flow anomalies along the hole, e.g. the conductive fracture frequency (CFF), may be obtained.

Besides the difference flow logging, the measuring program also included supporting measurements, performed for a better understanding of the overall hydrogeochemical conditions. These measurements included electric conductivity and temperature of the borehole fluid as well as single-point resistance of the borehole wall. Furthermore, the recovery of the groundwater level after pumping was registered.

Single point resistance measurements were also combined with caliper (borehole diameter) measurements for detection of depth marks milled into the borehole wall at accurately determined positions along the borehole. This procedure was applied for depth calibration of all results.

A more correct notion instead of “depth” is “borehole length”. However, since borehole KFM01A is almost vertical (inclined c 85º from the horizon), “depth” and “borehole length” are almost synonymous. For simplicity, the word “depth” will be used below.

3 Principles of measurements and interpretation

3.1 Measurements

In contradiction to other types of borehole flowmeters, the Difference flowmeter measures the flow rate into or out of packed off borehole sections, instead of measuring the accumulated flow rate along the borehole. However, the incremental changes of flow along the borehole are generally very small and can easily be missed using conventional types of flowmeters. The name "Difference flowmeter" emanates from the fact that this instrument directly measures differences of flow along the borehole, instead of measuring accumulated flow. These flow differences originate from seepage of groundwater from the bedrock into the borehole or, reversed, outflow from the borehole into the bedrock.

A set of rubber disks is used at both ends of the equipment to isolate the test section from the borehole, see Figure 3-1. The flow along the borehole is diverted via a by-pass pipe through the test section and is discharged at the upper end of the down-hole tool. In this way, the flow along the borehole is separated from the flow to be measured, implying that the only flow that passes through the flow sensor is the flow into or out of the borehole in the test section.

The Difference flowmeter can be used in two modes: sequential and overlapping flow logging modes. In the sequential mode, the depth increment is the same as the section length. This mode is applied for determination of hydraulic conductivity and head /Öhberg and Rouhiainen, 2000/. The overlapping mode, in which the depth increment is shorter than the section length, is mostly used to determine the exact location of hydraulically conductive fractures and to classify them by flow rates.

In the sequential mode, the flow rate is measured by a thermal pulse as well as a thermal dilution method. The overlapping mode employs only the thermal dilution method due to its more rapid performance compared to the thermal pulse method.

The electric conductivity (EC) of the borehole water can also be measured with the flowmeter tool. The electrode is placed on top of the flow sensor, Figure 3-1.

Single point resistance (SPR) is another parameter that can be measured with the flowmeter tool. The electrode of the single point resistance sensor is located within the upper rubber disks, see Figure 3-1. This method is used to achieve a high resolution of the depth determination of fractures and geological structures.

Finally, a caliper tool is also connected to the flowmeter electronics. This tool, combined with SPR, is used for detection of the depth marks milled into the borehole wall, see Chapter 2. This enables an accurate depth calibration of the difference flow measurements.

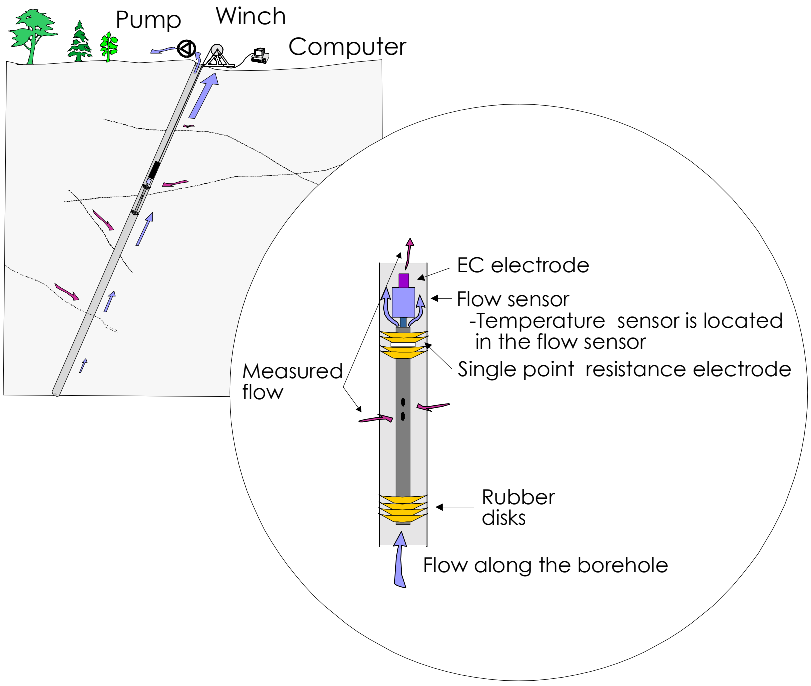


Figure 3-1. *Schematic of the downhole equipment used in the Difference flowmeter.*

The principles of difference flow measurements are described in Figures 3-2 and 3-3. The flow sensor includes three thermistors, see Figure 3-2 a). The central thermistor, A, is used both as a heating element for the thermal pulse method and for registration of temperature changes in the thermal dilution method, Figures 3-2 b) and c). The side thermistors, B1 and B2, serve to detect the moving thermal pulse, Figure 3-2 d), caused by the constant power heating in A, Figure 3-2 b).

Flow rate is measured during the constant power heating (Figure 3-2 b). If the flow rate exceeds 10 mL/min, the constant power heating is increased, Figure 3-3 a), and the thermal dilution method is applied.

If the flow rate during the constant power heating (Figure 3-2 b) falls below 10 mL/min, the measurement continues with monitoring of the thermal dilution transient and the thermal pulse response (Figure 3-2 d). When applying the thermal pulse method, also thermal dilution is always measured. The same heat pulse is used for both methods.

Flow is measured when the tool is at rest. After transfer to a new position, there is a waiting time (length can be adjusted according to the prevailing circumstances) before the heat pulse (Figure 3-2 b) is launched. The waiting time after the constant power thermal pulse can also be adjusted, but is normally 10 s long for thermal dilution P1 and 300 s long for the thermal pulse method. The measuring range of each method is given in Table 3-1.

Table 3-1. Ranges of flow measurement.

Method	Range of measurement (mL/min)
Thermal dilution P1	0.5–100
Thermal dilution P2	10–5000
Thermal pulse	0.1–10

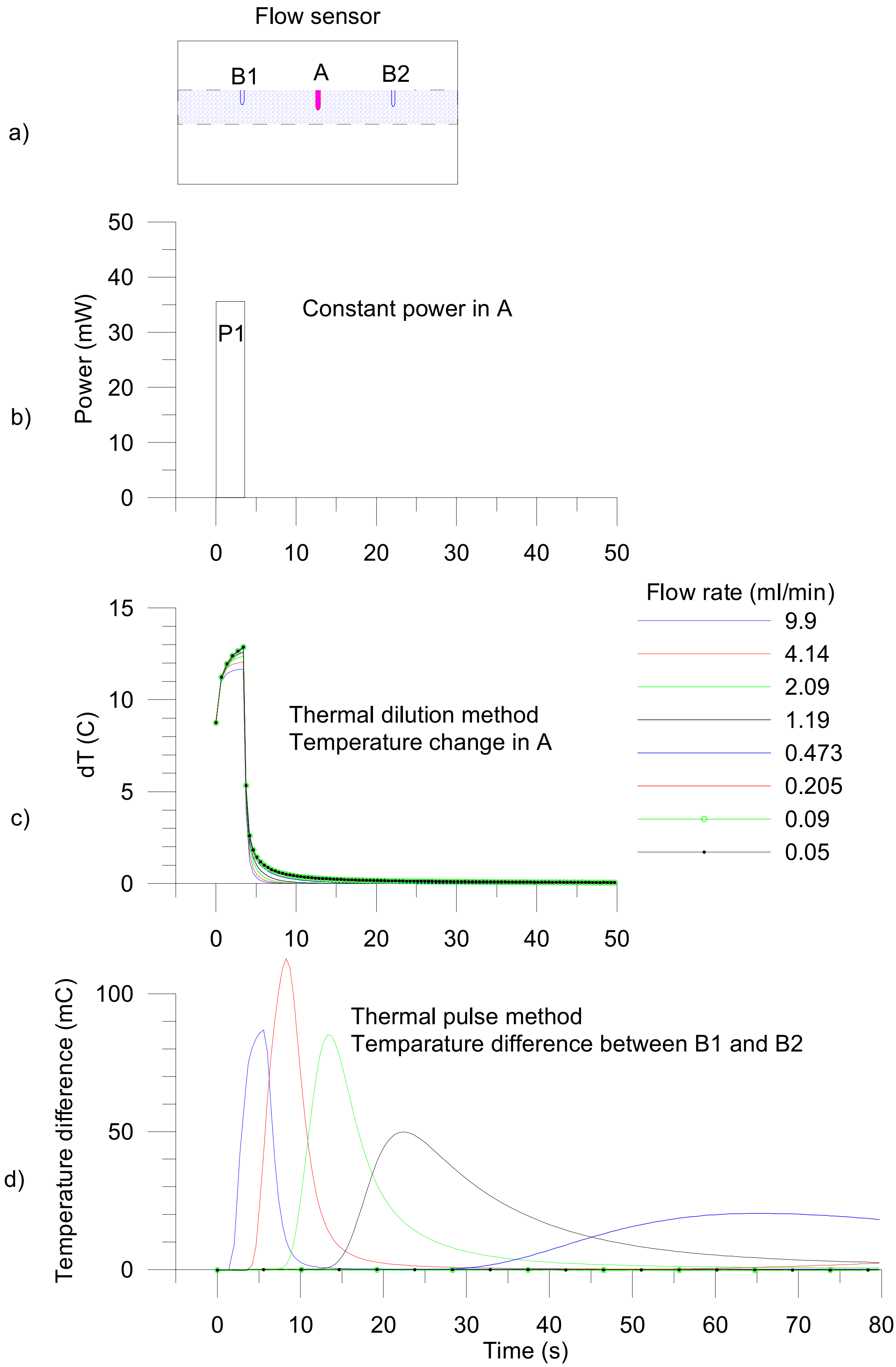


Figure 3-2. *Flow measurement, flow rate < 10 mL/min.*

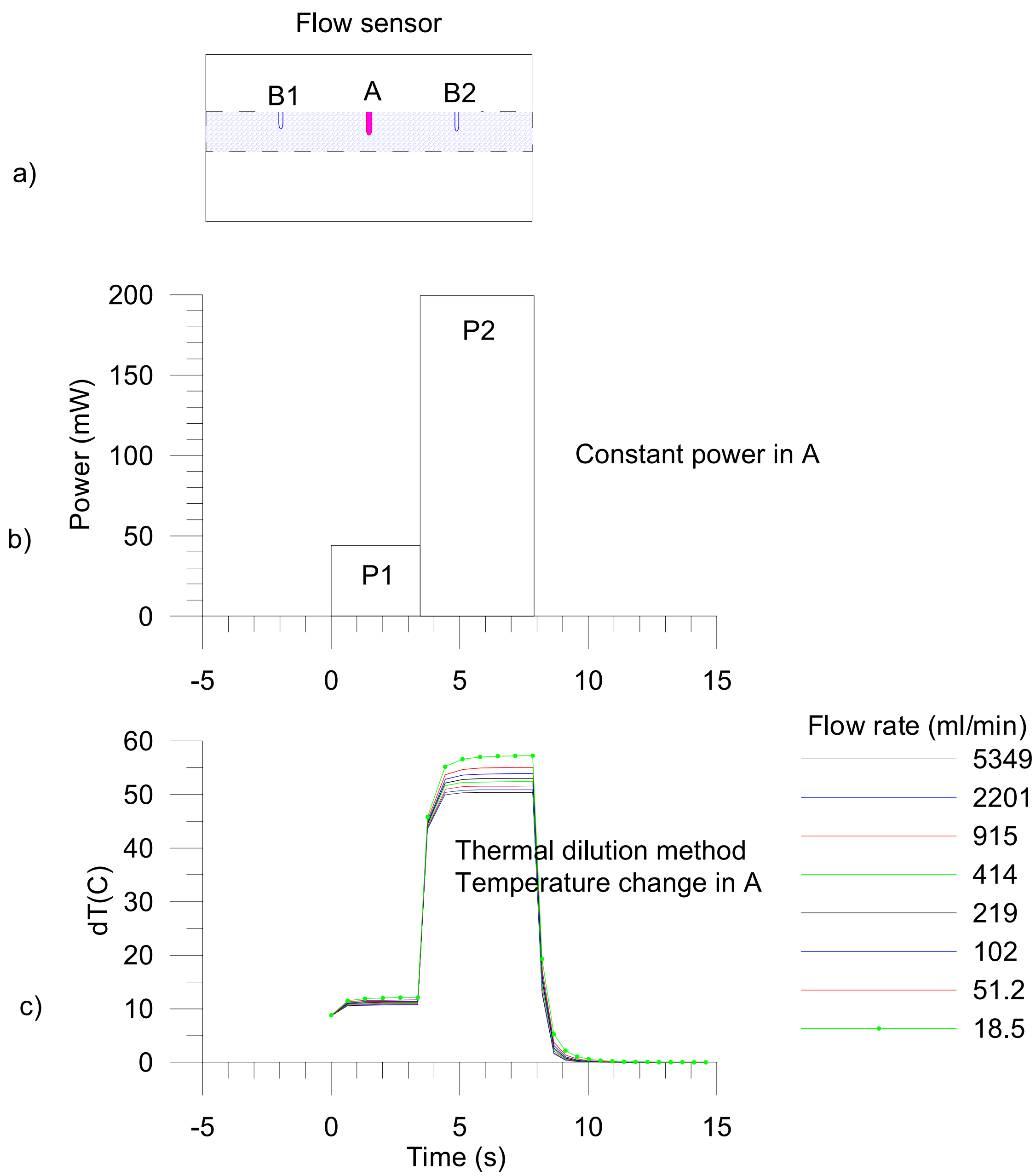


Figure 3-3. *Flow measurement, flow rate > 10 mL/min.*

3.2 Interpretation

If flow rate measurements are carried out using two levels of pump-induced hydraulic heads, then the undisturbed (natural) hydraulic head and the hydraulic conductivity of the tested borehole sections can be calculated, see Equations 3-1 and 3-2. The calculations assume steady state flow conditions.

$$Q_{n1} = K_n \, a \, (h_0 - h_1) \qquad 3\text{-}1$$

$$Q_{n2} = K_n \, a \, (h_0 - h_2) \qquad 3\text{-}2$$

where

h_1 and h_2 are the pump-induced hydraulic heads in the test section,

a is a constant depending on the assumed flow geometry,

Q_{n1} and Q_{n2} are the measured flows rates in the test section,

K_n is hydraulic conductivity of the test section, and

h_0 is the undisturbed hydraulic head zone far from the test section.

Since, in general, very little is known of the flow geometry, cylindrical flow without skin zones is assumed. Cylindrical flow geometry is also justified because the borehole is at a constant head and there are no strong pressure gradients along the borehole, except at the ends of the borehole. For cylindrical flow, the constant a is:

$$a = 2 \pi L / \ln(R/r_0) \qquad 3\text{-}3$$

where

L is the length of the test section,

R is the radial distance to the undisturbed hydraulic head h_0, and

r_0 is the nominal radius of the borehole.

The radial distance to the undisturbed hydraulic head h_0 is not known and it must be assumed. Here a value of 500 is selected for the quotient R/r_0.

Hydraulic head and conductivity can be deduced from the two measurements:

$h_0 = (h_1 - b\ h_2)/(1-b)$ 3-4

$K_n = (1/a)\ (Q_{n1} - Q_{n2})\ /(h_2 - h_1)$ 3-5

where

$b = Q_{n1}/Q_{n2}$

Transmissivity of individual fractures can be calculated if flow rates of individual fractures are known. Similar assumptions as before have to be used (cylindrical flow without skin zones and steady state flow).

$h_0 = (h_1 - b\ h_2)/(1-b)$ 3-6

$T_n = (1/a)\ L\ (Q_{n1} - Q_{n2})\ /(h_2 - h_1)$ 3-7

where

Q_{n1} and Q_{n2} are flow rates at fracture n

h_0 and T_n are the hydraulic head and the transmissivity of fracture n

Since the actual flow geometry is not known, calculated conductivity values should be taken as indicating orders of magnitude. As the calculated hydraulic heads do not depend on geometrical properties but only on the ratio of the flows measured at different heads in the borehole, they should be less sensitive to unknown fracture geometry.

4 Equipment specifications

The Posiva Flow Log/Difference flow method monitors the flow of groundwater into or out from a borehole section by means of a flow guide (rubber discs). The flow guide thereby defines the test section to be measured without altering the hydraulic head. Groundwater flowing into or out from the test section is guided to the flow sensor. Flow is measured using the thermal pulse and/or thermal dilution methods. Measured values are transferred in digital form to the PC computer.

Type of instrument:	Posiva Flow Log/Difference Flowmeter.
Borehole diameters:	56 mm, 66 mm and 76 mm.
Length of test section:	A variable length flow guide is used.
Method of flow measurement:	Thermal pulse and/or thermal dilution.
Range of measurement:	0.1–5000 mL/min.
Additional measurements:	Temperature, Single point resistance, conductivity of water, Caliper.
Winch:	Mount Sopris Wna 10, 0.55 kW, 220V/50Hz. Steel wire cable 1450 m, four conductors, Gerhard-Owen cable head.
Depth determination:	Based on the marked cable and on the digital depth counter.
Logging computer:	PC, Windows 95.
Software:	Based on MS Visual Basic.
Total power consumption:	1.5–2.5 kW depending on the pumps.
Calibrated:	November 2002.
Calibration of cable length:	Using depth marks in the borehole wall.

5 Performance

The Commission was performed according to Activity Plan AP PF 400-02-40 (SKB internal controlling document) following the SKB Method Description 322.010, Version 1.0 (Method description for difference flow logging). Prior to the measurements, the down-hole tools and the measurement cable were cleaned and disinfected. Time was synchronized to local Swedish time. The activity schedule of the borehole measurements is presented in Table 5-1. The items and activities in Table 5-1 are the same as in the Activity Plan, except for Items 1–6, which refer to preparations before testing, and therefore are excluded.

Logging cables, wires, and pipe strings are exposed to stretching when lowered into a vertical or sub-vertical borehole. This will introduce a certain error in defining the position of a test tool connected to the end of e.g. a logging cable. Immediately after completion of the drilling operations in borehole KFM01A, depth marks were milled into the borehole wall at certain intervals to be used for depth calibration of various logging tools. By using the known positions of the depth marks, logging cables etc can be calibrated in order to obtain an accurate depth correction of the testing tool.

Each depth mark includes two 20 mm wide tracks in the borehole wall. The distance between the tracks is 100 mm. The upper track represents the reference level. An inevitable condition for a successful depth calibration is that all depth marks, or at least the major part of them, are detectable. The Difference flow meter system uses caliper measurements in combination with single point resistance measurement (SPR) for this purpose, and these measurements were the first to be performed in borehole KFM01A (Item 7 in Table 5-1). These methods also reveal widened parts of the borehole.

The caliper- and SPR-measurements were succeeded by measurements of the electric conductivity (EC) of the borehole water (Item 8) during natural (un-pumped) conditions.

The combined sequential/overlapping flow logging (Item 9) was carried out in the borehole interval 100–1000 m. The section length was 5 m, and the depth increment (step length) 5 m for the thermal pulse method, respectively 0.5 m for thermal dilution method. The measurement were performed during natural (un-pumped) conditions.

Pumping was started on November 23. After 24 hours of waiting time, the combined sequential/overlapping flow logging (Item 10) was repeated in the same interval, 100–1000 m using the same section and step lengths as before.

The overlapping flow logging was then continued in the way that previously measured flow anomalies were re-measured with 1 m section length and 0.1 m step length (Item 11).

Still during pumped conditions, the EC of the borehole water (Item 12) was measured. Finally, the pump was stopped and the recovery of the groundwater level was monitored (Item 13).

Table 5-1. Flow logging and testing in KFM01A. Activity schedule.

Item	Activity	Explanation	Date
7	Length calibration of the down-hole tool	Dummy logging (SKB caliper and SPR). Logging without the lower rubber discs, no pumping	2002-11-18 2002-11-19
8	EC- and temp-logging of the borehole fluid	Logging without the lower rubber discs, no pumping	2002-11-19 2002-11-20
9	Combined sequential and overlapping flow logging	Section length L_w=5 m, Step length dL=0.5 m. Pulse measurement every 10^{th} point, no pumping	2002-11-20 2002-11-23
10	Combined sequential and overlapping flow logging	Section length L_w=5 m, Step length dL=0.5 m. Pulse measurem. every 10^{th} point during pumping (includes 1 day of waiting after start of pumping)	2002-11-23 2002-11-27
11	Overlapping flow logging	Section length L_w=1 m, Step length dL=0.1 m, during pumping (only in conductive borehole intervals)	2002-11-27 2002-11-28
12	EC- and temp- logging of the borehole fluid	Logging without the lower rubber discs, during pumping	2002-11-28
13	Recovery transient	Monitoring of the recovery of the groundwater level in the borehole after pump stop	2002-11-28 2002-11-30

6 Results

6.1 Caliper- and SPR-measurements

The result of the caliper and single point resistance measurements from the entire borehole is presented in Appendix 1.1. Four SPR-curves are plotted together with the caliper-data. These measurements correspond to Items 7, 9, 10 and 11 in Table 5-1.

Zoomed results of caliper and SPR are plotted in Appendices 1.2–1.27. The depth marks were detected at 110 m, 150 m, 200 m, 250 m, 300 m, 350 m, 400 m, 500 m, 550 m, 600 m, and 650 m and at 750 m. They can be seen also in the SPR-results. However, the anomaly is complicated due to the four rubber disks used at the upper end of the section, two at each side of the resistance electrode. A selection of depth intervals where SPR-anomalies were found are plotted as well.

The aim of the plots in Appendices 1.2–1.27 is to verify the accuracy of the depth correction. The curves in these plots represent already depth corrected results. The same depth corrections were applied to the flow- and EC-results.

The magnitude of the depth correction is presented in Appendix 1.28. The error is negative, due to the fact that the stretching extends the logging cable (i.e. the cable will be longer than the nominal length marked on the cable).

The procedure of depth correction was the following:

- Caliper- + SPR-measurements (Item 7) were initially depth corrected in relation to the known depth marks, Appendix 1.28 black curve. Corrections between the borehole depth marks were obtained for each depth by linear interpolation. The depths below 750 m were extrapolated.
- The SPR-curve of Item 7 was then compared with the SPR-curves of Items 9, 10, 11 to obtain relative depth errors of Items 9, 10, 11.
- All SPR-curves could then be synchronized, as can be seen in Appendices 1.2–1.27.

The first SPR-measurement (black curve plots in Appendices 1.2–1.27) displays less noise than the rest of the measurements. This feature is clearer above a depth of about 400 m, except for large SPR-anomalies (see Appendix 1.3). The reason of the noise is probably uneven movement of the tool due to friction variations. During down-hoisting of the testing tool for the SPR-measurements, it was noticed that the cable tension varied with the same phase as the noise in the SPR-results. The first measurement (Caliper + SPR measurement) exposed reduced frictional resistance compared to the succeeding measurements, which is explained by the fact that only the upper rubber disks were used. In this case variation of cable tension was not observed.

The general impression is that friction was exceptionally high in borehole KFM01A. High viscosity material, interpreted as a mixture of grease and drilling mud, was found to be attached on the rubber disks after each logging session and possibly contributed to the increased frictional resistance. The fact that the borehole is very low-transmissive may offer another plausible explanation to the high resistance observed during transfer of the testing tool along the borehole.

6.2 Electric conductivity and temperature of borehole water

The electric conductivity of the borehole water (EC) was initially measured when the borehole was at rest, i.e. at natural , un-pumped conditions. Measurements were performed in both directions, downwards and upwards, see Appendix 2.1.

The EC-measurements were repeated during pumping (after a pumping period of about seven days), see Appendix 2.1, red curves. The results clearly indicate inflow of saline water at the depth of about 180 m.

The temperature of the borehole water was measured simultaneously with the EC-measurements. The EC-values are temperature corrected to 25°C to make them more comparable with other EC-measurements /Heikkonen et al, 2002/. The temperature results in Appendix 2.2 correspond to the EC-results in Appendix 2.1. The four temperature results are similar. Pumping caused very limited changes of the temperature profiles. The minor flow rate is an apparent reason to this.

6.3 Flow logging

6.3.1 General comments on the results

The flow logging was performed with a 5 m section length and with 0.5 m depth increments, see Appendices 3.1–3.45. The method (overlapping flow logging) gives the depth and the thickness of conductive zones with a depth resolution of 0.5 m. To obtain quick results, only the thermal dilution method is used for flow determination.

Every tenth measurement was carried out using the thermal pulse method (sequential flow logging). This method is slower but has the advantage of rendering measurements of very small flow rates possible, as well as of their flow directions (into the borehole or out of it).

The test section length determines the width of a flow anomaly of a single fracture. If the distance between flow yielding fractures is less than the section length, the anomalies will be overlapped, resulting in a stepwise flow anomaly. The overlapping flow logging was therefore repeated in the vicinity of identified flow anomalies using a 0.5 m long test section and 0.1 m depth increments.

The depths of flowing fractures are marked with lines in the appendices of the detailed flow logs. A long line represents the depth of a leaky fracture; a short line denotes that the existence of a leaky fracture is uncertain. A short line is used if the flow rate is less than 30 mL/h or if the flow anomalies are overlapped.

The electrode of the single point resistance tool is located within the upper rubber disks. Thus, the depth of the resistance anomalies of the leaky fractures fits with the lower end of the flow anomalies.

6.3.2 Flow anomalies caused by fluctuation

An increased “noise” level (i.e. an anomalous flow rate not depending on stationary flow from fractures) during flow logging was observed in some parts of borehole, most obvious during the measurements at un-pumped conditions. The origin of the noise is at least partly unknown. Its behavior is, though, described below.

It was first noticed that the noise always disappeared during the thermal pulse measurements (every tenth measurement). Thermal dilution and thermal pulse measurements are carried out similarly, however with two exceptions:

- The stabilization time before the thermal pulse (P1 in Figure 3-2 b) is 2 seconds for the thermal dilution method but 100 seconds for the thermal pulse measurements.
- The waiting time after the thermal pulse (P1 in Figure 3-2 b) is 10 seconds for the thermal dilution method but 300 seconds for the thermal pulse measurements.

The effect of stabilization time was tested on November 24 during a waiting period after start of pumping, see Figure 6-1. The same part of the borehole was measured with the normal 2 seconds and with 20 seconds of stabilization time. The flow anomalies (fractures at 178.3 m and 187.8 m) repeated well with the respective methods. A difference in the noise level was observed between 188 m and 195 m. The conclusion of this test was that the noise could be removed by increasing the stabilization time before the thermal pulse.

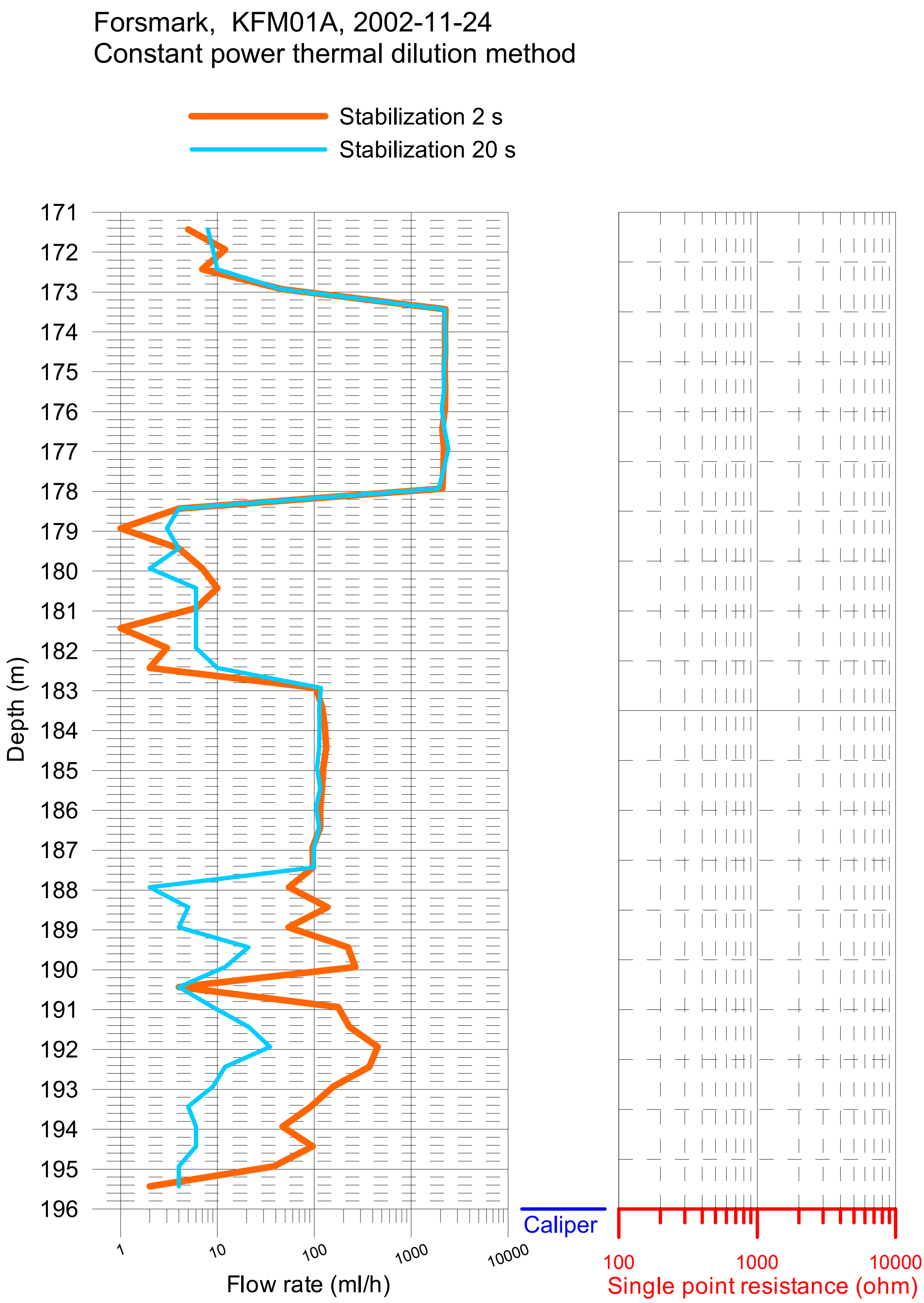


Figure 6-1. *Test of waiting time before flow measurement.*

A strong noise anomaly was detected between 358–363 m, Appendices 3.13 and 3.14. The noise was caused by fluctuation of water in the flow sensor. This was seen during the stabilization time before the flow measurement, Figure 6-2. Temperature variation was measured by the thermistors used for detection of thermal pulse. These thermistors are situated on each sides of the middle thermistor. A long lasting, decaying fluctuation in the flow sensor was observed. The result does neither show the alternating flow rate nor its origin. It just illustrates the frequency and duration of the fluctuation after the tool was moved to a new position.

No fluctuation was seen just below the anomaly at the depth of 364.0 m, see Figure 6-3.

Similar fluctuations were detected in some other anomalous parts of the borehole. However, the fluctuation displayed the longest duration at the anomaly between 358 m and 363 m.

Figure 6-2. *Screen copy of stabilization time before flow measurement on November 28 at the depth of 362.9 m. Temperature difference of thermistors used for detection of thermal pulse. Long lasting fluctuation in the flow sensor.*

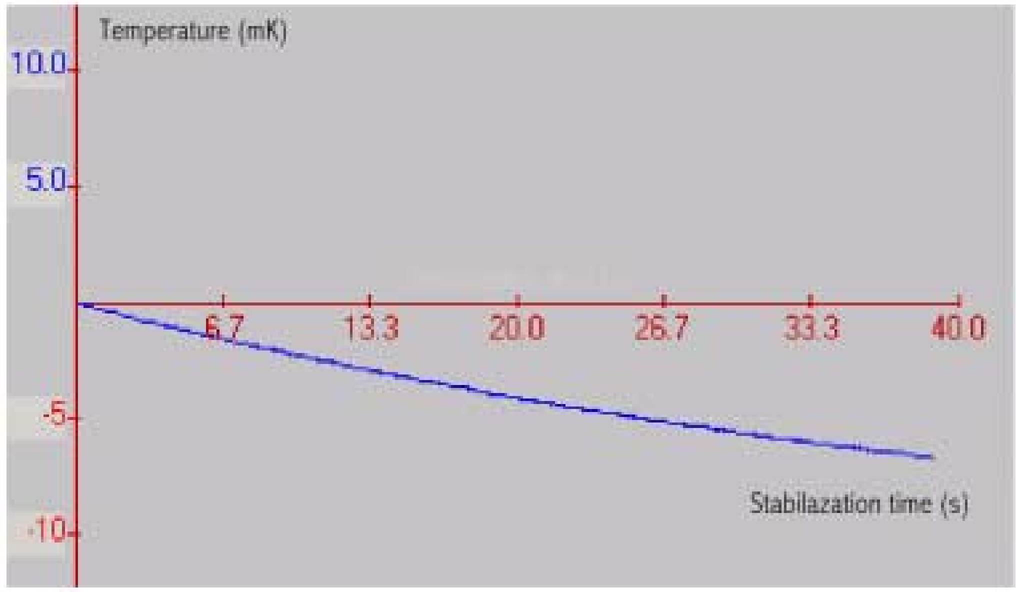


Figure 6-3. *Screen copy of stabilization time before flow measurement on November 28 at the depth of 364.0 m. Temperature difference of thermistors used for detection of thermal pulse. Normal temperature drift without fluctuation.*

Table 6-1 lists the observed main fluctuation anomalies. There may however be other, smaller fluctuation anomalies elsewhere in the borehole.

Widened part of the borehole may cause disturbances in flow rate. At such locations the rubber disks may leak causing spikes in the measured flow rate. They can usually be separated from real anomalies if their length along the borehole is shorter than the section length. This phenomeon is different in character compared to the fluctuation described above.

In anomalies listed in Table 6-1, "zero" flow was always measured at every tenth point, where thermal pulse was measured and where stabilization time was longer.

An interesting observation is that the anomaly often has the same extension as the section length, 5 m, if it was detected with a 5 m section, and 1 m if detected with a 1 m section. This suggests that an essential part of the phenomenon is related to the borehole wall, possible an open fracture with a low transmissivity. In three cases (292.6 m, 325.9 m, 363.4 m) also real fracture flow caused the observed fluctuating flow. The existence of a fracture causing fluctuation was less clear when the amplitude was smaller, mainly below the depths of about 400 m.

The transfer of the flowmeter probably initiated the fluctuation, which was smaller with the shorter depth increment (1 m section length and a depth increment of 0.1 m).

Fluctuation described above has never been noticed before. An exceptional thing in this borehole is its low transmissivity, which may explain at least part of the observed phenomenon.

Table 6-1. Fluctuation anomalies.

Depth interval (m)	Noise detected in measuring phase	Comments
191–193	L=5 m without pumping	
288–293	L=5 m without pumping	"Zero" flow at 290.4 m with 100 s stabilization time. Real flow from a fracture at 292.6 m
321–326	L=5 m without pumping L=5 m with pumping L=1 m with pumping	"Zero" flow at 325.5 m with 100 s stabilization time. Real flow from a fracture at 325.9 m
358–363	L=5 m without pumping L=5 m with pumping L=1 m with pumping	"Zero" flow at 360.5 m with 100 s stabilization time. Real flow from a fracture at 363.4 m
601–606	L=5 m without pumping L=5 m with pumping	"Zero" flow at 605.6 m with 100 s stabilization time.
659–675	L=5 m without pumping L=5 m with pumping	"Zero" flow at 660.6 m, 665.6 m and 670.6 m with 100 s stabilization time.
777–782	L=5 m without pumping L=5 m with pumping	"Zero" flow at 780.7 m with 100 s stabilization time.

Stabilization times used in different measurements are given in Table 6-2.

Table 6-2. Stabilization times.

Measuring phase	Stabilization time (s)	Depth interval (m)
L=5 m without pumping	2	100–1000
L=5 m with pumping	2	100–1000
L=5 m with pumping, repeated	30	141–150, 189–196, 286–295, 320–327, 357–365
L=5 m with pumping, repeated	60	590–875
L=1 m with pumping	4	100–365
L=1 m with pumping, repeated	40	317–327

6.3.3 Hydraulic conductivity and head of sections

The entire borehole between 100 m and 1000 m was flow logged. The major part of the flow logging results presented in this report are derived from measurements with the thermal dilution method. However, every tenth flow measurement was carried out using the thermal pulse method (sequential flow logging), which enables measurements of smaller flow rates than the thermal dilution method. Thermal pulse flow results were selected for test sections with flow rates less than 600 mL/h, above which limit thermal pulse results were used only for detection of flow direction.

Flow rate data are presented in Appendices 4.1–4.4. Depth1 and Depth2 presented in Appendix 4.1 are calculated as the distance from the reference level (top of casing) to the middle point of the test section. Depth1 refers to the measurement at natural, i.e. un-pumped conditions, and Depth2 to measurements during pumping. They are not identical, due to a minor difference of the cable stretching between the two runs.

Fresh water head of the entire borehole was obtained from the groundwater level measurements assuming constant density of water (1 g/cm^3). Head1 and Head2 in Appendix 4.1–4.4 represent heads determined without respectively with pumping. Head in the borehole and calculated heads in single fractures are given in RHB 70 scale.

The flow results presented in Appendix 4.1–4.4 (Flow1 and Flow2), representing flow rates derived from measurements during un-pumped respectively pumped conditions, are presented side by side to make comparison easier. Flow rates are positive if the flow direction is from the bedrock into the borehole and vice versa. With the borehole at rest, five sections were detected as flow yielding, of which one (at c 148 m) had a flow direction from the borehole into the bedrock (negative flow). During pumping, all detected flows were directed towards the borehole.

Data in the flow rate plots are presented in a logarithmic scale, see Appendix 4.5. The left hand side of each diagram represents flow from the borehole into the bedrock for the respective test sections, whereas the right hand side represents the opposite. If the measured flow was zero (below the measurement limit), it is not visible in the logarithmic scale of the appendices.

Fresh water head of fractures and hydraulic conductivity can be calculated from flow data using the method described in Chapter 3. Fresh water heads of fractures are presented in the plots, if none of the two flow values at the same depth is equal to zero. Hydraulic conductivity is presented if none or just one of the flow values is equal to zero, see Appendix 4.6.

The lower limit of hydraulic conductivity can be evaluated, assuming that the lower limit of flow measurements is 6 mL/h, see Appendix 4.6.

The results of the first measurement (100.48 m–105.48 m) are left out from Appendix 4, since these results were mutually inconsistent. Without pumping, the flow rate amounted to about 70 mL/h (positive flow), but during pumping only to 40 mL/h. The position during measurements of at least some of the upper rubber disks was in the widened part of the borehole, i.e. inside the casing, see the Caliper result in Appendix 3.1, a factor which may be the reason for the observed inconsistency.

In the single point resistance log the lower end of the casing tube is clearly visible at 102.0 m, see Appendix 3.1. The overlapping method with L=1 m here indicates a flow anomaly of 100 mL/h. This is probably due to a minor leak from the grouted gap between the borehole wall and the casing. Also here the result without pumping is inconsistent with the result from measurement during pumping.

6.3.4 Transmissivity and head of fractures

An attempt was made to evaluate the magnitude of fracture-specific flow rates. The first step in this procedure is to identify the individual flowing fractures and then to evaluate their flow rates. The measurements with a short section length are useful for mapping the individual fractures, see e.g. Appendix 3.1, the fractures at 113.8 m, 115.2 m and 118.3 m. Typically, the added flow rates from five one metre sections were lower than the flow rate of the corresponding five metre section. The decreasing pumping rate versus time (with a constant draw-down) is an apparent reason to this, see Figure 6-5, since the five metre measurements were performed prior to the one metre measurements. In cases where the distance between individual fracture was less than one metre, it was more difficult to evaluate the flow rate, see Appendix 3.2, 120 m–129 m.

Flow was also detected without pumping in measurements with the five metre section length. The shape of the flow curve between 110 m and 119 m without pumping suggests that water yielding fractures are situated at 115.2 m and 118.3 m. The flow rates for these fractures (47 respectively 40 mL/h) were derived from thermal pulse measurements at 112.95 m and 117.95 m, where each fracture was the only existing fracture within the section.

During measurements without pumping, negative flow was detected in the 5 m section between 145.43 m and 150.43 m. The overlapping log at this location (Appendix 3.3, blue curve) indicates that the flow could may origin from the fractures at 146.8 m, 147.7 m and 149.1 m. A negative flow rate of 15 mL/h was estimated for each of them. This value falls below the measurement limit and represents just an approximate estimate.

Without pumping the borehole, flow was also detected in the fractures at 178.3 m and 187.8 m. The flow rates connected to these fractures were derived from the corresponding thermal pulse flow measurements.

Fresh water head in the borehole was estimated in two ways. In both cases the groundwater level in the borehole was the starting point. Correction to this was obtained by:

1) assuming constant density of water (1 g/cm^3) and

2) assuming saline water.

Density of groundwater depends on its temperature, pressure (compressibility), salinity (and composition of salts) and amount of solid particles and dissolved gas as well as the content of gas bubbles in water. Here, only salinity is taken into account in the following way /Pöllänen, 2002/:

$$\Delta P_{Salt} = \sum_{0}^{s} c \; EC_{25} \; \Delta s \qquad 5\text{-}1$$

where

ΔP_{Salt}	is increase of pressure caused by salinity (mH_2O)
c	is an experimental constant $4.8659 \cdot 10^{-3}$ (m/S)
Δs	is depth increment of EC-measurement (m)
EC_{25}	is electric conductivity of water in 25°C (S/m)

A head difference between the two mentioned methods is obvious already at the depth of 100 m, due to the fact that the water column inside the casing is also saline, see Appendix 5.1. Head1 and Head2 represent heads without respectively during pumping the borehole. Also the EC-profiles originate from measurements without respectively during pumping. Heads are given in RHB 70 scale.

Transmissivity of fractures and head of fractures were calculated using the assumption of constant density of water (1 g/cm^3) and the assumption of saline water. Head of a fracture was calculated if there was a measurable flow at both water levels, see Appendices 5.1–5.3.

Most fracture-specific results were rated as "uncertain" results, see Appendix 5.1. The criterion of "uncertain" was in most cases a minor flow rate (< 30 mL/h). In some cases fracture anomalies were unclear, since the distance between them was less than one m.

6.4 Groundwater level and pumping rate

The level of the groundwater table in the borehole during the measurements is presented in Figure 6-4. The borehole was not pumped between November 19 and 23 when the first session of caliper-, EC- and flow measurements was carried out. During the first EC-measurement, in November 19 and 21, the water level rose during lowering of the test tool and cable. The groundwater table recovered to the original level when the EC- measurement were repeated with transfer of the tool in the opposite direction (upwards). The borehole is extremely low-transmissive, and even moving the thin cable (the diameter is 5.9 mm) affects the water level. However, during pumping, this phenomenon was not observed, since a regulator was used to keep the groundwater table at a constant level.

The borehole was apparently still in a recovery state during the flow measurements without pumping. A tendency of recovery of the groundwater level is observed in the level plot in Figure 6-4 during the period November 21–23. During 24 h (November 22), the water level rose 0.2 m. The inner diameter of the casing is 200 mm. The water volume corresponding to the 0.2 m level shift is 6280 mL. This results in 256 mL/h as an average "flow rate" during the 24 hours. This value can be compared with the sum of flow rates measured during the non-pumping phase, 176 mL/h.

The borehole was pumped with a draw-down of about eleven metres. The recovery was measured as the last phase of the field work, November 28–30, Figure 6-4.

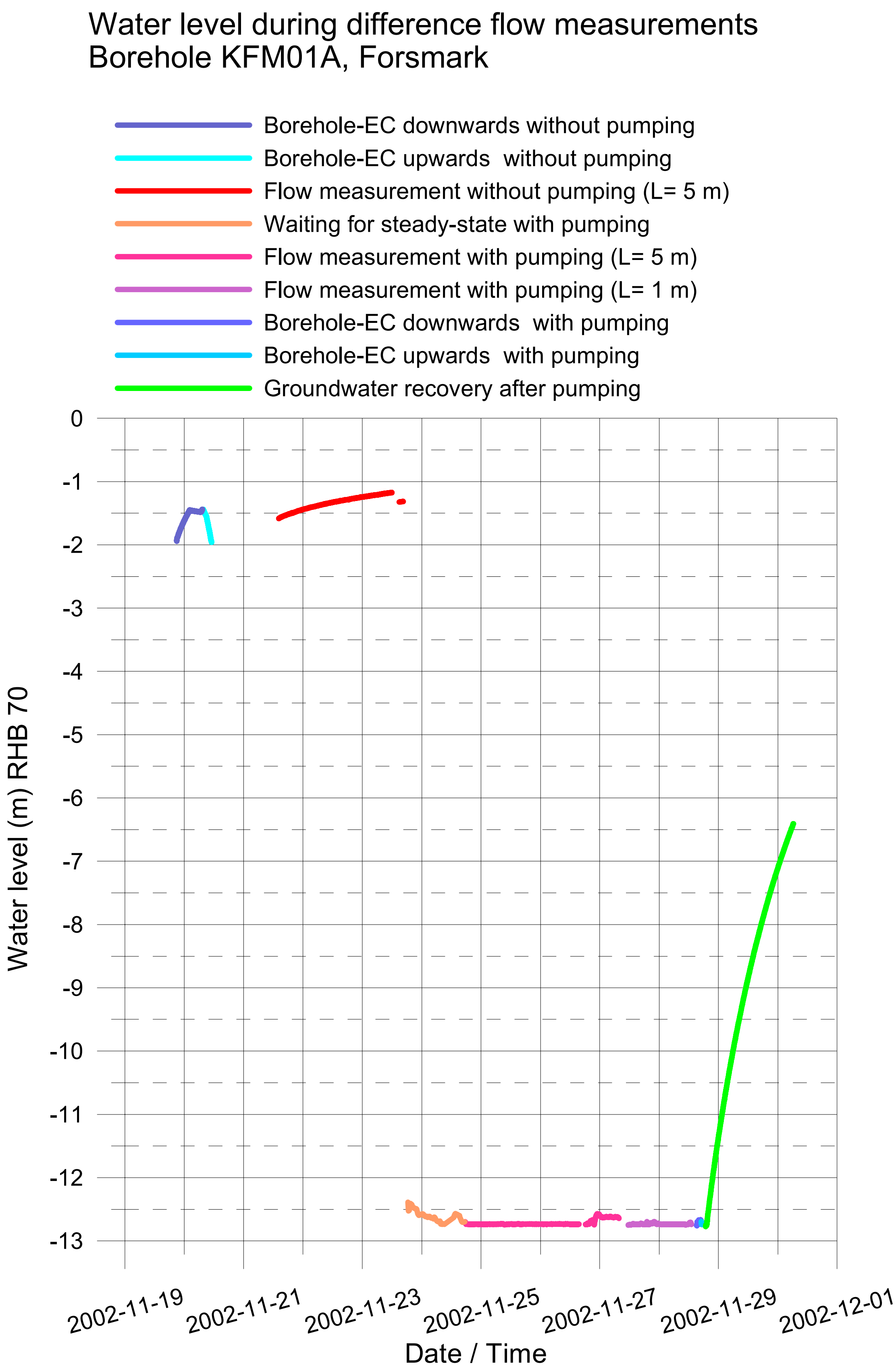


Figure 6-4. *Groundwater level in borehole KFM01A.*

Also the pumping rate was recorded, see Figure 6-5. It showed a decreasing trend from the beginning of the pumping period, changing from about 0.2 L/min to 0.17 L/min. This can be compared with the summed up flow results of the flow measurements from the entire borehole. The sum is about 0.16 L/min.

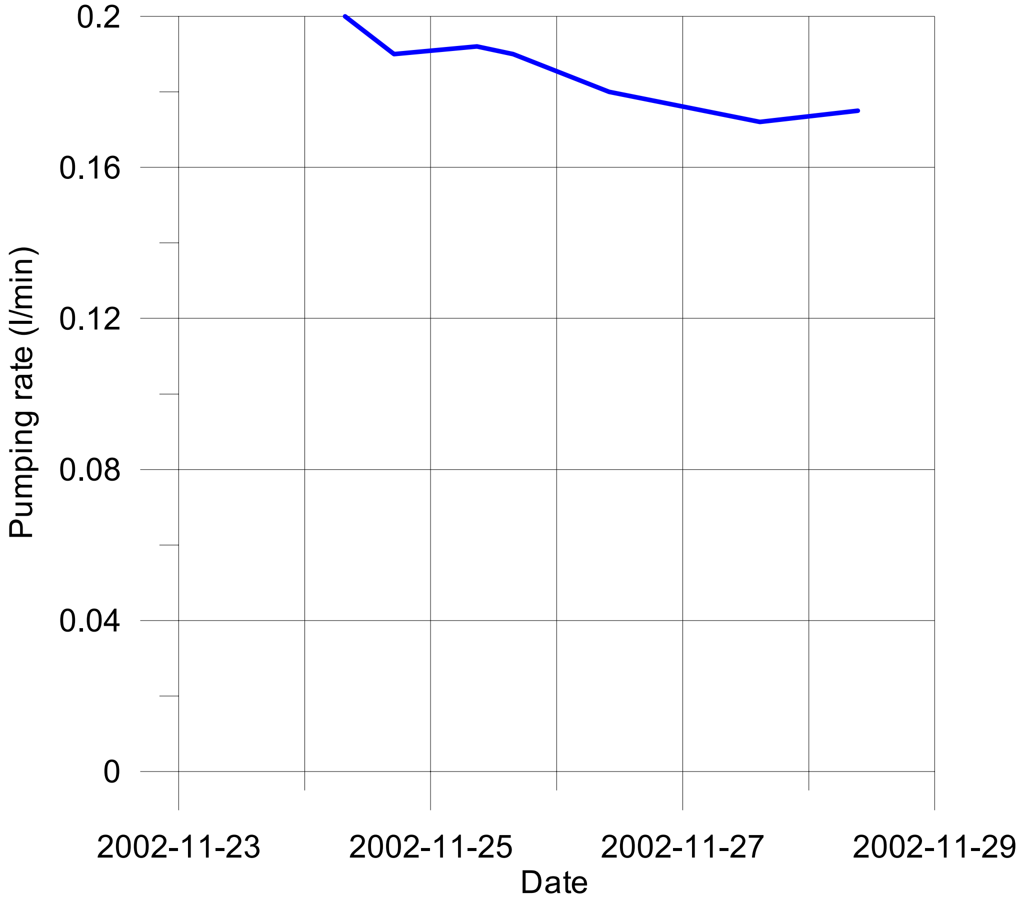


Figure 6-5. *Pumping rate during the flow logging.*

7 Discussion and conclusions

In this study the Posiva Flow Log/Difference Flow method has been used in combined sequential/overlapping logging mode to determine the depth to and flow rate of flowing fractures. Measurements were carried out when the borehole was at rest and during pumping. A 5 m section length with 0.5 m depth increments was used. The measurements were repeated using 1 m section length with 0.1 m depth increments over flow anomalies.

Depth calibration was made using depth marks in the borehole. The depth marks were detected by caliper and single point resistance logging. The latter method was performed simultaneously with the flow measurements, and thus all flow results could be depth calibrated.

The distribution of saline water in the borehole was logged by electric conductivity and temperature measurements of the borehole water.

Exceptional features observed in borehole KFM01A were its tightness, detected fluctuation of flow and high frictional resistance during transfer of the testing tool up and down in the borehole.

Only a few flow yielding fractures were detected. Transmissivity and head were calculated for these fractures. The highest transmissivity was observed in the fractures at 118.3 m and 178.3 m depth.

The base level of flow (lower measurement limit) was low. This usually indicates that the borehole and fracture system is well cleaned from drill cuttings.

The field work went smoothly, at least from the contractors point of view. An important reason to this is that the site was well organized. The measurements, which were going on round the clock, including weekends, could be carried out in a relatively short time.

8 References

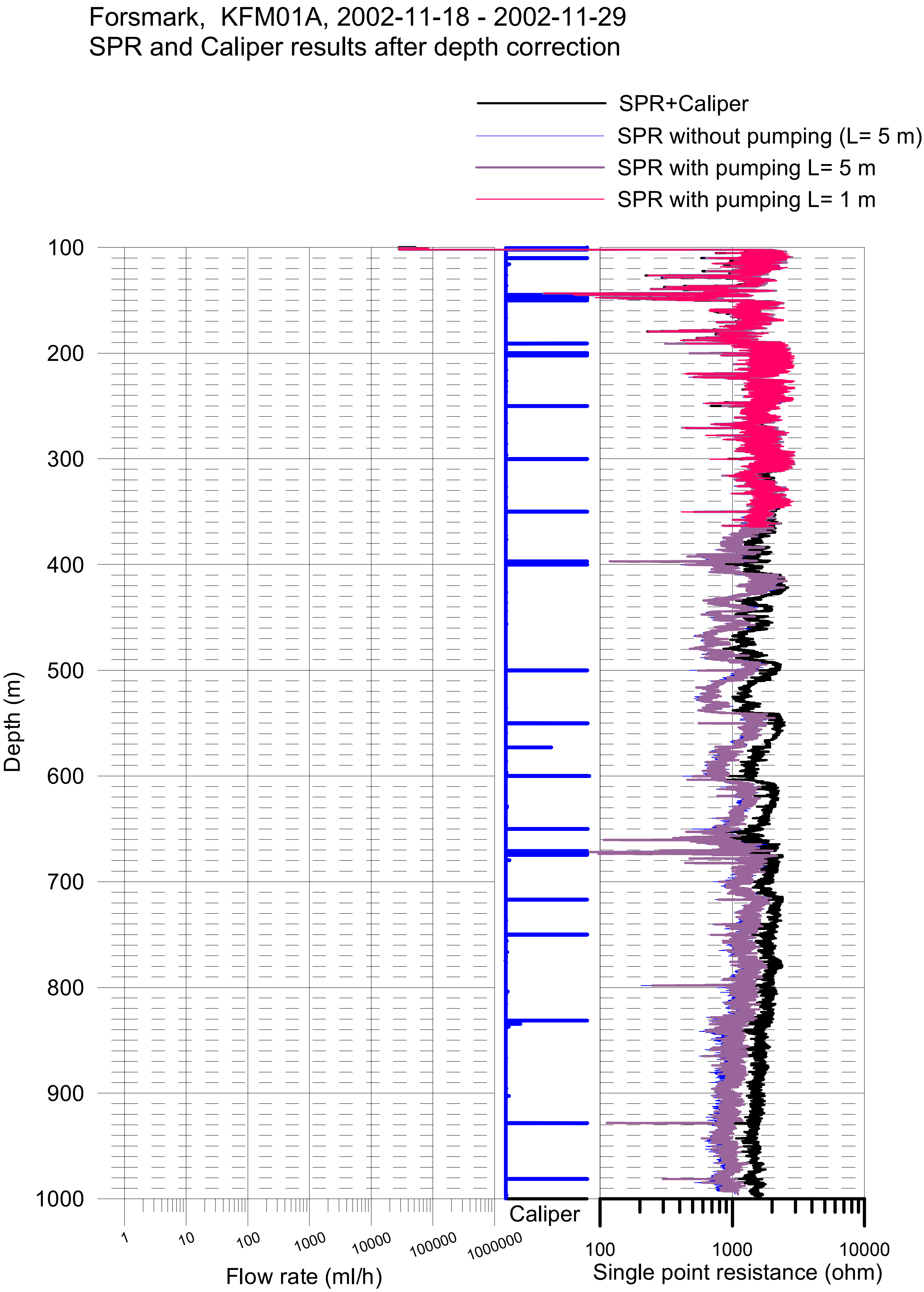
Heikkonen J, Heikkinen E, Mäntynen M, 2002. Mathematical modelling of temperature adjustment algorithm for groundwater electrical conductivity on basis of synthetic water sample analysis. Helsinki, Posiva Oy. Working report 2002-10 (in Finnish).

Ludvigson J-E, Hansson K, Rouhiainen P, 2002. Methodology study of Posiva difference flow meter in borehole KLX02 at Laxemar. SKB Rapport R-01-52.

Pöllänen J, 2002. Density and pressure of water in deep boreholes. Helsinki, Posiva Oy. Working Report 2002-17 (in Finnish).

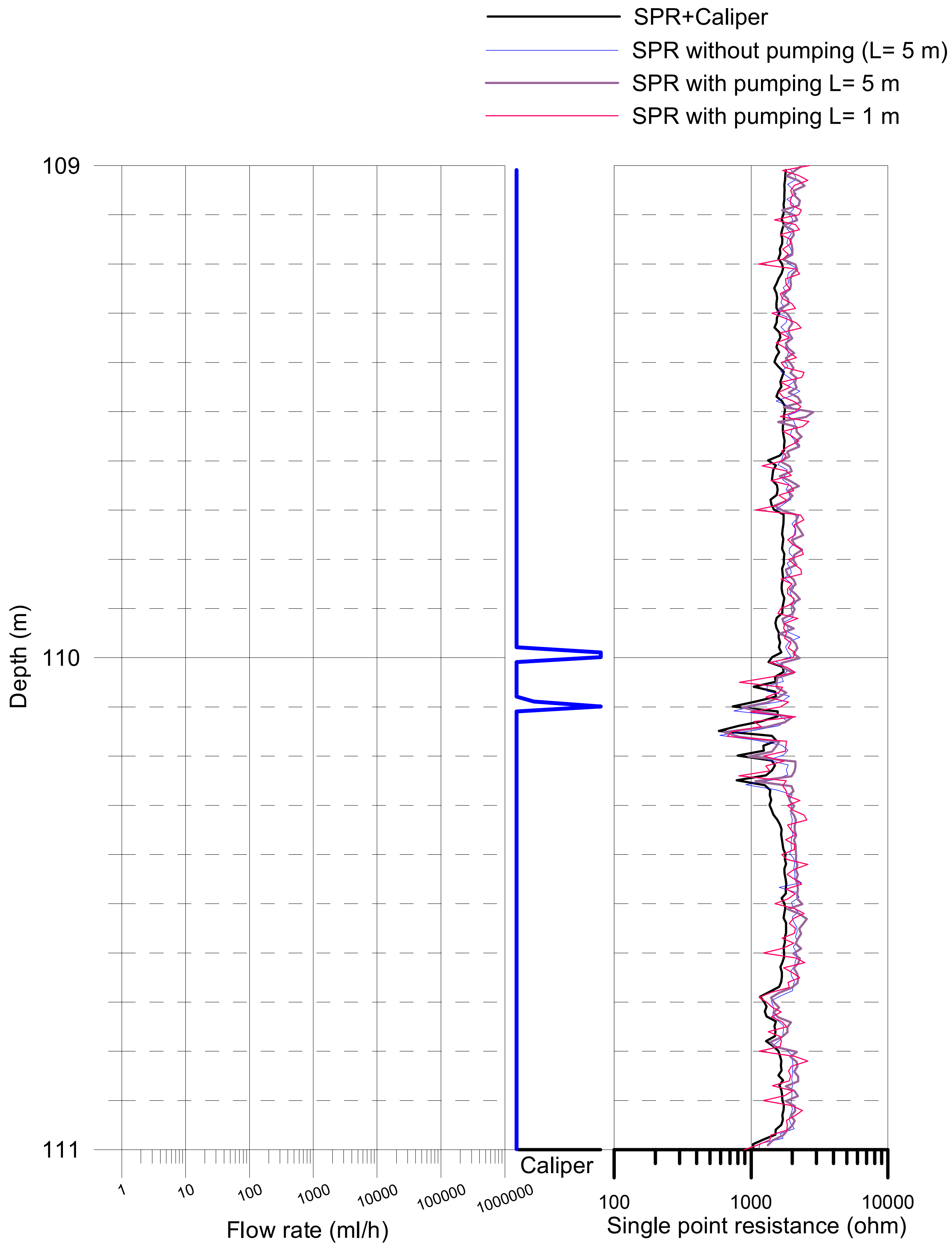
Öhberg A, Rouhiainen P, 2000. Posiva groundwater flow measuring techniques. Helsinki, Posiva Oy. Report POSIVA 2000-12.

9 Appendices

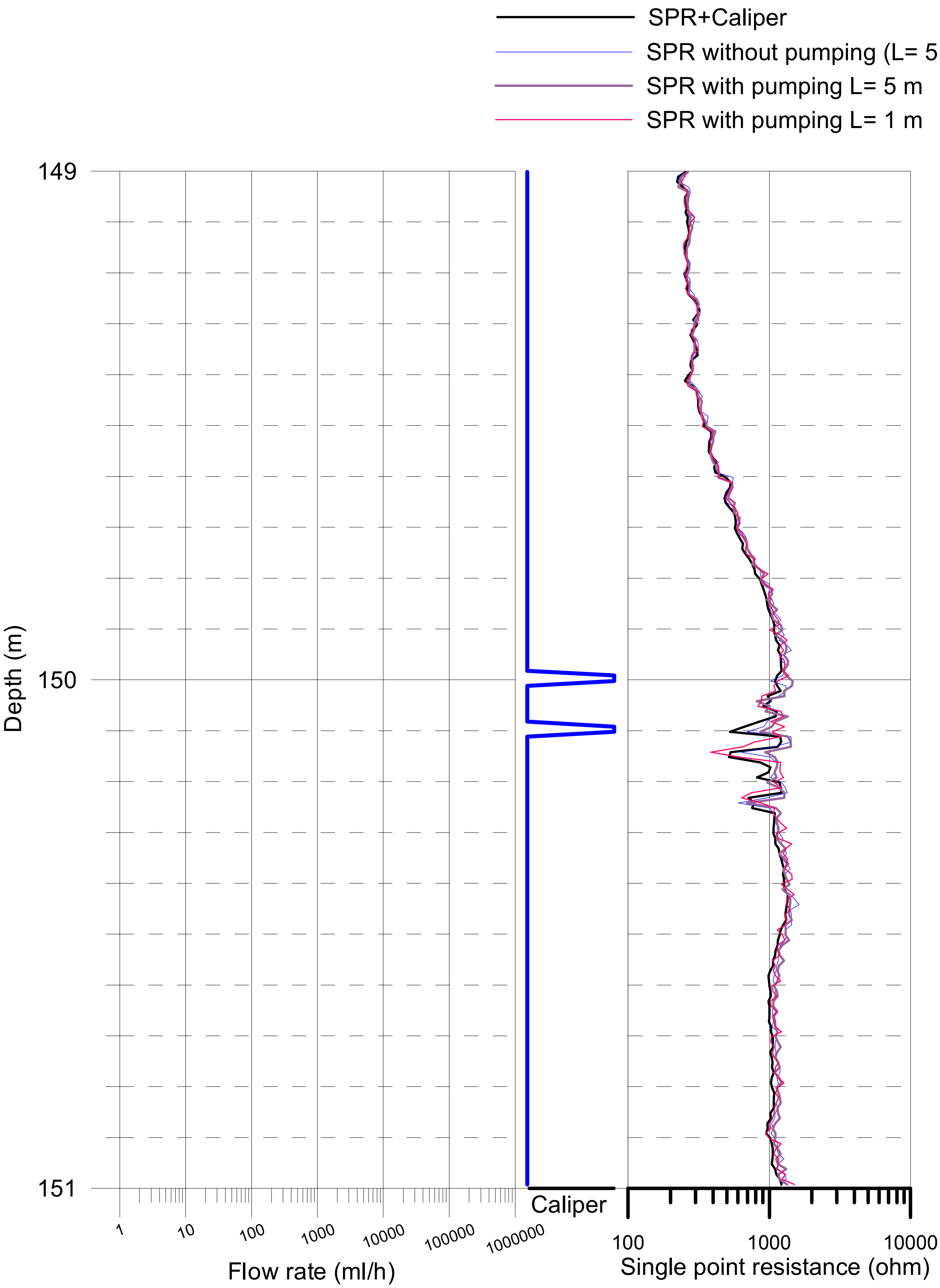


Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction
SPR+Caliper
SPR without pumping (L= 5 m)
SPR with pumping L= 5 m
SPR with pumping L= 1 m
Depth (m)
100
200
300
400
500
600
700
800
900
1000
1
10
100
1000
10000
100000
1000000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

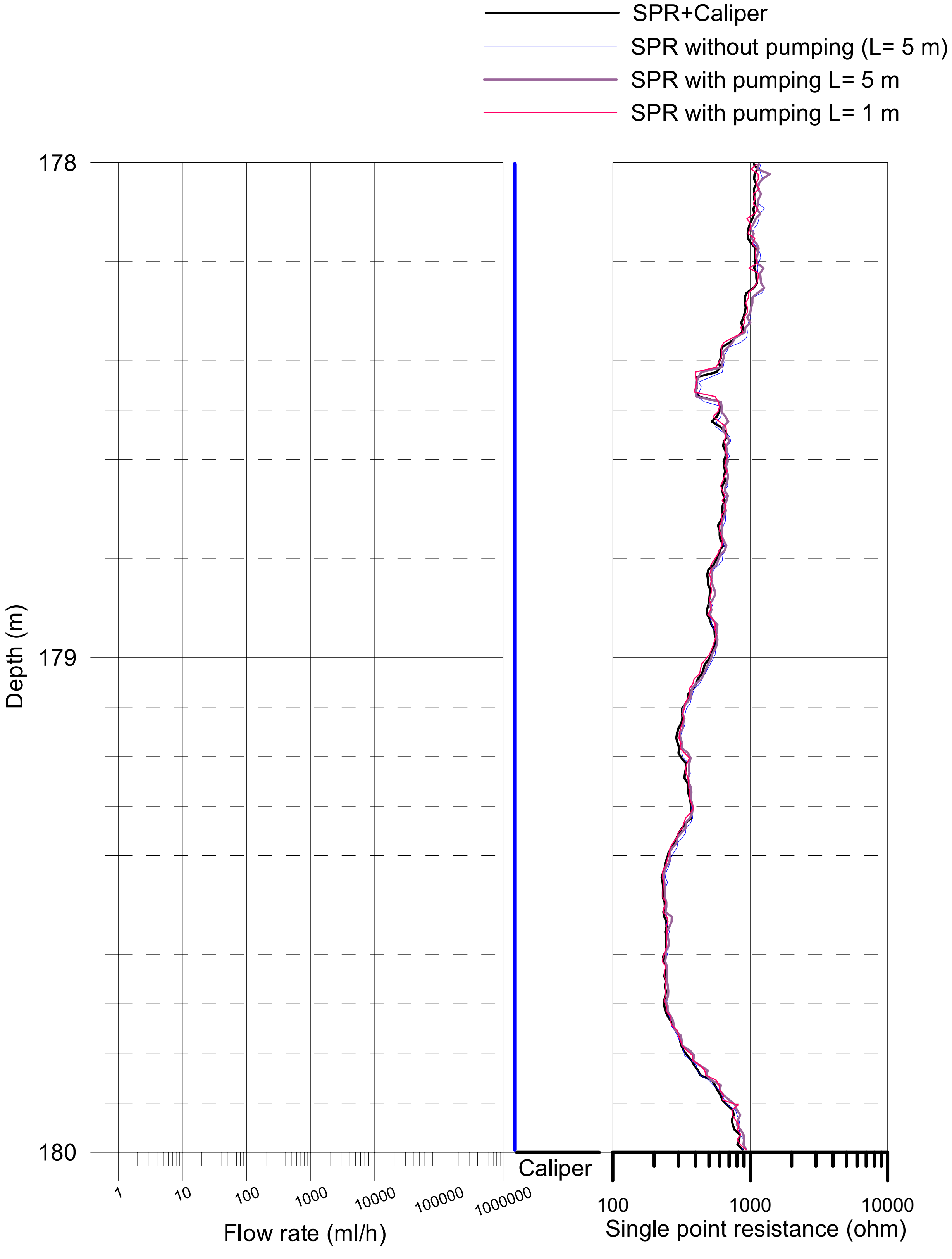
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



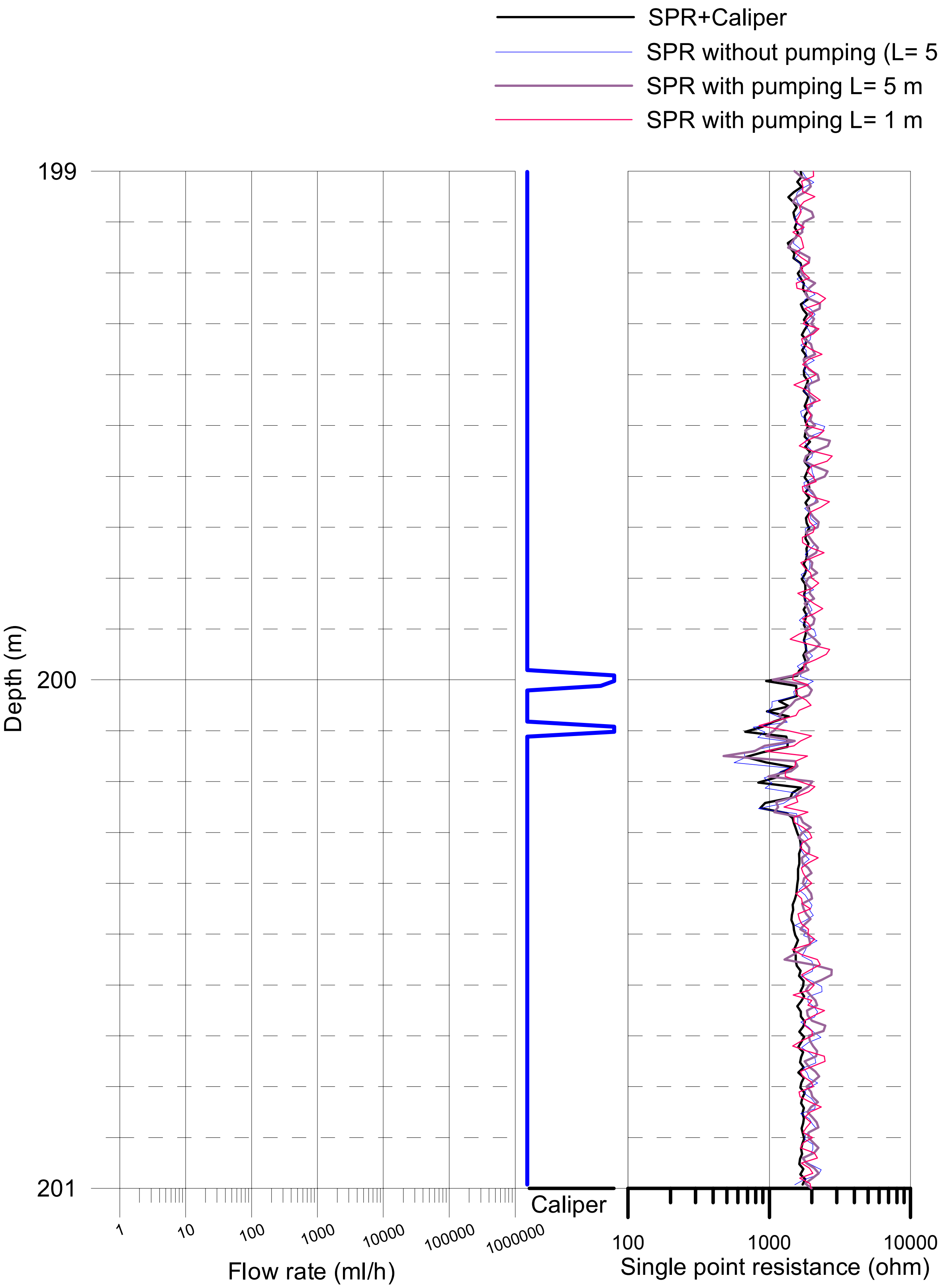
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



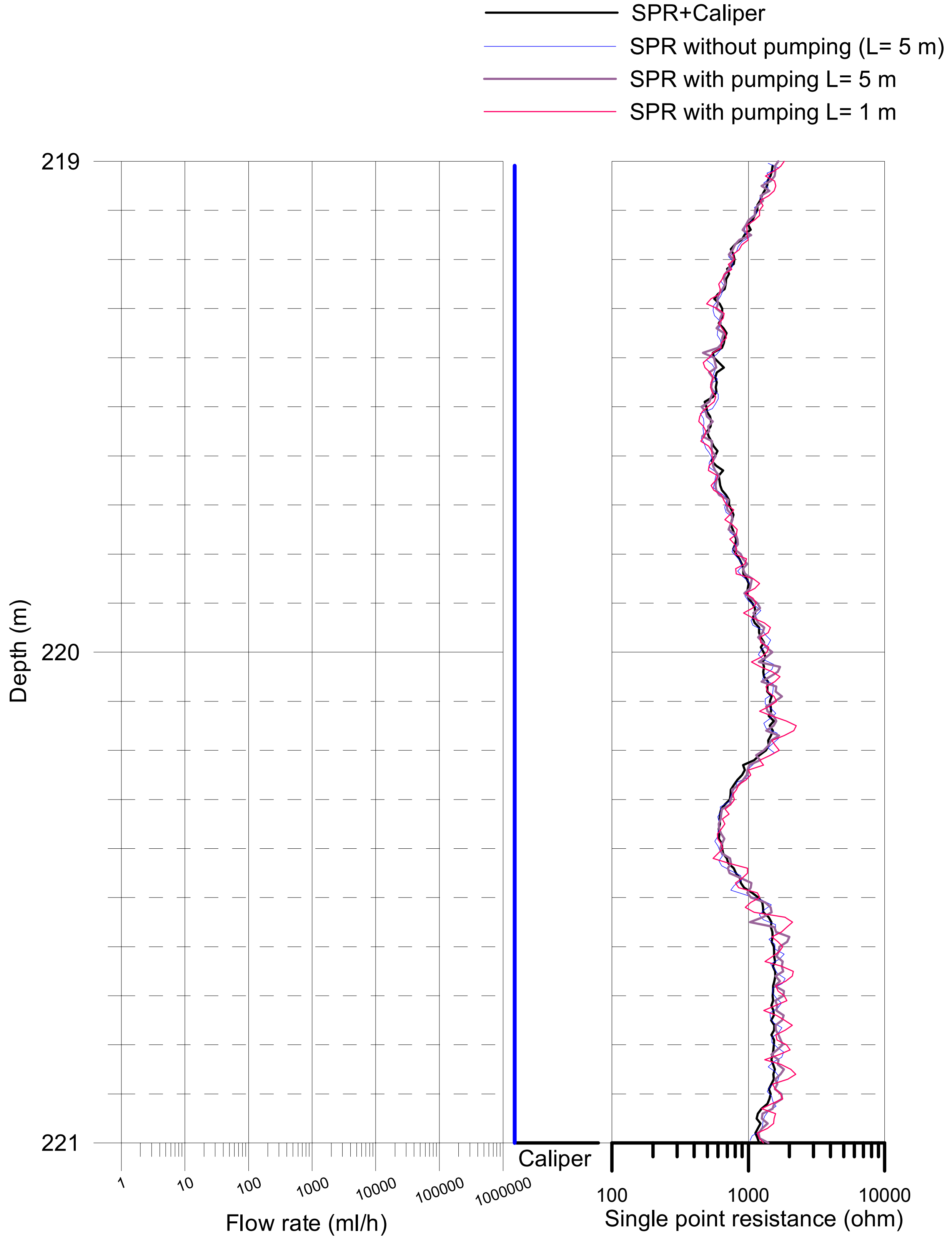
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



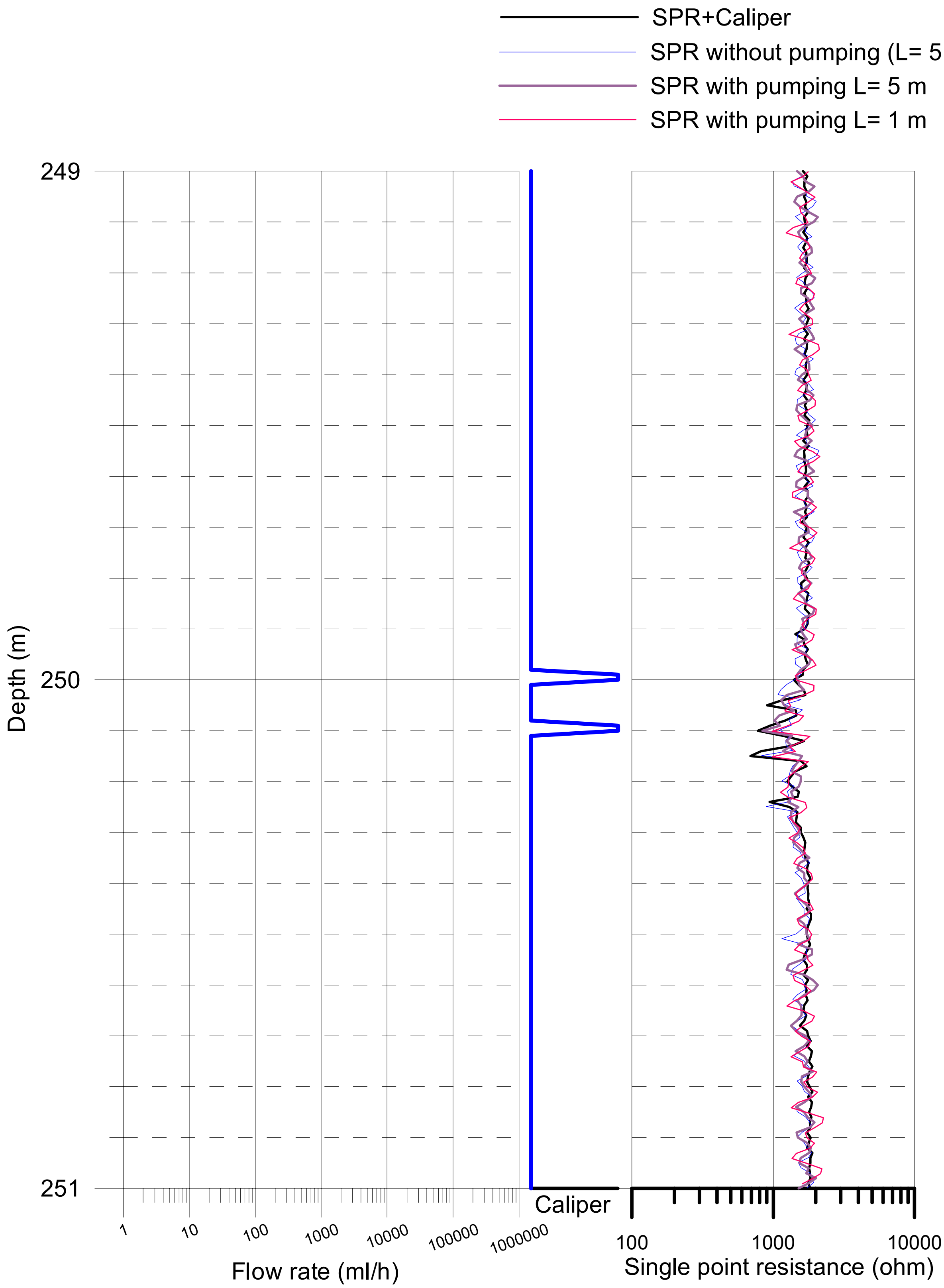
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



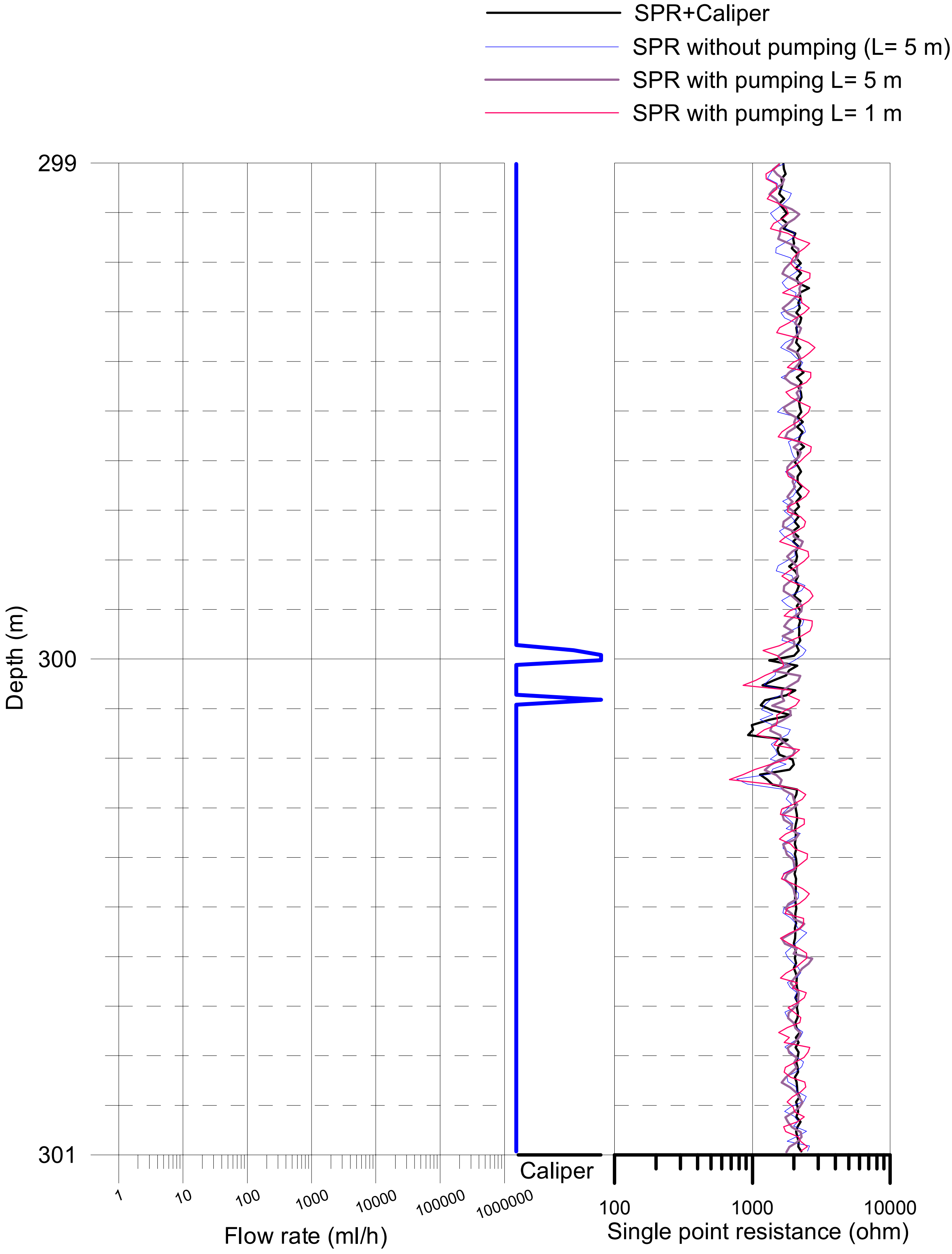
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



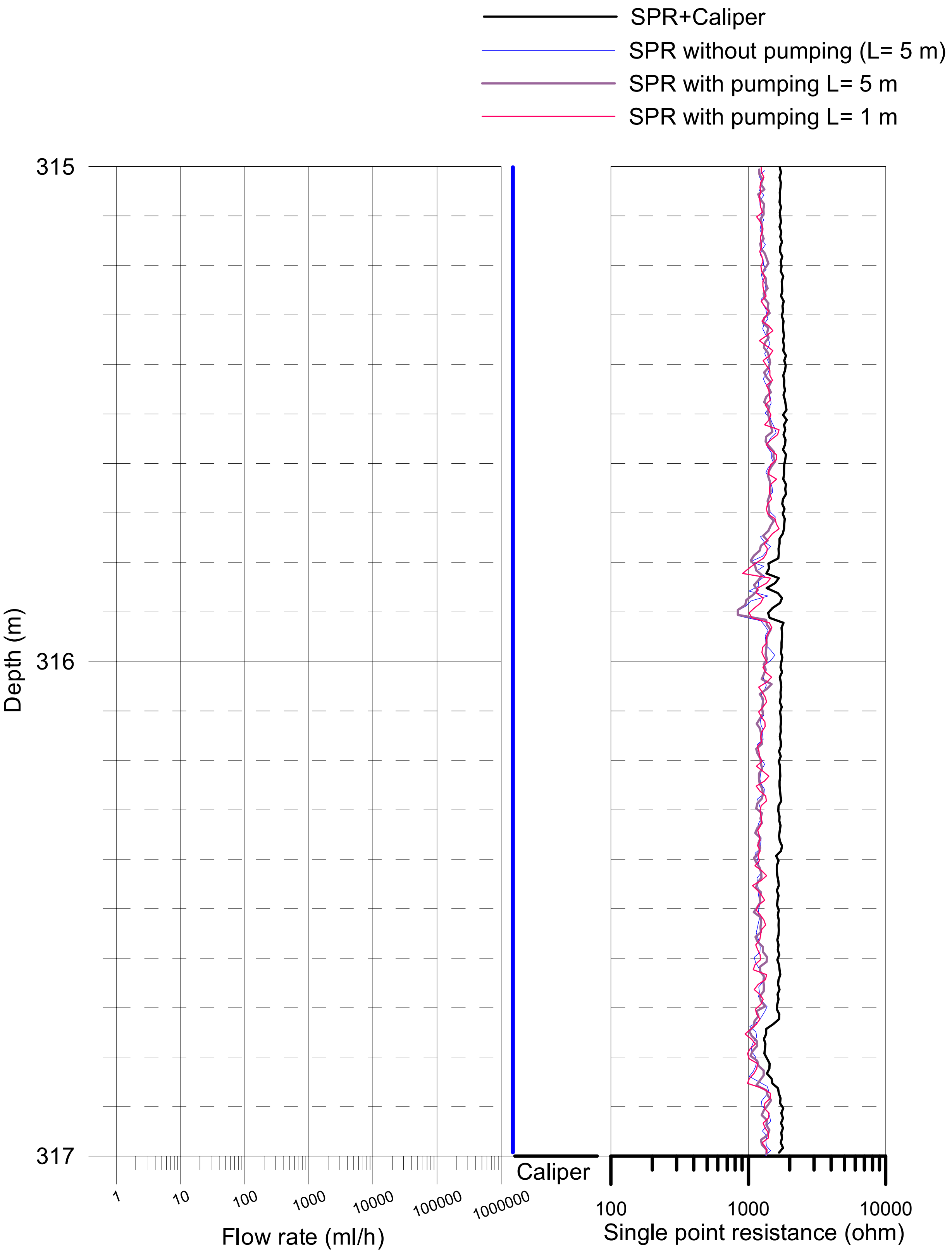
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



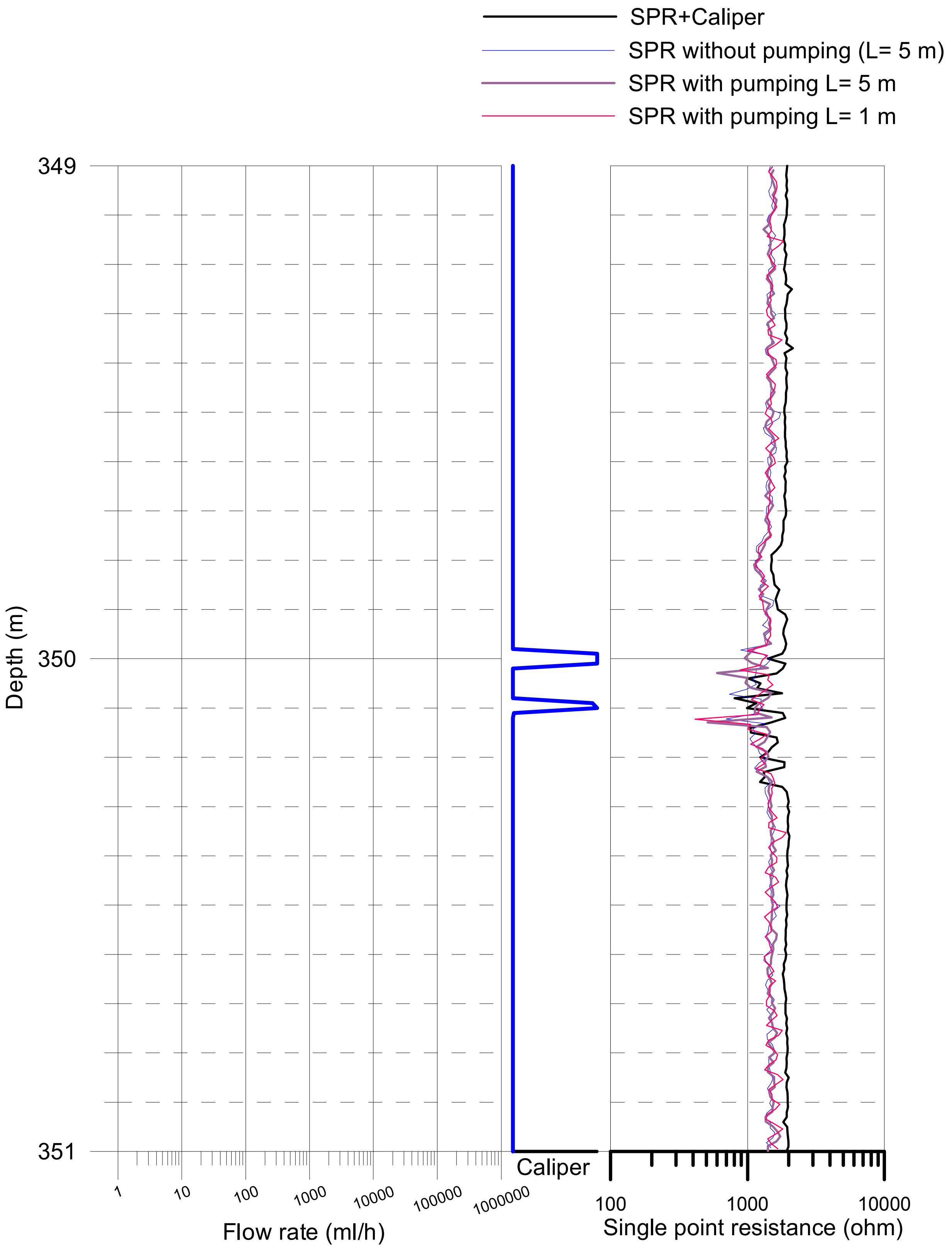
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



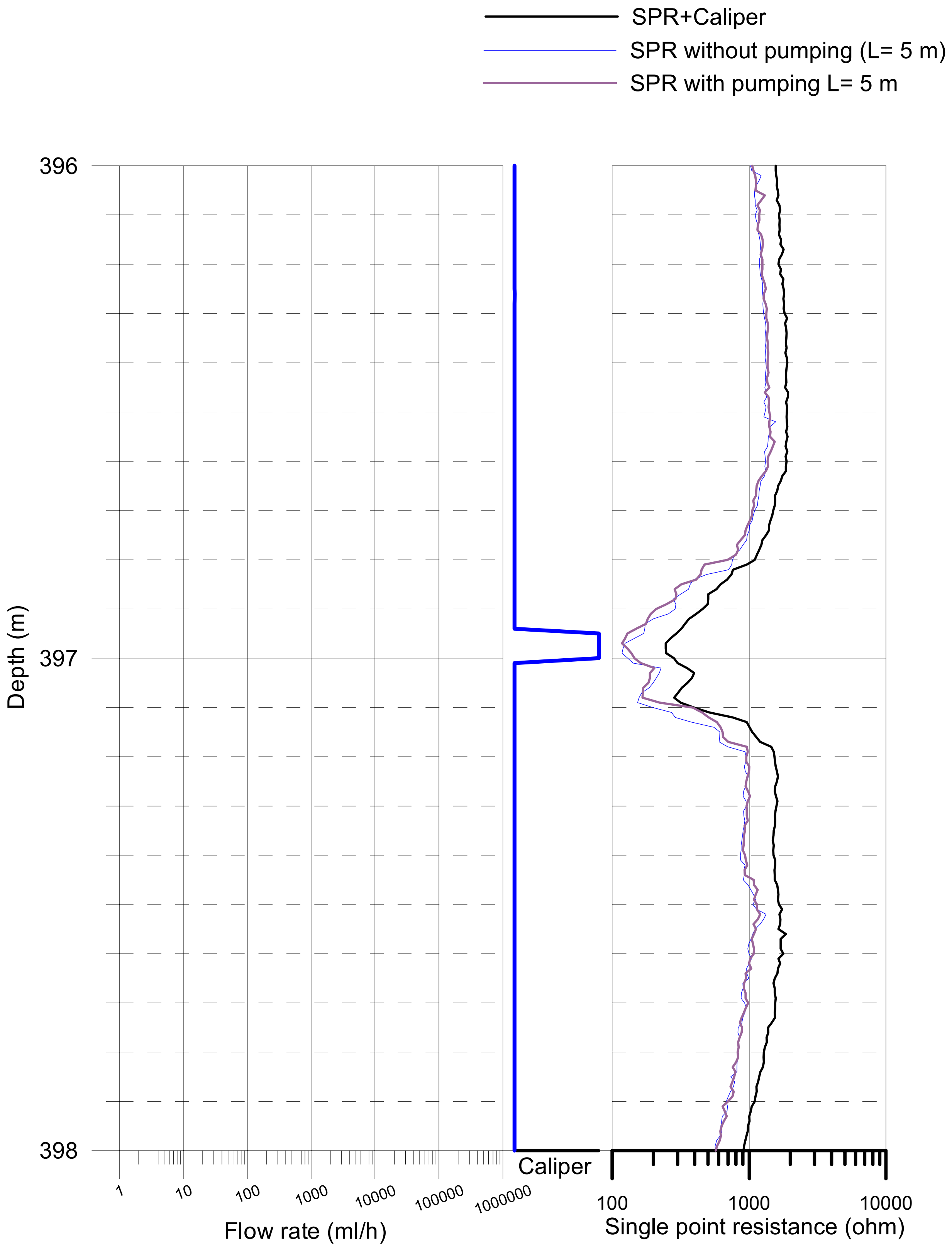
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



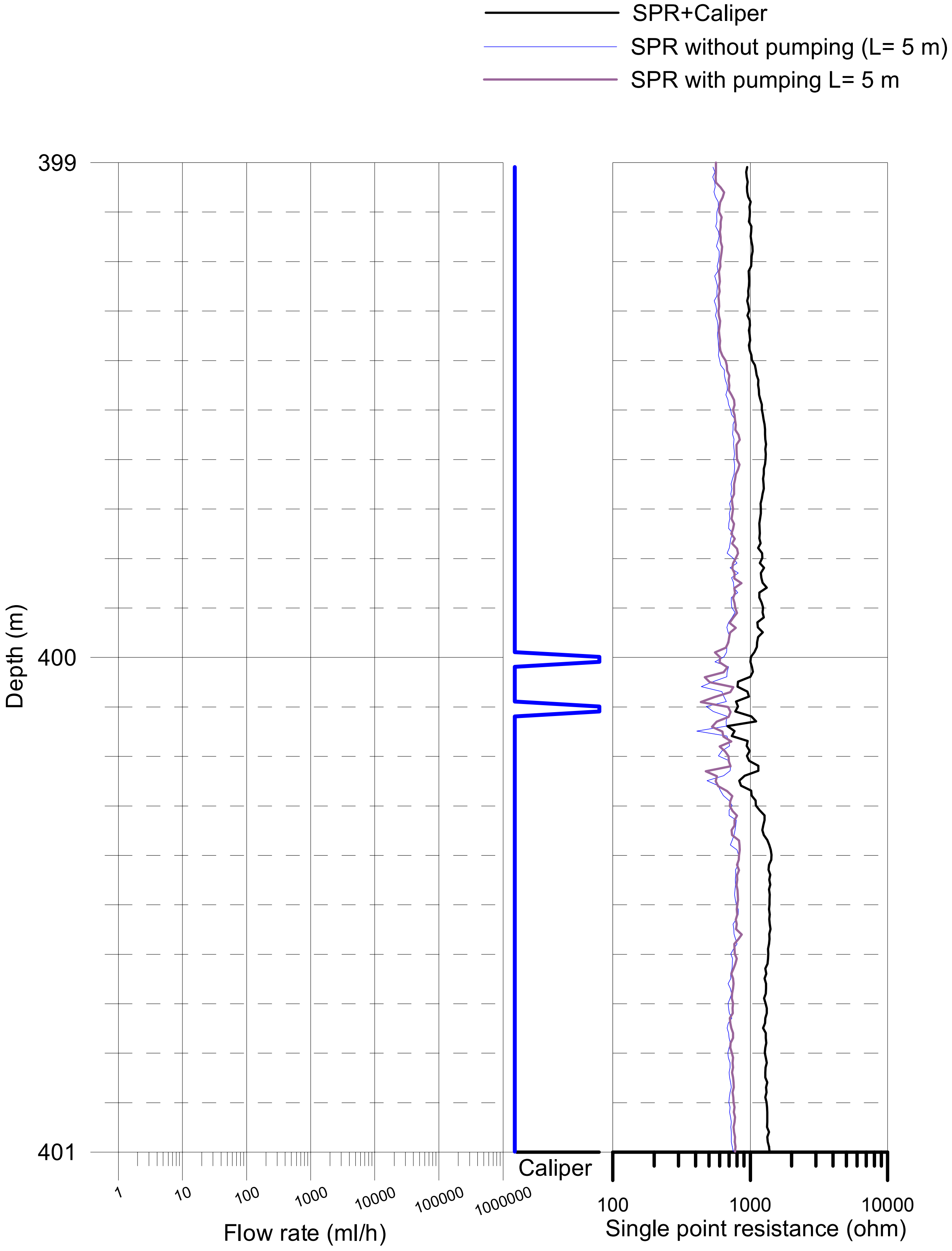
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



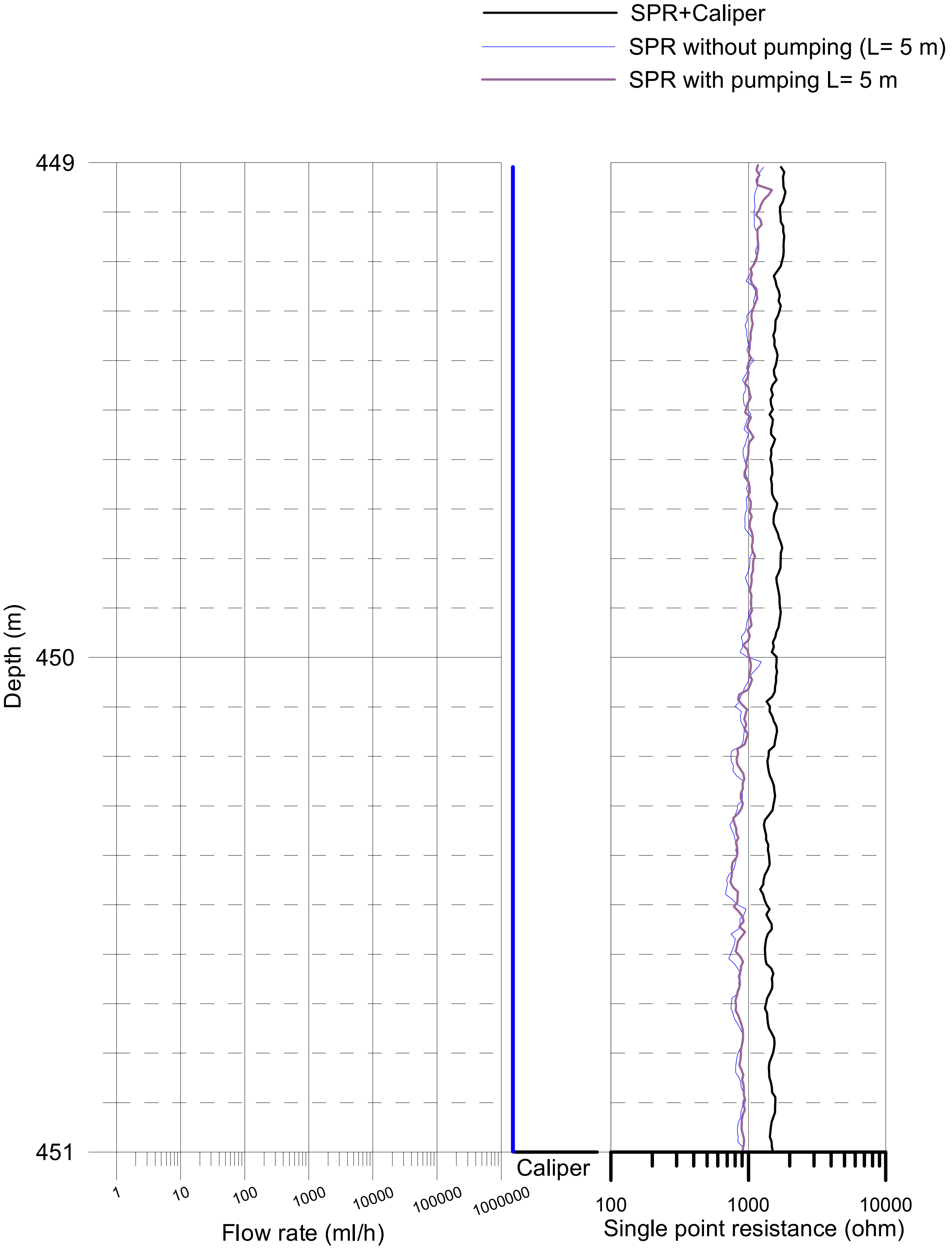
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



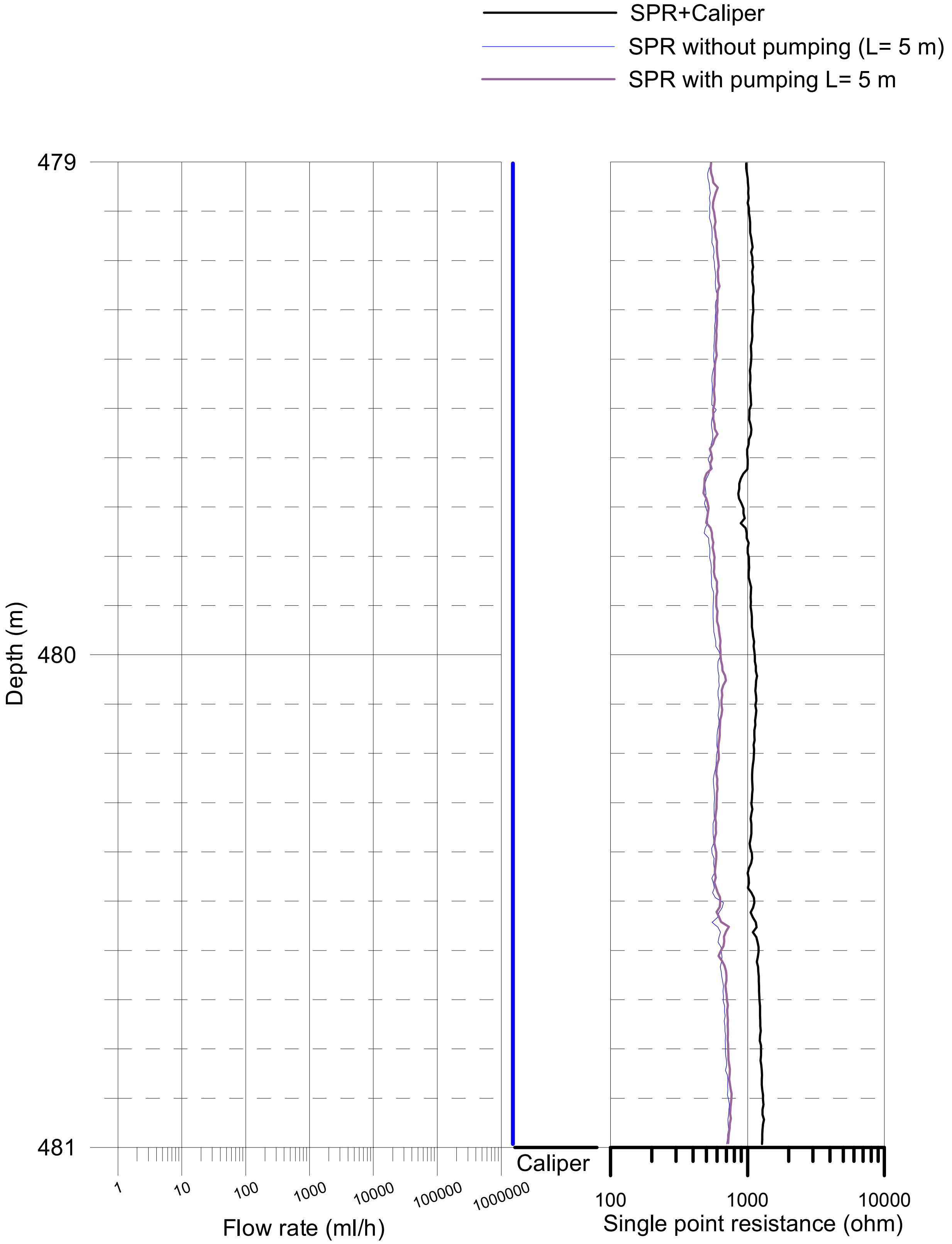
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



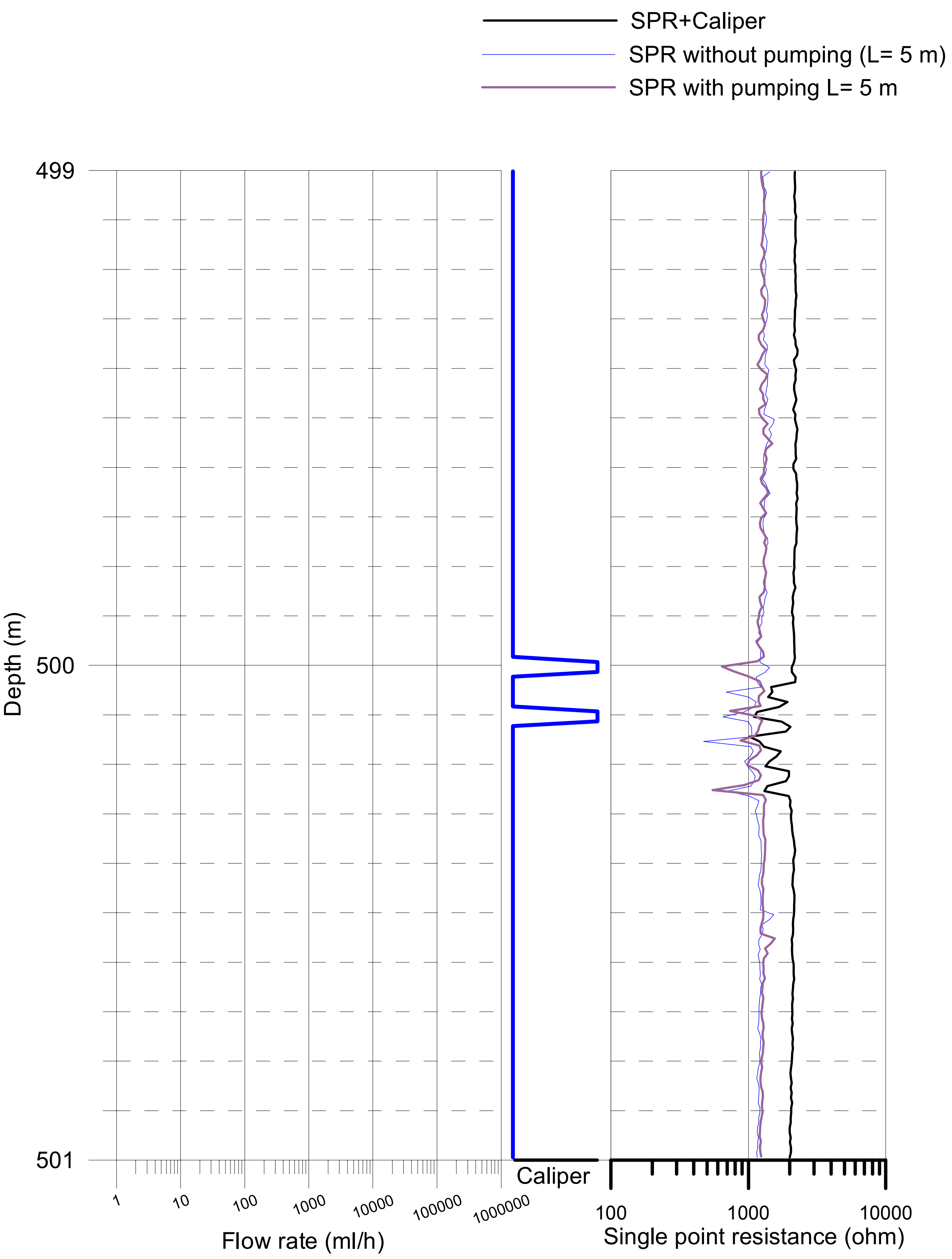
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction

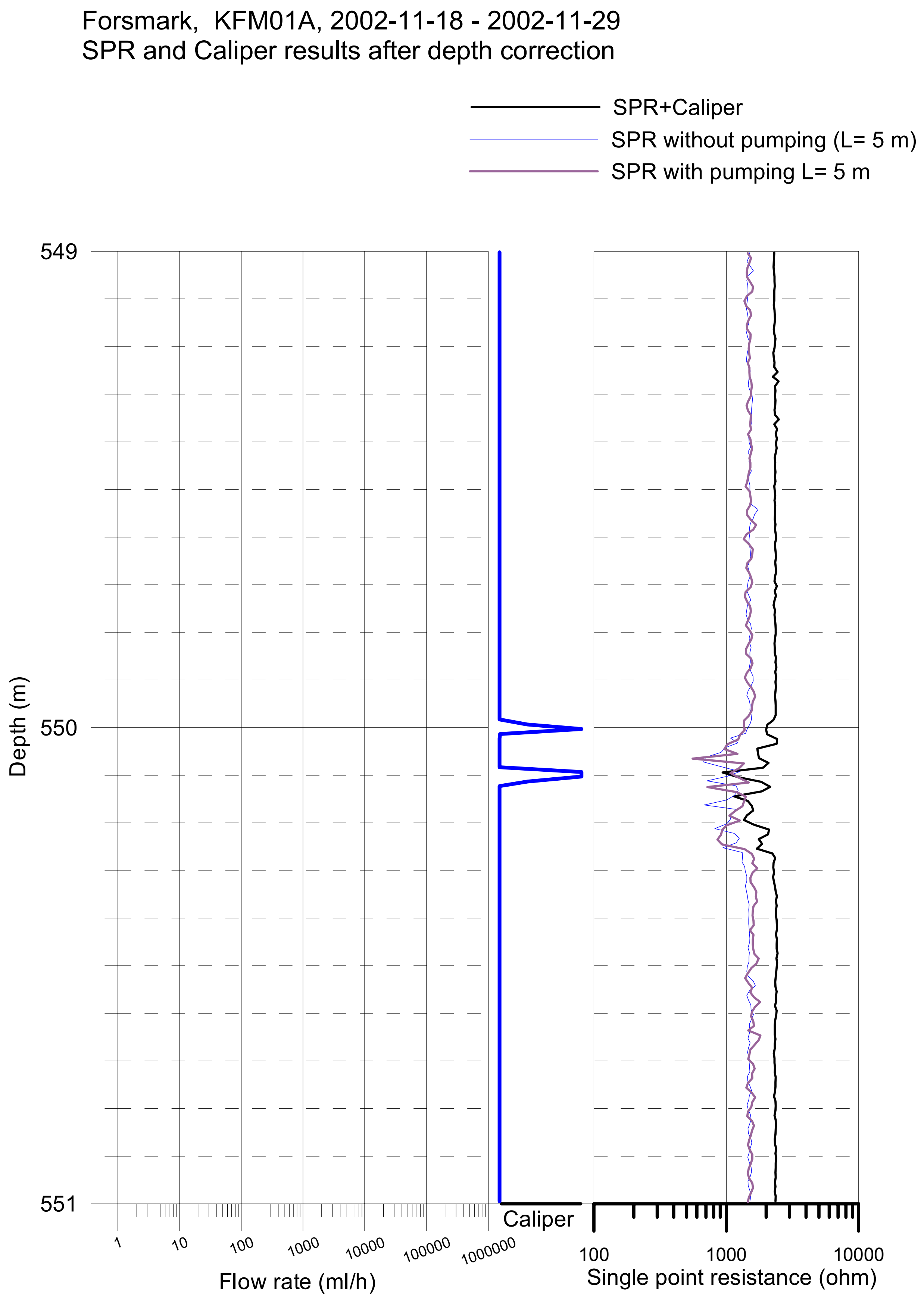


Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



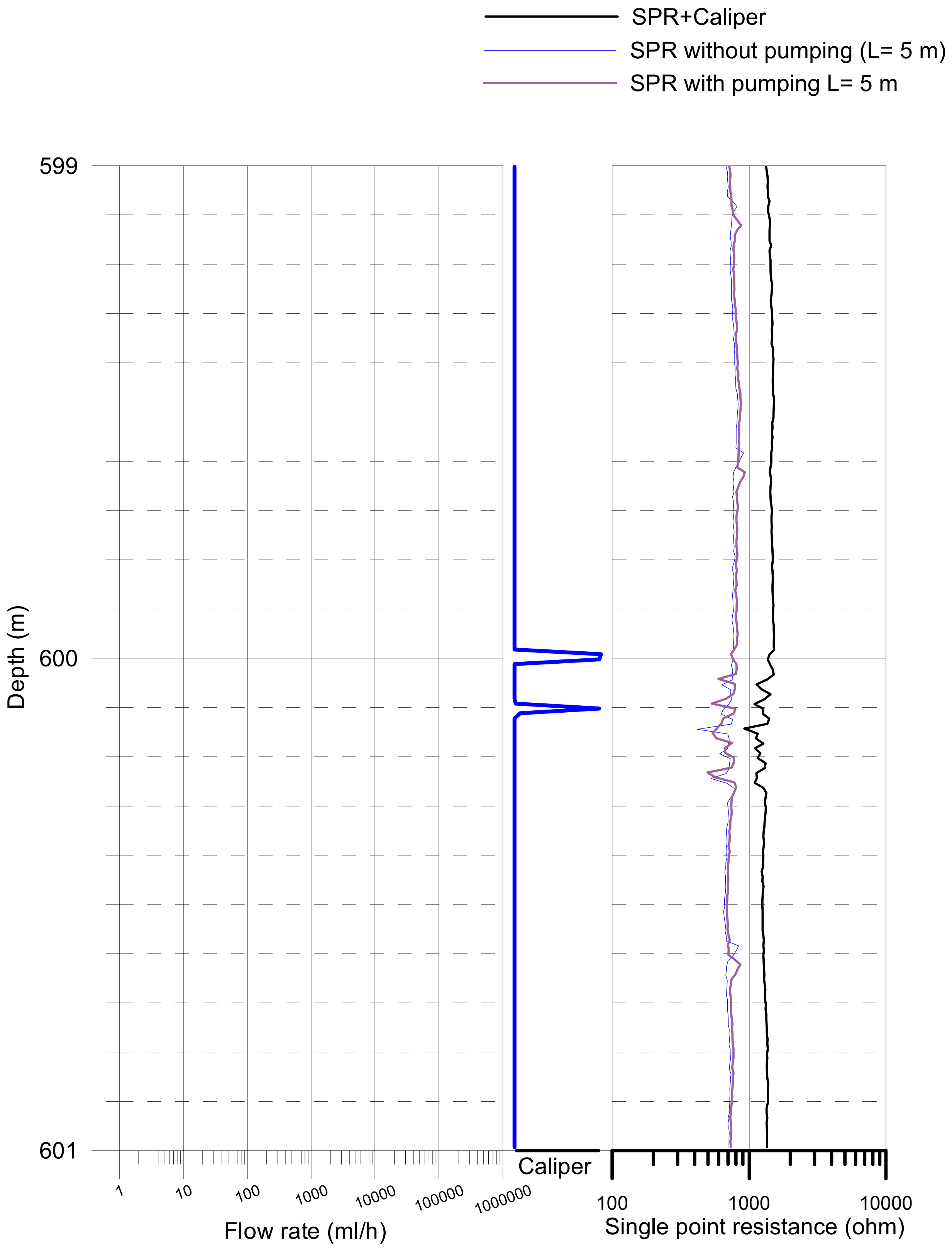
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



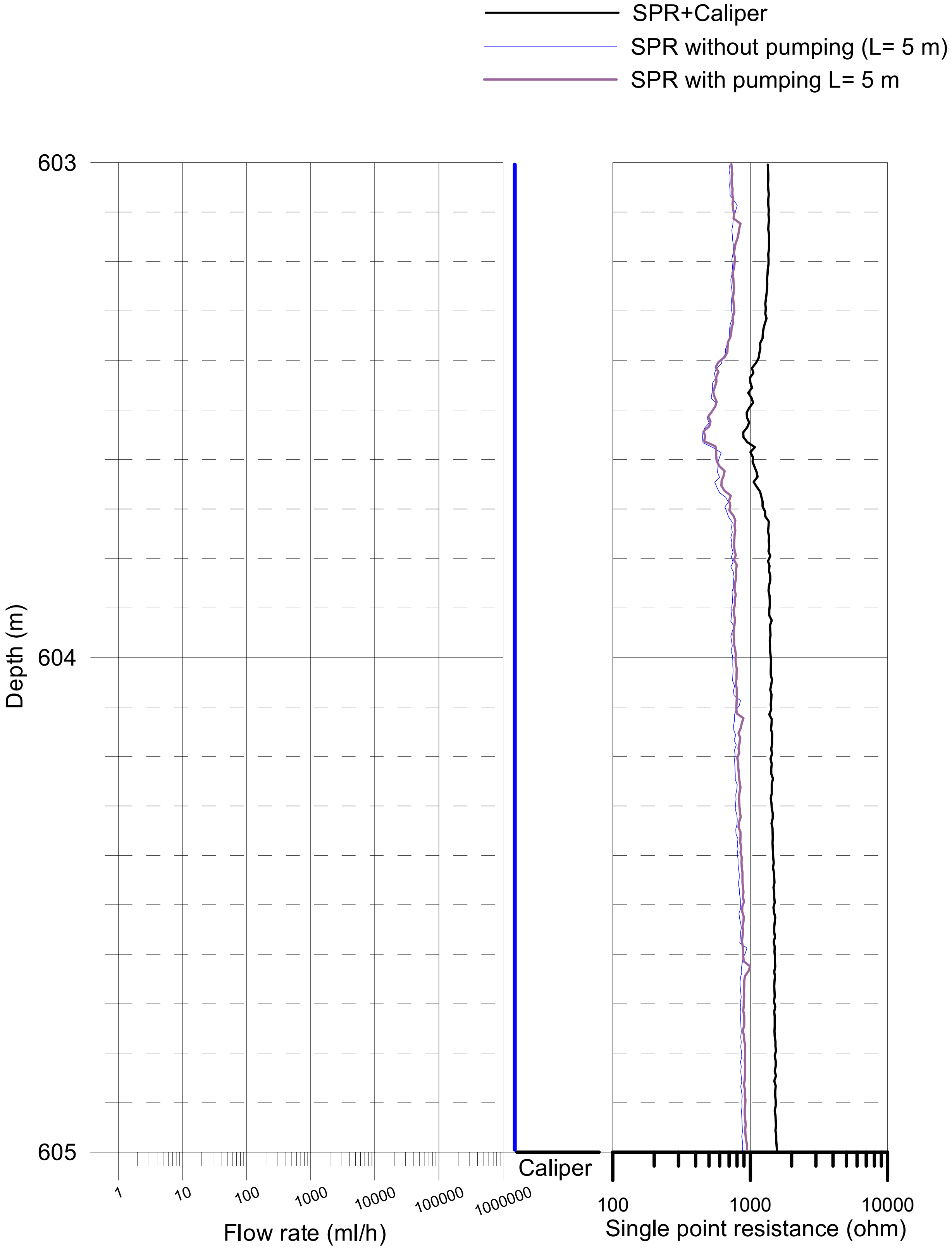


Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction
SPR+Caliper
SPR without pumping (L= 5 m)
SPR with pumping L= 5 m
549
550
551
Depth (m)
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (ml/h)
100
1000
10000
Single point resistance (ohm)

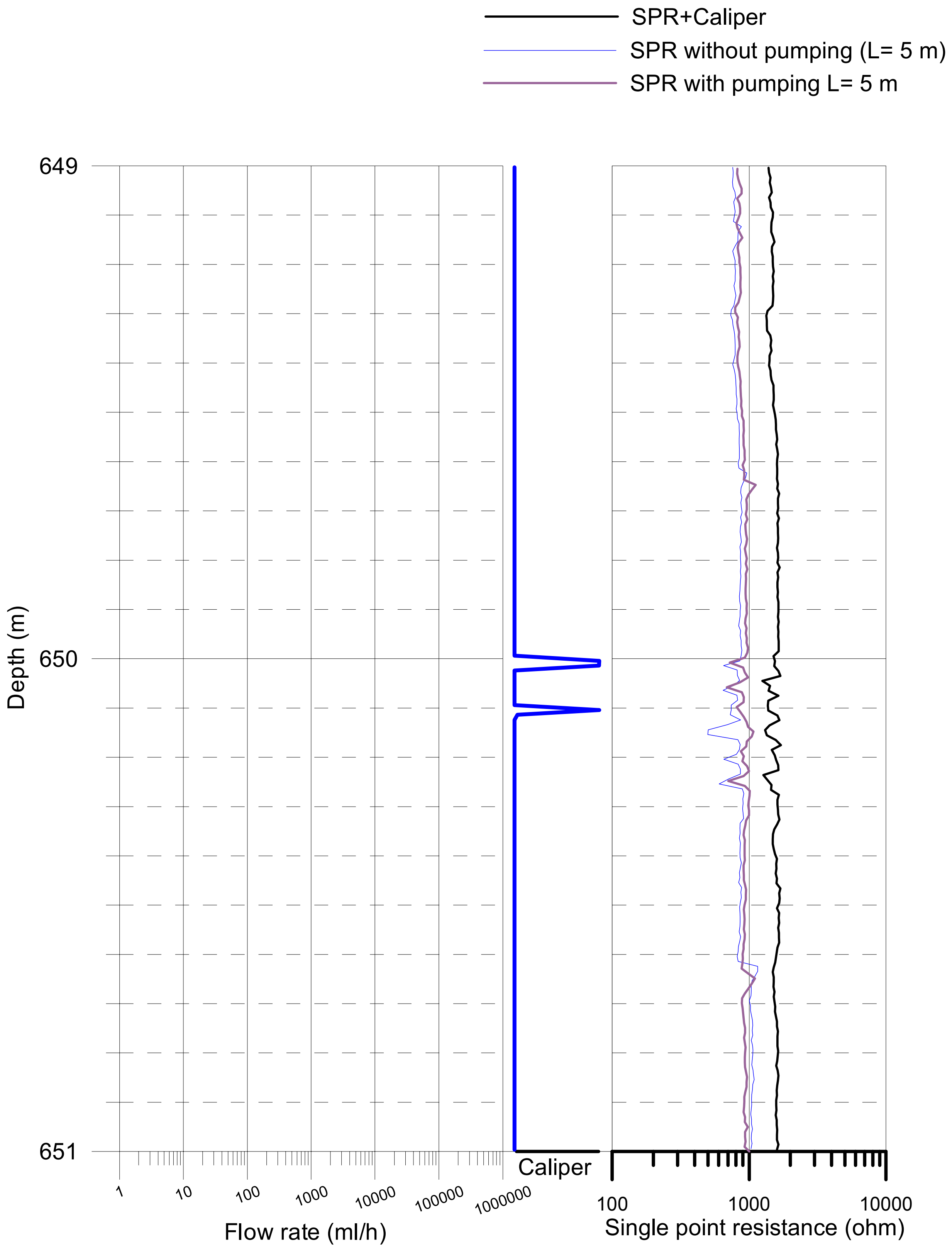
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



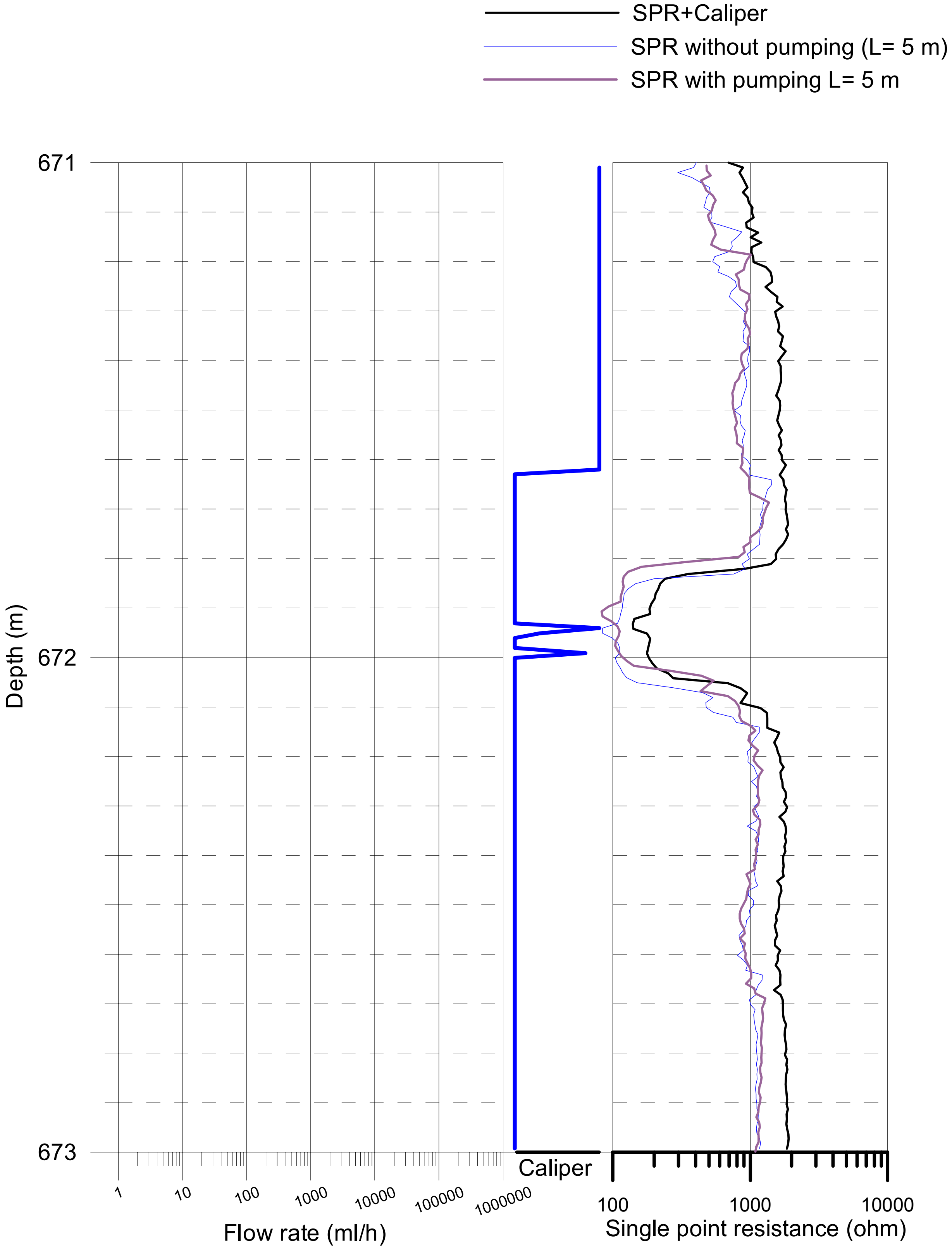
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



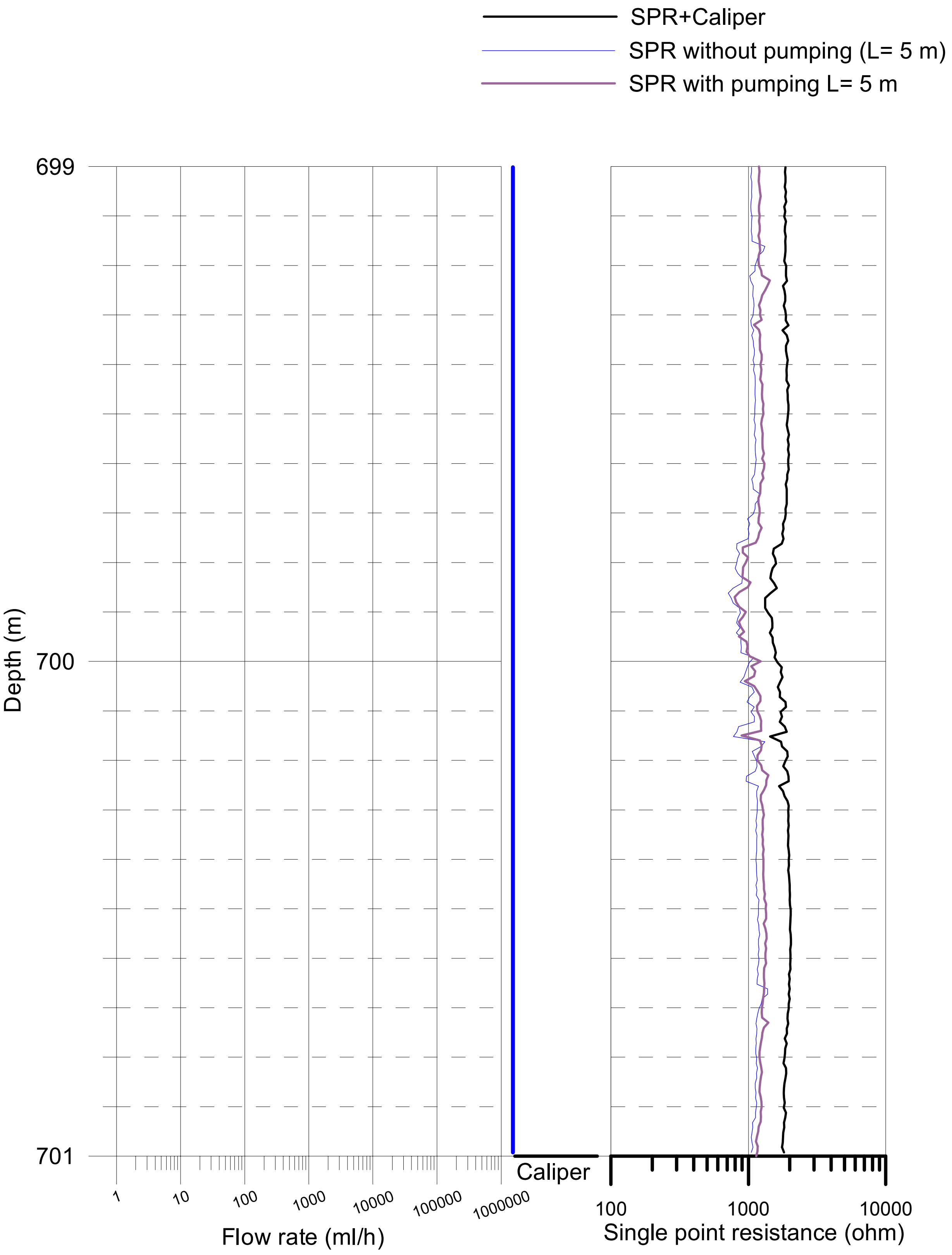
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



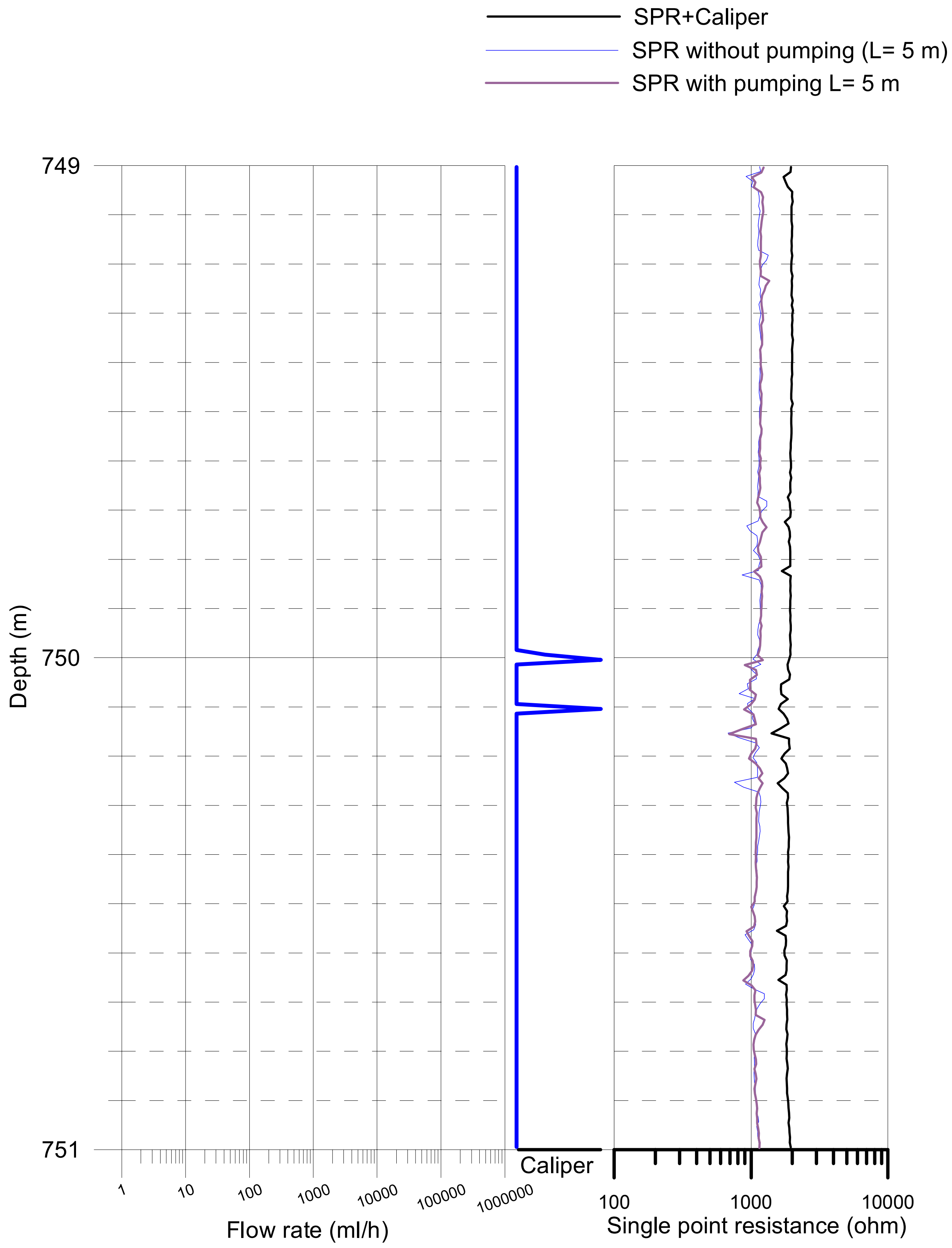
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



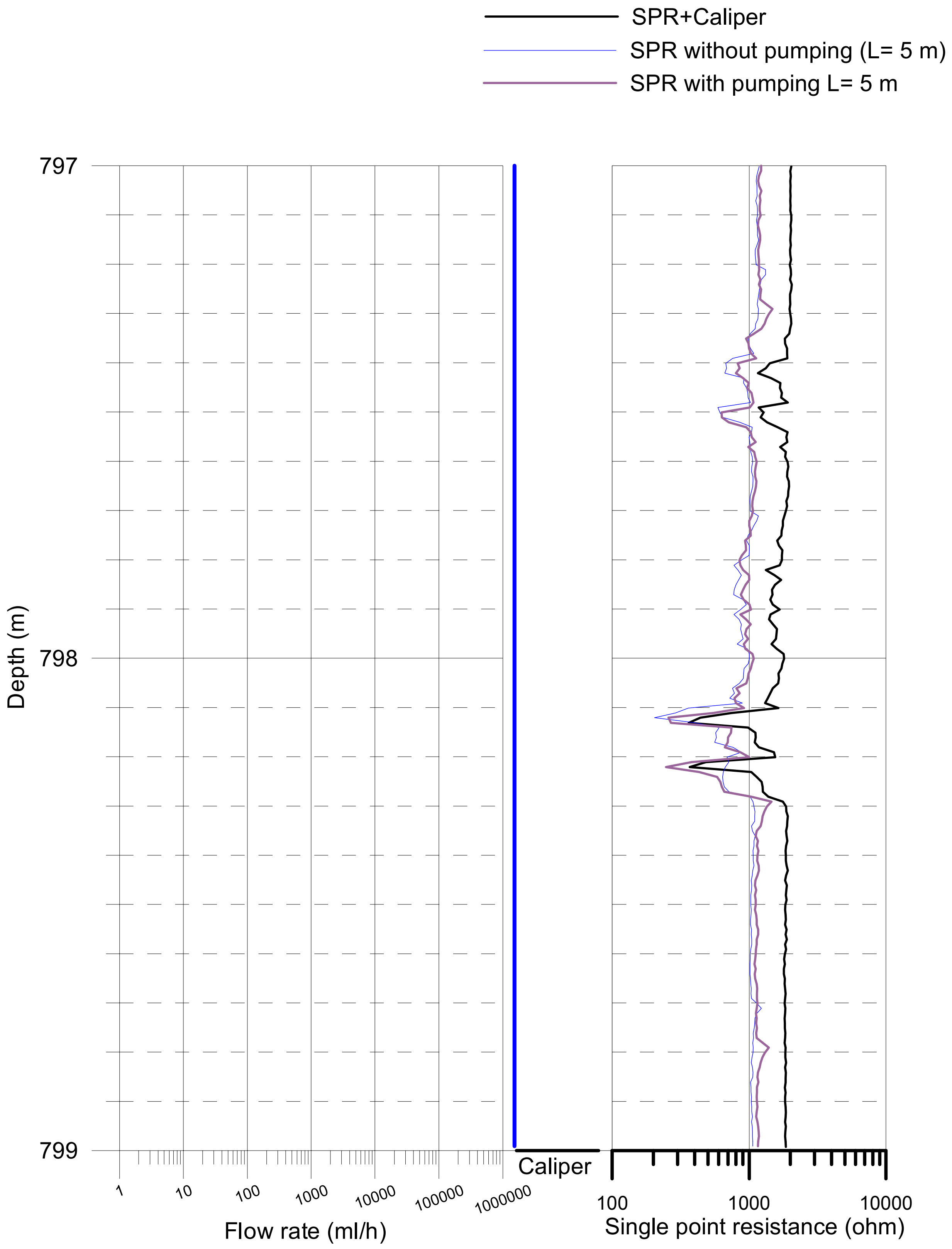
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



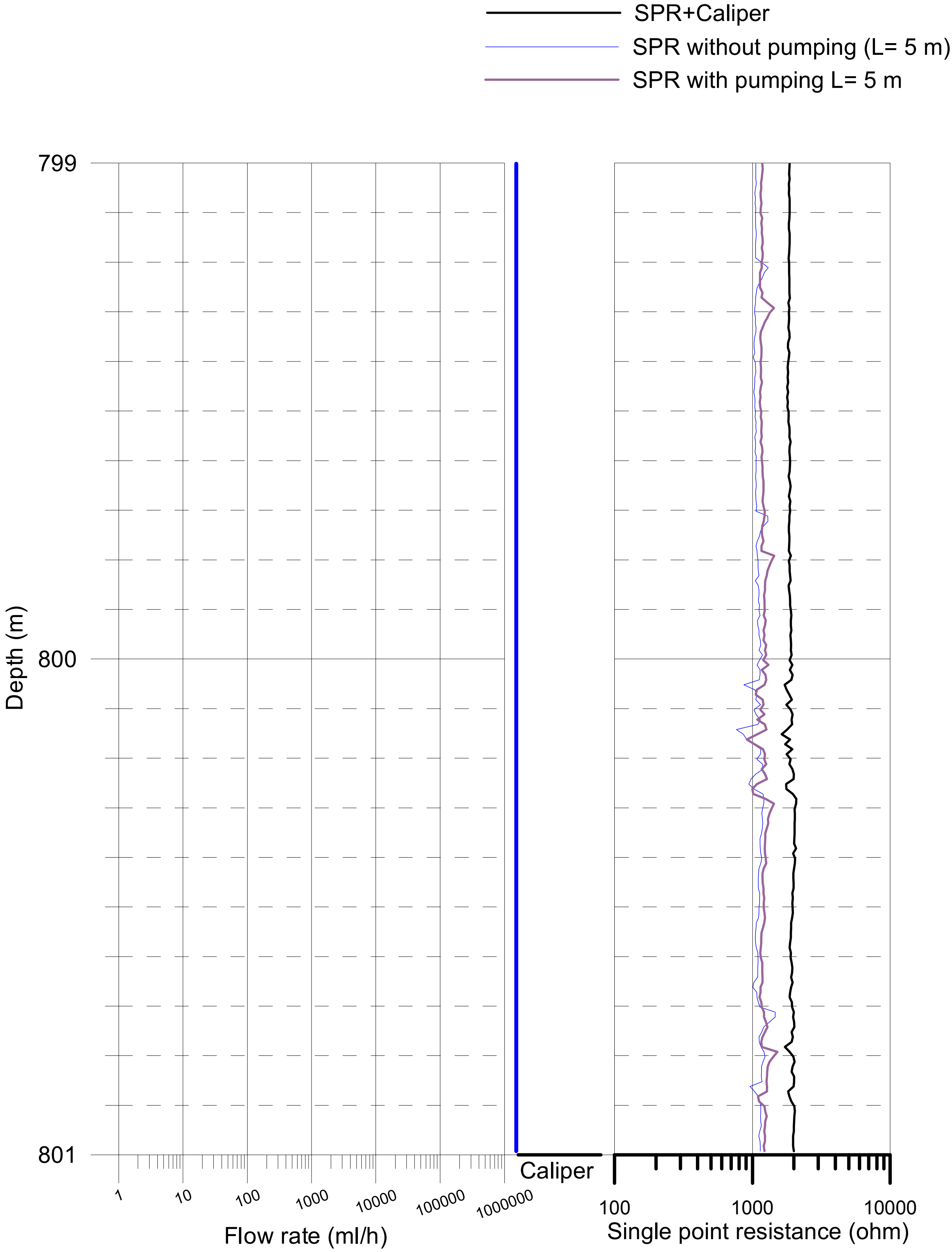
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



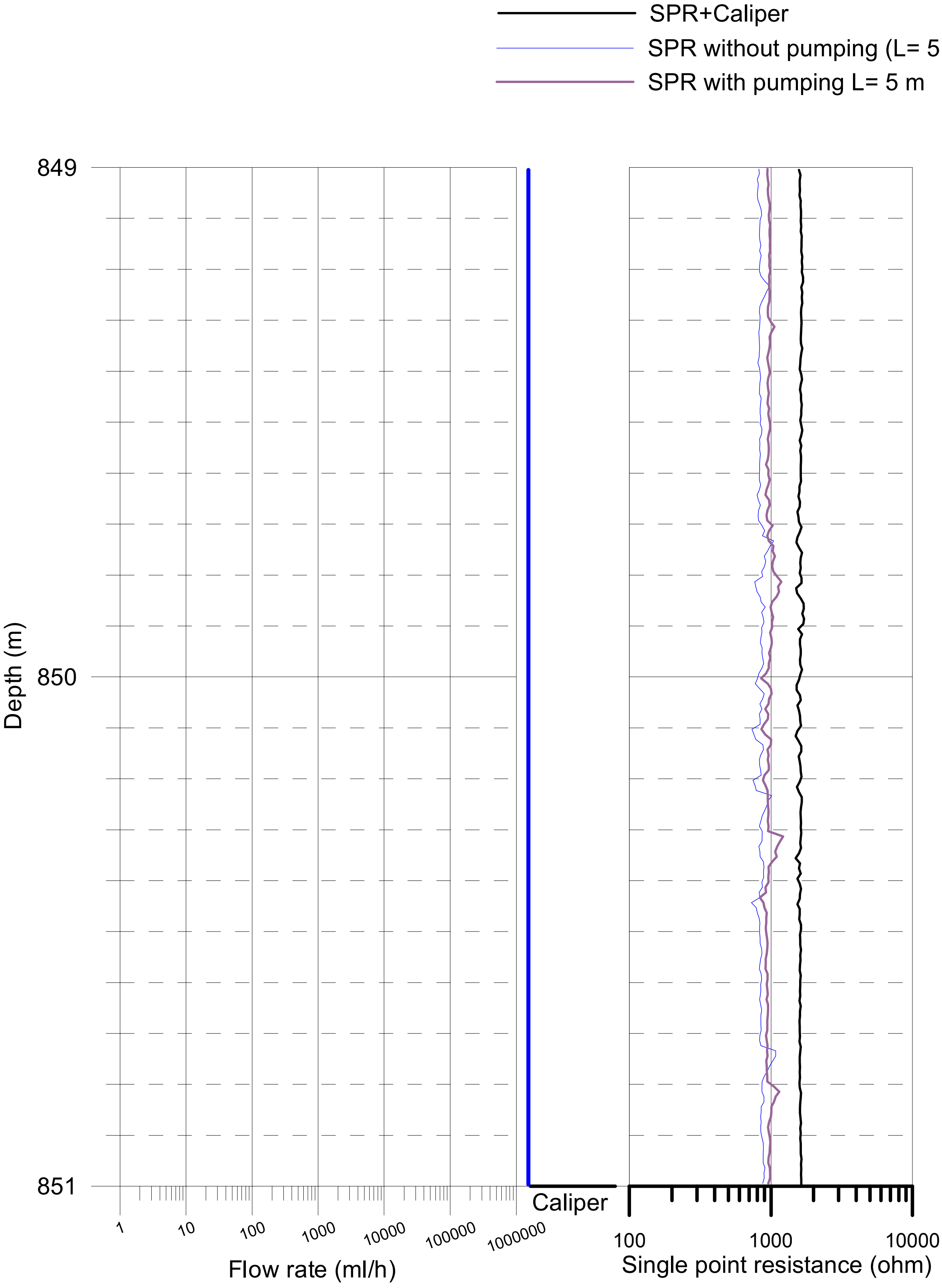
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



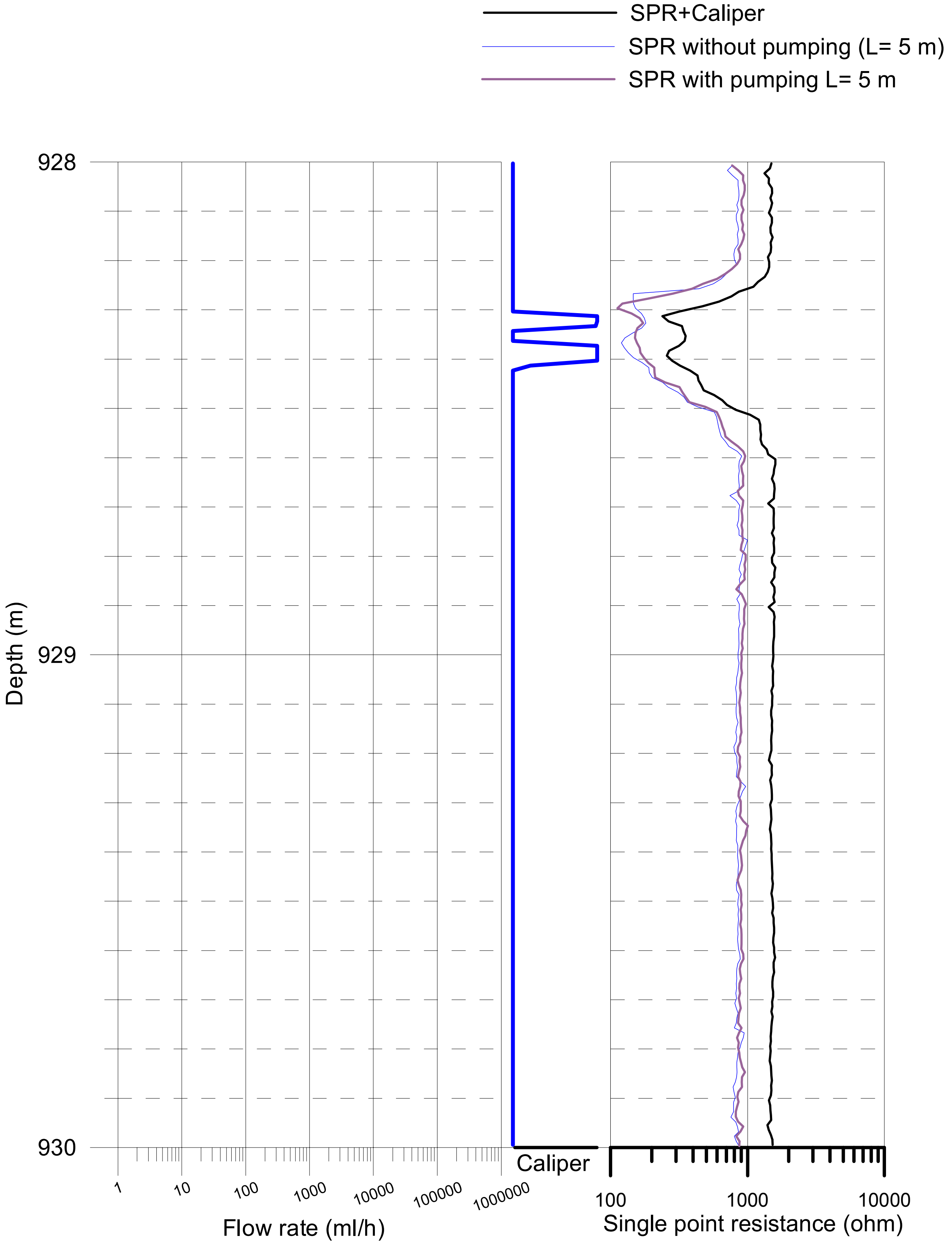
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



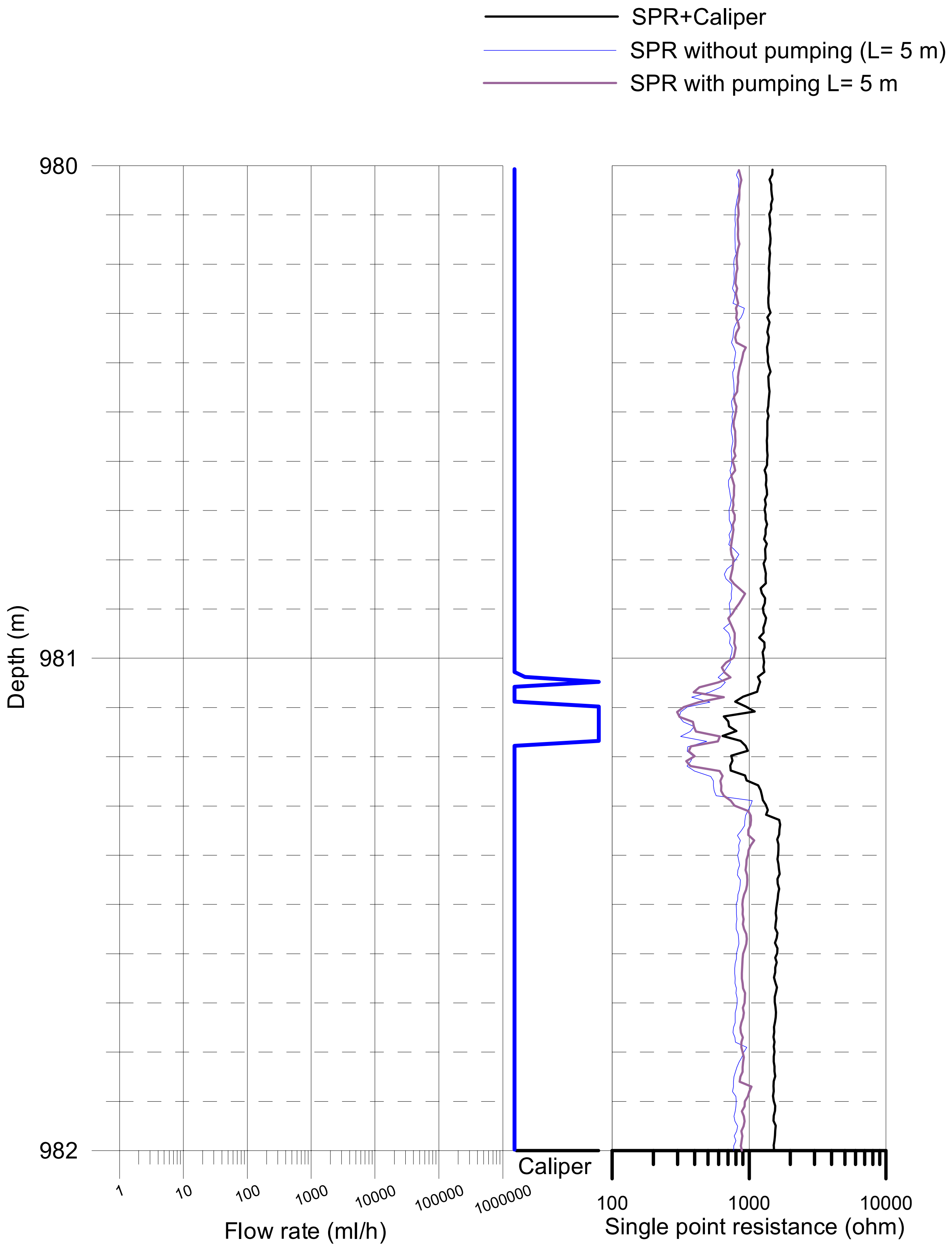
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction

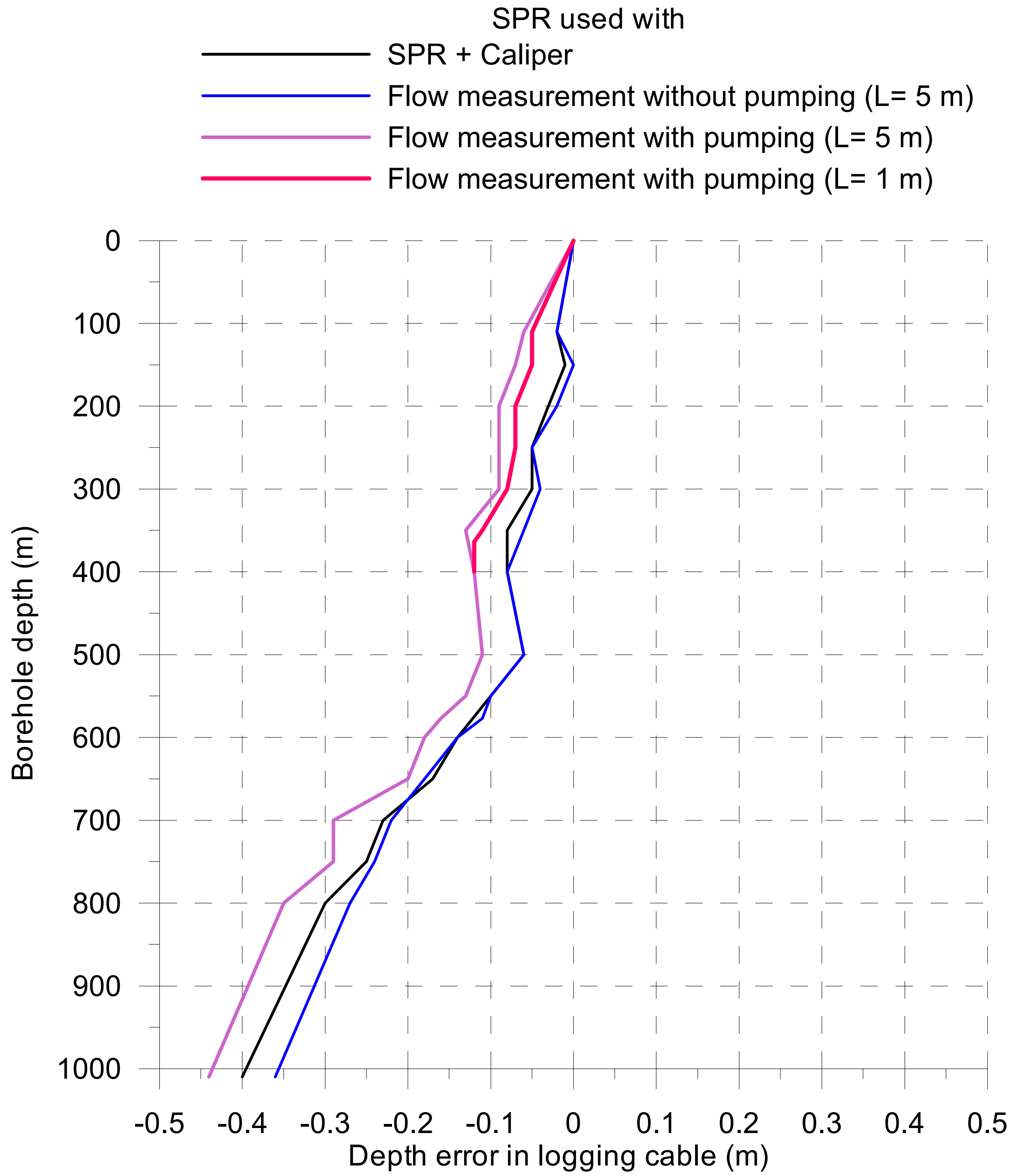


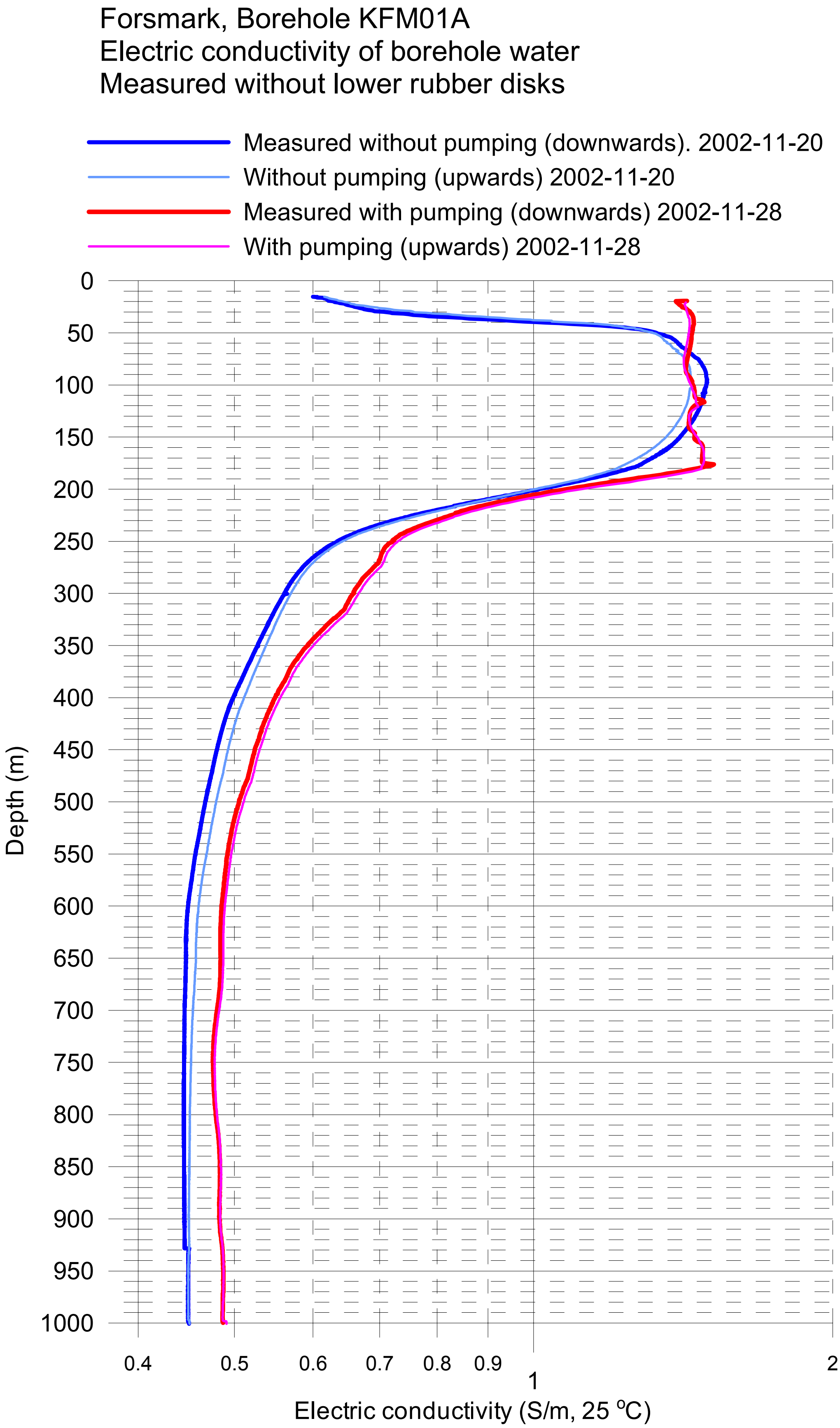
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction



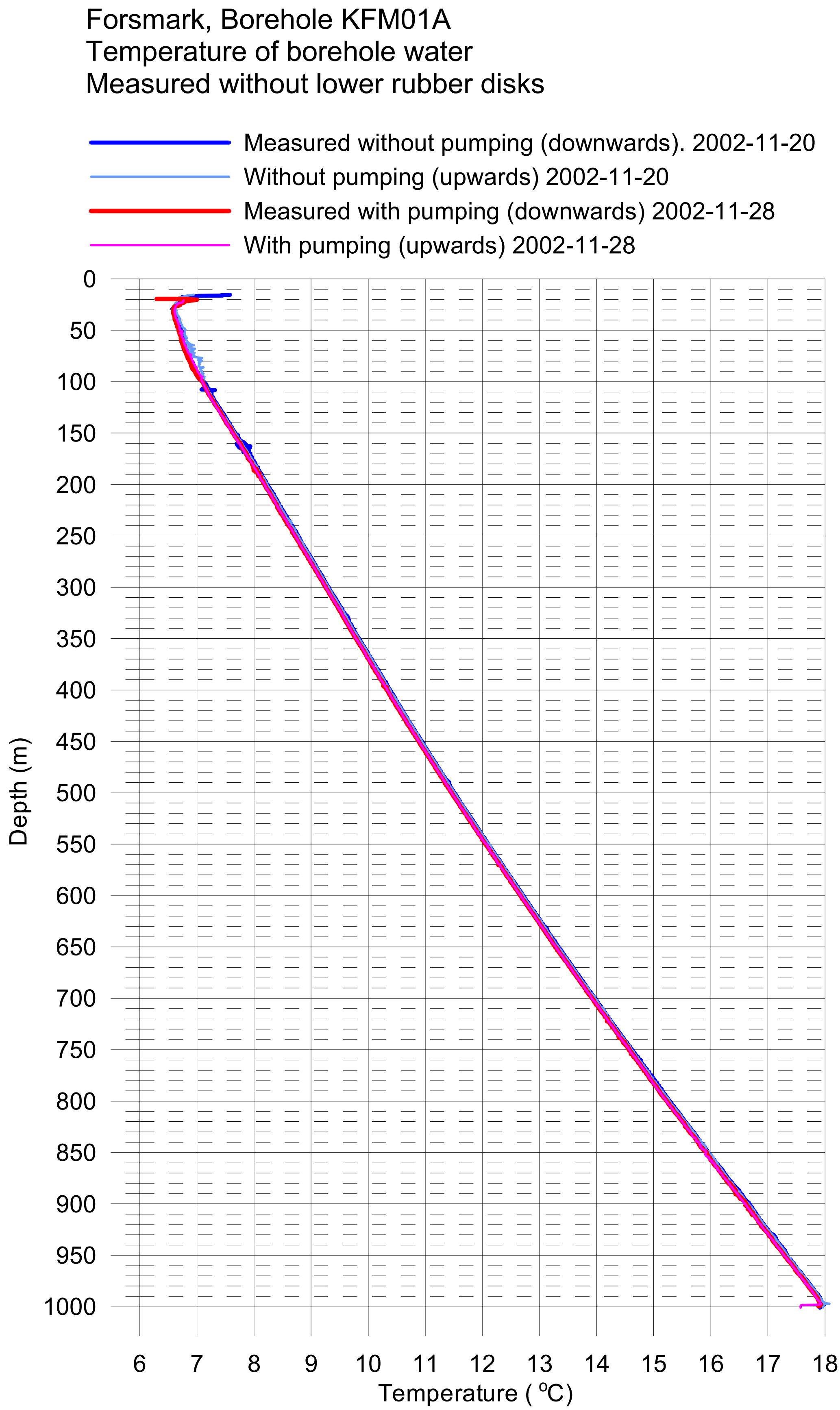
Forsmark, KFM01A, 2002-11-18 - 2002-11-29
SPR and Caliper results after depth correction

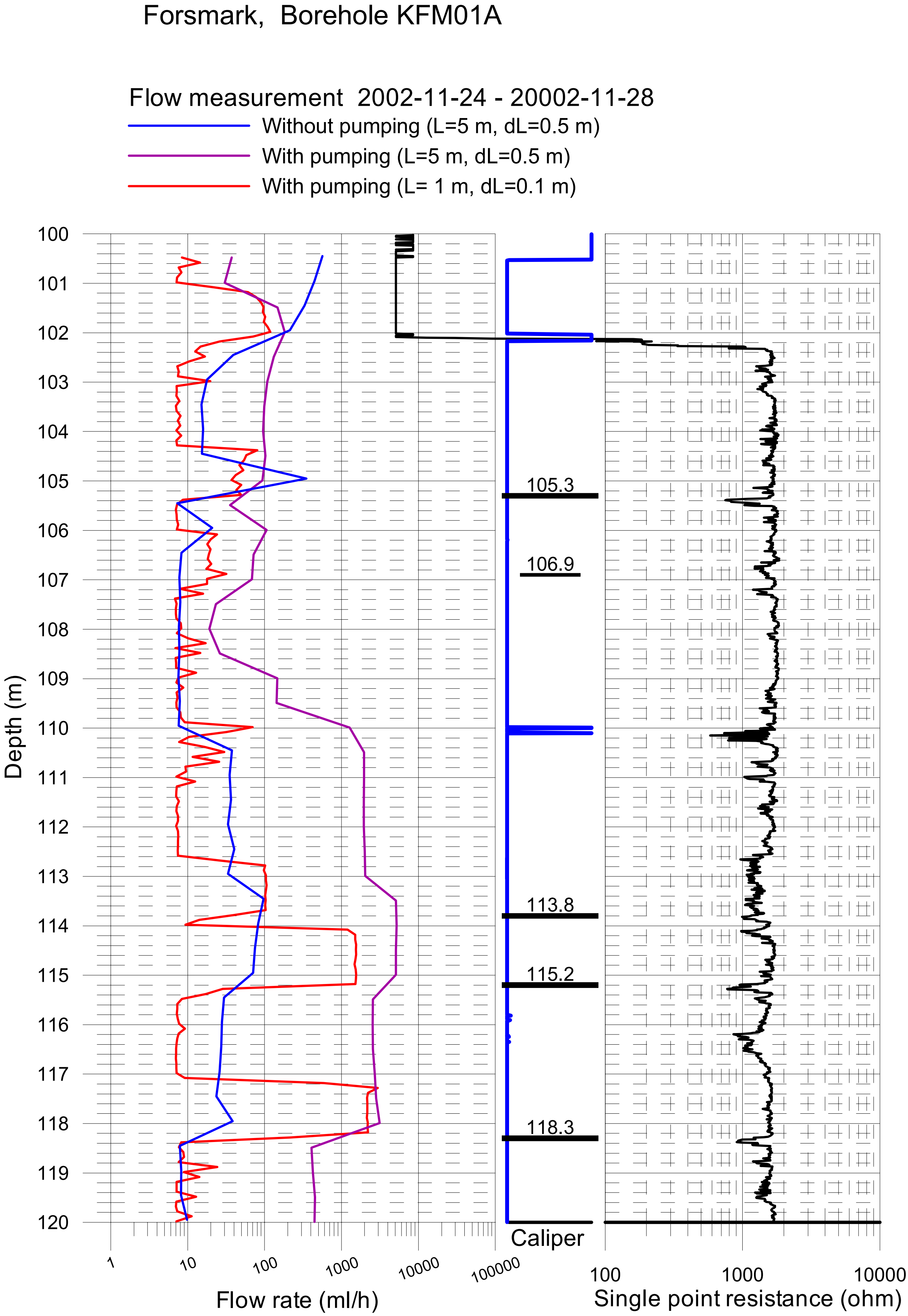



SPR used with
SPR + Caliper
Flow measurement without pumping (L= 5 m)
Flow measurement with pumping (L= 5 m)
Flow measurement with pumping (L= 1 m)
Borehole depth (m)
0
100
200
300
400
500
600
700
800
900
1000
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5
Depth error in logging cable (m)

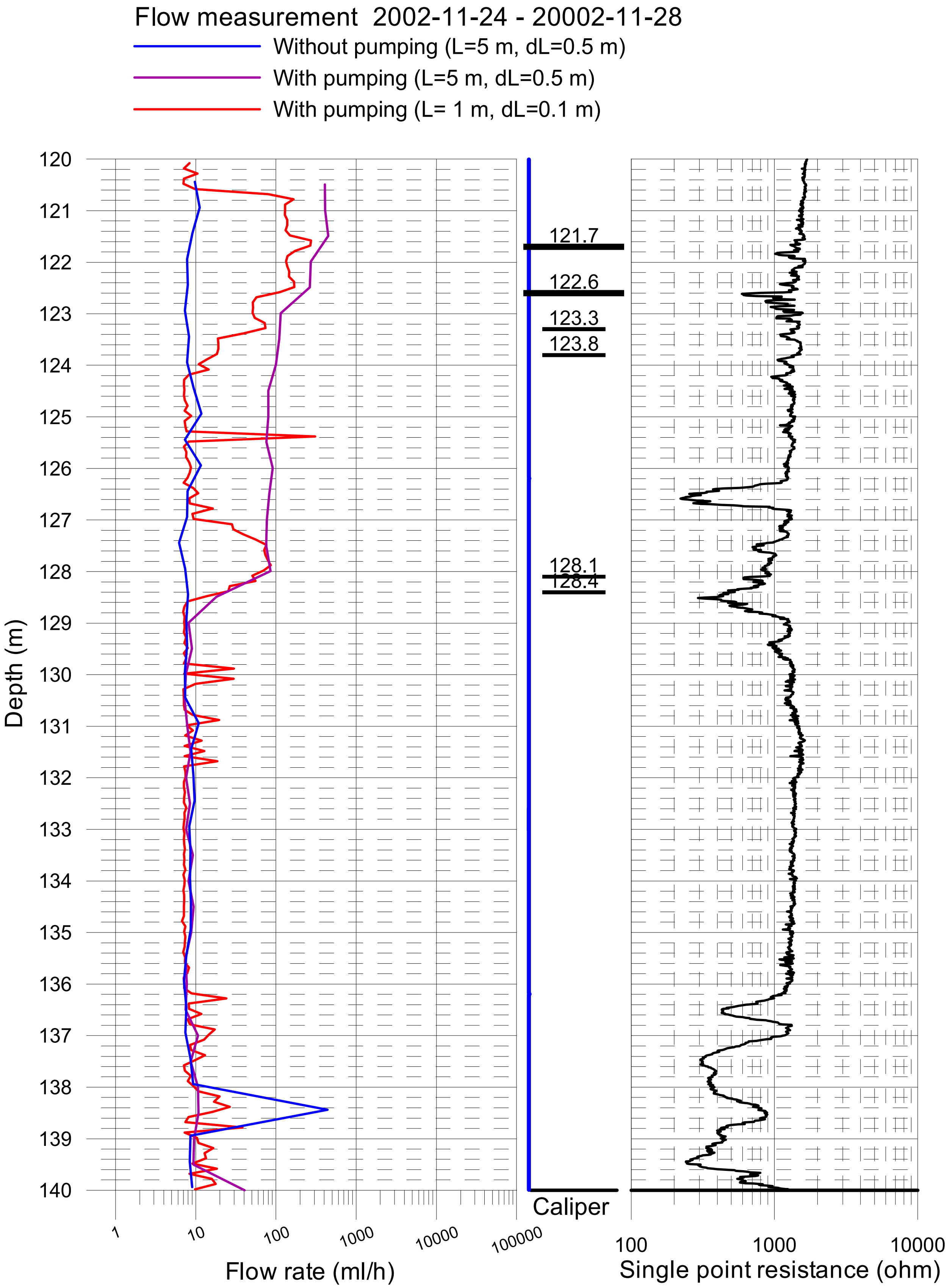


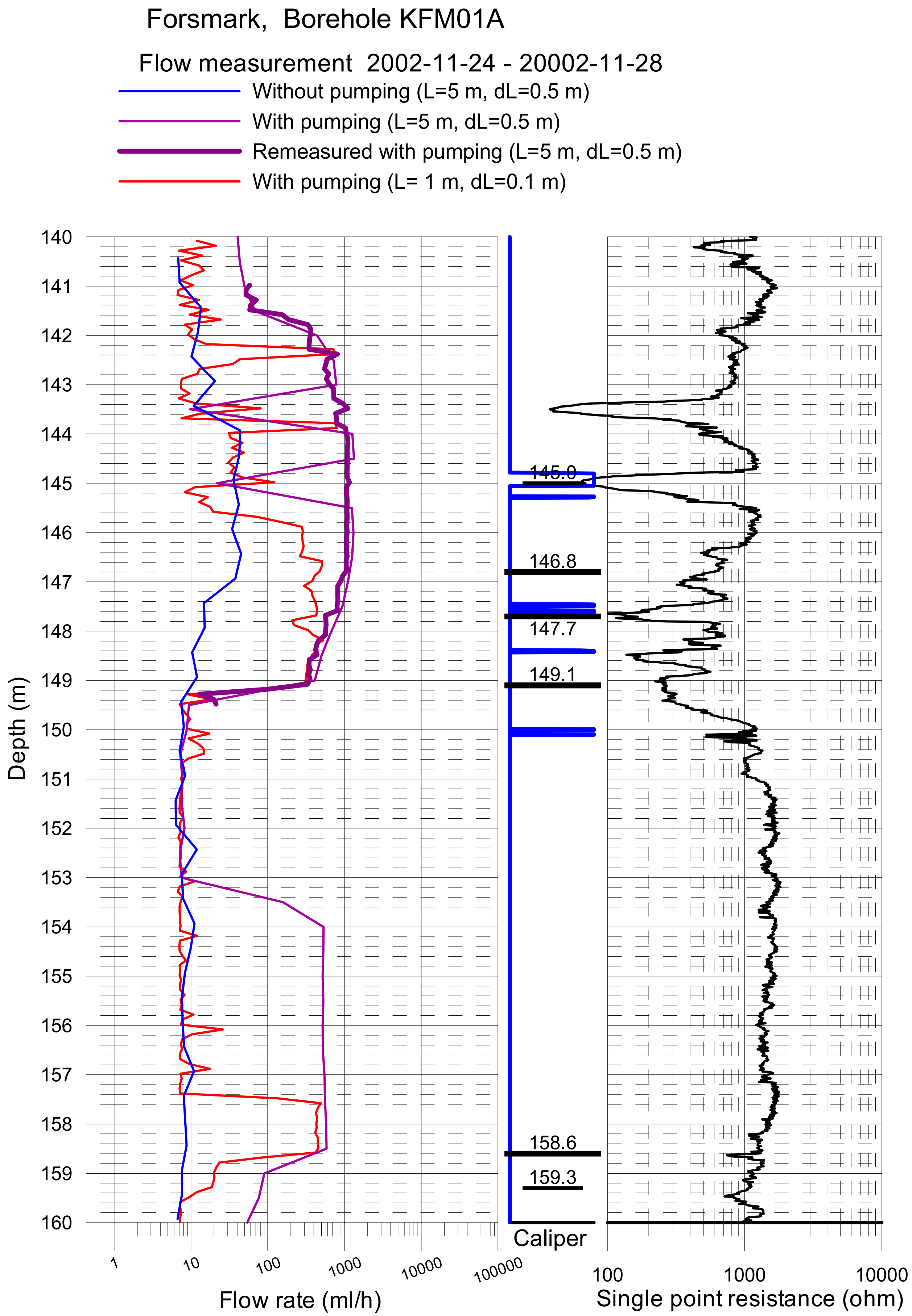
Forsmark, Borehole KFM01A
Electric conductivity of borehole water
Measured without lower rubber disks
Measured without pumping (downwards). 2002-11-20
Without pumping (upwards) 2002-11-20
Measured with pumping (downwards) 2002-11-28
With pumping (upwards) 2002-11-28
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
Depth (m)
0.4
0.5
0.6
0.7
0.8
0.9
1
2
Electric conductivity (S/m, 25 °C)


Forsmark, Borehole KFM01A
Temperature of borehole water
Measured without lower rubber disks
Measured without pumping (downwards). 2002-11-20
Without pumping (upwards) 2002-11-20
Measured with pumping (downwards) 2002-11-28
With pumping (upwards) 2002-11-28
Depth (m)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
6
7
8
9
10
11
12
13
14
15
16
17
18
Temperature (°C)

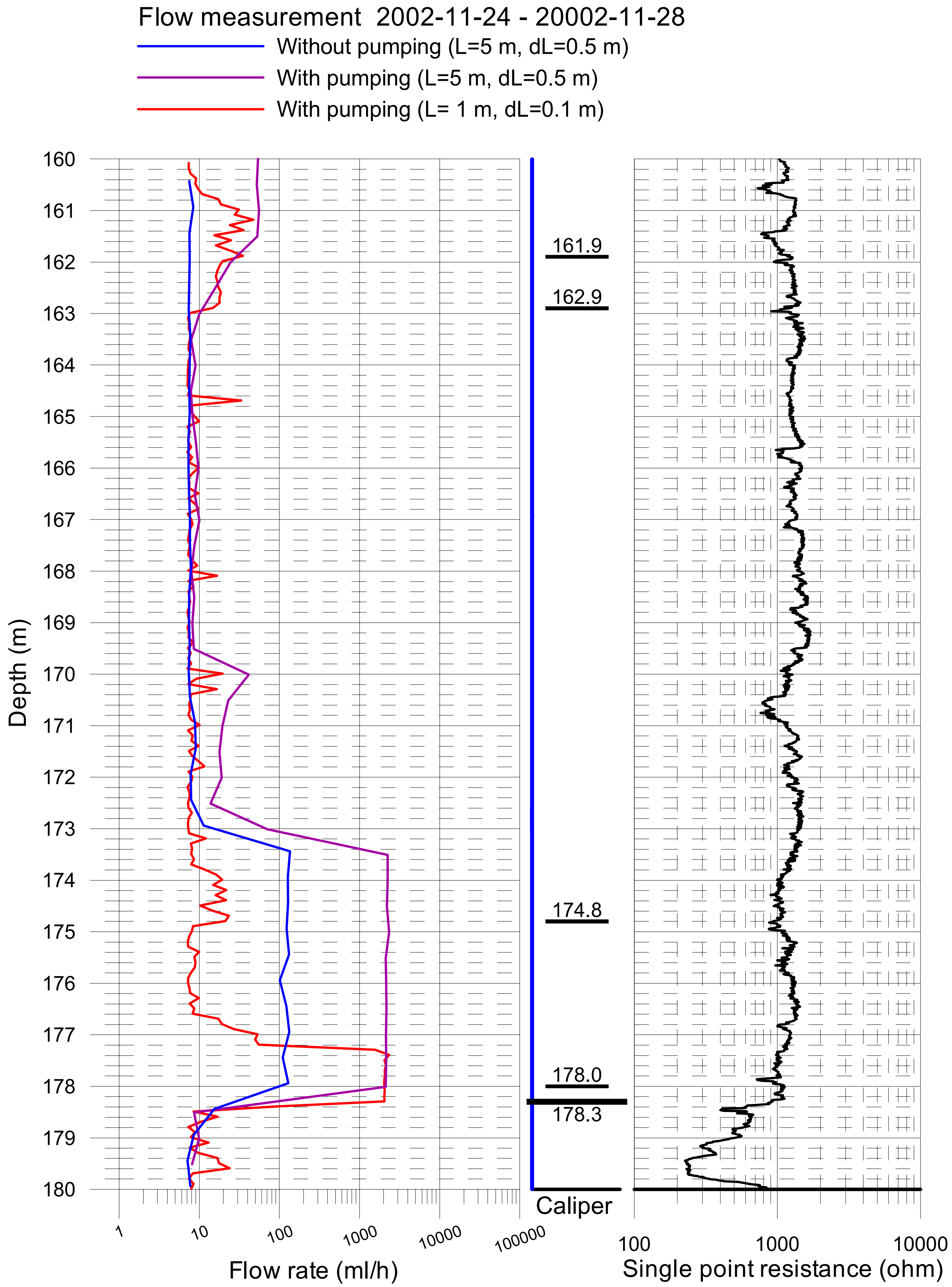

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Depth (m)
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
105.3
106.9
113.8
115.2
118.3
Caliper
1
10
100
1000
10000
100000
Flow rate (ml/h)
100
1000
10000
Single point resistance (ohm)

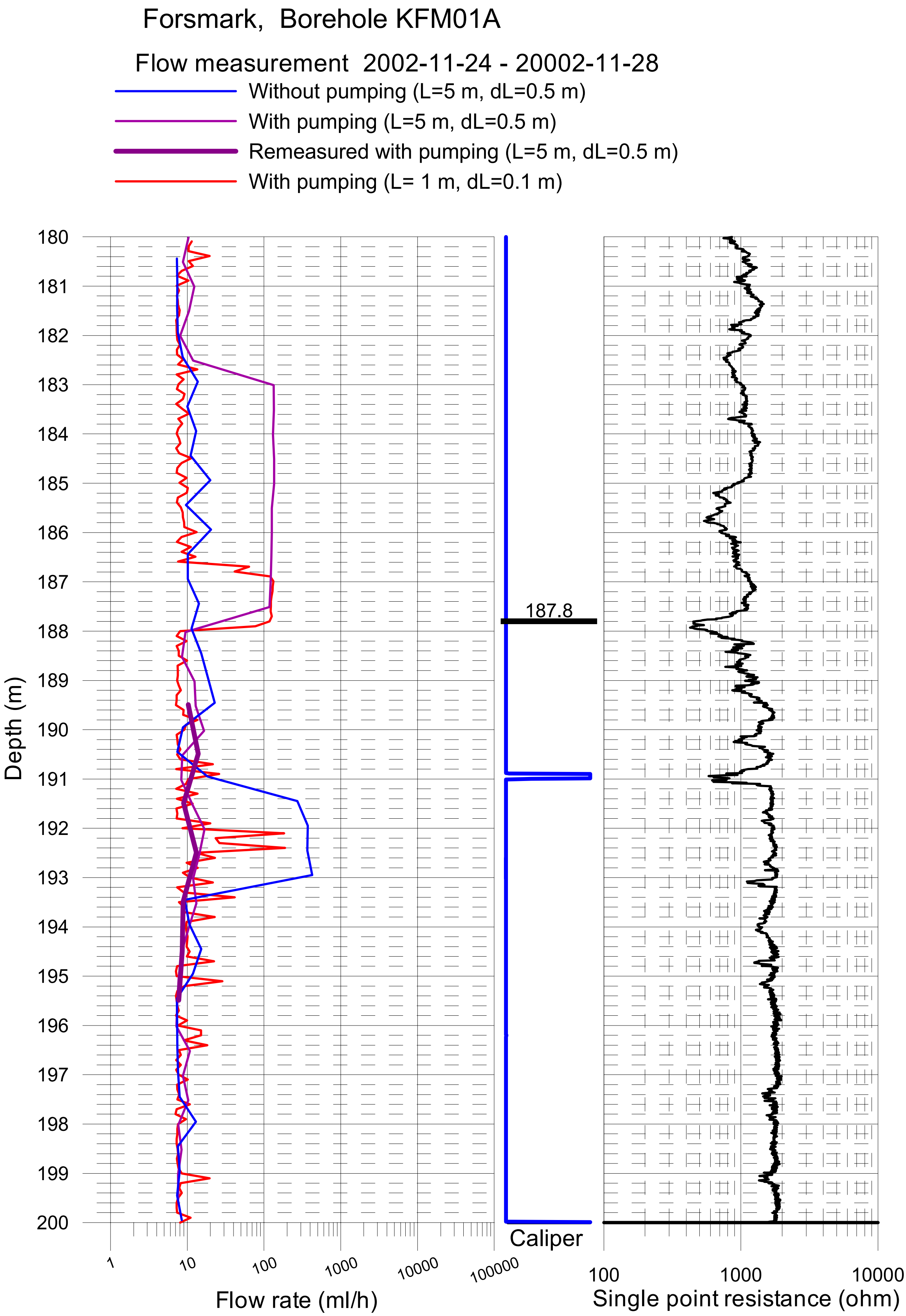
Forsmark, Borehole KFM01A




Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Depth (m)
Flow rate (ml/h)
Caliper
Single point resistance (ohm)
145.0
146.8
147.7
149.1
158.6
159.3

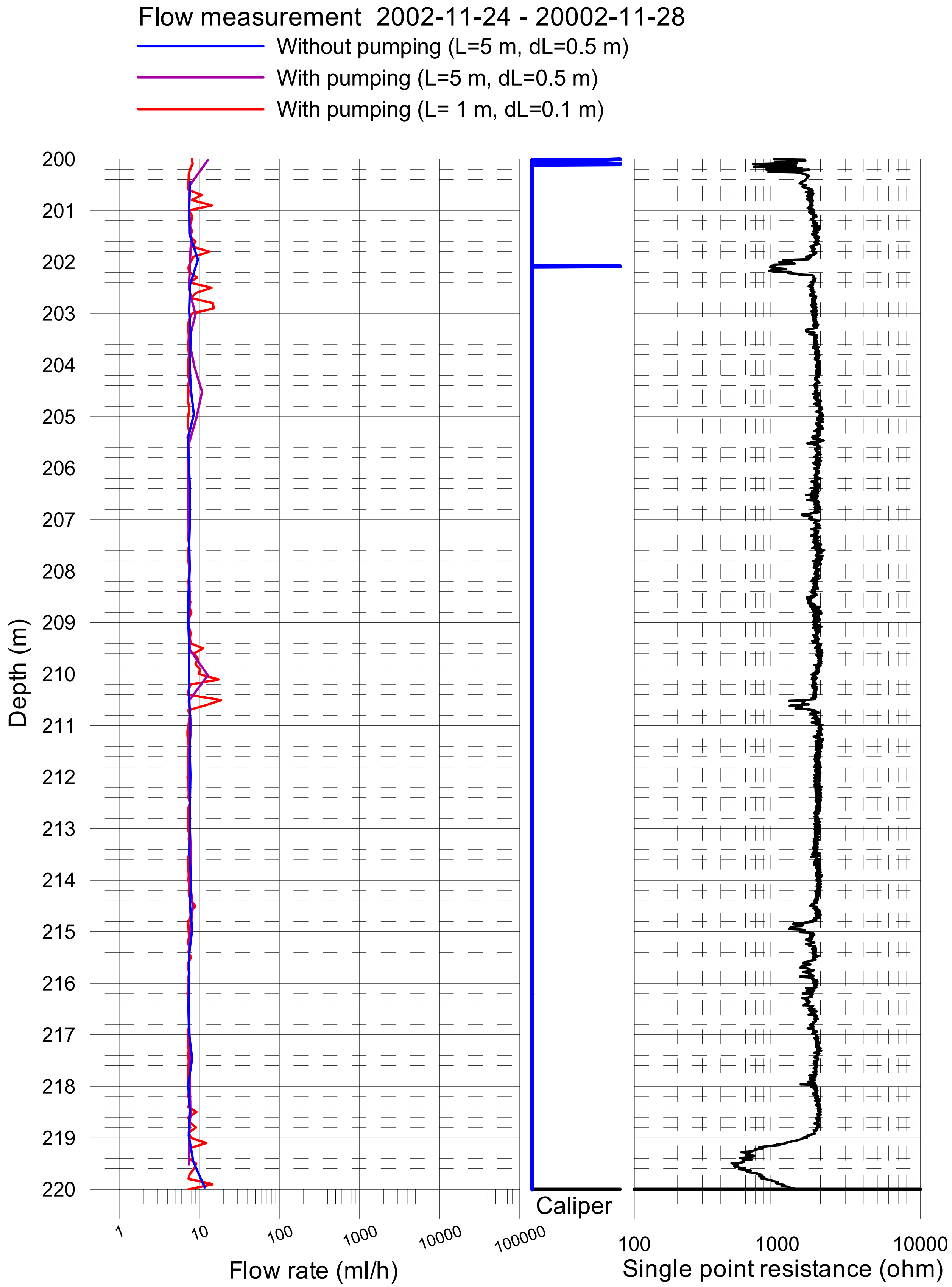
Forsmark, Borehole KFM01A



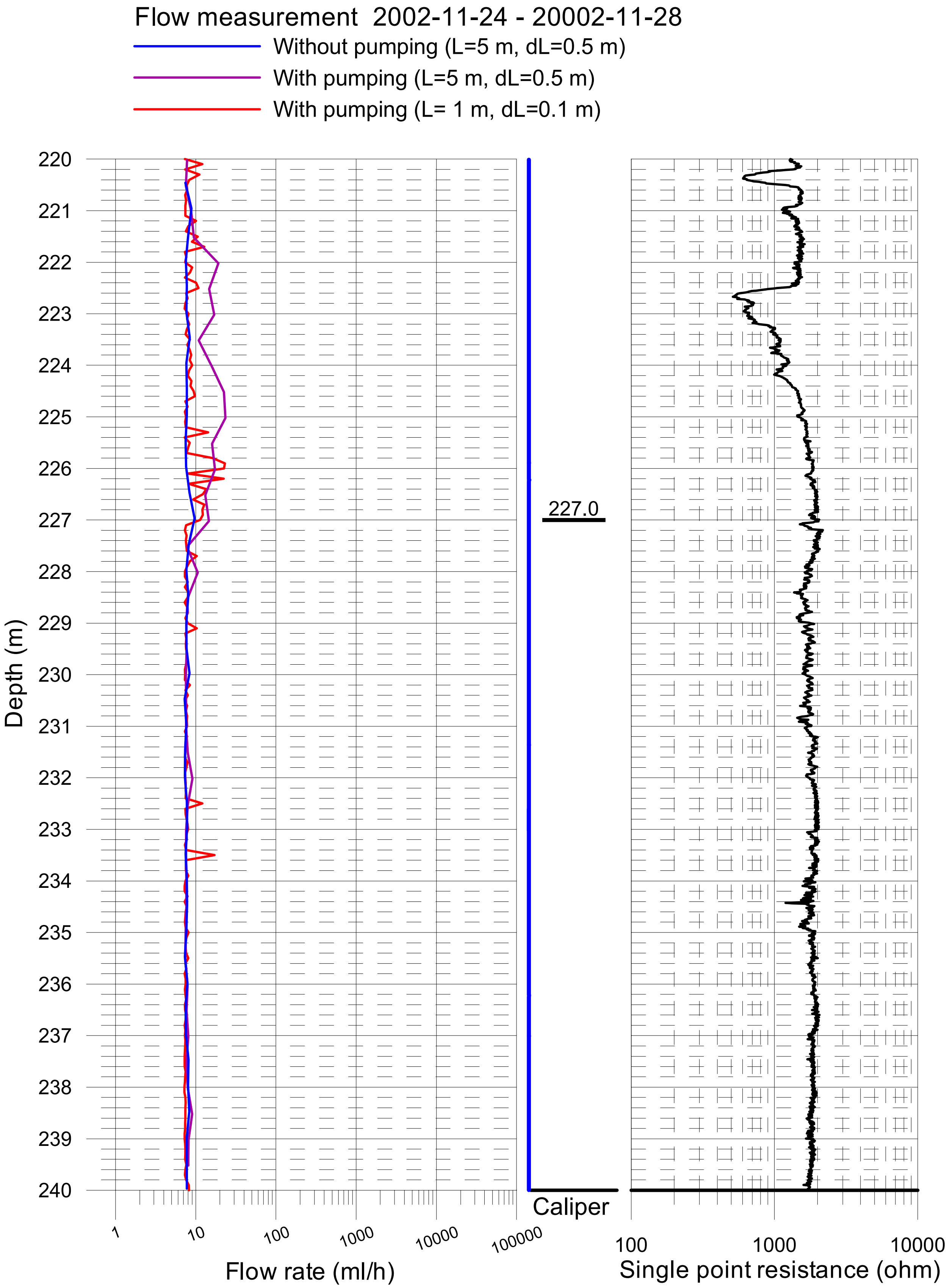


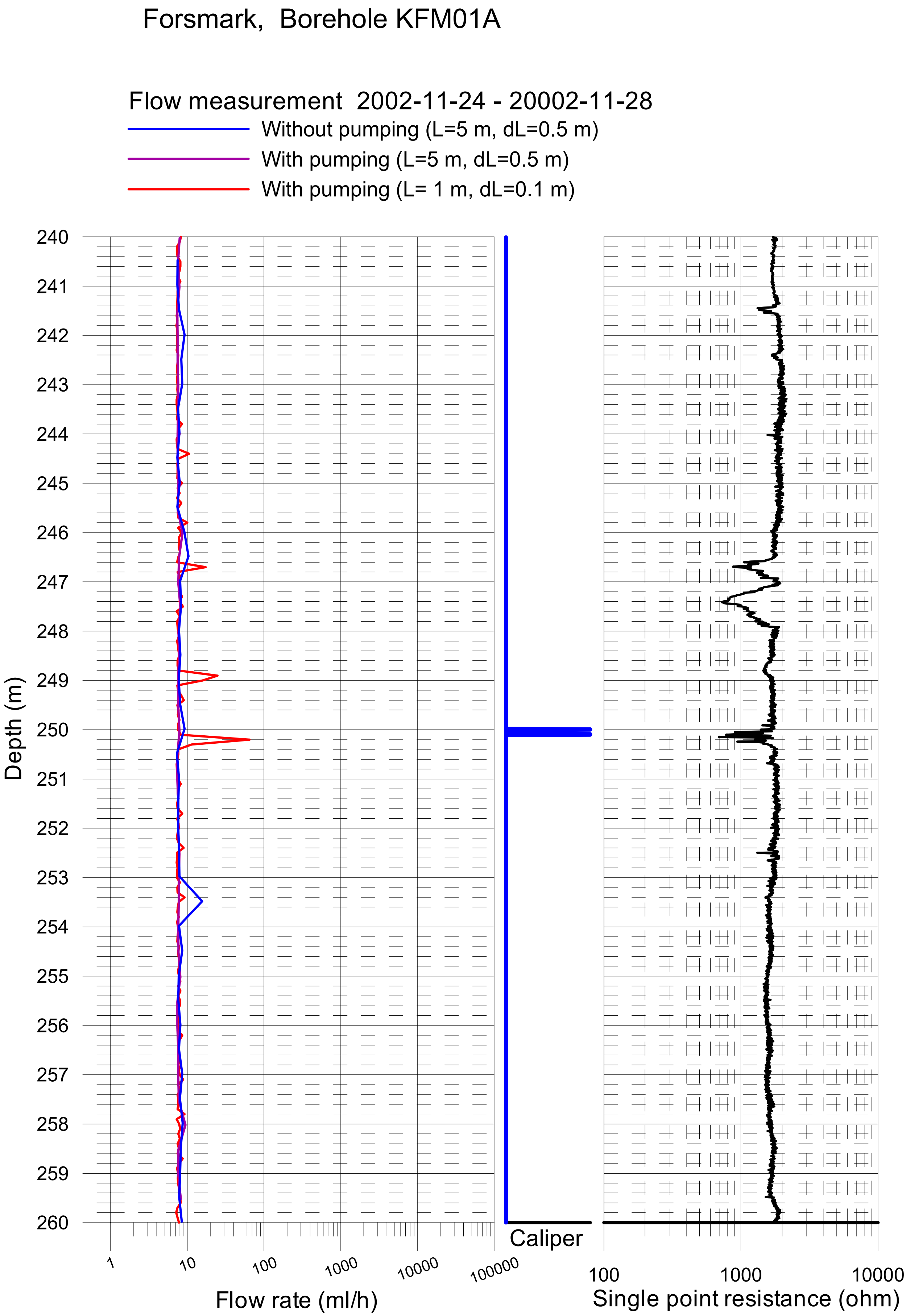
Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Depth (m)
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
187.8
Caliper
1
10
100
1000
10000
100000
Flow rate (ml/h)
100
1000
10000
Single point resistance (ohm)

Forsmark, Borehole KFM01A

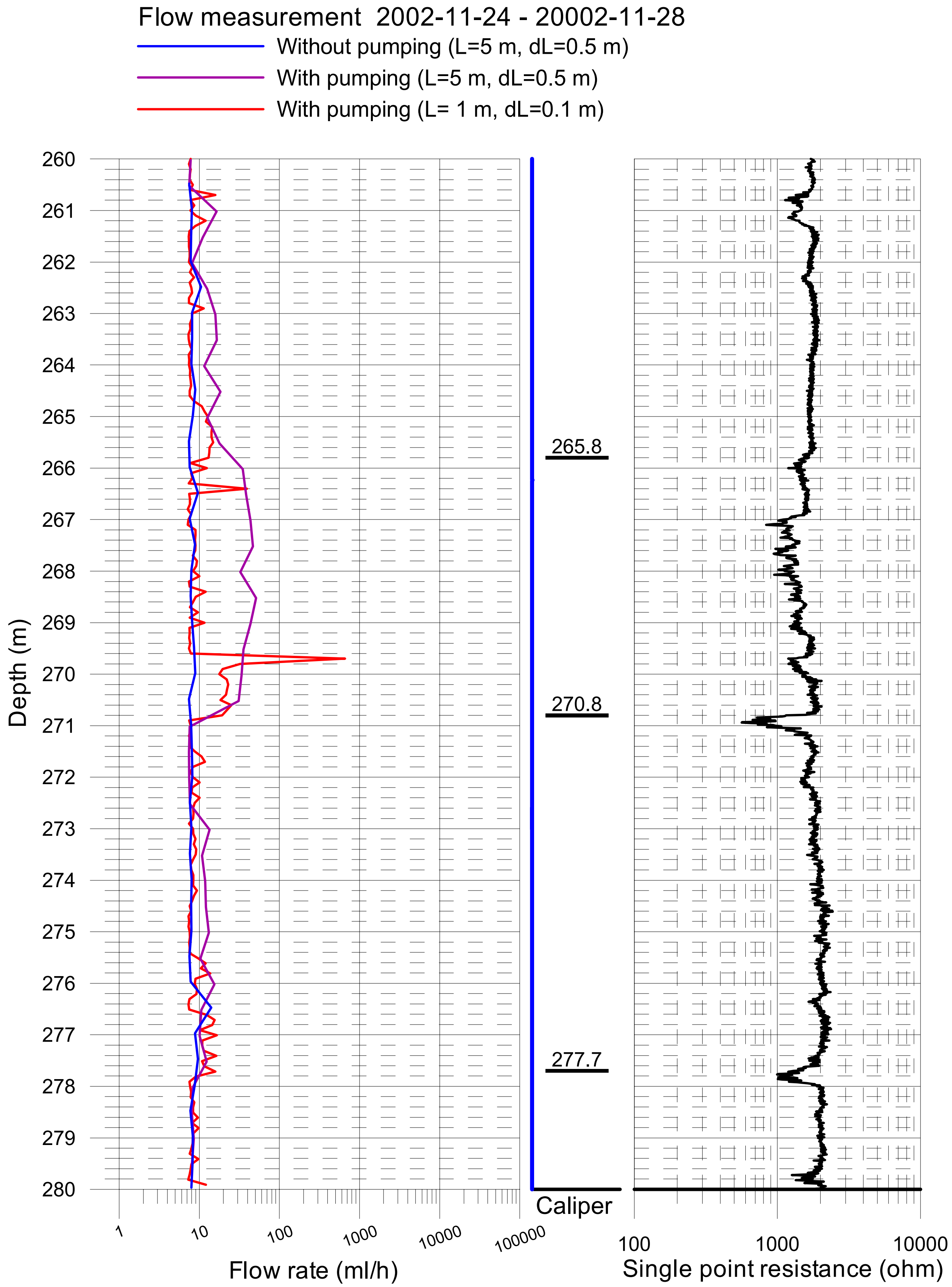


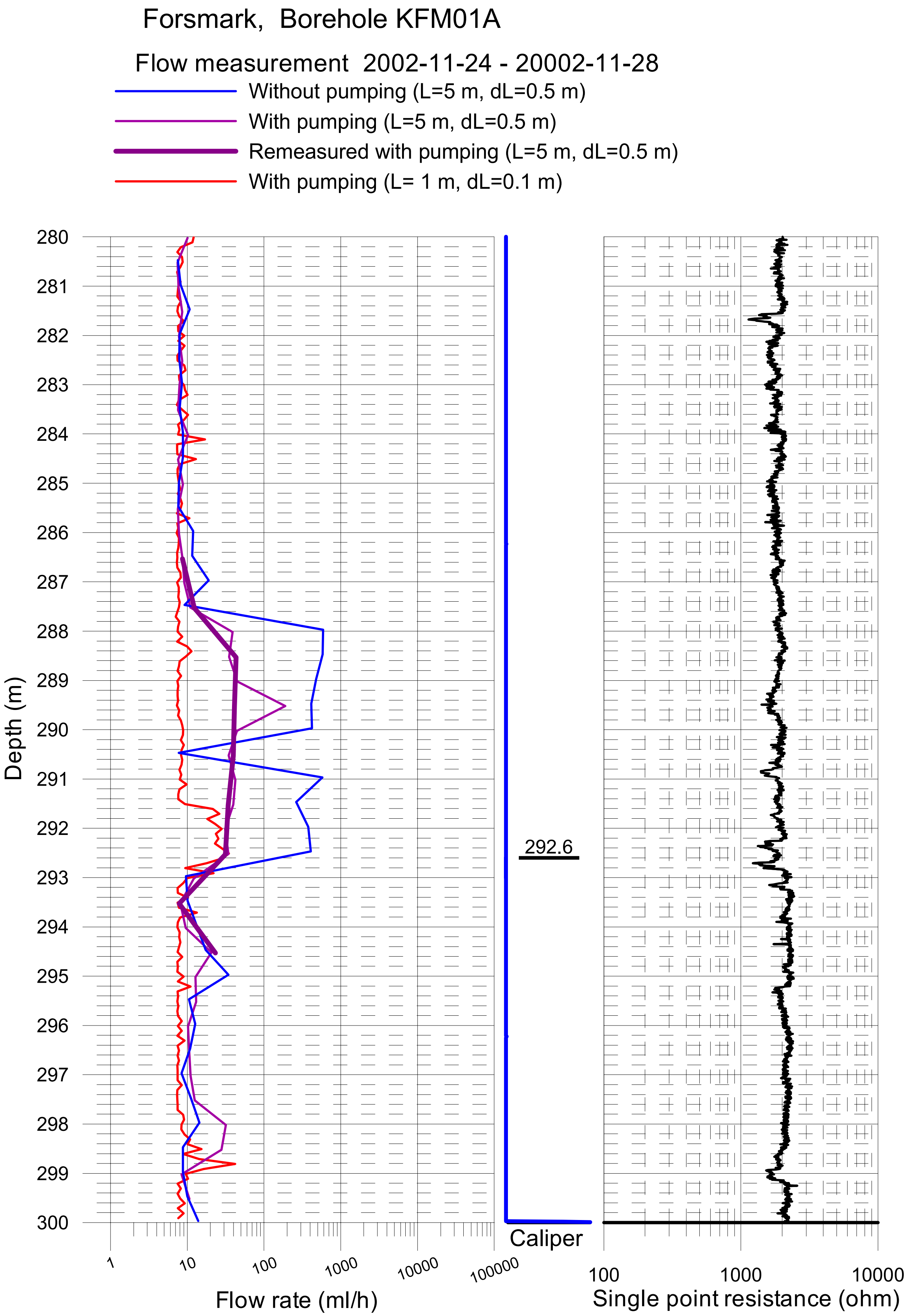
Forsmark, Borehole KFM01A

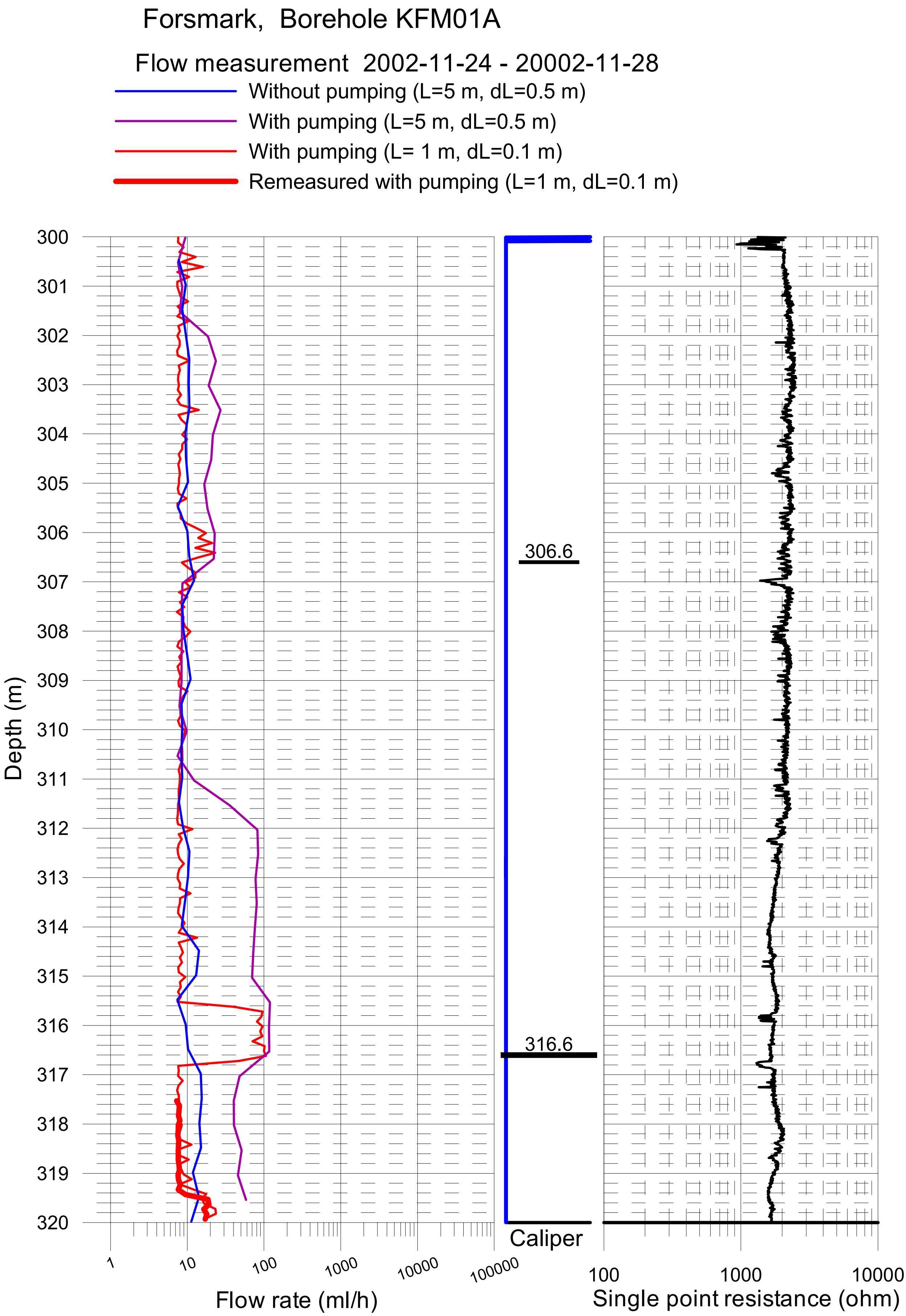



Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Depth (m)
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

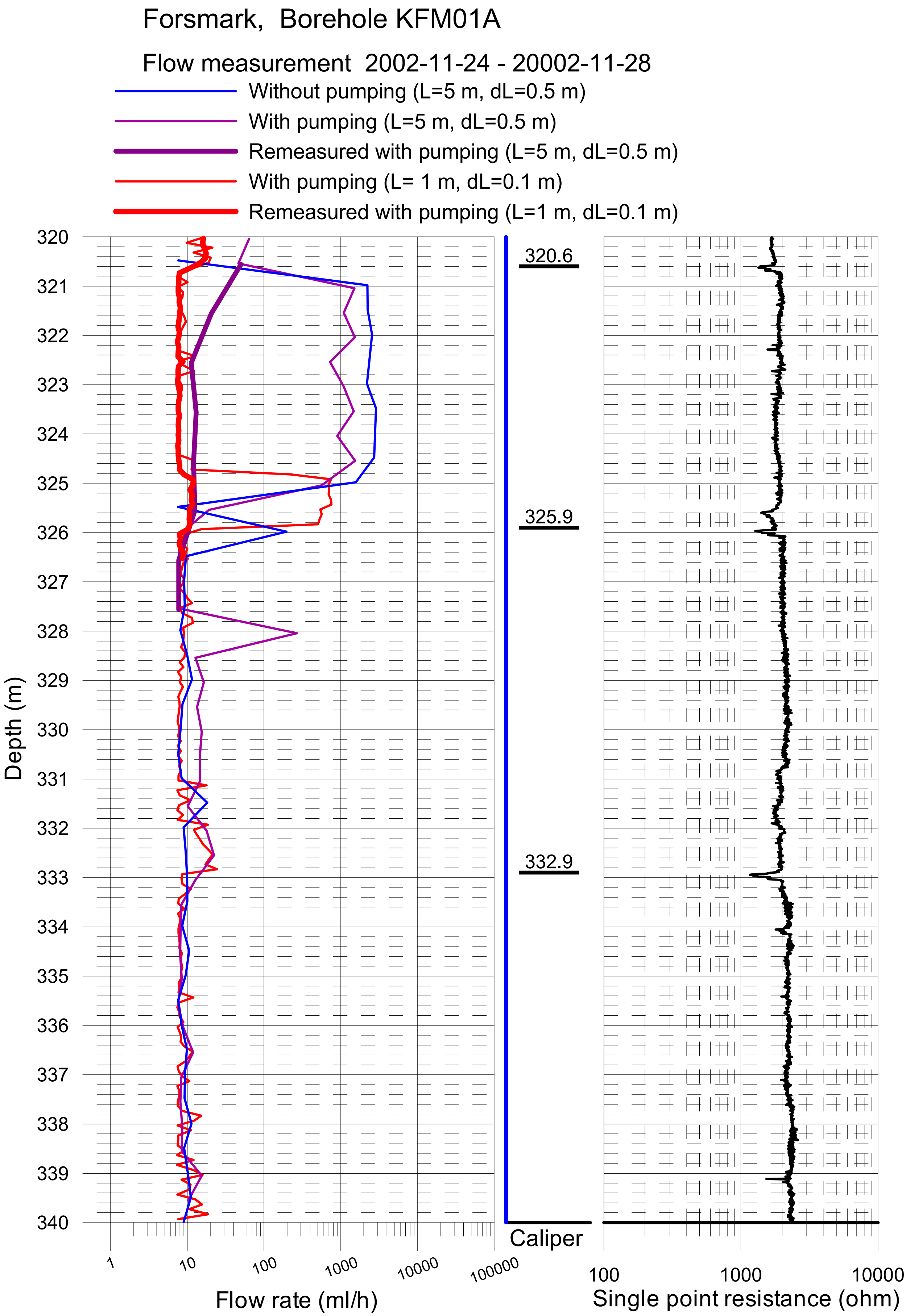
Forsmark, Borehole KFM01A

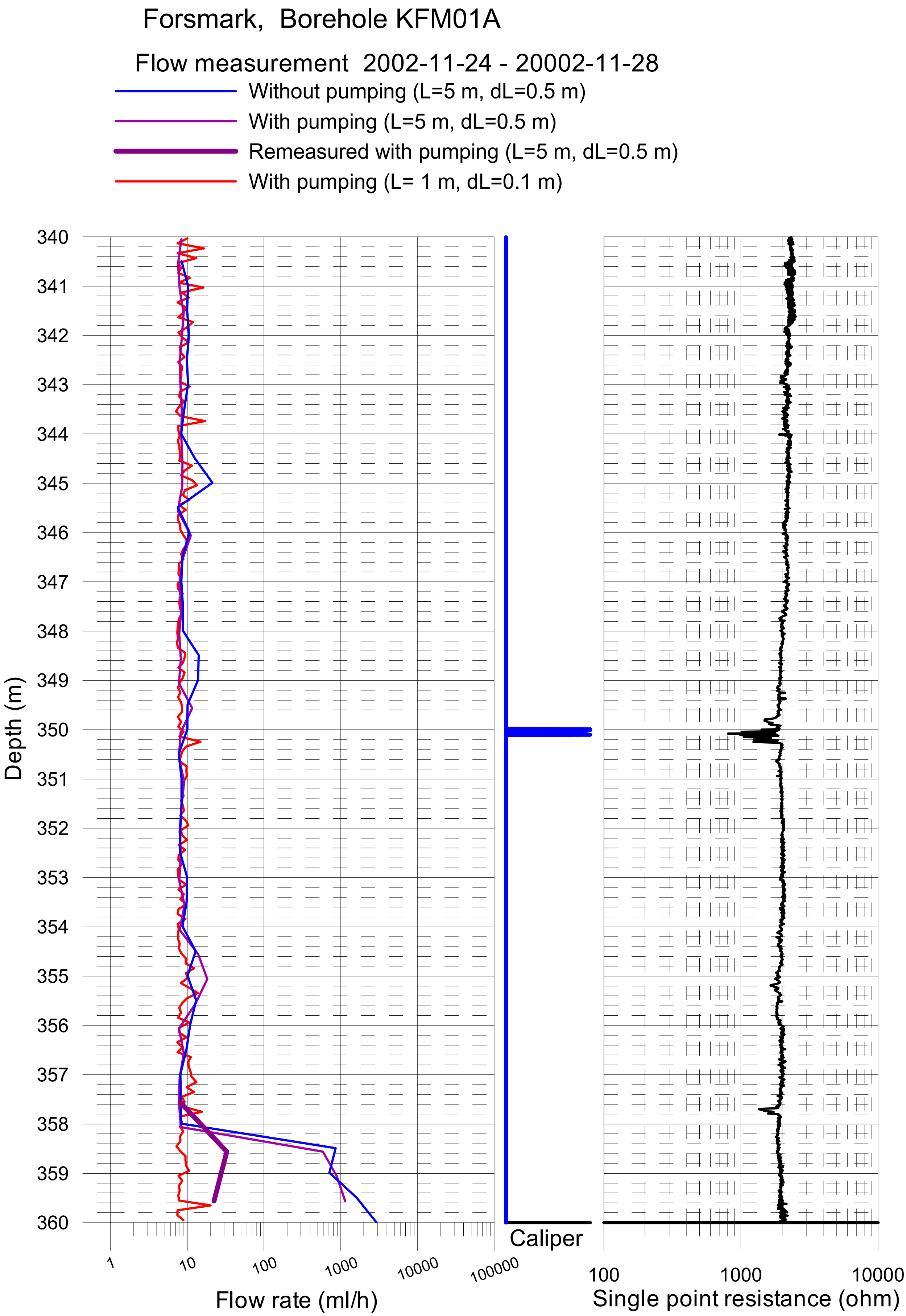



Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Depth (m)
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
292.6
Caliper
1
10
100
1000
10000
100000
Flow rate (ml/h)
100
1000
10000
Single point resistance (ohm)

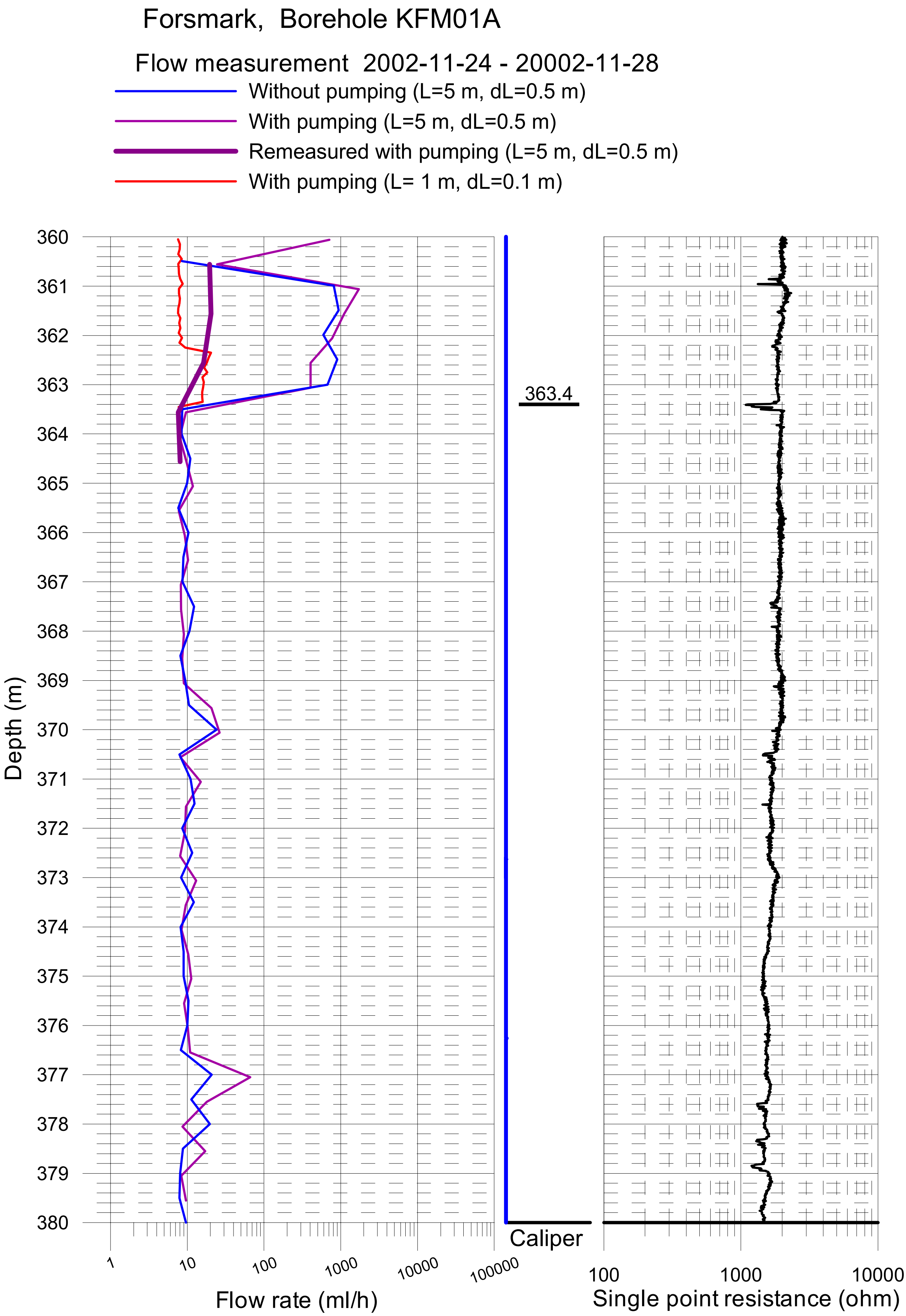


Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Remeasured with pumping (L=1 m, dL=0.1 m)
Depth (m)
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
306.6
316.6
Caliper
1
10
100
1000
10000
100000
Flow rate (ml/h)
100
1000
10000
Single point resistance (ohm)

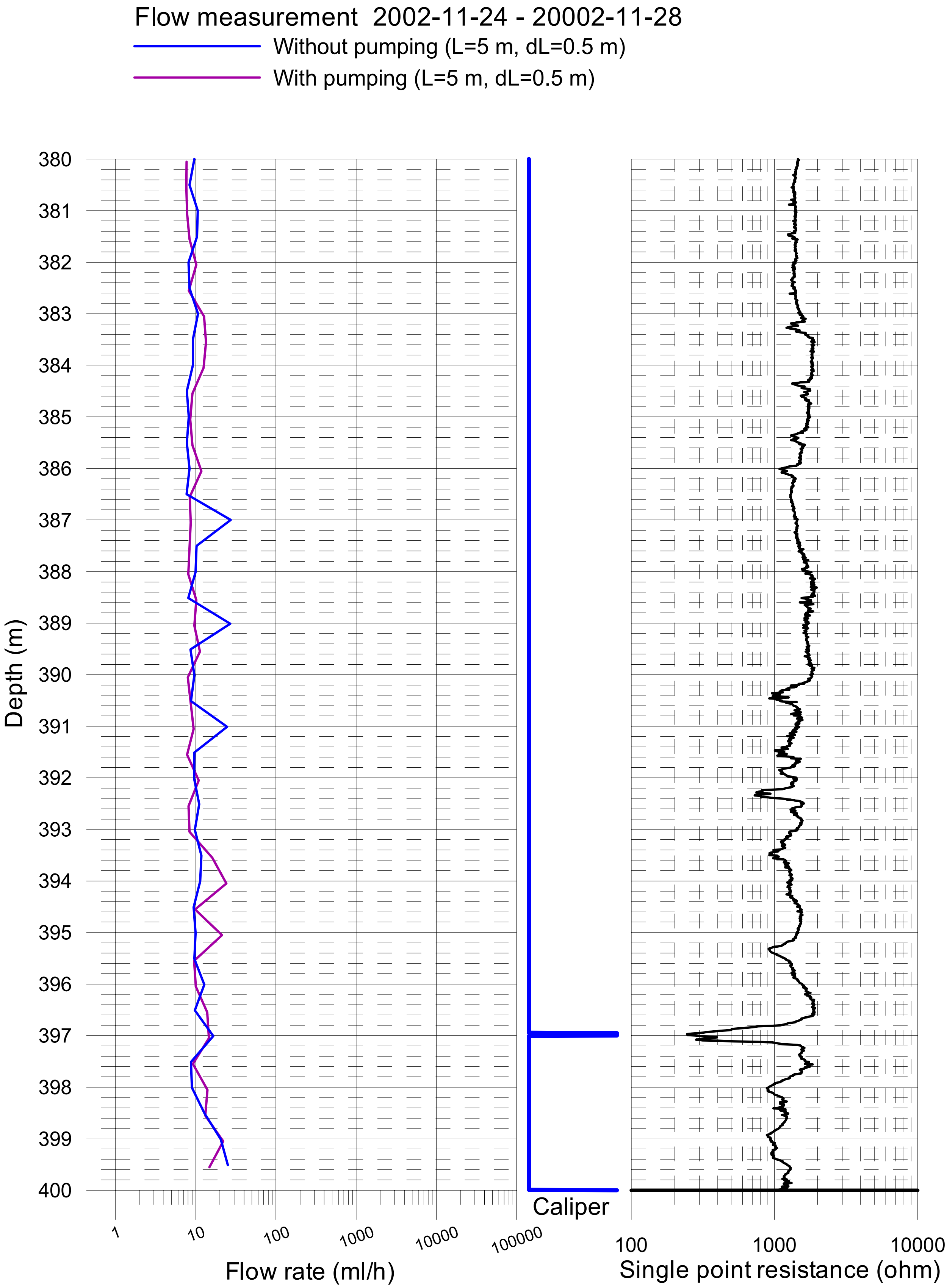

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Remeasured with pumping (L=1 m, dL=0.1 m)
Depth (m)
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
320.6
325.9
332.9
Caliper
1
10
100
1000
10000
100000
Flow rate (ml/h)
100
1000
10000
Single point resistance (ohm)

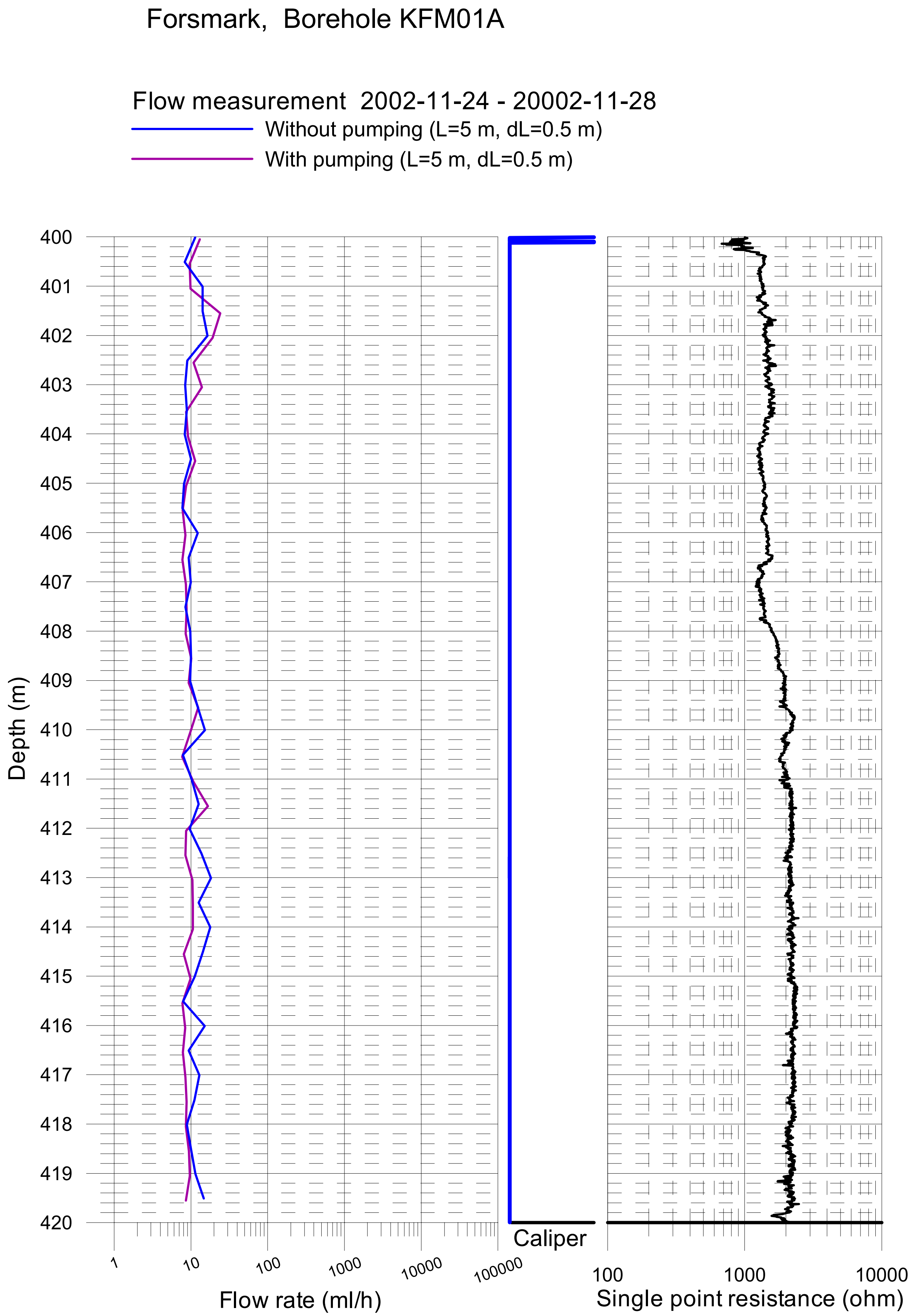


Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Depth (m)
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

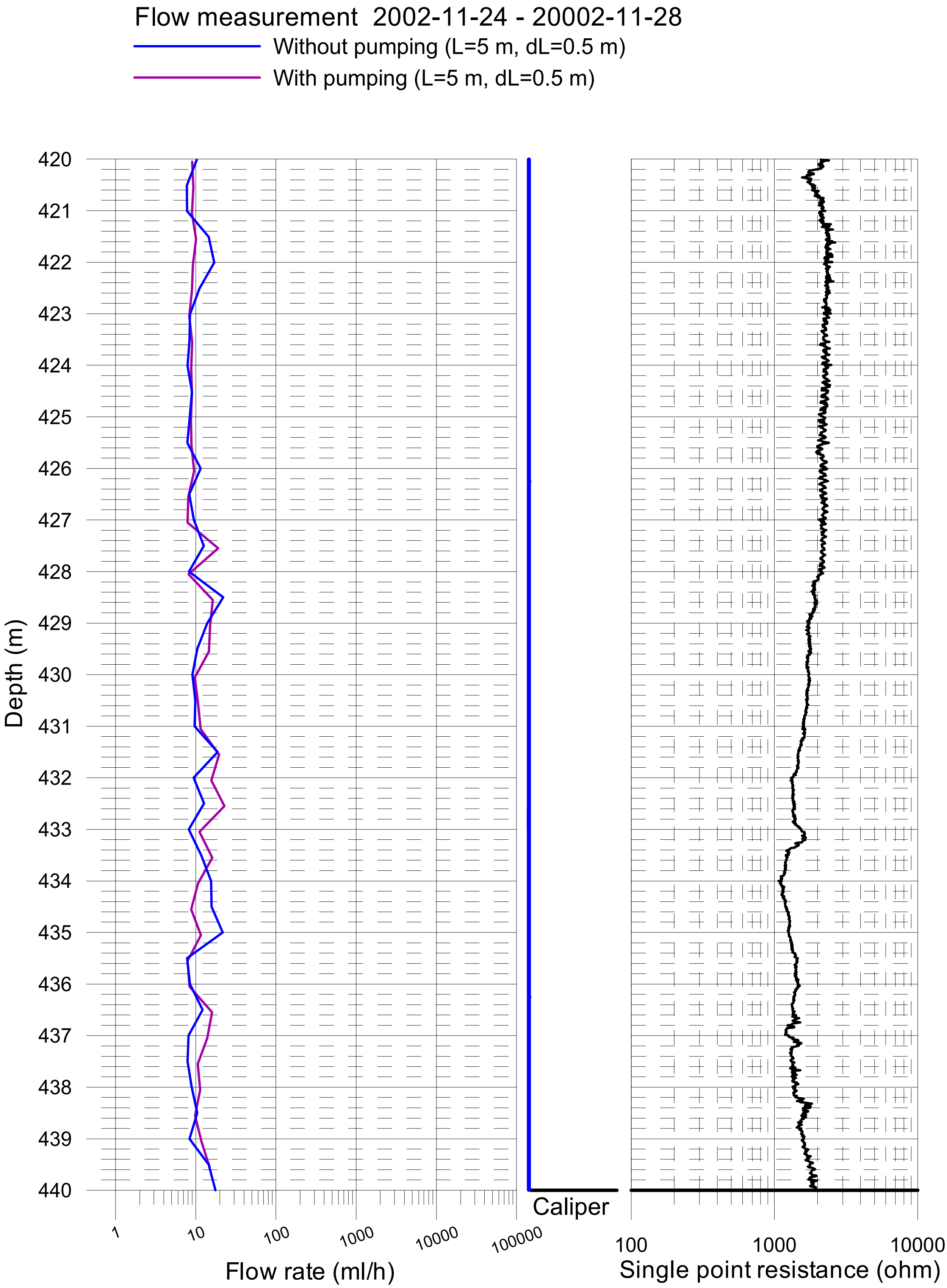

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Depth (m)
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
363.4
Caliper
1
10
100
1000
10000
100000
Flow rate (ml/h)
100
1000
10000
Single point resistance (ohm)

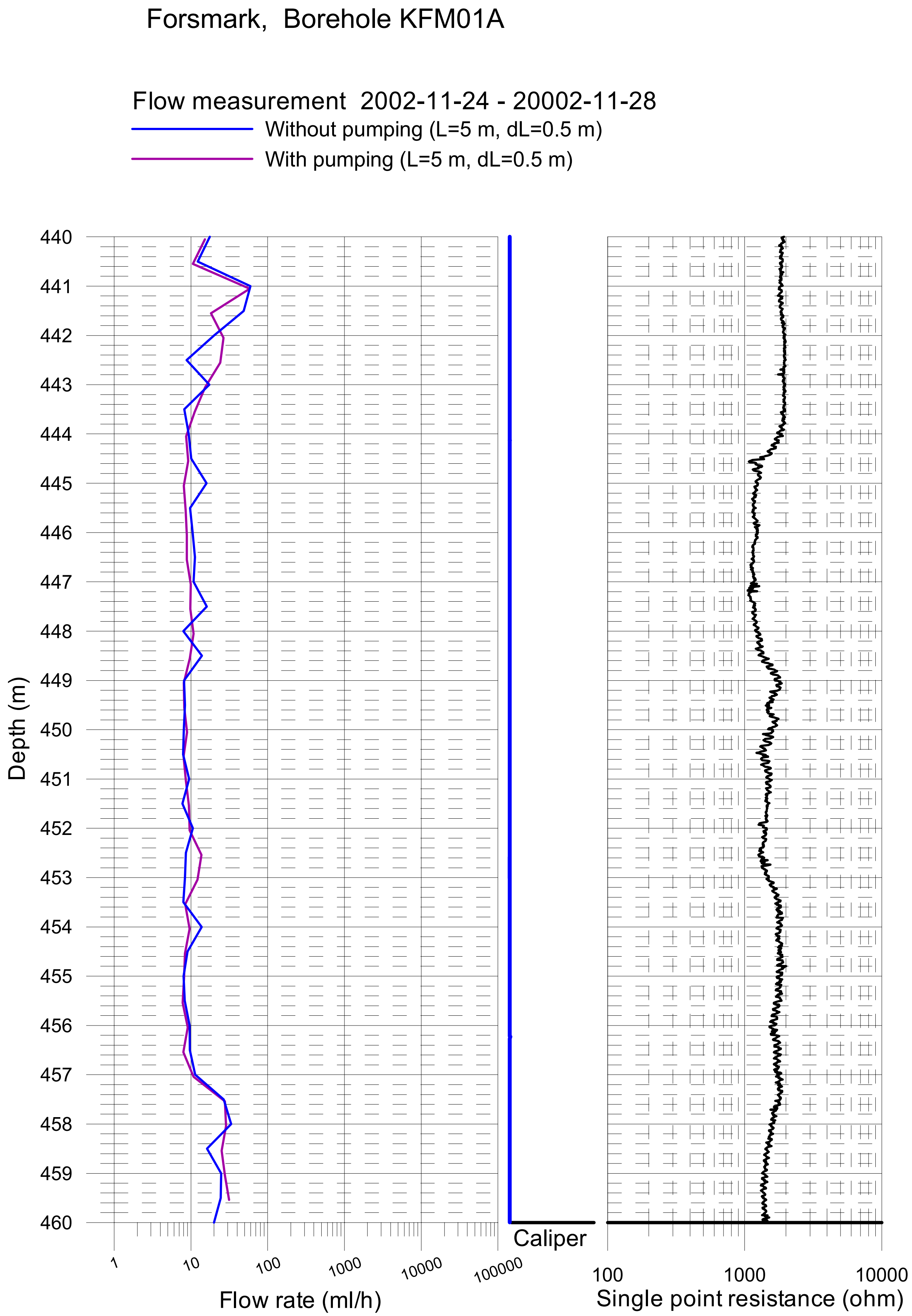
Forsmark, Borehole KFM01A



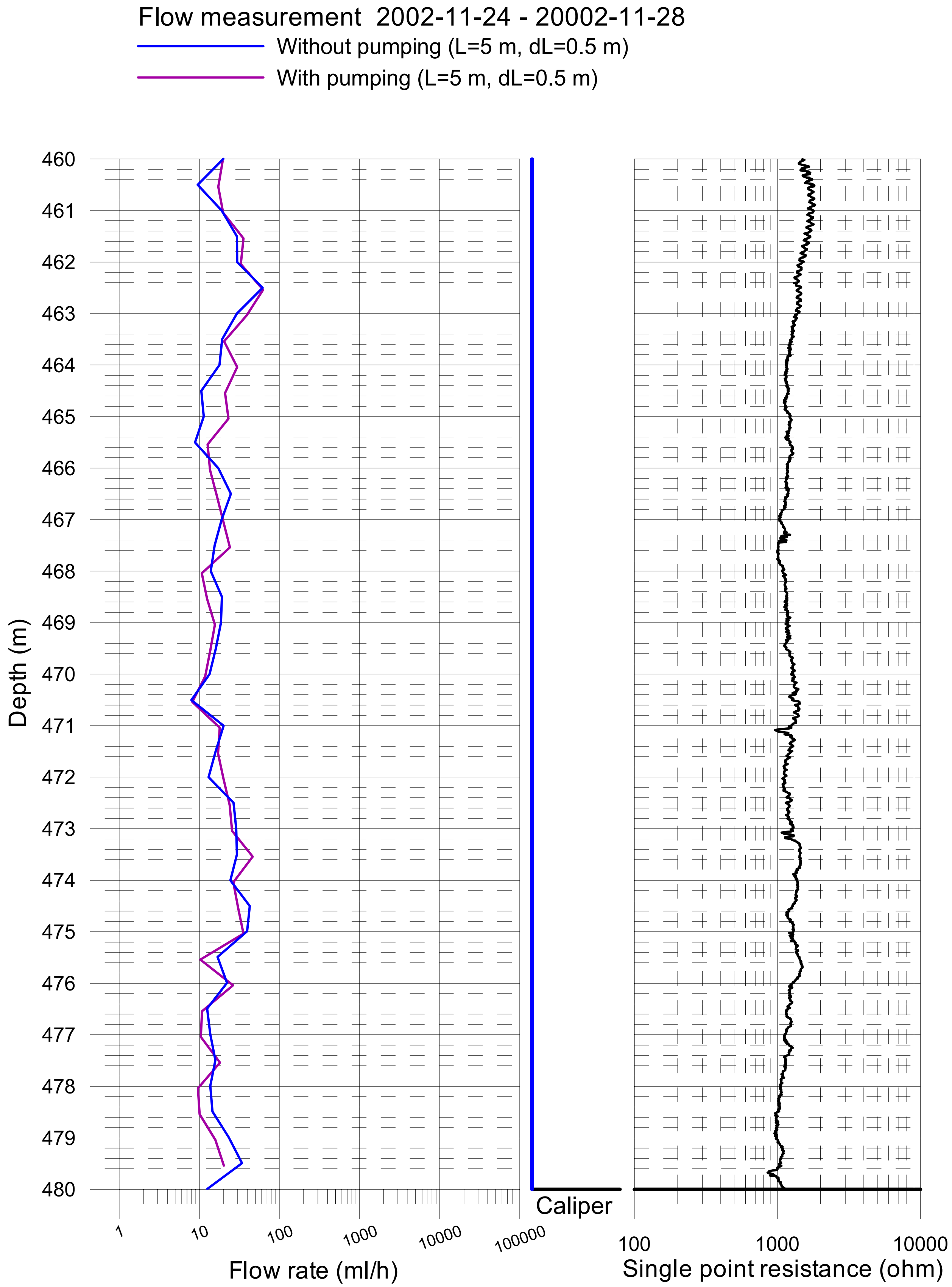

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Depth (m)
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

Forsmark, Borehole KFM01A

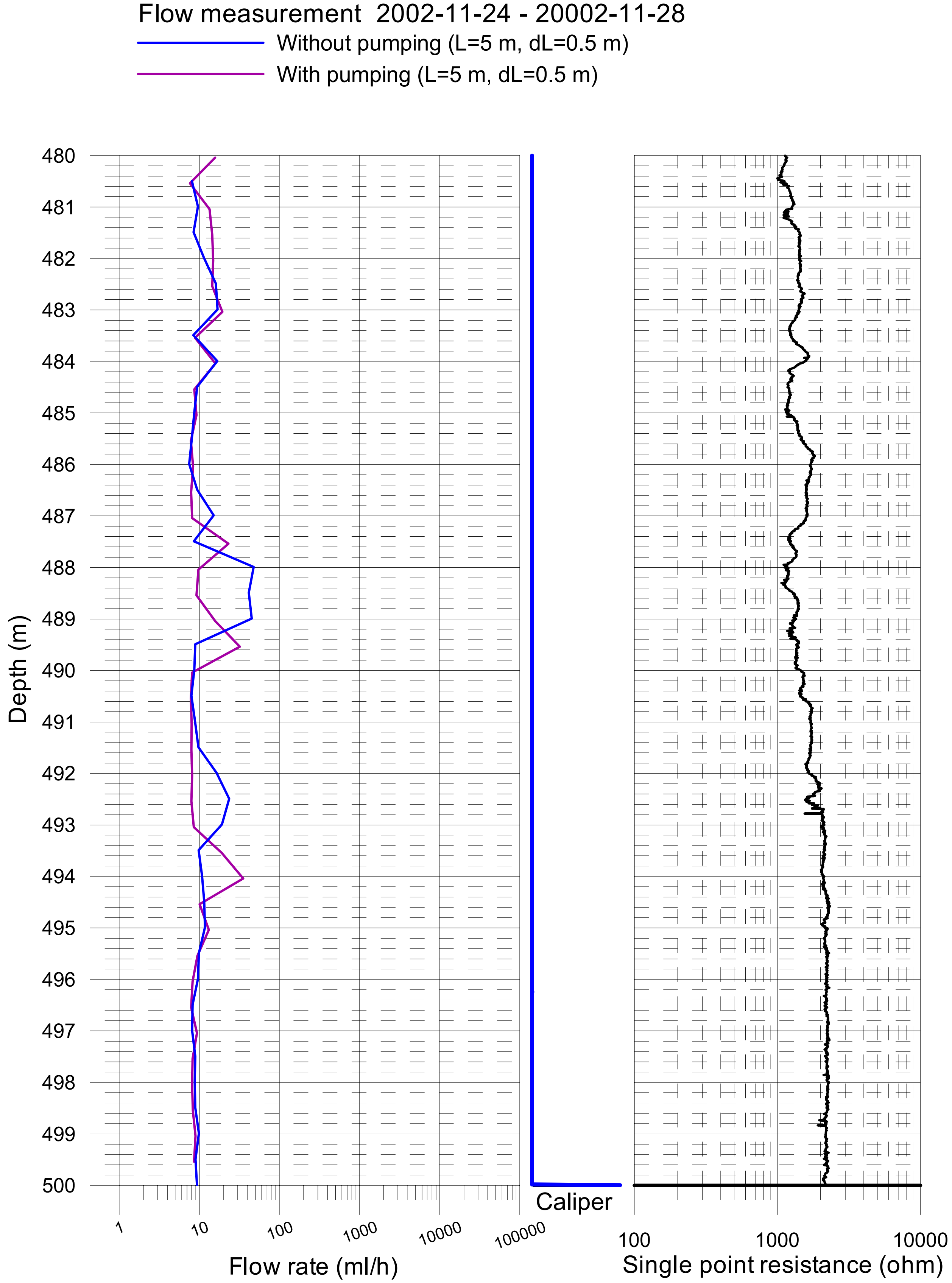


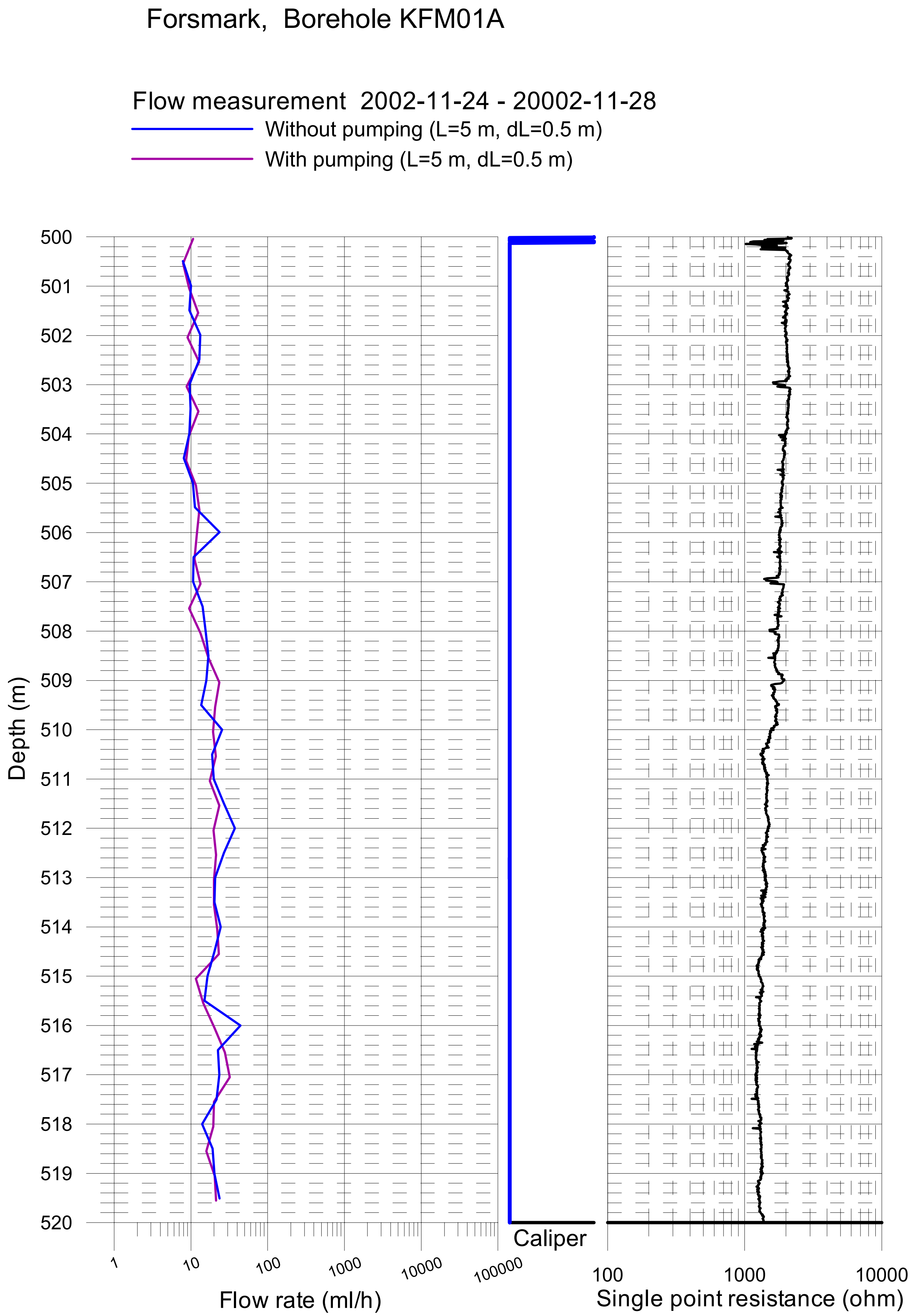

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Depth (m)
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

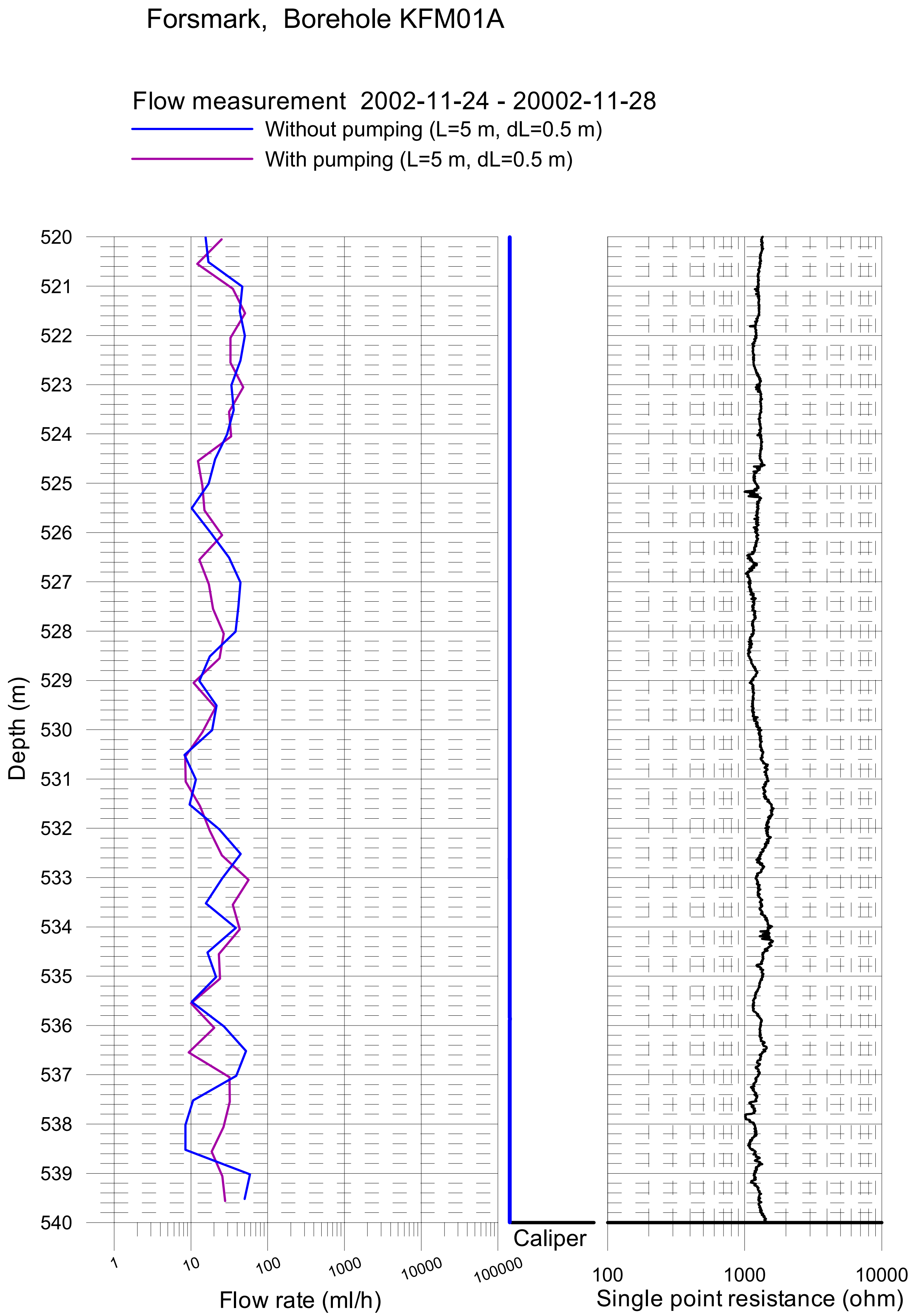
Forsmark, Borehole KFM01A



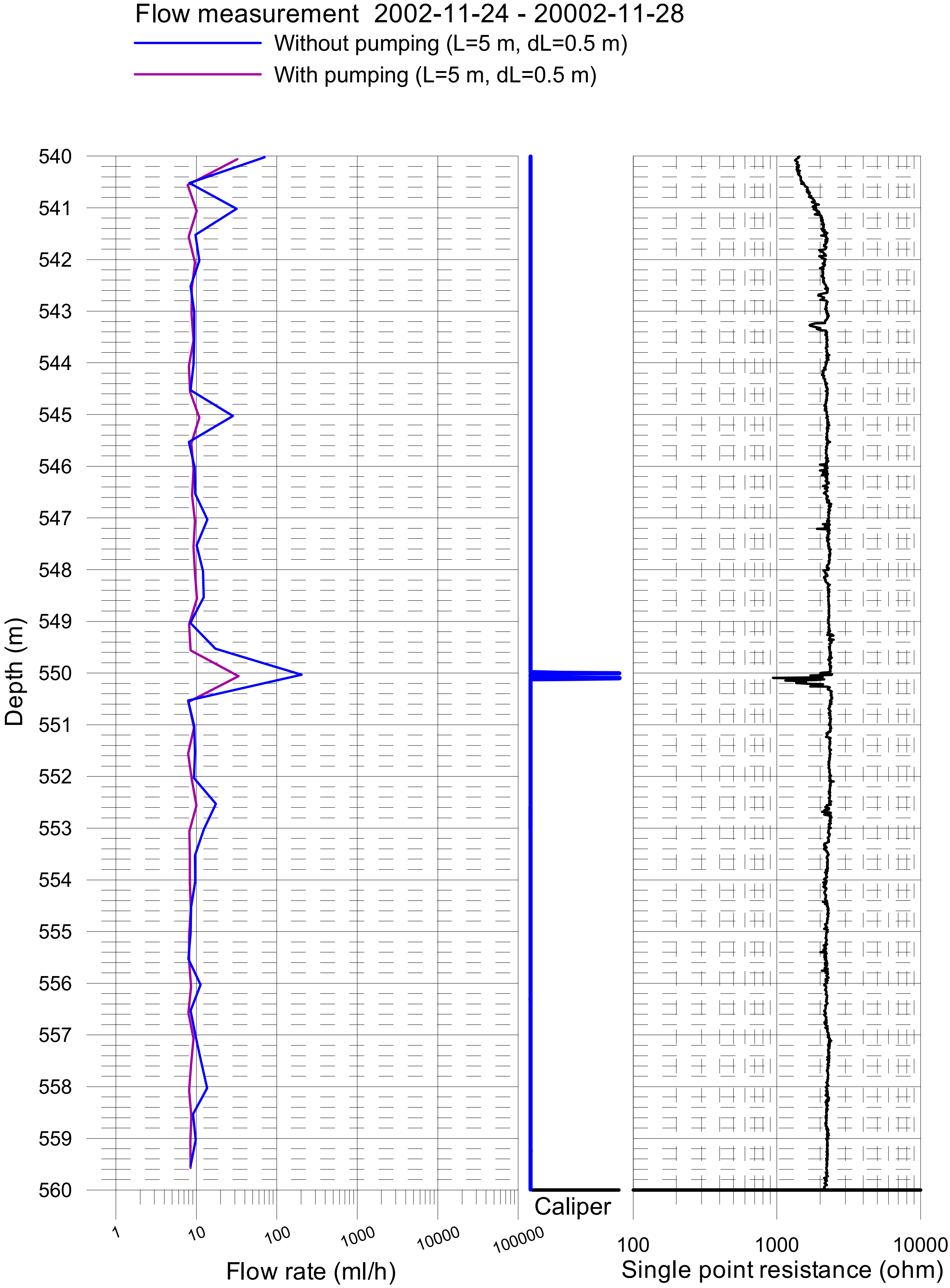
Forsmark, Borehole KFM01A



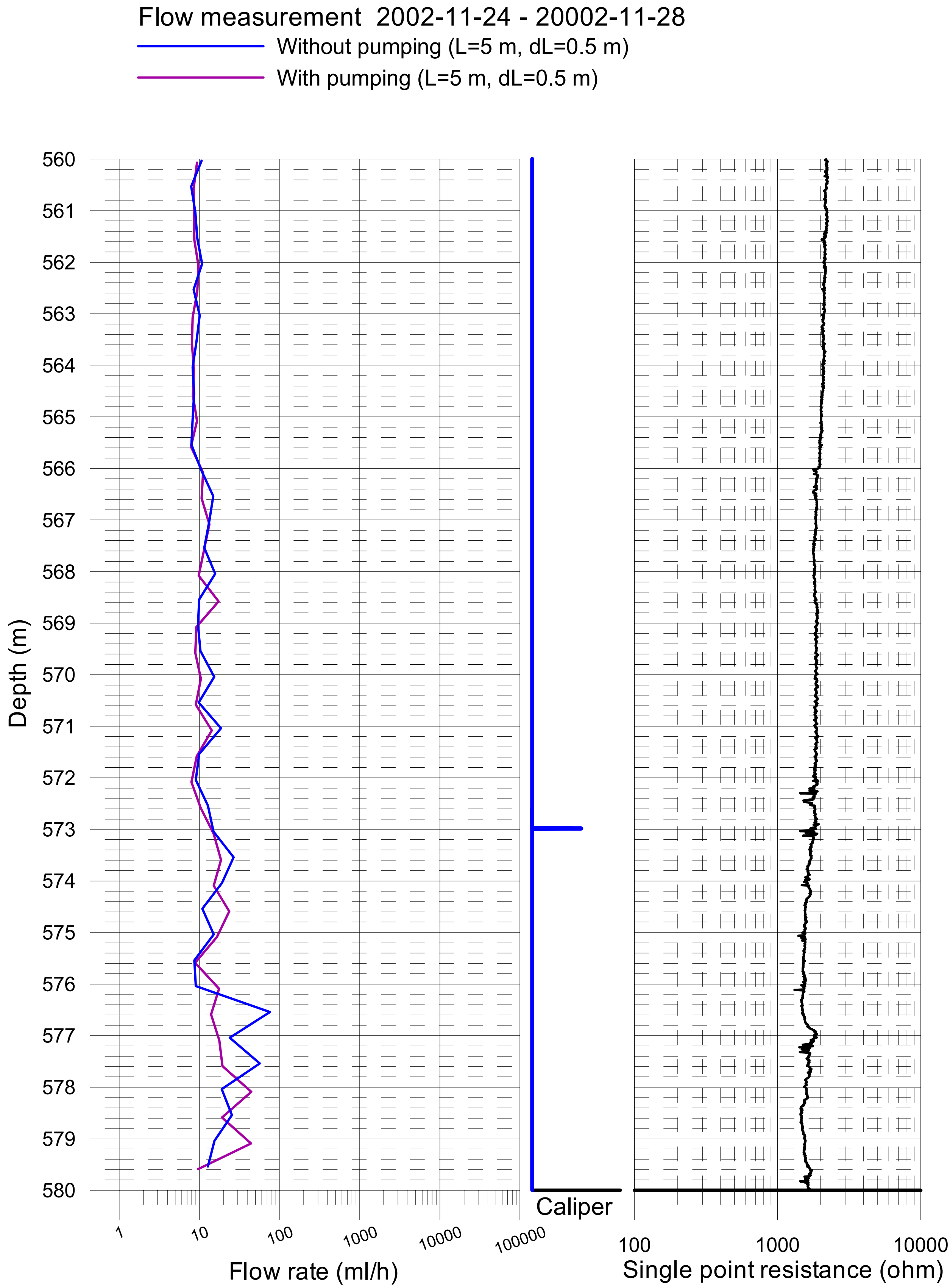

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Depth (m)
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

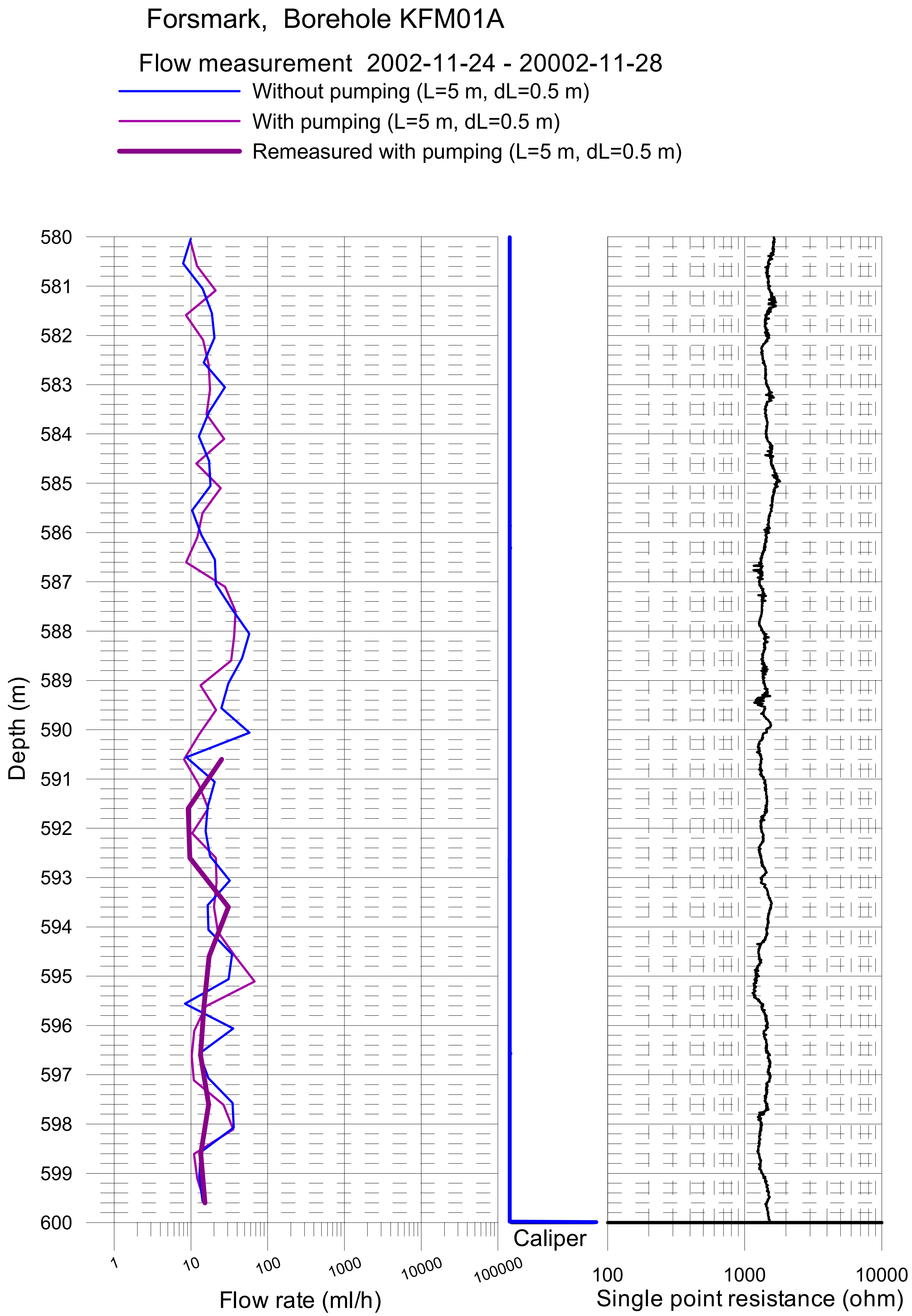

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Depth (m)
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

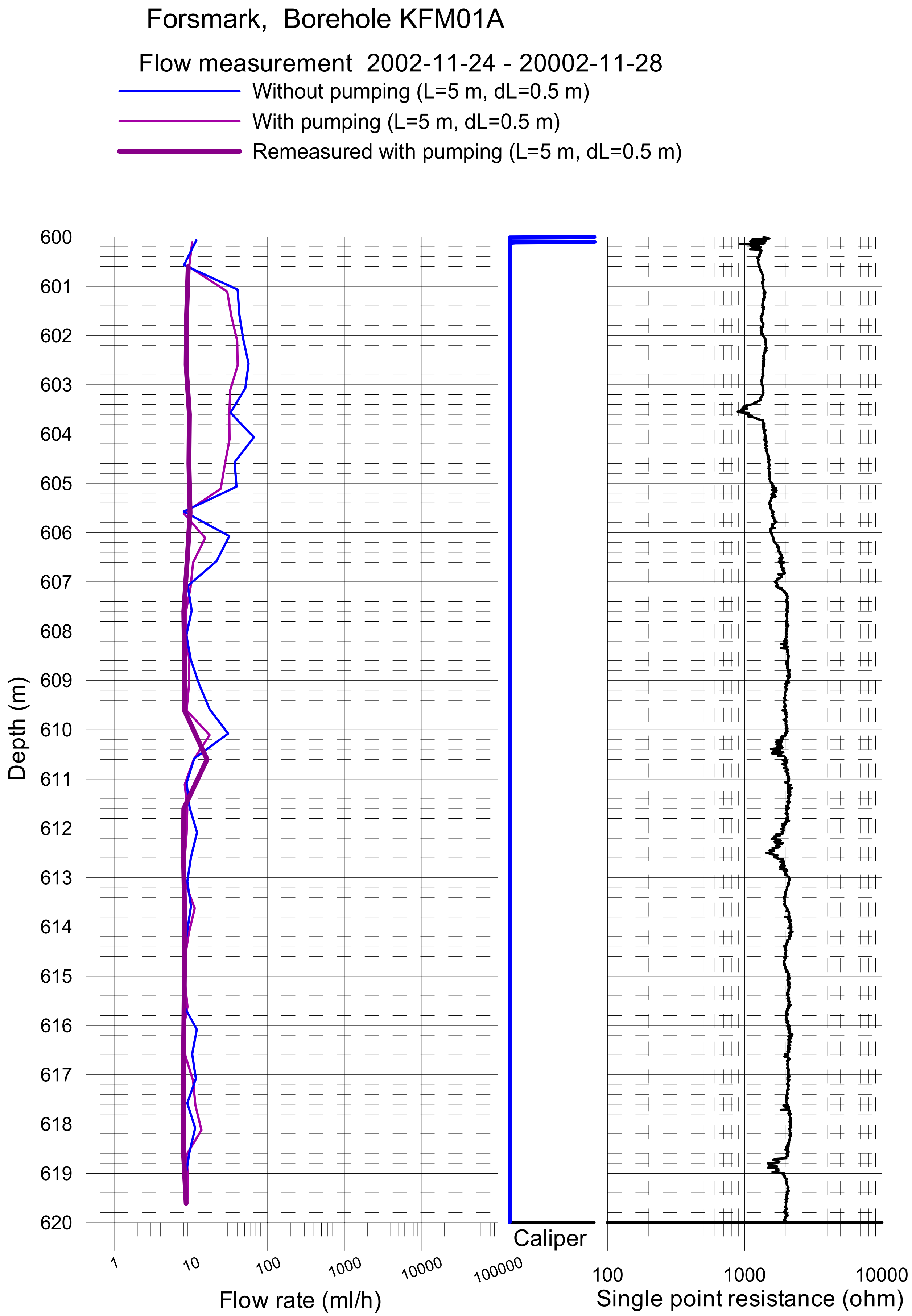
Forsmark, Borehole KFM01A

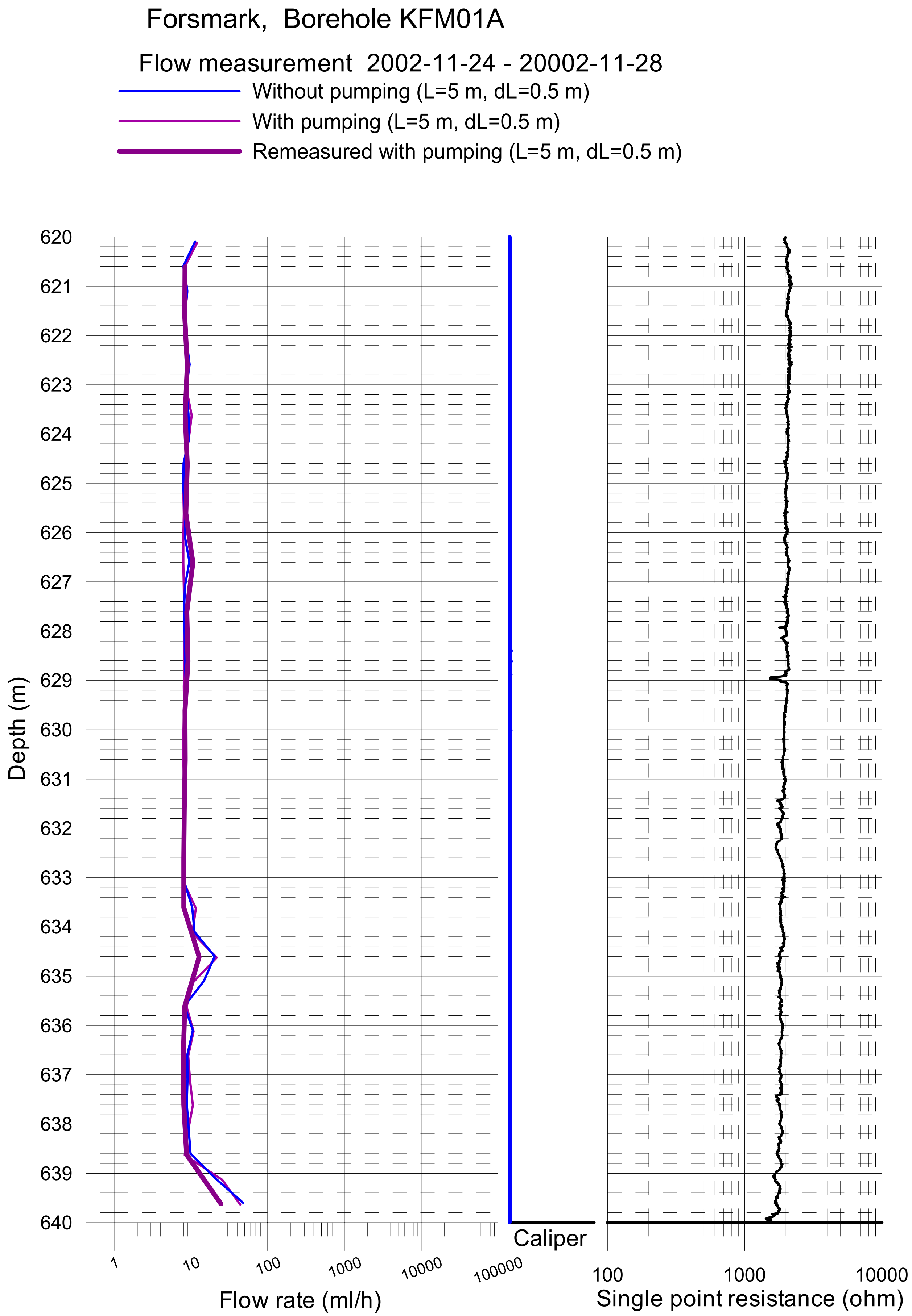


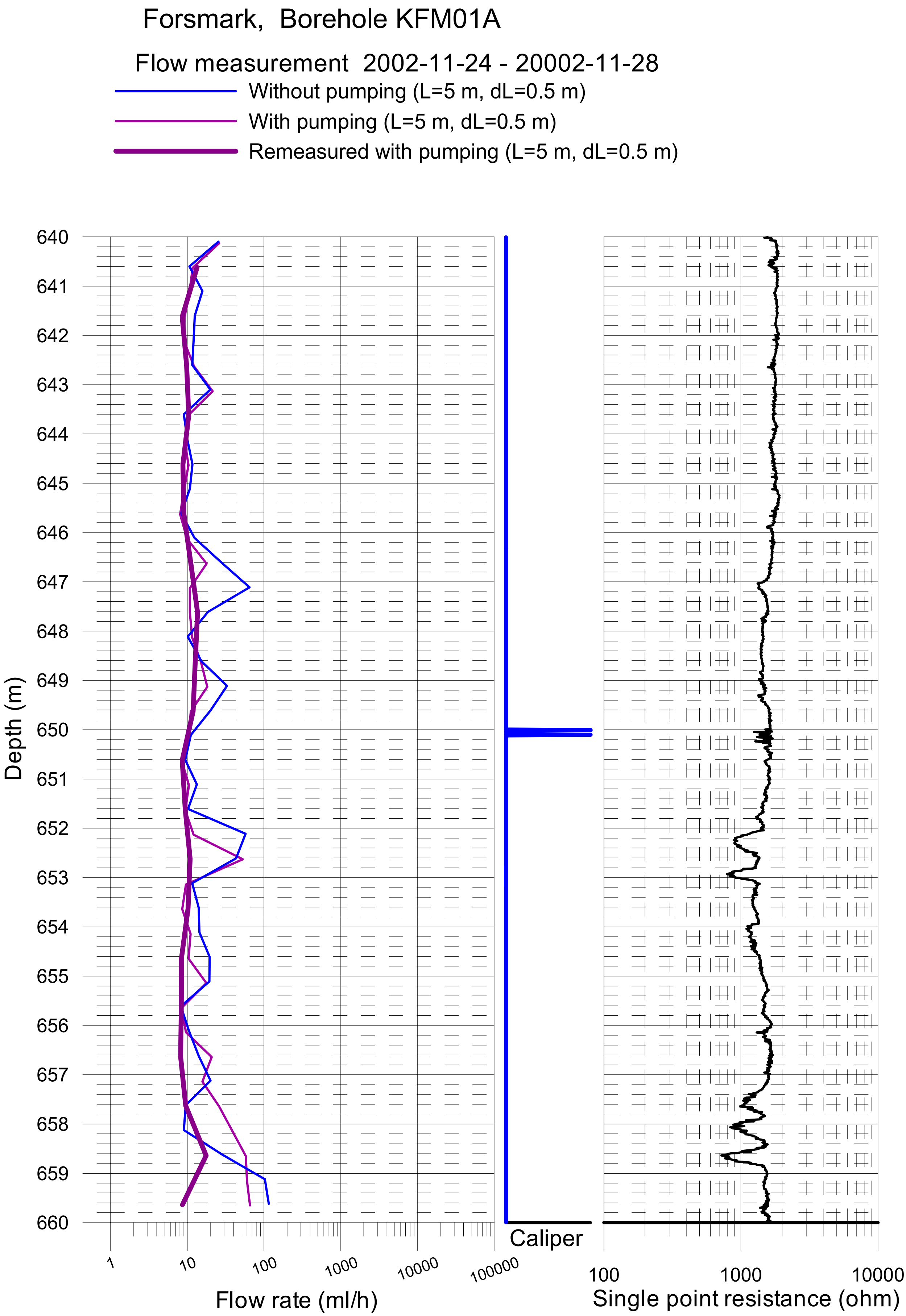
Forsmark, Borehole KFM01A



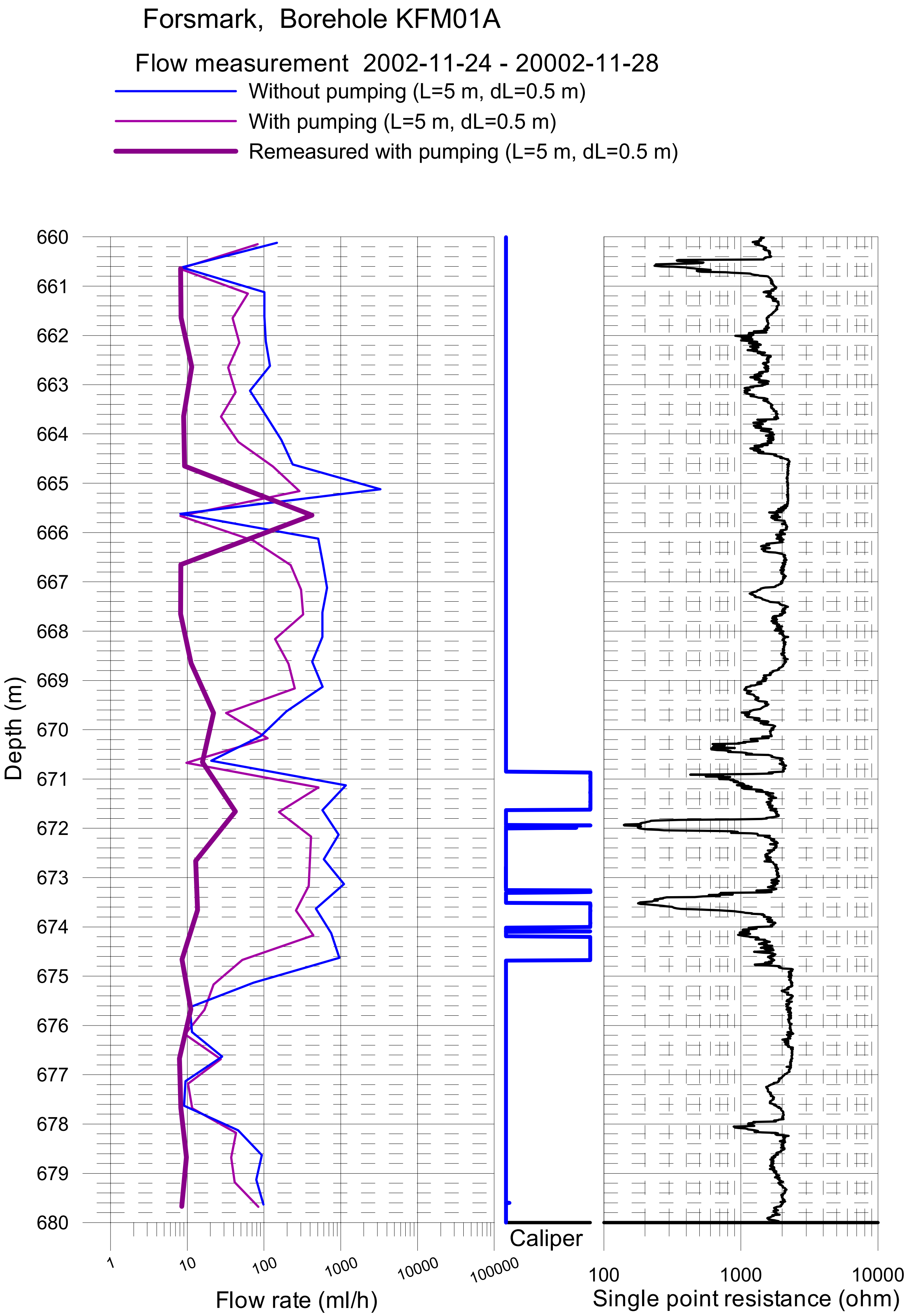

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
Depth (m)
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

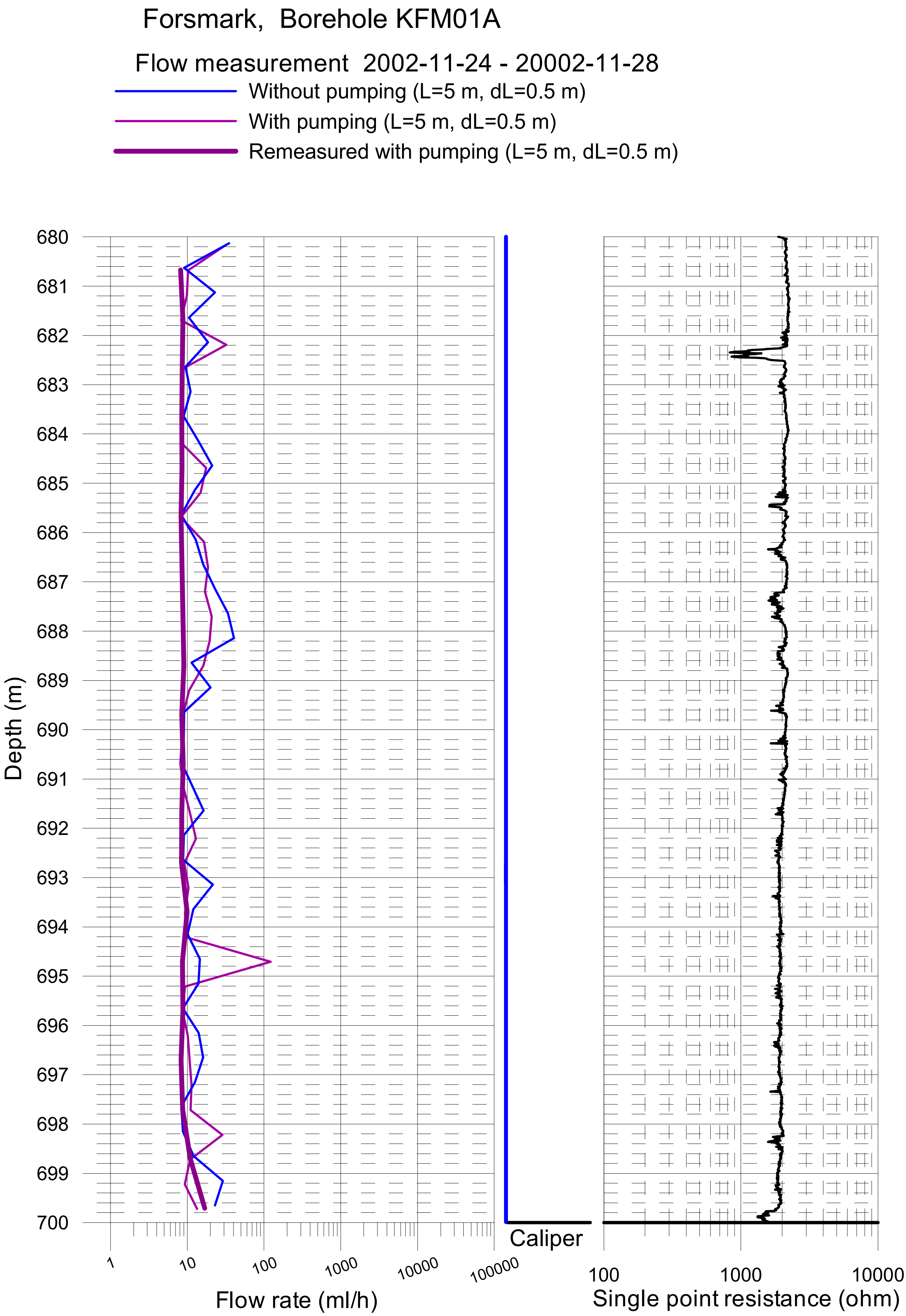

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
Depth (m)
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

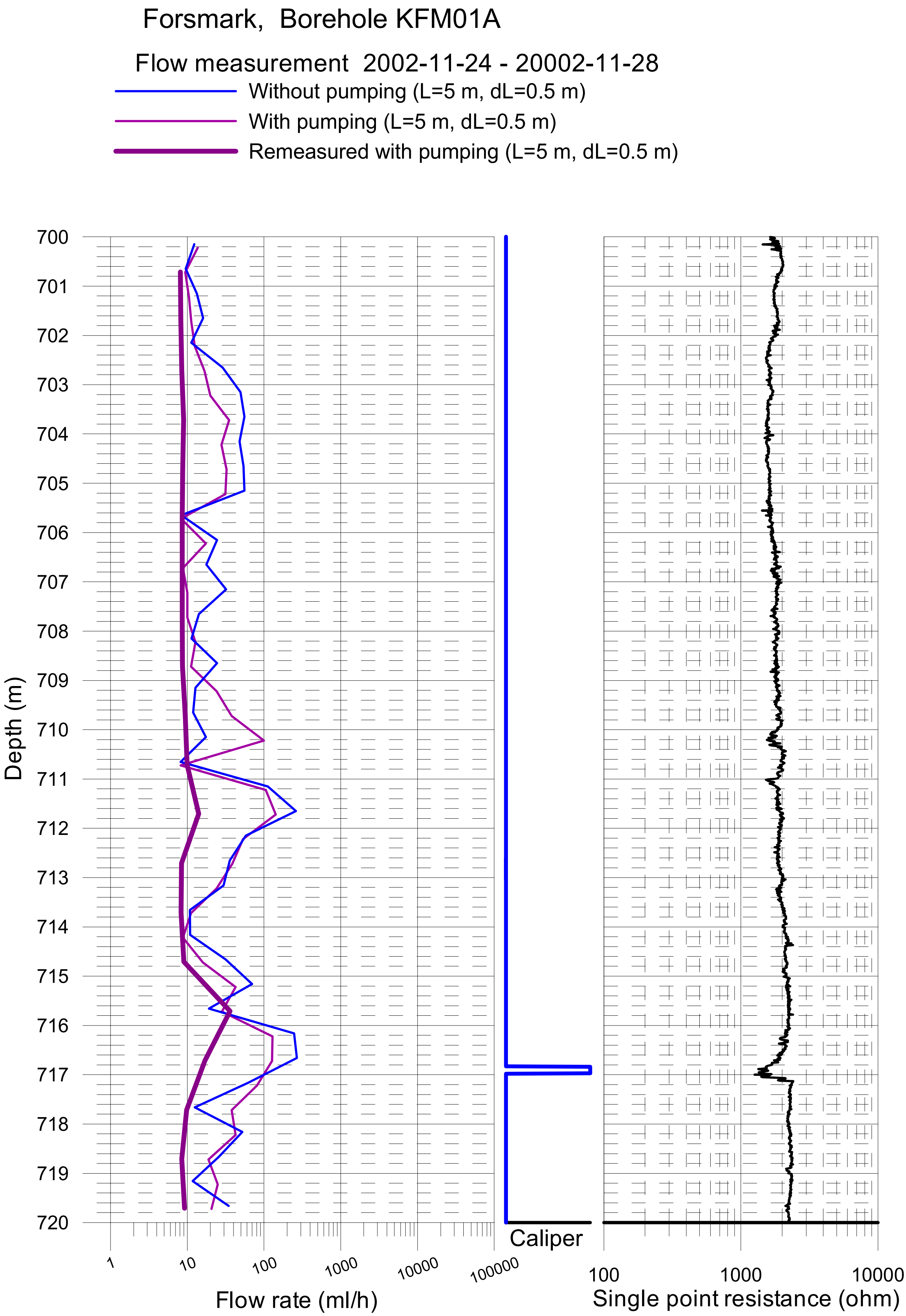

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
Depth (m)
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

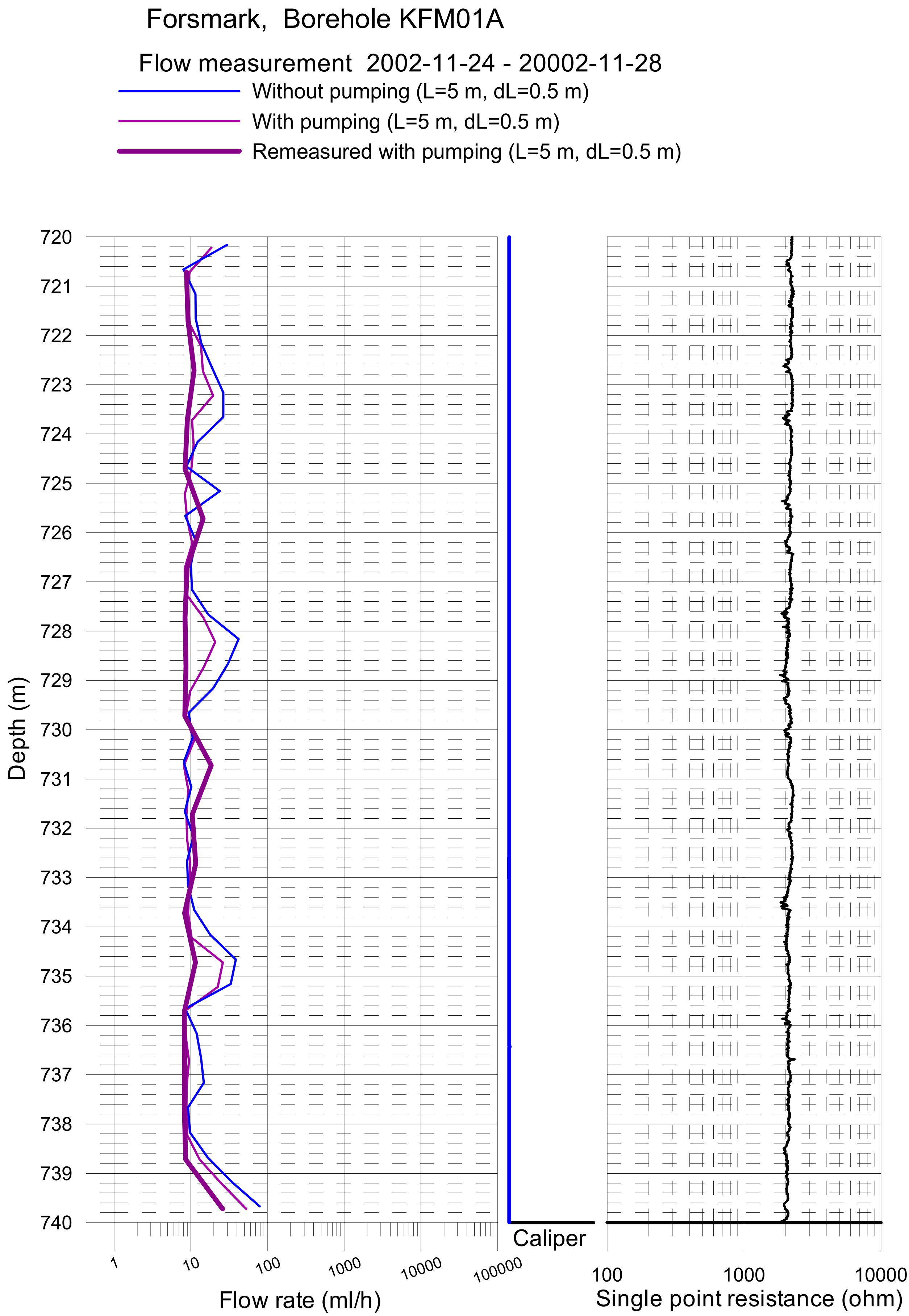


Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
Depth (m)
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

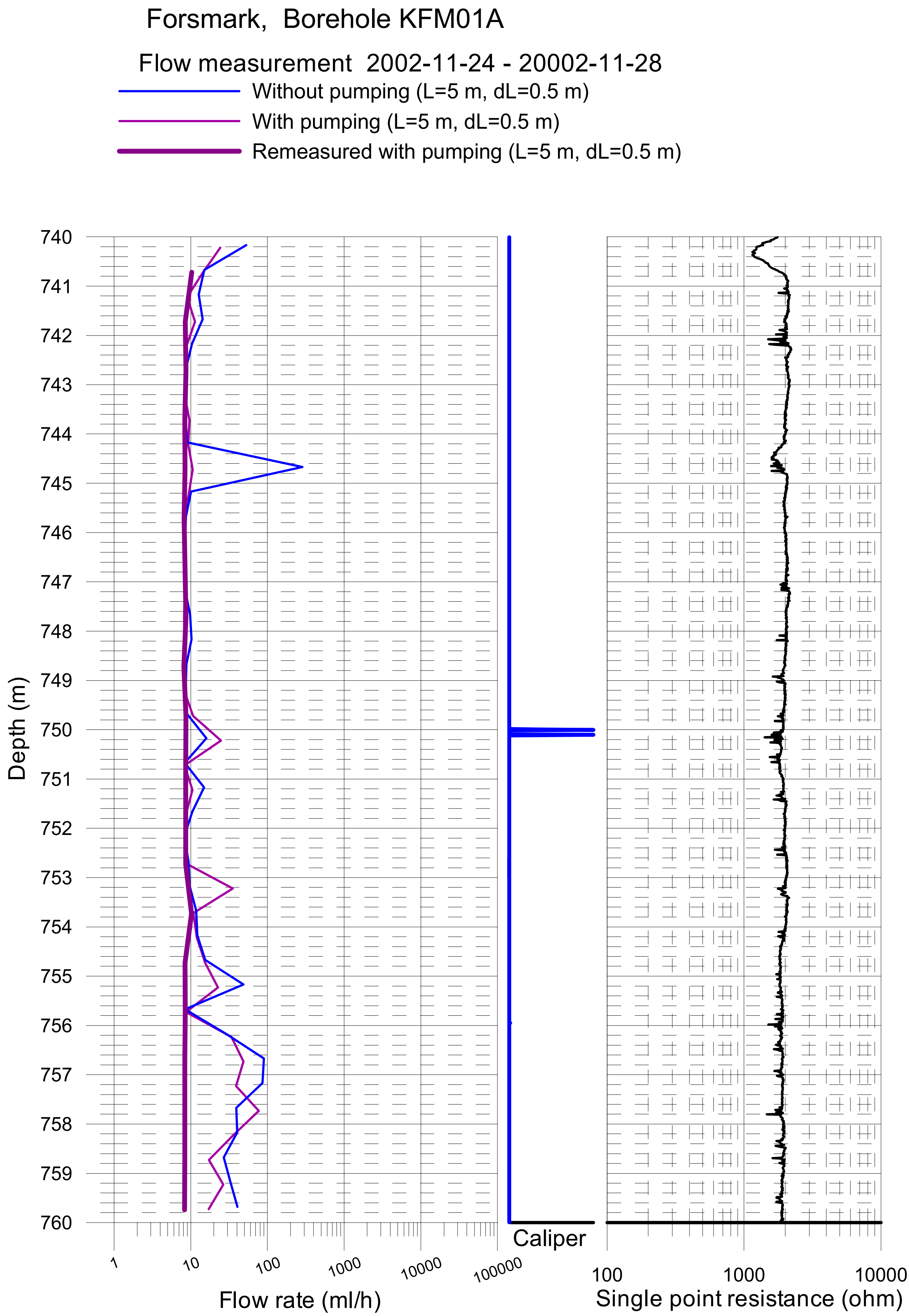

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
Depth (m)
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)


Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
Depth (m)
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

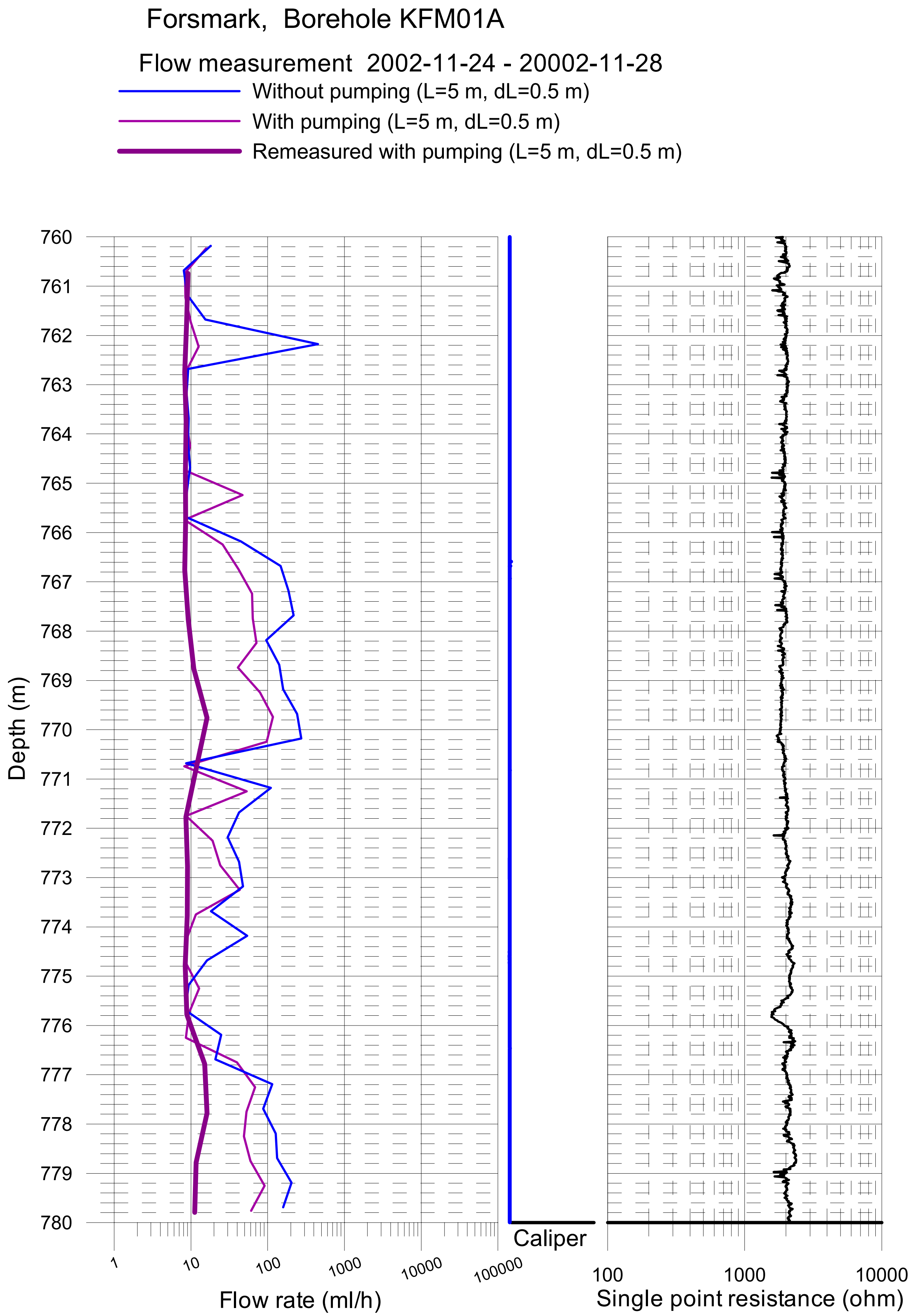

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
Depth (m)
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

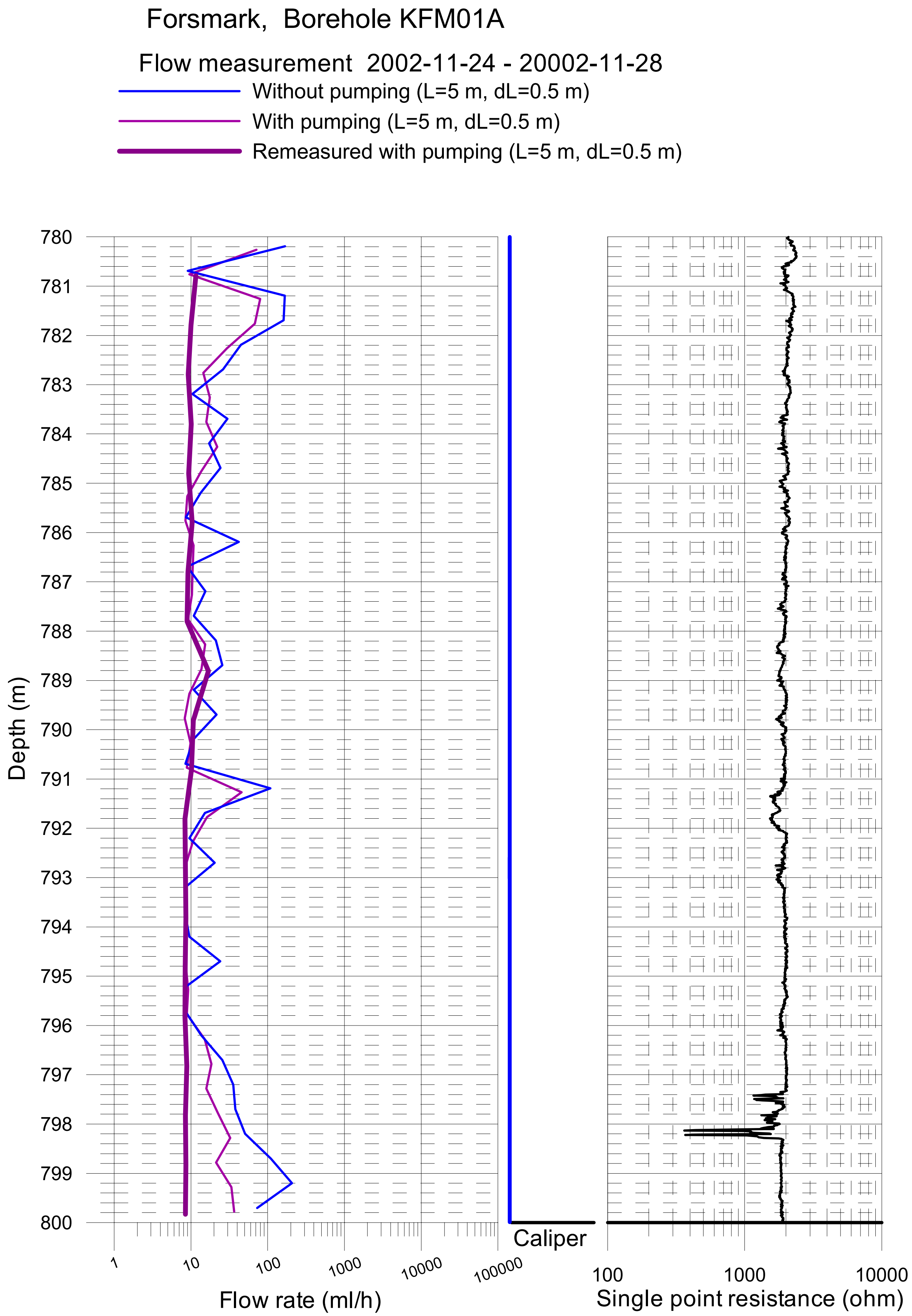


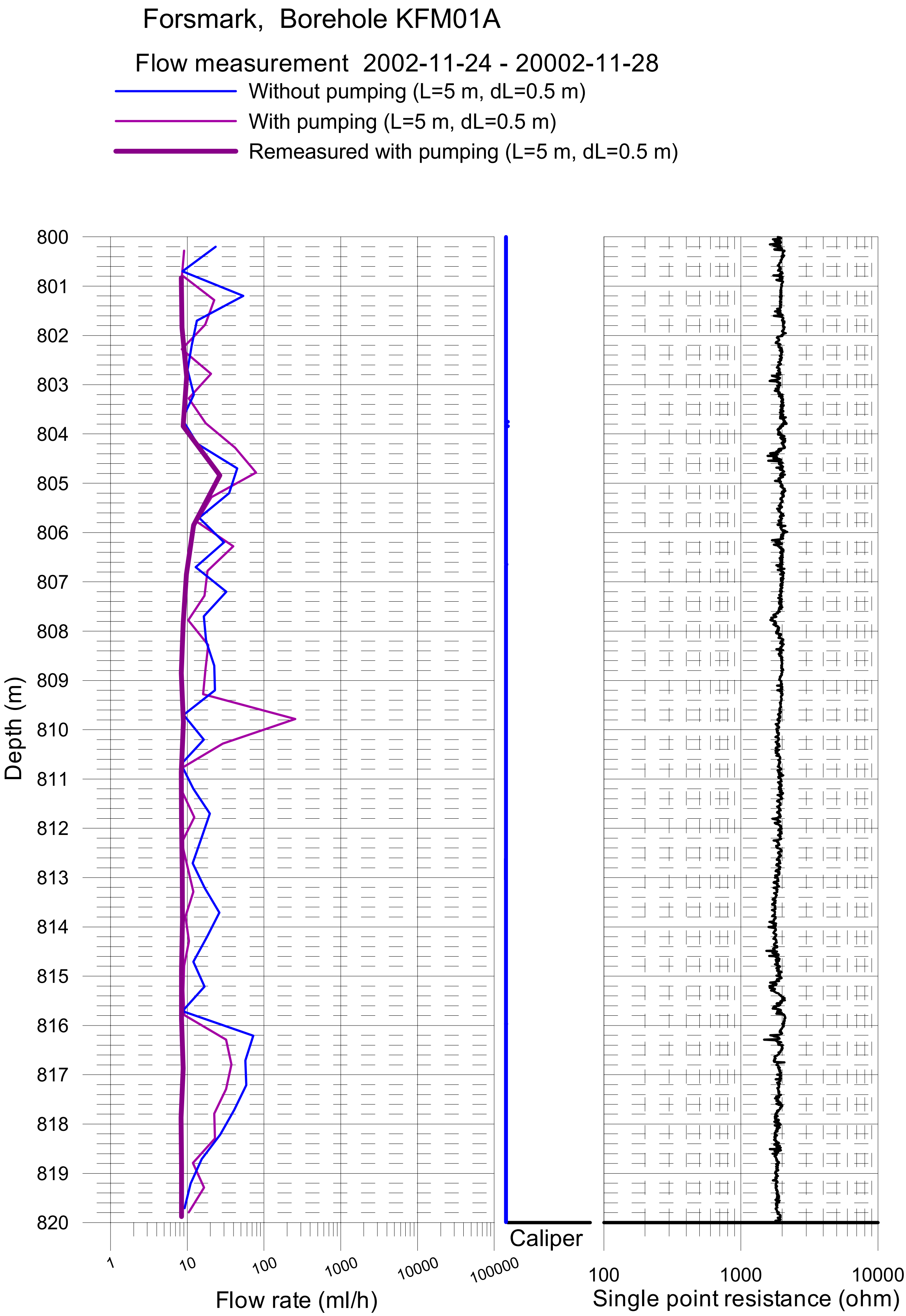
Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
Depth (m)
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

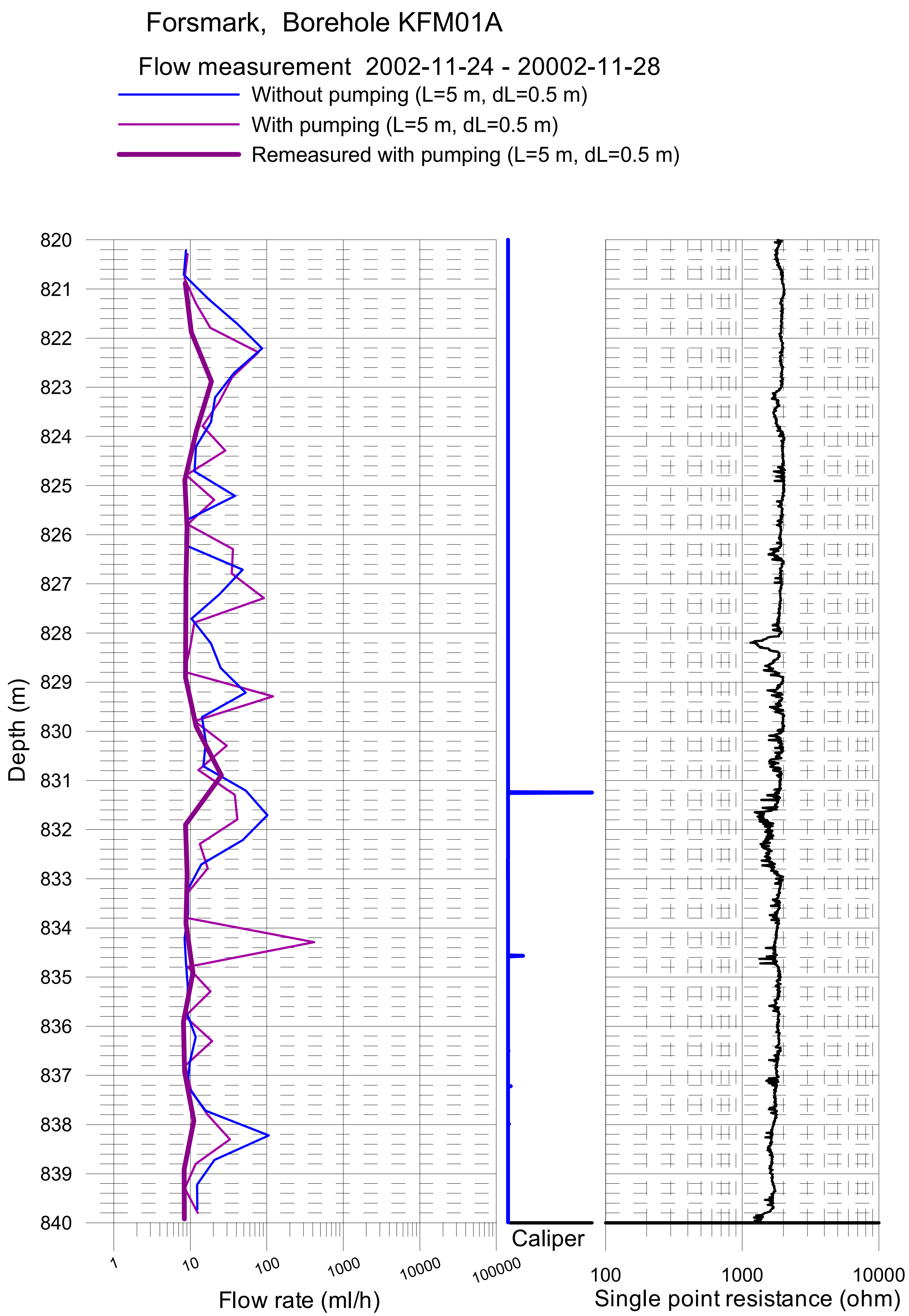


Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
Depth (m)
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

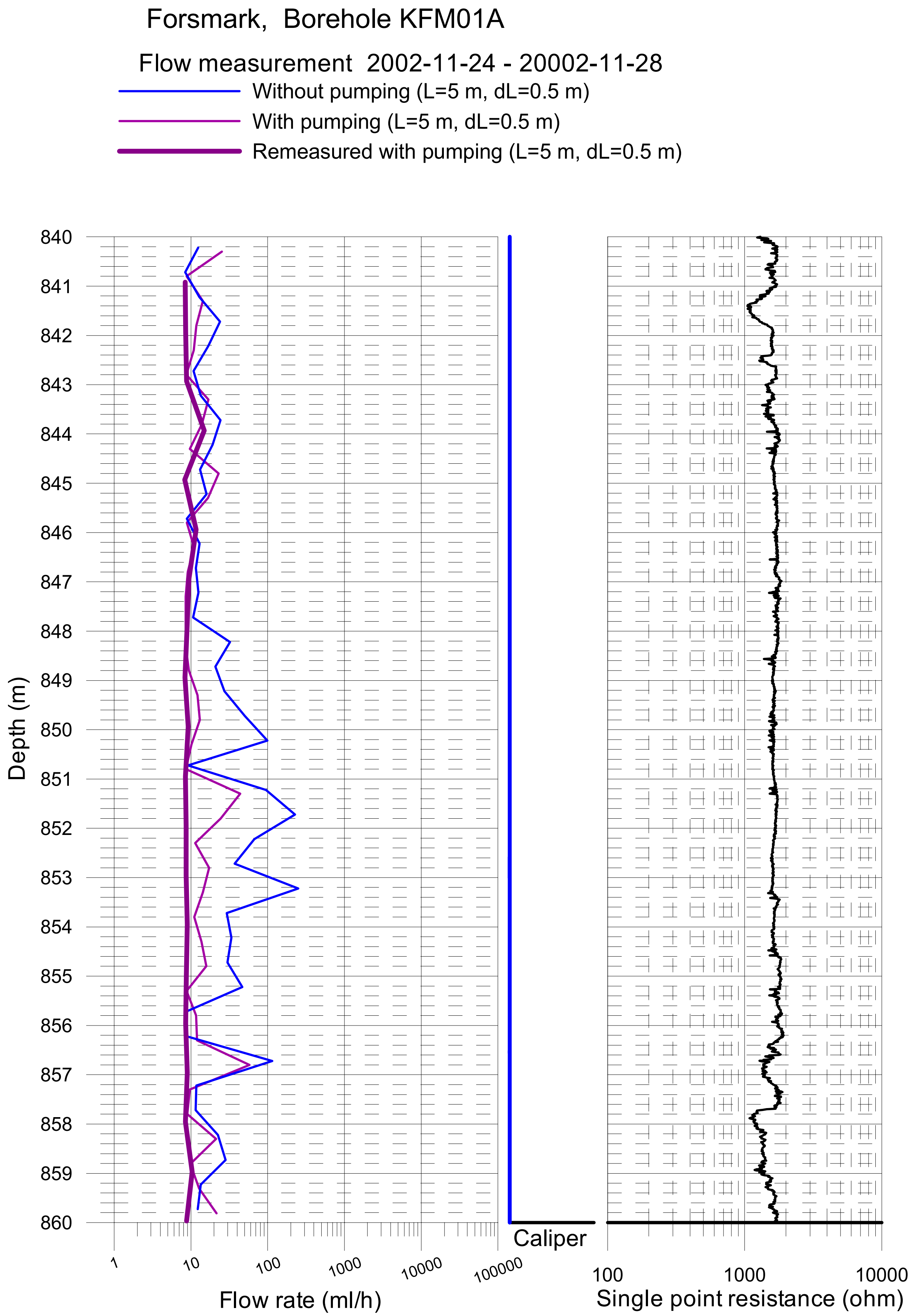

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
Depth (m)
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)


Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
Depth (m)
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

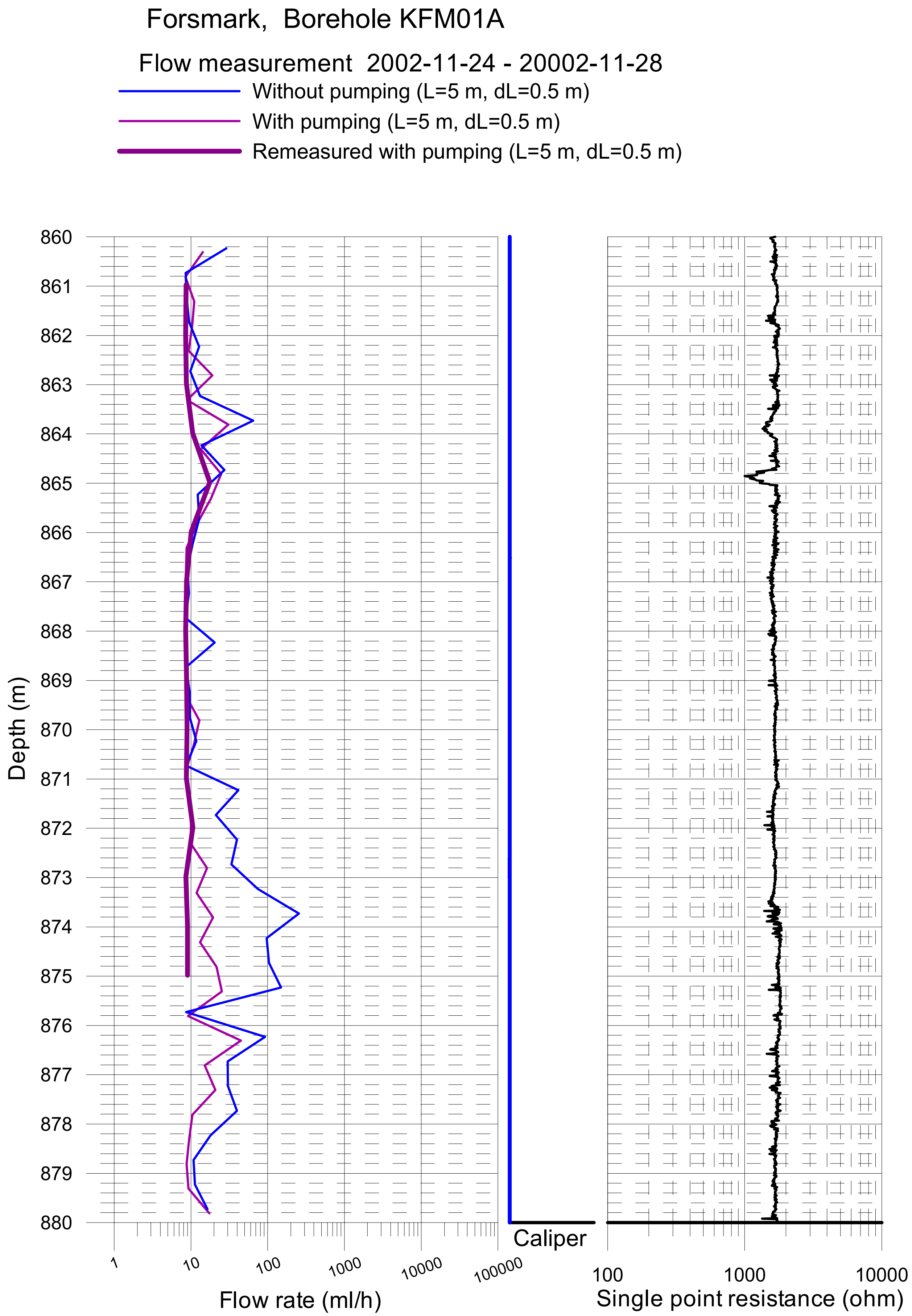

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
Depth (m)
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

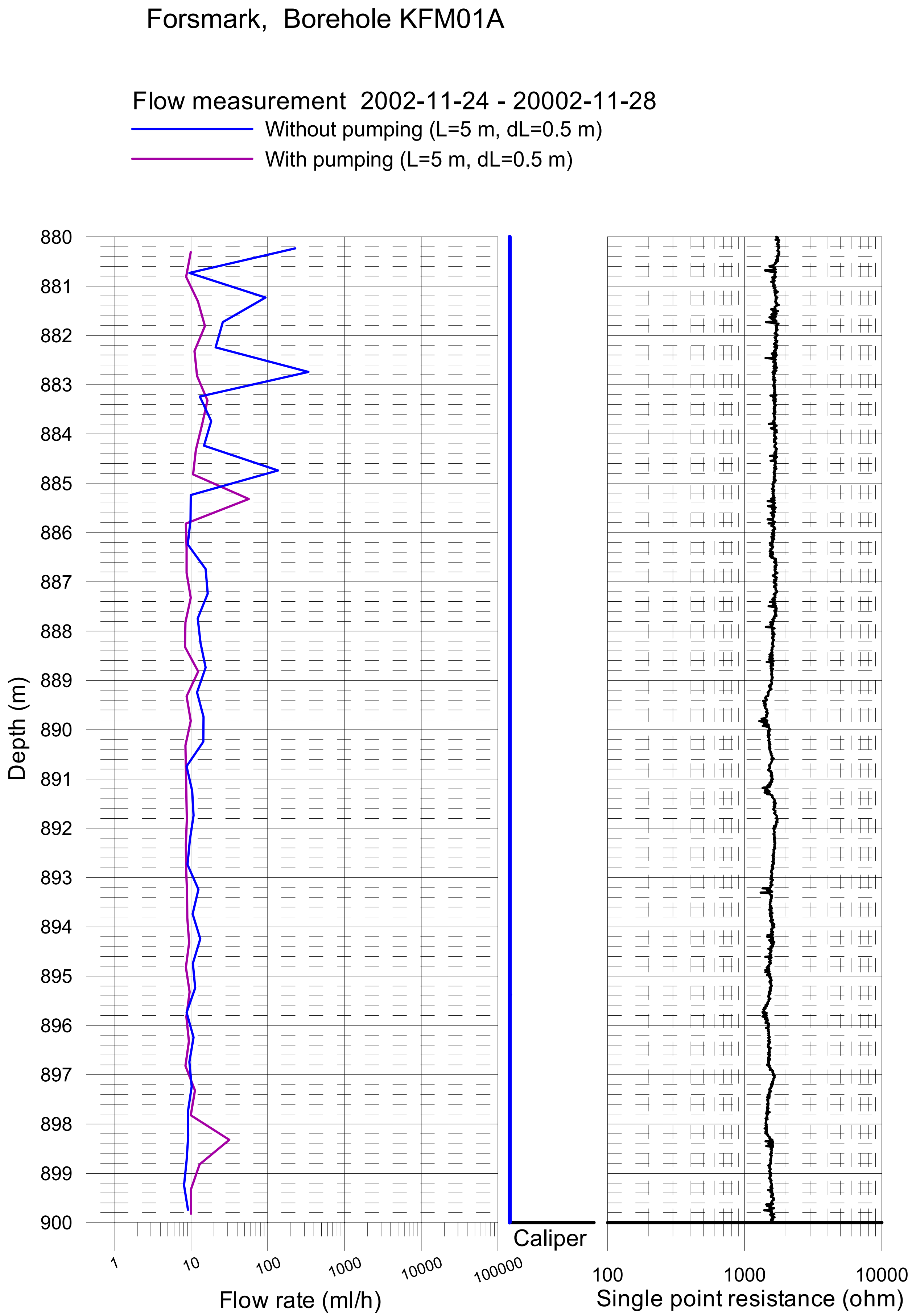


Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
Depth (m)
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

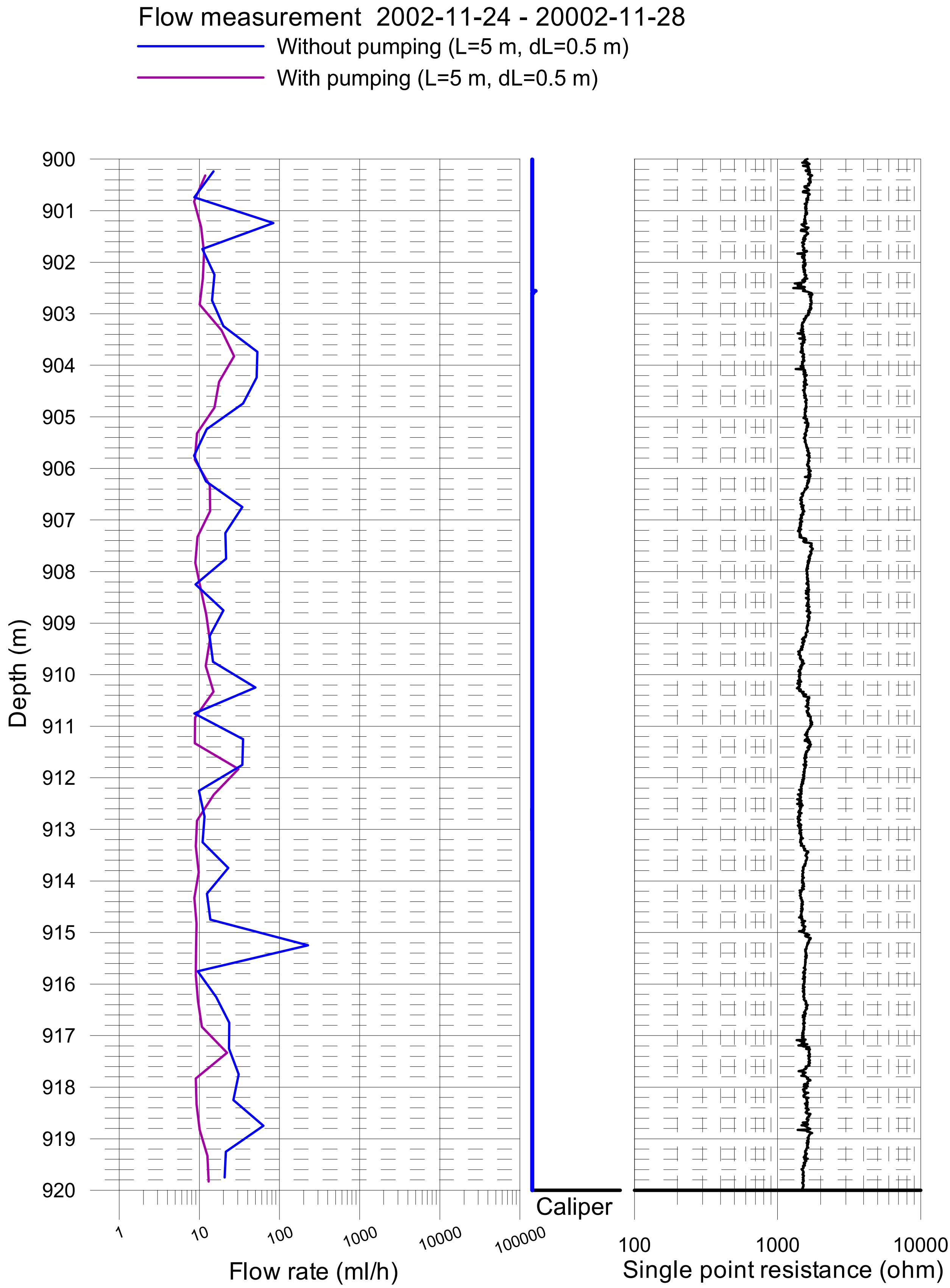


Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
Depth (m)
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

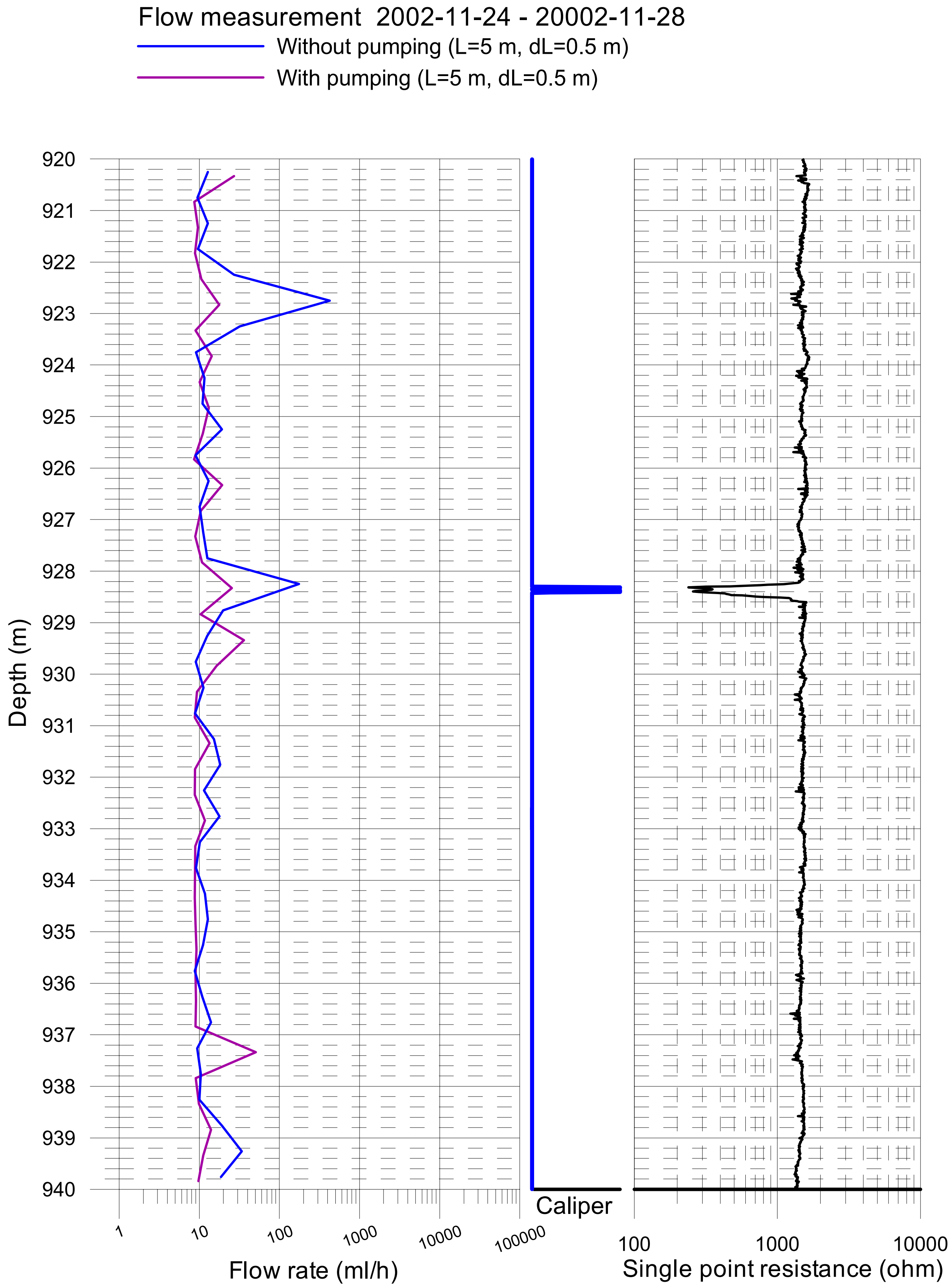

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Remeasured with pumping (L=5 m, dL=0.5 m)
Depth (m)
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)


Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 20002-11-28
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Depth (m)
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
1
10
100
1000
10000
100000
Flow rate (ml/h)
Caliper
100
1000
10000
Single point resistance (ohm)

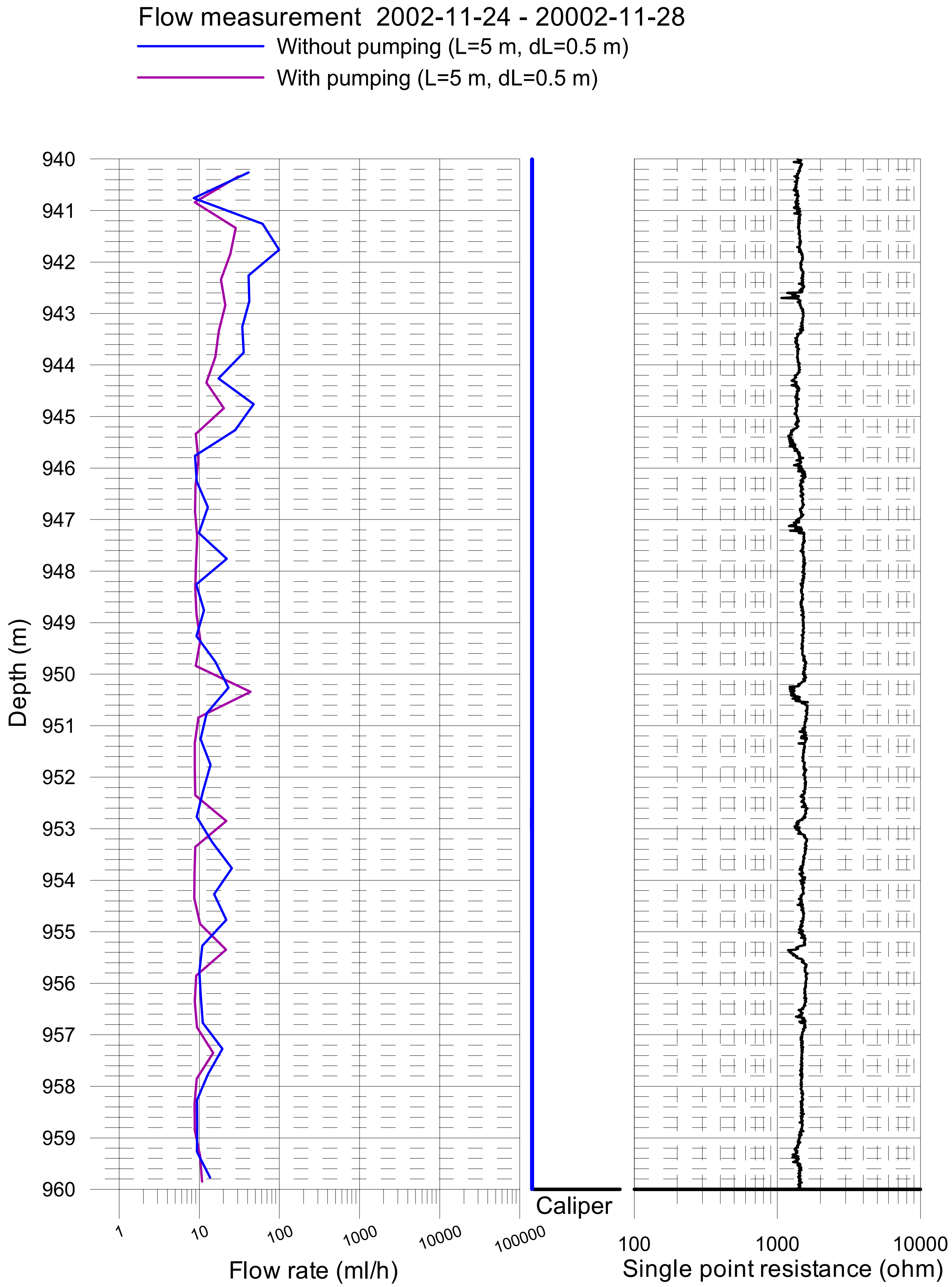
Forsmark, Borehole KFM01A



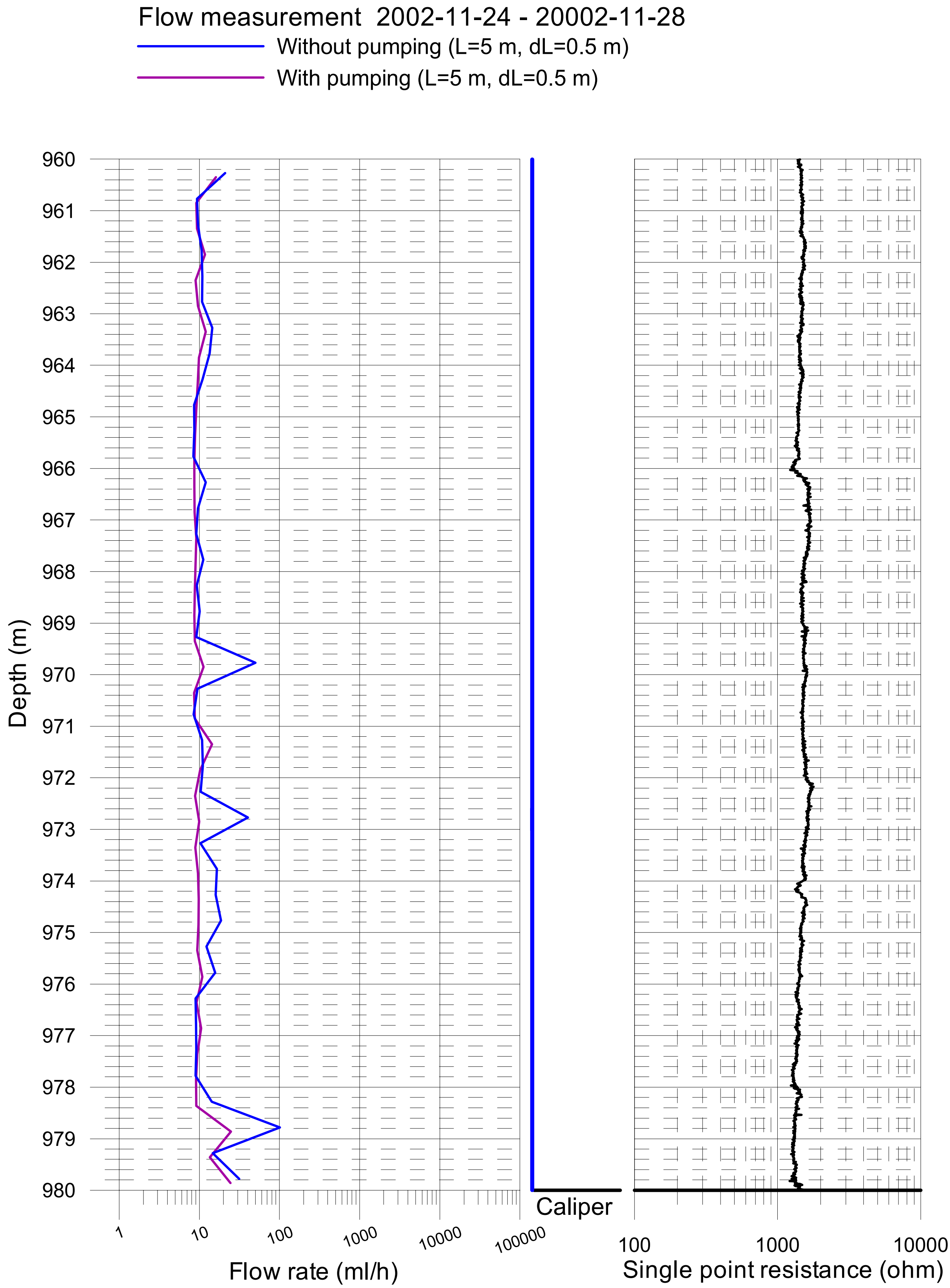
Forsmark, Borehole KFM01A



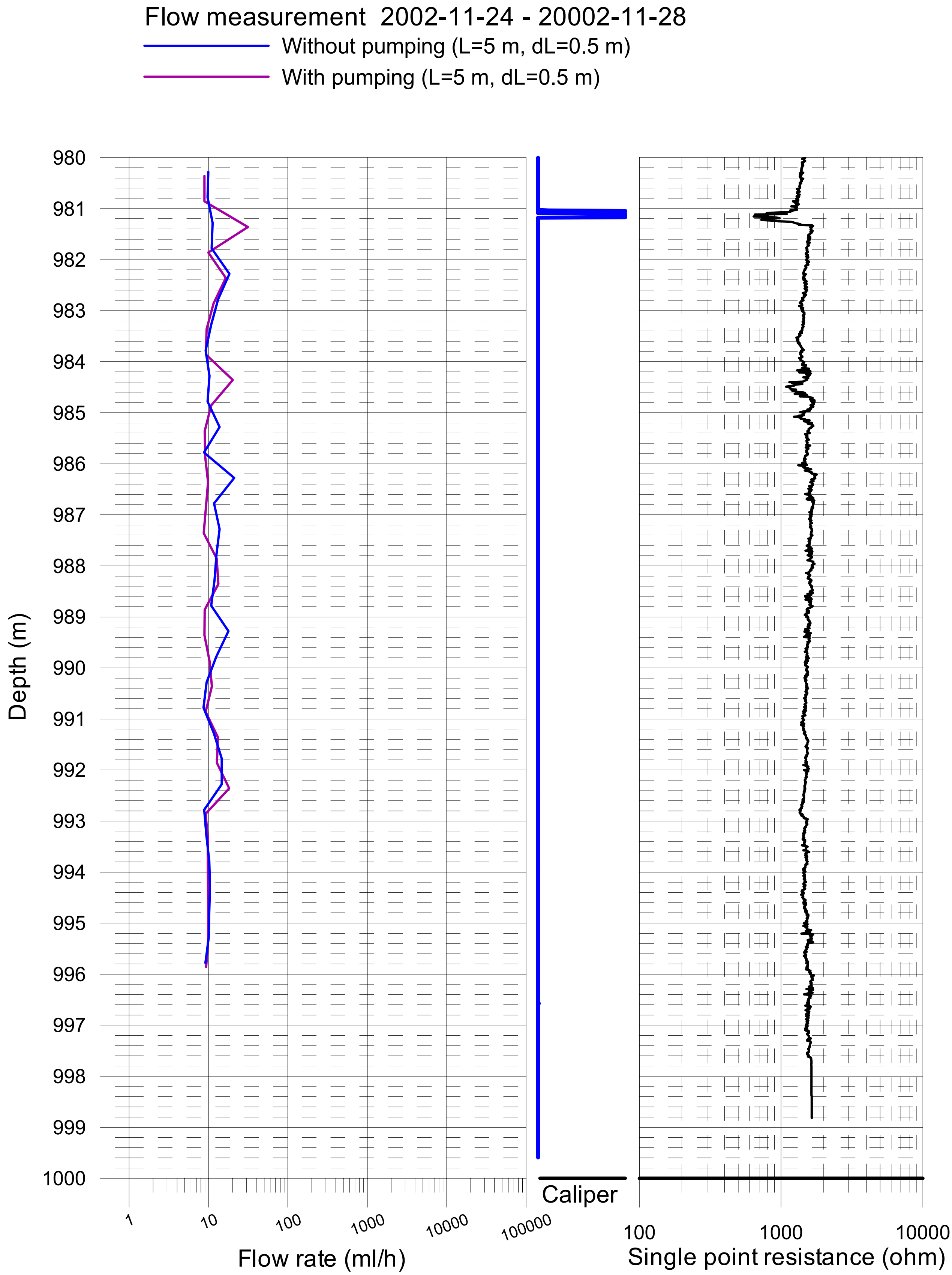
Forsmark, Borehole KFM01A



Forsmark, Borehole KFM01A



Forsmark, Borehole KFM01A



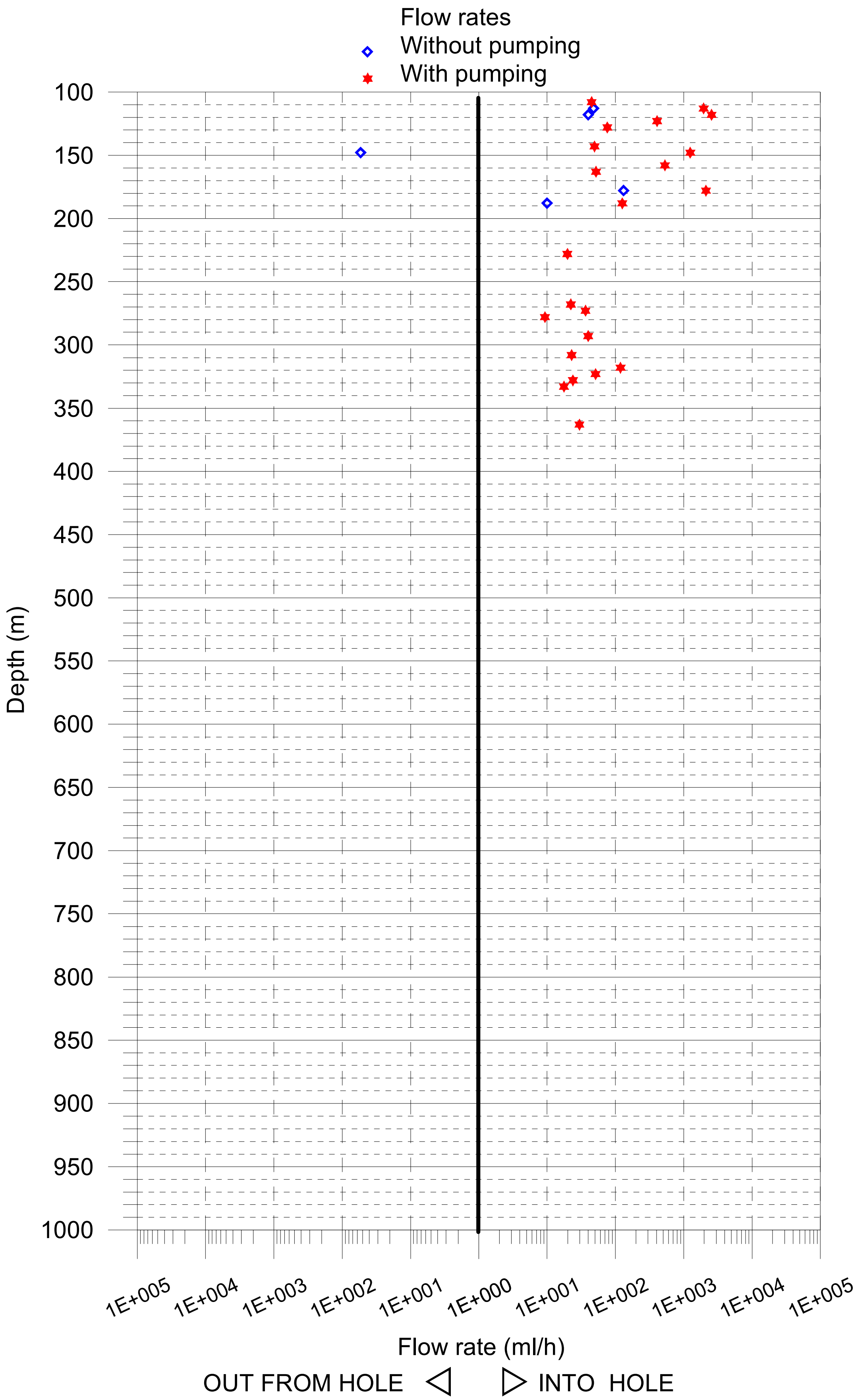
Depth1(m)	Borehole Head1(fresh water, masl)	Flow1(mL/h)	Depth2(m)	Borehole Head2(fresh water, masl)	Flow2(mL/h)	Formation Head (fresh water, masl)	K(m/s)
107.95	-1.579	0	107.99	-12.703	44.75		2.21E-10
112.95	-1.576	47.75	112.99	-12.736	1962	-1.3	9.43E-09
117.95	-1.571	40.15	117.99	-12.734	2563	-1.39	1.24E-08
122.94	-1.565	0	122.99	-12.735	407		2.00E-09
127.94	-1.56	0	127.99	-12.736	76.21		3.75E-10
132.94	-1.558	0	133	-12.735	0		
137.94	-1.554	0	138	-12.735	0		
142.93	-1.549	0	143	-12.733	49.45		2.43E-10
147.93	-1.545	-53.7	148	-12.737	1247	-2.01	6.39E-09
152.93	-1.543	0	153	-12.738	0		
157.93	-1.537	0	158	-12.737	530		2.60E-09
162.94	-1.534	0	163.01	-12.736	52.02		2.55E-10
167.94	-1.53	0	168.01	-12.736	0		
172.94	-1.528	0	173.01	-12.733	0		
177.94	-1.524	131.49	178.01	-12.735	2116	-0.78	9.73E-09
182.94	-1.519	0	183.01	-12.733	0		
187.95	-1.515	10	188.02	-12.737	126.15	-0.55	5.69E-10
192.95	-1.512	0	193.02	-12.733	0		
197.95	-1.509	0	198.02	-12.736	0		
202.95	-1.504	0	203.02	-12.735	0		
207.95	-1.501	0	208.02	-12.736	0		
212.96	-1.498	0	213.02	-12.735	0		
217.96	-1.498	0	218.02	-12.736	0		
222.96	-1.499	0	223.02	-12.733	0		
227.97	-1.497	0	228.02	-12.737	19.8		9.68E-11
232.97	-1.491	0	233.02	-12.734	0		
237.97	-1.485	0	238.02	-12.733	0		
242.98	-1.483	0	243.02	-12.733	0		
247.98	-1.479	0	248.02	-12.735	0		
252.98	-1.474	0	253.02	-12.734	0		
257.98	-1.471	0	258.02	-12.734	0		
262.98	-1.466	0	263.02	-12.736	0		
267.98	-1.463	0	268.02	-12.731	22.25		1.09E-10
272.98	-1.46	0	273.02	-12.731	36.55		1.78E-10
277.97	-1.459	0	278.02	-12.733	9.3		4.53E-11
282.97	-1.453	0	283.02	-12.732	0		
287.97	-1.45	0	288.02	-12.735	0		
292.97	-1.449	0	293.02	-12.734	39.95		1.95E-10
297.97	-1.444	0	298.02	-12.733	0		
302.97	-1.442	0	303.02	-12.735	0		
307.97	-1.438	0	308.03	-12.734	22.8		1.11E-10
312.98	-1.436	0	313.03	-12.735	0		
317.98	-1.432	0	318.03	-12.734	118.88		5.78E-10
322.98	-1.43	0	323.04	-12.732	51.2		2.49E-10
327.98	-1.427	0	328.04	-12.731	23.9		1.16E-10
332.98	-1.424	0	333.05	-12.731	17.65		8.58E-11
337.99	-1.423	0	338.05	-12.734	0		
342.99	-1.42	0	343.05	-12.732	0		
347.99	-1.416	0	348.06	-12.734	0		

Depth1(m)	Borehole Head1(fresh water, masl)	Flow1(mL/h)	Depth2(m)	Borehole Head2(fresh water, masl)	Flow2(mL/h)	Formation Head (fresh water, masl)	K(m/s)
352.99	-1.414	0	353.06	-12.73	0		
357.99	-1.412	0	358.06	-12.735	0		
363	-1.409	0	363.06	-12.734	29.75		1.44E-10
368	-1.406	0	368.06	-12.732	0		
373	-1.403	0	373.06	-12.733	0		
378	-1.4	0	378.05	-12.73	0		
383	-1.4	0	383.05	-12.732	0		
388.01	-1.397	0	388.05	-12.732	0		
393.01	-1.394	0	393.05	-12.733	0		
398.01	-1.393	0	398.05	-12.732	0		
403.01	-1.39	0	403.05	-12.73	0		
408.01	-1.387	0	408.05	-12.737	0		
413.01	-1.386	0	413.05	-12.742	0		
418.01	-1.383	0	418.05	-12.743	0		
423.01	-1.378	0	423.05	-12.741	0		
428	-1.378	0	428.05	-12.736	0		
433	-1.374	0	433.05	-12.735	0		
438	-1.373	0	438.05	-12.732	0		
443	-1.369	0	443.05	-12.733	0		
448	-1.365	0	448.05	-12.731	0		
453	-1.365	0	453.04	-12.737	0		
458	-1.363	0	458.04	-12.735	0		
463	-1.361	0	463.04	-12.734	0		
468	-1.357	0	468.04	-12.734	0		
473	-1.355	0	473.04	-12.733	0		
477.99	-1.354	0	478.04	-12.732	0		
482.99	-1.353	0	483.04	-12.738	0		
487.99	-1.348	0	488.04	-12.736	0		
492.99	-1.35	0	493.04	-12.74	0		
497.99	-1.345	0	498.04	-12.733	0		
502.99	-1.341	0	503.04	-12.737	0		
508	-1.341	0	508.04	-12.733	0		
513	-1.339	0	513.05	-12.733	0		
518	-1.336	0	518.05	-12.733	0		
523.01	-1.333	0	523.05	-12.732	0		
528.01	-1.331	0	528.05	-12.733	0		
533.02	-1.332	0	533.05	-12.73	0		
538.02	-1.328	0	538.06	-12.738	0		
543.02	-1.326	0	543.06	-12.736	0		
548.03	-1.322	0	548.06	-12.735	0		
553.03	-1.322	0	553.06	-12.734	0		
558.03	-1.319	0	558.07	-12.734	0		
563.03	-1.318	0	563.07	-12.736	0		
568.04	-1.316	0	568.08	-12.732	0		
573.04	-1.313	0	573.09	-12.735	0		

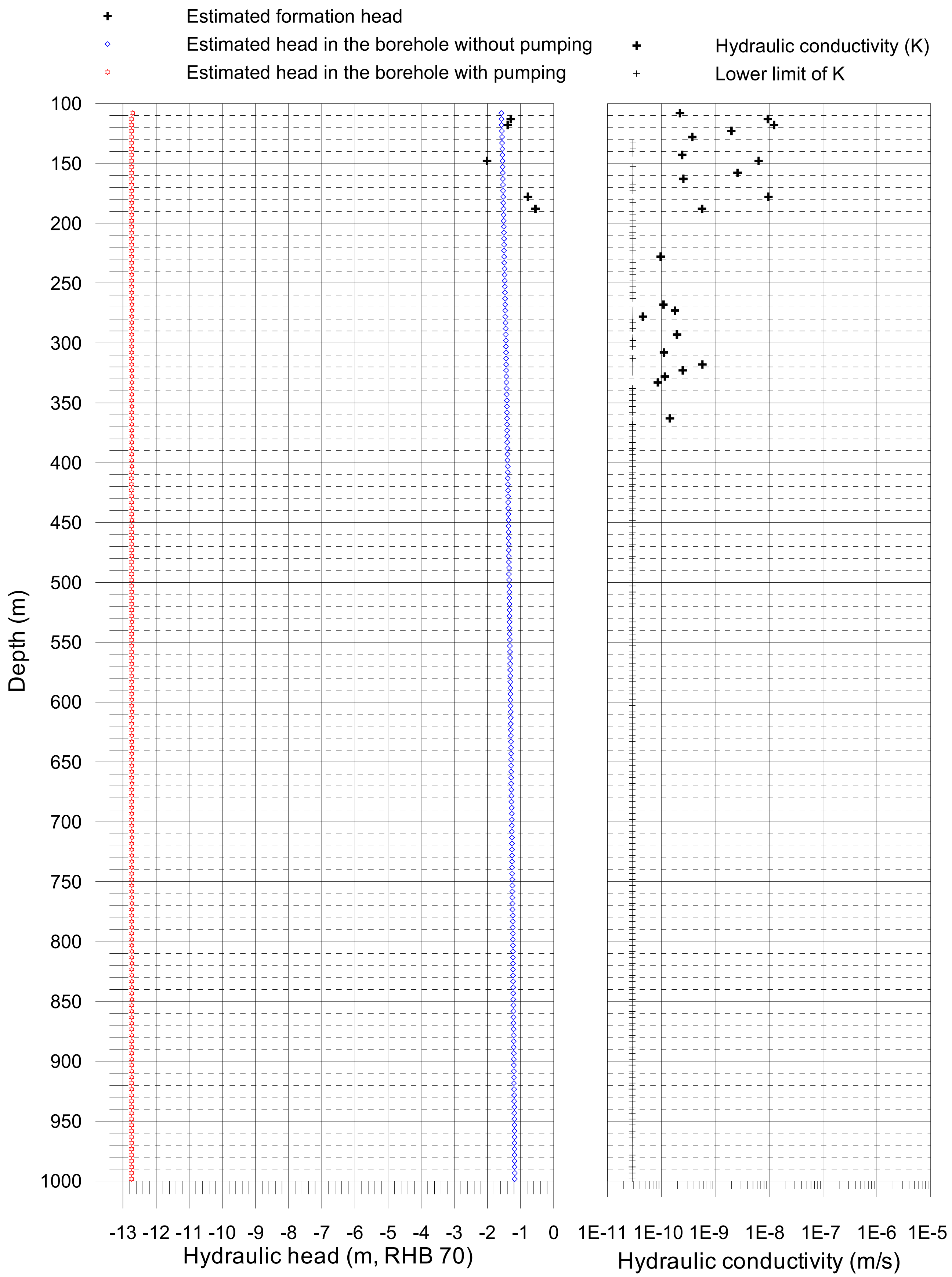
Depth1(m)	Borehole Head1(fresh water, masl)	Flow1(mL/h)	Depth2(m)	Borehole Head2(fresh water, masl)	Flow2(mL/h)	Formation Head (fresh water, masl)	K(m/s)
578.04	-1.311	0	578.09	-12.732	0		
583.05	-1.31	0	583.1	-12.733	0		
588.05	-1.308	0	588.1	-12.732	0		
593.06	-1.306	0	593.1	-12.733	0		
598.07	-1.306	0	598.11	-12.732	0		
603.07	-1.302	0	603.11	-12.735	0		
608.08	-1.3	0	608.11	-12.731	0		
613.08	-1.298	0	613.12	-12.734	0		
618.08	-1.297	0	618.12	-12.735	0		
623.09	-1.295	0	623.12	-12.733	0		
628.09	-1.292	0	628.12	-12.732	0		
633.1	-1.291	0	633.12	-12.732	0		
638.1	-1.288	0	638.13	-12.73	0		
643.1	-1.286	0	643.13	-12.732	0		
648.11	-1.287	0	648.13	-12.734	0		
653.11	-1.287	0	653.14	-12.732	0		
658.12	-1.284	0	658.14	-12.732	0		
663.12	-1.283	0	663.15	-12.734	0		
668.12	-1.28	0	668.16	-12.731	0		
673.13	-1.277	0	673.17	-12.734	0		
678.13	-1.274	0	678.18	-12.734	0		
683.14	-1.274	0	683.19	-12.734	0		
688.14	-1.271	0	688.2	-12.733	0		
693.14	-1.268	0	693.21	-12.732	0		
698.15	-1.268	0	698.22	-12.734	0		
703.15	-1.266	0	703.22	-12.735	0		
708.15	-1.264	0	708.22	-12.732	0		
713.16	-1.262	0	713.22	-12.73	0		
718.16	-1.26	0	718.22	-12.734	0		
723.16	-1.259	0	723.22	-12.735	0		
728.16	-1.256	0	728.22	-12.732	0		
733.16	-1.254	0	733.22	-12.733	0		
738.17	-1.254	0	738.22	-12.733	0		
743.17	-1.252	0	743.22	-12.735	0		
748.17	-1.249	0	748.22	-12.735	0		
753.17	-1.247	0	753.22	-12.734	0		
758.17	-1.246	0	758.23	-12.733	0		
763.18	-1.247	0	763.24	-12.732	0		
768.18	-1.243	0	768.24	-12.731	0		
773.18	-1.243	0	773.25	-12.733	0		
778.19	-1.24	0	778.25	-12.734	0		
783.19	-1.239	0	783.26	-12.735	0		
788.19	-1.239	0	788.27	-12.732	0		
793.2	-1.234	0	793.27	-12.734	0		
798.2	-1.235	0	798.28	-12.732	0		
803.2	-1.233	0	803.28	-12.733	0		

Depth1(m)	Borehole Head1(fresh water, masl)	Flow1(mL/h)	Depth2(m)	Borehole Head2(fresh water, masl)	Flow2(mL/h)	Formation Head (fresh water, masl)	K(m/s)
808.2	-1.23	0	808.28	-12.732	0		
813.21	-1.229	0	813.29	-12.733	0		
818.21	-1.228	0	818.29	-12.731	0		
823.21	-1.227	0	823.29	-12.735	0		
828.21	-1.225	0	828.29	-12.732	0		
833.21	-1.223	0	833.29	-12.733	0		
838.22	-1.221	0	838.3	-12.732	0		
843.22	-1.221	0	843.3	-12.732	0		
848.22	-1.22	0	848.3	-12.73	0		
853.22	-1.216	0	853.3	-12.734	0		
858.22	-1.216	0	858.3	-12.733	0		
863.23	-1.214	0	863.31	-12.734	0		
868.23	-1.214	0	868.31	-12.732	0		
873.23	-1.213	0	873.31	-12.734	0		
878.23	-1.211	0	878.31	-12.732	0		
883.24	-1.207	0	883.32	-12.735	0		
888.24	-1.208	0	888.32	-12.732	0		
893.24	-1.205	0	893.32	-12.733	0		
898.24	-1.204	0	898.32	-12.732	0		
903.24	-1.203	0	903.32	-12.732	0		
908.25	-1.202	0	908.33	-12.732	0		
913.25	-1.198	0	913.33	-12.733	0		
918.25	-1.199	0	918.33	-12.735	0		
923.25	-1.195	0	923.33	-12.733	0		
928.25	-1.193	0	928.33	-12.737	0		
933.26	-1.193	0	933.34	-12.739	0		
938.26	-1.19	0	938.34	-12.736	0		
943.26	-1.189	0	943.34	-12.738	0		
948.26	-1.189	0	948.34	-12.736	0		
953.27	-1.187	0	953.35	-12.737	0		
958.27	-1.184	0	958.35	-12.736	0		
963.27	-1.183	0	963.35	-12.737	0		
968.27	-1.183	0	968.35	-12.733	0		
973.27	-1.181	0	973.35	-12.735	0		
978.28	-1.18	0	978.36	-12.736	0		
983.28	-1.179	0	983.36	-12.736	0		
988.28	-1.177	0	988.36	-12.733	0		
993.28	-1.174	0	993.36	-12.734	0		
998.28	-1.175	0	998.36	-12.735	0		

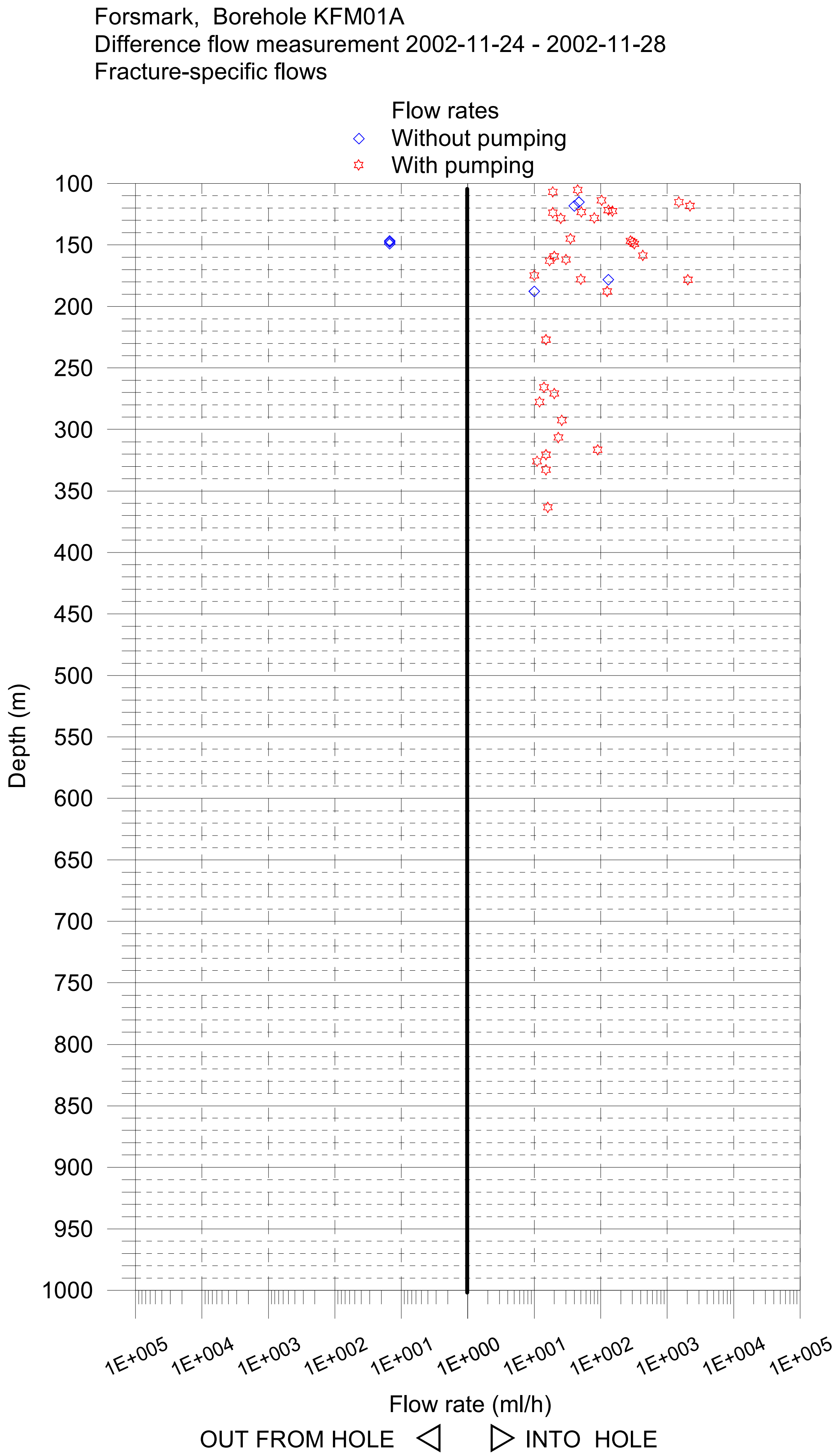
Forsmark, Borehole KFM01A
Difference flow measurement with thermal pulse 2002-11-24 - 2002-11-28
Length of section 5 m, depth increment 5 m



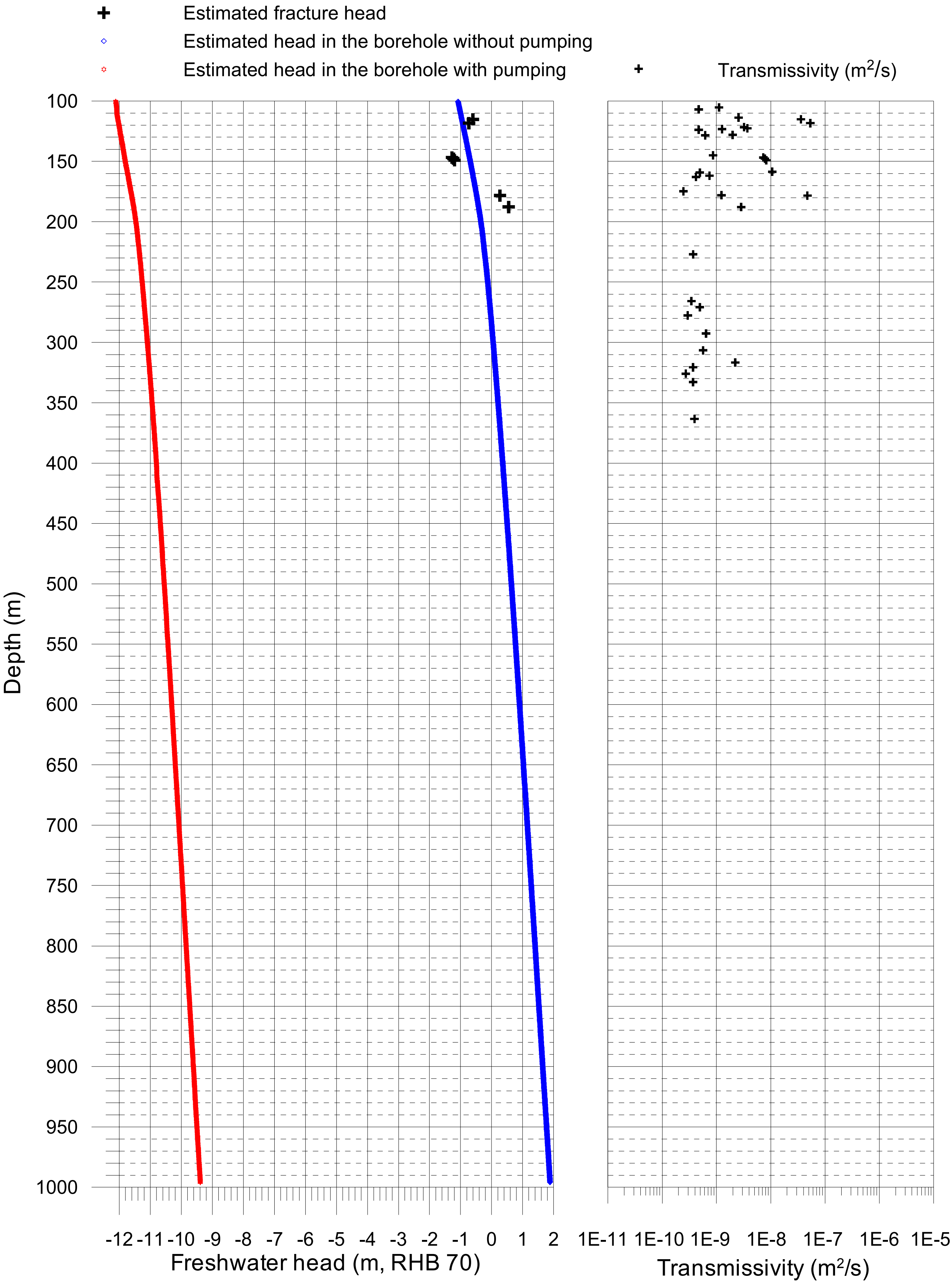
Forsmark, Borehole KFM01A
Difference flow measurement with thermal pulse 2002-11-24 - 2002-11-28
Length of section 5 m, depth increment 5 m



Depth Of Fracture	Flow1 (mL/h)	Borehole head1 (fresh water, masl)	Borehole head1 (saline water, masl)	Flow2 (mL/h)	Borehole head2 (fresh water, masl)	Borehole head2 (saline water, masl)	Transmissivity (fresh water, m*m/s)	Transmissivity (saline water, m*m/s)	Fracture Head (fresh water, masl)	Fracture Head (saline water, masl)	Uncertain
105.30	0	-1.58	-1.04	45	-12.74	-12.13	1.11E-09	1.11E-09			
106.90	0	-1.58	-1.03	19	-12.74	-12.12	4.68E-10	4.71E-10			*
113.80	0	-1.57	-0.96	103	-12.74	-12.07	2.53E-09	2.55E-09			
115.20	47	-1.57	-0.96	1500	-12.74	-12.05	3.57E-08	3.60E-08	-1.21	-0.60	
118.30	40	-1.57	-0.93	2200	-12.74	-12.03	5.31E-08	5.35E-08	-1.36	-0.73	
121.70	0	-1.56	-0.91	130	-12.74	-12.00	3.20E-09	3.22E-09			
122.60	0	-1.56	-0.90	150	-12.73	-11.99	3.69E-09	3.72E-09			
123.30	0	-1.56	-0.89	51	-12.73	-11.99	1.25E-09	1.26E-09			*
123.80	0	-1.56	-0.89	19	-12.73	-11.99	4.67E-10	4.70E-10			*
128.10	0	-1.56	-0.86	80	-12.74	-11.96	1.97E-09	1.98E-09			*
128.40	0	-1.56	-0.85	25	-12.74	-11.96	6.15E-10	6.19E-10			*
145.00	0	-1.55	-0.73	35	-12.74	-11.85	8.59E-10	8.65E-10			*
146.80	-15	-1.55	-0.71	280	-12.74	-11.83	7.24E-09	7.29E-09	-2.11	-1.28	
147.70	-15	-1.54	-0.70	300	-12.74	-11.82	7.73E-09	7.78E-09	-2.08	-1.23	
149.10	-15	-1.54	-0.70	320	-12.74	-11.81	8.22E-09	8.28E-09	-2.04	-1.19	
158.60	0	-1.54	-0.63	430	-12.73	-11.74	1.06E-08	1.06E-08			
159.30	0	-1.54	-0.62	20	-12.73	-11.73	4.91E-10	4.94E-10			*
161.90	0	-1.53	-0.60	30	-12.73	-11.71	7.36E-10	7.42E-10			*
162.90	0	-1.53	-0.59	17	-12.73	-11.71	4.17E-10	4.20E-10			*
174.80	0	-1.52	-0.51	10	-12.74	-11.63	2.45E-10	2.47E-10			*
178.00	0	-1.52	-0.48	50	-12.74	-11.61	1.22E-09	1.24E-09			*
178.30	130	-1.52	-0.48	2050	-12.74	-11.60	4.70E-08	4.74E-08	-0.76	0.27	
187.80	10	-1.51	-0.42	125	-12.73	-11.53	2.82E-09	2.84E-09	-0.54	0.55	
227.00	0	-1.49	-0.22	15	-12.71	-11.32	3.68E-10	3.71E-10			*
265.80	0	-1.46	-0.07	14	-12.74	-11.21	3.41E-10	3.45E-10			*
270.80	0	-1.46	-0.05	20	-12.74	-11.19	4.87E-10	4.93E-10			*
277.70	0	-1.46	-0.02	12	-12.74	-11.17	2.92E-10	2.96E-10			*
292.60	0	-1.45	0.03	26	-12.74	-11.12	6.33E-10	6.41E-10			*
306.60	0	-1.44	0.07	23	-12.74	-11.08	5.59E-10	5.67E-10			*
316.60	0	-1.43	0.10	90	-12.74	-11.05	2.19E-09	2.22E-09			
320.60	0	-1.43	0.12	15	-12.74	-11.03	3.64E-10	3.70E-10			*
325.90	0	-1.43	0.13	11	-12.74	-11.02	2.67E-10	2.71E-10			*
332.90	0	-1.42	0.16	15	-12.74	-11.00	3.64E-10	3.70E-10			*
363.40	0	-1.41	0.25	16	-12.75	-10.92	3.88E-10	3.94E-10			*


Forsmark, Borehole KFM01A
Difference flow measurement 2002-11-24 - 2002-11-28
Fracture-specific flows
Flow rates
Without pumping
With pumping
Depth (m)
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1E+005
1E+004
1E+003
1E+002
1E+001
1E+000
1E+001
1E+002
1E+003
1E+004
1E+005
Flow rate (ml/h)
OUT FROM HOLE
INTO HOLE

Forsmark, Borehole KFM01A
Difference flow measurement 2002-11-24 - 2002-11-28



Appendix 6 – Result tables to SICADA

PFL-Difference flow logging- Basic data

PFL-DIFFERENCE FLOW LOGGING - Basic data

Borehole	Logged interval		Test type	Q-measl-L	Q-measl-U	Item in AP	Formation type	Date and time of test, start	Date and time of flowl., start	Date and time of flowl., stop	L_w	dL	Q_{p1}	Q_{p2}	t_{p1}	t_{p2}	t_{F1}	t_{F2}
	from	to																
ID	L (m)	L (m)	(1-6)	(mL/min)	(mL/min)		(-)	YYYYMMDD hh:mm	YYYYMMDD hh:mm	YYYYMMDD hh:mm	(m)	(m)	(L/min)	(L/min)	(s)	(s)	(s)	(s)
KFM01A	100.45	1000.78	5A	0.1	5000	9	1	2002-11-21 14:00	2002-11-21 14:00	2002-11-23 16:30	5	5						
KFM01A	100.45	1000.78	5B	0.5	5000	9	1	2002-11-21 14:00	2002-11-21 14:00	2002-11-23 16:30	5	0.5						
KFM01A	100.49	1000.86	5A	0.1	5000	10	1	2002-11-23 17:20	2002-11-24 17:30	2002-11-26 15:40	5	5	0.175		425400			
KFM01A	100.49	1000.86	5B	0.5	5000	10	1	2002-11-23 17:20	2002-11-24 17:30	2002-11-26 15:40	5	0.5	0.175		425400			
KFM01A	100.48	364.55	5B	0.5	5000	11	1	2002-11-27 11:30	2002-11-27 11:30	2002-11-28 13:30	1	0.1	0.175		425400		132600	

cont.

h_0	h_1	h_2	h_F	s_1	s_2	Reference	Comments
(m a s l)	(m a s l)	(m)	(m a s l)	(m)	(m)	(-)	(-)
						R-03-37	No pumping
-1.17						R-03-37	No pumping
						R-03-37	Continuous pumping
						R-03-37	Continuous pumping
	-12.75		-6.41	11.58		R-03-37	Continuous pumping

PFL-Difference flow logging- Sequential logging

5A. PFL-DIFF - Sequential flow logging

Bore-hole	Date and time of test, start	Logged interval from (m)	Logged interval to (m)	Secup (m)	Seclow (m)	b (m)	Test type	Q_0 (mL/h)	Value type-Q_0	Q_1 (mL/h)	Value type-Q_1	h_{0f} (m.a.s.l.)	h_{1f} (m.a.s.l.)	T_D (m^2/s)	Value type-T_D	T_D-measl-L (m^2/s)	T_D-measl-U (m^2/s)	h_i (m)	Te_w (°C)
KFM01A	2002-11-21 14:00	105.45	1000.78	105.45	110.45	5	5A	6	-1			-1.579		1.11E-09	0	1.48E-10	7.41E-06		7.2
KFM01A	2002-11-21 14:00	105.45	1000.78	110.45	115.45	5	5A	47.75	0			-1.576		4.72E-08	0	1.48E-10	7.39E-06	-1.30	7.2
KFM01A	2002-11-21 14:00	105.45	1000.78	115.45	120.45	5	5A	40.15	0			-1.571		6.20E-08	0	1.48E-10	7.38E-06	-1.39	7.3
KFM01A	2002-11-21 14:00	105.45	1000.78	120.44	125.44	5	5A	6	-1			-1.565		1.00E-08	0	1.48E-10	7.38E-06		7.4
KFM01A	2002-11-21 14:00	105.45	1000.78	125.44	130.44	5	5A	6	-1			-1.560		1.88E-09	0	1.48E-10	7.38E-06		7.4
KFM01A	2002-11-21 14:00	105.45	1000.78	130.44	135.44	5	5A	6	-1			-1.558		1.47E-10	-1	1.47E-10	7.37E-06		7.5
KFM01A	2002-11-21 14:00	105.45	1000.78	135.44	140.44	5	5A	6	-1			-1.554		1.47E-10	-1	1.47E-10	7.37E-06		7.5
KFM01A	2002-11-21 14:00	105.45	1000.78	140.43	145.43	5	5A	6	-1			-1.549		1.22E-09	0	1.47E-10	7.37E-06		7.6
KFM01A	2002-11-21 14:00	105.45	1000.78	145.43	150.43	5	5A	-53.70	0			-1.545		3.20E-08	0	1.47E-10	7.36E-06	-2.01	7.6
KFM01A	2002-11-21 14:00	105.45	1000.78	150.43	155.43	5	5A	6	-1			-1.543		1.47E-10	-1	1.47E-10	7.36E-06		7.7
KFM01A	2002-11-21 14:00	105.45	1000.78	155.43	160.43	5	5A	6	-1			-1.537		1.30E-08	0	1.47E-10	7.36E-06		7.8
KFM01A	2002-11-21 14:00	105.45	1000.78	160.44	165.44	5	5A	6	-1			-1.534		1.28E-09	0	1.47E-10	7.36E-06		7.8
KFM01A	2002-11-21 14:00	105.45	1000.78	165.44	170.44	5	5A	6	-1			-1.530		1.47E-10	-1	1.47E-10	7.36E-06		7.9
KFM01A	2002-11-21 14:00	105.45	1000.78	170.44	175.44	5	5A	6	-1			-1.528		1.47E-10	-1	1.47E-10	7.36E-06		7.9
KFM01A	2002-11-21 14:00	105.45	1000.78	175.44	180.44	5	5A	131.49	0			-1.524		4.87E-08	0	1.47E-10	7.35E-06	-0.78	8.0
KFM01A	2002-11-21 14:00	105.45	1000.78	180.44	185.44	5	5A	6	-1			-1.519		1.47E-10	-1	1.47E-10	7.35E-06		8.0
KFM01A	2002-11-21 14:00	105.45	1000.78	185.45	190.45	5	5A	10.00	0			-1.515		2.85E-09	0	1.47E-10	7.34E-06	-0.55	8.1
KFM01A	2002-11-21 14:00	105.45	1000.78	190.45	195.45	5	5A	6	-1			-1.512		1.47E-10	-1	1.47E-10	7.35E-06		8.2
KFM01A	2002-11-21 14:00	105.45	1000.78	195.45	200.45	5	5A	6	-1			-1.509		1.47E-10	-1	1.47E-10	7.34E-06		8.2
KFM01A	2002-11-21 14:00	105.45	1000.78	200.45	205.45	5	5A	6	-1			-1.504		1.47E-10	-1	1.47E-10	7.34E-06		8.3
KFM01A	2002-11-21 14:00	105.45	1000.78	205.45	210.45	5	5A	6	-1			-1.501		1.47E-10	-1	1.47E-10	7.34E-06		8.3
KFM01A	2002-11-21 14:00	105.45	1000.78	210.46	215.46	5	5A	6	-1			-1.498		1.47E-10	-1	1.47E-10	7.34E-06		8.4
KFM01A	2002-11-21 14:00	105.45	1000.78	215.46	220.46	5	5A	6	-1			-1.498		1.47E-10	-1	1.47E-10	7.33E-06		8.4
KFM01A	2002-11-21 14:00	105.45	1000.78	220.46	225.46	5	5A	6	-1			-1.499		1.47E-10	-1	1.47E-10	7.34E-06		8.5
KFM01A	2002-11-21 14:00	105.45	1000.78	225.47	230.47	5	5A	6	-1			-1.497		4.84E-10	-1	1.47E-10	7.33E-06		8.5
KFM01A	2002-11-21 14:00	105.45	1000.78	230.47	235.47	5	5A	6	-1			-1.491		1.47E-10	-1	1.47E-10	7.33E-06		8.6
KFM01A	2002-11-21 14:00	105.45	1000.78	235.47	240.47	5	5A	6	-1			-1.485		1.47E-10	-1	1.47E-10	7.33E-06		8.6
KFM01A	2002-11-21 14:00	105.45	1000.78	240.48	245.48	5	5A	6	-1			-1.483		1.47E-10	-1	1.47E-10	7.33E-06		8.7
KFM01A	2002-11-21 14:00	105.45	1000.78	245.48	250.48	5	5A	6	-1			-1.479		1.46E-10	-1	1.46E-10	7.32E-06		8.7
KFM01A	2002-11-21 14:00	105.45	1000.78	250.48	255.48	5	5A	6	-1			-1.474		1.46E-10	-1	1.46E-10	7.32E-06		8.8
KFM01A	2002-11-21 14:00	105.45	1000.78	255.48	260.48	5	5A	6	-1			-1.471		1.46E-10	-1	1.46E-10	7.32E-06		8.8
KFM01A	2002-11-21 14:00	105.45	1000.78	260.48	265.48	5	5A	6	-1			-1.466		1.46E-10	-1	1.46E-10	7.31E-06		8.9
KFM01A	2002-11-21 14:00	105.45	1000.78	265.48	270.48	5	5A	6	-1			-1.463		5.45E-10	0	1.46E-10	7.31E-06		8.9
KFM01A	2002-11-21 14:00	105.45	1000.78	270.48	275.48	5	5A	6	-1			-1.460		8.90E-10	0	1.46E-10	7.31E-06		9.0
KFM01A	2002-11-21 14:00	105.45	1000.78	275.47	280.47	5	5A	6	-1			-1.459		2.27E-10	0	1.46E-10	7.31E-06		9.1
KFM01A	2002-11-21 14:00	105.45	1000.78	280.47	285.47	5	5A	6	-1			-1.453		1.46E-10	-1	1.46E-10	7.31E-06		9.1
KFM01A	2002-11-21 14:00	105.45	1000.78	285.47	290.47	5	5A	6	-1			-1.450		1.46E-10	-1	1.46E-10	7.30E-06		9.2
KFM01A	2002-11-21 14:00	105.45	1000.78	290.47	295.47	5	5A	6	-1			-1.449		9.75E-10	0	1.46E-10	7.30E-06		9.2
KFM01A	2002-11-21 14:00	105.45	1000.78	295.47	300.47	5	5A	6	-1			-1.444		1.46E-10	-1	1.46E-10	7.30E-06		9.3
KFM01A	2002-11-21 14:00	105.45	1000.78	300.47	305.47	5	5A	6	-1			-1.442		1.46E-10	-1	1.46E-10	7.30E-06		9.3
KFM01A	2002-11-21 14:00	105.45	1000.78	305.47	310.47	5	5A	6	-1			-1.438		5.55E-10	0	1.46E-10	7.30E-06		9.4
KFM01A	2002-11-21 14:00	105.45	1000.78	310.48	315.48	5	5A	6	-1			-1.436		1.46E-10	-1	1.46E-10	7.29E-06		9.4
KFM01A	2002-11-21 14:00	105.45	1000.78	315.48	320.48	5	5A	6	-1			-1.432		2.89E-09	0	1.46E-10	7.29E-06		9.5
KFM01A	2002-11-21 14:00	105.45	1000.78	320.48	325.48	5	5A	6	-1			-1.430		1.25E-09	0	1.46E-10	7.29E-06		9.5

cont.

KFM01A	2002-11-21 14:00	105.45	1000.78	325.48	330.48	5	5A	6	-1			-1.427		5.80E-10	0	1.46E-10	7.29E-06		9.6
KFM01A	2002-11-21 14:00	105.45	1000.78	330.48	335.48	5	5A	6	-1			-1.424		4.29E-10	0	1.46E-10	7.29E-06		9.7
KFM01A	2002-11-21 14:00	105.45	1000.78	335.49	340.49	5	5A	6	-1			-1.423		1.46E-10	-1	1.46E-10	7.29E-06		9.7
KFM01A	2002-11-21 14:00	105.45	1000.78	340.49	345.49	5	5A	6	-1			-1.420		1.46E-10	-1	1.46E-10	7.29E-06		9.8
KFM01A	2002-11-21 14:00	105.45	1000.78	345.49	350.49	5	5A	6	-1			-1.416		1.46E-10	-1	1.46E-10	7.28E-06		9.8
KFM01A	2002-11-21 14:00	105.45	1000.78	350.49	355.49	5	5A	6	-1			-1.414		1.46E-10	-1	1.46E-10	7.28E-06		9.9
KFM01A	2002-11-21 14:00	105.45	1000.78	355.49	360.49	5	5A	6	-1			-1.412		1.46E-10	-1	1.46E-10	7.28E-06		9.9
KFM01A	2002-11-21 14:00	105.45	1000.78	360.50	365.50	5	5A	6	-1			-1.409		7.20E-10	-1	1.46E-10	7.28E-06		10.0
KFM01A	2002-11-21 14:00	105.45	1000.78	365.50	370.50	5	5A	6	-1			-1.406		1.46E-10	-1	1.46E-10	7.28E-06		10.0
KFM01A	2002-11-21 14:00	105.45	1000.78	370.50	375.50	5	5A	6	-1			-1.403		1.45E-10	-1	1.45E-10	7.27E-06		10.1
KFM01A	2002-11-21 14:00	105.45	1000.78	375.50	380.50	5	5A	6	-1			-1.400		1.45E-10	-1	1.45E-10	7.27E-06		10.1
KFM01A	2002-11-21 14:00	105.45	1000.78	380.50	385.50	5	5A	6	-1			-1.400		1.45E-10	-1	1.45E-10	7.27E-06		10.2
KFM01A	2002-11-21 14:00	105.45	1000.78	385.51	390.51	5	5A	6	-1			-1.397		1.45E-10	-1	1.45E-10	7.27E-06		10.2
KFM01A	2002-11-21 14:00	105.45	1000.78	390.51	395.51	5	5A	6	-1			-1.394		1.45E-10	-1	1.45E-10	7.27E-06		10.3
KFM01A	2002-11-21 14:00	105.45	1000.78	395.51	400.51	5	5A	6	-1			-1.393		1.45E-10	-1	1.45E-10	7.27E-06		10.4
KFM01A	2002-11-21 14:00	105.45	1000.78	400.51	405.51	5	5A	6	-1			-1.390		1.45E-10	-1	1.45E-10	7.27E-06		10.4
KFM01A	2002-11-21 14:00	105.45	1000.78	405.51	410.51	5	5A	6	-1			-1.387		1.45E-10	-1	1.45E-10	7.26E-06		10.5
KFM01A	2002-11-21 14:00	105.45	1000.78	410.51	415.51	5	5A	6	-1			-1.386		1.45E-10	-1	1.45E-10	7.26E-06		10.5
KFM01A	2002-11-21 14:00	105.45	1000.78	415.51	420.51	5	5A	6	-1			-1.383		1.45E-10	-1	1.45E-10	7.26E-06		10.6
KFM01A	2002-11-21 14:00	105.45	1000.78	420.51	425.51	5	5A	6	-1			-1.378		1.45E-10	-1	1.45E-10	7.25E-06		10.6
KFM01A	2002-11-21 14:00	105.45	1000.78	425.50	430.50	5	5A	6	-1			-1.378		1.45E-10	-1	1.45E-10	7.26E-06		10.7
KFM01A	2002-11-21 14:00	105.45	1000.78	430.50	435.50	5	5A	6	-1			-1.374		1.45E-10	-1	1.45E-10	7.25E-06		10.7
KFM01A	2002-11-21 14:00	105.45	1000.78	435.50	440.50	5	5A	6	-1			-1.373		1.45E-10	-1	1.45E-10	7.26E-06		10.8
KFM01A	2002-11-21 14:00	105.45	1000.78	440.50	445.50	5	5A	6	-1			-1.369		1.45E-10	-1	1.45E-10	7.25E-06		10.8
KFM01A	2002-11-21 14:00	105.45	1000.78	445.50	450.50	5	5A	6	-1			-1.365		1.45E-10	-1	1.45E-10	7.25E-06		10.9
KFM01A	2002-11-21 14:00	105.45	1000.78	450.50	455.50	5	5A	6	-1			-1.365		1.45E-10	-1	1.45E-10	7.25E-06		11.0
KFM01A	2002-11-21 14:00	105.45	1000.78	455.50	460.50	5	5A	6	-1			-1.363		1.45E-10	-1	1.45E-10	7.25E-06		11.0
KFM01A	2002-11-21 14:00	105.45	1000.78	460.50	465.50	5	5A	6	-1			-1.361		1.45E-10	-1	1.45E-10	7.25E-06		11.1
KFM01A	2002-11-21 14:00	105.45	1000.78	465.50	470.50	5	5A	6	-1			-1.357		1.45E-10	-1	1.45E-10	7.24E-06		11.1
KFM01A	2002-11-21 14:00	105.45	1000.78	470.50	475.50	5	5A	6	-1			-1.355		1.45E-10	-1	1.45E-10	7.24E-06		11.2
KFM01A	2002-11-21 14:00	105.45	1000.78	475.49	480.49	5	5A	6	-1			-1.354		1.45E-10	-1	1.45E-10	7.24E-06		11.2
KFM01A	2002-11-21 14:00	105.45	1000.78	480.49	485.49	5	5A	6	-1			-1.353		1.45E-10	-1	1.45E-10	7.24E-06		11.3
KFM01A	2002-11-21 14:00	105.45	1000.78	485.49	490.49	5	5A	6	-1			-1.348		1.45E-10	-1	1.45E-10	7.24E-06		11.4
KFM01A	2002-11-21 14:00	105.45	1000.78	490.49	495.49	5	5A	6	-1			-1.350		1.45E-10	-1	1.45E-10	7.24E-06		11.4
KFM01A	2002-11-21 14:00	105.45	1000.78	495.49	500.49	5	5A	6	-1			-1.345		1.45E-10	-1	1.45E-10	7.24E-06		11.5
KFM01A	2002-11-21 14:00	105.45	1000.78	500.49	505.49	5	5A	6	-1			-1.341		1.45E-10	-1	1.45E-10	7.23E-06		11.5
KFM01A	2002-11-21 14:00	105.45	1000.78	505.50	510.50	5	5A	6	-1			-1.341		1.45E-10	-1	1.45E-10	7.24E-06		11.6
KFM01A	2002-11-21 14:00	105.45	1000.78	510.50	515.50	5	5A	6	-1			-1.339		1.45E-10	-1	1.45E-10	7.23E-06		11.6
KFM01A	2002-11-21 14:00	105.45	1000.78	515.50	520.50	5	5A	6	-1			-1.336		1.45E-10	-1	1.45E-10	7.23E-06		11.7
KFM01A	2002-11-21 14:00	105.45	1000.78	520.51	525.51	5	5A	6	-1			-1.333		1.45E-10	-1	1.45E-10	7.23E-06		11.8
KFM01A	2002-11-21 14:00	105.45	1000.78	525.51	530.51	5	5A	6	-1			-1.331		1.45E-10	-1	1.45E-10	7.23E-06		11.8
KFM01A	2002-11-21 14:00	105.45	1000.78	530.52	535.52	5	5A	6	-1			-1.332		1.45E-10	-1	1.45E-10	7.23E-06		11.9
KFM01A	2002-11-21 14:00	105.45	1000.78	535.52	540.52	5	5A	6	-1			-1.328		1.44E-10	-1	1.44E-10	7.22E-06		12.0
KFM01A	2002-11-21 14:00	105.45	1000.78	540.52	545.52	5	5A	6	-1			-1.326		1.44E-10	-1	1.44E-10	7.22E-06		12.0
KFM01A	2002-11-21 14:00	105.45	1000.78	545.53	550.53	5	5A	6	-1			-1.322		1.44E-10	-1	1.44E-10	7.22E-06		12.1
KFM01A	2002-11-21 14:00	105.45	1000.78	550.53	555.53	5	5A	6	-1			-1.322		1.44E-10	-1	1.44E-10	7.22E-06		12.1

cont.

KFM01A	2002-11-21 14:00	105.45	1000.78	555.53	560.53	5	5A	6	-1			-1.319		1.44E-10	-1	1.44E-10	7.22E-06		12.2
KFM01A	2002-11-21 14:00	105.45	1000.78	560.53	565.53	5	5A	6	-1			-1.318		1.44E-10	-1	1.44E-10	7.22E-06		12.3
KFM01A	2002-11-21 14:00	105.45	1000.78	565.54	570.54	5	5A	6	-1			-1.316		1.44E-10	-1	1.44E-10	7.22E-06		12.3
KFM01A	2002-11-21 14:00	105.45	1000.78	570.54	575.54	5	5A	6	-1			-1.313		1.44E-10	-1	1.44E-10	7.22E-06		12.4
KFM01A	2002-11-21 14:00	105.45	1000.78	575.54	580.54	5	5A	6	-1			-1.311		1.44E-10	-1	1.44E-10	7.22E-06		12.4
KFM01A	2002-11-21 14:00	105.45	1000.78	580.55	585.55	5	5A	6	-1			-1.310		1.44E-10	-1	1.44E-10	7.22E-06		12.5
KFM01A	2002-11-21 14:00	105.45	1000.78	585.55	590.55	5	5A	6	-1			-1.308		1.44E-10	-1	1.44E-10	7.21E-06		12.5
KFM01A	2002-11-21 14:00	105.45	1000.78	590.56	595.56	5	5A	6	-1			-1.306		1.44E-10	-1	1.44E-10	7.21E-06		12.6
KFM01A	2002-11-21 14:00	105.45	1000.78	595.57	600.57	5	5A	6	-1			-1.306		1.44E-10	-1	1.44E-10	7.21E-06		12.7
KFM01A	2002-11-21 14:00	105.45	1000.78	600.57	605.57	5	5A	6	-1			-1.302		1.44E-10	-1	1.44E-10	7.21E-06		12.7
KFM01A	2002-11-21 14:00	105.45	1000.78	605.58	610.58	5	5A	6	-1			-1.300		1.44E-10	-1	1.44E-10	7.21E-06		12.8
KFM01A	2002-11-21 14:00	105.45	1000.78	610.58	615.58	5	5A	6	-1			-1.298		1.44E-10	-1	1.44E-10	7.21E-06		12.9
KFM01A	2002-11-21 14:00	105.45	1000.78	615.58	620.58	5	5A	6	-1			-1.297		1.44E-10	-1	1.44E-10	7.21E-06		12.9
KFM01A	2002-11-21 14:00	105.45	1000.78	620.59	625.59	5	5A	6	-1			-1.295		1.44E-10	-1	1.44E-10	7.21E-06		13.0
KFM01A	2002-11-21 14:00	105.45	1000.78	625.59	630.59	5	5A	6	-1			-1.292		1.44E-10	-1	1.44E-10	7.20E-06		13.0
KFM01A	2002-11-21 14:00	105.45	1000.78	630.60	635.60	5	5A	6	-1			-1.291		1.44E-10	-1	1.44E-10	7.20E-06		13.1
KFM01A	2002-11-21 14:00	105.45	1000.78	635.60	640.60	5	5A	6	-1			-1.288		1.44E-10	-1	1.44E-10	7.20E-06		13.2
KFM01A	2002-11-21 14:00	105.45	1000.78	640.60	645.60	5	5A	6	-1			-1.286		1.44E-10	-1	1.44E-10	7.20E-06		13.2
KFM01A	2002-11-21 14:00	105.45	1000.78	645.61	650.61	5	5A	6	-1			-1.287		1.44E-10	-1	1.44E-10	7.20E-06		13.3
KFM01A	2002-11-21 14:00	105.45	1000.78	650.61	655.61	5	5A	6	-1			-1.287		1.44E-10	-1	1.44E-10	7.20E-06		13.4
KFM01A	2002-11-21 14:00	105.45	1000.78	655.62	660.62	5	5A	6	-1			-1.284		1.44E-10	-1	1.44E-10	7.20E-06		13.4
KFM01A	2002-11-21 14:00	105.45	1000.78	660.62	665.62	5	5A	6	-1			-1.283		1.44E-10	-1	1.44E-10	7.20E-06		13.5
KFM01A	2002-11-21 14:00	105.45	1000.78	665.62	670.62	5	5A	6	-1			-1.280		1.44E-10	-1	1.44E-10	7.20E-06		13.6
KFM01A	2002-11-21 14:00	105.45	1000.78	670.63	675.63	5	5A	6	-1			-1.277		1.44E-10	-1	1.44E-10	7.19E-06		13.6
KFM01A	2002-11-21 14:00	105.45	1000.78	675.63	680.63	5	5A	6	-1			-1.274		1.44E-10	-1	1.44E-10	7.19E-06		13.7
KFM01A	2002-11-21 14:00	105.45	1000.78	680.64	685.64	5	5A	6	-1			-1.274		1.44E-10	-1	1.44E-10	7.19E-06		13.7
KFM01A	2002-11-21 14:00	105.45	1000.78	685.64	690.64	5	5A	6	-1			-1.271		1.44E-10	-1	1.44E-10	7.19E-06		13.8
KFM01A	2002-11-21 14:00	105.45	1000.78	690.64	695.64	5	5A	6	-1			-1.268		1.44E-10	-1	1.44E-10	7.19E-06		13.9
KFM01A	2002-11-21 14:00	105.45	1000.78	695.65	700.65	5	5A	6	-1			-1.268		1.44E-10	-1	1.44E-10	7.19E-06		13.9
KFM01A	2002-11-21 14:00	105.45	1000.78	700.65	705.65	5	5A	6	-1			-1.266		1.44E-10	-1	1.44E-10	7.19E-06		14.0
KFM01A	2002-11-21 14:00	105.45	1000.78	705.65	710.65	5	5A	6	-1			-1.264		1.44E-10	-1	1.44E-10	7.19E-06		14.1
KFM01A	2002-11-21 14:00	105.45	1000.78	710.66	715.66	5	5A	6	-1			-1.262		1.44E-10	-1	1.44E-10	7.19E-06		14.1
KFM01A	2002-11-21 14:00	105.45	1000.78	715.66	720.66	5	5A	6	-1			-1.260		1.44E-10	-1	1.44E-10	7.18E-06		14.2
KFM01A	2002-11-21 14:00	105.45	1000.78	720.66	725.66	5	5A	6	-1			-1.259		1.44E-10	-1	1.44E-10	7.18E-06		14.3
KFM01A	2002-11-21 14:00	105.45	1000.78	725.66	730.66	5	5A	6	-1			-1.256		1.44E-10	-1	1.44E-10	7.18E-06		14.3
KFM01A	2002-11-21 14:00	105.45	1000.78	730.66	735.66	5	5A	6	-1			-1.254		1.44E-10	-1	1.44E-10	7.18E-06		14.4
KFM01A	2002-11-21 14:00	105.45	1000.78	735.67	740.67	5	5A	6	-1			-1.254		1.44E-10	-1	1.44E-10	7.18E-06		14.4
KFM01A	2002-11-21 14:00	105.45	1000.78	740.67	745.67	5	5A	6	-1			-1.252		1.44E-10	-1	1.44E-10	7.18E-06		14.5
KFM01A	2002-11-21 14:00	105.45	1000.78	745.67	750.67	5	5A	6	-1			-1.249		1.44E-10	-1	1.44E-10	7.18E-06		14.6
KFM01A	2002-11-21 14:00	105.45	1000.78	750.67	755.67	5	5A	6	-1			-1.247		1.44E-10	-1	1.44E-10	7.18E-06		14.6
KFM01A	2002-11-21 14:00	105.45	1000.78	755.67	760.67	5	5A	6	-1			-1.246		1.44E-10	-1	1.44E-10	7.18E-06		14.7
KFM01A	2002-11-21 14:00	105.45	1000.78	760.68	765.68	5	5A	6	-1			-1.247		1.44E-10	-1	1.44E-10	7.18E-06		14.8
KFM01A	2002-11-21 14:00	105.45	1000.78	765.68	770.68	5	5A	6	-1			-1.243		1.43E-10	-1	1.43E-10	7.17E-06		14.8
KFM01A	2002-11-21 14:00	105.45	1000.78	770.68	775.68	5	5A	6	-1			-1.243		1.43E-10	-1	1.43E-10	7.17E-06		14.9
KFM01A	2002-11-21 14:00	105.45	1000.78	775.69	780.69	5	5A	6	-1			-1.240		1.43E-10	-1	1.43E-10	7.17E-06		15.0

cont.

KFM01A	2002-11-21 14:00	105.45	1000.78	780.69	785.69	5	5A	6	-1			-1.239		1.43E-10	-1	1.43E-10	7.17E-06		15.0
KFM01A	2002-11-21 14:00	105.45	1000.78	785.69	790.69	5	5A	6	-1			-1.239		1.43E-10	-1	1.43E-10	7.17E-06		15.1
KFM01A	2002-11-21 14:00	105.45	1000.78	790.70	795.70	5	5A	6	-1			-1.234		1.43E-10	-1	1.43E-10	7.17E-06		15.2
KFM01A	2002-11-21 14:00	105.45	1000.78	795.70	800.70	5	5A	6	-1			-1.235		1.43E-10	-1	1.43E-10	7.17E-06		15.2
KFM01A	2002-11-21 14:00	105.45	1000.78	800.70	805.70	5	5A	6	-1			-1.233		1.43E-10	-1	1.43E-10	7.17E-06		15.3
KFM01A	2002-11-21 14:00	105.45	1000.78	805.70	810.70	5	5A	6	-1			-1.230		1.43E-10	-1	1.43E-10	7.17E-06		15.4
KFM01A	2002-11-21 14:00	105.45	1000.78	810.71	815.71	5	5A	6	-1			-1.229		1.43E-10	-1	1.43E-10	7.16E-06		15.5
KFM01A	2002-11-21 14:00	105.45	1000.78	815.71	820.71	5	5A	6	-1			-1.228		1.43E-10	-1	1.43E-10	7.17E-06		15.5
KFM01A	2002-11-21 14:00	105.45	1000.78	820.71	825.71	5	5A	6	-1			-1.227		1.43E-10	-1	1.43E-10	7.16E-06		15.6
KFM01A	2002-11-21 14:00	105.45	1000.78	825.71	830.71	5	5A	6	-1			-1.225		1.43E-10	-1	1.43E-10	7.16E-06		15.7
KFM01A	2002-11-21 14:00	105.45	1000.78	830.71	835.71	5	5A	6	-1			-1.223		1.43E-10	-1	1.43E-10	7.16E-06		15.7
KFM01A	2002-11-21 14:00	105.45	1000.78	835.72	840.72	5	5A	6	-1			-1.221		1.43E-10	-1	1.43E-10	7.16E-06		15.8
KFM01A	2002-11-21 14:00	105.45	1000.78	840.72	845.72	5	5A	6	-1			-1.221		1.43E-10	-1	1.43E-10	7.16E-06		15.9
KFM01A	2002-11-21 14:00	105.45	1000.78	845.72	850.72	5	5A	6	-1			-1.220		1.43E-10	-1	1.43E-10	7.16E-06		15.9
KFM01A	2002-11-21 14:00	105.45	1000.78	850.72	855.72	5	5A	6	-1			-1.216		1.43E-10	-1	1.43E-10	7.16E-06		16.0
KFM01A	2002-11-21 14:00	105.45	1000.78	855.72	860.72	5	5A	6	-1			-1.216		1.43E-10	-1	1.43E-10	7.16E-06		16.1
KFM01A	2002-11-21 14:00	105.45	1000.78	860.73	865.73	5	5A	6	-1			-1.214		1.43E-10	-1	1.43E-10	7.15E-06		16.1
KFM01A	2002-11-21 14:00	105.45	1000.78	865.73	870.73	5	5A	6	-1			-1.214		1.43E-10	-1	1.43E-10	7.16E-06		16.2
KFM01A	2002-11-21 14:00	105.45	1000.78	870.73	875.73	5	5A	6	-1			-1.213		1.43E-10	-1	1.43E-10	7.15E-06		16.3
KFM01A	2002-11-21 14:00	105.45	1000.78	875.73	880.73	5	5A	6	-1			-1.211		1.43E-10	-1	1.43E-10	7.15E-06		16.4
KFM01A	2002-11-21 14:00	105.45	1000.78	880.74	885.74	5	5A	6	-1			-1.207		1.43E-10	-1	1.43E-10	7.15E-06		16.4
KFM01A	2002-11-21 14:00	105.45	1000.78	885.74	890.74	5	5A	6	-1			-1.208		1.43E-10	-1	1.43E-10	7.15E-06		16.5
KFM01A	2002-11-21 14:00	105.45	1000.78	890.74	895.74	5	5A	6	-1			-1.205		1.43E-10	-1	1.43E-10	7.15E-06		16.5
KFM01A	2002-11-21 14:00	105.45	1000.78	895.74	900.74	5	5A	6	-1			-1.204		1.43E-10	-1	1.43E-10	7.15E-06		16.6
KFM01A	2002-11-21 14:00	105.45	1000.78	900.74	905.74	5	5A	6	-1			-1.203		1.43E-10	-1	1.43E-10	7.15E-06		16.7
KFM01A	2002-11-21 14:00	105.45	1000.78	905.75	910.75	5	5A	6	-1			-1.202		1.43E-10	-1	1.43E-10	7.15E-06		16.8
KFM01A	2002-11-21 14:00	105.45	1000.78	910.75	915.75	5	5A	6	-1			-1.198		1.43E-10	-1	1.43E-10	7.15E-06		16.8
KFM01A	2002-11-21 14:00	105.45	1000.78	915.75	920.75	5	5A	6	-1			-1.199		1.43E-10	-1	1.43E-10	7.14E-06		16.9
KFM01A	2002-11-21 14:00	105.45	1000.78	920.75	925.75	5	5A	6	-1			-1.195		1.43E-10	-1	1.43E-10	7.14E-06		16.9
KFM01A	2002-11-21 14:00	105.45	1000.78	925.75	930.75	5	5A	6	-1			-1.193		1.43E-10	-1	1.43E-10	7.14E-06		17.0
KFM01A	2002-11-21 14:00	105.45	1000.78	930.76	935.76	5	5A	6	-1			-1.193		1.43E-10	-1	1.43E-10	7.14E-06		17.1
KFM01A	2002-11-21 14:00	105.45	1000.78	935.76	940.76	5	5A	6	-1			-1.190		1.43E-10	-1	1.43E-10	7.14E-06		17.2
KFM01A	2002-11-21 14:00	105.45	1000.78	940.76	945.76	5	5A	6	-1			-1.189		1.43E-10	-1	1.43E-10	7.14E-06		17.2
KFM01A	2002-11-21 14:00	105.45	1000.78	945.76	950.76	5	5A	6	-1			-1.189		1.43E-10	-1	1.43E-10	7.14E-06		17.3
KFM01A	2002-11-21 14:00	105.45	1000.78	950.77	955.77	5	5A	6	-1			-1.187		1.43E-10	-1	1.43E-10	7.14E-06		17.4
KFM01A	2002-11-21 14:00	105.45	1000.78	955.77	960.77	5	5A	6	-1			-1.184		1.43E-10	-1	1.43E-10	7.14E-06		17.4
KFM01A	2002-11-21 14:00	105.45	1000.78	960.77	965.77	5	5A	6	-1			-1.183		1.43E-10	-1	1.43E-10	7.13E-06		17.5
KFM01A	2002-11-21 14:00	105.45	1000.78	965.77	970.77	5	5A	6	-1			-1.183		1.43E-10	-1	1.43E-10	7.14E-06		17.6
KFM01A	2002-11-21 14:00	105.45	1000.78	970.77	975.77	5	5A	6	-1			-1.181		1.43E-10	-1	1.43E-10	7.13E-06		17.6
KFM01A	2002-11-21 14:00	105.45	1000.78	975.78	980.78	5	5A	6	-1			-1.180		1.43E-10	-1	1.43E-10	7.13E-06		17.7
KFM01A	2002-11-21 14:00	105.45	1000.78	980.78	985.78	5	5A	6	-1			-1.179		1.43E-10	-1	1.43E-10	7.13E-06		17.8
KFM01A	2002-11-21 14:00	105.45	1000.78	985.78	990.78	5	5A	6	-1			-1.177		1.43E-10	-1	1.43E-10	7.13E-06		17.9
KFM01A	2002-11-21 14:00	105.45	1000.78	990.78	995.78	5	5A	6	-1			-1.174		1.43E-10	-1	1.43E-10	7.13E-06		17.9
KFM01A	2002-11-21 14:00	105.45	1000.78	995.78	1000.78	5	5A	6	-1			-1.175		1.43E-10	-1	1.43E-10	7.13E-06		18.0
KFM01A	2002-11-24 17:30	105.49	1000.86	105.49	110.49	5	5A			44.75	0		-12.703	1.11E-09	0	1.48E-10	7.41E-06		7.2

cont.

KFM01A	2002-11-24 17:30	105.49	1000.86	110.49	115.49	5	5A			1962	0		-12.736	4.72E-08	0	1.48E-10	7.39E-06	-1.30	7.2
KFM01A	2002-11-24 17:30	105.49	1000.86	115.49	120.49	5	5A			2563	0		-12.734	6.20E-08	0	1.48E-10	7.38E-06	-1.39	7.2
KFM01A	2002-11-24 17:30	105.49	1000.86	120.49	125.49	5	5A			407	0		-12.735	1.00E-08	0	1.48E-10	7.38E-06		7.3
KFM01A	2002-11-24 17:30	105.49	1000.86	125.49	130.49	5	5A			76.21	0		-12.736	1.88E-09	0	1.48E-10	7.38E-06		7.4
KFM01A	2002-11-24 17:30	105.49	1000.86	130.50	135.50	5	5A			6	-1		-12.735	1.47E-10	-1	1.47E-10	7.37E-06		7.4
KFM01A	2002-11-24 17:30	105.49	1000.86	135.50	140.50	5	5A			6	-1		-12.735	1.47E-10	-1	1.47E-10	7.37E-06		7.5
KFM01A	2002-11-24 17:30	105.49	1000.86	140.50	145.50	5	5A			49.45	0		-12.733	1.22E-09	0	1.47E-10	7.37E-06		7.5
KFM01A	2002-11-24 17:30	105.49	1000.86	145.50	150.50	5	5A			1247	0		-12.737	3.20E-08	0	1.47E-10	7.36E-06	-2.01	7.6
KFM01A	2002-11-24 17:30	105.49	1000.86	150.50	155.50	5	5A			6	-1		-12.738	1.47E-10	-1	1.47E-10	7.36E-06		7.7
KFM01A	2002-11-24 17:30	105.49	1000.86	155.50	160.50	5	5A			530	0		-12.737	1.30E-08	0	1.47E-10	7.36E-06		7.7
KFM01A	2002-11-24 17:30	105.49	1000.86	160.51	165.51	5	5A			52.02	0		-12.736	1.28E-09	0	1.47E-10	7.36E-06		7.8
KFM01A	2002-11-24 17:30	105.49	1000.86	165.51	170.51	5	5A			6	-1		-12.736	1.47E-10	-1	1.47E-10	7.36E-06		7.8
KFM01A	2002-11-24 17:30	105.49	1000.86	170.51	175.51	5	5A			6	-1		-12.733	1.47E-10	-1	1.47E-10	7.36E-06		7.9
KFM01A	2002-11-24 17:30	105.49	1000.86	175.51	180.51	5	5A			2116	0		-12.735	4.87E-08	0	1.47E-10	7.35E-06	-0.78	7.9
KFM01A	2002-11-24 17:30	105.49	1000.86	180.51	185.51	5	5A			6	-1		-12.733	1.47E-10	-1	1.47E-10	7.35E-06		8.0
KFM01A	2002-11-24 17:30	105.49	1000.86	185.52	190.52	5	5A			126.15	0		-12.737	2.85E-09	0	1.47E-10	7.34E-06	-0.55	8.1
KFM01A	2002-11-24 17:30	105.49	1000.86	190.52	195.52	5	5A			6	-1		-12.733	1.47E-10	-1	1.47E-10	7.35E-06		8.1
KFM01A	2002-11-24 17:30	105.49	1000.86	195.52	200.52	5	5A			6	-1		-12.736	1.47E-10	-1	1.47E-10	7.34E-06		8.2
KFM01A	2002-11-24 17:30	105.49	1000.86	200.52	205.52	5	5A			6	-1		-12.735	1.47E-10	-1	1.47E-10	7.34E-06		8.2
KFM01A	2002-11-24 17:30	105.49	1000.86	205.52	210.52	5	5A			6	-1		-12.736	1.47E-10	-1	1.47E-10	7.34E-06		8.3
KFM01A	2002-11-24 17:30	105.49	1000.86	210.52	215.52	5	5A			6	-1		-12.735	1.47E-10	-1	1.47E-10	7.34E-06		8.3
KFM01A	2002-11-24 17:30	105.49	1000.86	215.52	220.52	5	5A			6	-1		-12.736	1.47E-10	-1	1.47E-10	7.33E-06		8.4
KFM01A	2002-11-24 17:30	105.49	1000.86	220.52	225.52	5	5A			6	-1		-12.733	1.47E-10	-1	1.47E-10	7.34E-06		8.4
KFM01A	2002-11-24 17:30	105.49	1000.86	225.52	230.52	5	5A			19.8	0		-12.737	4.84E-10	0	1.47E-10	7.33E-06		8.5
KFM01A	2002-11-24 17:30	105.49	1000.86	230.52	235.52	5	5A			6	-1		-12.734	1.47E-10	-1	1.47E-10	7.33E-06		8.5
KFM01A	2002-11-24 17:30	105.49	1000.86	235.52	240.52	5	5A			6	-1		-12.733	1.47E-10	-1	1.47E-10	7.33E-06		8.6
KFM01A	2002-11-24 17:30	105.49	1000.86	240.52	245.52	5	5A			6	-1		-12.733	1.47E-10	-1	1.47E-10	7.33E-06		8.6
KFM01A	2002-11-24 17:30	105.49	1000.86	245.52	250.52	5	5A			6	-1		-12.735	1.46E-10	-1	1.46E-10	7.32E-06		8.7
KFM01A	2002-11-24 17:30	105.49	1000.86	250.52	255.52	5	5A			6	-1		-12.734	1.46E-10	-1	1.46E-10	7.32E-06		8.7
KFM01A	2002-11-24 17:30	105.49	1000.86	255.52	260.52	5	5A			6	-1		-12.734	1.46E-10	-1	1.46E-10	7.32E-06		8.8
KFM01A	2002-11-24 17:30	105.49	1000.86	260.52	265.52	5	5A			6	-1		-12.736	1.46E-10	-1	1.46E-10	7.31E-06		8.9
KFM01A	2002-11-24 17:30	105.49	1000.86	265.52	270.52	5	5A			22.25	0		-12.731	5.45E-10	0	1.46E-10	7.31E-06		8.9
KFM01A	2002-11-24 17:30	105.49	1000.86	270.52	275.52	5	5A			36.55	0		-12.731	8.90E-10	0	1.46E-10	7.31E-06		9.0
KFM01A	2002-11-24 17:30	105.49	1000.86	275.52	280.52	5	5A			9.3	0		-12.733	2.27E-10	0	1.46E-10	7.31E-06		9.0
KFM01A	2002-11-24 17:30	105.49	1000.86	280.52	285.52	5	5A			6	-1		-12.732	1.46E-10	-1	1.46E-10	7.31E-06		9.1
KFM01A	2002-11-24 17:30	105.49	1000.86	285.52	290.52	5	5A			6	-1		-12.735	1.46E-10	-1	1.46E-10	7.30E-06		9.1
KFM01A	2002-11-24 17:30	105.49	1000.86	290.52	295.52	5	5A			39.95	0		-12.734	9.75E-10	0	1.46E-10	7.30E-06		9.2
KFM01A	2002-11-24 17:30	105.49	1000.86	295.52	300.52	5	5A			6	-1		-12.733	1.46E-10	-1	1.46E-10	7.30E-06		9.2
KFM01A	2002-11-24 17:30	105.49	1000.86	300.52	305.52	5	5A			6	-1		-12.735	1.46E-10	-1	1.46E-10	7.30E-06		9.3
KFM01A	2002-11-24 17:30	105.49	1000.86	305.53	310.53	5	5A			22.8	0		-12.734	5.55E-10	0	1.46E-10	7.30E-06		9.3
KFM01A	2002-11-24 17:30	105.49	1000.86	310.53	315.53	5	5A			6	-1		-12.735	1.46E-10	-1	1.46E-10	7.29E-06		9.4
KFM01A	2002-11-24 17:30	105.49	1000.86	315.53	320.53	5	5A			118.88	0		-12.734	2.89E-09	0	1.46E-10	7.29E-06		9.5
KFM01A	2002-11-24 17:30	105.49	1000.86	320.54	325.54	5	5A			51.20	0		-12.732	1.25E-09	0	1.46E-10	7.29E-06		9.5
KFM01A	2002-11-24 17:30	105.49	1000.86	325.54	330.54	5	5A			23.90	0		-12.731	5.80E-10	0	1.46E-10	7.29E-06		9.6
KFM01A	2002-11-24 17:30	105.49	1000.86	330.55	335.55	5	5A			17.65	0		-12.731	4.29E-10	0	1.46E-10	7.29E-06		9.6

cont.

KFM01A	2002-11-24 17:30	105.49	1000.86	335.55	340.55	5	5A			6	-1		-12.734	1.46E-10	-1	1.46E-10	7.29E-06		9.7
KFM01A	2002-11-24 17:30	105.49	1000.86	340.55	345.55	5	5A			6	-1		-12.732	1.46E-10	-1	1.46E-10	7.29E-06		9.7
KFM01A	2002-11-24 17:30	105.49	1000.86	345.56	350.56	5	5A			6	-1		-12.734	1.46E-10	-1	1.46E-10	7.28E-06		9.8
KFM01A	2002-11-24 17:30	105.49	1000.86	350.56	355.56	5	5A			6	-1		-12.73	1.46E-10	-1	1.46E-10	7.28E-06		9.8
KFM01A	2002-11-24 17:30	105.49	1000.86	355.56	360.56	5	5A			6	-1		-12.735	1.46E-10	-1	1.46E-10	7.28E-06		9.9
KFM01A	2002-11-24 17:30	105.49	1000.86	360.56	365.56	5	5A			29.75	0		-12.734	7.20E-10	0	1.46E-10	7.28E-06		9.9
KFM01A	2002-11-24 17:30	105.49	1000.86	365.56	370.56	5	5A			6	-1		-12.732	1.46E-10	-1	1.46E-10	7.28E-06		10.0
KFM01A	2002-11-24 17:30	105.49	1000.86	370.56	375.56	5	5A			6	-1		-12.733	1.45E-10	-1	1.45E-10	7.27E-06		10.0
KFM01A	2002-11-24 17:30	105.49	1000.86	375.55	380.55	5	5A			6	-1		-12.73	1.45E-10	-1	1.45E-10	7.27E-06		10.1
KFM01A	2002-11-24 17:30	105.49	1000.86	380.55	385.55	5	5A			6	-1		-12.732	1.45E-10	-1	1.45E-10	7.27E-06		10.1
KFM01A	2002-11-24 17:30	105.49	1000.86	385.55	390.55	5	5A			6	-1		-12.732	1.45E-10	-1	1.45E-10	7.27E-06		10.2
KFM01A	2002-11-24 17:30	105.49	1000.86	390.55	395.55	5	5A			6	-1		-12.733	1.45E-10	-1	1.45E-10	7.27E-06		10.3
KFM01A	2002-11-24 17:30	105.49	1000.86	395.55	400.55	5	5A			6	-1		-12.732	1.45E-10	-1	1.45E-10	7.27E-06		10.3
KFM01A	2002-11-24 17:30	105.49	1000.86	400.55	405.55	5	5A			6	-1		-12.73	1.45E-10	-1	1.45E-10	7.27E-06		10.4
KFM01A	2002-11-24 17:30	105.49	1000.86	405.55	410.55	5	5A			6	-1		-12.737	1.45E-10	-1	1.45E-10	7.26E-06		10.4
KFM01A	2002-11-24 17:30	105.49	1000.86	410.55	415.55	5	5A			6	-1		-12.742	1.45E-10	-1	1.45E-10	7.26E-06		10.5
KFM01A	2002-11-24 17:30	105.49	1000.86	415.55	420.55	5	5A			6	-1		-12.743	1.45E-10	-1	1.45E-10	7.26E-06		10.5
KFM01A	2002-11-24 17:30	105.49	1000.86	420.55	425.55	5	5A			6	-1		-12.741	1.45E-10	-1	1.45E-10	7.25E-06		10.6
KFM01A	2002-11-24 17:30	105.49	1000.86	425.55	430.55	5	5A			6	-1		-12.736	1.45E-10	-1	1.45E-10	7.26E-06		10.6
KFM01A	2002-11-24 17:30	105.49	1000.86	430.55	435.55	5	5A			6	-1		-12.735	1.45E-10	-1	1.45E-10	7.25E-06		10.7
KFM01A	2002-11-24 17:30	105.49	1000.86	435.55	440.55	5	5A			6	-1		-12.732	1.45E-10	-1	1.45E-10	7.26E-06		10.7
KFM01A	2002-11-24 17:30	105.49	1000.86	440.55	445.55	5	5A			6	-1		-12.733	1.45E-10	-1	1.45E-10	7.25E-06		10.8
KFM01A	2002-11-24 17:30	105.49	1000.86	445.55	450.55	5	5A			6	-1		-12.731	1.45E-10	-1	1.45E-10	7.25E-06		10.9
KFM01A	2002-11-24 17:30	105.49	1000.86	450.54	455.54	5	5A			6	-1		-12.737	1.45E-10	-1	1.45E-10	7.25E-06		10.9
KFM01A	2002-11-24 17:30	105.49	1000.86	455.54	460.54	5	5A			6	-1		-12.735	1.45E-10	-1	1.45E-10	7.25E-06		11.0
KFM01A	2002-11-24 17:30	105.49	1000.86	460.54	465.54	5	5A			6	-1		-12.734	1.45E-10	-1	1.45E-10	7.25E-06		11.0
KFM01A	2002-11-24 17:30	105.49	1000.86	465.54	470.54	5	5A			6	-1		-12.734	1.45E-10	-1	1.45E-10	7.24E-06		11.1
KFM01A	2002-11-24 17:30	105.49	1000.86	470.54	475.54	5	5A			6	-1		-12.733	1.45E-10	-1	1.45E-10	7.24E-06		11.1
KFM01A	2002-11-24 17:30	105.49	1000.86	475.54	480.54	5	5A			6	-1		-12.732	1.45E-10	-1	1.45E-10	7.24E-06		11.2
KFM01A	2002-11-24 17:30	105.49	1000.86	480.54	485.54	5	5A			6	-1		-12.738	1.45E-10	-1	1.45E-10	7.24E-06		11.3
KFM01A	2002-11-24 17:30	105.49	1000.86	485.54	490.54	5	5A			6	-1		-12.736	1.45E-10	-1	1.45E-10	7.24E-06		11.3
KFM01A	2002-11-24 17:30	105.49	1000.86	490.54	495.54	5	5A			6	-1		-12.74	1.45E-10	-1	1.45E-10	7.24E-06		11.4
KFM01A	2002-11-24 17:30	105.49	1000.86	495.54	500.54	5	5A			6	-1		-12.733	1.45E-10	-1	1.45E-10	7.24E-06		11.4
KFM01A	2002-11-24 17:30	105.49	1000.86	500.54	505.54	5	5A			6	-1		-12.737	1.45E-10	-1	1.45E-10	7.23E-06		11.5
KFM01A	2002-11-24 17:30	105.49	1000.86	505.54	510.54	5	5A			6	-1		-12.733	1.45E-10	-1	1.45E-10	7.24E-06		11.5
KFM01A	2002-11-24 17:30	105.49	1000.86	510.55	515.55	5	5A			6	-1		-12.733	1.45E-10	-1	1.45E-10	7.23E-06		11.6
KFM01A	2002-11-24 17:30	105.49	1000.86	515.55	520.55	5	5A			6	-1		-12.733	1.45E-10	-1	1.45E-10	7.23E-06		11.7
KFM01A	2002-11-24 17:30	105.49	1000.86	520.55	525.55	5	5A			6	-1		-12.732	1.45E-10	-1	1.45E-10	7.23E-06		11.7
KFM01A	2002-11-24 17:30	105.49	1000.86	525.55	530.55	5	5A			6	-1		-12.733	1.45E-10	-1	1.45E-10	7.23E-06		11.8
KFM01A	2002-11-24 17:30	105.49	1000.86	530.55	535.55	5	5A			6	-1		-12.73	1.45E-10	-1	1.45E-10	7.23E-06		11.8
KFM01A	2002-11-24 17:30	105.49	1000.86	535.56	540.56	5	5A			6	-1		-12.738	1.44E-10	-1	1.44E-10	7.22E-06		11.9
KFM01A	2002-11-24 17:30	105.49	1000.86	540.56	545.56	5	5A			6	-1		-12.736	1.44E-10	-1	1.44E-10	7.22E-06		12.0
KFM01A	2002-11-24 17:30	105.49	1000.86	545.56	550.56	5	5A			6	-1		-12.735	1.44E-10	-1	1.44E-10	7.22E-06		12.0
KFM01A	2002-11-24 17:30	105.49	1000.86	550.56	555.56	5	5A			6	-1		-12.734	1.44E-10	-1	1.44E-10	7.22E-06		12.1
KFM01A	2002-11-24 17:30	105.49	1000.86	555.57	560.57	5	5A			6	-1		-12.734	1.44E-10	-1	1.44E-10	7.22E-06		12.1

cont.

KFM01A	2002-11-24 17:30	105.49	1000.86	560.57	565.57	5	5A			6	-1		-12.736	1.44E-10	-1	1.44E-10	7.22E-06		12.2
KFM01A	2002-11-24 17:30	105.49	1000.86	565.58	570.58	5	5A			6	-1		-12.732	1.44E-10	-1	1.44E-10	7.22E-06		12.3
KFM01A	2002-11-24 17:30	105.49	1000.86	570.59	575.59	5	5A			6	-1		-12.735	1.44E-10	-1	1.44E-10	7.22E-06		12.3
KFM01A	2002-11-24 17:30	105.49	1000.86	575.59	580.59	5	5A			6	-1		-12.732	1.44E-10	-1	1.44E-10	7.22E-06		12.4
KFM01A	2002-11-24 17:30	105.49	1000.86	580.60	585.60	5	5A			6	-1		-12.733	1.44E-10	-1	1.44E-10	7.22E-06		12.4
KFM01A	2002-11-24 17:30	105.49	1000.86	585.60	590.60	5	5A			6	-1		-12.732	1.44E-10	-1	1.44E-10	7.21E-06		12.5
KFM01A	2002-11-24 17:30	105.49	1000.86	590.60	595.60	5	5A			6	-1		-12.733	1.44E-10	-1	1.44E-10	7.21E-06		12.6
KFM01A	2002-11-24 17:30	105.49	1000.86	595.61	600.61	5	5A			6	-1		-12.732	1.44E-10	-1	1.44E-10	7.21E-06		12.6
KFM01A	2002-11-24 17:30	105.49	1000.86	600.61	605.61	5	5A			6	-1		-12.735	1.44E-10	-1	1.44E-10	7.21E-06		12.7
KFM01A	2002-11-24 17:30	105.49	1000.86	605.61	610.61	5	5A			6	-1		-12.731	1.44E-10	-1	1.44E-10	7.21E-06		12.7
KFM01A	2002-11-24 17:30	105.49	1000.86	610.62	615.62	5	5A			6	-1		-12.734	1.44E-10	-1	1.44E-10	7.21E-06		12.8
KFM01A	2002-11-24 17:30	105.49	1000.86	615.62	620.62	5	5A			6	-1		-12.735	1.44E-10	-1	1.44E-10	7.21E-06		12.9
KFM01A	2002-11-24 17:30	105.49	1000.86	620.62	625.62	5	5A			6	-1		-12.733	1.44E-10	-1	1.44E-10	7.21E-06		12.9
KFM01A	2002-11-24 17:30	105.49	1000.86	625.62	630.62	5	5A			6	-1		-12.732	1.44E-10	-1	1.44E-10	7.20E-06		13.0
KFM01A	2002-11-24 17:30	105.49	1000.86	630.62	635.62	5	5A			6	-1		-12.732	1.44E-10	-1	1.44E-10	7.20E-06		13.1
KFM01A	2002-11-24 17:30	105.49	1000.86	635.63	640.63	5	5A			6	-1		-12.73	1.44E-10	-1	1.44E-10	7.20E-06		13.1
KFM01A	2002-11-24 17:30	105.49	1000.86	640.63	645.63	5	5A			6	-1		-12.732	1.44E-10	-1	1.44E-10	7.20E-06		13.2
KFM01A	2002-11-24 17:30	105.49	1000.86	645.63	650.63	5	5A			6	-1		-12.734	1.44E-10	-1	1.44E-10	7.20E-06		13.2
KFM01A	2002-11-24 17:30	105.49	1000.86	650.64	655.64	5	5A			6	-1		-12.732	1.44E-10	-1	1.44E-10	7.20E-06		13.3
KFM01A	2002-11-24 17:30	105.49	1000.86	655.64	660.64	5	5A			6	-1		-12.732	1.44E-10	-1	1.44E-10	7.20E-06		13.4
KFM01A	2002-11-24 17:30	105.49	1000.86	660.65	665.65	5	5A			6	-1		-12.734	1.44E-10	-1	1.44E-10	7.20E-06		13.4
KFM01A	2002-11-24 17:30	105.49	1000.86	665.66	670.66	5	5A			6	-1		-12.731	1.44E-10	-1	1.44E-10	7.20E-06		13.5
KFM01A	2002-11-24 17:30	105.49	1000.86	670.67	675.67	5	5A			6	-1		-12.734	1.44E-10	-1	1.44E-10	7.19E-06		13.6
KFM01A	2002-11-24 17:30	105.49	1000.86	675.68	680.68	5	5A			6	-1		-12.734	1.44E-10	-1	1.44E-10	7.19E-06		13.6
KFM01A	2002-11-24 17:30	105.49	1000.86	680.69	685.69	5	5A			6	-1		-12.734	1.44E-10	-1	1.44E-10	7.19E-06		13.7
KFM01A	2002-11-24 17:30	105.49	1000.86	685.70	690.70	5	5A			6	-1		-12.733	1.44E-10	-1	1.44E-10	7.19E-06		13.7
KFM01A	2002-11-24 17:30	105.49	1000.86	690.71	695.71	5	5A			6	-1		-12.732	1.44E-10	-1	1.44E-10	7.19E-06		13.8
KFM01A	2002-11-24 17:30	105.49	1000.86	695.72	700.72	5	5A			6	-1		-12.734	1.44E-10	-1	1.44E-10	7.19E-06		13.9
KFM01A	2002-11-24 17:30	105.49	1000.86	700.72	705.72	5	5A			6	-1		-12.735	1.44E-10	-1	1.44E-10	7.19E-06		13.9
KFM01A	2002-11-24 17:30	105.49	1000.86	705.72	710.72	5	5A			6	-1		-12.732	1.44E-10	-1	1.44E-10	7.19E-06		14.0
KFM01A	2002-11-24 17:30	105.49	1000.86	710.72	715.72	5	5A			6	-1		-12.73	1.44E-10	-1	1.44E-10	7.19E-06		14.1
KFM01A	2002-11-24 17:30	105.49	1000.86	715.72	720.72	5	5A			6	-1		-12.734	1.44E-10	-1	1.44E-10	7.18E-06		14.1
KFM01A	2002-11-24 17:30	105.49	1000.86	720.72	725.72	5	5A			6	-1		-12.735	1.44E-10	-1	1.44E-10	7.18E-06		14.2
KFM01A	2002-11-24 17:30	105.49	1000.86	725.72	730.72	5	5A			6	-1		-12.732	1.44E-10	-1	1.44E-10	7.18E-06		14.3
KFM01A	2002-11-24 17:30	105.49	1000.86	730.72	735.72	5	5A			6	-1		-12.733	1.44E-10	-1	1.44E-10	7.18E-06		14.3
KFM01A	2002-11-24 17:30	105.49	1000.86	735.72	740.72	5	5A			6	-1		-12.733	1.44E-10	-1	1.44E-10	7.18E-06		14.4
KFM01A	2002-11-24 17:30	105.49	1000.86	740.72	745.72	5	5A			6	-1		-12.735	1.44E-10	-1	1.44E-10	7.18E-06		14.5
KFM01A	2002-11-24 17:30	105.49	1000.86	745.72	750.72	5	5A			6	-1		-12.735	1.44E-10	-1	1.44E-10	7.18E-06		14.5
KFM01A	2002-11-24 17:30	105.49	1000.86	750.72	755.72	5	5A			6	-1		-12.734	1.44E-10	-1	1.44E-10	7.18E-06		14.6
KFM01A	2002-11-24 17:30	105.49	1000.86	755.73	760.73	5	5A			6	-1		-12.733	1.44E-10	-1	1.44E-10	7.18E-06		14.7
KFM01A	2002-11-24 17:30	105.49	1000.86	760.74	765.74	5	5A			6	-1		-12.732	1.44E-10	-1	1.44E-10	7.18E-06		14.7
KFM01A	2002-11-24 17:30	105.49	1000.86	765.74	770.74	5	5A			6	-1		-12.731	1.43E-10	-1	1.43E-10	7.17E-06		14.8
KFM01A	2002-11-24 17:30	105.49	1000.86	770.75	775.75	5	5A			6	-1		-12.733	1.43E-10	-1	1.43E-10	7.17E-06		14.9
KFM01A	2002-11-24 17:30	105.49	1000.86	775.75	780.75	5	5A			6	-1		-12.734	1.43E-10	-1	1.43E-10	7.17E-06		14.9
KFM01A	2002-11-24 17:30	105.49	1000.86	780.76	785.76	5	5A			6	-1		-12.735	1.43E-10	-1	1.43E-10	7.17E-06		15.0

cont.

KFM01A	2002-11-24 17:30	105.49	1000.86	785.77	790.77	5	5A			6	-1		-12.732	1.43E-10	-1	1.43E-10	7.17E-06		15.1
KFM01A	2002-11-24 17:30	105.49	1000.86	790.77	795.77	5	5A			6	-1		-12.734	1.43E-10	-1	1.43E-10	7.17E-06		15.1
KFM01A	2002-11-24 17:30	105.49	1000.86	795.78	800.78	5	5A			6	-1		-12.732	1.43E-10	-1	1.43E-10	7.17E-06		15.2
KFM01A	2002-11-24 17:30	105.49	1000.86	800.78	805.78	5	5A			6	-1		-12.733	1.43E-10	-1	1.43E-10	7.17E-06		15.2
KFM01A	2002-11-24 17:30	105.49	1000.86	805.78	810.78	5	5A			6	-1		-12.732	1.43E-10	-1	1.43E-10	7.17E-06		15.3
KFM01A	2002-11-24 17:30	105.49	1000.86	810.79	815.79	5	5A			6	-1		-12.733	1.43E-10	-1	1.43E-10	7.16E-06		15.4
KFM01A	2002-11-24 17:30	105.49	1000.86	815.79	820.79	5	5A			6	-1		-12.731	1.43E-10	-1	1.43E-10	7.17E-06		15.5
KFM01A	2002-11-24 17:30	105.49	1000.86	820.79	825.79	5	5A			6	-1		-12.735	1.43E-10	-1	1.43E-10	7.16E-06		15.5
KFM01A	2002-11-24 17:30	105.49	1000.86	825.79	830.79	5	5A			6	-1		-12.732	1.43E-10	-1	1.43E-10	7.16E-06		15.6
KFM01A	2002-11-24 17:30	105.49	1000.86	830.79	835.79	5	5A			6	-1		-12.733	1.43E-10	-1	1.43E-10	7.16E-06		15.7
KFM01A	2002-11-24 17:30	105.49	1000.86	835.80	840.80	5	5A			6	-1		-12.732	1.43E-10	-1	1.43E-10	7.16E-06		15.7
KFM01A	2002-11-24 17:30	105.49	1000.86	840.80	845.80	5	5A			6	-1		-12.732	1.43E-10	-1	1.43E-10	7.16E-06		15.8
KFM01A	2002-11-24 17:30	105.49	1000.86	845.80	850.80	5	5A			6	-1		-12.73	1.43E-10	-1	1.43E-10	7.16E-06		15.9
KFM01A	2002-11-24 17:30	105.49	1000.86	850.80	855.80	5	5A			6	-1		-12.734	1.43E-10	-1	1.43E-10	7.16E-06		15.9
KFM01A	2002-11-24 17:30	105.49	1000.86	855.80	860.80	5	5A			6	-1		-12.733	1.43E-10	-1	1.43E-10	7.16E-06		16.0
KFM01A	2002-11-24 17:30	105.49	1000.86	860.81	865.81	5	5A			6	-1		-12.734	1.43E-10	-1	1.43E-10	7.15E-06		16.1
KFM01A	2002-11-24 17:30	105.49	1000.86	865.81	870.81	5	5A			6	-1		-12.732	1.43E-10	-1	1.43E-10	7.16E-06		16.2
KFM01A	2002-11-24 17:30	105.49	1000.86	870.81	875.81	5	5A			6	-1		-12.734	1.43E-10	-1	1.43E-10	7.15E-06		16.2
KFM01A	2002-11-24 17:30	105.49	1000.86	875.81	880.81	5	5A			6	-1		-12.732	1.43E-10	-1	1.43E-10	7.15E-06		16.3
KFM01A	2002-11-24 17:30	105.49	1000.86	880.82	885.82	5	5A			6	-1		-12.735	1.43E-10	-1	1.43E-10	7.15E-06		16.4
KFM01A	2002-11-24 17:30	105.49	1000.86	885.82	890.82	5	5A			6	-1		-12.732	1.43E-10	-1	1.43E-10	7.15E-06		16.4
KFM01A	2002-11-24 17:30	105.49	1000.86	890.82	895.82	5	5A			6	-1		-12.733	1.43E-10	-1	1.43E-10	7.15E-06		16.5
KFM01A	2002-11-24 17:30	105.49	1000.86	895.82	900.82	5	5A			6	-1		-12.732	1.43E-10	-1	1.43E-10	7.15E-06		16.6
KFM01A	2002-11-24 17:30	105.49	1000.86	900.82	905.82	5	5A			6	-1		-12.732	1.43E-10	-1	1.43E-10	7.15E-06		16.6
KFM01A	2002-11-24 17:30	105.49	1000.86	905.83	910.83	5	5A			6	-1		-12.732	1.43E-10	-1	1.43E-10	7.15E-06		16.7
KFM01A	2002-11-24 17:30	105.49	1000.86	910.83	915.83	5	5A			6	-1		-12.733	1.43E-10	-1	1.43E-10	7.15E-06		16.8
KFM01A	2002-11-24 17:30	105.49	1000.86	915.83	920.83	5	5A			6	-1		-12.735	1.43E-10	-1	1.43E-10	7.14E-06		16.8
KFM01A	2002-11-24 17:30	105.49	1000.86	920.83	925.83	5	5A			6	-1		-12.733	1.43E-10	-1	1.43E-10	7.14E-06		16.9
KFM01A	2002-11-24 17:30	105.49	1000.86	925.83	930.83	5	5A			6	-1		-12.737	1.43E-10	-1	1.43E-10	7.14E-06		17.0
KFM01A	2002-11-24 17:30	105.49	1000.86	930.84	935.84	5	5A			6	-1		-12.739	1.43E-10	-1	1.43E-10	7.14E-06		17.0
KFM01A	2002-11-24 17:30	105.49	1000.86	935.84	940.84	5	5A			6	-1		-12.736	1.43E-10	-1	1.43E-10	7.14E-06		17.1
KFM01A	2002-11-24 17:30	105.49	1000.86	940.84	945.84	5	5A			6	-1		-12.738	1.43E-10	-1	1.43E-10	7.14E-06		17.2
KFM01A	2002-11-24 17:30	105.49	1000.86	945.84	950.84	5	5A			6	-1		-12.736	1.43E-10	-1	1.43E-10	7.14E-06		17.3
KFM01A	2002-11-24 17:30	105.49	1000.86	950.85	955.85	5	5A			6	-1		-12.737	1.43E-10	-1	1.43E-10	7.14E-06		17.3
KFM01A	2002-11-24 17:30	105.49	1000.86	955.85	960.85	5	5A			6	-1		-12.736	1.43E-10	-1	1.43E-10	7.14E-06		17.4
KFM01A	2002-11-24 17:30	105.49	1000.86	960.85	965.85	5	5A			6	-1		-12.737	1.43E-10	-1	1.43E-10	7.13E-06		17.4
KFM01A	2002-11-24 17:30	105.49	1000.86	965.85	970.85	5	5A			6	-1		-12.733	1.43E-10	-1	1.43E-10	7.14E-06		17.5
KFM01A	2002-11-24 17:30	105.49	1000.86	970.85	975.85	5	5A			6	-1		-12.735	1.43E-10	-1	1.43E-10	7.13E-06		17.6
KFM01A	2002-11-24 17:30	105.49	1000.86	975.86	980.86	5	5A			6	-1		-12.736	1.43E-10	-1	1.43E-10	7.13E-06		17.7
KFM01A	2002-11-24 17:30	105.49	1000.86	980.86	985.86	5	5A			6	-1		-12.736	1.43E-10	-1	1.43E-10	7.13E-06		17.7
KFM01A	2002-11-24 17:30	105.49	1000.86	985.86	990.86	5	5A			6	-1		-12.733	1.43E-10	-1	1.43E-10	7.13E-06		17.8
KFM01A	2002-11-24 17:30	105.49	1000.86	990.86	995.86	5	5A			6	-1		-12.734	1.43E-10	-1	1.43E-10	7.13E-06		17.9
KFM01A	2002-11-24 17:30	105.49	1000.86	995.86	1000.86	5	5A			6	-1		-12.735	1.43E-10	-1	1.43E-10	7.13E-06		18.0

PFL-Difference flow logging- Overlapping logging

5B. PFL-DIFF - Inferred flow anomalies from overlapping flow logging

Bore-hole	Date and time of test, start	Logged interval from	Logged interval to	b	dL	Test type	L_i	Upper limit-L_i	Lower limit-L_i	Q_0	Value type-Q_0	Q_1	h_{0f} fresh water	h_{0f} saline water	h_{1f} fresh water	h_{1f} saline water	b_i	T_D- fresh water	T_D- saline water	T_D- measl-L	T_D- measl-U	h_i- fresh water	h_i- saline water
ID	yyyymmdd hhmm	(m)	(m)	(m)	(m)	(1-6)	(m)	L (m)	L (m)	(mL/h)		(mL/h)	(m a s l)	(m a s l)	(m a s l)	(m a s l)	(m)	(m^2/s)	(m^2/s)	(m^2/s)	(m^2/s)	(m)	(m)
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	105.3	105.28	105.38	30	-1	45	-1.58	-1.04	-12.74	-12.13	0.1	1.11E-09	1.11E-09	1.48E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	106.9	106.88	106.98	30	-1	19	-1.58	-1.03	-12.74	-12.12	0.1	4.68E-10	4.71E-10	1.48E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	113.8	113.78	113.88	30	-1	103	-1.57	-0.96	-12.74	-12.07	0.1	2.53E-09	2.55E-09	1.48E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	115.2	115.18	115.28	47	0	1500	-1.57	-0.96	-12.74	-12.05	0.1	3.57E-08	3.60E-08	1.48E-10	7.4E-06	-1.21	-0.60
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	118.3	118.28	118.38	40	0	2200	-1.57	-0.93	-12.74	-12.03	0.1	5.31E-08	5.35E-08	1.48E-10	7.4E-06	-1.36	-0.73
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	121.7	121.68	121.78	30	-1	130	-1.56	-0.91	-12.74	-12.00	0.1	3.20E-09	3.22E-09	1.48E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	122.6	122.58	122.68	30	-1	150	-1.56	-0.90	-12.73	-11.99	0.1	3.69E-09	3.72E-09	1.48E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	123.3	123.28	123.38	30	-1	51	-1.56	-0.89	-12.73	-11.99	0.1	1.25E-09	1.26E-09	1.48E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	123.8	123.78	123.88	30	-1	19	-1.56	-0.89	-12.73	-11.99	0.1	4.67E-10	4.70E-10	1.48E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	128.1	128.08	128.18	30	-1	80	-1.56	-0.86	-12.74	-11.96	0.1	1.97E-09	1.98E-09	1.47E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	128.4	128.38	128.48	30	-1	25	-1.56	-0.85	-12.74	-11.96	0.1	6.15E-10	6.19E-10	1.47E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	145.0	144.98	145.08	30	-1	35	-1.55	-0.73	-12.74	-11.85	0.1	8.59E-10	8.65E-10	1.47E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	146.8	146.78	146.88	-15	0	280	-1.55	-0.71	-12.74	-11.83	0.1	7.24E-09	7.29E-09	1.47E-10	7.4E-06	-2.11	-1.28
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	147.7	147.68	147.78	-15	0	300	-1.54	-0.70	-12.74	-11.82	0.1	7.73E-09	7.78E-09	1.47E-10	7.4E-06	-2.08	-1.23
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	149.1	149.08	149.18	-15	0	320	-1.54	-0.70	-12.74	-11.81	0.1	8.22E-09	8.28E-09	1.47E-10	7.4E-06	-2.04	-1.19
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	158.6	158.58	158.68	0	-1	430	-1.54	-0.63	-12.73	-11.74	0.1	1.06E-08	1.06E-08	1.47E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	159.3	159.28	159.38	0	-1	20	-1.54	-0.62	-12.73	-11.73	0.1	4.91E-10	4.94E-10	1.47E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	161.9	161.88	161.98	0	-1	30	-1.53	-0.60	-12.73	-11.71	0.1	7.36E-10	7.42E-10	1.47E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	162.9	162.88	162.98	0	-1	17	-1.53	-0.59	-12.73	-11.71	0.1	4.17E-10	4.20E-10	1.47E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	174.8	174.78	174.88	0	-1	10	-1.52	-0.51	-12.74	-11.63	0.1	2.45E-10	2.47E-10	1.47E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	178.0	177.98	178.08	0	-1	50	-1.52	-0.48	-12.74	-11.61	0.1	1.22E-09	1.24E-09	1.47E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	178.3	178.28	178.38	130	0	2050	-1.52	-0.48	-12.74	-11.60	0.1	4.70E-08	4.74E-08	1.47E-10	7.4E-06	-0.76	0.27
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	187.8	187.78	187.88	10	0	125	-1.51	-0.42	-12.73	-11.53	0.1	2.82E-09	2.84E-09	1.47E-10	7.4E-06	-0.54	0.55
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	227.0	226.98	227.08	0	-1	15	-1.49	-0.22	-12.71	-11.32	0.1	3.68E-10	3.71E-10	1.47E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	265.8	265.78	265.88	0	-1	14	-1.46	-0.07	-12.74	-11.21	0.1	3.41E-10	3.45E-10	1.46E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	270.8	270.78	270.88	0	-1	20	-1.46	-0.05	-12.74	-11.19	0.1	4.87E-10	4.93E-10	1.46E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	277.7	277.68	277.78	0	-1	12	-1.46	-0.02	-12.74	-11.17	0.1	2.92E-10	2.96E-10	1.46E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	292.6	292.58	292.68	0	-1	26	-1.45	0.03	-12.74	-11.12	0.1	6.33E-10	6.41E-10	1.46E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	306.6	306.58	306.68	0	-1	23	-1.44	0.07	-12.74	-11.08	0.1	5.59E-10	5.67E-10	1.46E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	316.6	316.58	316.68	0	-1	90	-1.43	0.10	-12.74	-11.05	0.1	2.19E-09	2.22E-09	1.46E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	320.6	320.58	320.68	0	-1	15	-1.43	0.12	-12.74	-11.03	0.1	3.64E-10	3.70E-10	1.46E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	325.9	325.88	325.98	0	-1	11	-1.43	0.13	-12.74	-11.02	0.1	2.67E-10	2.71E-10	1.46E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	332.9	332.88	332.98	0	-1	15	-1.42	0.16	-12.74	-11.00	0.1	3.64E-10	3.70E-10	1.46E-10	7.4E-06		
KFM01A	2002-11-27 11:30	100.48	364.55	1	0.1	5B	363.4	363.38	363.48	0	-1	16	-1.41	0.25	-12.75	-10.92	0.1	3.88E-10	3.94E-10	1.45E-10	7.4E-06		

Explanations

Header	Unit	Description
Borehole		borehole identification code
Secup	m	Length coordinate along the borehole for the upper limit of the logged section (Based on corrected length L)
Seclow	m	Length coordinate along the borehole for the lower limit of the logged section. (Based on corrected length L)
Test type		1A: Pumping test - wireline eq., 1B:Pumping test-submersible pump, 1C: Pumpingtest-airlift pumping, 2: Interference test, 3: Injection test, 4: Slug test, 5A: Difference flow logging-PFL-DIFF-Sequential, 5B: Difference flow logging-PFL-DIFF-Overlapping, 6: Flow logging-Impeller
Formation type		1: Rock, 2: Soil (superficial deposits)
Date and time of test, start		Date and time for the start of the test (YYYY-MM-DD hh:mm)
Date and time of test, stop		Date and time for the stop of the test (YYYY-MM-DD hh:mm)
Date and time of flow logging, start		Date and time of flow logging start (YYYY-MM-DD hh:mm)
Date and time of flow logging, stop		Date and time of flow logging stop (YYYY-MM-DD hh:mm)
L_w	m	Section length used in the difference flow logging
dL	m	Step length (increment) used in the difference flow logging
Q-measl-L	mL/h	Estimated lower measurement limit for borehole flow rate in flowlogging probe
Q-measl-U	mL/h	Estimated upper measurement limit for borehole flow rate in flowlogging probe
Q_{p1}	m^3/s	Flow rate at surface by the end of the first flow period of the flow logging
Q_{p2}	m^3/s	Flow rate at surface by the end of the second flow period of the flow logging
t_{p1}	s	Duration of the first flow period
t_{p2}	s	Duration of the second flow period
t_{F1}	s	Duration of the first recovery period
t_{F2}	s	Duration of the second recovery period
h_0	m.a.s.l.	Initial hydraulic head. Measured as water level in open borehole with reference level in the local coordinates system with z=0 m
h_1	m.a.s.l.	Stabilized hydraulic head during first flow period. Measured as water level in open borehole with reference level in the local coordinates system with z=0 m
h_2	m.a.s.l.	Stabilized hydraulic head during second flow period.Measured as water level in open borehole with reference level in the local coordinates system with z=0 m
h_F	m.a.s.l.	Stabilized hydraulic head at the end of the recovery period.Measured as water level in open borehole with reference level in the local coordinates system with z=0 m.
s_1	m	Drawdown of the water level in the borehole during first flow period. Difference between the actual hydraulic head and the initial head ($s_1= h_1-h_0$)
s_2	m	Drawdown of the water level in the borehole during second flow period. Difference between the actual hydraulic head and the initial head ($s_2=h_2-h_0$)
b	m	Represenative thickness estimated as section length L_w used in the difference flow logging.
Q_0	mL/h	Measured flow rate through the test section or flow anomaly under natural conditions (no pumping) with $h=h_0$ in the open borehole

Value type-Q_0		Code for Q_0-value; -1 means Q_0< lower measurement limit, 0 means measured value, 1 means Q_0>upper measurement limit.
Q_1	mL/h	Measured flow rate through the test section or flow anomaly during the first flow period
Value type-Q_1		Code for Q_1-value; -1 means Q_1< lower measurement limit, 0 means measured value, 1 means Q_1 Q_1>upper measurement limit.
Q_2	mL/h	Measured flow rate through the test section or flow anomaly during the second flow period
Value type-Q_2		Code for Q_2-value; -1 means Q_2< lower measurement limit, 0 means measured value, 1 means Q_2>upper measurement limit.
h_{0f}	m.a.s.l.	Initial hydraulic head distribution along the borehole before pumping
h_{0f} -fresh water	m.a.s.l.	Initial hydraulic head distribution along the borehole before pumping based on assumed freshwater head conditions
h_{0f} -saline water	m.a.s.l.	Initial hydraulic head distribution along the borehole before pumping based on assumed saline water conditions
h_{1f}	m.a.s.l.	Hydraulic head distribution along the borehole during the first flow period
h_{1f}- fresh water	m.a.s.l.	Hydraulic head distribution along the borehole during the first flow period based on assumed fresh water head conditions
h_{1f}- saline water	m.a.s.l.	Hydraulic head distribution along the borehole during the second flow period based on assumed saline water conditions
T_D	m^2/s	Transmissivity of section or flow anomaly based on 2D model for evaluation of formation properties based on PFL-DIFF
$T_{D\text{-}}$fresh water	m^2/s	Transmissivity of section or flow anomaly based on 2D model for evaluation of formation properties based on PFL-DIFF at assumed fresh water conditions
$T_{D\text{-}}$saline water	m^2/s	Transmissivity of section or flow anomaly based on 2D model for evaluation of formation properties based on PFL-DIFFat assumed saline water conditions
T_D-measl-L	m^2/s	Estimated measurement limit for evaluated $T_{D.}$ If the estimated T_D equals T_D-measlim, the actual T_D is considered to be equal or less than T_D-measlim
T_D-measl-U	m^2/s	Estimated measurement limit for evaluated $T_{D.}$ If the estimated T_D equals T_D-measlim, the actual T_D is considered to be equal or grater than T_D-measlim
Value type-T_D		Code for T_D -value; -1 means T_D < lower measurement limit, 0 means evaluated value, 1 means T_D >upper measurement limit.
h_i	m	Calculated relative, natural freshwater head for test section or flow anomaly (undisturbed conditions)
h_i -fresh water	m	Calculated relative, natural freshwater head for test section or flow anomaly (undisturbed conditions) based on assumed freshwater conditions along the borehole
h_i -saline water	m	Calculated relative, natural freshwater head for test section or flow anomaly (undisturbed conditions) based on assumed saline water conditions along the hole
Te_w	centigrade	Measured borehole fluid temperature in the test section during difference flow logging
EC_w	mS/m	Measured electric conductivity of the borehole fluid in the test section during difference flow logging
TDS_w	mg/L	Total salinity of the fluid in the test section representative for the evaluated parameters based on EC
L_i	m	Length along the borehole to inferred flow anomaly from overlapping flow logging
Upper limit-L_i	m	Length along the borehole for the upper limit of the test section or flow anomaly (based on corrected length L)
Lower limit-L_i	m	Length along the borehole for the lower limit of the test section or flow anomaly (based on corrected length L)
b_i	m	Estimated thickness of flow anomaly or, alternatively the step length used in the overlapping logging
Te_f	ºC	Measured fracture-specific fluid temperature in flow anomaly during difference flow logging
EC_f	mS/m	Measured fracture-specific electric conductivity (EC) of the fluid in flow anomaly during difference flow logging
TDS_f	mg/L	Total salinity of the fluid in the test section representative for the evaluated parameters based on EC
t_f	s	Duration of fracture-specific EC-measurement in flow anomaly
references		SKB report No for reports describing data and evaluation
comments		Short comment to the evaluated parameters

Appendix 7

PUMPING TEST DURING DIFFERENCE FLOW LOGGING IN BOREHOLE KFM01A

Jan-Erik Ludvigson

May 2003

Abstract

The recovery of the groundwater level in borehole KFM01A after the open-hole pumping test with constant draw-down during the difference flow logging was used to calculate the total transmissivity of the borehole. The recovery was recorded by a pressure transducer with frequent sampling to permit analysis by transient methods. During the flow logging period the flow rate was measured manually circa once a day.

The transient recovery phase of the groundwater head in the borehole was analysed by type curve matching. It was found that the recovery phase was strongly affected by wellbore storage, due to the very low hydraulic conductivity of the bedrock. An approximate evaluation of the borehole transmissivity was nevertheless possible to make, resulting in T=approx. $3 \cdot 10^{-7}$ m^2/s.

An estimation of the borehole transmissivity was also made from the preceding flow period. This estimated transmissivity value was similar to the calculated transmissivity from the recovery period, which corresponds to an average hydraulic conductivity of the bedrock in the vicinity of the borehole of c $3.5 \cdot 10^{-10}$ m/s.

Sammanfattning

Återhämtningen av grundvattnets trycknivå i borrhål KFM01A efter pumptesten i öppet hål med konstant avsänkning under differensflödesloggningen användes för att beräkna borrhålets totala transmissivitet. Återhämtningen registrerades med tryckgivare med tät mätfrekvens för att möjliggöra transient analys. Under flödesperioden mättes flödet manuellt ca en gång per dag.

Det transienta återhämtningsförloppet av grundvattnets trycknivå analyserades genom typkurvepassning. Det befanns att återhämtningsfasen var starkt påverkad av borrhålsmagasinet på grund av berggrundens mycket låga hydrauliska konduktivitet. En approximativ utvärdering av borrhålets transmissivitet var emellertid möjlig att göra, resulterande i T = c:a $3 \cdot 10^{-7}$ m^2/s.

Dessutom gjordes en skattning av transmissiviteten från den föregående flödesperioden, som resulterade i ett transmissivitetsvärde av samma storlek som den beräknade transmissiviteten från återhämtningsperioden, vilket motsvarar ett medelvärde på den hydrauliska konduktiviteten för berggrunden närmast borrhålet av ca $3.5 \cdot 10^{-10}$ m/s.

Contents

1 INTRODUCTION

During the difference flow logging in borehole KFM01A, pumping of the borehole with a constant draw-down was performed during some of the flow logging sequences. The groundwater head in the open borehole was registered during both the flow- and recovery period by a pressure transducer as described in the Activity Plan AP PF 400-02-40 (SKB internal controlling document). Manual readings of the flow rate were made during the flow period.

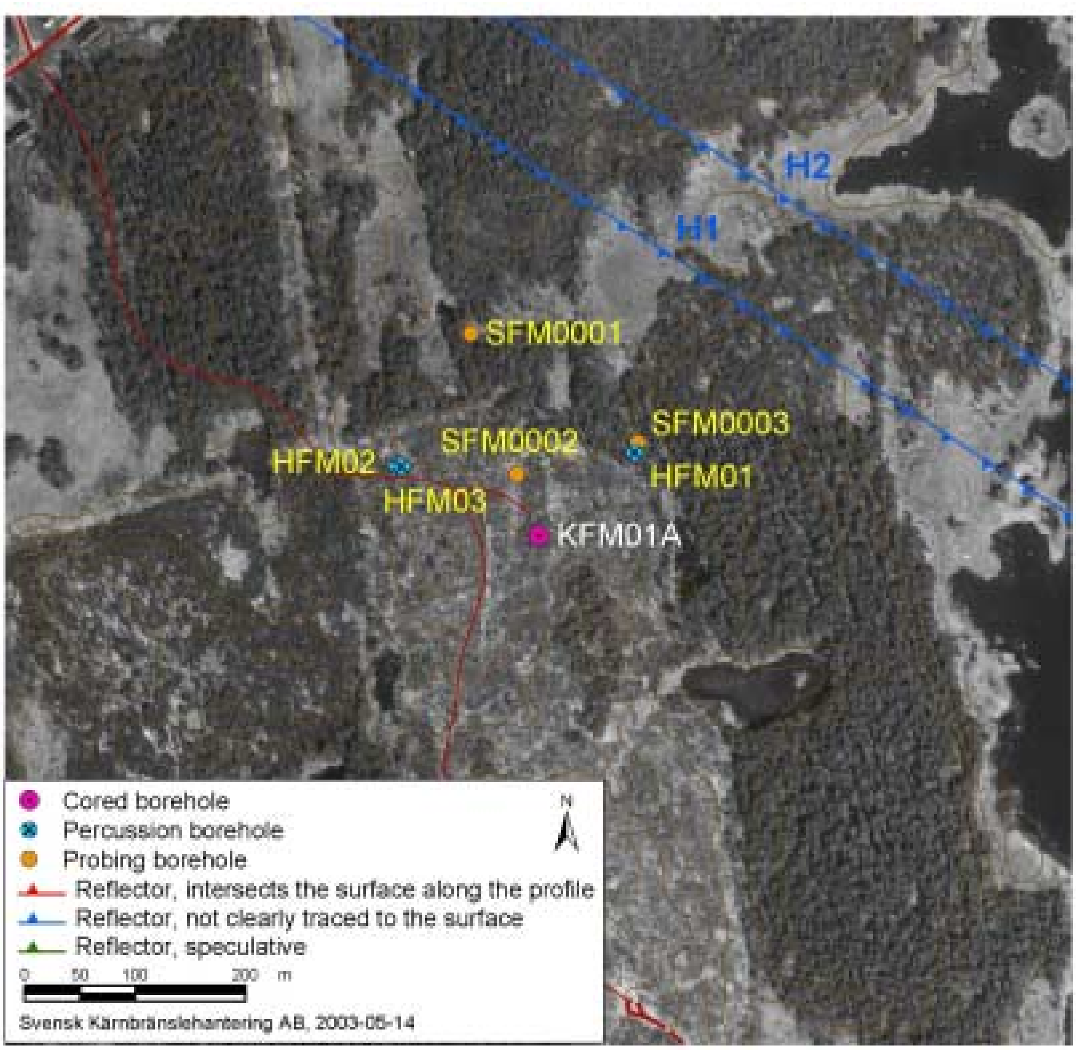


Figure 1-1. *Map showing the location of the cored borehole KFM01A and adjacent percussion boreholes and monitoring wells in the soil layer at drillsite 1 at Forsmark.*

2 OBJECTIVES

The purpose of the analysis of the pumping test during difference flow logging was to estimate the transmissivity of the entire borehole. This value may then be compared with the estimated cumulative transmissivity of the measured sections and flow anomalies from the difference flow logging.

3 SCOPE

3.1 Borehole

Generalised technical data for borehole KFM01A are shown in Table 3-1. More detailed data are available from SICADA. The reference point in the borehole is top of casing (ToC). The reference coordinate system is RT90-RHB70. The bearing of the borehole is towards north. The starting point coordinates (at ToC) of the borehole are:

Northing (m): 6699529.813

Easting (m): 1631397.160

Table 3-1. Generalized technical data of cored borehole KFM01A. (From SICADA).

Borehole KFM01A							
ID	Elevation of top of casing (ToC) (m.a.s.l.)	Borehole interval from ToC (m)	Casing/ Bh-diam. (m)	Inclination-top of bh (from horizontal plane) (º)	Dip-direction-top of borehole (from local N) (º)	Remarks	Drilling finished Date (YYYY-MM-DD)
KFM01A	3.125	0.0-100.43	0.200	-84.734	318.352	Casing ID	
”		100.43-101.99	0.080			Casing ID	
”		102.13-1001.45	0.076			Open hole	2002-10-28

3.2 Tests performed

The registration of the recovery of the groundwater level and the flow rate during the flow period were performed according to the Activity Plan, cf above and the methodology description for difference flow logging (SKB MD 322.010, Version 1.0). Pertinent data of the pumping test during the difference flow logging in borehole KFM01A are shown in Table 3-2.

Table 3-2. Pertinent data of the pumping test with constant drawdown during difference flow logging in borehole KFM01A.

Pumping Bh ID	Pumped section (open hole) (m)	Test type[1]	Test no	Test start date and time (YYYY-MM-DD tt:mm:ss)	Test stop date and time (YYYY-MM-DD tt:mm:ss)
KFM01A	100.52-1001.45	1B	1	2002-11-23 17:20:00	2002-11-30 06:17:26

1) 1B: Pumping test with submersible pump

3.3 Equipment check

An equipment check was performed at the site as a simple and fast test to establish the operating status of sensors and other equipment. In addition, calibration constants were implemented and checked.

4 EQUIPMENT

4.1 Description of equipment

The pumping test was carried out with the standard equipment in the Posiva difference flow logging system including the following parts:

- submersible pump and hose to the ground surface
- winch and steel wire
- flow rate control valve at the surface
- vessel in the borehole to maintain a constant water level
- pressure transducer in the borehole
- data logger
- logging computer

4.2 Sensors

Technical specifications of the pressure transducer used for registration of the groundwater level in the borehole during the pumping test in conjunction with the difference flow logging are listed in Table 4-1.

Table 4-1. Technical specification of the superficial pressure transducer used for registration of the groundwater level in the borehole. FS=Full Scale.

Technical specification				
Parameter	**Name**	**Unit**	**Value/range**	**Comments**
Pressure (groundwater level)	Output signal Meas. Range Resolution Accuracy	mV kPa kPa kPa	0 – 100 10 – 200 0.1 <±5% of FS	

Table 4-2 illustrates the position of the pressure sensor and other borehole equipment during the pumping test. The position of the pressure sensor (P) together with the (lower) level of the submersible pump (Pump) is shown. Positions are given in metres from top of casing (ToC). Equipment affecting wellbore storage is given in terms of diameter of the submerged parts. Position is given as "in section" or "above section". The volume of the submerged pump (~a few dm^3) is in most cases of minor importance.

Table 4-2. Position along the borehole (from ToC) of sensors and equipment affecting wellbore storage in the pumping borehole KFM01A during the pumping test in conjunction with difference flow logging.

Borehole information			Sensors		Equipment affecting wellbore storage (WBS)		
ID	**Test section (m)**	**Test no**	**Type**	**Position (m b. ToC)**	**Position***	**Function**	**Outer diameter (mm)**
KFM01A	102.13-1001.45	1	Pump vessel (upper level) P (P1)	15.92 16.71	In open borehole	Pump hose Signal cable Pump cable wire	18 5 3x13 5

* Position of equipment that can affect wellbore storage. Position given as "In Section" or "Above Test section".

5 EXECUTION

5.1 Performance of the test

5.1.1 Test principle

The pumping test during difference flow logging in KFM01A was carried out as a single-hole constant drawdown test followed by a pressure recovery period in the open borehole.

5.1.2 Test procedure

The flow rate was adjusted to obtain a suitable constant drawdown (c 10 m) in the borehole by returning a certain flow back into the borehole by the control valve. The flow rate was discharged at the ground surface sloping downhill from the pumping borehole. The flow rate was measured manually by a stop watch and vessel.

The flow period during the difference flow logging campaign was c 5 d, followed by a recovery period of c 1.5 d. The sampling frequency of pressure in the pumping borehole was according to Table 5-1.

Table 5-1. Sampling frequency for pressure registration in the pumping borehole KFM01A during the recovery period.

Time interval (s) from stop of pumping	Sampling frequency (s)
1-c 900	1
c 900-c 43000	30
c 43000-132600	60

5.2 Data handling

A list of the data files of pressure versus time from the recovery phase from the data logger is shown in Sub-appendix 7:1. Files in mio-format, to be further processed by the program PUMPKONV, were created through macro-editing the original logger file in the text editor UltraEdit.

The *.mio-file with pressure versus time data was converted to recovery files by the code PUMPKONV and plotted in selected diagrams by the code SKB-plot in accordance with the Method Instruction SKB MD 320.004, Version 1.0 (Instruktion för analys av injektions- och enhålspumptester.) In addition, log-log and lin-log diagrams were prepared from the data file of the manually registered flow rate data versus time.

By the conversion to recovery files, different values were applied on the filter coefficient (step length) by the calculation of the pressure recovery derivative to study the effect of this coefficient on the derivative. It is desired to achieve maximal smoothing of the derivative without altering the original shape of the data. No derivative was calculated from the flow period due to the limited manual readings.

5.3 Analyses and interpretation

Firstly, a qualitative evaluation was performed of the actual flow regimes during the recovery period (e.g. wellbore storage, pseudo-linear, pseudo-radial and pseudo-spherical flow) and possible outer boundary conditions. The qualitative analysis was made from the transient recovery response in the log-log diagram together with the corresponding pressure derivative versus time. Since the draw-down was constant during the flow period, the recovery was plotted versus real time after stop of pumping (instead of equivalent time).

Quantitative, transient interpretation of hydraulic parameters (transmissivity, skin factor and wellbore storage coefficient from the pumping borehole) is primarily based on the identified pseudo-radial flow regime, if occurring, in log-log and lin-log data diagrams according to methods described in /1/ and in the instruction above for tests in an equivalent porous medium. For tests indicating a wellbore storage dominated response, relevant type curves are used by the analysis. Estimation of the borehole storage coefficient, in constant flow rate- and recovery tests, is based on the early borehole response with 1:1 slope.

Analysis of the flow period for constant drawdown tests can be made according to e.g. the Jacob and Lohman method described in /1/. In addition, a steady-state analysis (Moye's formula) is generally made from the flow period.

6 RESULTS

6.1 Nomenclature and symbols

The nomenclature and symbols used for the results of the pumping test are according to SKB MD 320.004. Additional symbols used are explained in the text.

6.2 Pumping test in KFM01A

General test data from the pumping borehole KFM01A are presented in Table 6-1. No corrections of the measured data, e.g. for variations in barometric pressure, precipitation etc, were made prior to the evaluation of the test. For single-hole tests, such corrections are generally not needed, unless very small draw-downs are applied in the borehole.

Since no data from observation boreholes were available, a value on the storativity must be assumed by the calculation of the skin factor. In this case the value $S^*=5\cdot10^{-5}$, obtained from interference tests between HFM01 and HFM02, was used. The results of the pumping tests in KFM01A are presented in Section 6.3. Test diagrams are displayed in Sub-appendix 7:2.

Table 6-1. General test data from the pumping borehole KFM01A.

General test data			
Testtype[1]	Constant Drawdown and recovery test		
Test section (open borehole/packed-off section):	open borehole		
Test No	1		
Field crew	P. Rouhiainen and P. Heikkinen, PRG Tec-Oy		
Test equipment system	Posiva difference flow logging system		
General comment	Single hole test		
	Nomen-clature	**Unit**	**Value**
Borehole length	L	m	1001.45
Casing length	L_c	m	101.99
Test section- secup	Secup	m	102.13
Test section- seclow	Seclow	m	1001.45
Test section length	L_w	m	899.32
Test section diameter	$2\cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm	021123 17:20
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	021123 17:20:00
Stop of flow period		yymmdd hh:mm:ss	021128 19:14:30
Test stop (stop of pressure registration)		yymmdd hh:mm	021130 06:17:26
Total flow time	t_p	min	7090
Total recovery time	t_F	min	2210

Groundwater level data

Groundwater level data in pumping borehole KFM01A	**Nomen-clature**	**Unit**	**Value (m.a.s.l)**
Level in borehole before start of flow period	h_i	m	-1.17
Level in borehole before stop of flow period	h_p	m	-12.75
Level in borehole at stop of recovery period	h_F	m	-6.41
Maximal drawdown in borehole during flow period	s_p	m	11.58

Manual water level measurements in pumping borehole KFM01A				
Date YYYY-MM-DD	**Time tt:mm.ss**	**Time (min)**	**GW level (m b. ToC)**	**GW level (m a s l)**
2002-11-23	17:25:00	5	16.29	-13.10

Flow data

Flow data in pumping borehole KFM01A	Nomen-clature	Unit	Value
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$2.92 \cdot 10^{-6}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	
Total volume discharged during flow period	V_p	m^3	

Manual flow measurements			Flow rate
Date YYYY-MM-DD	**Time tt:mm.ss**	**Time (min)**	**(L/min)**
2002-11-24	07:40:00	860	0.200
2002-11-24	17:00:00	1420	0.190
2002-11-25	08:50:00	2370	0.192
2002-11-25	15:40:00	2780	0.190
2002-11-26	10:00:00	3880	0.180
2002-11-27	14:40:00	5600	0.172
2002-11-28	09:20:00	6720	0.175

Interpreted flow regimes

Selected test diagrams according to the Instruction for analysis of single-hole injection- and pumping tests are presented in Sub-appendix 7:2. Due to the low-conductive borehole conditions, wellbore storage effects (WBS) dominated the entire response in the (open) pumping borehole during the recovery period. This fact is manifested by the 1:1 slope in the log-log diagram in Figure 7:2-3. After this slope, a transition period started, but no pseudo-radial flow regime developed within the time of the recovery period.

Interpreted parameters

An approximate quantitative interpretation by type curve analysis was made of the recovery period due to wellbore storage effects as shown in Figure 7:2-3 in Sub-appendix 7:2. The results are shown in the tables below.

In addition, analysis was also made on the flow period in the semi-logarithmic diagram (Figure 7:2-2) according to the methods described in section 5-3, assuming approximate pseudo-radial flow.

6.3 Summary of test data

Data from the pumping test in conjunction with difference flow logging in borehole KFM01A are summarized in Table 6-2. The calculated hydraulic parameters together with the estimated measurement limits are presented in Table 6-3 and in the Test Summary Sheets below.

Table 6-2. Summary of test data of the single-hole pumping test during the difference flow logging in the open borehole KFM01A .

Borehole ID	Interval (m)	Test type[1)]	h_i (m a s l)	h_p (m a s l)	h_F (m a s l)	Q_p (m^3/s)
KFM01A	102.13-1001.45	1B	-1.17	-12.75	-6.41	$2.92 \cdot 10^{-6}$

[1)] 1B: Pumping test-submersible pump

Table 6-3. Summary of calculated hydraulic parameters from the pumping test in borehole KFM01A in conjunction with difference flow logging.

Borehole ID	Interval (m)	Q/s (m^2/s)	T_M (m^2/s)	T (m^2/s)	S* (-)	C (m^3/Pa)	ζ (-)	Q/s-L (m^2/s)	Q/s-U (m^2/s)
KFM01A	102.13-1001.45	$2.52 \cdot 10^{-7}$	$4.16 \cdot 10^{-7}$	$3.06 \cdot 10^{-7}$	$5 \cdot 10^{-5}$	$2.97 \cdot 10^{-6}$	0.15	$2 \cdot 10^{-8}$	$2 \cdot 10^{-3}$

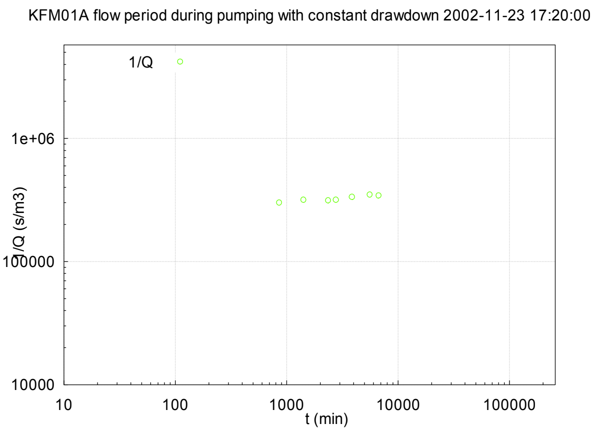
Q/s= specific flow
T_M= steady-state transmissivity from Moye´s formula
T = calculated transmissivity from transient evaluation of the test
C = wellbore storage coefficient
ζ = skin factor

Q/s-L=lower measurement limit for specific flow for the test system used
Q/s-U=upper measurement limit for specific flow for the test system used

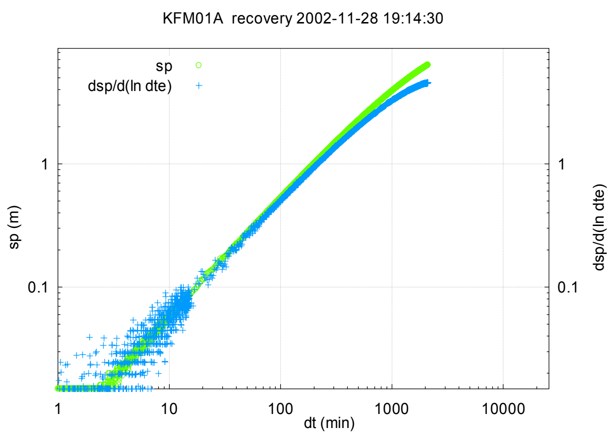
Test Summary Sheet – Pumping borehole KFM01A

Project:	PLU	Test type:	1B
Area:	Forsmark	Test no:	1
Borehole ID:	KFM01A	Test start:	2002-11-23 17:20
Test section (m):	102.13-1001.45	Responsible for test performance:	P. Rouhiainen, PRG-Tec Oy
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB J-E Ludvigson

Log-Log plot incl. derivative- flow period



Log-Log plot incl. derivative- recovery period



Flow period		**Recovery period**	
Indata		**Indata**	
h_0 (m a sl)	-1.17		
h_i (m a sl)	-1.17		
h_p (m a sl)	-12.75	h_F (m a sl)	-6.41
Q_p (m^3/s)	$2.92 \cdot 10^{-6}$		
tp (min)	7090	t_F (min)	2210
S^*	$5 \cdot 10^{-5}$	S^*	$5 \cdot 10^{-5}$
EC_w (mS/m)	-		
Te_w(gr C)	-		
Derivative fact.	-	Derivative fact.	0.1
Results		**Results**	
Q/s (m^2/s)	$2.52 \cdot 10^{-7}$		
T_{Moye}(m^2/s)	$4.16 \cdot 10^{-7}$		
Flow regime:	(PRF)	Flow regime:	WBS
t_1 (min)	860	dt_1 (min)	3
t_2 (min)	7090	dt_2 (min)	2210
T_w (m^2/s)	$3.06 \cdot 10^{-7}$	T_w (m^2/s)	$3.31 \cdot 10^{-7}$
S_w (-)	-	S_w (-)	-
K_{sw} (m/s)	-	K_{sw} (m/s)	-
S_{sw} (1/m)	-	S_{sw} (1/m)	-
C (m^3/Pa)	-	C (m^3/Pa)	$2.97 \cdot 10^{-6}$
C_D (-)	-	C_D (-)	-
ξ (-)	0.15	ξ (-)	0.10
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Interpreted formation and well parameters.

Flow regime:	(PRF)	C (m^3/Pa)	$2.97 \cdot 10^{-6}$
t_1 (min)	860	C_D (-)	-
t_2 (min)	7090	ξ (-)	0.15
T_T (m^2/s)	$3.06 \cdot 10^{-7}$		
S (-)	-		
K_s (m/s)	-		
S_s (1/m)	-		

Comments: Wellbore storage dominated flow during the recovery period.

7 REFERENCES

/1/ **Almén K-E , Andersson J-E, Carlsson L, Hansson K, Larsson N-Å, 1986.**

Hydraulic testing in crystalline rock. A comparative study of single-hole test methods. Technical Report 86-27, Svensk Kärnbränslehantering AB.

8 SUB-APPENDICES

Sub-appendix 7:1: Test data files

Sub-appendix 7:2: Test diagrams

Sub-appendix 7:3: Data table to the SICADA data base

SUB-APPENDIX 7:1 – TEST DATA FILES

Bh ID	Test section (m)	Test type[1]	Test start Date, time YYYY-MM-DD tt:mm:ss	Test stop Date, time YYYY-MM-DD tt:mm:ss	Datafile, start Date, time YYYY-MM-DD tt:mm:ss	Datafile, stop Date, time YYYY-MM-DD tt:mm:ss	Data files of raw and primary data	Parameters[2]	Comments
KFM01A	100.52 - 1001.45	1B	2002-11-28 19:14:30	2002-11-30 06:17:26	2002-11-28 18:52:39	2002-11-30 06:17:26	FOF01AGL16R010D104.csv	P	Recovery period

1: 1B: Pumping test-submersible pump

SUB-APPENDIX 7:2 TEST DIAGRAMS

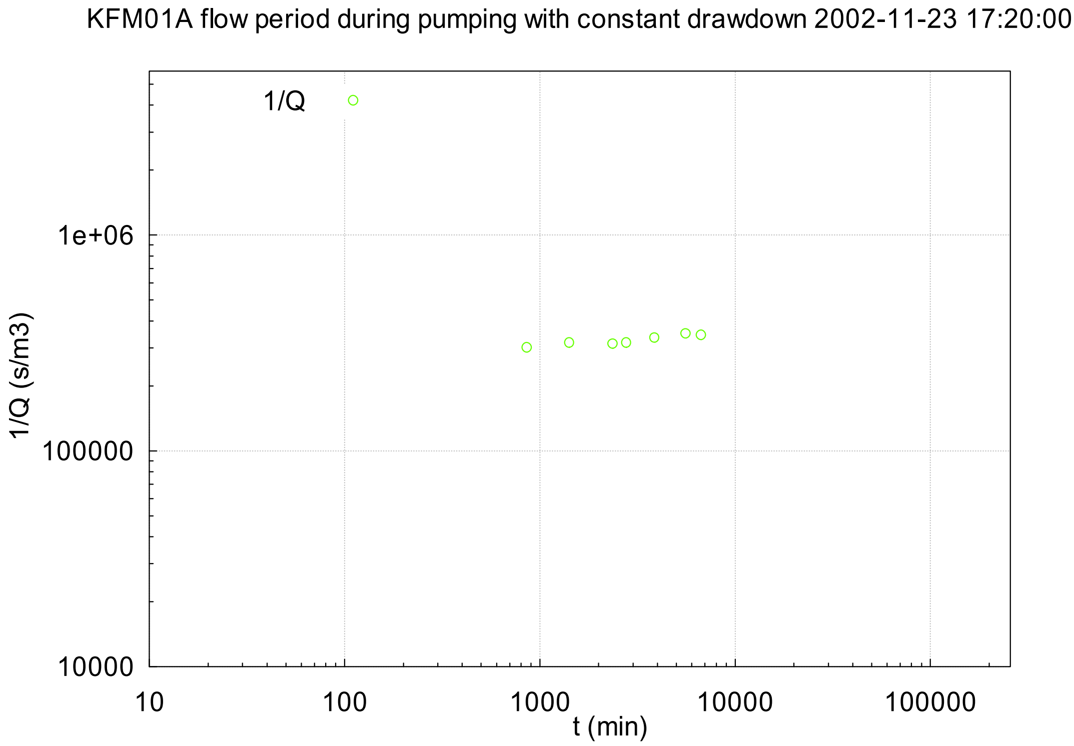


Fig 7:2-1. Log-log plot of reciprocal flow rate (1/Q) versus time (t) during constant drawdown test in borehole KFM01A during difference flow logging.

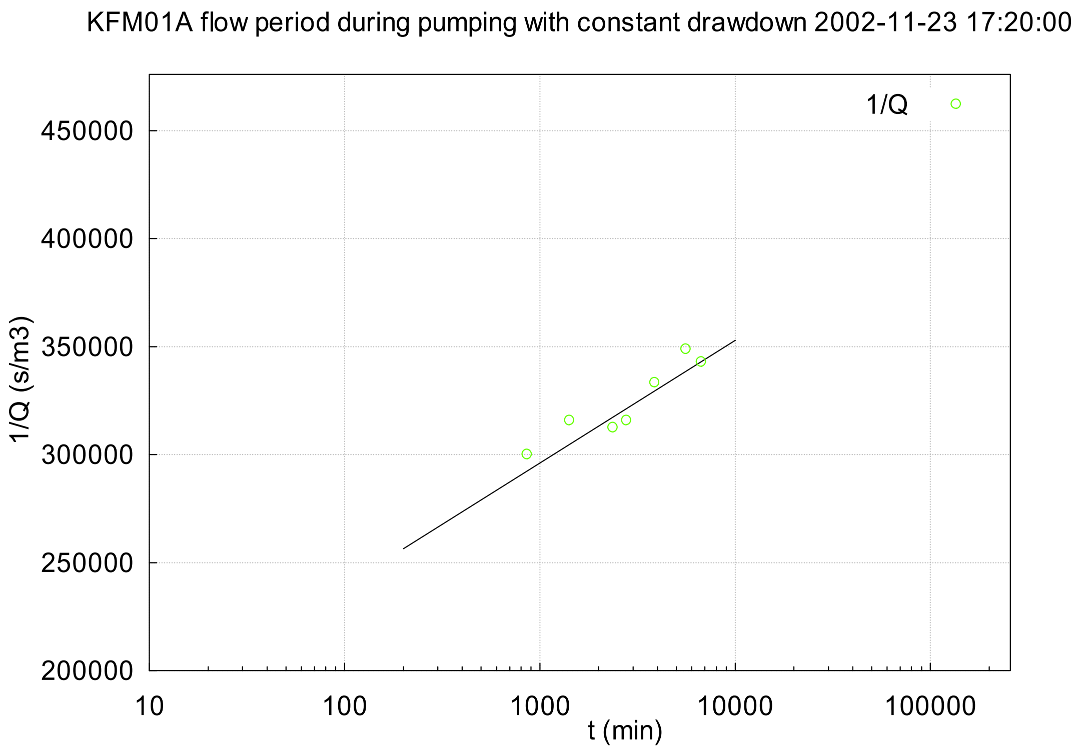


Fig 7:2-2. Lin-log plot of reciprocal flow rate (1/Q) versus time (t) during constant drawdown test in borehole KFM01A during difference flow logging.

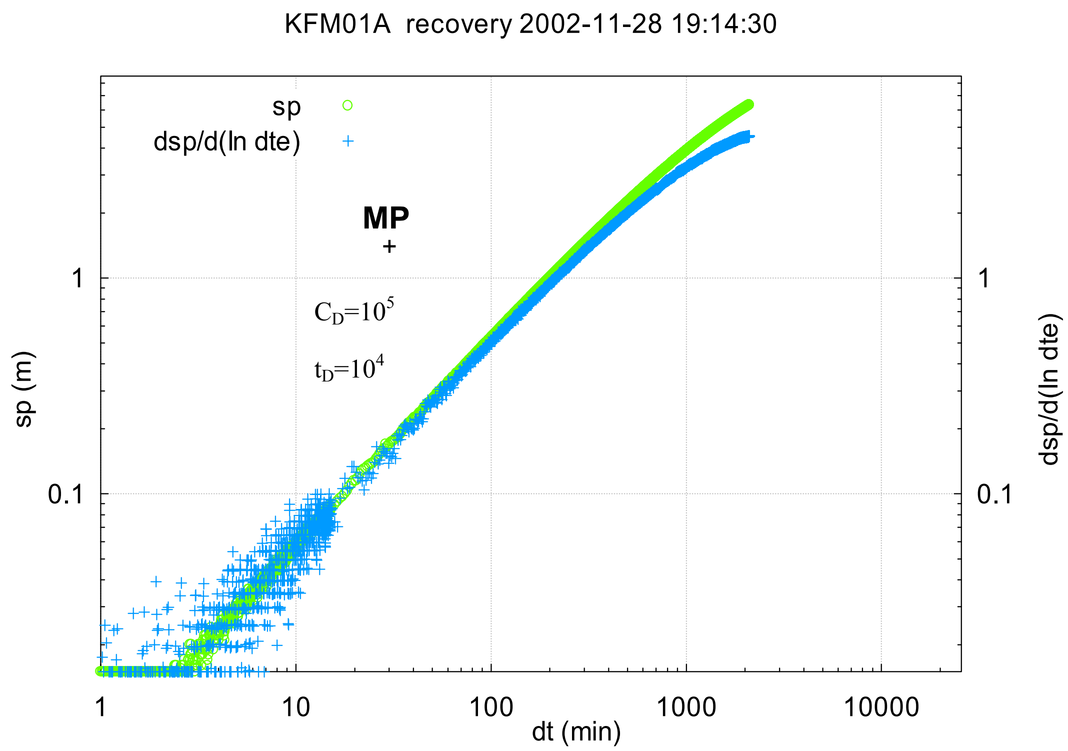


Fig 7:2-3. Log-log plot of pressure recovery (sp) and - derivative, dsp/d(ln dte), versus time (dt) in borehole KFM01A during difference flow logging.

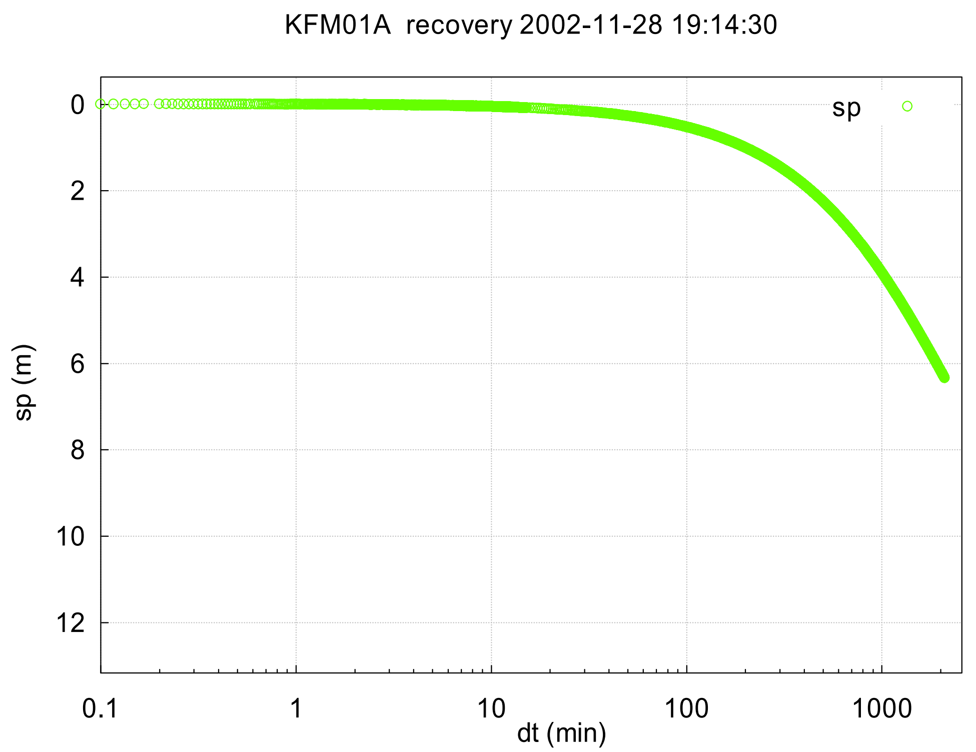


Fig 7:2-4. Lin-log plot of pressure recovery (sp) versus time (dt) in borehole KFM01A during difference flow logging.

SUB-APPENDIX 7:3 RESULT TABLES TO SICADA

Result Table for Single hole tests in borehole KFM01A during difference flow logging at Forsmark for submission to Sicada

SINGLEHOLE TESTS, Pumping and injection, s_hole_test_d; General information

Borehole	Borehole secup (m)	Borehole seclow (m)	Test type (1-7)	Formation type (-)	Date and time for test, start YYYYMMDD hh:mm	Date and time for test, stop YYYYMMDD hh:mm	Date and time of flow/ injection, start YYYYMMDD hh:mm:ss	Date and time of flow/ injection, stop YYYYMMDD hh:mm:ss	Q_p (m**3/s)	Q-measl-L (m**3)/s	Q-measl-U (m**3)/s	V_p (m**3)	Q_m (m**3/s)
KFM01A	102.13	1001.45	1B	1	2002-11-23 17:20	2002-11-28 19:30	20021123 17:20:00	20021128 19:15:00	2.92E-06				

cont.

V_p (m**3)	Q_m (m**3/s)	tp (s)	t_F (s)	h_i (m a sl)	h_p (m a sl)	h_F (m a sl)	p_i (kPa)	p_p (kPa)	p_F (kPa)	Te_w (°C)	EC_w (mS/m)	TDS_w (mg/ L)	TDS_{wm} (mg/ L)	Reference	Comments (-)
		425400	132600	-1.17	-12.75	-6.41								P-03-37	Constant drawdown

SINGLEHOLE TESTS, Pumping and injection, s_hole_test_ed1; Basic evaluation

Borehole	Borehole secup (m)	Borehole seclow (m)	Date and time for test, start YYYYMMDD hh:mm	Q/s (m^2/ s)	T_Q (m^2/ s)	T_M (m^2/ s)	b (m)	B (m)	TB (1D) (m^3/ s)	TB-measl-L (1D) (m^3/ s)	TB-measl-U (1D) (m^3/ s)	SB (1D) (m)	SB* (1D) (m)	L_f (1D) (m)	T_T (2D) (m^2/ s)	Q/s-measl-L (m^2/ s)	Q/s-measl-U (m^2/ s)	S (2D) (-)	S* (2D) (-)
KFM01A	102.13	1001.45	20021123 17:20	2.52E-07		4.16E-07	901.02								3.06E-07	2.00E-08	2.00E-03		5.00E-05

cont.

K´/b´ (2D) (1/s)	K_S (3D) (m/s)	K_S-measl-L (3D) (m/s)	K_S-measl-U (3D) (m/s)	S_S (3D) (1/m)	S_S* (3D) (1/m)	L_p (m)	C (m**3/Pa)	C_D (-)	ξ (2D) (-)	ω (-)	λ (-)	t_1 (s)	t_2 (s)	Comments (-)
							2.97E-06		0.15			51600	403200	WBS

Header	Unit	Explanation
Borehole		ID for borehole
Borehole secup	m	Length coordinate along the borehole for the upper limit of the test section
Borehole seclow	m	Length coordinate along the borehole for the lower limit of the test section
Test type (1- 7)	(-)	1A: Pumping test - wireline eq., 1B:Pumping test-submersible pump, 1C: Pumpingtest-airlift pumping, 2: Interference test, 3: Injection test, 4: Slug test, 5A: Difference flow logging-PFL-DIFF-sequential, 5B: Difference flow logging-PFL-DIFF-overlapping, 6:Flow logging_Impeller,7:Grain size analysis
Date for test start		Date for the start of the pumping or injection test (YYYYMMDD hh:mm)
Start flow / injection		Date and time for the start of the pumping or injection period (YYMMDD hh:mm:ss)
Start flow / injection		Date and time for the end of the pumping or injection period (YYMMDD hh:mm:ss)
Q_m	m^3/s	Arithmetic mean flow rate of the pumping/injection period.
Q_p	m^3/s	Flow rate at the end of the pumping/injection period.
Value type	-	Code for Q_p-value; -1 means Q_p<lower measurement limit, 0 means measured value, 1 means Q_p> upper measurement value of flowrate
Q-measl_L	m^3/s	Estimated lower measurement limit for flow rate
Q-measl_U	m^3/s	Estimated upper measurement limit for flow rate
V_p	m^3	Total volume pumped (positive) or injected (negative) water during the flow period.
t_p	s	Time for the flowing phase of the test
t_F	s	Time for the recovery phase of the test
h_i	m	Initial formation hydraulic head. Measured as water level in open stand pipes from borehole section with reference level in the local coordinates system with z=0 m.
h_p	m	Final hydraulic head at the end of the pumping/injection period. Measured as water level in open stand pipes from borehole section with reference level in the local coordinates system with z=0 m.
h_F	m	Final hydraulic head at the end of the recovery period. Measured as water level in open stand pipes from borehole section with reference level in the local coordinates system with z=0 m.
p_i	kPa	Initial formation pressure.
p_p	kPa	Final pressure at the end of the pumping/injection period.
p_F	kPa	Final pressure at the end of the recovery period.
Te_w	gr C	Fluid temperature in the test section representative for the evaluated parameters
EC_w	mS/m	Electrical conductivity of the fluid in the test section representative for the evaluated parameters
TDS_w	mg/L	Total salinity of the fluid in formation at test section based on EC.
TDS_{wn}	mg/L	Total salinity of the fluid in formation at test section based on water sampling and chemical analysis.
Sec.type,	(-)	Test section (pumping or injection) is labeled 1 and all observation sections are labeled 2
Q/s	m2/s	Specific capacity, based on Qp and s=abs(pi-pp). Only given for test section (label 1) in interference test.
T_Q	m2/s	Transmissivity based on specific capacity and a a function for T=f(Q/s). The fuction used should be refered in "Comments"
T_M	m2/s	Transmissivity based on Moye (1967)
b	m	Interpreted formation thickness representative for evaluated T ot TB.
B	m	Interpreted witdth of a formation with evaluated TB
TB	m3/s	1D model for evaluation of formation properties. T=transmissivity, B=width of formation
TB-measl-L	m2/s	Estimated measurement limit for evaluated TB. If estimated TB equals TB-measlim in the table actual TB is considered to be equal or less than TB-measlim
TB-measl-L	m2/s	Estimated measurement limit for evaluated TB. If estimated TB equals TB-measlim in the table actual TB is considered to be equal or greater than TB-measlim
SB	m	1D model for evaluation of formation properties. S= Storativity, B=width of formation
SB*	m	1D model for evaluation of formation properties. Assumed SB. S= Storativity, B=width of formation

L_f	m	1D model for evaluation of Leakage factor
T_T	m2/s	2D model for evaluation of formation properties. T=transmissivity
T-measl-L	m2/s	Estimated measurement limit for evaluated T (TT, TQ, TM). If estimated T equals T-measlim in the table actual T is considered to be equal or less than T-measlim
T-measl-U	m2/s	Estimated measurement limit for evaluated T (TT, TQ, TM). If estimated T equals T-measlim in the table actual T is considered to be equal or grater than T-measlim
S	(-)	2D model for evaluation of formation properties. S= Storativity
S*	(-)	2D model for evaluation of formation properties. Assumed S. S= Storativity
K´/b´	(1/s)	2D model for evaluation of leakage coefficient. K´= hydraulic conductivity in direction of leaking flow for the aquitard, b´= Saturated thickness of aquitard (leaking formation)
K_S	m/s	3D model for evaluation of formation properties. K=Hydraulic conductivity
K_S-measl-L	m/s	Estimated measurement limit for evaluated KS. If estimated KS equals KS-measlim in the table actual KS is considered to be equal or less than KS-measlim
K_S-measl-U	m/s	Estimated measurement limit for evaluated KS. If estimated KS equals KS-measlim in the table actual KS is considered to be equal or greater than KS-measlim
S_S	1/m	3D model for evaluation of formation properties. Ss=Specific Storage
S_S*	1/m	3D model for evaluation of formation properties. Assumed Ss. Ss=Specific Storage
L_p	m	Hydraulic point of appication, based on hydraulic conductivity distribution (if available) or the midpoint of the borehole test section
C	(m3/Pa)	Wellbore storage coefficient
C_D	(-)	Dimensionless wellbore storage coefficient
ξ	(-)	Skin factor
ω	(-)	Storativity ratio
λ	(-)	Interporosity flow coefficient
dt_1	s	Estimated start time after pump/injection start OR recovery start, for the period used for the evaluated parameter
dt_2	s	Estimated stop time after pump/injection start OR recovery start, for the period used for the evaluated parameter
	m	Length coordinate along the borehole for the upper limit of the observation section
	m	Length coordinate along the borehole for the lower limit of the observation section
p_{ai}	kPa	Initial formation pressure of the observation section, which is located above the test section in the borehole
p_{ap}	kPa	Final pressure at the end of the pumping/injection period in the observation section, which is located above the test section in the borehole
p_{aF}	kPa	Final pressure at the end of the recovery period in the observation section, which is located above the test section in the borehole
p_{bi}	kPa	Initial formation pressure of the observation section, which is located below the test section in the borehole
p_{bp}	kPa	Final pressure at the end of the pumping/injection period in the observation section, which is located below the test section in the borehole
p_{bF}	kPa	Final pressure at the end of the recovery period in the observation section, which is located below the test section in the borehole
References		SKB report No for reports describing data and evaluation
Index w		Active borehole or borehole section