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Forsmark site investigation

Addendum to Difference flow logging in borehole KFM01A

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August, 2004

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Abstract

The difference flow logging in the core drilled borehole KFM01A at Forsmark was conducted during November 18–30, 2002. The results were presented in the SKB report R-03-28. Subsequently, some modifications and extensions of the evaluation and documentation of the results of the difference flow logging have currently been made for other boreholes. It was decided to update the report for KFM01A with these modifications and extensions which are described and presented in this addendum.

The main modifications and extensions by the documentation of difference flow logging made in subsequent boreholes are summarized below:

- interpretation of transmissivity instead of hydraulic conductivity for tested sections,
- evaluation of the practical, lower measurement limits for flow rate and transmissivity,
- estimation of errors in the location of interpreted conductive fractures along the borehole,
- use of Secup instead of midpoint of section in result tables and “length” instead of “depth” along the borehole.

Sammanfattning

Differensflödesloggningen i kärnborrhål KFM01A i Forsmark utfördes mellan 18–30 november 2002. Resultaten presenterades i SKB rapport R-03-28. Därefter har vissa modifieringar och tillägg gjorts löpande vid tolkningen och dokumenteringen av resultaten av differensflödes-loggning för andra borrhål. Det beslöts att uppdatera rapporten för KFM01A med dessa modifieringar och tillägg vilka beskrivs i detta addendum.

De huvudsakliga modifieringarna och tilläggen vid dokumentationen av differensflödes-loggningen som gjorts i senare borrhål sammanfattas nedan:

- tolkning av transmissivitet i stället för hydraulisk konduktivitet för testade sektioner,
- tolkning av de praktiska nedre mätgränserna för flöde och transmissivitet,
- skattning av fel i läget av tolkade konduktiva sprickor längs borrhålet,
- användning av Secup i stället för sektionens mittpunkt i resultattabeller och beteckningen ”längd” i stället för ”djup” längs borrhålet.

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1 Introduction

The difference flow logging in the core drilled borehole KFM01A at Forsmark was conducted during November 18–30, 2002. KFM01A was the first core drilled borehole in the Forsmark candidate area. The borehole is sub-vertical, c. 1,000 m and cased to c. 100 m. Below this depth, the borehole is core drilled with the diameter 76 mm. The location of borehole KFM01A at drilling site 1 within the Forsmark area is shown in Figure 1-1.

The field work and subsequent interpretation were conducted by PRG-Tec Oy according to Activity Plan AP PF 400-02-40 (SKB internal controlling document) referring the SKB Method Description 322.010, Version 1.0 (Method description for difference flow logging). The results of the difference flow logging in KFM01A are presented in /1/. Subsequently, some modifications and extensions of the evaluation and documentation of the results of the difference flow logging have currently been made for other boreholes. It was decided to update the report for KFM01A with these modifications which are described and presented in this addendum.

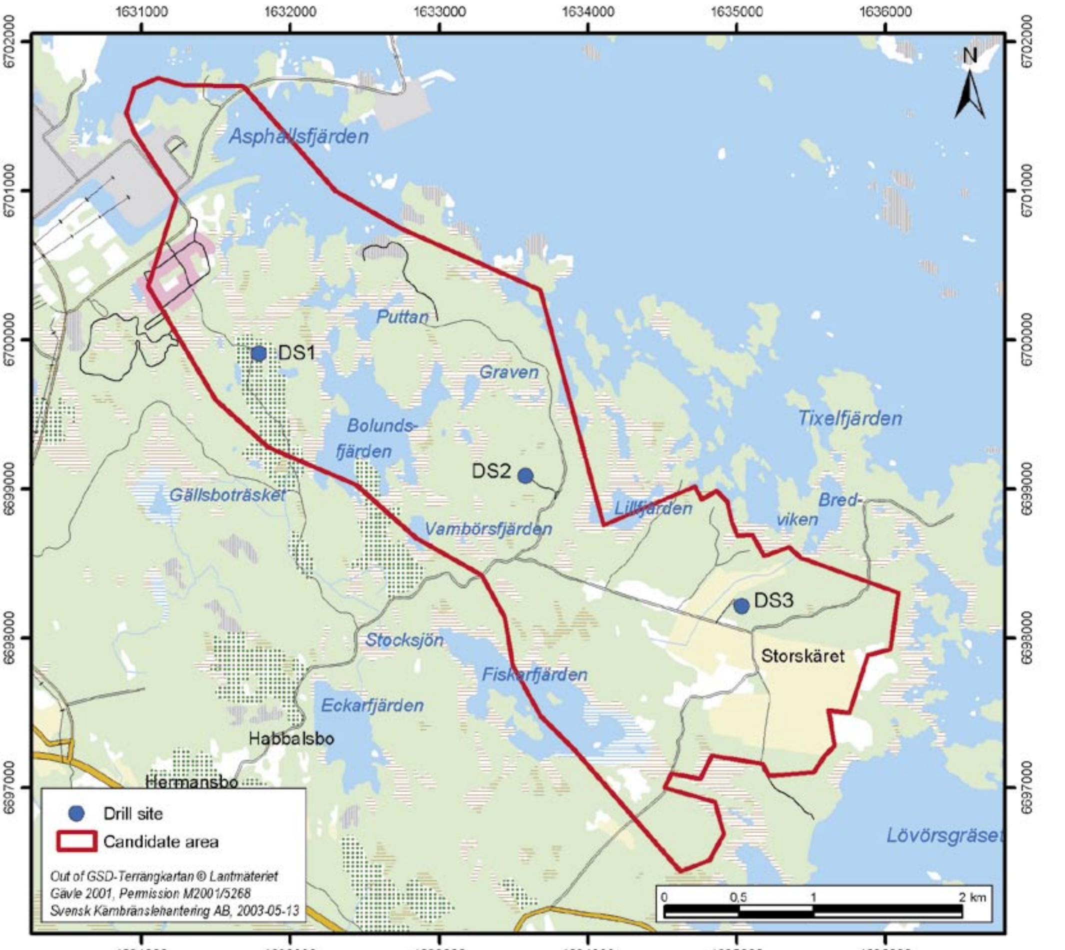

Figure 1-1. *The investigation area at Forsmark including the candidate area selected for more detailed investigations. The drilling sites for the earliest drilled deep cored boreholes are marked with blue dots. Borehole KFM01A is situated at drilling site DS1.*

The main modifications and extensions of the documentation of difference flow logging made in subsequent boreholes are summarized below:

- interpretation of transmissivity instead of hydraulic conductivity for tested sections,
- evaluation of the practical, lower measurement limits for flow rate and transmissivity,
- estimation of errors in the location of conductive fractures along the borehole,
- use of Secup instead of midpoint of section and “length” instead of “depth” along the borehole.

2 Objective and scope

The principles of measurement and interpretation of difference flow logging using the Posiva Flow Meter in borehole KFM01A are described in /1/. In the latter report, the hydraulic conductivity of the tested 5 m sections was interpreted from sequential difference flow logging. In addition, the transmissivity of the conductive fractures identified was interpreted from overlapping flow logging in 1 m sections using a step length of 0.1 m.

For the boreholes investigated subsequent to KFM01A, it was decided to calculate the transmissivity of the tested 5 m sections instead of the hydraulic conductivity, in order to allow a more direct comparison between the interpreted hydraulic properties of the test section. In this addendum, the transmissivity of the tested 5 m sections in KFM01A has been calculated and presented together with a comparison of the section transmissivities with the sum of fracture transmissivities in corresponding sections.

The theoretical lower measurement limits for flow rate in sequential and overlapping difference flow logging, respectively, valid under favourable test conditions in the borehole, are presented in /1/. Experiences from difference flow logging in several boreholes at Forsmark (KFM01A–5A) have shown that the actual borehole conditions are not favourable enough to achieve the theoretical measurements limits for flow rate. Therefore, the practical lower measurement limits for the actual borehole conditions have been estimated for the sequential flow logging in subsequent boreholes at Forsmark.

As a consequence of the increased practical lower limit for flow rate, the practical lower measurement limit for transmissivity also differs from the theoretical limit. Possible reasons to the discrepancy between the theoretical and practical measurement limits in sequential flow logging are discussed below. In this addendum, the estimated practical lower measurement limits for flow rate and transmissivity in KFM01A from the sequential flow logging are presented in tables and diagrams in the Appendices.

General estimations of the magnitude of possible errors in the location of identified conductive fractures along the borehole, accounting for potential sources of error by the length calibration, are discussed below.

In the following chapters, new additional text paragraphs associated with the above described modifications, used in the reports for subsequent boreholes, are presented. In Chapter 4, the revised results of the difference flow logging in KFM01A are presented and discussed. In this addendum, the structure of contents in the original report /1/ regarding the main chapters is maintained as much as possible, but only sections that have been revised are presented.

To make the list of appendices complete, all appendices are presented in the addendum. Appendices 1–2 are unchanged whereas Appendices 3–7 are revised.

3 Principles of measurements and interpretation

3.1 Interpretation

The interpretation is based on Thiems or Dupuits formula that describes a steady state and two dimensional radial flow into the borehole /2/:

$$h_s - h = Q / (T \cdot a) \qquad 3\text{-}1$$

where

h is hydraulic head in the vicinity of the borehole and $h = h_s$ at the radius of influence (R),

Q is the flow rate into the borehole,

T is the transmissivity of the test section,

a is a constant depending on the assumed flow geometry. For cylindrical flow, the constant a is:

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

where

r_0 is the radius of the well and

R is the radius of influence, i.e. the zone inside which the effect of the pumping is felt.

If flow rate measurements are carried out using two levels of hydraulic heads in the borehole, i.e. natural or pump-induced hydraulic heads, then the undisturbed (natural) hydraulic head and transmissivity of the tested borehole sections can be calculated. Two equations can be written directly from equation 3-1:

$$Q_{s1} = T_s \cdot a \cdot (h_s - h_1) \qquad 3\text{-}3$$

$$Q_{s2} = T_s \cdot a \cdot (h_s - h_2) \qquad 3\text{-}4$$

where

h_1 and h_2 are the hydraulic heads in the borehole at the test level,

Q_{s1} and Q_{s2} are the measured flow rates in the test section,

T_s is transmissivity of the test section and

h_s is the undisturbed hydraulic head of the tested zone far from the borehole.

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 its ends.

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

The hydraulic head and the test section transmissivity can be deduced from the two measurements:

$h_s = (h_1 – b \cdot h_2) / (1 – b)$ 3-5

$T_s = (1/a) (Q_{s1} – Q_{s2}) / (h_2 – h_1)$ 3-6

where

$b = Q_{s1}/Q_{s2}$

Transmissivity (T_f) and hydraulic head (h_f) of individual fractures can be calculated provided that the flow rates of individual fractures are known. Similar assumptions as above have to be used (a steady state cylindrical flow regime without skin zones).

$h_f = (h_1 – b\ h_2) / (1 – b)$ 3-7

$T_f = (1/a) (Q_{f1} – Q_{f2}) / (h_2 – h_1)$ 3-8

where

Q_{f1} and Q_{f2} are flow rates from a fracture and

h_f and T_f are the hydraulic head (far away from borehole) and the transmissivity of a fracture, respectively.

Since the actual flow geometry and the skin effects are unknown, transmissivity 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. A discussion of potential uncertainties in the calculation of transmissivity and hydraulic head is provided in /3/.

4 Results

4.1 Length calibration

4.1.1 Estimated error in location of detected fractures

In spite of the length correction described in /1/, there are still length errors due to the following reasons:

1. Point interval in flow measurements is 0.1 m in overlapping mode. This could cause an error of +/– 0.05 m.
2. The length of the test section is not exact. The specified section length denotes the distance between the nearest upper and lower rubber disks. Effectively, the section length can be larger. At the upper end of the test section there are four rubber disks. The distance between these is 5 cm. This will cause rounded flow anomalies. Flow may be detected already when a fracture is situated between the upper rubber disks. These phenomena, which can only be seen with a short step length (0.1 m), could cause an error of +/– 0.05 m.
3. Corrections between the length marks can be other than linear. This could cause an error of +/– 0.1 m in the caliper/SPR (Single Point Resistance) measurement.
4. SPR curves may be imperfectly synchronized. This could cause an error of +/– 0.1 m.

In the worst case, the errors of points 1, 2, 3 and 4 are summed up. Then the total estimated error between the length marks would be +/– 0.3 m.

Near the length marks the situation is slightly better. In the worst case, the errors of points 1, 2, and 4 are summed up. Then the total estimated error near the length marks would be +/– 0.2 m.

Accurate location is important when different measurements are compared, for instance if the flow logging and borehole TV are compared. In that case the situation may not be as severe as the worst case above, since part of the length errors is systematic and the length error is nearly constant in fractures near each other. However, the error of point 1 is of random type.

Fractures nearly parallel with the borehole may also be problematic. Fracture location may be difficult to accurately define in such cases.

4.2 Flow logging

4.2.1 Theoretical and practical measurements limits for flow and transmissivity

The theoretical lower measurement limit for flow rate in sequential flow logging (thermal pulse method) is about 6 mL/h. The theoretical minimum of measurable flow rate in the overlapping measurements (thermal dilution method only) is about 30 mL/h. The upper limit of flow measurement is 300 000 mL/h. These limits are determined on the basis of flow calibration. It is assumed that flow can be reliably detected between the upper and lower theoretical limits in favourable borehole conditions.

The minimum measurable flow rate may, however be much higher in practice, because the borehole conditions may have an influence on the base level of flow (noise level). The noise level, which may vary along the borehole can be evaluated for borehole intervals without any flowing fractures or other structures.

There are several known reasons for increased noise in flow:

1) Rough borehole wall.

2) Solid particles in water such as clay or drilling debris.

3) Gas bubbles in water.

4) High flow rate along the borehole.

Rough borehole walls always cause high noise, not only in flow but also in the single point resistance results. Flow curve and SPR curves are typically spiky when the borehole wall is rough.

Drilling debris usually increases the noise level. Typically this kind of noise is seen both without pumping and with pumping.

Pumping causes a pressure drop in the borehole water and in fracture water near the bore-hole. This may lead to release of gas from dissolved form to gas bubbles. Some fractures may produce more gas than others. Sometimes, an increased noise level is obtained just above certain conductive fractures (when the borehole is measured upwards). The reason is assumed to be gas bubbles. Bubbles may cause decrease of the average density of water and therefore also decrease of the measured head in the borehole.

The effect of a high flow rate along the borehole can often be seen above high-flowing fractures. Any minor leak at the lower rubber disks is directly measured as increased noise in flow.

A high noise level in flow rate masks a "real" flow, smaller than the noise. Real flows are totally invisible if they are about ten times smaller than the noise but are registered correctly if they are about ten times larger than the noise. By experience, real flows between 1/10 times the noise and 10 times the noise are summed up with the noise. Therefore, the noise level could be subtracted from the measured flow to get the real flow. This correction has not been done so far, because it is not clear whether it is applicable in each case.

The noise level in flow rate was not a serious problem in borehole KFM01A. The practical minimum level of flow rate in the sequential flow logging is evaluated and presented in Appendices 3.1–3.45 using a grey dashed line (Lower limit of flow rate). Below this line there may be fractures or structures that remain undetected. In addition, the fracture-specific flows for the identified conductive fractures, measured in the overlapping logging, are also shown.

The noise level in KFM01A during the sequential flow logging was estimated at 30 mL/h along the entire borehole, see Appendix 5.1. In several sections it fell below 30 mL/h. However, the noise level (grey dashed line) was never drawn below 30 mL/h. Flow anomalies smaller than 30 mL/h are marked with a short thin horizontal line indicating "uncertain" in Appendices 3.1–3.45 cf the longer and thicker line indication a certain flow anomaly.

The practical minimum of measurable flow rate in KFM01A is also presented in the tables in Appendix 4 (Q-lower limit Practical). It is taken from the plotted curve in Appendix 3 (Lower limit of flow rate). The practical minimum of measurable transmissivity was evaluated using Q-lower limit and the actual head difference at each measurement, see Appendix 4. The theoretical lower measurement limit for transmissivity was also evaluated using a Q-value of 6 mL/h (minimum theoretical flow rate with the thermal pulse method) instead of Q-lower limit Practical, see Appendix 4.

In some boreholes the upper limit of flow measurement (300 000 mL/h) may be exceeded. Such fractures or structures hardly remain undetected (as the fractures below the lower limit). High flowing fractures can be measured separately at smaller drawdown in the borehole. The upper measurement limit of transmissivity was evaluated using the maximum flow rate (300 000 mL/h) at the actual head difference as above, see Appendix 4 (T_s–Upper Limit).

All three flow measurement limits for sequential flow logging are plotted together with measured flow rates, see Appendix 5.1. The three transmissivity limits are also presented graphically, see Appendix 5.2.

The corresponding lower measurement limits for flow and transmissivity were not evaluated for the fracture-specific results from the overlapping flow logging, see Appendices 6.1–6.2. Approximately the same limits as for the sequential flow logging would possibly be valid also for these results. The limits for fracture-specific results are however more difficult to define. For instance, it may be difficult to detect a small flow rate close to (< 1 m) a high-flowing fracture. The situation is similar for the upper flow measurement limit. If there are several high-flowing fractures nearer each other than one metre, the upper flow measurement limit depends on the sum of flows which must be below 300 000 mL/h.

4.2.2 Transmissivity and hydraulic head of borehole sections

The revised results of the sequential measurements with a 5 m section length are presented in the tables in Appendices 4.1–4.6. The results are identical with the results presented in /1/ except the modifications and extensions discussed below. The upper limit of the sections (Secup) is used instead of the midpoints to the sections along the borehole (Depth) used in /1/. Secup is calculated as the distance along the borehole from the reference level (top of the casing tube) to the upper end of the test section. Secup1 refers to the flow measurements at natural, i.e. un-pumped conditions, and Secup2 to the measurements during pumping. They are not identical, due to a minor difference of the cable stretching between the two sequences.

In addition, the calculated transmissivity of the sections (T_s) is presented rather than the hydraulic conductivity together with the lower and upper measurement limits of flow and transmissivity, see Appendix 5.2.

4.2.3 Transmissivity and hydraulic head of fractures

The locations of the identified conductive fractures from the overlapping flow logging together with their transmissivity and hydraulic head are presented in the table in Appendix 6.1 and graphically in Appendix 6.2. The results are identical with the results presented in /1/ but only the hydraulic parameters based on the assumption of a saline water profile along the borehole are presented. This assumption is considered more realistic than the assumption of a freshwater profile along the borehole.

6 References

/1/ **Rouhiainen P, Pöllänen J, 2003.** Forsmark site investigation. Difference flow logging in borehole KFM01A. SKB P-03-28, Svensk Kärnbränslehantering AB.

/2/ **Marsily G, 1986.** Quantitative Hydrology, Groundwater Hydrology for Engineers. Academic Press, Inc., London.

/3/ **Ludvigson J-E, Hansson K, Rouhiainen P, 2002.** Methodology study of Posiva difference flow meter in borehole KLX02 at Laxemar. SKB R-01-52, Svensk Kärnbränslehantering AB.

Appendices

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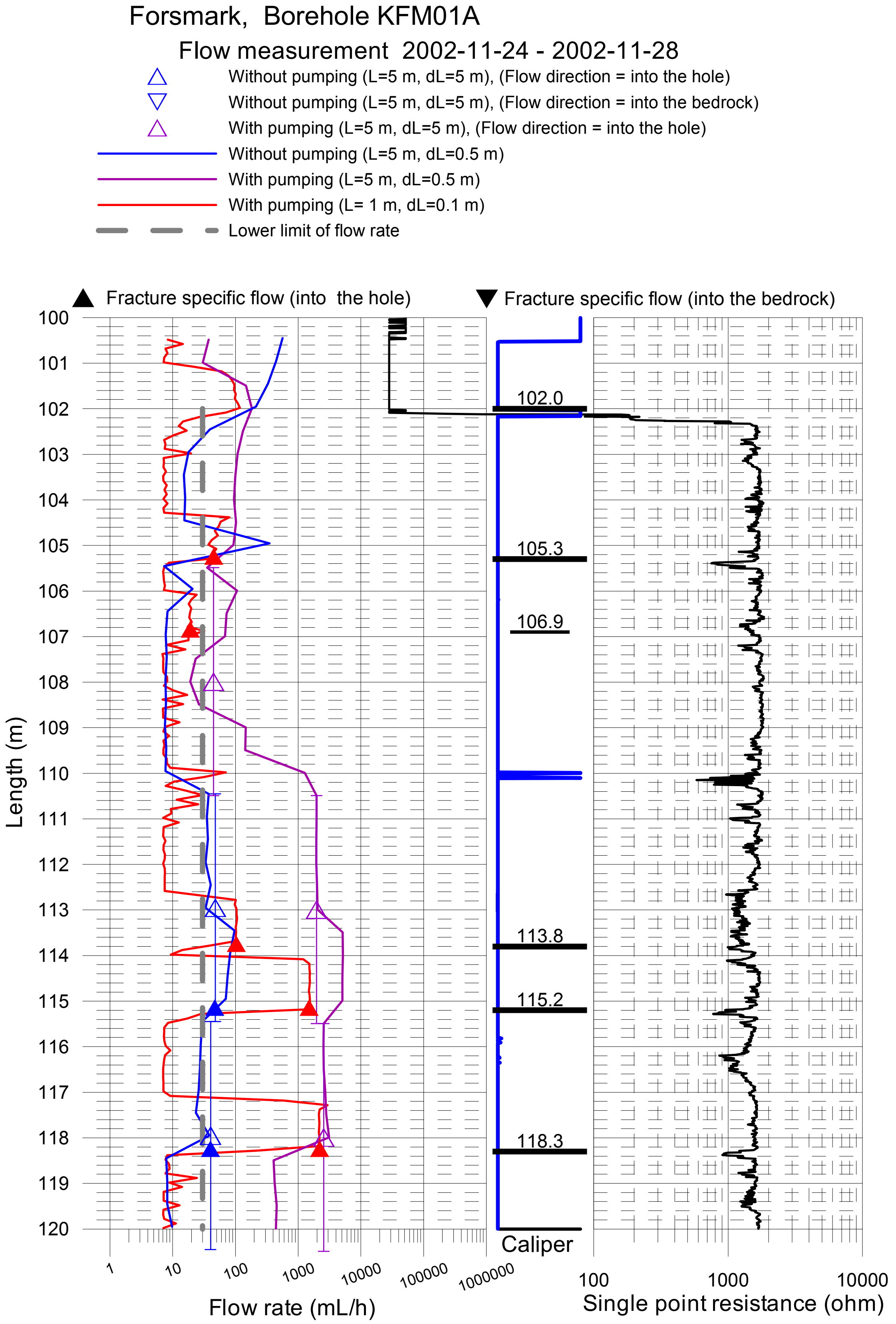
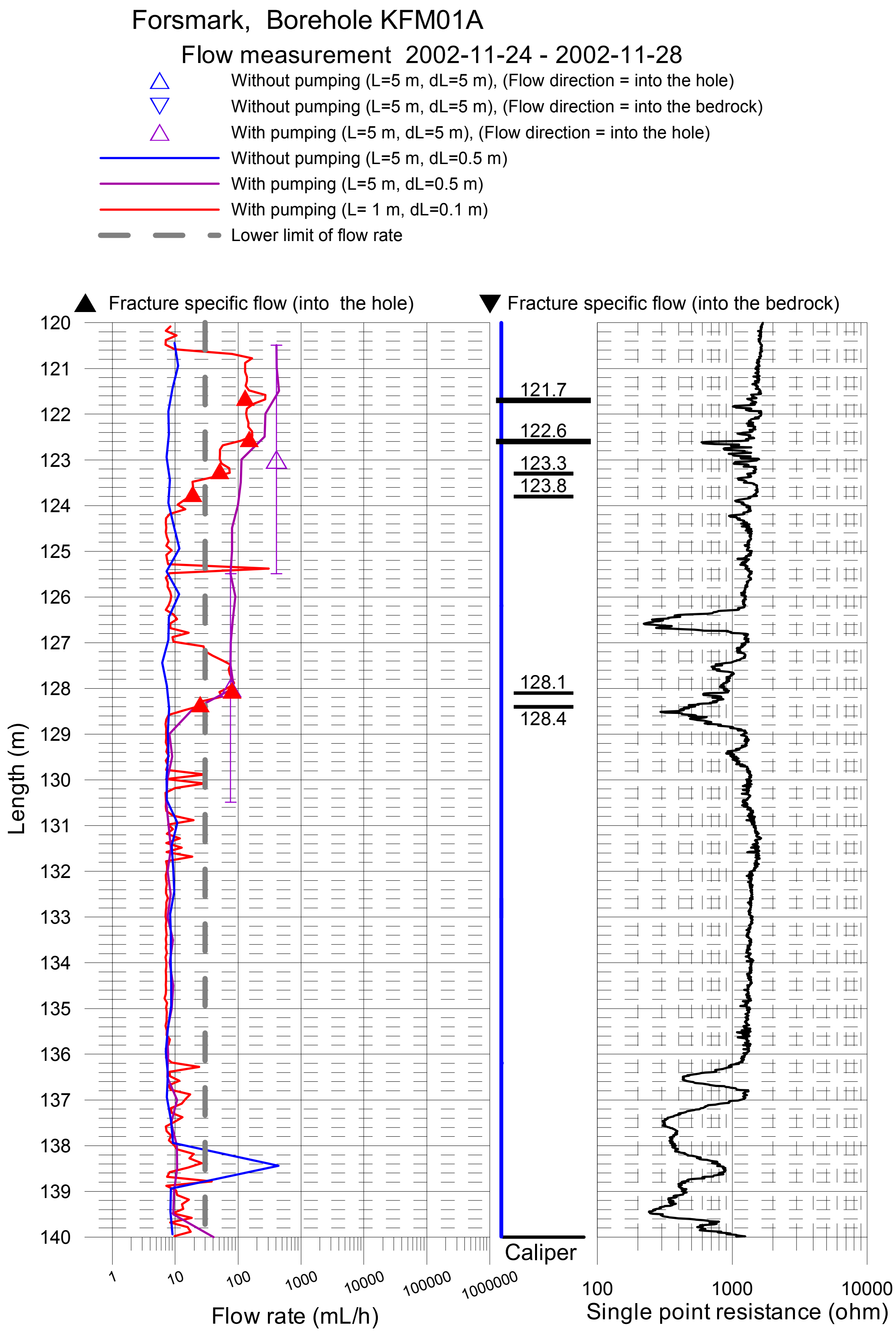
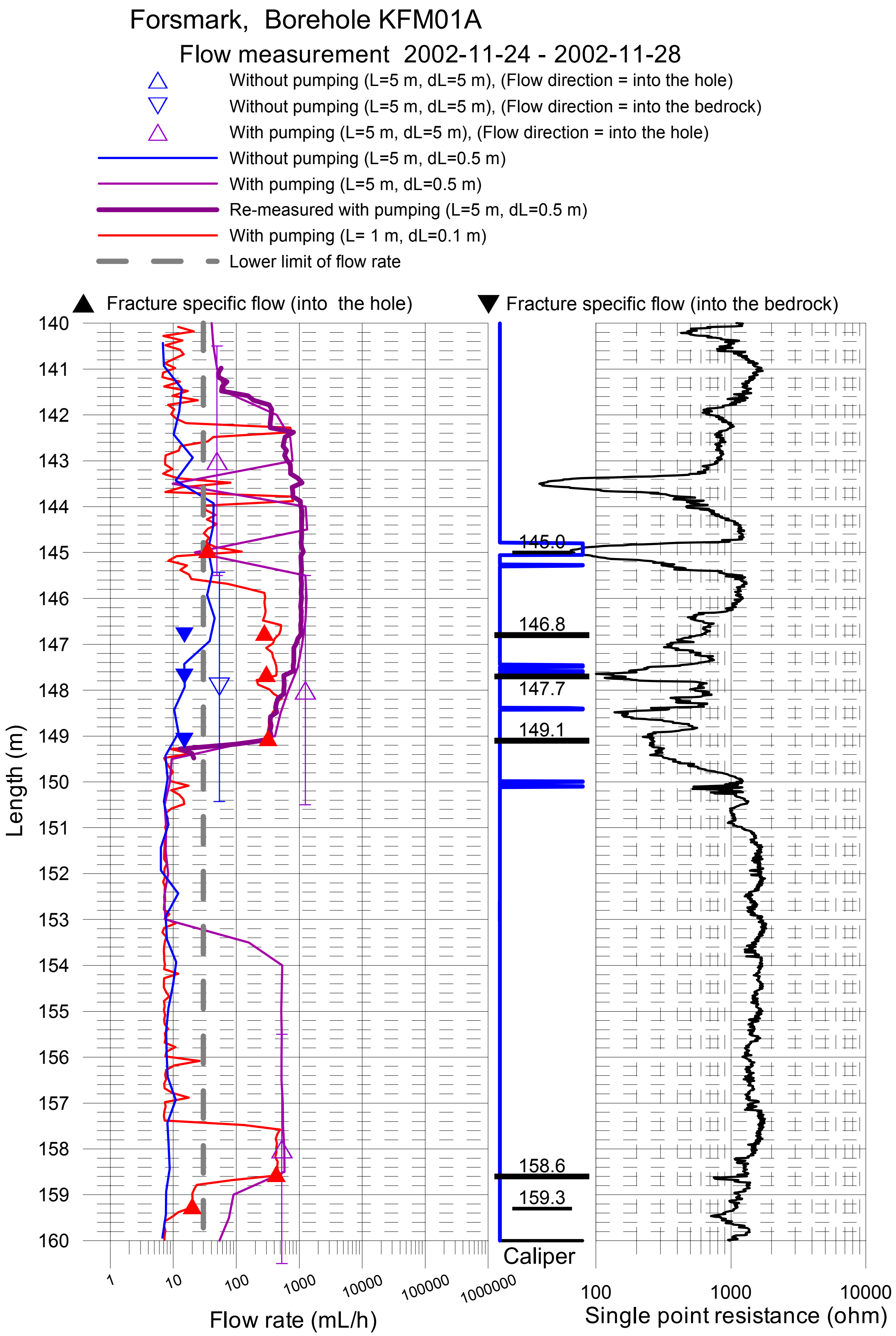

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 2002-11-28
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
102.0
105.3
106.9
113.8
115.2
118.3
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
100
1000
10000
Single point resistance (ohm)


Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 2002-11-28
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
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)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
121.7
122.6
123.3
123.8
128.1
128.4
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
100
1000
10000
Single point resistance (ohm)

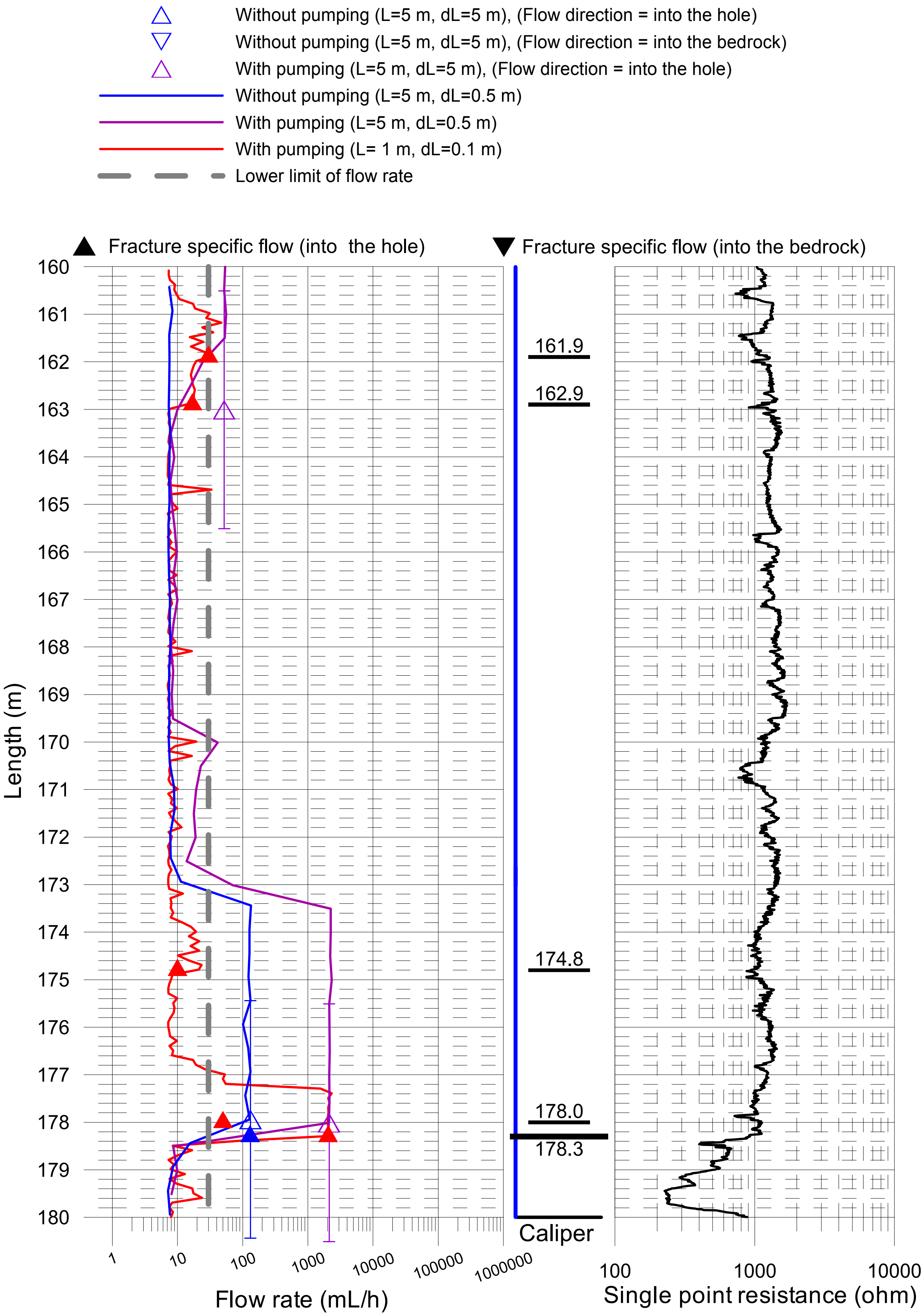
Appendix 3.3

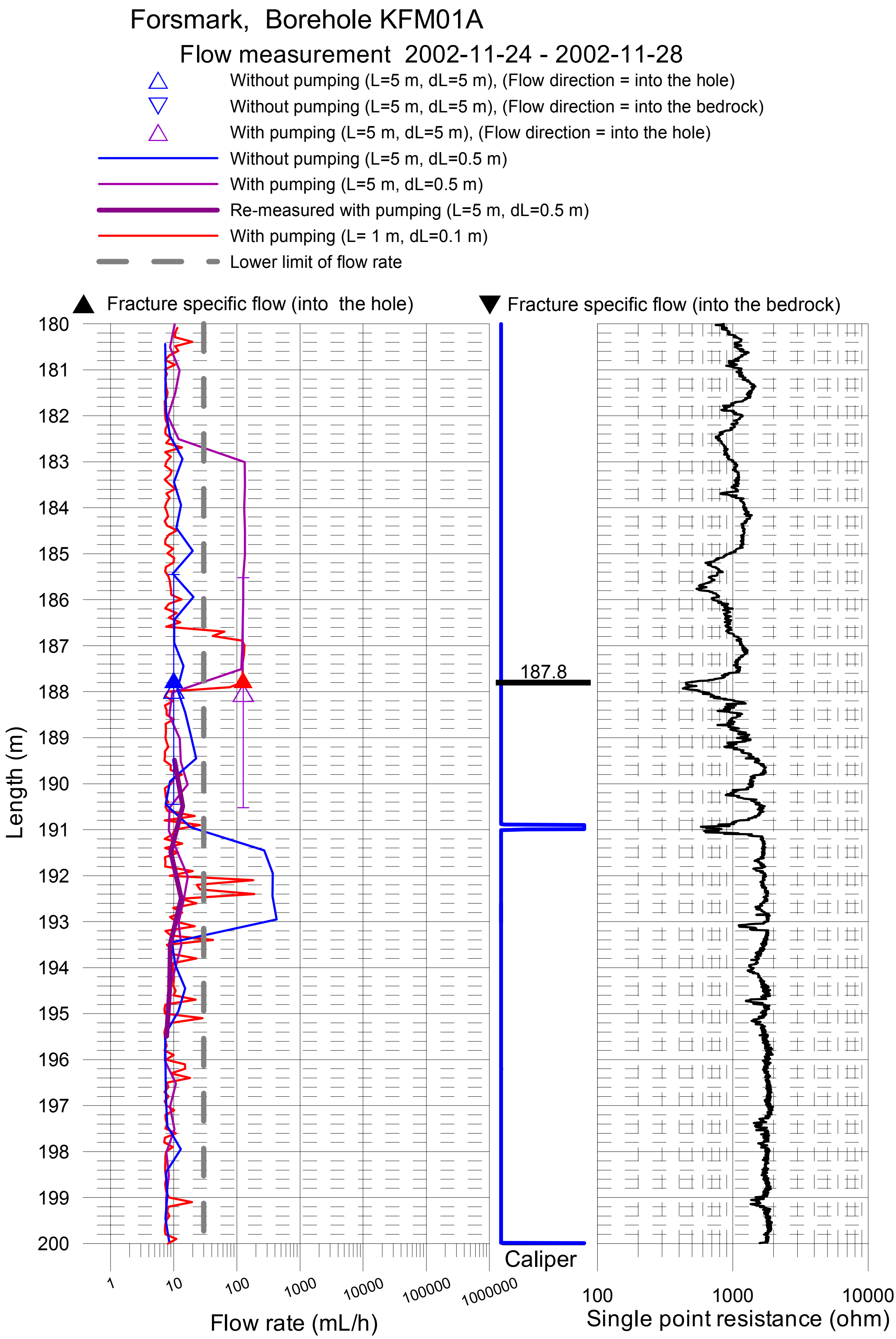


Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 2002-11-28
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Re-measured with pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
145.0
146.8
147.7
149.1
158.6
159.3
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
100
1000
10000
Single point resistance (ohm)

Forsmark, Borehole KFM01A

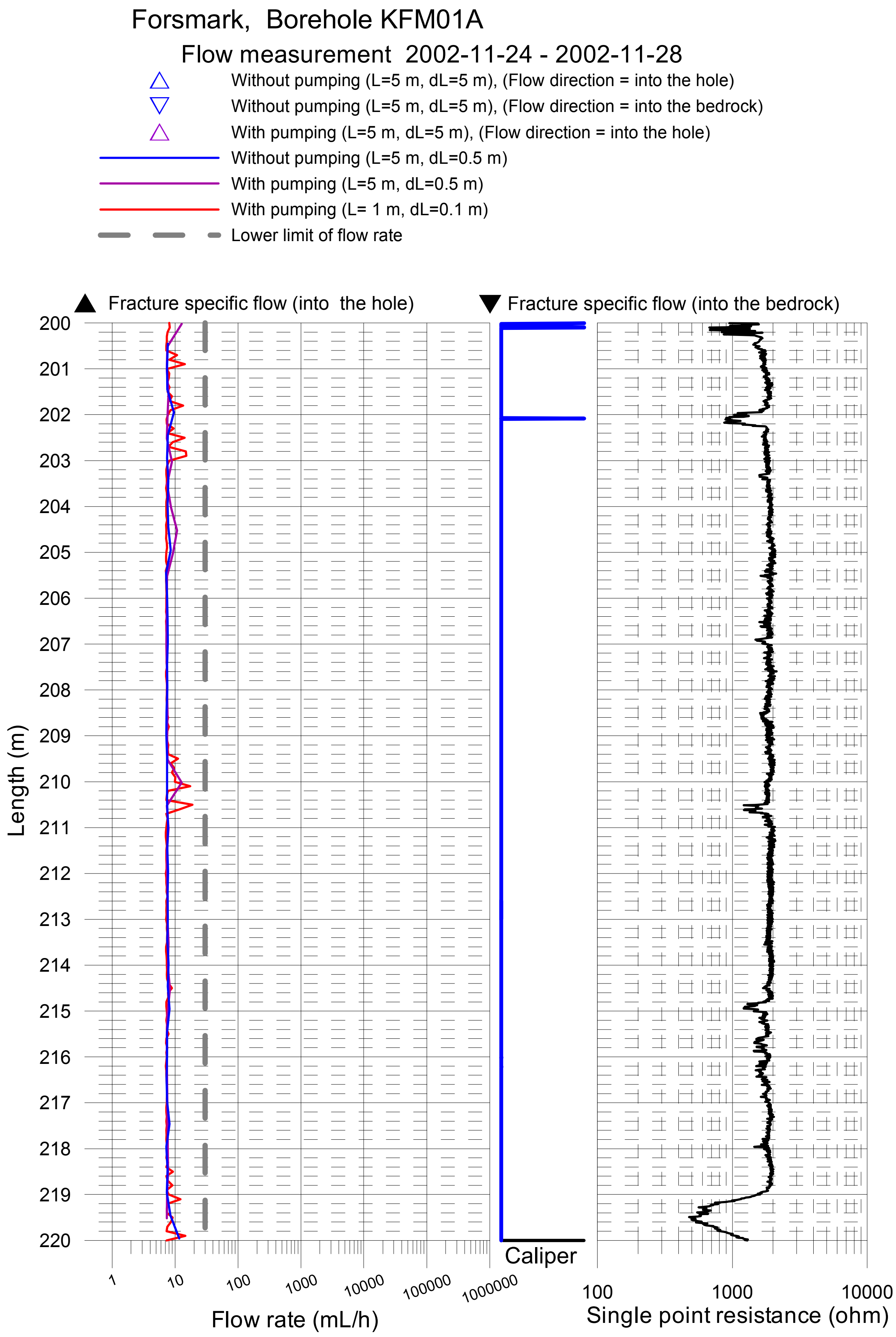
Flow measurement 2002-11-24 - 2002-11-28



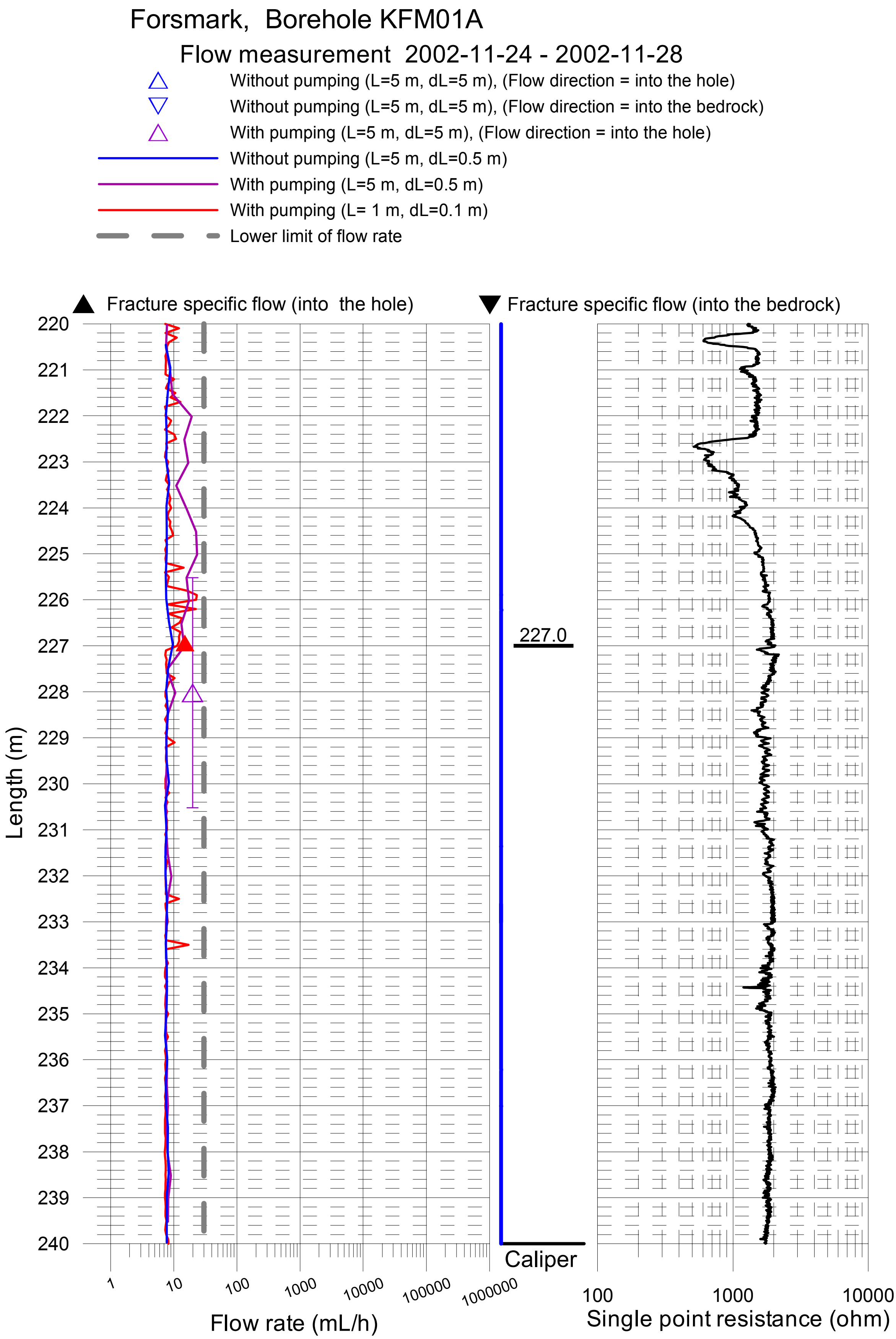


Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 2002-11-28
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Re-measured with pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
187.8
Caliper
100
1000
10000
Single point resistance (ohm)

Appendix 3.6



Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 2002-11-28
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
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)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
100
1000
10000
Single point resistance (ohm)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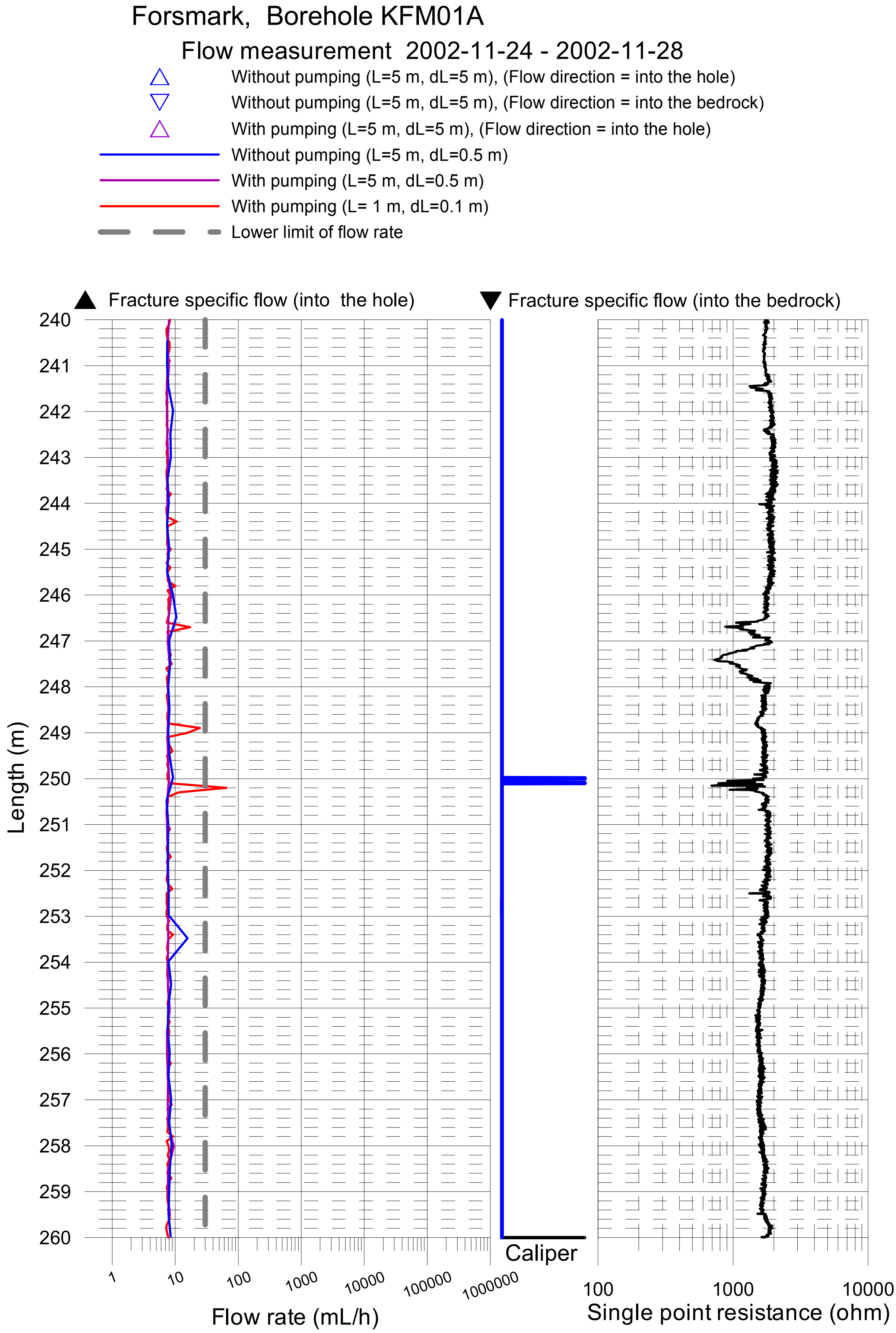
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
227.0
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
100
1000
10000
Single point resistance (ohm)

Appendix 3.8

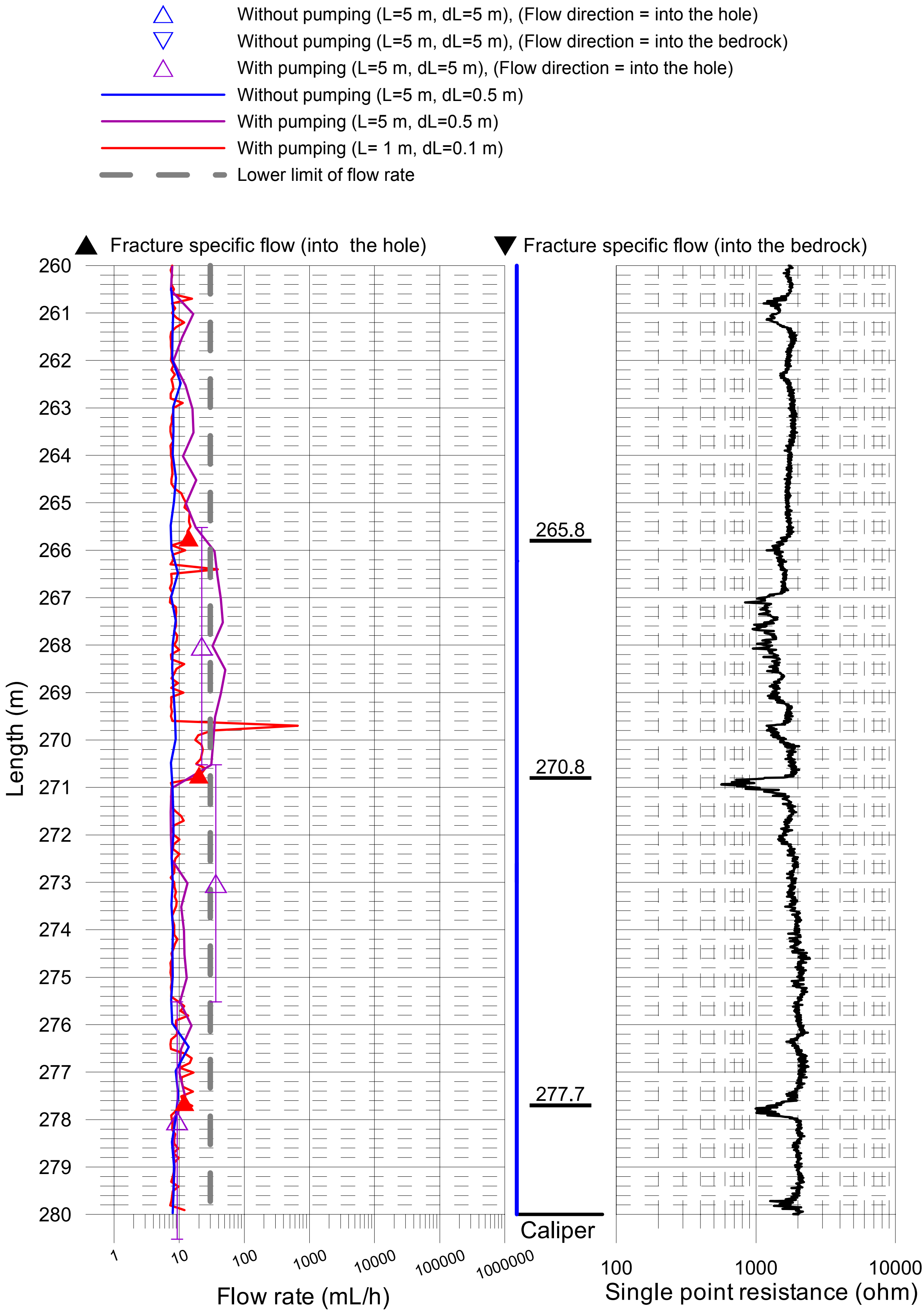


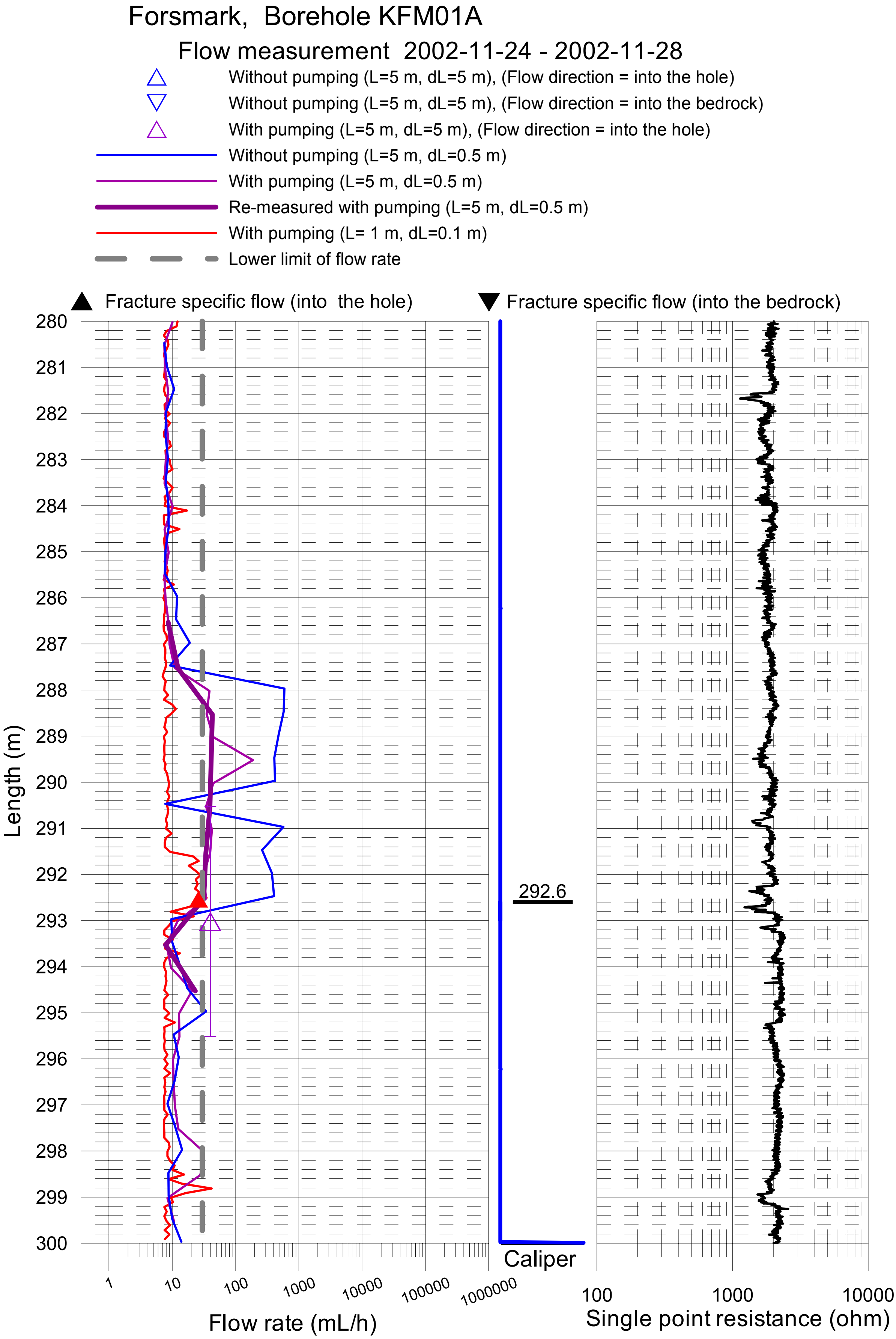
Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 2002-11-28
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (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
1000000
Flow rate (mL/h)
Caliper
100
1000
10000
Single point resistance (ohm)

Appendix 3.9

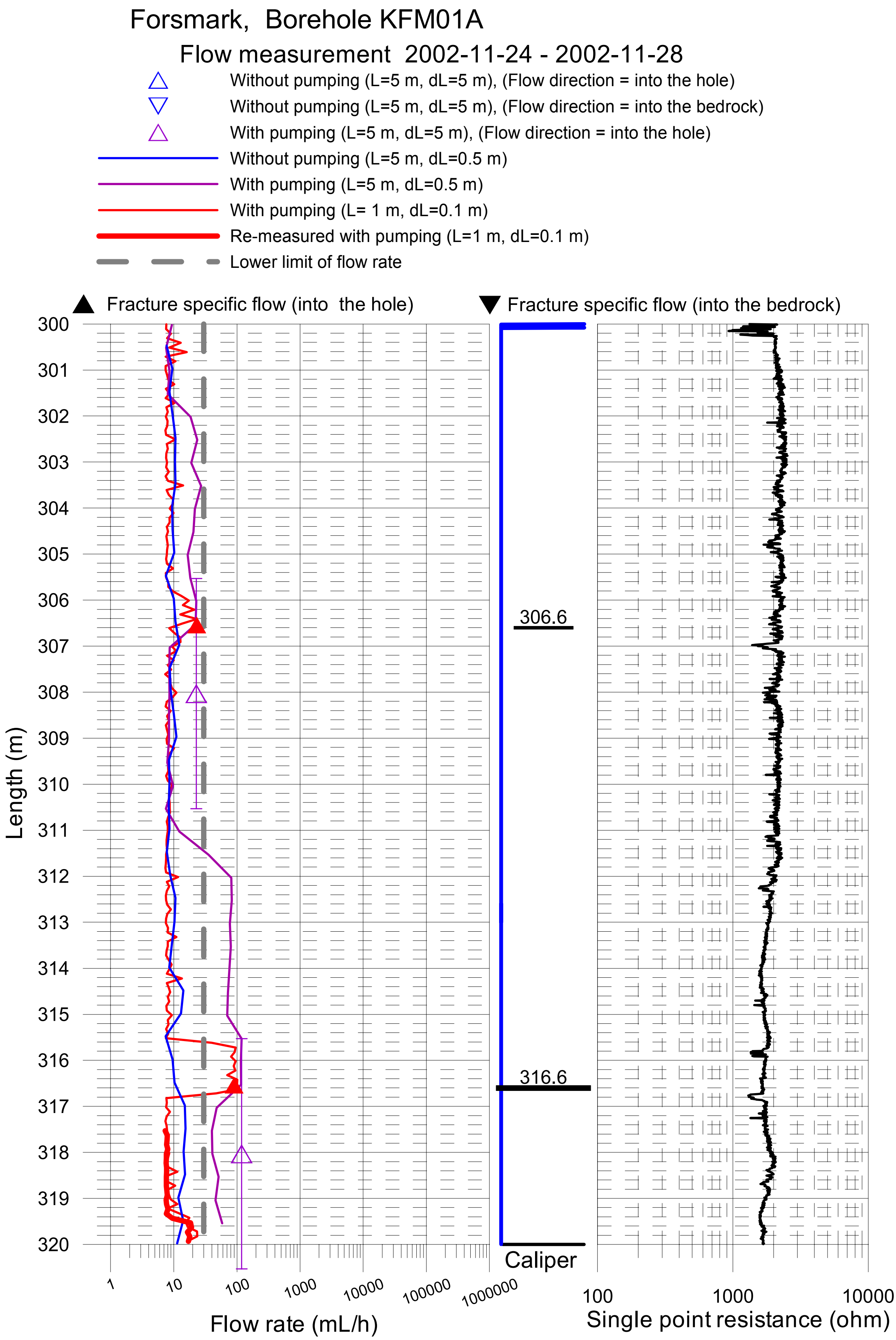
Forsmark, Borehole KFM01A

Flow measurement 2002-11-24 - 2002-11-28



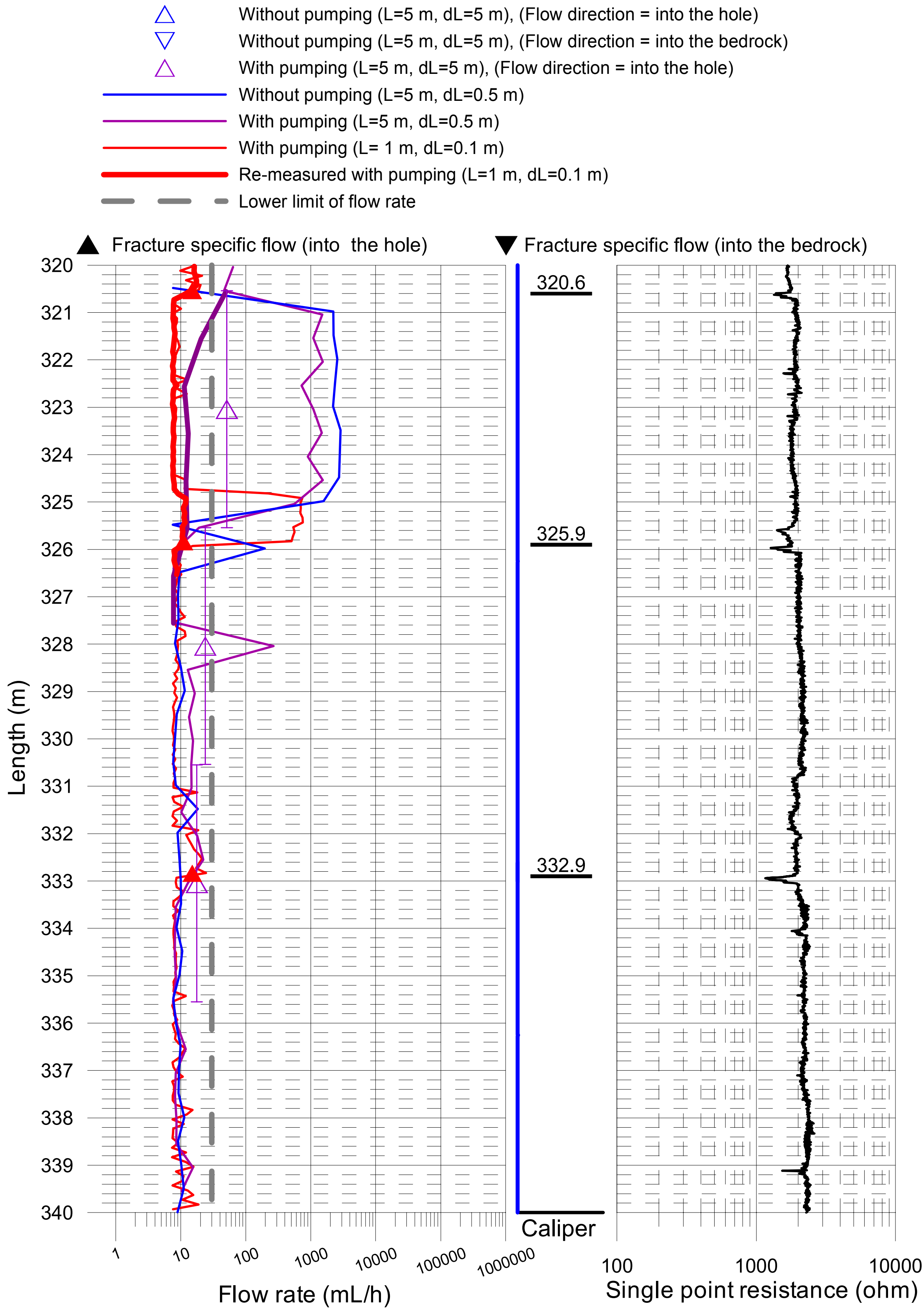

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 2002-11-28
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Re-measured with pumping (L=5 m, dL=0.5 m)
With pumping (L= 1 m, dL=0.1 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (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
1000000
Flow rate (mL/h)
100
1000
10000
Single point resistance (ohm)

Appendix 3.11



Forsmark, Borehole KFM01A

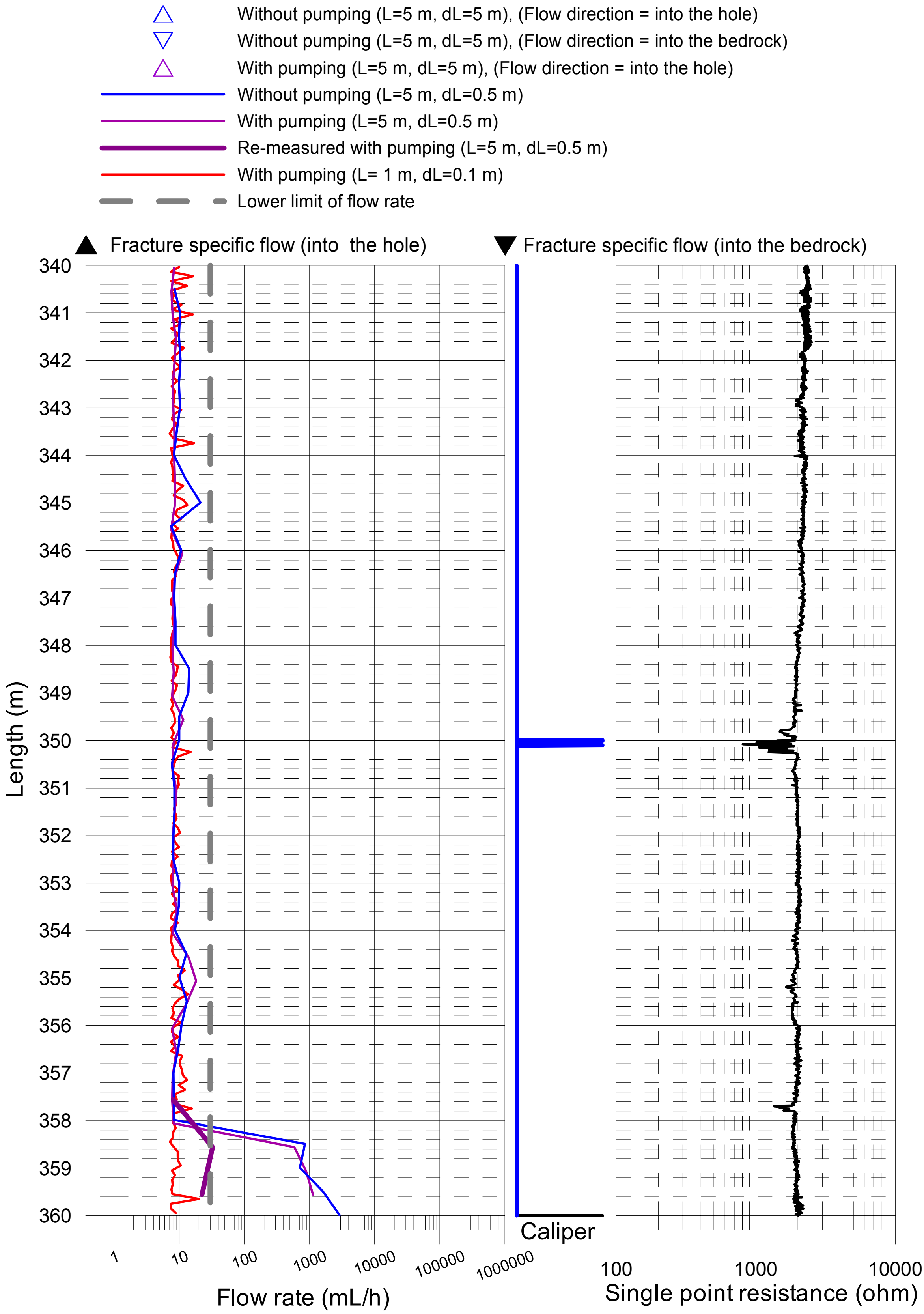
Flow measurement 2002-11-24 - 2002-11-28



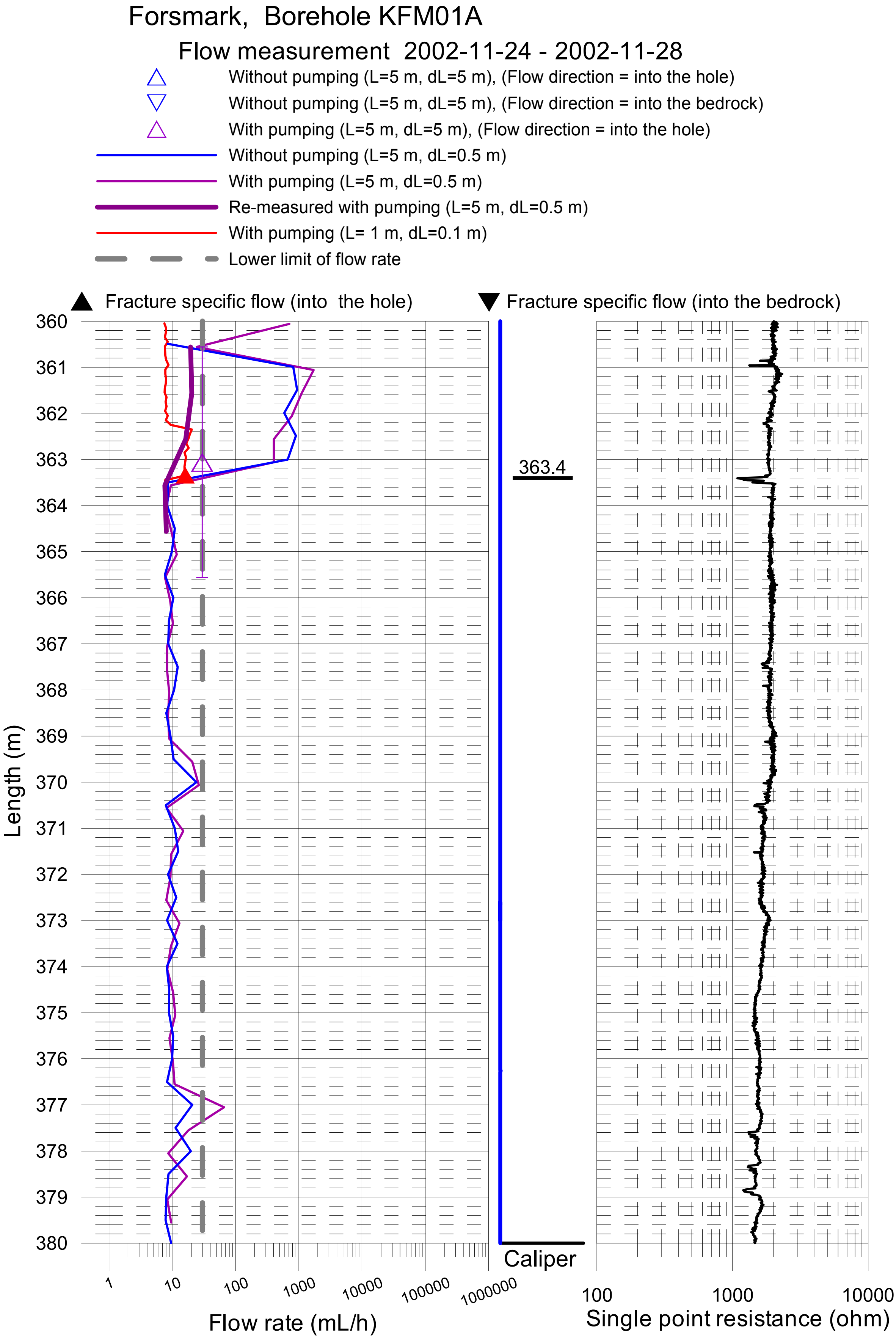
Appendix 3.13

Forsmark, Borehole KFM01A

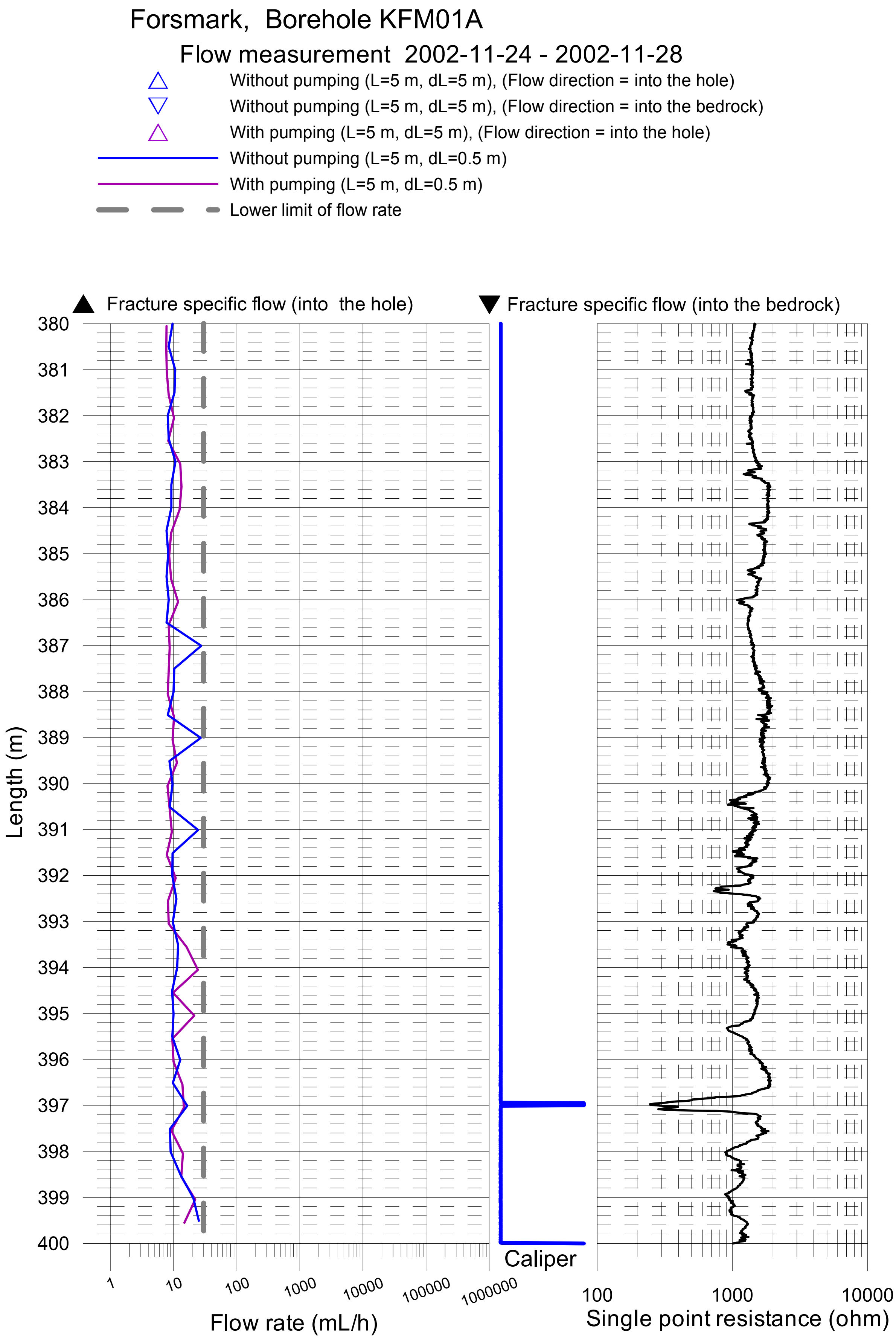
Flow measurement 2002-11-24 - 2002-11-28



Appendix 3.14



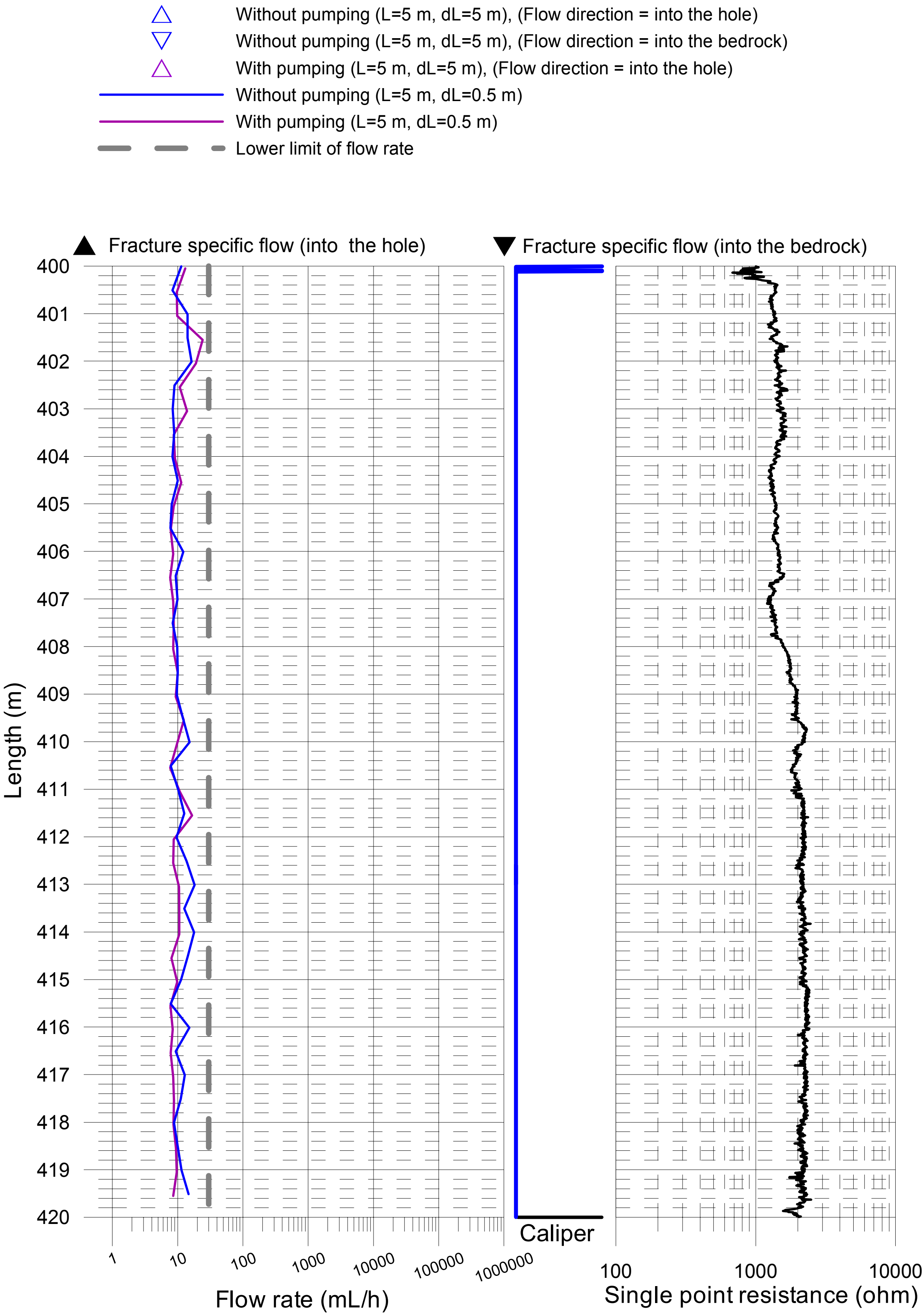
Appendix 3.15



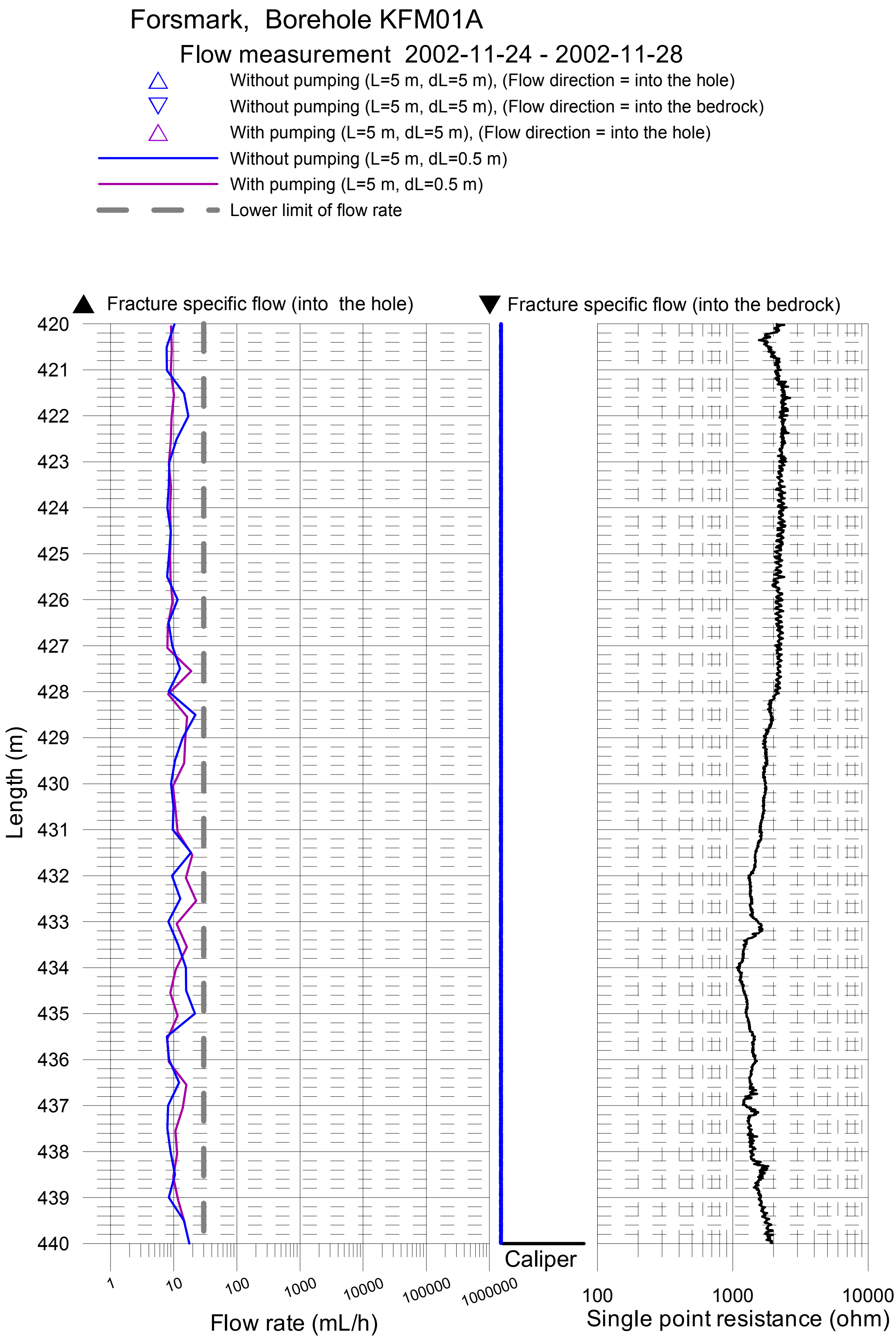
Appendix 3.16

Forsmark, Borehole KFM01A

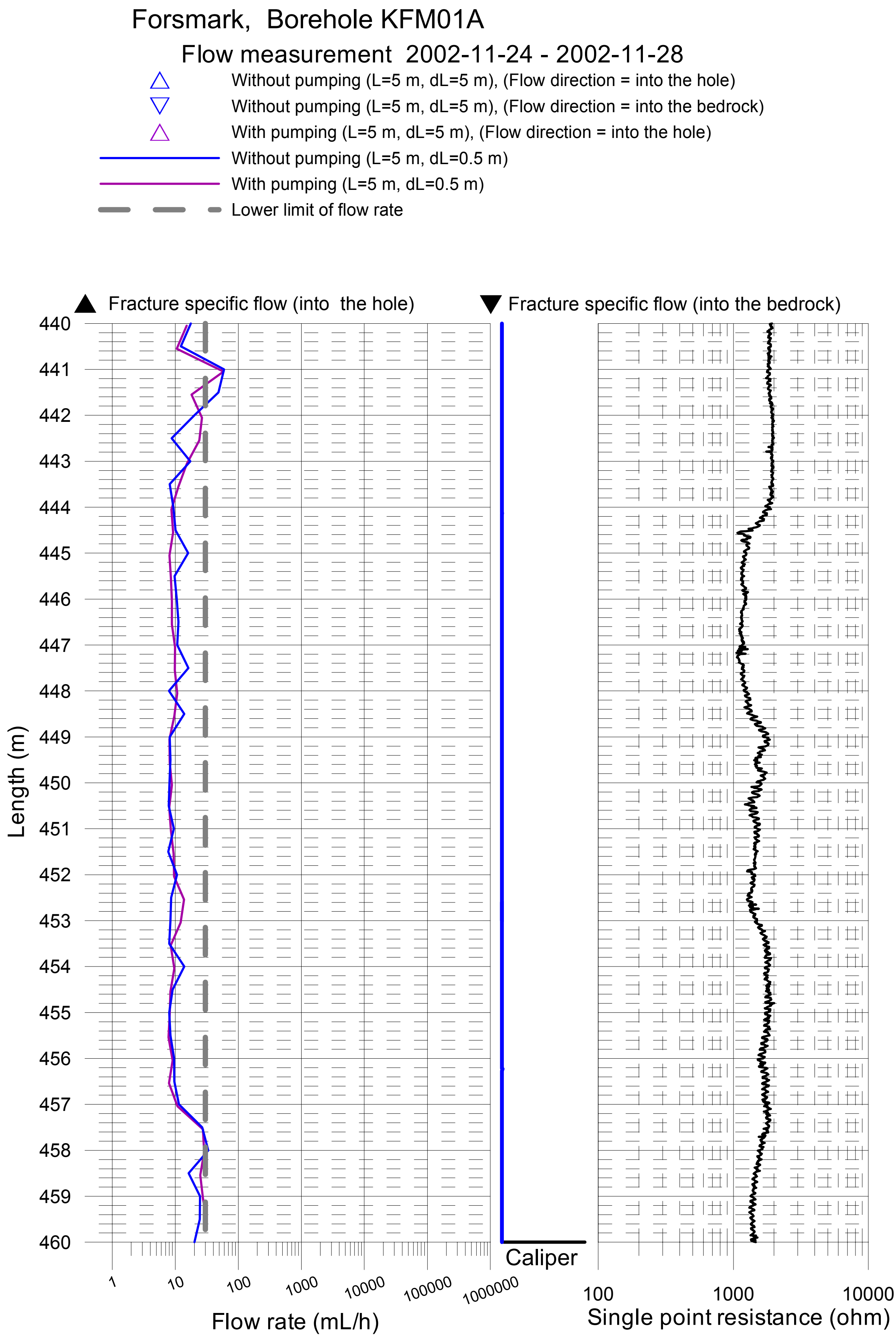
Flow measurement 2002-11-24 - 2002-11-28



Appendix 3.17

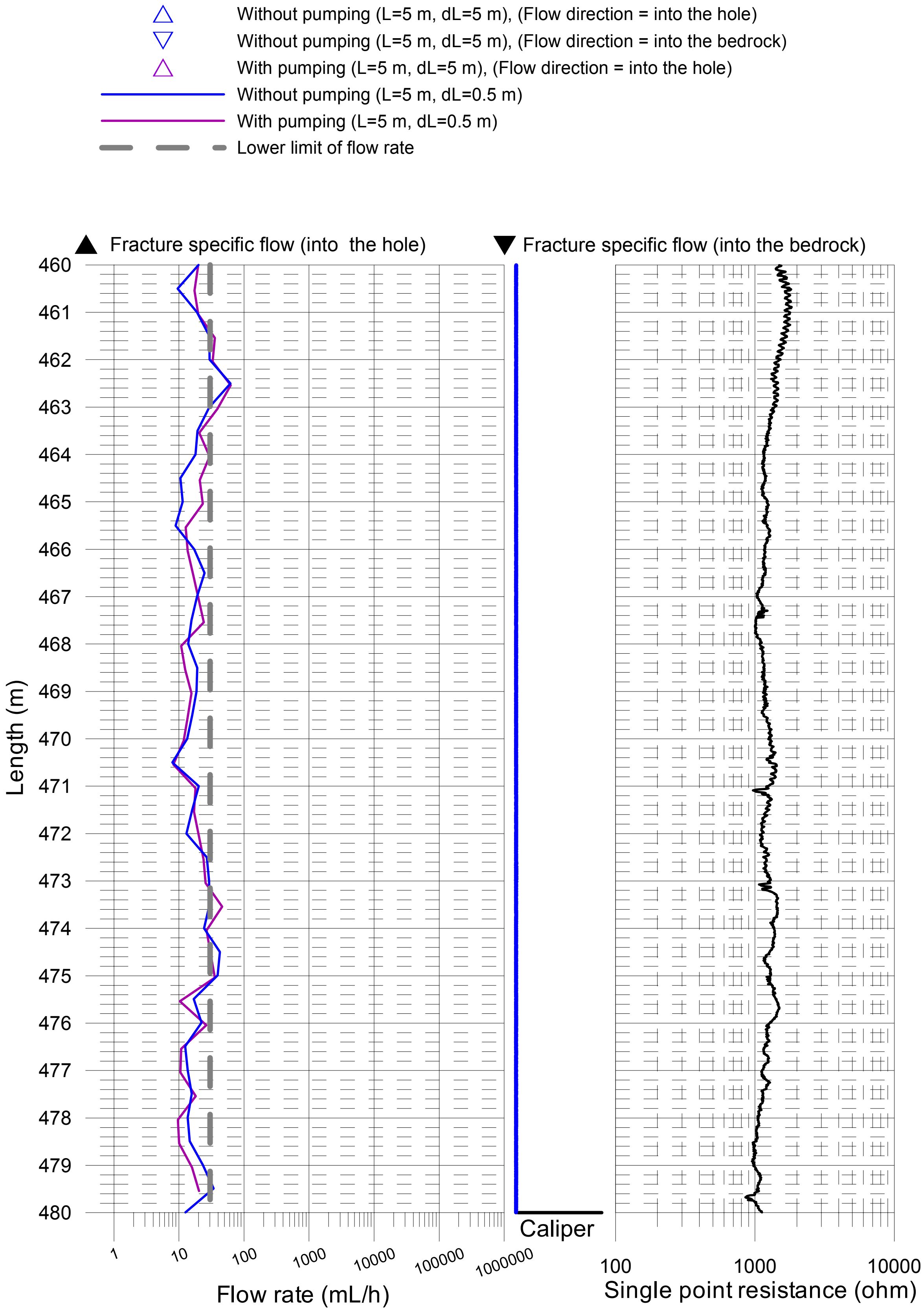


Appendix 3.18

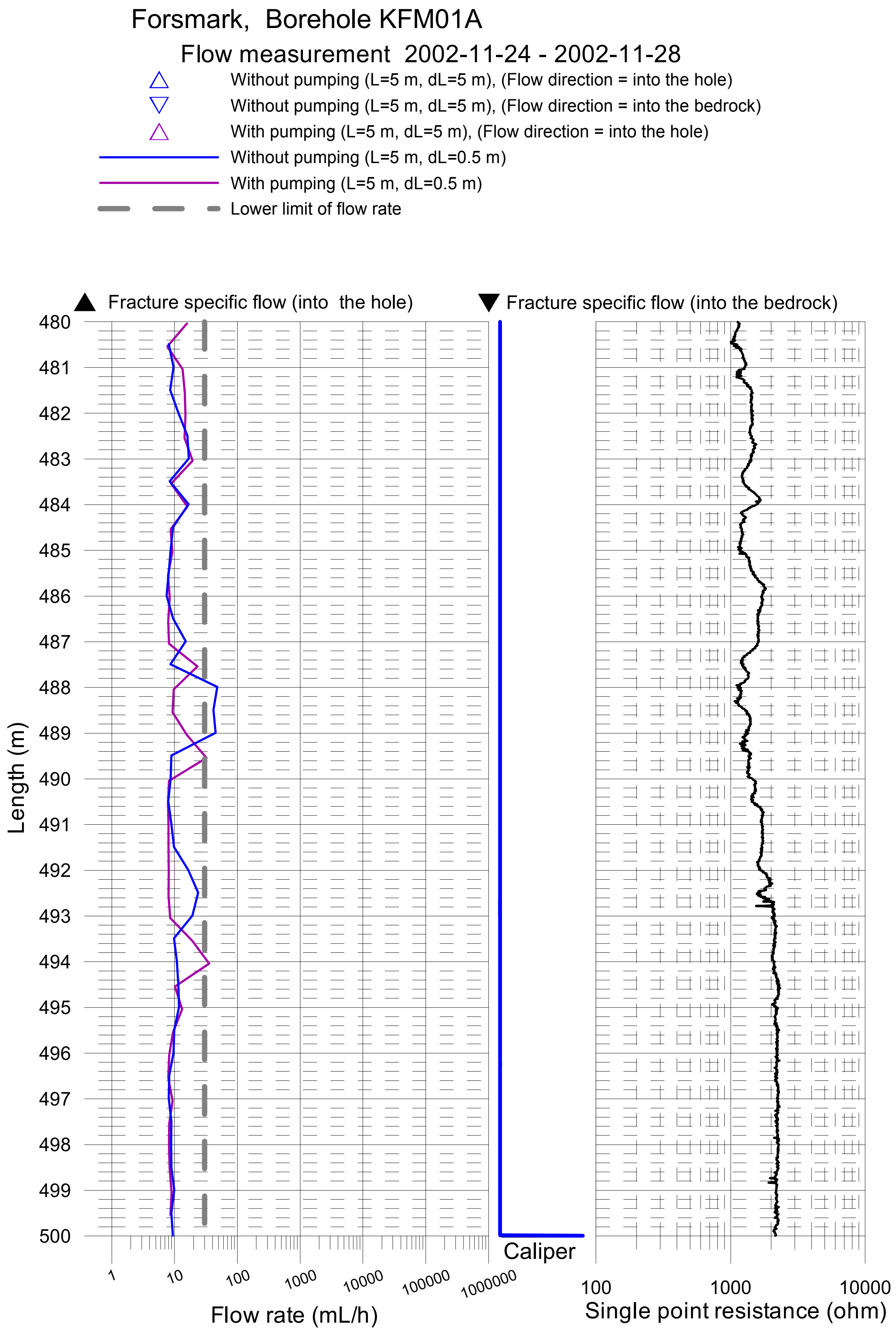


Forsmark, Borehole KFM01A

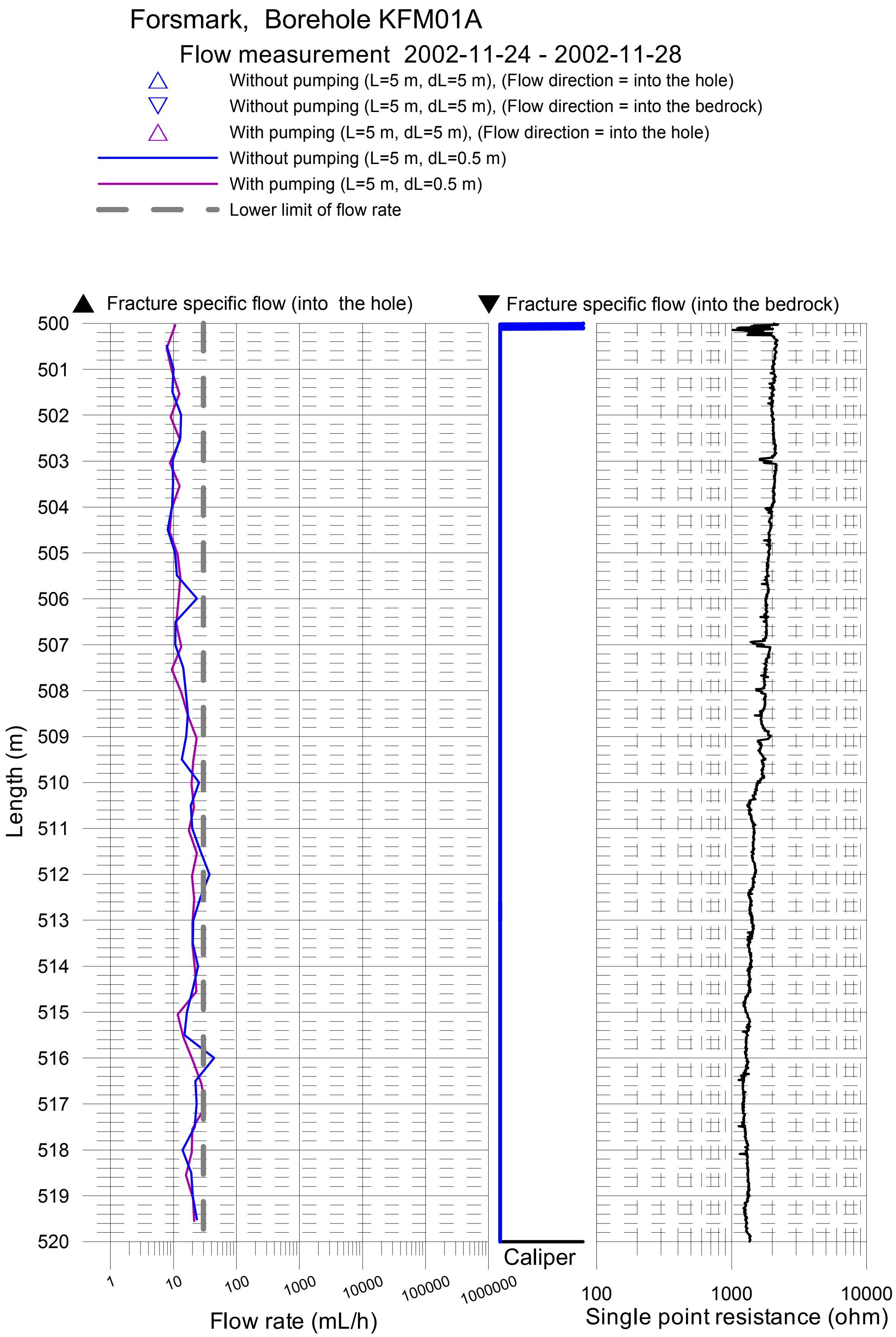
Flow measurement 2002-11-24 - 2002-11-28



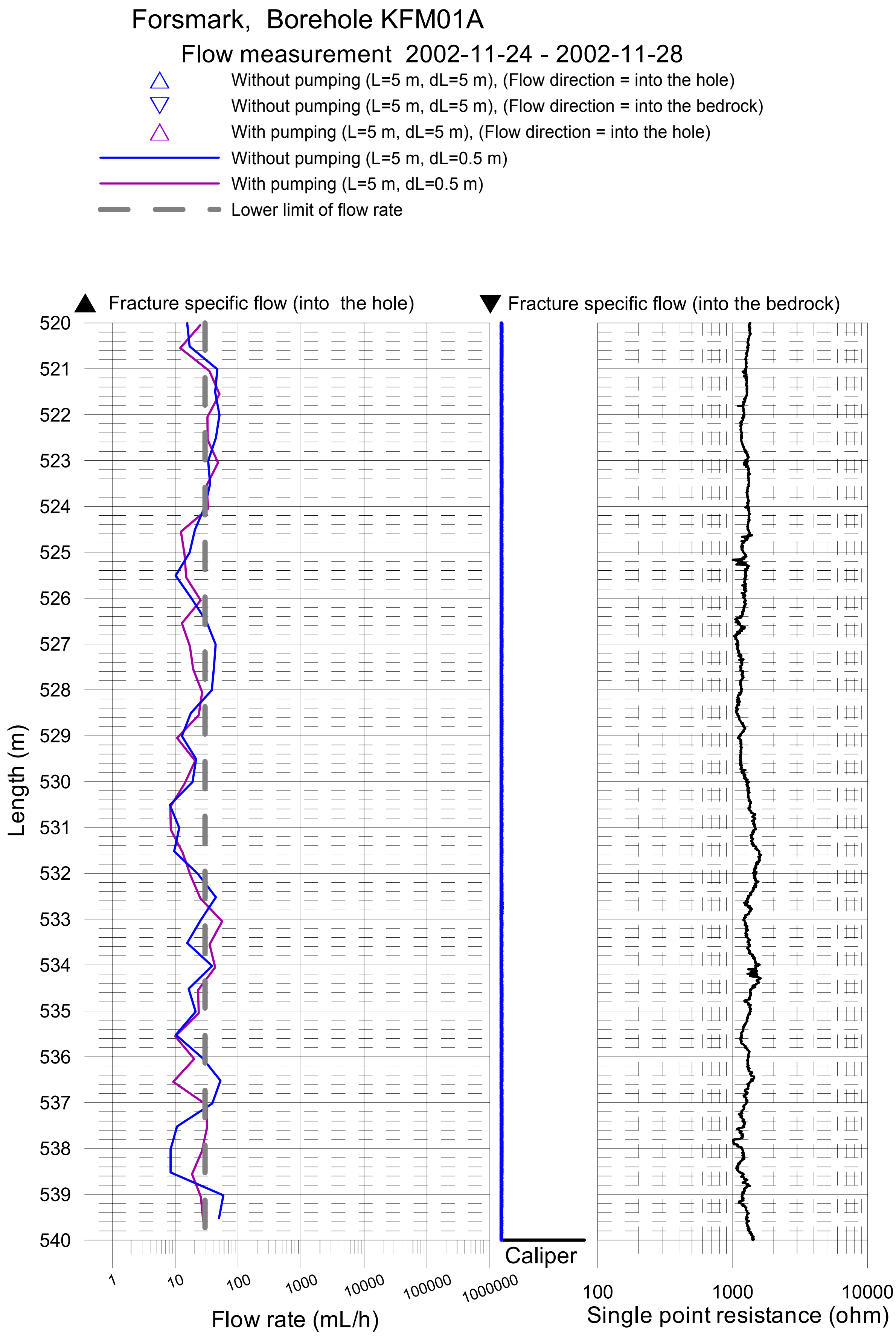
Appendix 3.20



Appendix 3.21

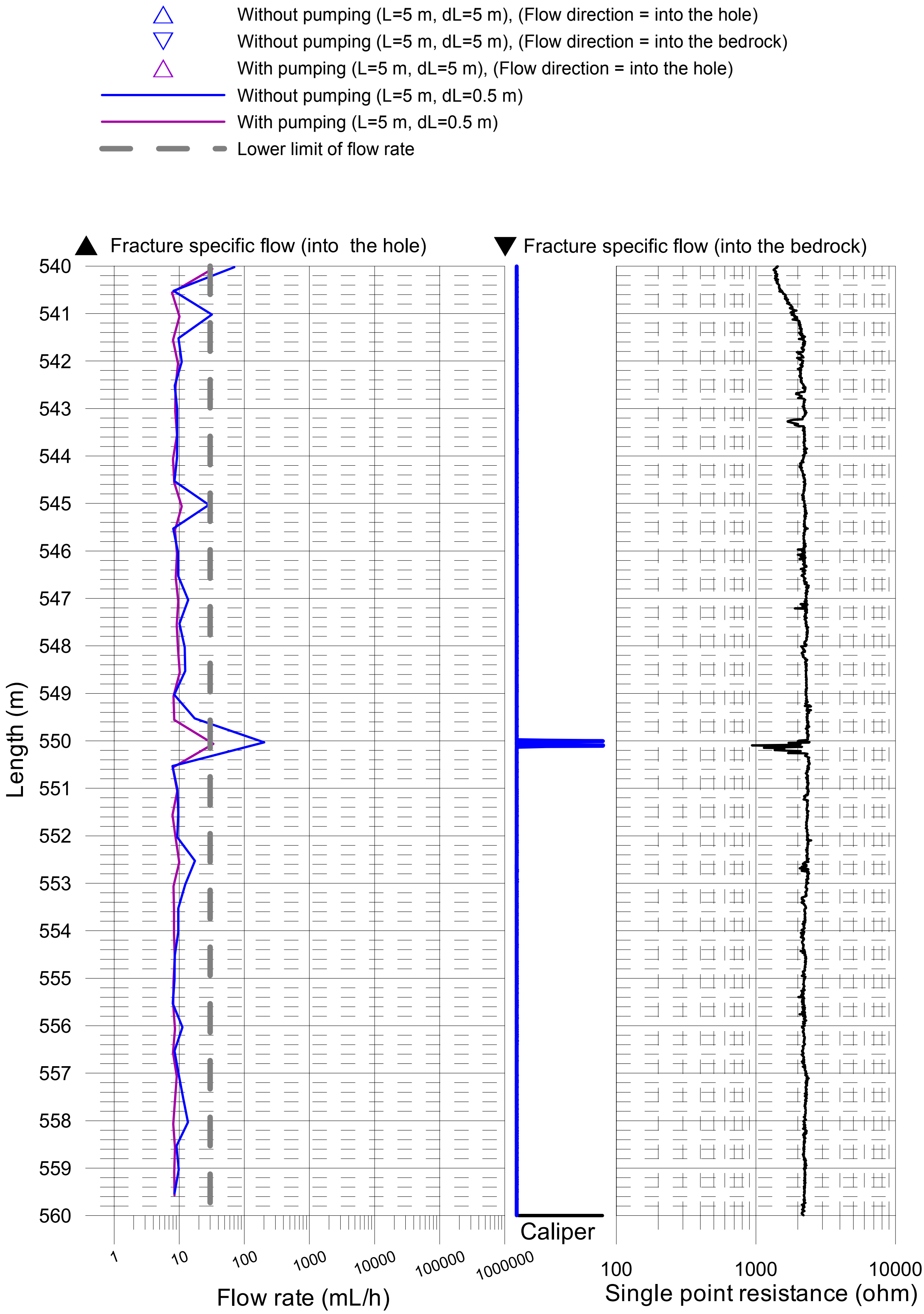


Appendix 3.22

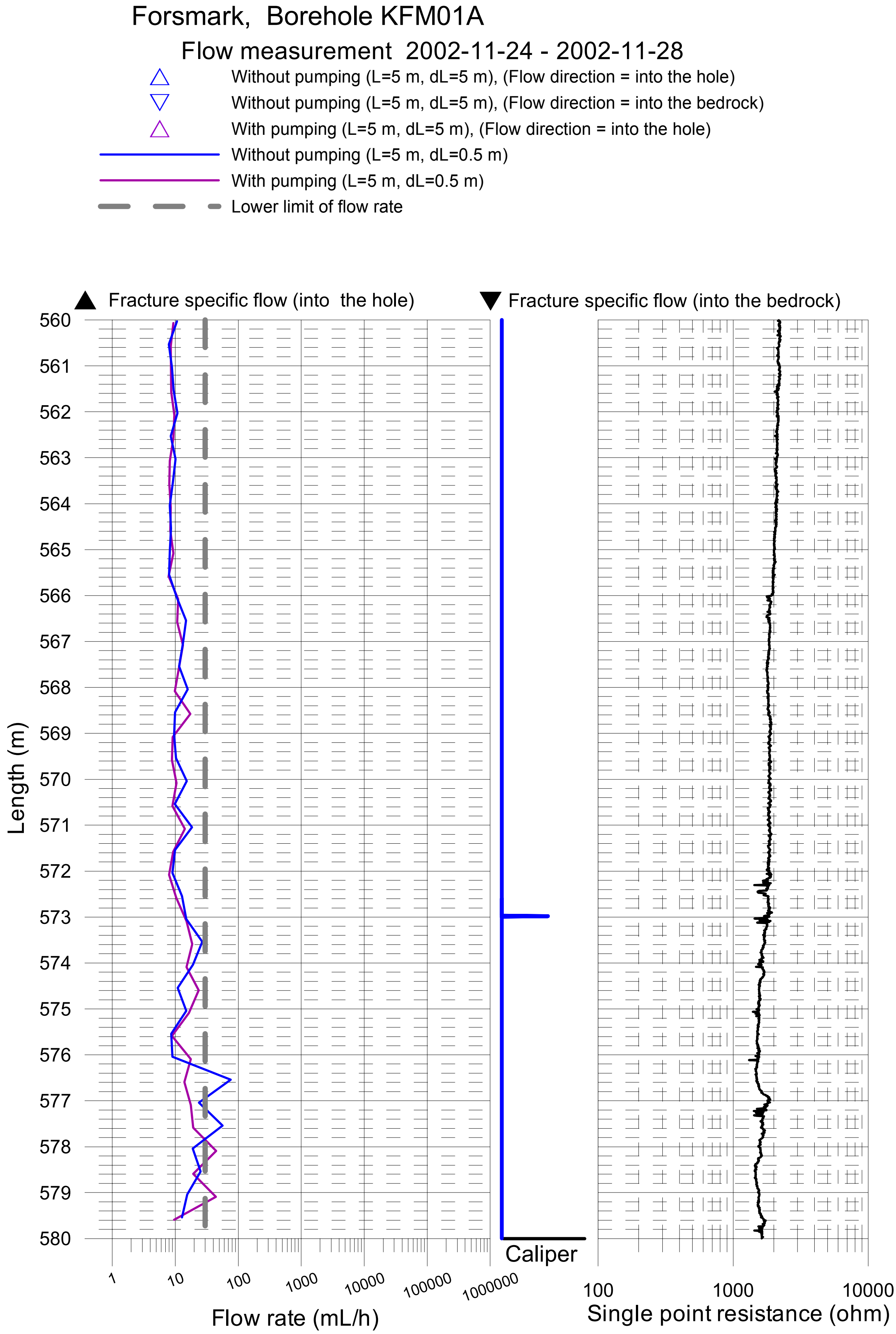


Forsmark, Borehole KFM01A

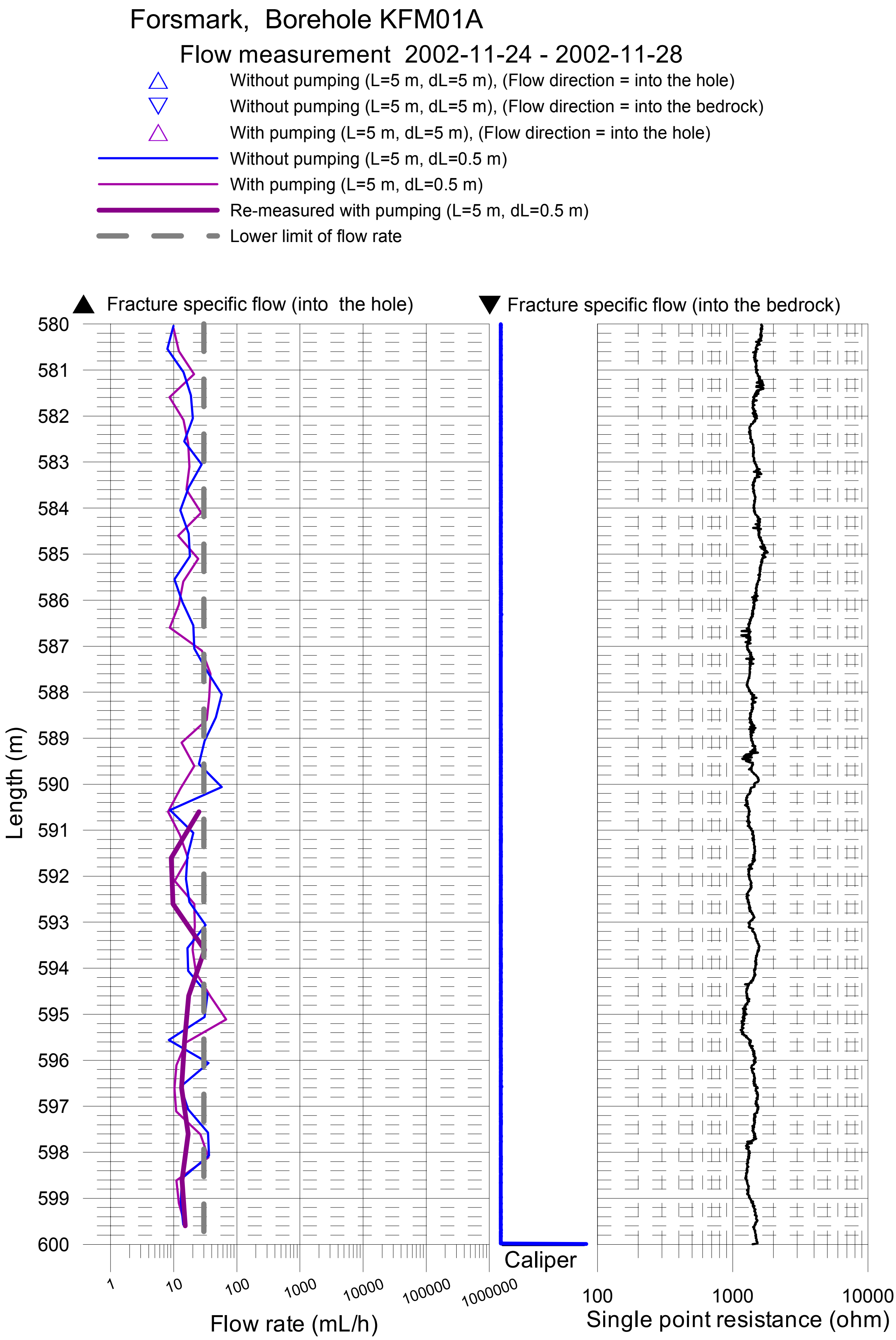
Flow measurement 2002-11-24 - 2002-11-28



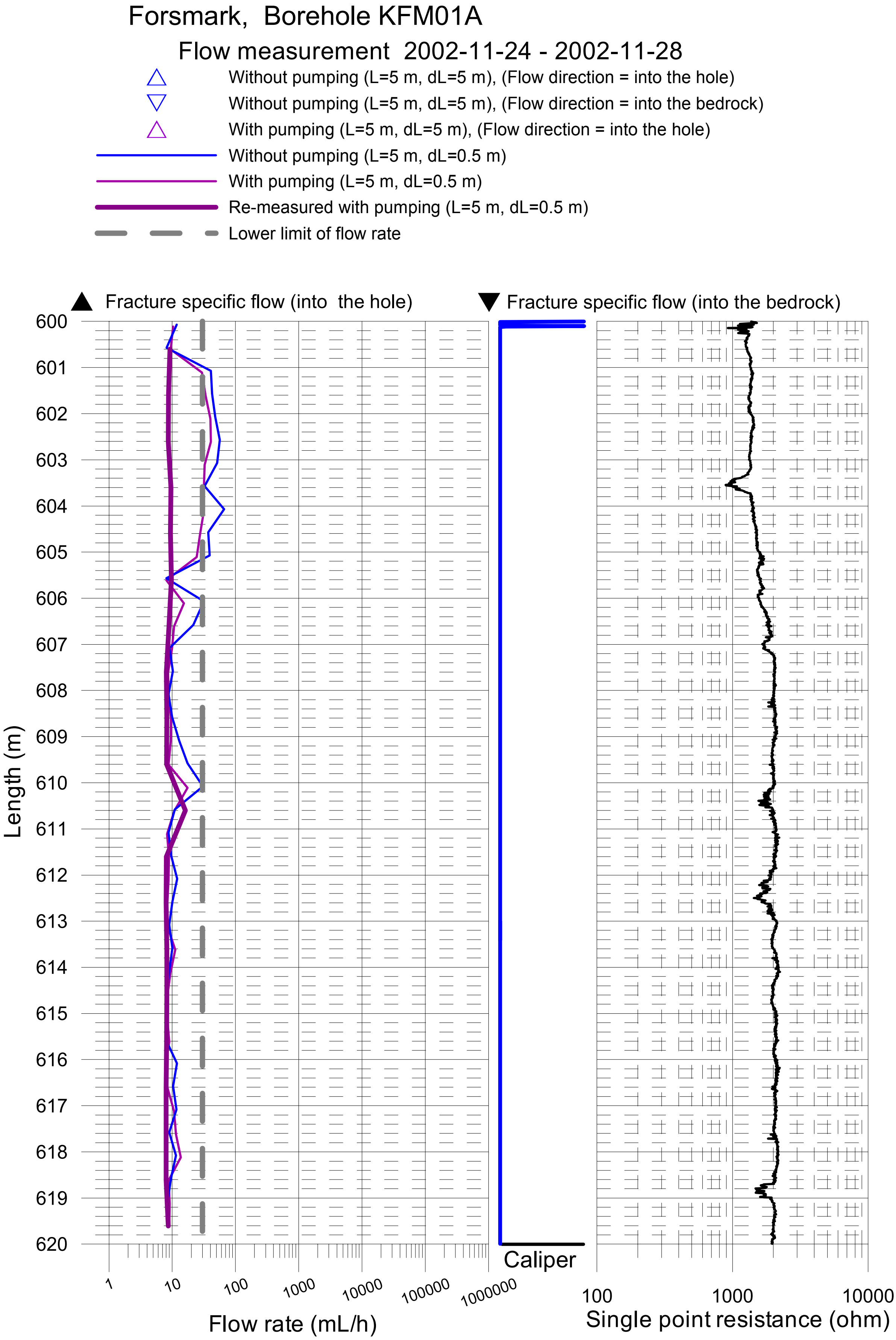
Appendix 3.24

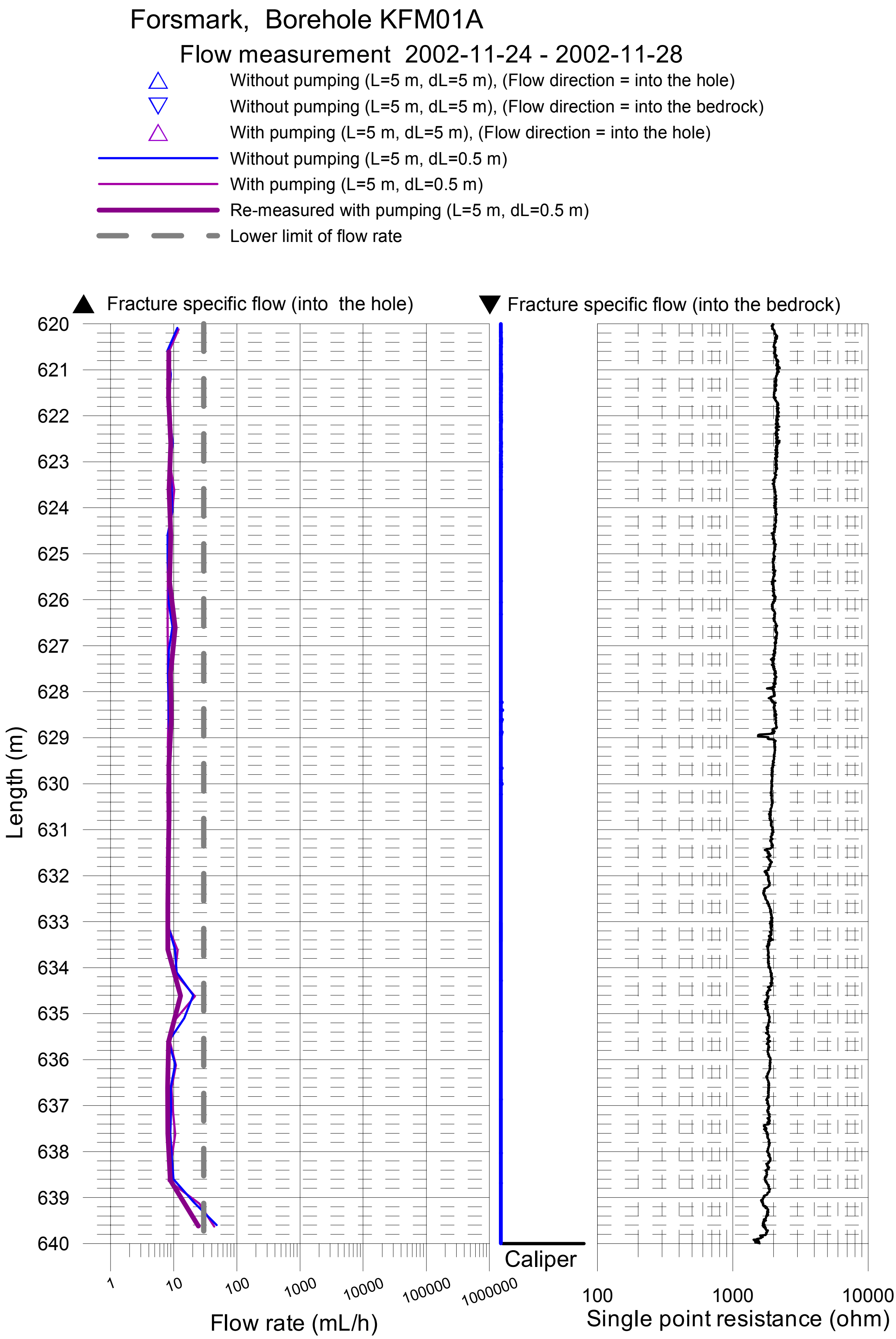


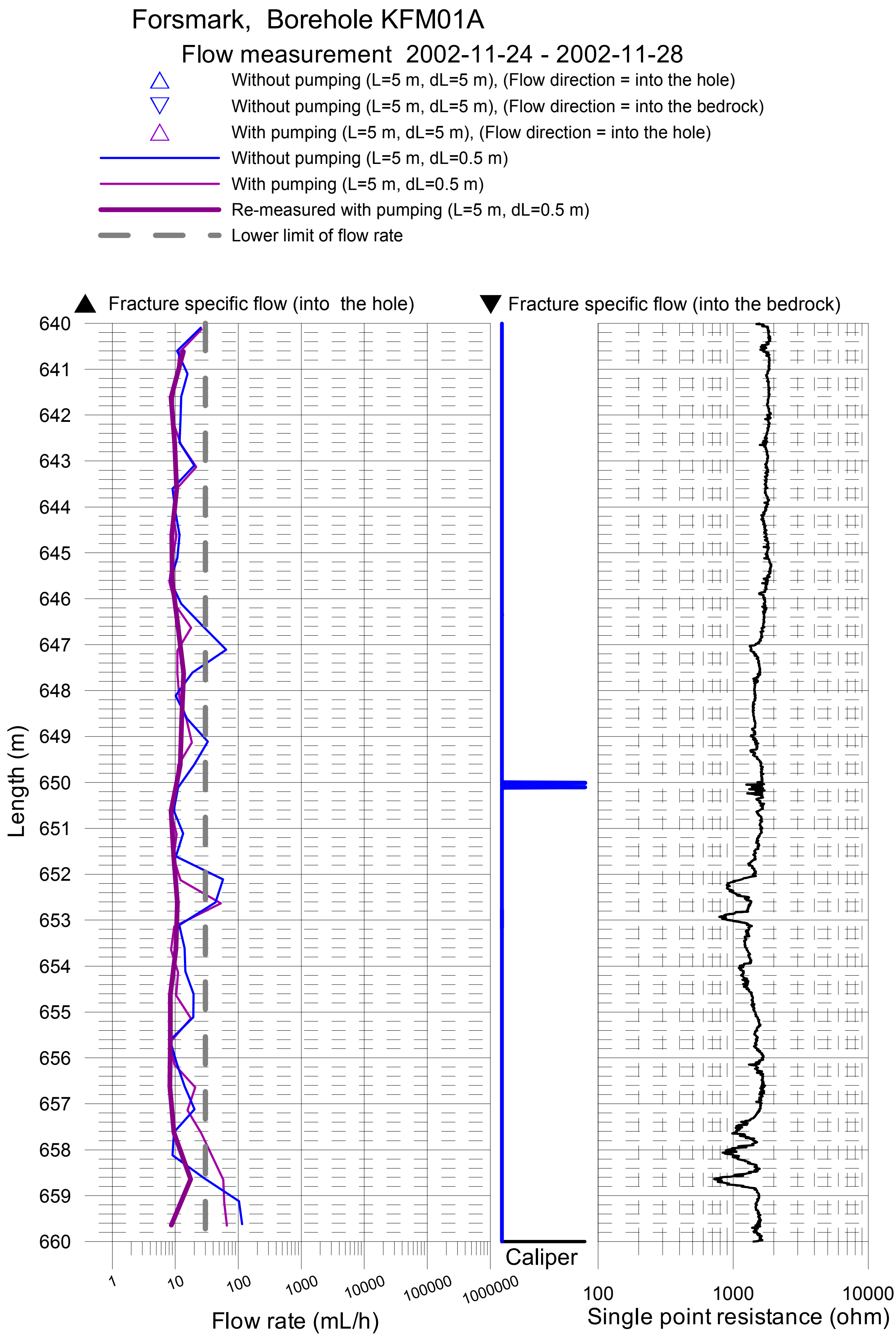
Appendix 3.25



Appendix 3.26

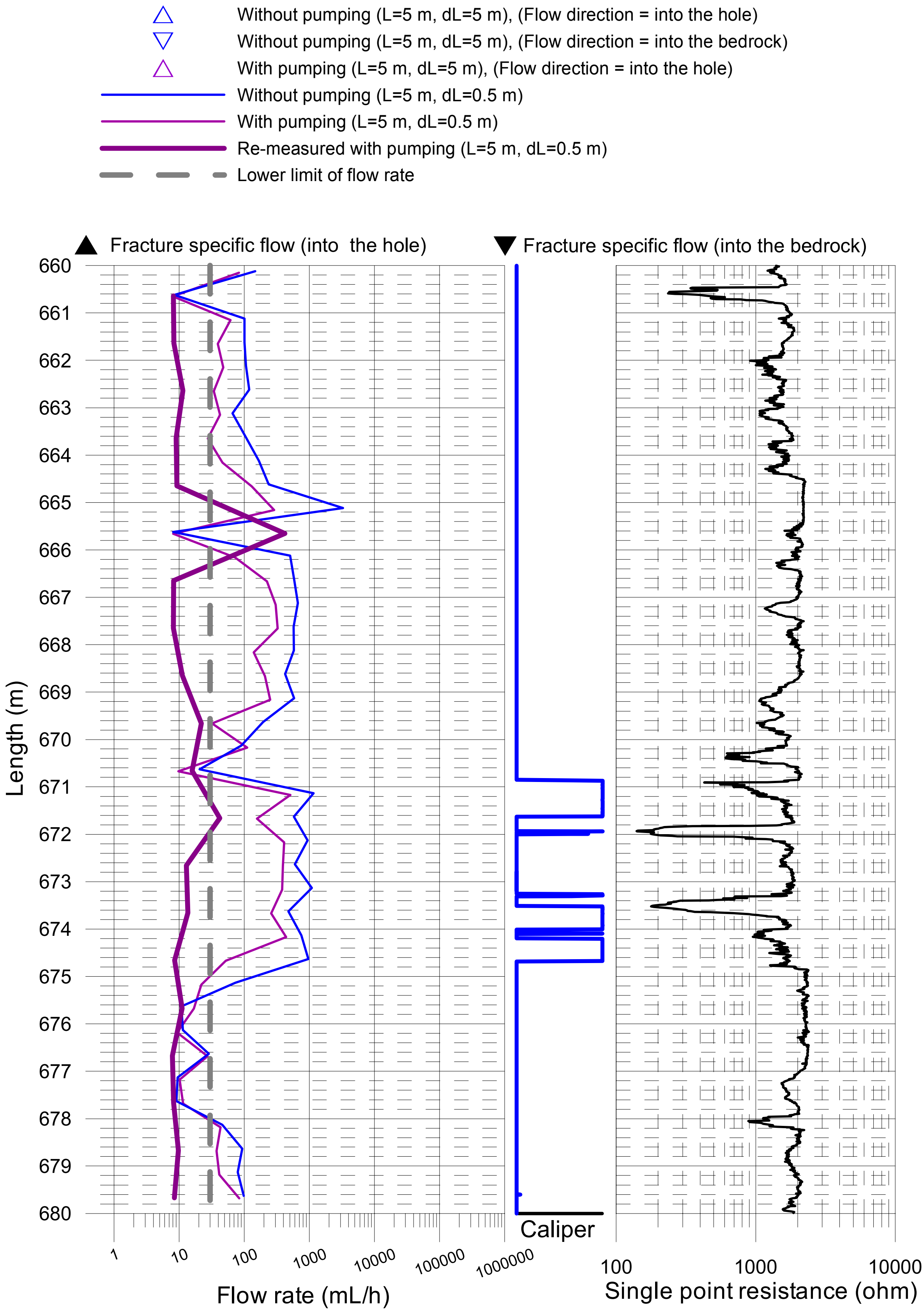



Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 2002-11-28
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Re-measured with pumping (L=5 m, dL=0.5 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (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
1000000
Flow rate (mL/h)
Caliper
100
1000
10000
Single point resistance (ohm)

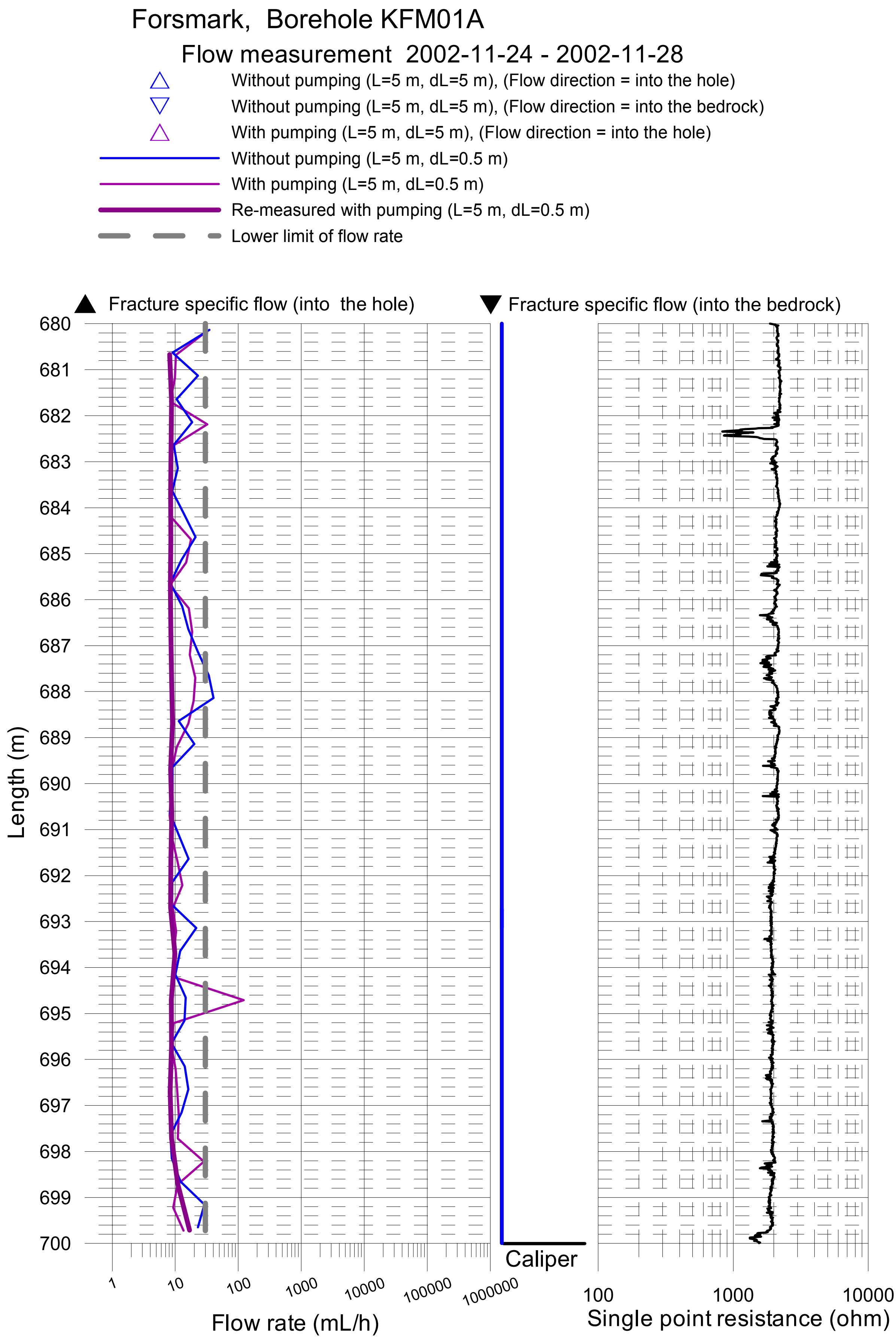

Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 2002-11-28
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Re-measured with pumping (L=5 m, dL=0.5 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (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
1000000
Flow rate (mL/h)
Caliper
100
1000
10000
Single point resistance (ohm)

Forsmark, Borehole KFM01A

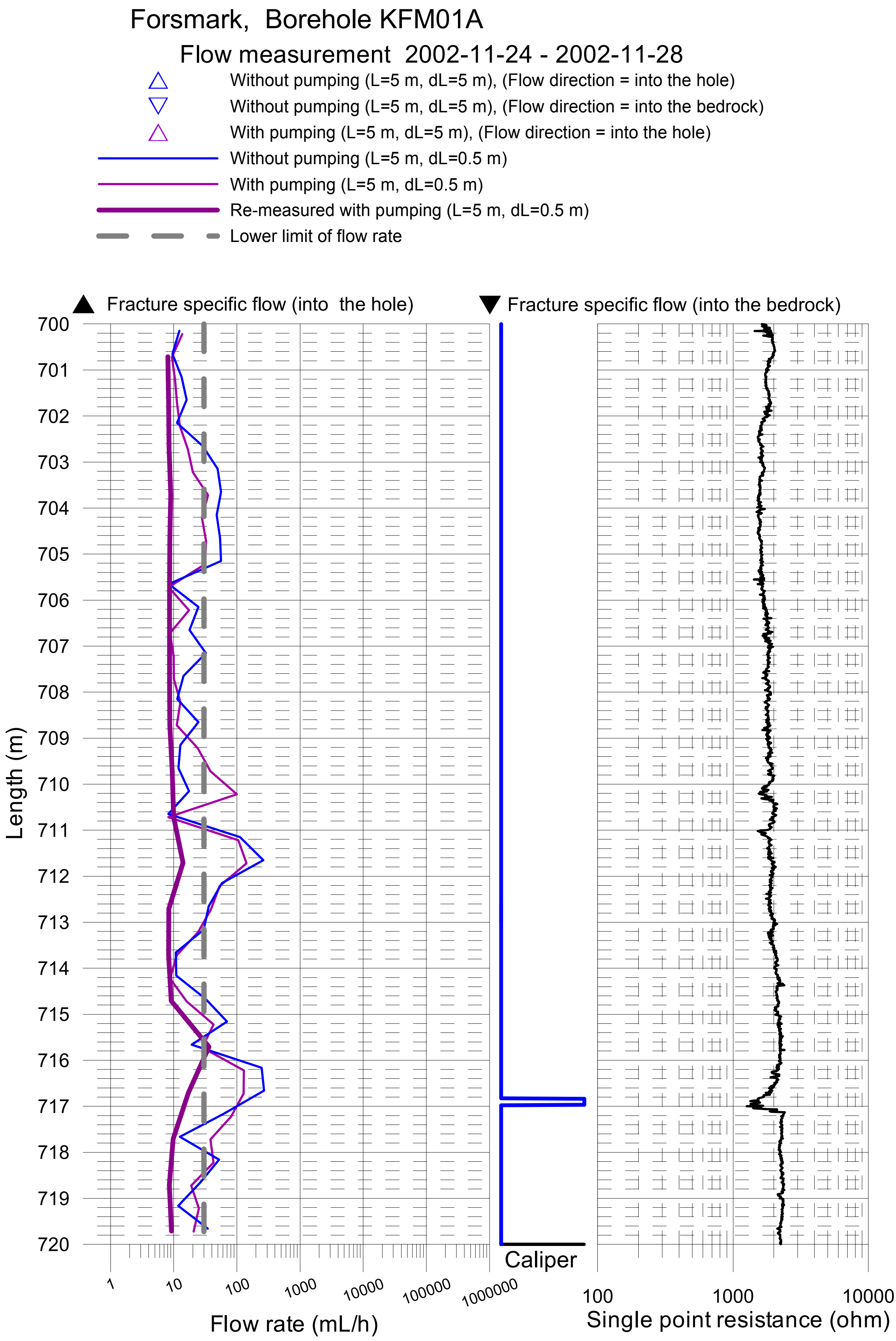
Flow measurement 2002-11-24 - 2002-11-28



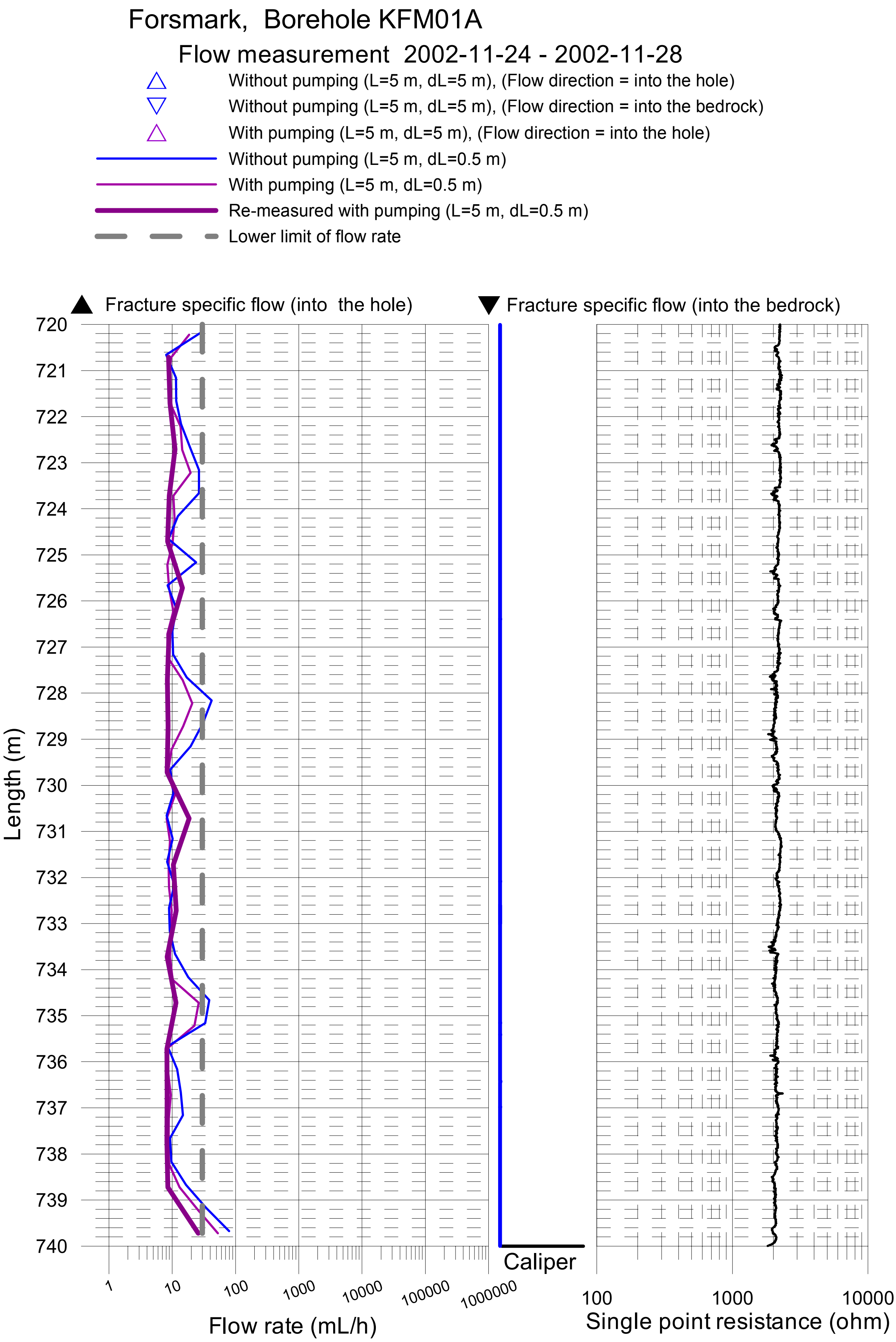
Appendix 3.30



Appendix 3.31

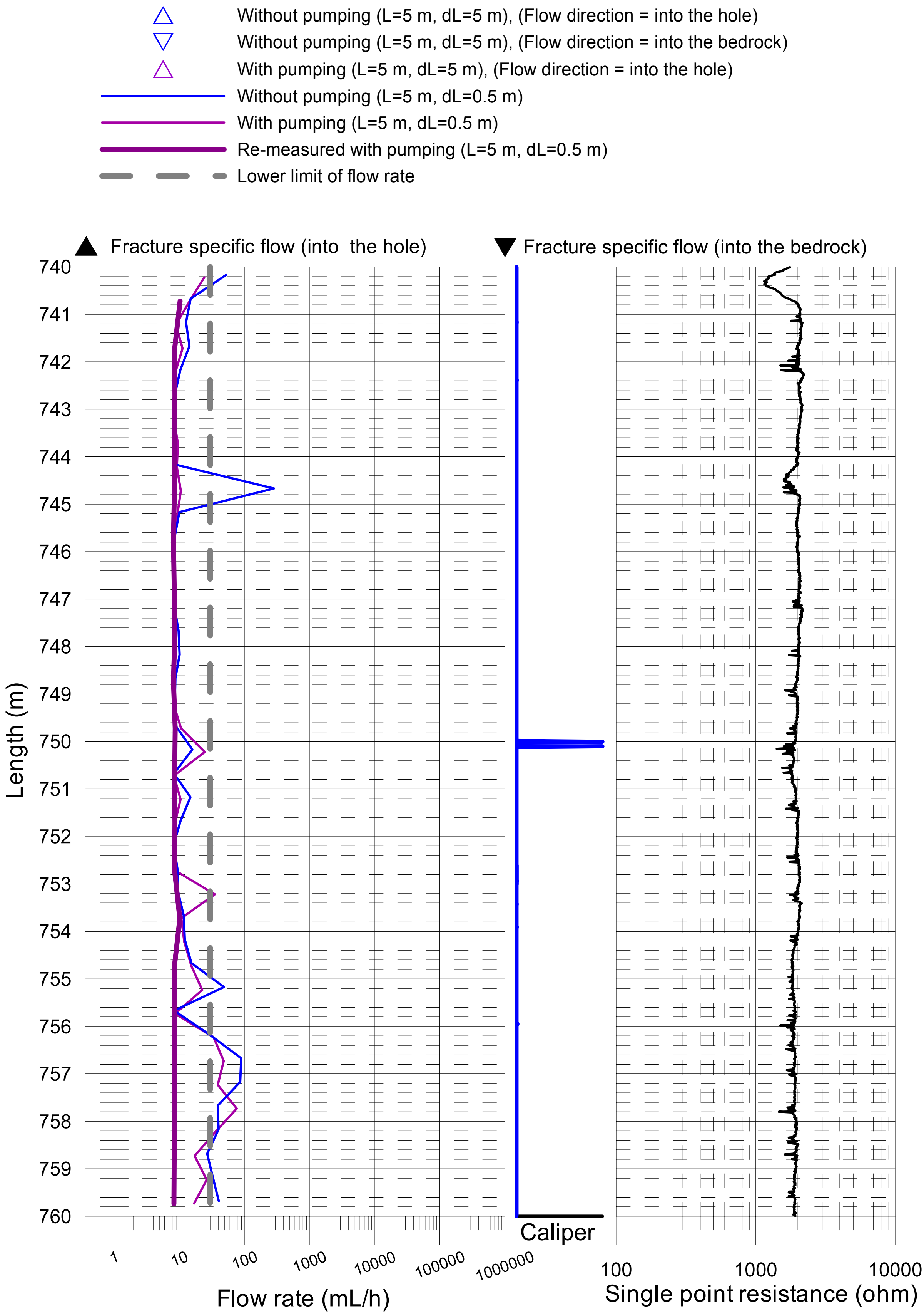


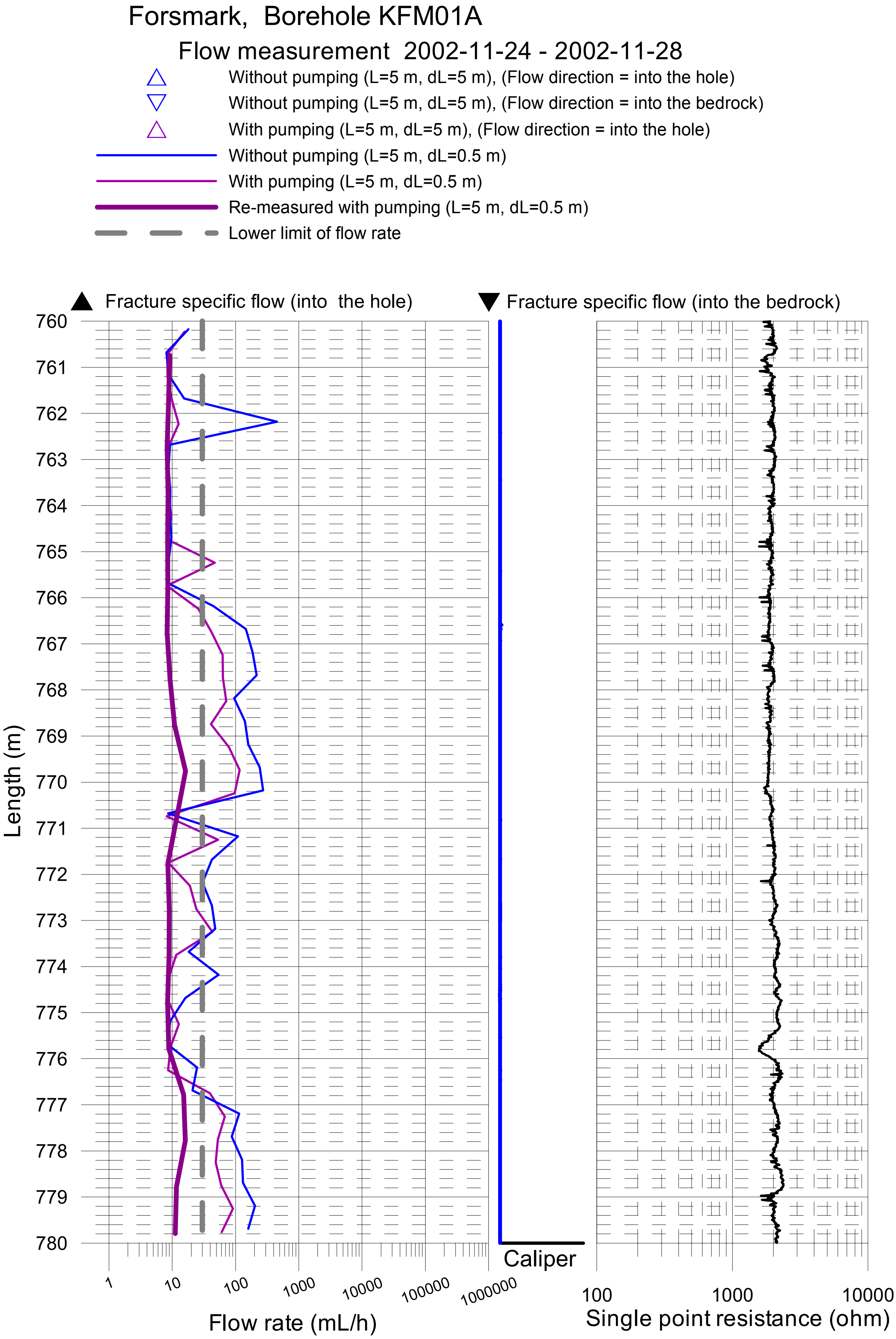
Appendix 3.32

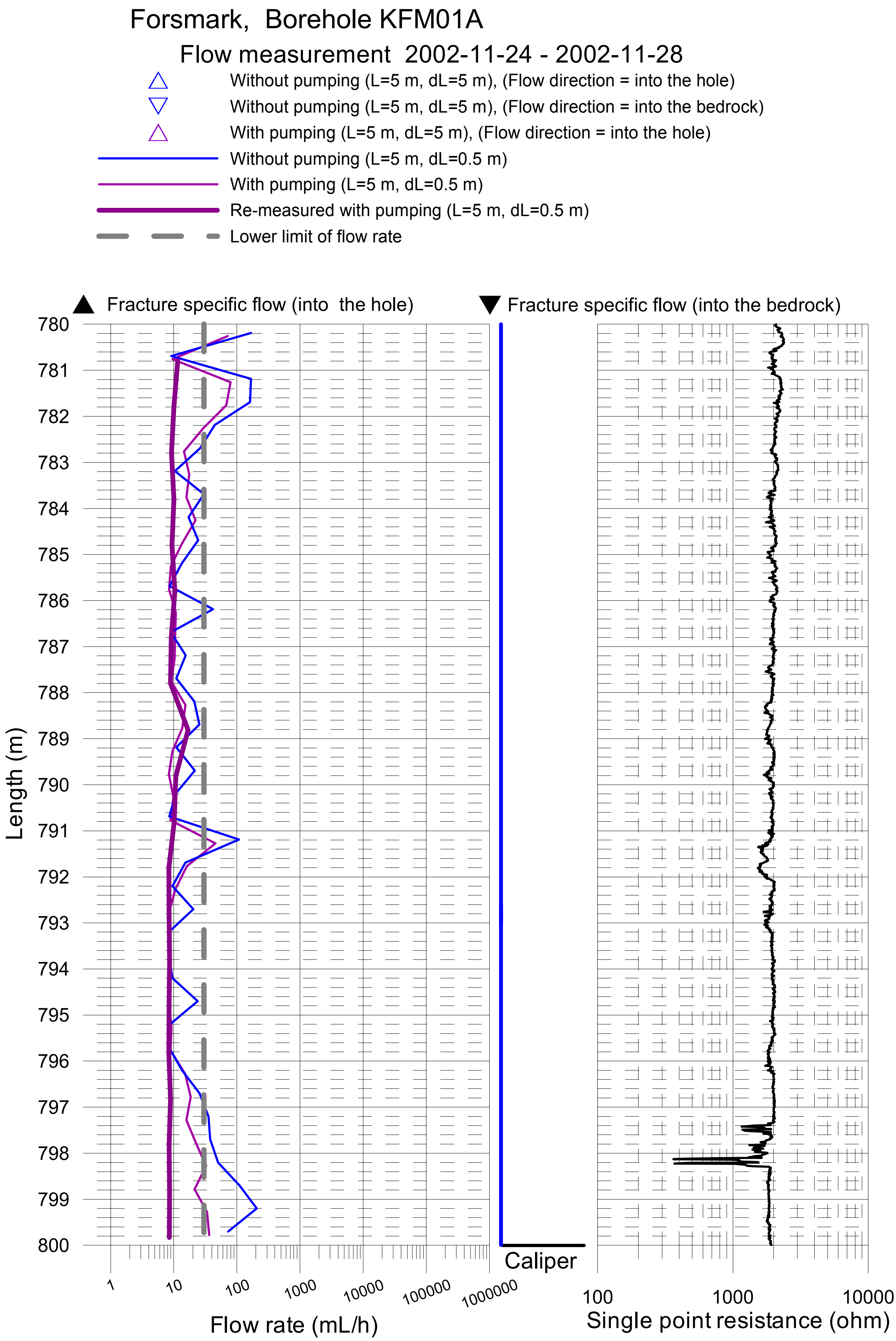


Forsmark, Borehole KFM01A

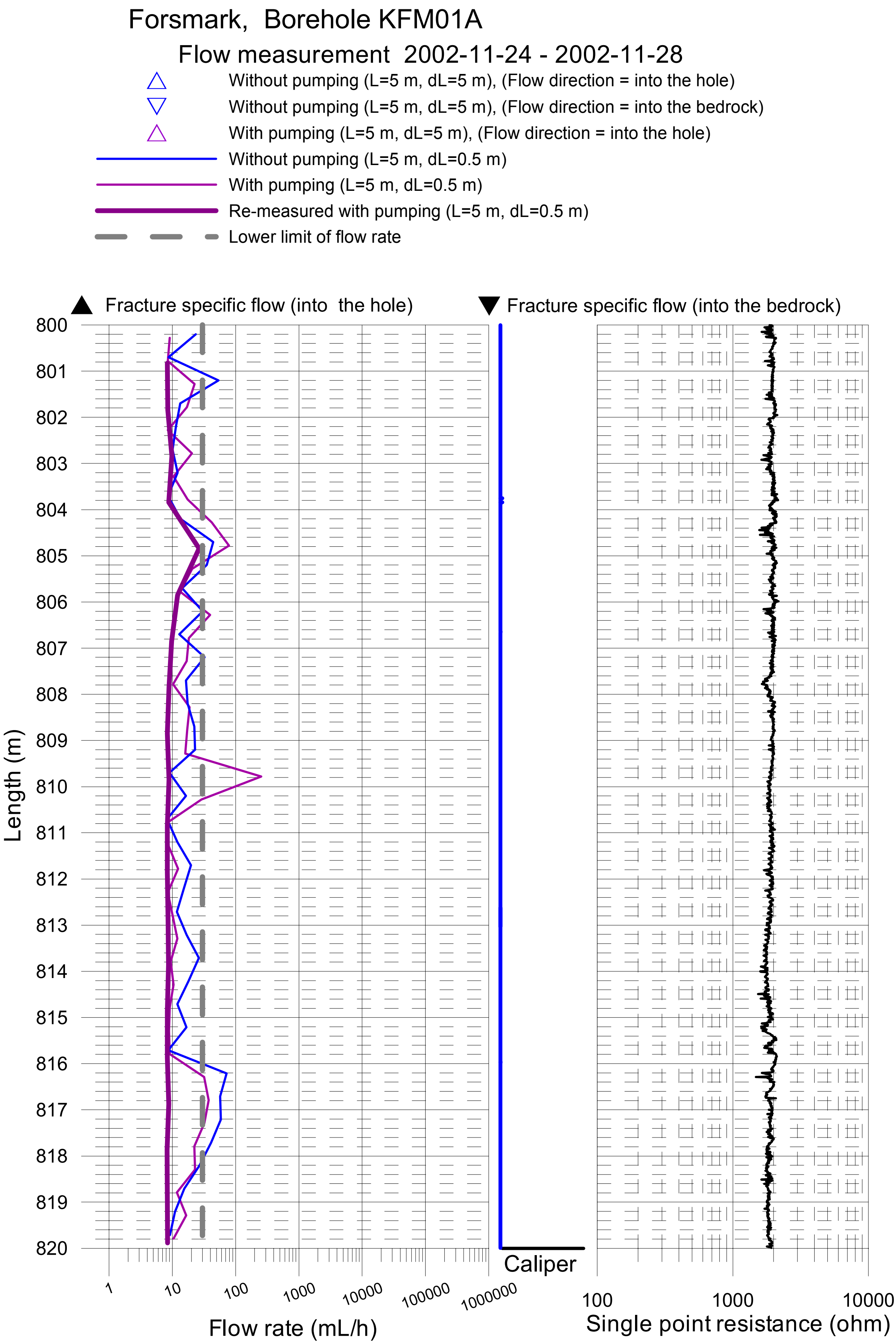
Flow measurement 2002-11-24 - 2002-11-28




Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 2002-11-28
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Re-measured with pumping (L=5 m, dL=0.5 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (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
1000000
Flow rate (mL/h)
Caliper
100
1000
10000
Single point resistance (ohm)


Forsmark, Borehole KFM01A
Flow measurement 2002-11-24 - 2002-11-28
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Re-measured with pumping (L=5 m, dL=0.5 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (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
1000000
Flow rate (mL/h)
Caliper
100
1000
10000
Single point resistance (ohm)

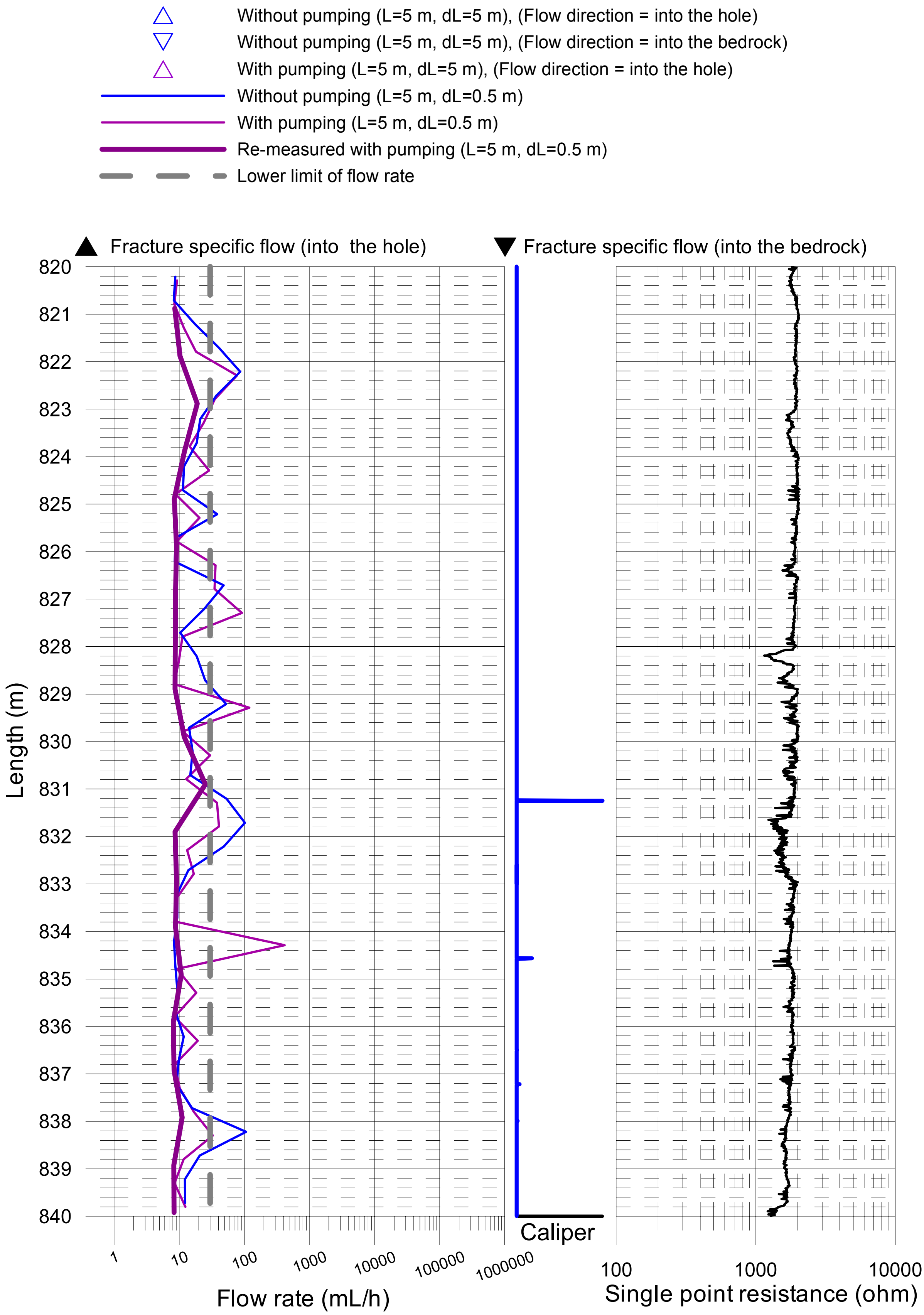
Appendix 3.36



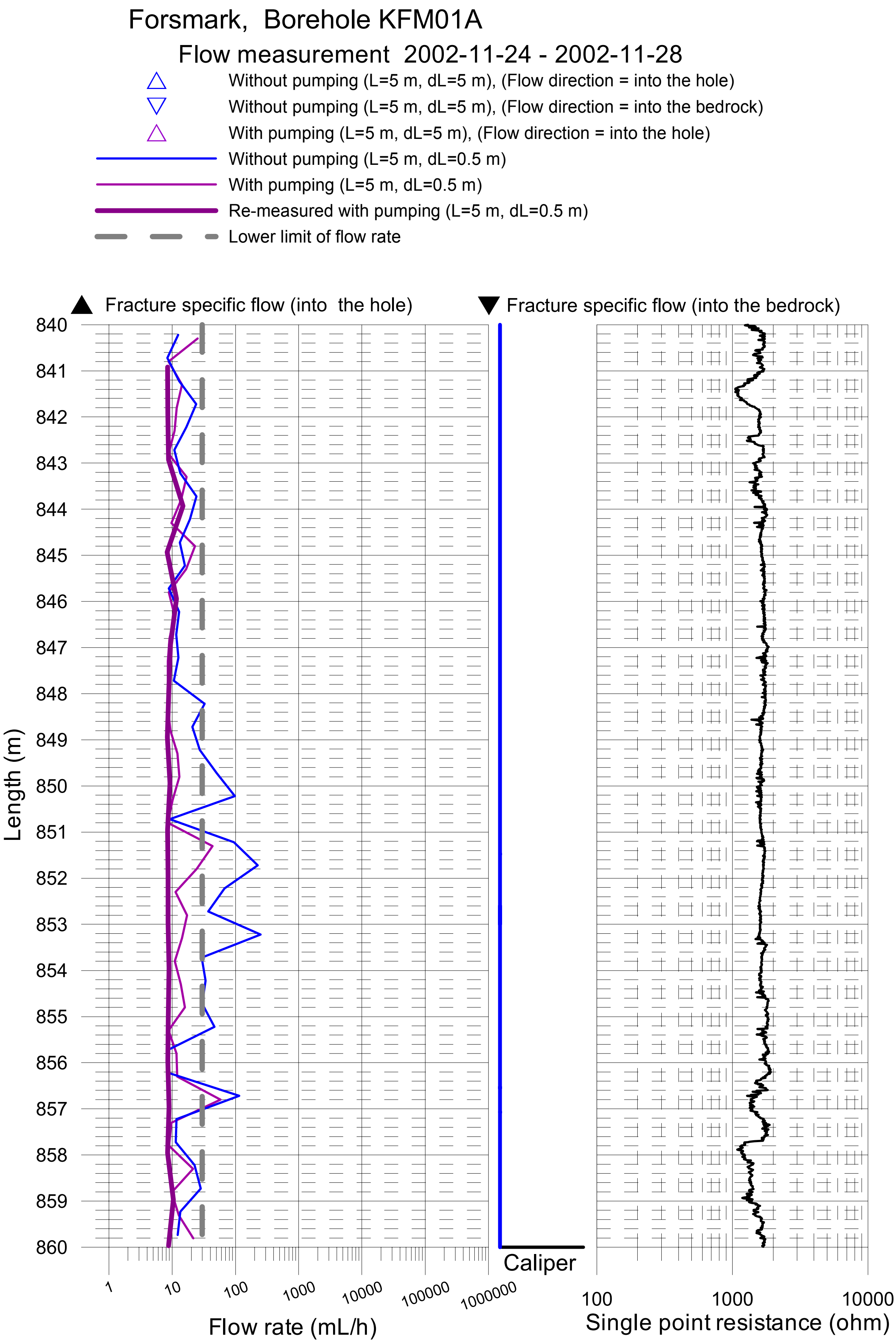
Appendix 3.37

Forsmark, Borehole KFM01A

Flow measurement 2002-11-24 - 2002-11-28

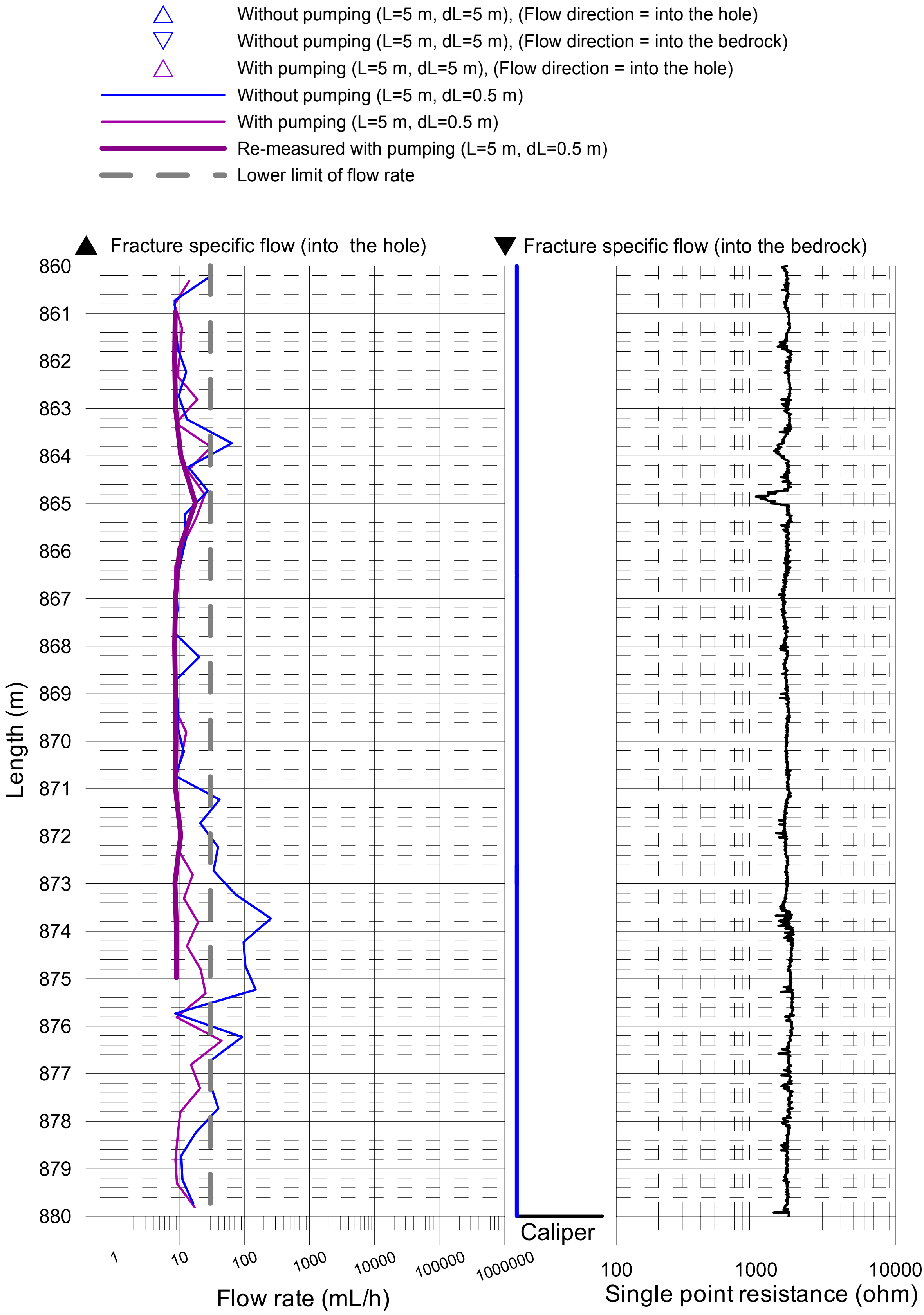


Appendix 3.38

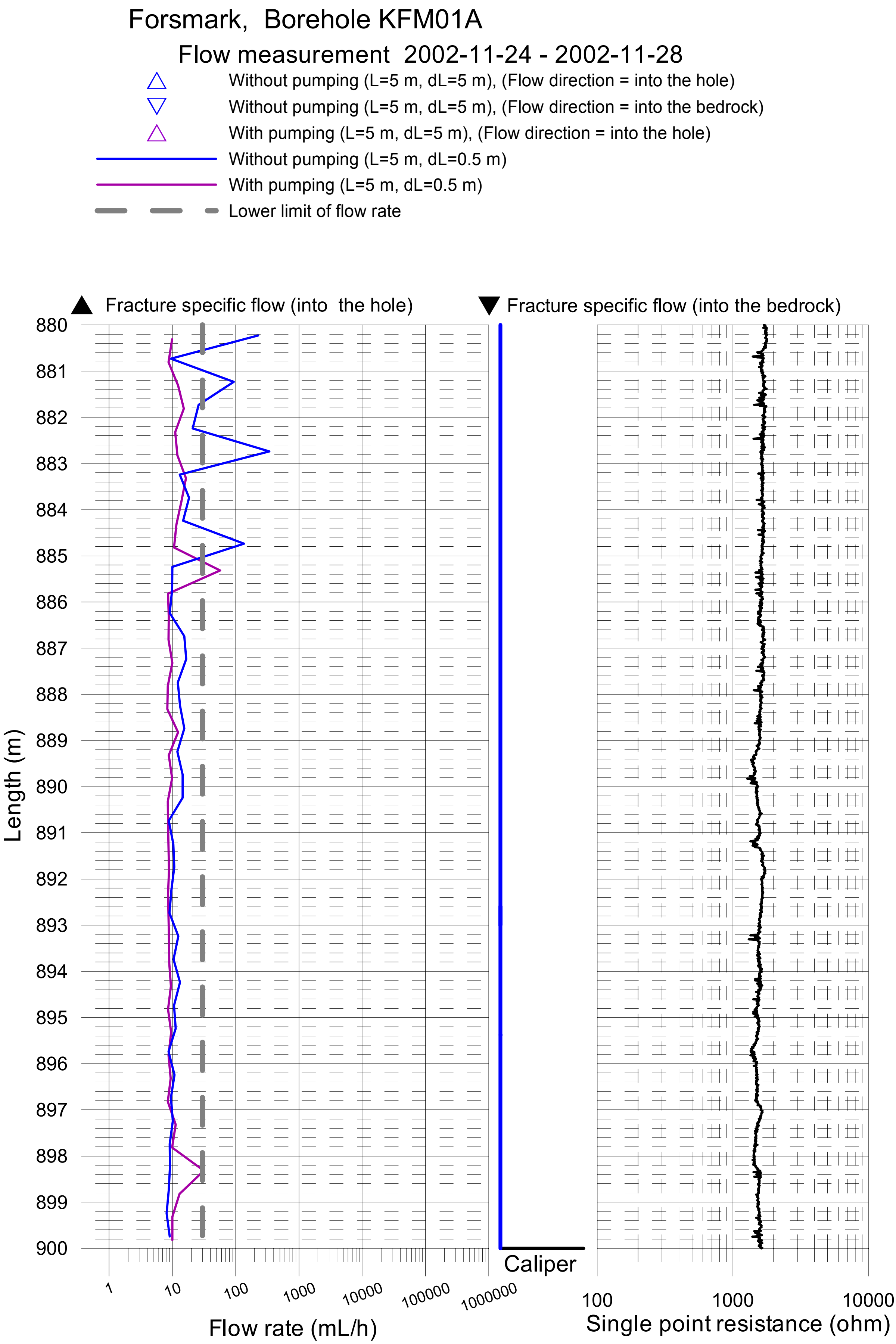


Forsmark, Borehole KFM01A

Flow measurement 2002-11-24 - 2002-11-28

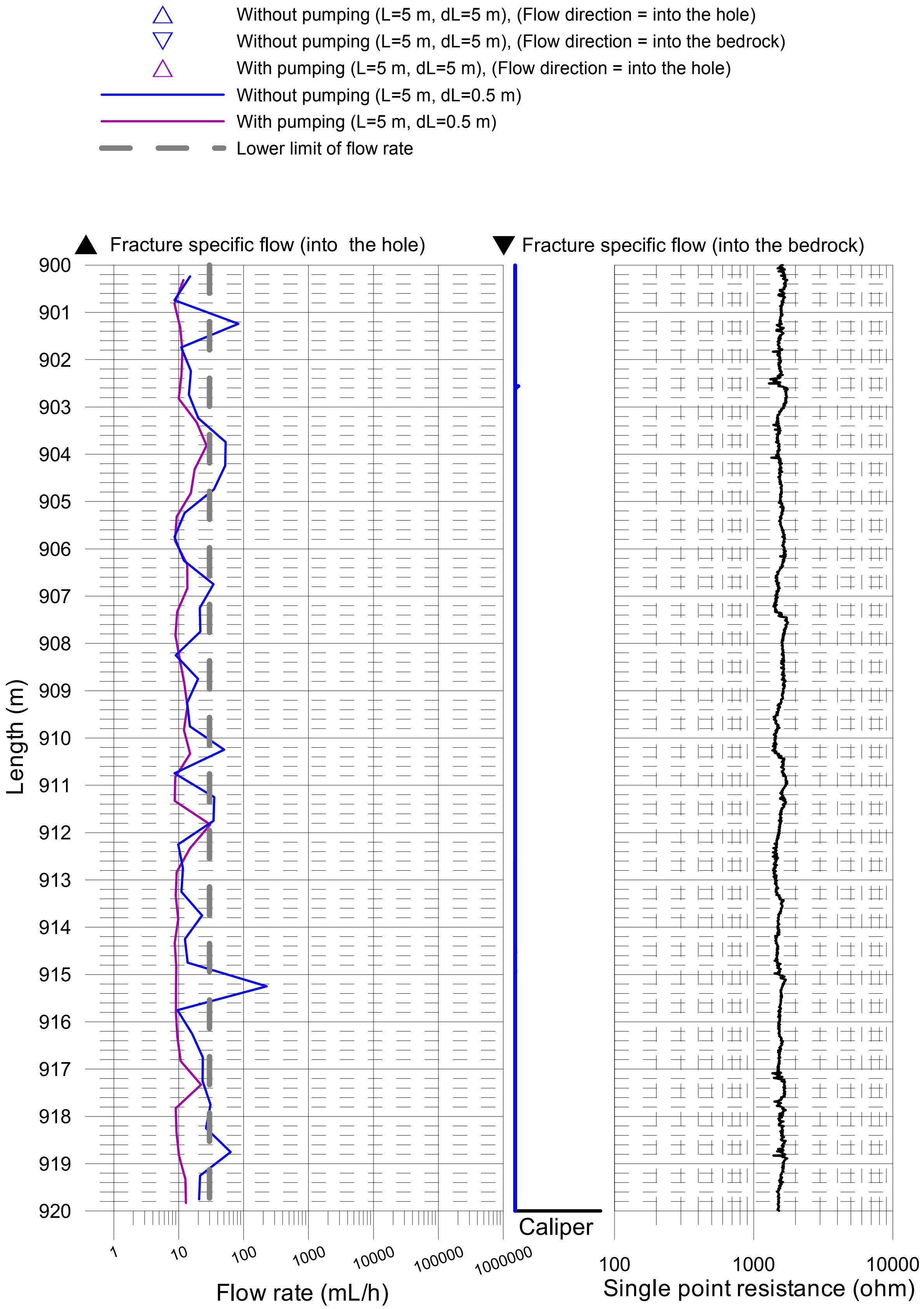


Appendix 3.40

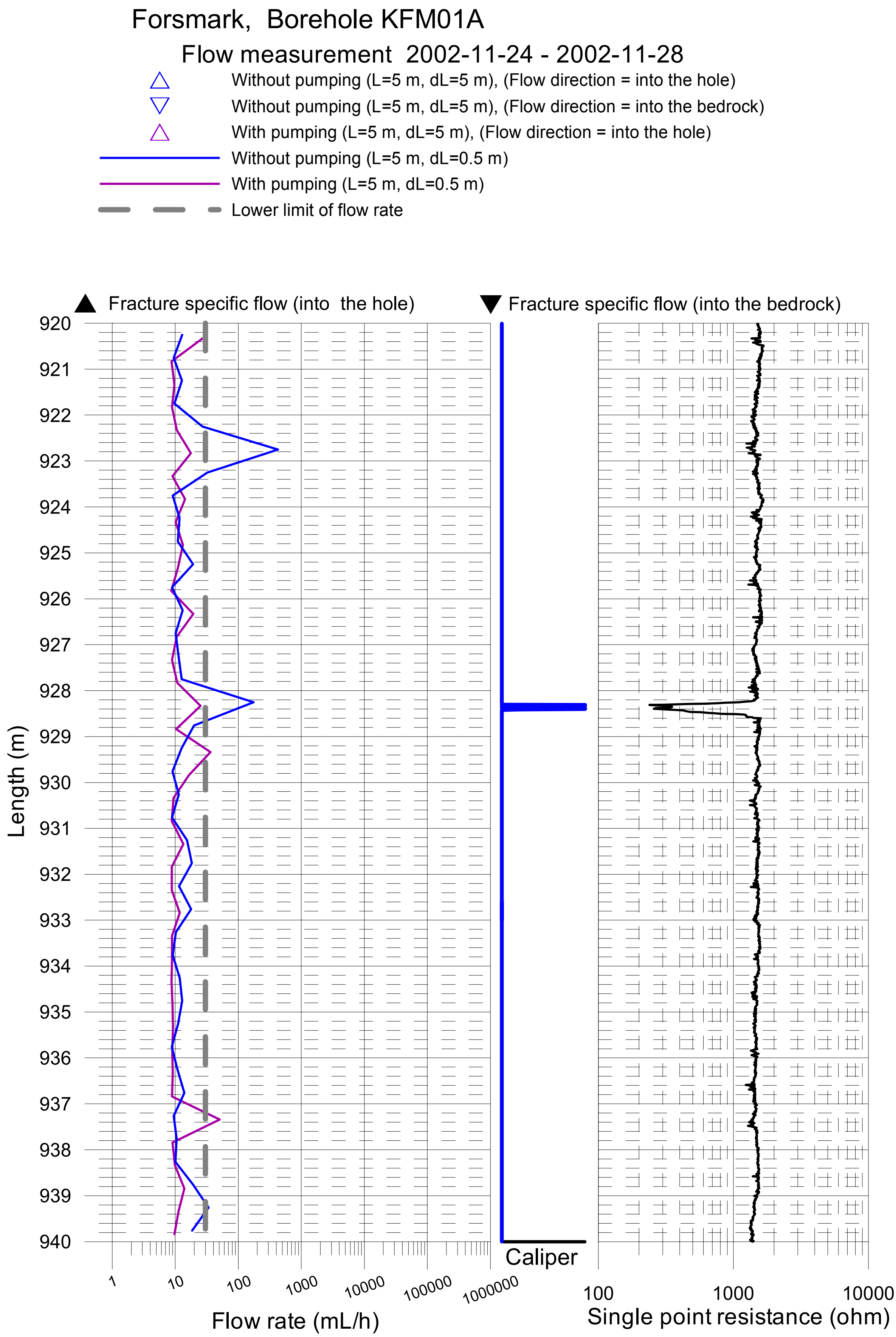


Forsmark, Borehole KFM01A

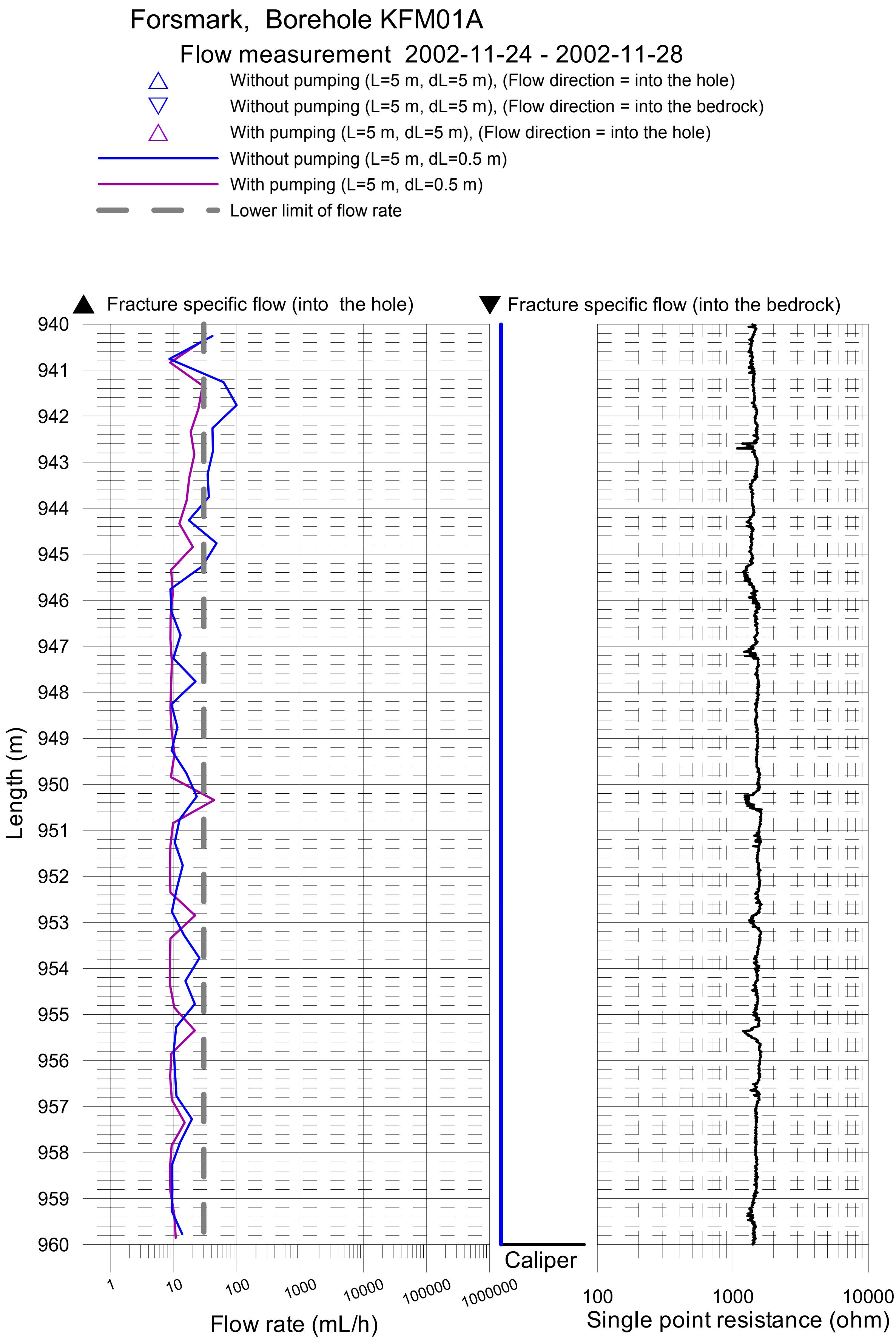
Flow measurement 2002-11-24 - 2002-11-28



Appendix 3.42



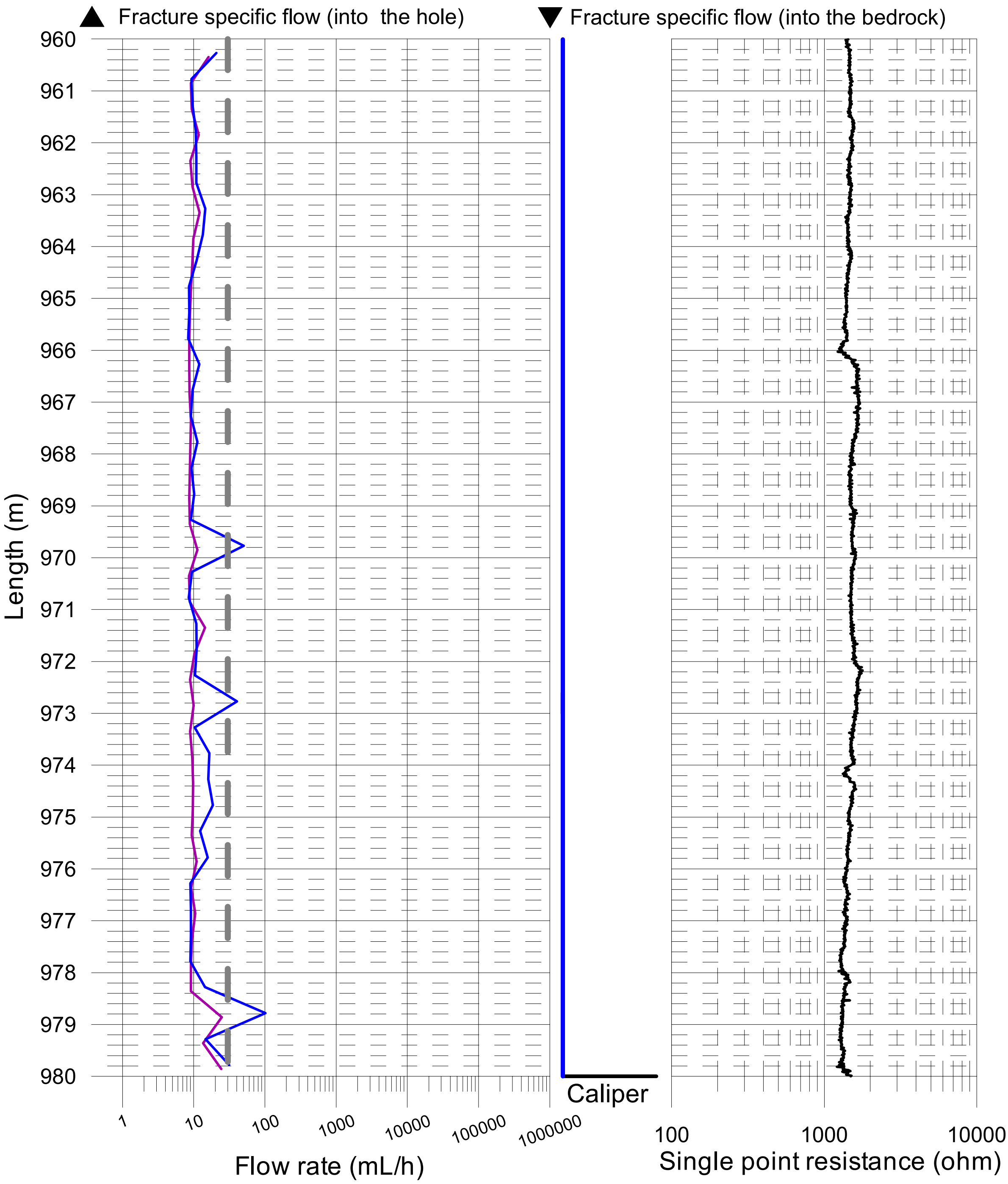
Appendix 3.43



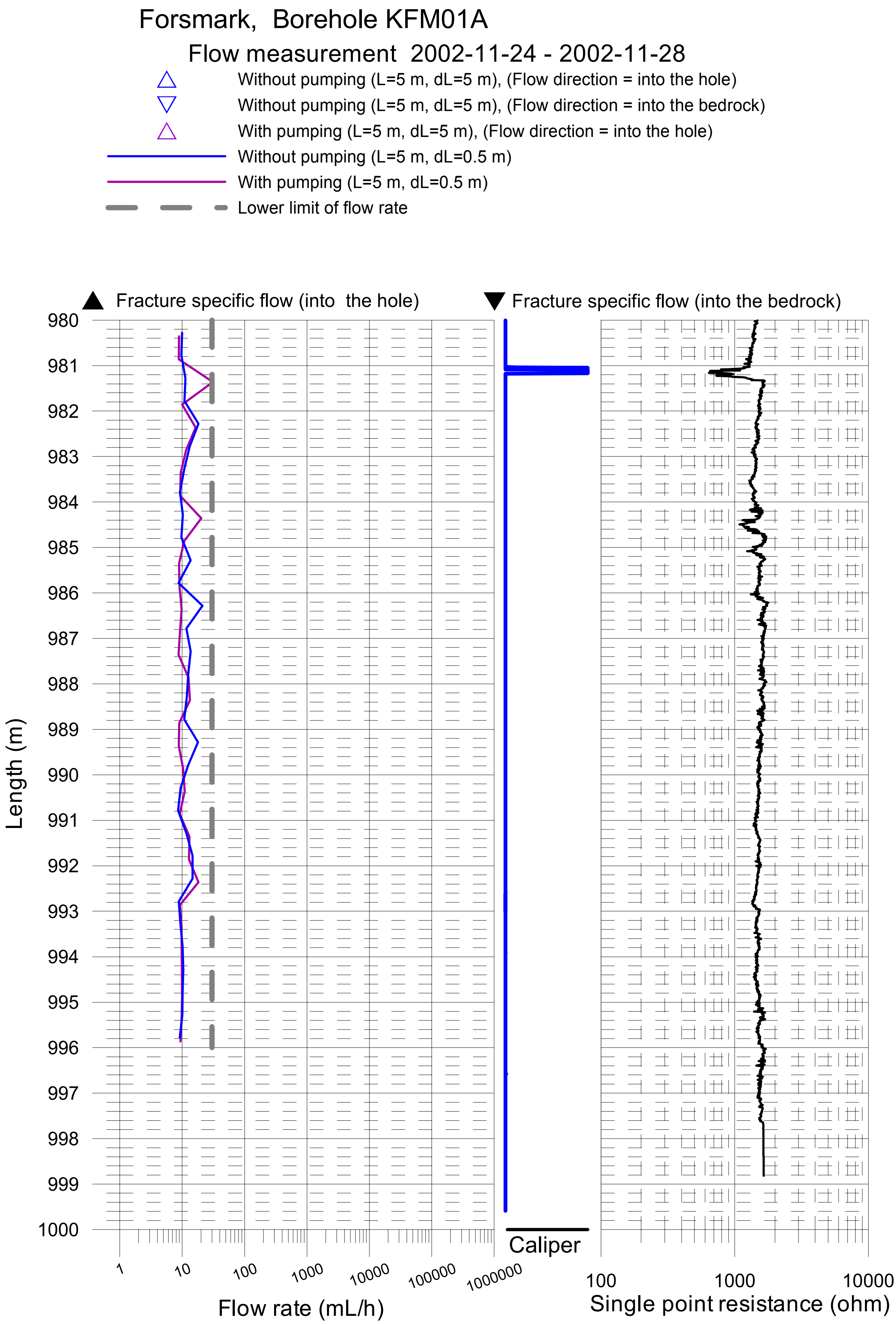
Forsmark, Borehole KFM01A

Flow measurement 2002-11-24 - 2002-11-28

△ Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
▽ Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
△ With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=0.5 m)
With pumping (L=5 m, dL=0.5 m)
Lower limit of flow rate



Appendix 3.45



Appendix 4.1

Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)	Borehole Head2 (masl)	Flow2 (mL/h)	Section Head (masl)	T_S (m^2/s)	Q-lower limit Practical (mL/h)	T_S-Lower Limit Theoretical (m^2/s)	T_S-Lower Limit Practical (m^2/s)	T_S-Upper Limit (m^2/s)
105.45	-1.58	0	105.49	-12.70	45	-	1.11E-09	30	1.48E-10	7.41E-10	7.41E-06
110.45	-1.58	48	110.49	-12.74	1962	-1.30	4.72E-08	30	1.48E-10	7.39E-10	7.39E-06
115.45	-1.57	40	115.49	-12.73	2563	-1.39	6.20E-08	30	1.48E-10	7.38E-10	7.38E-06
120.44	-1.57	0	120.49	-12.74	407	-	1.00E-08	30	1.48E-10	7.38E-10	7.38E-06
125.44	-1.56	0	125.49	-12.74	76	-	1.88E-09	30	1.48E-10	7.38E-10	7.38E-06
130.44	-1.56	0	130.50	-12.74	0	-	-	30	1.47E-10	7.37E-10	7.37E-06
135.44	-1.55	0	135.50	-12.74	0	-	-	30	1.47E-10	7.37E-10	7.37E-06
140.43	-1.55	0	140.50	-12.73	49	-	1.22E-09	30	1.47E-10	7.37E-10	7.37E-06
145.43	-1.55	-54	145.50	-12.74	1247	-2.01	3.20E-08	30	1.47E-10	7.36E-10	7.36E-06
150.43	-1.54	0	150.50	-12.74	0	-	-	30	1.47E-10	7.36E-10	7.36E-06
155.43	-1.54	0	155.50	-12.74	530	-	1.30E-08	30	1.47E-10	7.36E-10	7.36E-06
160.44	-1.53	0	160.51	-12.74	52	-	1.28E-09	30	1.47E-10	7.36E-10	7.36E-06
165.44	-1.53	0	165.51	-12.74	0	-	-	30	1.47E-10	7.36E-10	7.36E-06
170.44	-1.53	0	170.51	-12.73	0	-	-	30	1.47E-10	7.36E-10	7.36E-06
175.44	-1.52	131	175.51	-12.74	2116	-0.78	4.87E-08	30	1.47E-10	7.35E-10	7.35E-06
180.44	-1.52	0	180.51	-12.73	0	-	-	30	1.47E-10	7.35E-10	7.35E-06
185.45	-1.52	10	185.52	-12.74	126	-0.55	2.85E-09	30	1.47E-10	7.34E-10	7.34E-06
190.45	-1.51	0	190.52	-12.73	0	-	-	30	1.47E-10	7.35E-10	7.35E-06
195.45	-1.51	0	195.52	-12.74	0	-	-	30	1.47E-10	7.34E-10	7.34E-06
200.45	-1.50	0	200.52	-12.74	0	-	-	30	1.47E-10	7.34E-10	7.34E-06
205.45	-1.50	0	205.52	-12.74	0	-	-	30	1.47E-10	7.34E-10	7.34E-06
210.46	-1.50	0	210.52	-12.74	0	-	-	30	1.47E-10	7.34E-10	7.34E-06
215.46	-1.50	0	215.52	-12.74	0	-	-	30	1.47E-10	7.33E-10	7.33E-06
220.46	-1.50	0	220.52	-12.73	0	-	-	30	1.47E-10	7.34E-10	7.34E-06
225.47	-1.50	0	225.52	-12.74	20	-	4.84E-10	30	1.47E-10	7.33E-10	7.33E-06
230.47	-1.49	0	230.52	-12.73	0	-	-	30	1.47E-10	7.33E-10	7.33E-06
235.47	-1.49	0	235.52	-12.73	0	-	-	30	1.47E-10	7.33E-10	7.33E-06

Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)	Borehole Head2 (masl)	Flow2 (mL/h)	Section Head (masl)	T_S (m^2/s)	Q-lower limit Practical (mL/h)	T_S-Lower Limit Theoretical (m^2/s)	T_S-Lower Limit Practical (m^2/s)	T_S-Upper Limit (m^2/s)
240.48	-1.48	0	240.52	-12.73	0	-	-	30	1.47E-10	7.33E-10	7.33E-06
245.48	-1.48	0	245.52	-12.74	0	-	-	30	1.46E-10	7.32E-10	7.32E-06
250.48	-1.47	0	250.52	-12.73	0	-	-	30	1.46E-10	7.32E-10	7.32E-06
255.48	-1.47	0	255.52	-12.73	0	-	-	30	1.46E-10	7.32E-10	7.32E-06
260.48	-1.47	0	260.52	-12.74	0	-	-	30	1.46E-10	7.31E-10	7.31E-06
265.48	-1.46	0	265.52	-12.73	22	-	5.45E-10	30	1.46E-10	7.31E-10	7.31E-06
270.48	-1.46	0	270.52	-12.73	37	-	8.90E-10	30	1.46E-10	7.31E-10	7.31E-06
275.47	-1.46	0	275.52	-12.73	9	-	2.27E-10	30	1.46E-10	7.31E-10	7.31E-06
280.47	-1.45	0	280.52	-12.73	0	-	-	30	1.46E-10	7.31E-10	7.31E-06
285.47	-1.45	0	285.52	-12.74	0	-	-	30	1.46E-10	7.30E-10	7.30E-06
290.47	-1.45	0	290.52	-12.73	40	-	9.75E-10	30	1.46E-10	7.30E-10	7.30E-06
295.47	-1.44	0	295.52	-12.73	0	-	-	30	1.46E-10	7.30E-10	7.30E-06
300.47	-1.44	0	300.52	-12.74	0	-	-	30	1.46E-10	7.30E-10	7.30E-06
305.47	-1.44	0	305.53	-12.73	23	-	5.55E-10	30	1.46E-10	7.30E-10	7.30E-06
310.48	-1.44	0	310.53	-12.74	0	-	-	30	1.46E-10	7.29E-10	7.29E-06
315.48	-1.43	0	315.53	-12.73	119	-	2.89E-09	30	1.46E-10	7.29E-10	7.29E-06
320.48	-1.43	0	320.54	-12.73	51	-	1.25E-09	30	1.46E-10	7.29E-10	7.29E-06
325.48	-1.43	0	325.54	-12.73	24	-	5.80E-10	30	1.46E-10	7.29E-10	7.29E-06
330.48	-1.42	0	330.55	-12.73	18	-	4.29E-10	30	1.46E-10	7.29E-10	7.29E-06
335.49	-1.42	0	335.55	-12.73	0	-	-	30	1.46E-10	7.29E-10	7.29E-06
340.49	-1.42	0	340.55	-12.73	0	-	-	30	1.46E-10	7.29E-10	7.29E-06
345.49	-1.42	0	345.56	-12.73	0	-	-	30	1.46E-10	7.28E-10	7.28E-06
350.49	-1.41	0	350.56	-12.73	0	-	-	30	1.46E-10	7.28E-10	7.28E-06
355.49	-1.41	0	355.56	-12.74	0	-	-	30	1.46E-10	7.28E-10	7.28E-06
360.50	-1.41	0	360.56	-12.73	30	-	7.20E-10	30	1.46E-10	7.28E-10	7.28E-06
365.50	-1.41	0	365.56	-12.73	0	-	-	30	1.46E-10	7.28E-10	7.28E-06
370.50	-1.40	0	370.56	-12.73	0	-	-	30	1.45E-10	7.27E-10	7.27E-06

Appendix 4.3

Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)	Borehole Head2 (masl)	Flow2 (mL/h)	Section Head (masl)	T_S (m^2/s)	Q-lower limit Practical (mL/h)	T_S-Lower Limit Theoretical (m^2/s)	T_S-Lower Limit Practical (m^2/s)	T_S-Upper Limit (m^2/s)
375.50	-1.40	0	375.55	-12.73	0	-	-	30	1.45E-10	7.27E-10	7.27E-06
380.50	-1.40	0	380.55	-12.73	0	-	-	30	1.45E-10	7.27E-10	7.27E-06
385.51	-1.40	0	385.55	-12.73	0	-	-	30	1.45E-10	7.27E-10	7.27E-06
390.51	-1.39	0	390.55	-12.73	0	-	-	30	1.45E-10	7.27E-10	7.27E-06
395.51	-1.39	0	395.55	-12.73	0	-	-	30	1.45E-10	7.27E-10	7.27E-06
400.51	-1.39	0	400.55	-12.73	0	-	-	30	1.45E-10	7.27E-10	7.27E-06
405.51	-1.39	0	405.55	-12.74	0	-	-	30	1.45E-10	7.26E-10	7.26E-06
410.51	-1.39	0	410.55	-12.74	0	-	-	30	1.45E-10	7.26E-10	7.26E-06
415.51	-1.38	0	415.55	-12.74	0	-	-	30	1.45E-10	7.26E-10	7.26E-06
420.51	-1.38	0	420.55	-12.74	0	-	-	30	1.45E-10	7.25E-10	7.25E-06
425.50	-1.38	0	425.55	-12.74	0	-	-	30	1.45E-10	7.26E-10	7.26E-06
430.50	-1.37	0	430.55	-12.74	0	-	-	30	1.45E-10	7.25E-10	7.25E-06
435.50	-1.37	0	435.55	-12.73	0	-	-	30	1.45E-10	7.26E-10	7.26E-06
440.50	-1.37	0	440.55	-12.73	0	-	-	30	1.45E-10	7.25E-10	7.25E-06
445.50	-1.37	0	445.55	-12.73	0	-	-	30	1.45E-10	7.25E-10	7.25E-06
450.50	-1.37	0	450.54	-12.74	0	-	-	30	1.45E-10	7.25E-10	7.25E-06
455.50	-1.36	0	455.54	-12.74	0	-	-	30	1.45E-10	7.25E-10	7.25E-06
460.50	-1.36	0	460.54	-12.73	0	-	-	30	1.45E-10	7.25E-10	7.25E-06
465.50	-1.36	0	465.54	-12.73	0	-	-	30	1.45E-10	7.24E-10	7.24E-06
470.50	-1.36	0	470.54	-12.73	0	-	-	30	1.45E-10	7.24E-10	7.24E-06
475.49	-1.35	0	475.54	-12.73	0	-	-	30	1.45E-10	7.24E-10	7.24E-06
480.49	-1.35	0	480.54	-12.74	0	-	-	30	1.45E-10	7.24E-10	7.24E-06
485.49	-1.35	0	485.54	-12.74	0	-	-	30	1.45E-10	7.24E-10	7.24E-06
490.49	-1.35	0	490.54	-12.74	0	-	-	30	1.45E-10	7.24E-10	7.24E-06
495.49	-1.35	0	495.54	-12.73	0	-	-	30	1.45E-10	7.24E-10	7.24E-06
500.49	-1.34	0	500.54	-12.74	0	-	-	30	1.45E-10	7.23E-10	7.23E-06
505.50	-1.34	0	505.54	-12.73	0	-	-	30	1.45E-10	7.24E-10	7.24E-06

Appendix 4.4

Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)	Borehole Head2 (masl)	Flow2 (mL/h)	Section Head (masl)	T_S (m^2/s)	Q-lower limit Practical (mL/h)	T_S-Lower Limit Theoretical (m^2/s)	T_S-Lower Limit Practical (m^2/s)	T_S-Upper Limit (m^2/s)
510.50	-1.34	0	510.55	-12.73	0	-	-	30	1.45E-10	7.23E-10	7.23E-06
515.50	-1.34	0	515.55	-12.73	0	-	-	30	1.45E-10	7.23E-10	7.23E-06
520.51	-1.33	0	520.55	-12.73	0	-	-	30	1.45E-10	7.23E-10	7.23E-06
525.51	-1.33	0	525.55	-12.73	0	-	-	30	1.45E-10	7.23E-10	7.23E-06
530.52	-1.33	0	530.55	-12.73	0	-	-	30	1.45E-10	7.23E-10	7.23E-06
535.52	-1.33	0	535.56	-12.74	0	-	-	30	1.44E-10	7.22E-10	7.22E-06
540.52	-1.33	0	540.56	-12.74	0	-	-	30	1.44E-10	7.22E-10	7.22E-06
545.53	-1.32	0	545.56	-12.74	0	-	-	30	1.44E-10	7.22E-10	7.22E-06
550.53	-1.32	0	550.56	-12.73	0	-	-	30	1.44E-10	7.22E-10	7.22E-06
555.53	-1.32	0	555.57	-12.73	0	-	-	30	1.44E-10	7.22E-10	7.22E-06
560.53	-1.32	0	560.57	-12.74	0	-	-	30	1.44E-10	7.22E-10	7.22E-06
565.54	-1.32	0	565.58	-12.73	0	-	-	30	1.44E-10	7.22E-10	7.22E-06
570.54	-1.31	0	570.59	-12.74	0	-	-	30	1.44E-10	7.22E-10	7.22E-06
575.54	-1.31	0	575.59	-12.73	0	-	-	30	1.44E-10	7.22E-10	7.22E-06
580.55	-1.31	0	580.60	-12.73	0	-	-	30	1.44E-10	7.22E-10	7.22E-06
585.55	-1.31	0	585.60	-12.73	0	-	-	30	1.44E-10	7.21E-10	7.21E-06
590.56	-1.31	0	590.60	-12.73	0	-	-	30	1.44E-10	7.21E-10	7.21E-06
595.57	-1.31	0	595.61	-12.73	0	-	-	30	1.44E-10	7.21E-10	7.21E-06
600.57	-1.30	0	600.61	-12.74	0	-	-	30	1.44E-10	7.21E-10	7.21E-06
605.58	-1.30	0	605.61	-12.73	0	-	-	30	1.44E-10	7.21E-10	7.21E-06
610.58	-1.30	0	610.62	-12.73	0	-	-	30	1.44E-10	7.21E-10	7.21E-06
615.58	-1.30	0	615.62	-12.74	0	-	-	30	1.44E-10	7.21E-10	7.21E-06
620.59	-1.30	0	620.62	-12.73	0	-	-	30	1.44E-10	7.21E-10	7.21E-06
625.59	-1.29	0	625.62	-12.73	0	-	-	30	1.44E-10	7.20E-10	7.20E-06
630.60	-1.29	0	630.62	-12.73	0	-	-	30	1.44E-10	7.20E-10	7.20E-06
635.60	-1.29	0	635.63	-12.73	0	-	-	30	1.44E-10	7.20E-10	7.20E-06
640.60	-1.29	0	640.63	-12.73	0	-	-	30	1.44E-10	7.20E-10	7.20E-06

Appendix 4.5

Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)	Borehole Head2 (masl)	Flow2 (mL/h)	Section Head (masl)	T_S (m^2/s)	Q-lower limit Practical (mL/h)	T_S-Lower Limit Theoretical (m^2/s)	T_S-Lower Limit Practical (m^2/s)	T_S-Upper Limit (m^2/s)
645.61	-1.29	0	645.63	-12.73	0	-	-	30	1.44E-10	7.20E-10	7.20E-06
650.61	-1.29	0	650.64	-12.73	0	-	-	30	1.44E-10	7.20E-10	7.20E-06
655.62	-1.28	0	655.64	-12.73	0	-	-	30	1.44E-10	7.20E-10	7.20E-06
660.62	-1.28	0	660.65	-12.73	0	-	-	30	1.44E-10	7.20E-10	7.20E-06
665.62	-1.28	0	665.66	-12.73	0	-	-	30	1.44E-10	7.20E-10	7.20E-06
670.63	-1.28	0	670.67	-12.73	0	-	-	30	1.44E-10	7.19E-10	7.19E-06
675.63	-1.27	0	675.68	-12.73	0	-	-	30	1.44E-10	7.19E-10	7.19E-06
680.64	-1.27	0	680.69	-12.73	0	-	-	30	1.44E-10	7.19E-10	7.19E-06
685.64	-1.27	0	685.70	-12.73	0	-	-	30	1.44E-10	7.19E-10	7.19E-06
690.64	-1.27	0	690.71	-12.73	0	-	-	30	1.44E-10	7.19E-10	7.19E-06
695.65	-1.27	0	695.72	-12.73	0	-	-	30	1.44E-10	7.19E-10	7.19E-06
700.65	-1.27	0	700.72	-12.74	0	-	-	30	1.44E-10	7.19E-10	7.19E-06
705.65	-1.26	0	705.72	-12.73	0	-	-	30	1.44E-10	7.19E-10	7.19E-06
710.66	-1.26	0	710.72	-12.73	0	-	-	30	1.44E-10	7.19E-10	7.19E-06
715.66	-1.26	0	715.72	-12.73	0	-	-	30	1.44E-10	7.18E-10	7.18E-06
720.66	-1.26	0	720.72	-12.74	0	-	-	30	1.44E-10	7.18E-10	7.18E-06
725.66	-1.26	0	725.72	-12.73	0	-	-	30	1.44E-10	7.18E-10	7.18E-06
730.66	-1.25	0	730.72	-12.73	0	-	-	30	1.44E-10	7.18E-10	7.18E-06
735.67	-1.25	0	735.72	-12.73	0	-	-	30	1.44E-10	7.18E-10	7.18E-06
740.67	-1.25	0	740.72	-12.74	0	-	-	30	1.44E-10	7.18E-10	7.18E-06
745.67	-1.25	0	745.72	-12.74	0	-	-	30	1.44E-10	7.18E-10	7.18E-06
750.67	-1.25	0	750.72	-12.73	0	-	-	30	1.44E-10	7.18E-10	7.18E-06
755.67	-1.25	0	755.73	-12.73	0	-	-	30	1.44E-10	7.18E-10	7.18E-06
760.68	-1.25	0	760.74	-12.73	0	-	-	30	1.44E-10	7.18E-10	7.18E-06
765.68	-1.24	0	765.74	-12.73	0	-	-	30	1.43E-10	7.17E-10	7.17E-06
770.68	-1.24	0	770.75	-12.73	0	-	-	30	1.43E-10	7.17E-10	7.17E-06
775.69	-1.24	0	775.75	-12.73	0	-	-	30	1.43E-10	7.17E-10	7.17E-06

Appendix 4.6

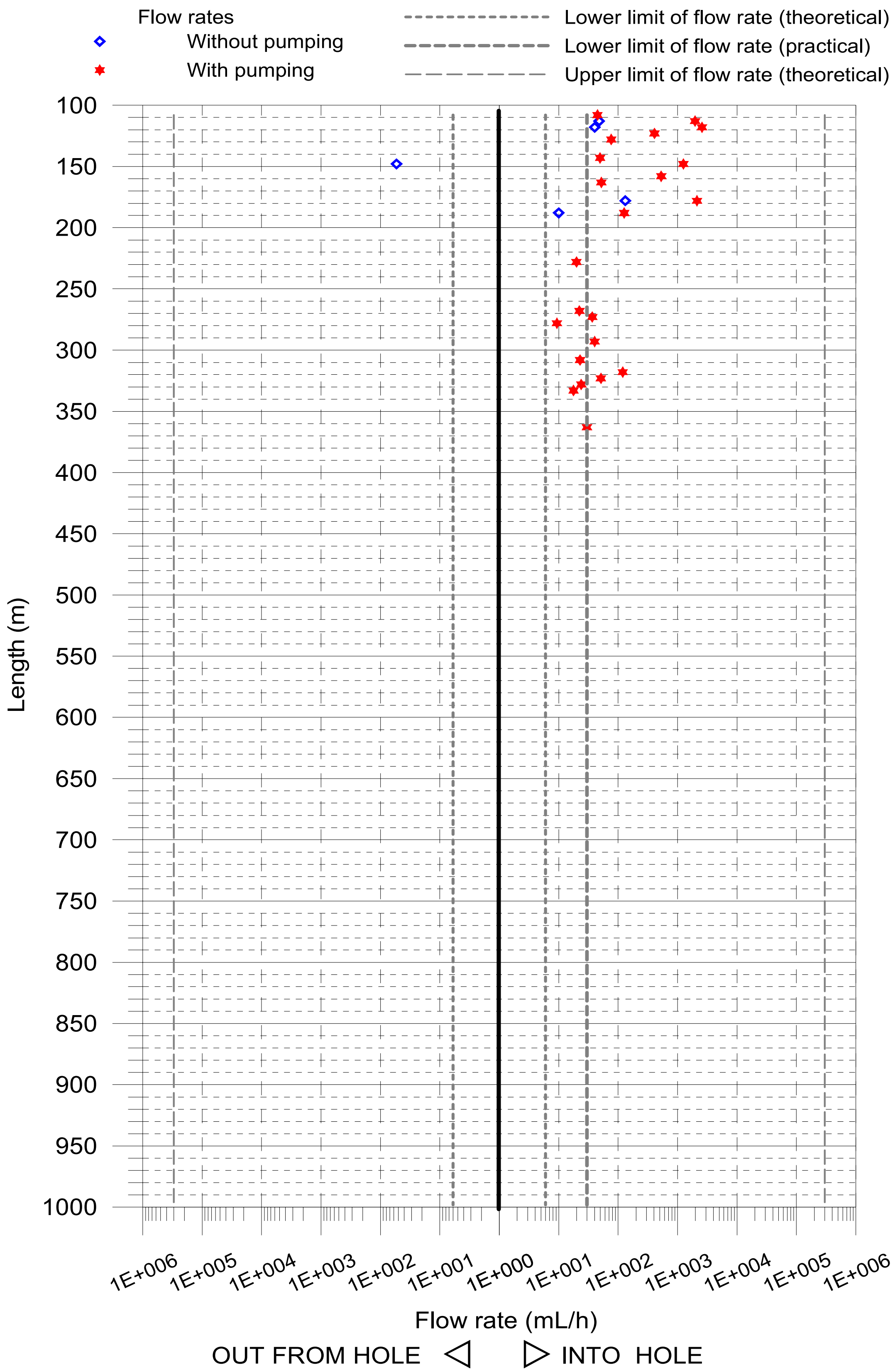
Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)	Borehole Head2 (masl)	Flow2 (mL/h)	Section Head (masl)	T_s (m^2/s)	Q-lower limit Practical (mL/h)	T_s-Lower Limit Theoretical (m^2/s)	T_s-Lower Limit Practical (m^2/s)	T_s-Upper Limit (m^2/s)
780.69	-1.24	0	780.76	-12.74	0	-	-	30	1.43E-10	7.17E-10	7.17E-06
785.69	-1.24	0	785.77	-12.73	0	-	-	30	1.43E-10	7.17E-10	7.17E-06
790.70	-1.23	0	790.77	-12.73	0	-	-	30	1.43E-10	7.17E-10	7.17E-06
795.70	-1.24	0	795.78	-12.73	0	-	-	30	1.43E-10	7.17E-10	7.17E-06
800.70	-1.23	0	800.78	-12.73	0	-	-	30	1.43E-10	7.17E-10	7.17E-06
805.70	-1.23	0	805.78	-12.73	0	-	-	30	1.43E-10	7.17E-10	7.17E-06
810.71	-1.23	0	810.79	-12.73	0	-	-	30	1.43E-10	7.16E-10	7.16E-06
815.71	-1.23	0	815.79	-12.73	0	-	-	30	1.43E-10	7.17E-10	7.17E-06
820.71	-1.23	0	820.79	-12.74	0	-	-	30	1.43E-10	7.16E-10	7.16E-06
825.71	-1.23	0	825.79	-12.73	0	-	-	30	1.43E-10	7.16E-10	7.16E-06
830.71	-1.22	0	830.79	-12.73	0	-	-	30	1.43E-10	7.16E-10	7.16E-06
835.72	-1.22	0	835.80	-12.73	0	-	-	30	1.43E-10	7.16E-10	7.16E-06
840.72	-1.22	0	840.80	-12.73	0	-	-	30	1.43E-10	7.16E-10	7.16E-06
845.72	-1.22	0	845.80	-12.73	0	-	-	30	1.43E-10	7.16E-10	7.16E-06
850.72	-1.22	0	850.80	-12.73	0	-	-	30	1.43E-10	7.16E-10	7.16E-06
855.72	-1.22	0	855.80	-12.73	0	-	-	30	1.43E-10	7.16E-10	7.16E-06
860.73	-1.21	0	860.81	-12.73	0	-	-	30	1.43E-10	7.15E-10	7.15E-06
865.73	-1.21	0	865.81	-12.73	0	-	-	30	1.43E-10	7.16E-10	7.16E-06
870.73	-1.21	0	870.81	-12.73	0	-	-	30	1.43E-10	7.15E-10	7.15E-06
875.73	-1.21	0	875.81	-12.73	0	-	-	30	1.43E-10	7.15E-10	7.15E-06
880.74	-1.21	0	880.82	-12.74	0	-	-	30	1.43E-10	7.15E-10	7.15E-06
885.74	-1.21	0	885.82	-12.73	0	-	-	30	1.43E-10	7.15E-10	7.15E-06
890.74	-1.21	0	890.82	-12.73	0	-	-	30	1.43E-10	7.15E-10	7.15E-06
895.74	-1.20	0	895.82	-12.73	0	-	-	30	1.43E-10	7.15E-10	7.15E-06
900.74	-1.20	0	900.82	-12.73	0	-	-	30	1.43E-10	7.15E-10	7.15E-06
905.75	-1.20	0	905.83	-12.73	0	-	-	30	1.43E-10	7.15E-10	7.15E-06
910.75	-1.20	0	910.83	-12.73	0	-	-	30	1.43E-10	7.15E-10	7.15E-06

Appendix 4.7

Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)	Borehole Head2 (masl)	Flow2 (mL/h)	Section Head (masl)	T_S (m^2/s)	Q-lower limit Practical (mL/h)	T_S-Lower Limit Theoretical (m^2/s)	T_S-Lower Limit Practical (m^2/s)	T_S-Upper Limit (m^2/s)
915.75	-1.20	0	915.83	-12.74	0	-	-	30	1.43E-10	7.14E-10	7.14E-06
920.75	-1.20	0	920.83	-12.73	0	-	-	30	1.43E-10	7.14E-10	7.14E-06
925.75	-1.19	0	925.83	-12.74	0	-	-	30	1.43E-10	7.14E-10	7.14E-06
930.76	-1.19	0	930.84	-12.74	0	-	-	30	1.43E-10	7.14E-10	7.14E-06
935.76	-1.19	0	935.84	-12.74	0	-	-	30	1.43E-10	7.14E-10	7.14E-06
940.76	-1.19	0	940.84	-12.74	0	-	-	30	1.43E-10	7.14E-10	7.14E-06
945.76	-1.19	0	945.84	-12.74	0	-	-	30	1.43E-10	7.14E-10	7.14E-06
950.77	-1.19	0	950.85	-12.74	0	-	-	30	1.43E-10	7.14E-10	7.14E-06
955.77	-1.18	0	955.85	-12.74	0	-	-	30	1.43E-10	7.14E-10	7.14E-06
960.77	-1.18	0	960.85	-12.74	0	-	-	30	1.43E-10	7.13E-10	7.13E-06
965.77	-1.18	0	965.85	-12.73	0	-	-	30	1.43E-10	7.14E-10	7.14E-06
970.77	-1.18	0	970.85	-12.74	0	-	-	30	1.43E-10	7.13E-10	7.13E-06
975.78	-1.18	0	975.86	-12.74	0	-	-	30	1.43E-10	7.13E-10	7.13E-06
980.78	-1.18	0	980.86	-12.74	0	-	-	30	1.43E-10	7.13E-10	7.13E-06
985.78	-1.18	0	985.86	-12.73	0	-	-	30	1.43E-10	7.13E-10	7.13E-06
990.78	-1.17	0	990.86	-12.73	0	-	-	30	1.43E-10	7.13E-10	7.13E-06
995.78	-1.18	0	995.86	-12.74	0	-	-	30	1.43E-10	7.13E-10	7.13E-06

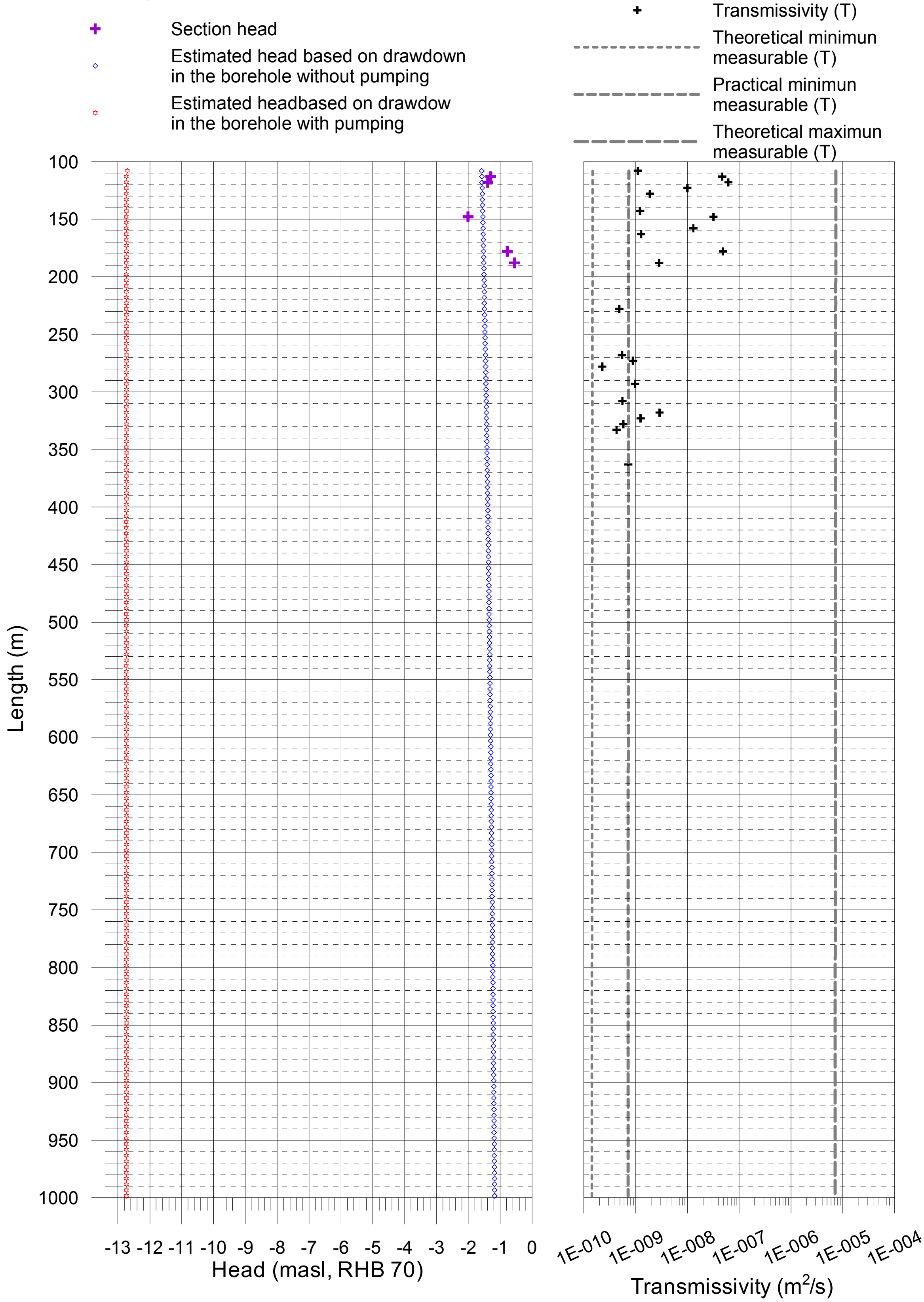
Appendix 5.1

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



Appendix 5.2

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



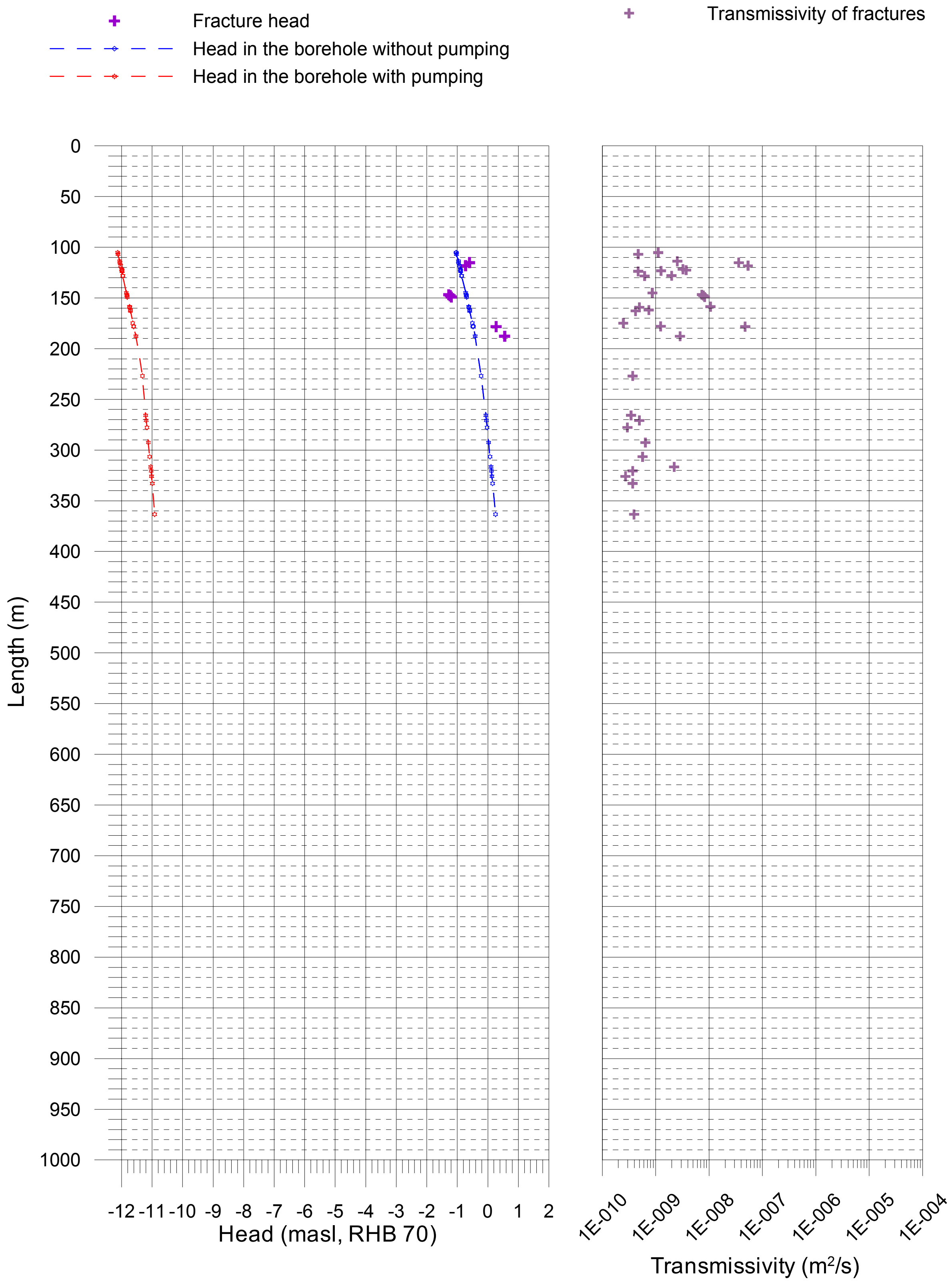
Appendix 6.1

Length to fracture (m)	Borehole head1 (masl)	Flow1 (mL/h)	Borehole head2 (masl)	Flow2 (mL/h)	T_f (m^2/s)	Fracture head (masl)
105.3	-1.04	0	-12.13	45	1.11E-09	-
106.9	-1.03	0	-12.12	19	4.71E-10 *	-
113.8	-0.96	0	-12.07	103	2.55E-09	-
115.2	-0.96	47	-12.05	1500	3.60E-08	-0.60
118.3	-0.93	40	-12.03	2200	5.35E-08	-0.73
121.7	-0.91	0	-12.00	130	3.22E-09	-
122.6	-0.90	0	-11.99	150	3.72E-09	-
123.3	-0.89	0	-11.99	51	1.26E-09 *	-
123.8	-0.89	0	-11.99	19	4.70E-10 *	-
128.1	-0.86	0	-11.96	80	1.98E-09 *	-
128.4	-0.85	0	-11.96	25	6.19E-10 *	-
145.0	-0.73	0	-11.85	35	8.66E-10 *	-
146.8	-0.71	-15	-11.83	280	7.29E-09	-1.28
147.7	-0.70	-15	-11.82	300	7.78E-09	-1.23
149.1	-0.70	-15	-11.81	320	8.28E-09	-1.19
158.6	-0.63	0	-11.74	430	1.06E-08	-
159.3	-0.62	0	-11.73	20	4.94E-10 *	-
161.9	-0.60	0	-11.71	30	7.42E-10 *	-
162.9	-0.59	0	-11.71	17	4.20E-10 *	-
174.8	-0.51	0	-11.63	10	2.47E-10 *	-
178.0	-0.48	0	-11.61	50	1.24E-09 *	-
178.3	-0.48	130	-11.60	2050	4.74E-08	0.27
187.8	-0.42	10	-11.53	125	2.84E-09	0.55
227.0	-0.22	0	-11.32	15	3.71E-10 *	-
265.8	-0.07	0	-11.21	14	3.45E-10 *	-
270.8	-0.05	0	-11.19	20	4.93E-10 *	-
277.7	-0.02	0	-11.17	12	2.96E-10*	-
292.6	0.03	0	-11.12	26	6.41E-10 *	-
306.6	0.07	0	-11.08	23	5.67E-10 *	-
316.6	0.10	0	-11.05	90	2.22E-09	-
320.6	0.12	0	-11.03	15	3.70E-10 *	-
325.9	0.13	0	-11.02	11	2.71E-10 *	-
332.9	0.16	0	-11.00	15	3.70E-10 *	-
363.4	0.25	0	-10.92	16	3.94E-10 *	-

* Uncertain

Appendix 6.2

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



Appendix 7

Forsmark, Borehole KFM01A
Comparison of transmissivity of borehole sections (5m) and fracture transmissivities