International Progress Report

IPR-01-06

Äspö Hard Rock Laboratory

Difference flow measurements in borehole KLX02 at Laxemar

Pekka Rouhiainen

PRG-Tec Oy

September 2000

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

Äspö Hard Rock Laboratory

Report no.	No.
IPR-01-06	F73K
Author	Date
Pekka Rouhiainen	01-09-01
Checked by	Date
Karl-Erik Almén	01-03-02
Approved	Date
Christer Svemar	01-04-18

Äspö Hard Rock Laboratory

Difference flow measurements in borehole KLX02 at Laxemar

Pekka Rouhiainen

PRG-Tec Oy

September 2000

Keywords: Hydrogeology, hydraulic tests, flow logging, site investigations

Abstract

Posiva Flow Log using the difference flow method (DIFF) can be used for relatively fast determination of hydraulic properties of fractures or fractured zones. In this study the difference flowmeter was used both in normal mode and in detailed logging mode. The normal mode is used to obtain hydraulic conductivity and fresh water head of formations. The detailed mode is used for exact depth determination of fractures or fracture zones. In this study the detailed mode was extended to transmissivity determination of individual fractures. Electrical conductivity of groundwater (EC) from chosen fractures was measured during the detailed flow logging.

The measurements were performed in the deep borehole Laxemar KLX02 in Sweden in two field campaigns, the first one on February and March 2000 and the second one on May and June 2000.

The main tasks in Campaign 1 were the normal mode flow measurements and fresh water head measurements both when the borehole was in its natural state (not pumped) and when the borehole was pumped.

One of the tasks of Campaign 2 was to test whether the detailed flow logging could be used for determination of transmissivity of individual fractures. The second task in Campaign 2 was the combined electric conductivity of water (EC) measurement and detailed flow logging between 200 m and 1400 m.

This report presents the principles of the method as well as the results of the measurements carried out.

Sammanfattning

Posiva Flow Log/Differensflödesmetoden (DIFF) kan användas för relativt snabb bestämning av hydrauliska egenskaper av sprickor eller sprickzoner. I denna utredning användes differensflödesmetoden både enligt normal och detaljerad mätmetodik. Den normala mätmetodiken kan användas för bestämning av hydraulisk konduktivitet och grundvattentryck av formationen. Den detaljerade mätmetodiken kan användas för noggrann bestämning av vattenförande sprickor eller sprickzoner. I denna utredning tillämpades den detaljerade mätmetodiken också för bestämning av transmissivitet för enskilda sprickor. Grundvattnets elektrisk konduktivitet (EC) från valda sprickor mättes samtidigt med den detaljerade flödesmätningen.

Mätningarna utfördes i det djupa borrhålet KLX02 i Laxemar, Sverige. De genomfördes under två mätperioder, den första i februari och mars 2000 och den andra i maj och juni 2000.

Den första mätperioden viktigaste uppgift var flödesmätningar enligt normal mätmetodik samt mätning av tryckprofil längs borrhålet, dels vid naturligt tillstånd (utan pumpning) och dels när borrhålet pumpades.

En huvuduppgift under den andra mätperioden var att prova om flödesmätning enligt den detaljerade mätmetodiken kunde användas för bestämning av transmissivitet för enskilda sprickor. Ett annan uppgift under den andra mätningsperioden var att genomföra mätningarna av elektrisk konduktivitet och detaljerat flöde mellan 200 m och 1400 m i borrhålet.

Denna rapport beskriver mätprincipen för metoden och presenterar resultaten från de genomförda mätningarna.

Contents

1 Introduction

To meet the demanding needs to measure the hydraulic parameters in bedrock Posiva launched development of new flowmeter techniques including measuring methods and equipment in co-operation with PRG-Tec Oy in 1986. Ten years of persistence development has resulted in a whole family of flow measuring tools, Posiva Flow Log. The techniques have been tested and used in the ongoing site investigations in Finland, in underground Hard Rock Laboratory (HRL) at Äspö in Sweden and in URL in Canada.

The tests described in this study are one step in the development process of the difference flow method. They are carried out in co-operation with Svenska Kärnbränslehantering AB (SKB) and GEOSIGMA. Measurements were performed in the deep borehole KLX02 at Laxemar, Sweden.

The difference flow method (normal mode) for small flows (0.1-10 ml/min) is based on measuring the pulse transit time and direction of a thermal pulse in the sensor. For high flows (2-5000 ml/min) the method is based on thermal dilution rate of the sensor. Flow direction is measured by monitoring thermistors. Inflow or outflow in the test interval is created due to natural or by pumping induced differences between heads in the borehole water and groundwater around the borehole.

The single point resistance (and the temperature of borehole water) measurement is carried out simultaneously with the difference flow measurements, both in normal and detailed flow logging modes, while the tool is moving. The result is utilised for checking the exact depth of the tool. As a result a continuous log is obtained from which single fractures can be detected.

The suite of groundwater flow logging tools includes also electric conductivity (EC) measurements from the fracture-specific water in the borehole test section. It has been found convenient to conduct EC measurements in connection with the detailed flow logging. In this way hydraulically conductive fractures can be located during the same logging phase as EC values are attained from the most conductive fractures. The results of both the EC and the detailed flow logging measurements give valuable information for the determination of groundwater sampling points. The objective of EC measurement is to determine the distribution of the content of Total Dissolved Solids (TDS) in the groundwater. The detailed flow logging makes it possible to stop the tool on a fracture and to measure there as long as the water volume within the test section is flushed well enough to get a reliable EC reading. EC measurements are carried out from fractures with higher flow rates than the pre-set limit.

2 Principles of measurement

The method is a development of the conventional measurement of flow along a borehole. However, it is not the flow along the hole, but the changes of flow with depth that are useful. Measurement of flow along a hole is problematic, especially when the flow is strong because small changes in the flow may be concealed. This problem can be avoided if the changes of flow are measured directly.

With the new flow guide, flow along the hole outside the test section is directed so that it does not come into contact with the flow sensor. The flow into or out from the borehole in the test section is the only flow that passes through the flow sensor. Instead of inflatable packers, rubber disks are used at both ends of the flow guide. These isolate the borehole section to be measured, see Figure 2.1. The rubber disks are designed in such a way that they are always pressed against the borehole wall. Difference flow measurements differ from the conventional double packer tests in that there is no extra hydraulic pressure difference in the borehole section being measured relative to the remaining part of the hole.

The flow can be measured with the thermal pulse method and with the thermal dilution method. The thermal dilution method is used to expand the range of measurement to include higher flow rates. The flow range measured is normally 0.1 – 5000 ml/min when both the thermal pulse and thermal dilution methods are used and 2 – 5000 ml/min when only the thermal dilution method is used. Flow rates can be measured in both directions and flow direction can be determined.

The difference flowmeter can be used in several ways. The main modes are flow measurement in the normal mode and in the detailed flow logging mode. In the normal mode both thermal pulse and thermal dilution methods are used. In the detailed mode only the thermal dilution method is used to make the measurement faster.

A single difference flow measurement in normal mode at one depth interval normally takes 15 minutes. This time includes waiting time for temperature stabilisation, a flow measurement by the thermal pulse method, a flow measurement by the thermal dilution method, EC-background measurement and lifting of the cable to the next depth interval.

In the detailed flow logging mode one measurement using the thermal dilution method takes about ten seconds. The flow rate is measured in small depth increments, typically 0.1 m. The results are used for exact location of the conductive fractures and classifying them on the basis of flow rates.

When difference flow measurements are carried out in the surface boreholes, the flow rates are measured two times, without pumping the borehole and when the borehole is pumped. This corresponds measurements in closed and open borehole conditions when the work is done in a tunnel. The hydraulic head along the borehole is then constant, since the hydraulic conductivity of the borehole is very high compared with the conductivity of bedrock. Consequently the difference in head over the rubber disks used in the flow guide is very small. Constant hydraulic head in the borehole implies that the water density in the hole is constant and that there are no losses due to friction. If this is not the case, the hydraulic head at the measuring depth needs to be ascertained.

Density of saline water is higher than density of fresh water. Therefore fresh water head had to be measured in such cases as in borehole KLX02. In the cases of saline water, the term fresh water head is used instead of hydraulic head, since hydraulic head is not well defined in saline conditions.

Fresh water head in KLX02 was measured with a long tube filled with fresh water. The tube is open at the both ends. The depth of measurement is the depth of the lower end of the tube. Fresh water head is then the water level in the tube above a reference level. The reference level is usually the groundwater level in the borehole.

The fresh water head described above does not give absolute pressure values since the density variations of the fresh water in the tube are not taken in to account. Density of fresh water is 1 g/cm^3 at 4 °C and smaller when temperature is higher. Temperature profile along the tube is nearly the same as the temperature profile along the borehole. Density profile along the tube could be calculated and absolute pressure at the depth of measurement could be then evaluated but this is not done in this study.

The calculated heads of formations and fractures (described later) are not presented in absolute pressure values since they are derived from the measured fresh water head in the borehole and the measured flow values.

One option of the flowmeter tool is the electrode for electrical conductivity (EC) of groundwater. EC electrode is attached on the flow sensor, see Figure 2.1. For the measurement of electrical conductivity of groundwater, the borehole is pumped so that the flow direction is always from the fractures into the borehole. This enables the determination of electrical conductivity from fracture specific water. Both electrical conductivity and temperature of flowing water from the fractures are measured.

The simultaneous flow measurement makes it possible to find the fractures for the EC measurement. The tool is moved so that the fracture to be tested will be located within the test section. The EC measurement begins if the flow rate is larger than a predetermined limit.

The tool is kept on the selected fracture. The measurement is continued at the given depth allowing the fracture-specific water to enter the section. The waiting time for the EC measurement is automatically calculated from the measured flow rate. The aim is to flush the water volume within the test section well enough. The measuring computer is programmed to change the water volume (0.5 l) three times within the 0.5 m long test section. A special spiral structure in the section is used to improve flushing. All these phases of the measurement can be carried out automatically controlled by the logging computer (Öhberg and Rouhiainen 2000).

The EC measuring geometry is well adapted for measuring the fracture specific water. It is not as good in measuring the water in the borehole since exchange of water in the section is not always assured, the tool may carry the same water while moving on. A modified geometry is needed for measurement of EC of borehole water.

The single point resistance measurement (grounding resistance) is another option in the flowmeter tool. The electrode of the single point resistance tool is located within the upper rubber disks, see Figure 2.1. This sensitive method is used for exact depth determination of fractures and geological structures.

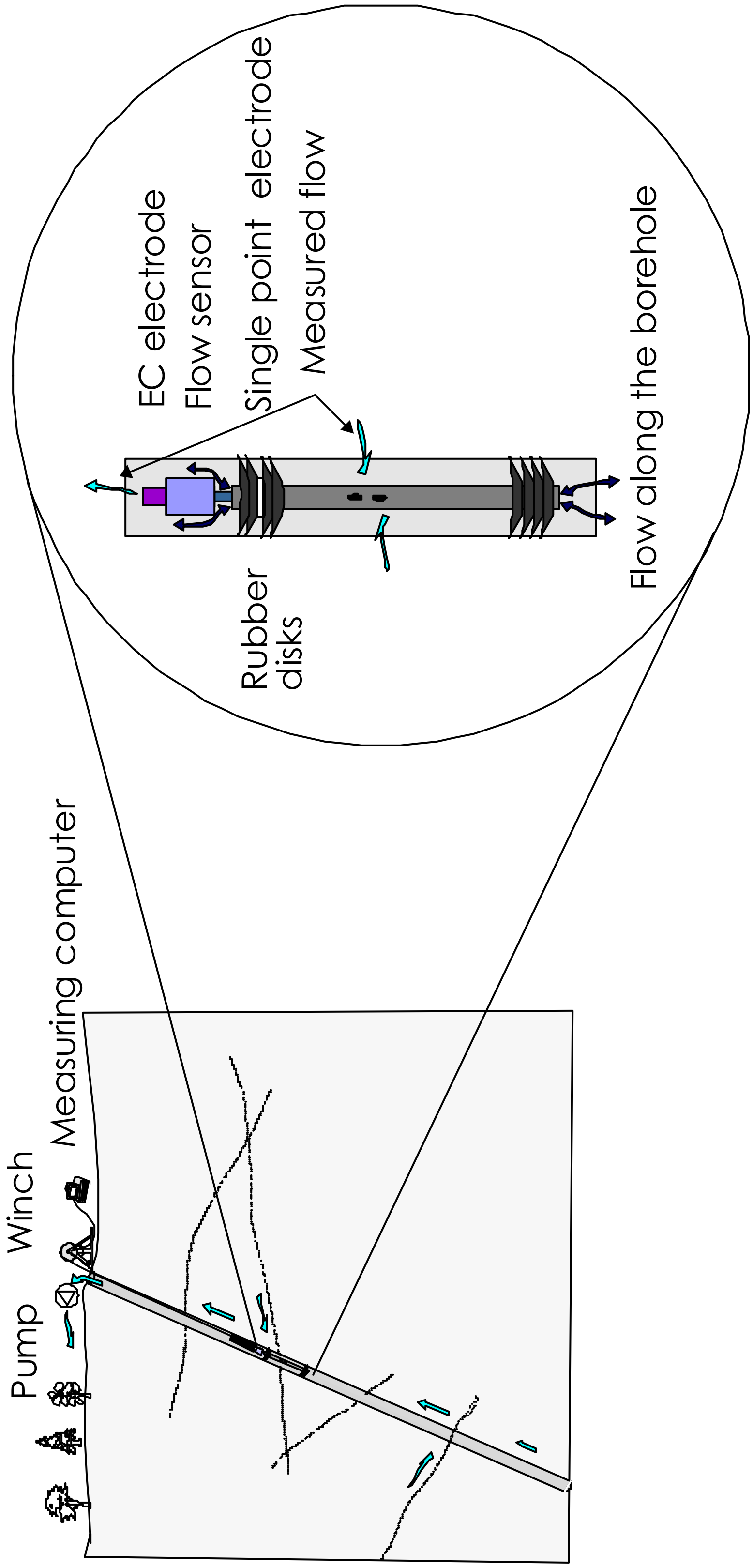


Figure 2-1 Schematic of the downhole equipment used in the DIFF flowmeter.

3 Interpretation

If measurements are carried out using two levels of potential in the borehole, then the hydraulic head in each of the sections and their conductivity can be calculated. It is assumed that a static flow condition exists.

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

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

where

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

K_n is hydraulic conductivity,

a is a constant depending on the flow geometry,

h_1 and h_2 are the hydraulic heads in the hole

h_0 is the head of the measured zone far from the hole

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, constant a is:

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

where

L is the length of the measured section,

R is the distance to constant potential h_0 and

r_0 is the radius of the hole.

The distance to constant potential h_0 is not known and it must be chosen. Here R/r_0 is chosen to be 500.

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

$$h_0 = (h_1 - b \cdot h_2)/(1-b) \quad \text{3-4}$$

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

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

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 (Rouhiainen and Pöllänen 1998).

4 Equipment specifications

The difference flowmeter measures the flow of groundwater into or out from a borehole within a given section. A flow guide is used to separate the section to be measured. Groundwater flowing into or out from the borehole within the section is guided past the flow sensor. Flow is measured using the thermal pulse and thermal dilution methods. Measured values are transmitted in digital form to the PC computer. (Rouhiainen and Pöllänen 1998).

Type of instrument:	Difference flow meter.
Borehole diameters:	56 mm, 66 mm and 76 mm.
Geometry of measurement:	A variable length of test section is used.
Method of flow measurement:	Thermal pulse and thermal dilution methods.
Range of flow measurement:	0.1 - 5000 ml/min, both directions when both the thermal pulse and thermal dilution methods are used. 2 – 5000 ml/min, both directions when only the thermal dilution method is used
Accuracy of flow measurement:	+/- 10 % of the current result.
Additional measurements:	
Temperature:	0 – 40 C, accuracy +/- 0.1 C
Single point resistance:	1 – 100000 Ohm
Conductivity of water:	0.2 – 100 S/m, accuracy +/- 5 % of the current reading
Winch:	Mount Sopris Wna 10, 0.55 kW, 220V/50Hz.
Logging computer:	PC, Windows 95/98

5 Field operation

The field operations were carried out in two campaigns. The main tasks in Campaign 1 were the normal mode flow measurements and fresh water head measurements both when the borehole was in its natural state (not pumped) and when the borehole was pumped. The section length and the depth increment (step) in the normal mode measurements were both 3 metres.

The pumping rate was smaller in the upper part of the borehole (200 – 400 m) where hydraulic conductivity was assumed to be high.

Table 3-1. Field operations in Campaign 1

Date	Description
2000-02-04	Installation
2000-02-05	Normal mode measurements 200 – 1400 m without pumping
2000-02-06	As above
2000-02-07	As above
2000-02-08	As above
2000-02-09	As above
2000-02-10	As above
2000-02-11	Fresh water head measurement 200 – 1400 m without pumping
2000-02-12	As above
2000-02-13	Pumping the borehole with 6. 2 m drawdown (about 20 l/min)
2000-02-14	As above
2000-02-15	Fresh water head measurement 200 – 400 m with 6. 2 m drawdown
2000-02-16	Normal mode measurements 200 – 400 m with 6. 2 m drawdown
2000-02-17	Preparation of fresh water head measurement at 1400 m
2000-02-18	Fresh water head transient measurement at 1400 m with 22 m drawdown
2000-02-19	As above
2000-02-20	As above
2000-02-21	Fresh water head measurement 400 - 1400 m with 22 m drawdown
2000-02-22	As above
2000-02-23	Normal mode measurements 400 – 1400 m with 22 m drawdown
2000-02-24	As above
2000-02-25	As above
2000-02-26	Checking the results with detailed mode (section 3 m, step 0.5 m) with 22 m drawdown
2000-02-27	Checking the results with normal mode with 22 m drawdown
2000-02-28	Fresh water head measurement 400 - 1400 m with 22 m drawdown
2000-02-29	As above
2000-03-01	Unpacking

One of the tasks of Campaign 2 was to test whether the detailed flow logging could be used for determination of transmissivity of individual fractures. The detailed flow logging utilises only the thermal dilution flow measuring techniques. For measuring transmissivity, the thermal dilution method was developed in such a way that it could measure flow direction in addition to flow rate. The detailed flow logging with thermal pulse flow measuring techniques was also used during this methodology test.

The second task in Campaign 2 was the combined electric conductivity of water (EC) measurement and detailed flow logging between 200 m and 1400 m.

Table 3-2. Field operations in Campaign 2

Date	Description
2000-05-26	Installation
2000-05-27	Normal mode measurements 200 – 400 m without pumping
2000-05-28	Detailed mode (section 3 m, step 0.5 m) 200 – 400 m without pumping
2000-05-29	Detailed mode (section 0.5 m, step 0.1 m) 200 – 400 m without pumping
2000-05-30	Detailed mode with thermal pulse (section 0.5 m, step 0.1 m) 205 – 226 m without pumping
2000-05-31	Beginning of pumping the borehole with 1.0 m drawdown
2000-06-01	Detailed mode (section 0.5 m, step 0.1 m) 200 – 400 m with 1.0 m drawdown
2000-06-02	Detailed mode (section 0.5 m, step 0.1 m) 200 – 400 m with 2.0 m drawdown
2000-06-03	Detailed mode (section 0.5 m, step 0.1 m) 200 – 400 m with 4.0 m drawdown
2000-06-04	Detailed mode with thermal pulse (section 0.5 m, step 0.1 m) 205 – 226 m with 8.0 m drawdown
2000-06-05	Detailed mode (section 0.5 m, step 0.1 m) 200 – 400 m with 8.0 m drawdown
2000-06-06	Normal mode measurements 200 – 400 m with 8.0 m drawdown
2000-06-07	Detailed mode (section 3 m, step 0.5 m) 200 – 400 m with 8.0 m drawdown
2000-06-08	Beginning of pumping the borehole with 22 m drawdown
2000-06-09	Pumping the borehole with 22 m drawdown
2000-06-10	As above
2000-06-11	Combined EC/detailed mode 200 – 1400 m with 22 m drawdown
2000-06-12	As above
2000-06-13	As above
2000-06-14	As above
2000-06-15	As above
2000-06-16	As above
2000-06-17	Extra fracture specific EC measurements
2000-02-18	Extra fracture specific EC measurements, Unpacking

6 Results of Campaign 1

6.1 Fresh water head

Fresh water head was firstly measured without pumping, see Appendix 1. The tube filled with tap water was lowered down to 1400 m. The valve at the lower end of the tube was opened and the water level in the tube was measured from the ground surface. The fresh water head was about 7 m at the depth of 1400 m, i.e. the water level in the fresh water tube was 7 m higher than the groundwater level in the borehole.

Above about 1200 m the water level in the fresh water tube was practically the same as the groundwater level in the borehole indicating that densities were identical in the fresh water tube and in the borehole.

The upper part of the borehole (200 – 400 m) was measured first with pumping. The drawdown was 6.2 m. On the basis of the fresh water head measurement, no saline water appeared during the pumping since the water levels in the borehole and in the measuring tube were the same, see Appendix 1. EC measurement with pumping between 200 m and 400 m confirms this, see Appendix 5.

The fresh water head with pumping (22 m drawdown) in the depth range 400 – 1400 m was measured twice, before and after the flow measurement, see Appendix 1. The results are practically the same between 1000 m and 1400 m. The results indicate more dense water between 400 m and 1000 m but less dense water above 400 m during the latter measurement. Density of water may increase with increasing salinity and/or with increasing amount of solid material in water. The average value of these two measurements was used when the hydraulic conductivity was calculated.

The transient of fresh water head was measured when pumping with 22 m drawdown was begun, see Appendix 2. The lower end of the measuring tube was at the depth of 1406 m. The water level in the measuring tube went first down to –10 m and settled during about three days at the level of + 1.5 m. The reason to this transient is the rising salinity in the upper part of the borehole.

6.2 Difference flow measurements

6.2.1 Normal mode flows

The measurements were begun with normal mode (3 m section length, 3 m depth increment) in the depth range of 200 –1400 m. After the fresh water head measurements flow logging was continued with pumping. The drawdown for the upper part (200 – 400 m) of the borehole was 6.2 m and 22 m for the lower part (400 – 1400 m).

The depths of the plotted results are presented from the top of casing. The measurements were done in the downward direction.

Flow values in the flow rate plots are shown using a logarithmic scale, see Appendix 3. The flows are shown in both directions, the left hand side of the scale represents flow out from the borehole within a test section and the right hand side represents flow into the borehole within a test section.

Flow direction without pumping the borehole is from the borehole into the bedrock. Pumping reversed flow direction.

The results of the measurements in normal mode are also presented in Appendix 7 (without pumping) and in Appendix 8 (with pumping). The vertical line represents the measured section.

6.2.2 Detailed mode flows

The detailed flow logging 400 – 1400 m, 3 m section length, 0.5 m depth increment, 22 m drawdown, in Campaign 1 was a part of the checking of the normal mode measurements. The detailed flow logging was used for the first time this way and it seemed to be fast and useful. It was carried out after the normal mode measurements with pumping during 19 hours from Feb 26 at 10 AM to Feb 27 at 03 AM between the depths of 365-1400 m.

The detailed flow logging curve shows square flow anomalies which are about 3 m long. The flow is measured as long as the flowing fracture is within the 3 m section, see Appendices 18.1 – 18.60.

Since the point interval (depth increment) was 0.5 m the shortest "real" anomaly can be 2.5 m long. Any anomaly in the detailed flow logging shorter than 2.5 m is not from a flowing fracture but probably caused by a leak at the rubber disks. Note however that in the cases when flowing fractures are nearer than 3 m from each other the measured flow anomaly of each fracture will be overlapped. This can create anomalies that look shorter than 2.5 m.

Correspondingly, the flow anomalies of the detailed flow logging with the section length of 0.5 m in Campaign 2 are square and about 0.5 m long, see Appendices 18.1 – 18.60.

6.2.3 Combination plots and flow anomalies

The normal mode flow results are also presented along with detailed mode results, caliper and single point resistance logs, see Appendices 18.1 – 18.60. The combination plots in detailed scale contain the following results:

- The normal mode 200-1400 m (3 m section length, 3 m depth increment) flow results from the time period 2000-02-05 – 2000-02-25
- Detailed flow logging 400 – 1400 m (3 m section length, 0.5 m depth increment, 22 m drawdown) from the time period 2000-02-26 – 2000-02-27
- Detailed flow logging 200 – 400 m (3 m section length, 0.5 m depth increment, 8 m drawdown) from the time period 2000-06-07 – 2000-06-08
- Detailed flow logging 200 – 1400 m (0.5 m section length, 0.1 m depth increment, 22 m drawdown) from the time period 2000-06-11 – 2000-06-17

- Caliper (borehole diameter) measured 1995, submitted by SKB
- Single point resistance results during the normal mode measurements without pumping

The combination plots of Appendices 18.1 – 18.60 contain results from both campaigns to make them easier to compare.

The depths of the plotted results are presented from the top of casing. All flow measurements were carried out downwards.

The lower edge of the detailed flow logging anomaly shows the depth of the flowing fracture, measured along the borehole from the top of the casing tube. The corresponding resistance anomaly can often be seen at the same depth.

The location of the single point resistance electrode is within the upper rubber disks. The anomalies seen in the caliper curve can also be seen in the single point resistance curve. The depth shift between these two curves is slightly increasing with depth.

The depths of leaky fractures are also marked in the Appendices 18.1 – 18.60 on the basis of the detailed flow logs.

6.2.4 Borehole condition

The single point resistance method is indicative of water filled fractures, conductive minerals and roughness of the borehole wall. In the upper part of the brothel, 200-450 m, the result looks “normal” with relatively smooth base level. Some anomalies are wide, for example at 283 m and 289 m which may be an indication of metallic minerals.

Below the depth of 450 m the noise level increases in single point resistance. It is high even between the depths of 550-700 m where very few flows were detected. This may be an indication of roughness of borehole wall rather than fracturing. The base line of the single point resistance curve becomes smoother again below the depth of 1150 m.

6.2.5 Changes made by the interpreter, observations

The normal mode and detailed mode results in Campaign 1 were occasionally inconsistent. The two normal mode measurements (with and without pumping) at the same depth may also be inconsistent. The reason may often be a leak at the rubber disks or depth shift between the two sets of the measurements.

In some cases it may be reasonable to change the normal mode results when it is obvious that the detailed mode results are more reliable. All such changes are mentioned in Table 6.1 with other comments and observations. These comments were made before Campaign 2, i.e. before the detailed mode measurements with 0.5 m section length.

Table 6-1. Changes made by the interpreter

P = With pumping
N = Without pumping

Depth (m)	File nr.	P / N	Measured Flow	Flow changed to	Comments
387.42	13173	N	-23.783	0	Rubber disks probably leaked, they were in the widened part of the brothel seen in Caliper and Single Point Resistance measurement
387.42	13248	P	33.590	0	Rubber disks probably leaked, they were in the widened part of the brothel seen in Caliper and Single Point Resistance measurement
390.42	13249	P	17.230	156	The upper rubber disks probably leaked. Changed on the basis of the detailed flow logging
462.42	12826	N	0	Not changed	No flow was measured without pumping though there was high flow with pumping (2279 ml/h). On the basis of the Single Point Resistance log and the detailed flow logging the leaky fracture was within the section (though at the upper end of it) without pumping and with pumping. Was the fracture opened because of pumping?
477.42	13621	P	40	60	Changed on the basis of the detailed flow logging
663.42	12893	N	0	Not changed	No flow was measured without pumping though there was flow with pumping (270 ml/h). On the basis of the Single Point Resistance log and the detailed flow logging, the leaky fracture was within the section (though at the upper end of it) without pumping and with pumping. Was the fracture opened because of pumping?
723.42	12913	N	-8.421	Not changed	Small flow rate was measured without pumping compared with the corresponding flow with pumping (725 ml/h). On the basis of the Single Point Resistance log and the detailed flow log the leaky fracture was at the lower end of the section. The lower rubber disks were on a Single Point Resistance anomaly
759.42	13612	P	61.5	100	Changed on the basis of the detailed flow logging
771.42	13391	P	0	208	Changed on the basis of the detailed flow logging. The lower rubber disks may have been on the leaky fracture.
780.42	13611	P	25.8	0	Rubber disks probably leaked, they were in the widened part of the brothel seen in Caliper and Single Point Resistance measurement. Changed also on the basis of the detailed flow logging, the anomaly was too short.
804.42	13402	P	0	65	Changed on the basis of the detailed flow logging
831.42	13608	P	78	102.333	Changed on the basis of the detailed flow logging
867.42	12961	N	-7.2	0	Rubber disks probably leaked, they were in the widened part of the brothel seen in Caliper and Single Point Resistance measurement. Changed also on the basis of the detailed flow logging
867.42	13423	P	361	0	Rubber disks probably leaked, they were in the widened part of the brothel seen in Caliper and Single Point Resistance measurement. Corrected also on the basis of the detailed flow logging
870.42	13606	P	47	120	Changed on the basis of the detailed flow logging
903.42	13435	P	0	Not changed	No flow was measured with pumping though there was flow without pumping

Table 6-1. Changes made by the interpreter (continued)

P = With pumping
N = Without pumping

Depth (m)	File nr.	P / N	Measured Flow	Flow changed to	Comments
909.42	13605	P	74.6	110	Changed on the basis of the detailed flow logging
933.42	12983	N	-598	0	The lower rubber disks probably leaked, they were in the widened part of the borehole seen in Caliper and Single Point Resistance measurement.
936.42	13446	P	572	320	Changed on the basis of the detailed flow logging
942.42	12986	N	-1162.83	0	Rubber disks probably leaked, they were in Single Point Resistance anomaly.
942.42	13448	P	2335	508	Changed on the basis of the detailed flow logging
948.42	13450	P	8494	2000	Estimated using the detailed flow logging. The section length was not long enough to reach over the widened part of the borehole
966.42	13457	P	0	Not changed	No flow was measured with pumping though there was flow without pumping
996.42	13004	N	-23.8	-69.779	Probable depth shift between the measurements with and without pumping
999.42	13005	N	-69.799	0	Probable depth shift between the measurements with and without pumping
1011.42	13472	P	0	110	Changed on the basis of the detailed flow logging
1014.42	13010	N	-939.8	0	This flow was left out (set to zero) because it had lead to unrealistic low head value. The reason for this high flow rate is unknown. The detailed flow logging at this depth looks reliable, the fracture at the caliper anomaly is flowing.
1023.42	13013	N	0	Not changed	No flow was measured without pumping though there was flow with pumping
1026.42	13014	N	0	Not changed	No flow was measured without pumping though there was flow with pumping
1032.42	13016	N	0	Not changed	No flow was measured without pumping though there was flow with pumping
1032.42	13479	P	443.218	187	Changed on the basis of the detailed flow logging
1038.42	13481	P	0	Not changed	No flow was measured with pumping though there was flow without pumping
1047.42	13021	N	0	Not changed	No flow was measured without pumping though there was flow with pumping
1080.42	13032	N	0	Not changed	No flow was measured without pumping though there was flow with pumping
1107.42	13504	P	0	Not changed	No flow was measured with pumping though there was flow without pumping. High noise level in flow possibly covered the flow.
11023.42	13476	P	0	130	Changed on the basis of the detailed flow logging
1149.42	13518	P	498.678	2548	Corrected on the basis of the detailed flow logging
1173.42					No flow was measured here though there is a small anomaly in the electric conductivity of groundwater during the pumping phase

6.2.6 Calculated natural fresh water head and hydraulic conductivity

Natural fresh water head and hydraulic conductivity of formation was calculated from the flow data (Appendix 3) and from the measured fresh water heads in the borehole (Appendix 1).

There is a big difference in the interpreted hydraulic heads above 450 m and below, see Appendix 4. Very even heads were calculated above 450 m and high variation in heads below 450 m, even in fractures near each other. It is unlikely that hydraulic head would actually vary as much within a short distance deep in the bedrock. This may be an indication of leaks at the rubber disks because of roughness of borehole wall, see above.

Another explanation for variation of the interpreted head may be unlinearity of transmissivity. High flow rate in fractures can cause turbulence and unlinear behaviour of transmissivity. Another reason to unlinearity may be the loose solid material seen in borehole water as explained in the following.

When the borehole was not pumped flow direction was from the borehole into the fractures in the measured depth range of 200-1400 m. In this state part of the solid material will get into the fractures. This has been going on for several years. Does the flow “heal” fractures mechanically with solid material or chemically creating minerals?

The flow direction was reversed in the depth range of 200-1400 m when the borehole was pumped. Especially the higher pumping rate for the measurements between the depths of 400-1400 m might have reopened some fractures. Therefore the fractures may not be measured in the same state when the borehole was not pumped and when it was pumped. This may cause unlinearity of transmissivity and “jumps” in head values.

Electric conductivity and temperature of groundwater during the normal mode measurements in Campaign 1 are presented in Appendices 5 and 6.

7 Results of campaign 2

7.1 Normal mode measurements between 200 m and 404 m

Normal mode results without pumping are presented in Appendix 7. Results from Campaign 1 and 2 are presented on the same plot. Single point resistance curves of the both measurements are also presented. There is a depth shift of about 20 cm between these two measurements.

The depth shift is smaller in the normal mode results with pumping, see Appendix 8. The trailer position (winch position) can be measured accurately with the cable counter. It was the same in all the cases. The cable is apparently 20 cm longer in the second measurement (Campaign 2) of Appendix 7.

The largest discrepancy in flow rates in Appendix 7 is at the depth of 297.42 m which can hardly be explained by the mentioned depth shift. There is also nearly similar discrepancy in flow rates during pumping at the same depth, see Appendix 8. The flow rates were smaller during Campaign 2 at this depth.

There are some other discrepancies in flow rates in the normal mode results with pumping, Appendix 8. These can possibly be explained by small depth shifts between the measurements. These are the results at depth of 210.42 m, a fracture at 212.0 m (see Appendix 13.1), the results at depth of 306.42 m, a fracture at 307.9 m (see Appendix 13.6) and the results at depth of 315.42 m, a large fracture at 317.1 m (see Appendix 13.6). In these cases a fracture has been under the lower rubber disks and it is undefined how the flow was divided to measured and to non-measured flow.

The normal mode flow results of Campaign 2 were much more consistent than those of Campaign 1. No changes were made to the normal mode flows values of Campaign 2.

7.2 Detailed mode measurements between 200 m and 404 m

Detailed mode measurements were carried out with two different section lengths, 0.5 m and 3 m, without pumping (Appendix 9) and with pumping (Appendix 10). Some of the typical features of the results in detailed mode were already mentioned in Chapters 6.2.2 and 6.2.3

The lower limit of measurement in detailed mode (with thermal dilution method) is about 2 ml/min (120 ml/hour). Even smaller flow rates can be seen in Appendices 9 and 10, the actual flow rate is then uncertain. Flow direction cannot be determined if the flow rate is below 2 ml/min.

The leaky fractures near each other can better be resolved with a short section length, see for instance Appendix 9.4 and Appendix 10.4. On the other, results with a short section length can be misleading where borehole wall is in “bad” condition longer than the section length, see for example the depths of 219 m and 385 m in Appendices 9 and 10. At the depth of 385 m there is a risk that the results with both section lengths are false since the length of the widened borehole is more than 3 m.

“False” anomalies can also be recognised if their length is smaller than the section length subtracted by the point interval.

Measurements with two section lengths are clearly complementary. Measurements are nearly five times faster with 3 m section and 0.5 m depth increment than with 0.5 m section and 0.1 m depth increment.

7.3 Detailed mode measurements with thermal pulse

Detailed mode measurements (section 0.5 m, step 0.1 m) with thermal pulse were carried out between the depths of 205 m and 226 m without and with pumping, see Appendices 11 and 12.

The range of flow measurement with the thermal pulse method is 0.1 ml/min – 10 ml/min. One measurement takes about 12 minutes. It is therefore very slow to measure with thermal pulse with 0.1 m depth increments. To speed up the measurements, the measured flow range was limited to 0.5 ml/min – 10 ml/min in this test.

The results are presented together with the results of the detailed mode in Appendices 11 and 12. All the points are measured between the depths of 205 m and 226 m, but because of the limited range of measurement a small number of points are visible in Appendices 11 and 12.

7.4 Transmissivity of flowing fractures

One of the tasks of Campaign 2 was to test whether the detailed flow logging could be used for determination of transmissivity of individual fractures. For this purpose the upper part of the borehole, 200 – 404 m, was measured with different drawdowns. The used drawdowns were 0, 1, 2, 4, 8 and 22 m. The stabilising time after changing drawdown was more than four hours.

The detailed flow logging utilises only the thermal dilution flow measuring techniques. For measuring transmissivity, the thermal dilution method was developed in such a way that it could measure flow direction in addition to flow rate.

The flow direction without pumping (0 m drawdown) was from the borehole into the bedrock as before. The interpreted fresh water heads of formations between the depths of 200 m and 404 m were all below one meter, see Appendix 4. This suggested that the flow direction would turn already with one meter’s drawdown. This was also the case in all measurements with pumping, see Appendices 13.1 – 13.11.

Logarithmic increase of drawdown was chosen because it should create equidistant increase in flow rates presented in logarithmic scale if the system is linear.

The upper limit of measurement in the detailed mode (with thermal dilution method) is about 5000 ml/min (30000 ml/hour). This limit may be exceeded at the depths of 251 m and possibly at 317 m with 22 m drawdown.

The flowing fracture depths were detected from these six measurements and the detailed flow logs with 3 m section length. The fracture depths are marked on the plots, see

Appendices 13.1 – 13.11. A long line represents the depth of a leaky fracture, a short line denotes that the existence of a leaky fracture is uncertain.

Calculated transmissivity and fresh water head of fractures are presented together with the normal mode transmissivity of Campaign 2 (0 and 8 m drawdown), see Appendices 14 and 15. Results with two drawdowns are needed to calculate transmissivity and fresh water head. The other chosen drawdown of a pair was always 0 m (no pumping).

Transmissivity of a fracture was calculated if one of the measured flow rates exceeds the measuring limit of 120 ml/hour. Fresh water head of a fracture was calculated if both of the measured flow rates exceed the measuring limit 120 ml/hour.

The normal mode and detailed mode results fit fairly well with each other. No systematic unlinearity can be seen in the results with different drawdown. It has to be taken into account that there is some uncertainty when picking flow values from the detailed flow logs, especially when fractures are nearer than 0.5 m from each other.

7.5 EC and temperature measurement between 0 and 404 m

Electrical conductivity (EC) and temperature of borehole water was measured during the methodology test, see Appendices 16 and 17. EC was measured also between 20 and 200 m in the steel casing. Pumping decreased EC value between 20 and 200 m. The drawdown of eight metres increased EC value between the depths of 200 and 404 m.

Both EC and temperature became more “noisy” with more pumping. The measuring geometry explains this, electric conductivity and temperature of water from fractures may deviate from those in the borehole at the same depth.

7.6 Combined detailed mode and EC measurement between 203 m and 1400 m

For the measurement of electrical conductivity (EC) of groundwater, the borehole is pumped so that the flow direction is always from the fractures into the borehole. This enables the determination of electrical conductivity from fracture-specific water. Both electrical conductivity and temperature of flowing water from the fractures are measured.

The water flowing from the fractures is guided through the flow sensor and through the EC electrode attached above it. The flow measurement makes it possible to find the fractures for the EC measurement. The tool is moved so that the fracture to be tested will be located at the lower end of the test section. The EC measurement begins if the flow rate is larger than a predetermined limit. In this study the fractures, which had flow rate less than 1.5 l/hour were not tested with the EC method.

The tool was kept on the selected fracture. The measurement was continued at the given depth allowing the fracture-specific water to enter the section. The waiting time for the EC measurement was automatically calculated from the measured flow rate. The aim was to flush the water volume within the test section well enough. The measuring computer was programmed to change the water volume (0.5 l) three times within the 0.5 m long test section. A special spiral structure in the section was used to improve flushing. All these phases of the measurement can be carried out automatically controlled by the logging computer.

EC results presented in Appendices 18.1 – 18.60 contain all the measured EC results. Some of the EC results were measured in unfavorable locations where the borehole was widened causing leak of the rubber disks. These results may be misleading. The results of these depths should be taken away based on analysis of flow anomalies and caliper results. Such depths are 213.9 m, 218.92 m, 251.82 m, 385.32 m, 386.3 m, possibly 799.62 m, 815.62 m, 863.62 m, 948.12 m, 977.72 m, 1340.2 m and 1340.6 m. There is also risk of leaks in some EC results near 1086 m.

EC and temperature results in the entire borehole are presented in Appendices 19 and 20. The fracture-specific EC results are shown as time transients in Appendices 21.1 – 21.5. Some of the transients are still changing when the fracture specific EC measurements were finished, for example at the depths of 385.30 m, 385.32 m and 977.72 m. The reason is probably the unfavorable location of the rubber disks mentioned above.

The noisy EC values were probably caused by gas bubbles. There is no unambiguous proof of this assumption. However, similar noisy EC results were earlier obtained in tunnel measurements in the Äspö Hard Rock Laboratory only in those boreholes where gas outflow was visible at the borehole collar. This suggests that the noise in EC results could be a qualitative measure of gas in gas form in groundwater.

High amounts of dissolved gases have been observed during groundwater sampling, especially in the most saline groundwater at Olkiluoto in Finland (Pitkänen et al 1999). Similar noisy EC results were measured also at the Olkiluoto site (Rouhiainen 2000).

Fracture locations are presented in Appendix 18. Long line represents the depth of a leaky fracture, short line denotes that the existence of a leaky fracture is uncertain.

7.7 Additional EC measurement between 724 m and 813 m

Some extra EC measurements were carried out at very small flow anomalies 724 m and 813 m, see Appendices 22 and 23. This measurement was the last phase of Campaign 2. One of these fractures at the depth of 772.4 m was not visible in the detailed mode measurement of Campaign 2, see Appendix 18.29. However, the noise level could be lowered by moving the tool up and down above the fracture at the depth of 772.4 m, see Appendix 22.4.

The noisy EC time transients indicate gas in groundwater. It can be discussed how representative such noisy EC results are. EC measurements are often used for evaluation of the amount of dissolved solids (TDS) in groundwater. The relationship between EC and TDS can be estimated in water without gas bubbles. Therefore the gas bubbles should be evacuated in some way before the final EC measurements. Here it is assumed once again that gas bubbles are the reason of noise.

8 Noise in flow results

The results of the detailed flow logging (3 m section, 0.5 m depth increment, Campaign 1) show high noise level in flow during pumping below the depth of about 1050 m. The noise level is about 1000 ml/h at the depth of 1400 m, see Appendix 18.

The noise level decreased with time during the pumping phase in Campaign 1. It was higher than normal even in the upper part of the borehole in the beginning of the normal mode measurements during pumping.

There was also an increased noise level in Campaign 1 during the measurements without pumping in the deeper part of the borehole, below the depth of 1182 m. The noise level was about 50 ml/h between the depths of 1182 m and 1206 m. It increased from 240 ml/h to 1000 ml/h between the depths of 1206 m and 1400 m. These noise levels could be seen when interpreting the normal mode flow measurements without pumping.

The increased noise level is the reason why small flows are missing, especially during the pumping phase and in the lower part of the borehole.

It has been found out earlier that the noise level of flow may increase if water is muddy.

Muddy water can also increase the density of the water and fresh water head in the borehole. Pumping possibly first increased muddiness in the upper part of the borehole. Then water possibly became clearer when it was flushed by clear water from fractures. This may explain the deviation of fresh water head in the upper part (400 - 1000 m) of the borehole during the pumping phase. Fresh water head decreased there during the flow measurements with pumping, see Appendix 1.

Another type of noise was seen in Campaign 2, especially during the combined detailed mode/EC measurements. The noise level was smaller with pumping than without pumping above 250 m and below 385 m, see Appendix 13. With the drawdown of 22 m, the noise level increased to 100 ml/hour below 250 m, to 300 ml/hour below 317 m and to about 500 ml/hour below 339 m. The noise level gradually decreased from 500 to 200 ml/hour in the intact part of the bedrock between the depths of 339 m and 382 m. The noise level decreased sharply at the large caliper anomaly at the depth of 384 m, see Appendix 13.

In the detailed mode (0.5 m section, 0.1 m depth increment, Campaign 2) with the drawdown of 22 m, the noise level increased back to 100 ml/hour below 435.6 m. It increased to 200 ml/hour at 461.3 m and to 500 ml/hour below 751.5 m and then it gradually decreased downwards, see Appendix 18.

The noise level suddenly decreased from 100 ml/hour to 40 ml/hour below a large caliper anomaly at the depth of 978 m. Then it sharply increased at the depth of 981.7 m to 800 ml/hour. There was an increase of noise level also at the depths of 1013.9 m and 1086.2 m.

Such increase in noise level cannot be seen in the detailed mode measurements logging (3 m section, 0.5 m depth increment) of Campaign 1 and noise level was smaller in Campaign 1, see Appendix 18.

On the contrary, below about 1200 m the noise level was smaller during the detailed mode measurements (0.5 m section, 0.1 m depth increment) of Campaign 2 than during the detailed mode measurements of Campaign 1. The noise level of Campaign 2 drops down to 40 ml/hour at the large caliper anomaly at the depth of 1340 m.

One possible reason for the noise with 22 m drawdown is gas. All the measurements were carried out downwards. With 22 m drawdown, more gas might enter into the section because of the higher pumping rate and because the tool was stopped on some fractures for the fracture specific EC measurements. The gas could possibly escape from the section when the upper rubber disks arrived to the widened part of the borehole at the large caliper anomalies.

Similar noise behaviour was seen earlier at the Olkiluoto site in Finland. There the combined detailed mode/EC measurements were carried out from the bottom upwards. Increased noise level was obtained above some fractures where fracture specific EC was measured (Rouhiainen 2000).

There are some observations that are against the assumption of gas as a noise source. The noise level of flow doesn't always increase at those fractures where there is noise in EC results. There are also a few such cases where the noise level of flow increases even if there is very little noise in the EC results.

The reason for the increased noise in flow seems to be a property of water that comes in from some fractures and is flushed away where the borehole is clearly widened. The reason for this kind of noise is not completely clear. The feature causing noise in EC and noise in flow may not necessarily be the same.

9 Conclusions

The fresh water head measurement in Campaign 1 was carried out using a long fresh water filled tube. The pumping of the borehole caused increase in salinity in the upper part of the borehole. In spite of this, a clear pressure change was obtained at the depth of 1400 during the pressure transient measurement. The pressure conditions during the pumping phase were relatively stabile after the transient period. This was shown by the fresh water head measurement carried out twice.

The main task of Campaign 1 was the normal mode flow measurement. The long list of comments (Table 6.1) indicates that all results were not straightforward to interpret. Flow measurement was not easy in water containing gas and solid particles and in borehole that was occasionally widened. The upper part of the borehole (200 – 400 m) was more consistent for unknown reasons.

The detailed flow logging with long section length was used for the first time as a complementary tool.

The aim of method test of Campaign 2 was to test whether the flowlogging could be used for determination of transmissivity of individual fractures. For this purpose the detailed mode was developed to resolve both flow rate and flow direction.

The many repeated measurements gave a good basis to evaluate the limits of transmissivity determination of individual fractures. The extensive data set can be also used for optimising the usage of the flow measurement in terms of time, costs, degree of details obtained and reliability.

Another task of Campaign 2 was the combined detailed mode/EC measurement. The flowguide geometry makes it possible to measure electric conductivity of fracture specific water. Conductivity of fracture specific water often deviated from conductivity of borehole water at the same depth.

Many new observations were found of the increased noise level in flow and in electric conductivity measurement.

The results of this study will be used in a later report containing optimisation and a feasibility evaluation of the difference flow method.

References

Pitkänen, P., Luukkonen, A., Ruotsalainen, P., Leino-Forsman, H. & Vuorinen, U. 1999. Geochemical modelling of groundwater evolution and residence time at the Olkiluoto site. Helsinki, Finland: Posiva Oy. 184 p. POSIVA-98-10.

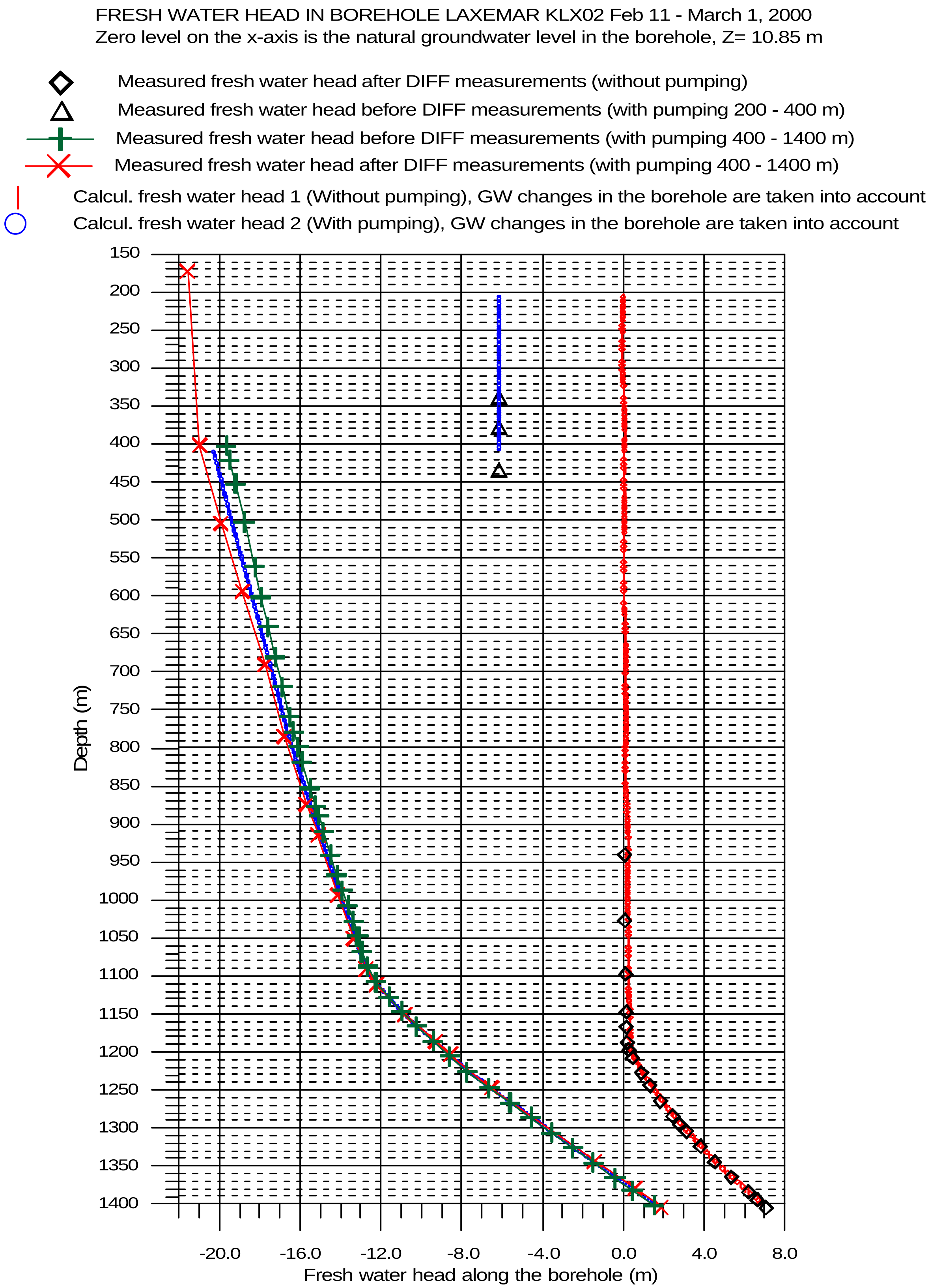
Rouhiainen, P. 2000. Electrical conductivity and detailed flow logging at the Olkiluoto site in Eurajoki, boreholes KR1-KR11. Helsinki, Finland: Posiva Oy. 2 Volumes, 387 p. Working Report 99-72.

Rouhiainen, P. and Pöllänen, J. 1998. Difference flow measurements in Äänekoski, boreholes KR4, KR12 and KR13. Posiva Oy.116 p. Working report 98-31e.

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

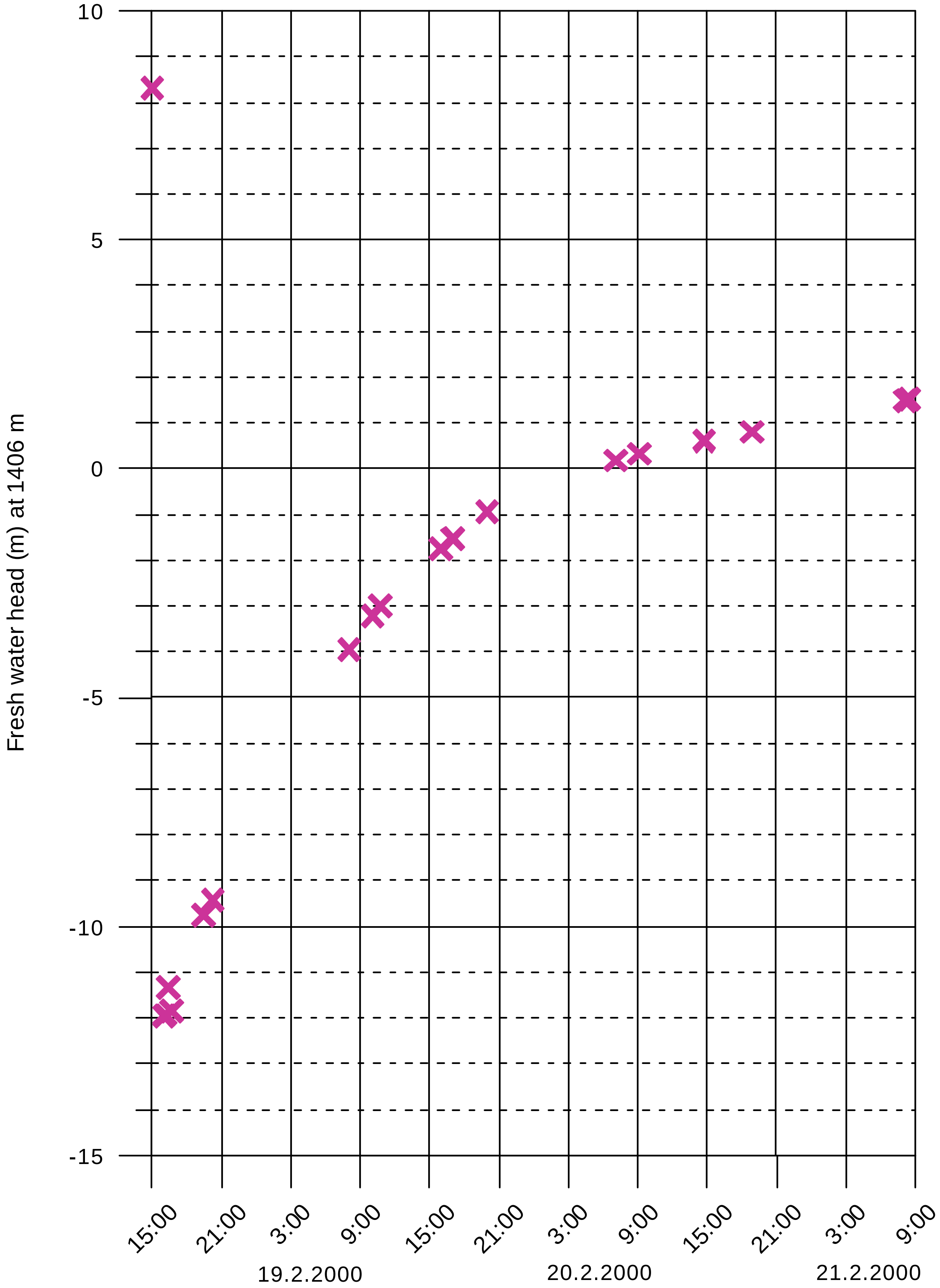
Appendices

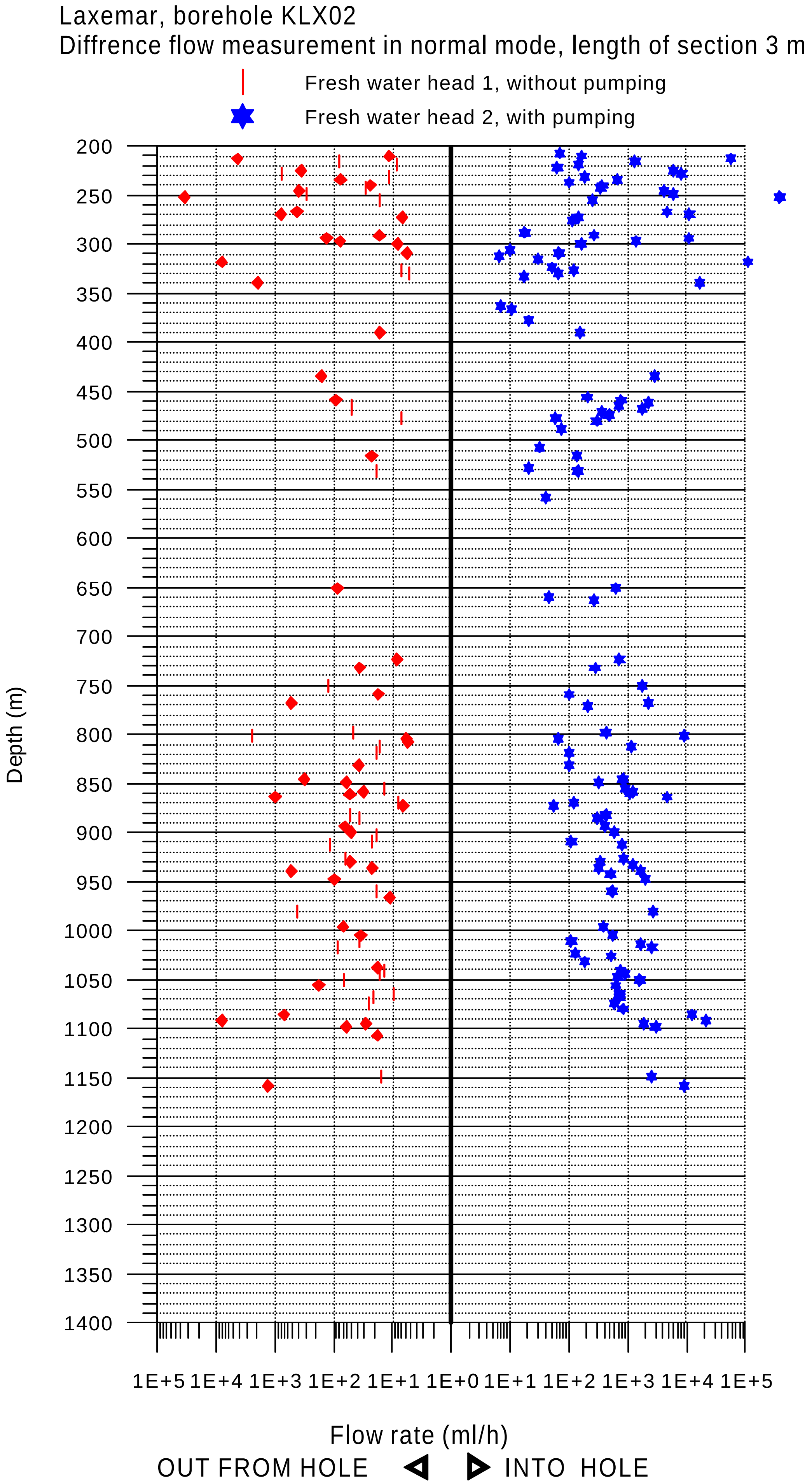
Appendices 18.1-18.60.	Normal mode results Campaign 1, Detailed flow logs (0.5 m, 0.1 m) with 22 m drawdown, Campaign 2, 203-1400 m, caliper 95, SP1, ECborehole, Ecfracturelast
Appendix 19.	EC with 22 m drawdown, Campaign 2, 203-1400 m
Appendix 20.	Temperature with 22 m drawdown, Campaign 2, 203-1400 m
Appendices 21.1-21.5.	EC Time transient plots 200-1400 m
Appendices 22.1-22.4.	Detailed flow logs (0.5 m, 0.1 m) with 22 m drawdown, Campaign 2, Extra program, 724-813 m, caliper 95, SP1, ECborehole, ECfracturelast
Appendix 23.	EC Time transient plots Campaign 2, Extra program, 724-813 m


FRESH WATER HEAD IN BOREHOLE LAXEMAR KLX02 Feb 11 - March 1, 2000
Zero level on the x-axis is the natural groundwater level in the borehole, Z= 10.85 m
Measured fresh water head after DIFF measurements (without pumping)
Measured fresh water head before DIFF measurements (with pumping 200 - 400 m)
Measured fresh water head before DIFF measurements (with pumping 400 - 1400 m)
Measured fresh water head after DIFF measurements (with pumping 400 - 1400 m)
Calcul. fresh water head 1 (Without pumping), GW changes in the borehole are taken into account
Calcul. fresh water head 2 (With pumping), GW changes in the borehole are taken into account
Depth (m)
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
-20.0
-16.0
-12.0
-8.0
-4.0
0.0
4.0
8.0
Fresh water head along the borehole (m)

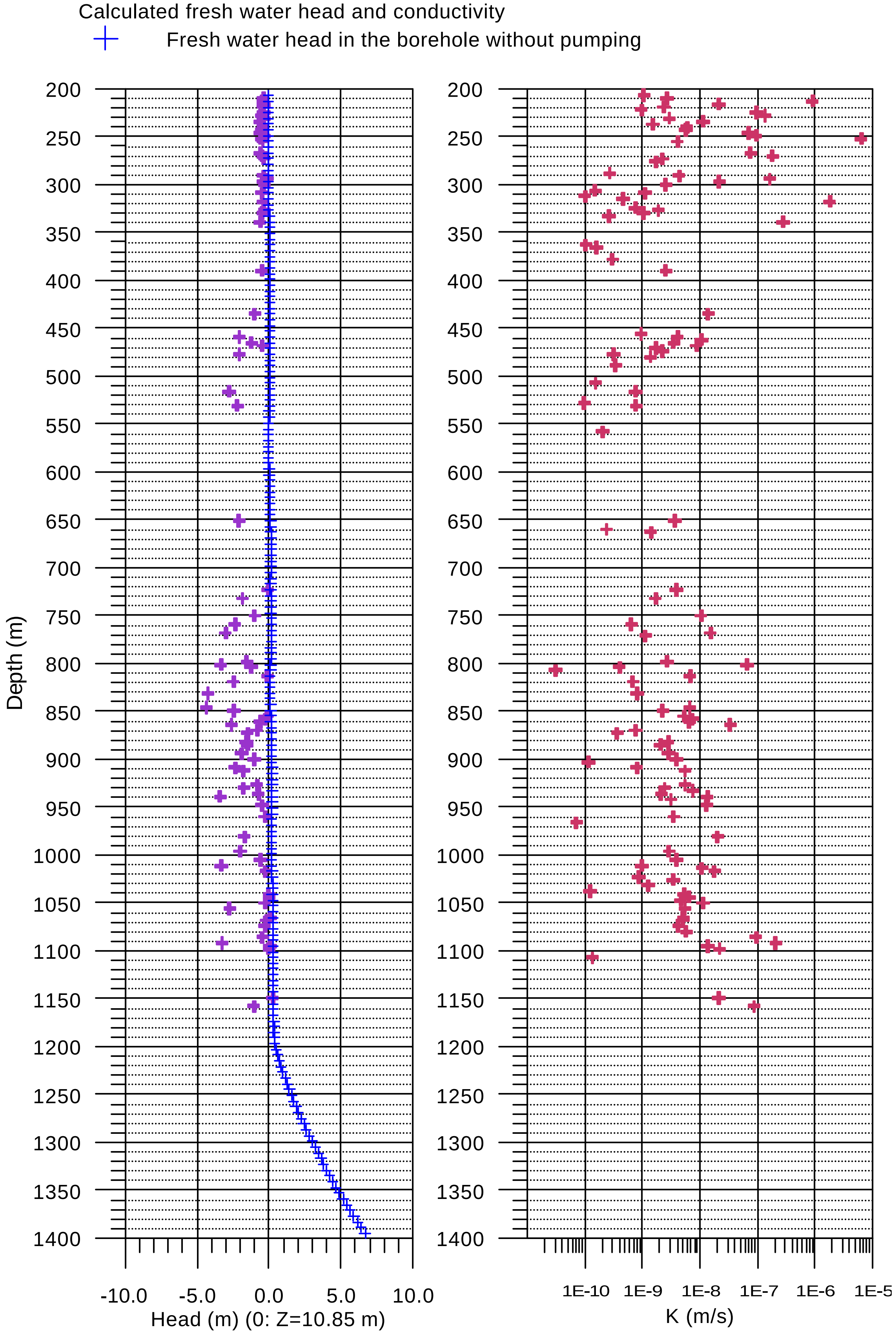
Fresh water head transient during pumping in borehole Laxemar KLX02

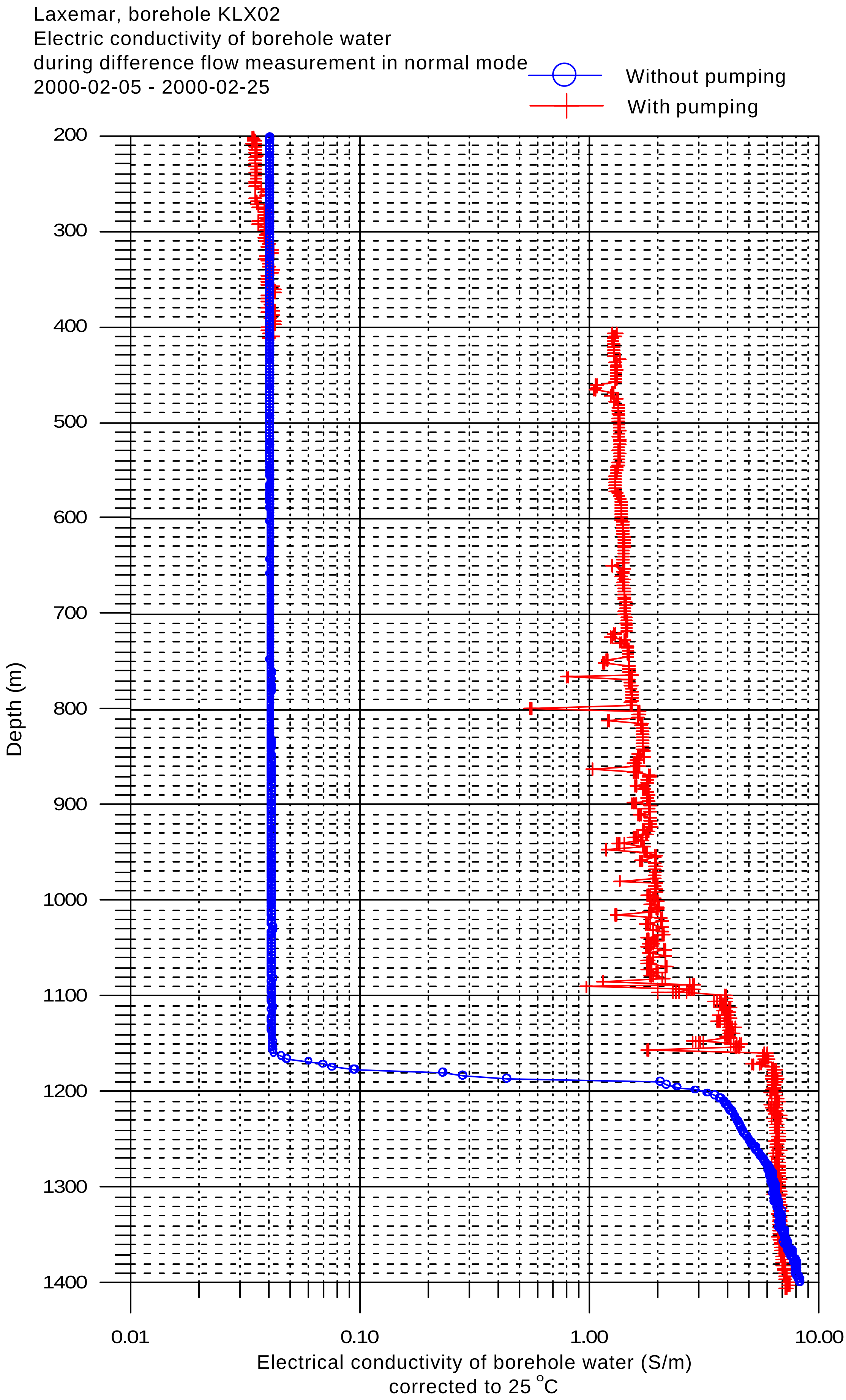
Pumping was started 18.2.2000, 15:03
The lower end of the measuring tube was at the depth of 1406 m
Zero level is the natural groundwater level in the borehole, Z= 10.85 m

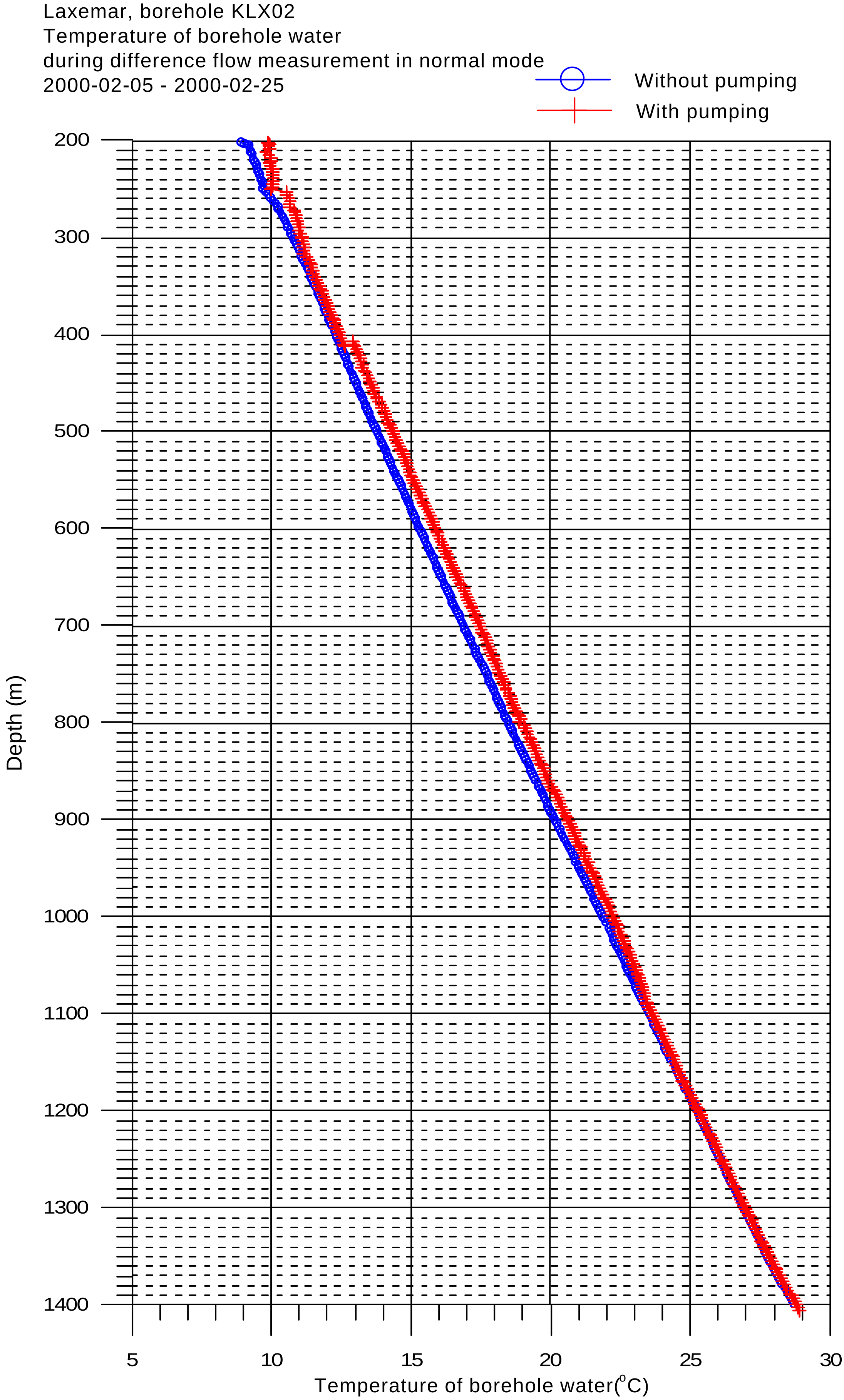


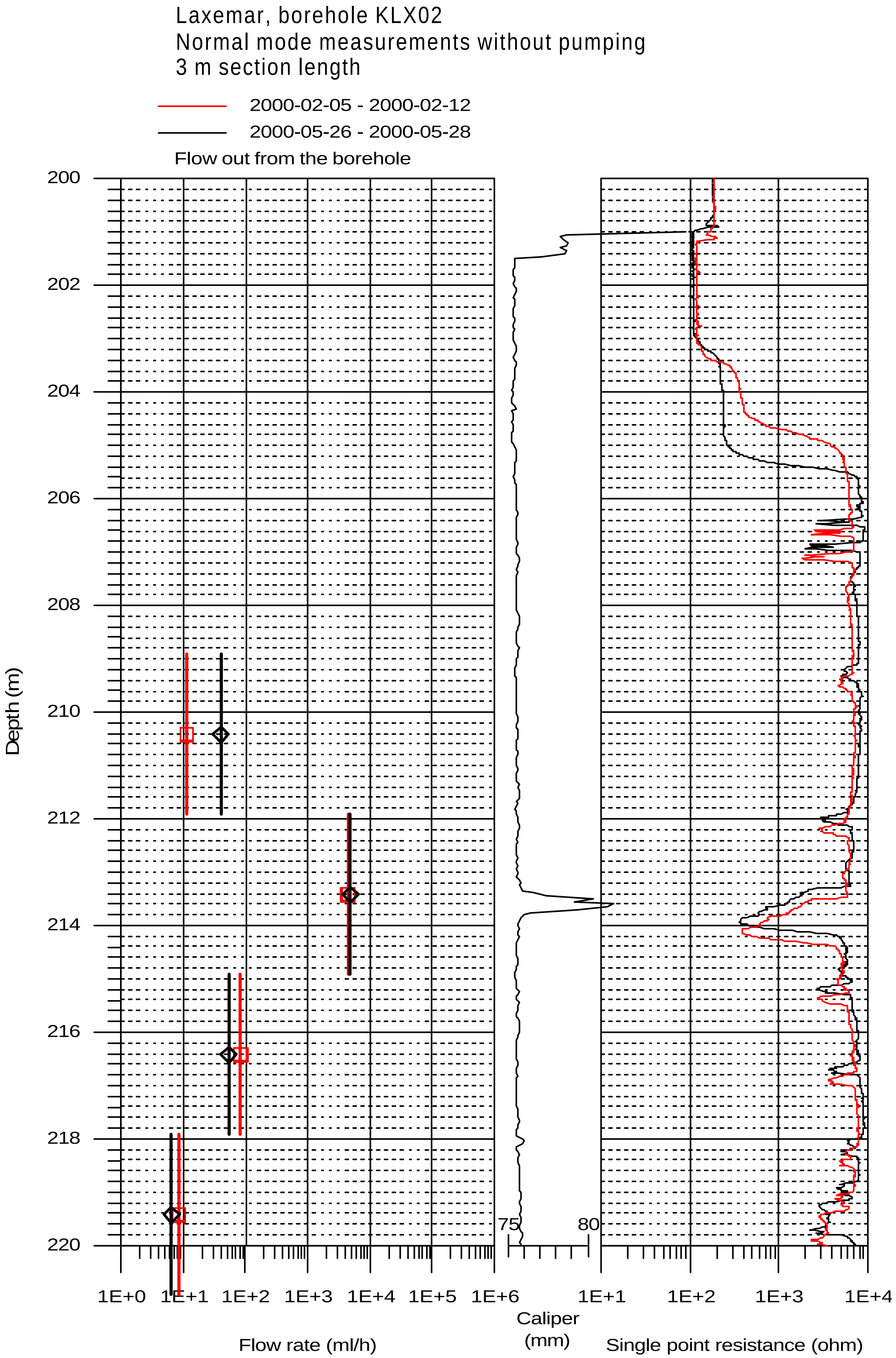

Laxemar, borehole KLX02
Diffrence flow measurement in normal mode, length of section 3 m
Fresh water head 1, without pumping
Fresh water head 2, with pumping
Depth (m)
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
1E+5 1E+4 1E+3 1E+2 1E+1 1E+0 1E+1 1E+2 1E+3 1E+4 1E+5
Flow rate (ml/h)
OUT FROM HOLE
INTO HOLE

Laxemar, borehole KLX02
Difference flow measurement in normal mode, length of section 3 m
Calculated fresh water head and conductivity



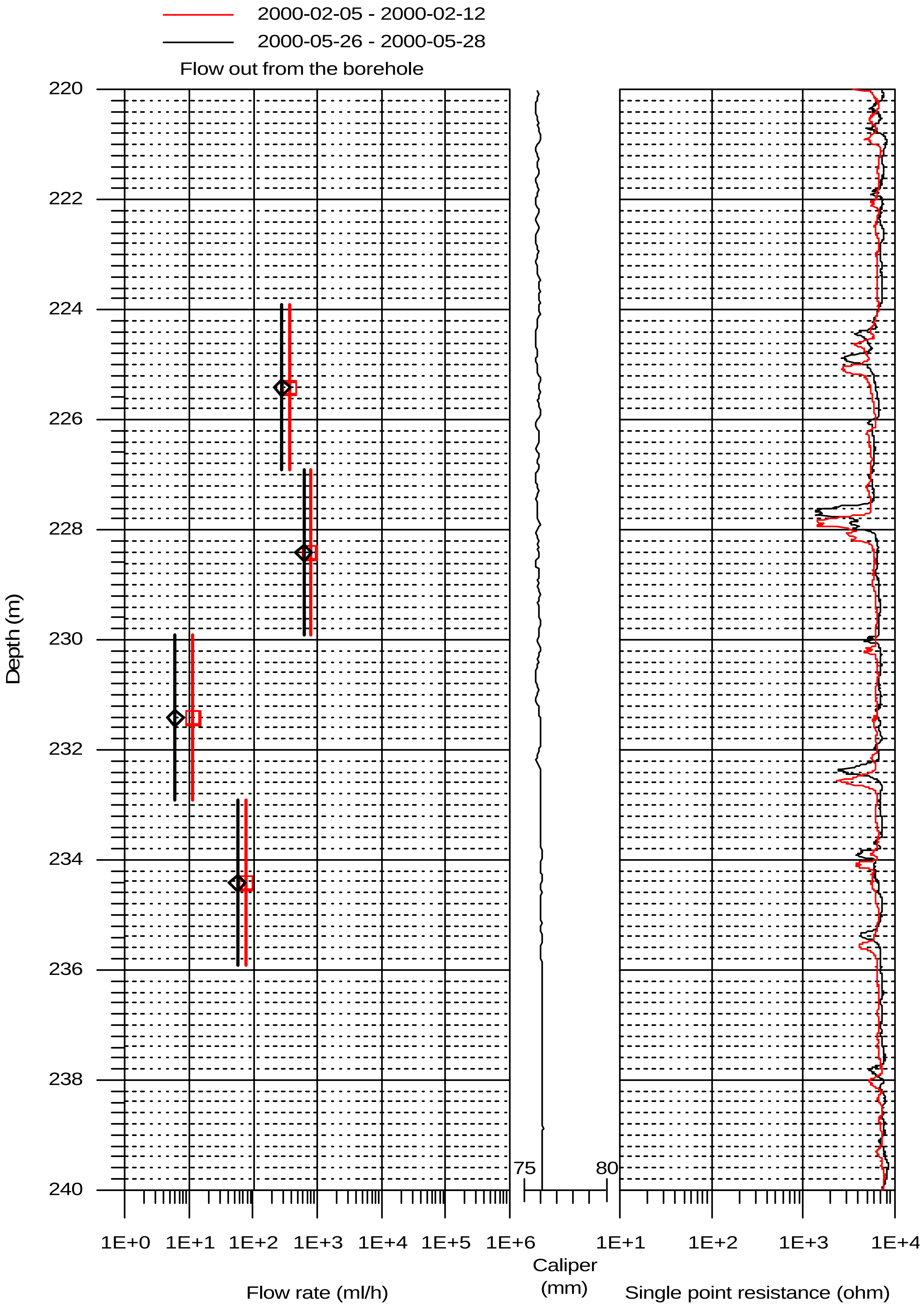

Laxemar, borehole KLX02
Electric conductivity of borehole water
during difference flow measurement in normal mode
2000-02-05 - 2000-02-25
Without pumping
With pumping
Depth (m)
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
0.01
0.10
1.00
10.00
Electrical conductivity of borehole water (S/m)
corrected to 25 °C


Laxemar, borehole KLX02
Temperature of borehole water
during difference flow measurement in normal mode
2000-02-05 - 2000-02-25
Without pumping
With pumping
Depth (m)
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
5
10
15
20
25
30
Temperature of borehole water(^{o}C)

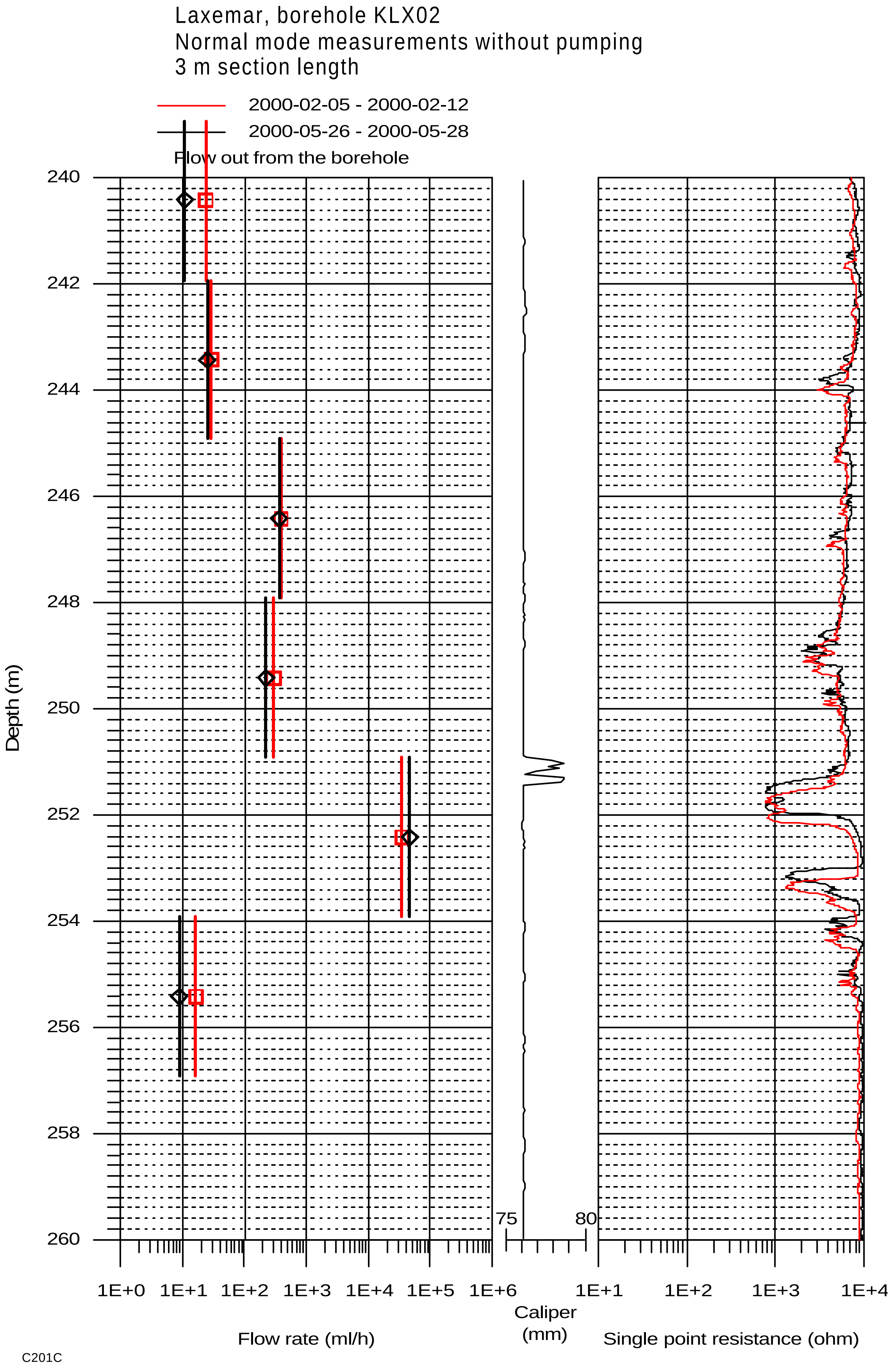

Laxemar, borehole KLX02
Normal mode measurements without pumping
3 m section length
2000-02-05 - 2000-02-12
2000-05-26 - 2000-05-28
Flow out from the borehole
Depth (m)
200
202
204
206
208
210
212
214
216
218
220
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)

C201C

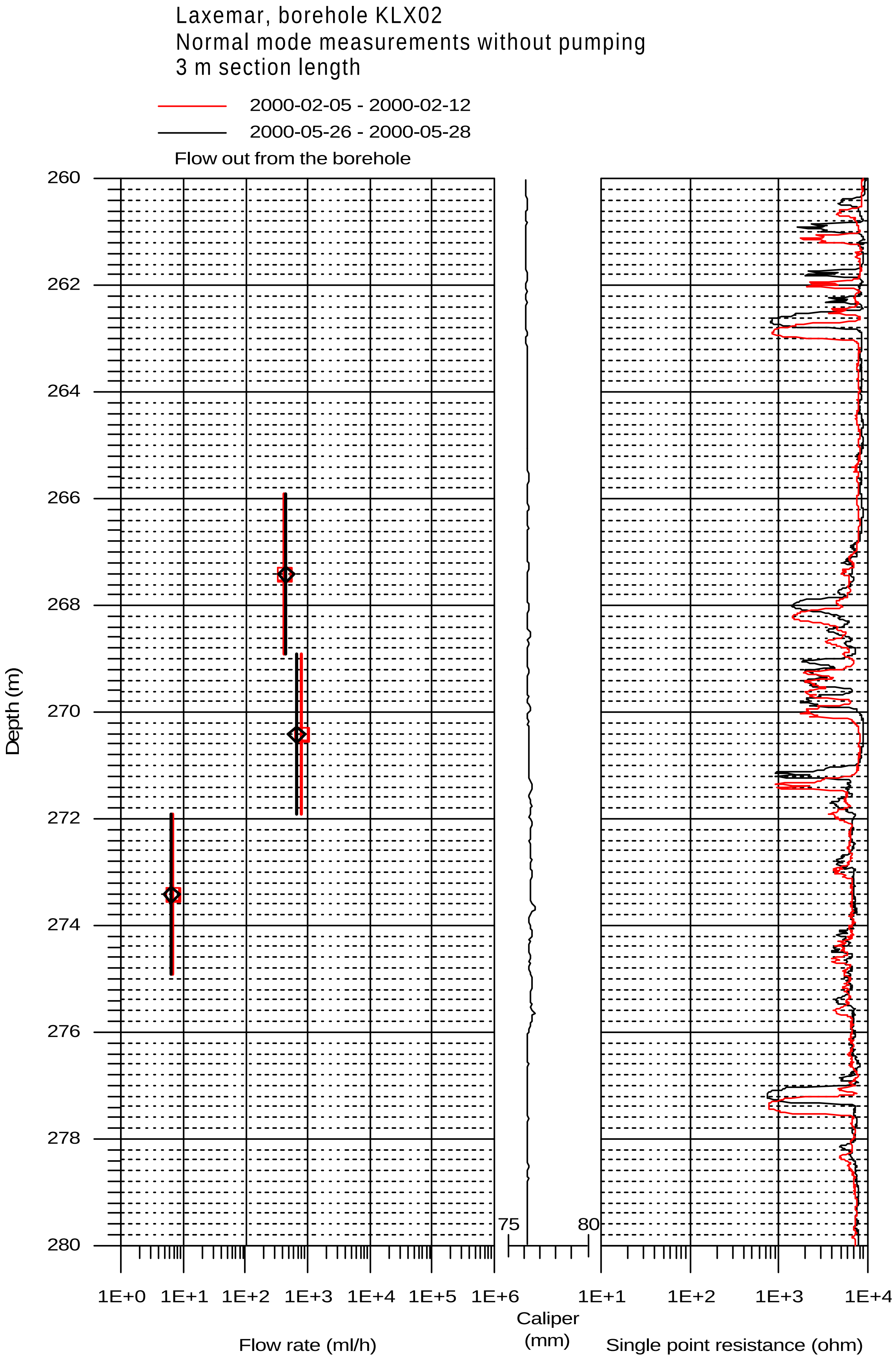
Laxemar, borehole KLX02
Normal mode measurements without pumping
3 m section length



C201C



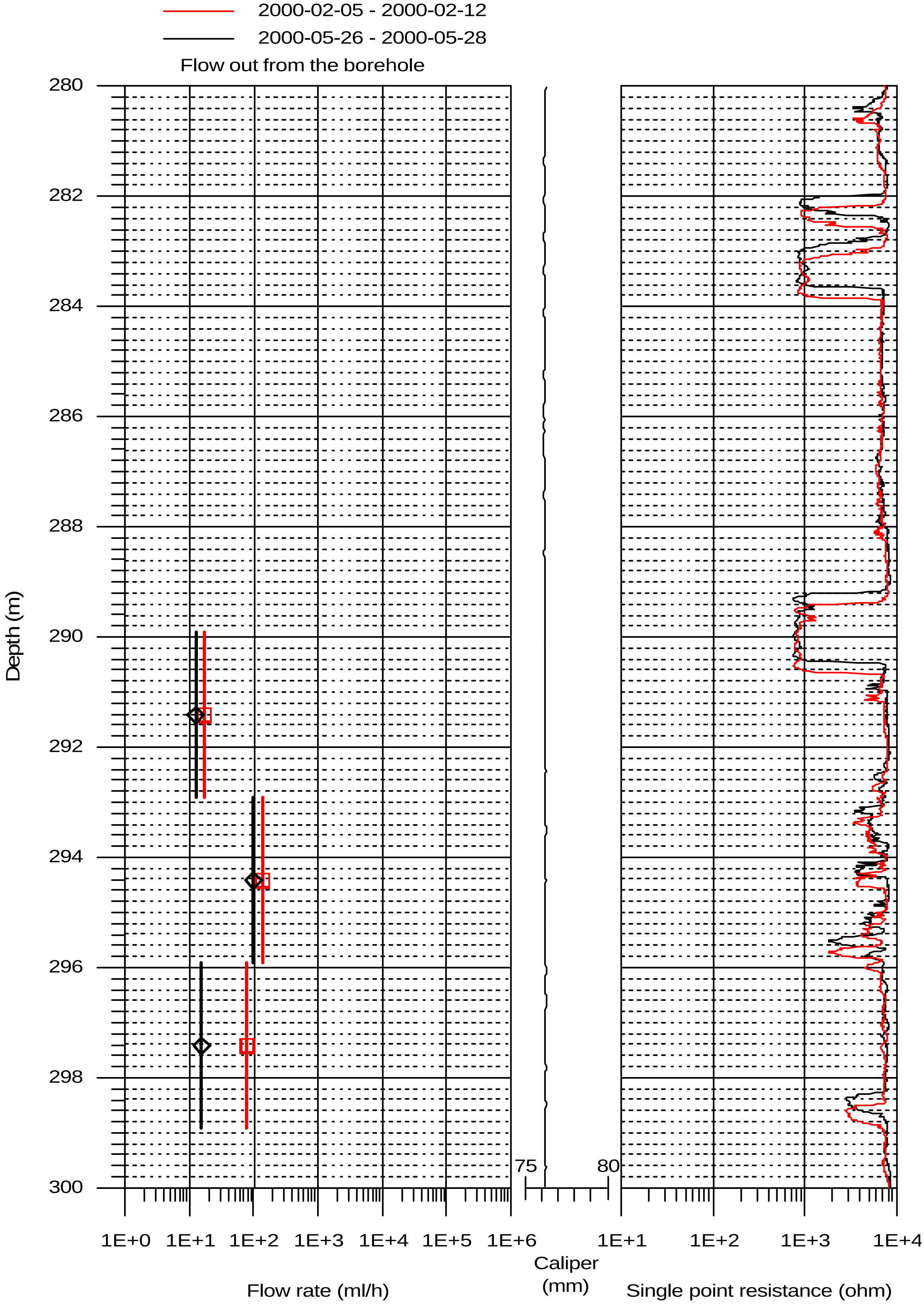
Laxemar, borehole KLX02
Normal mode measurements without pumping
3 m section length
2000-02-05 - 2000-02-12
2000-05-26 - 2000-05-28
Flow out from the borehole
Depth (m)
240
242
244
246
248
250
252
254
256
258
260
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C201C



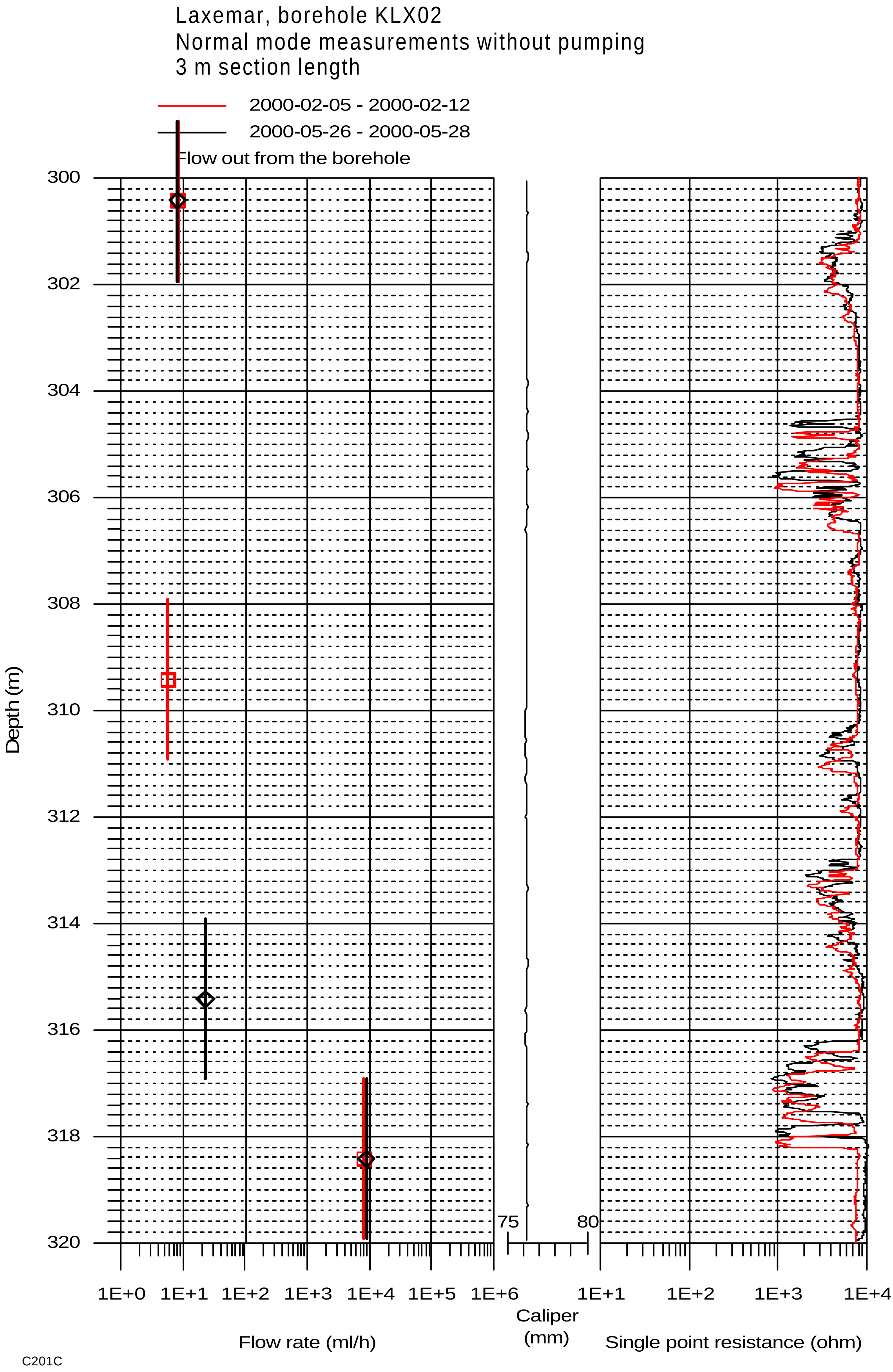
Laxemar, borehole KLX02
Normal mode measurements without pumping
3 m section length
2000-02-05 - 2000-02-12
2000-05-26 - 2000-05-28
Flow out from the borehole
Depth (m)
260
262
264
266
268
270
272
274
276
278
280
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper (mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)

C201C

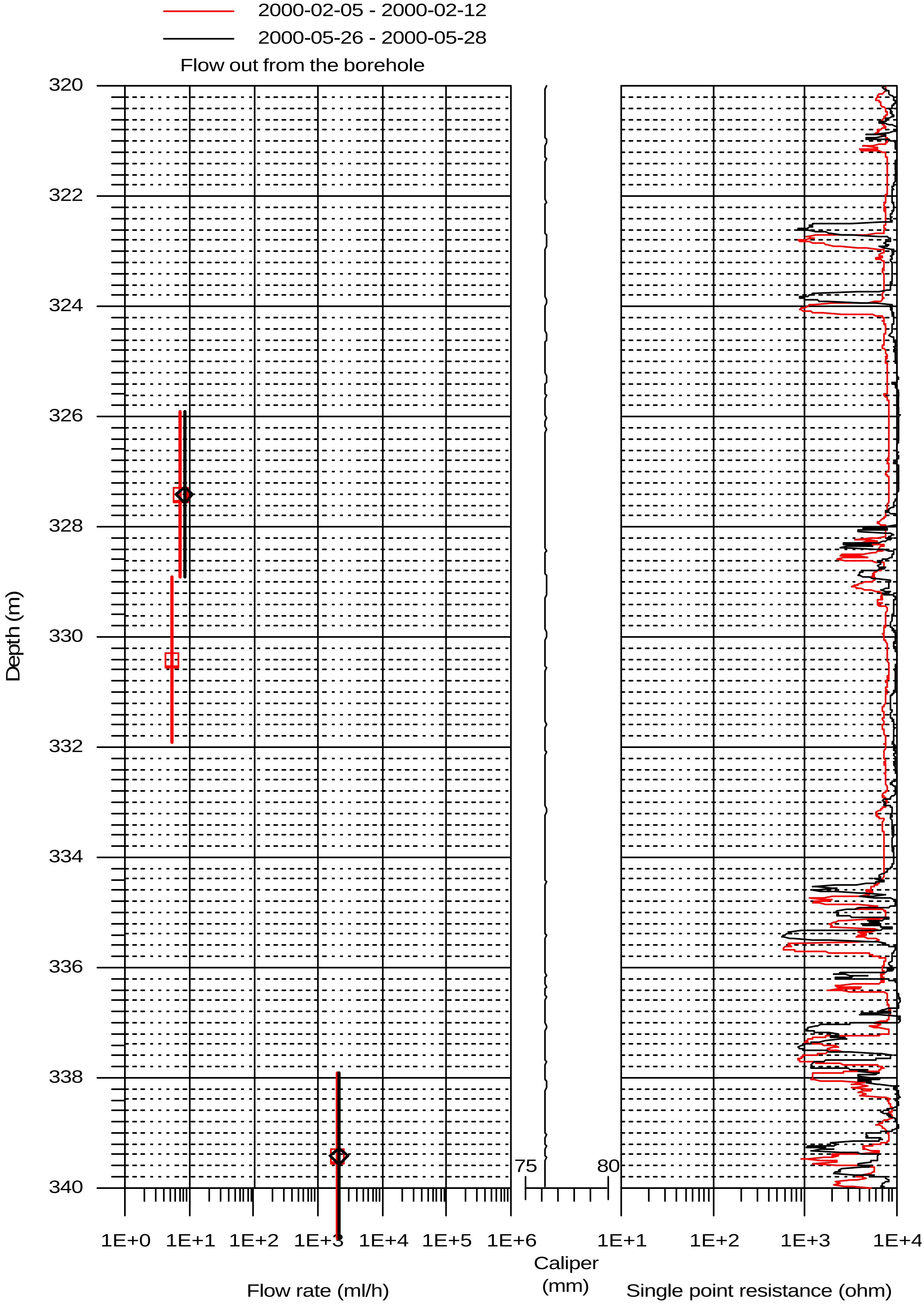
Laxemar, borehole KLX02
Normal mode measurements without pumping
3 m section length



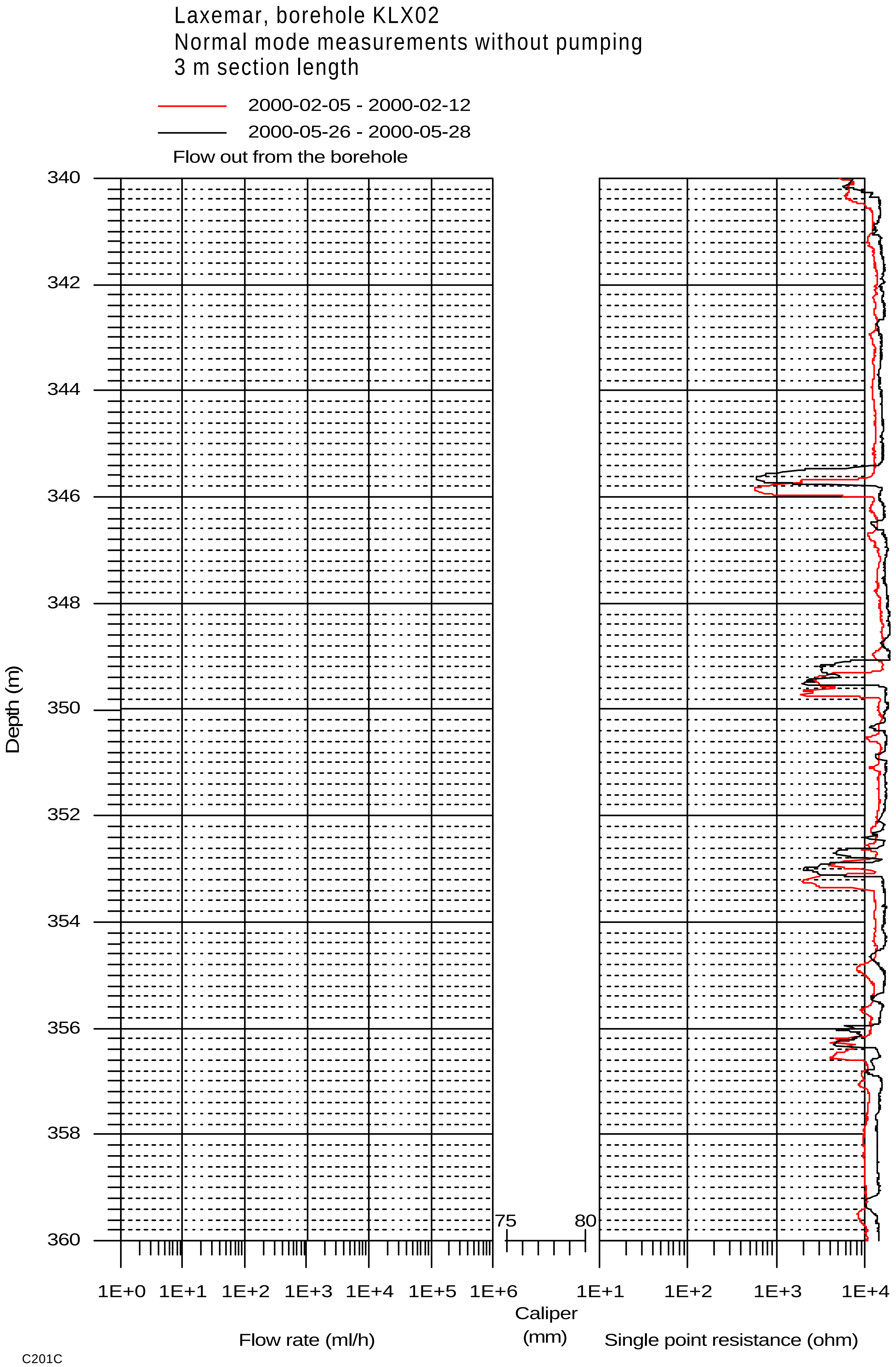
C201C

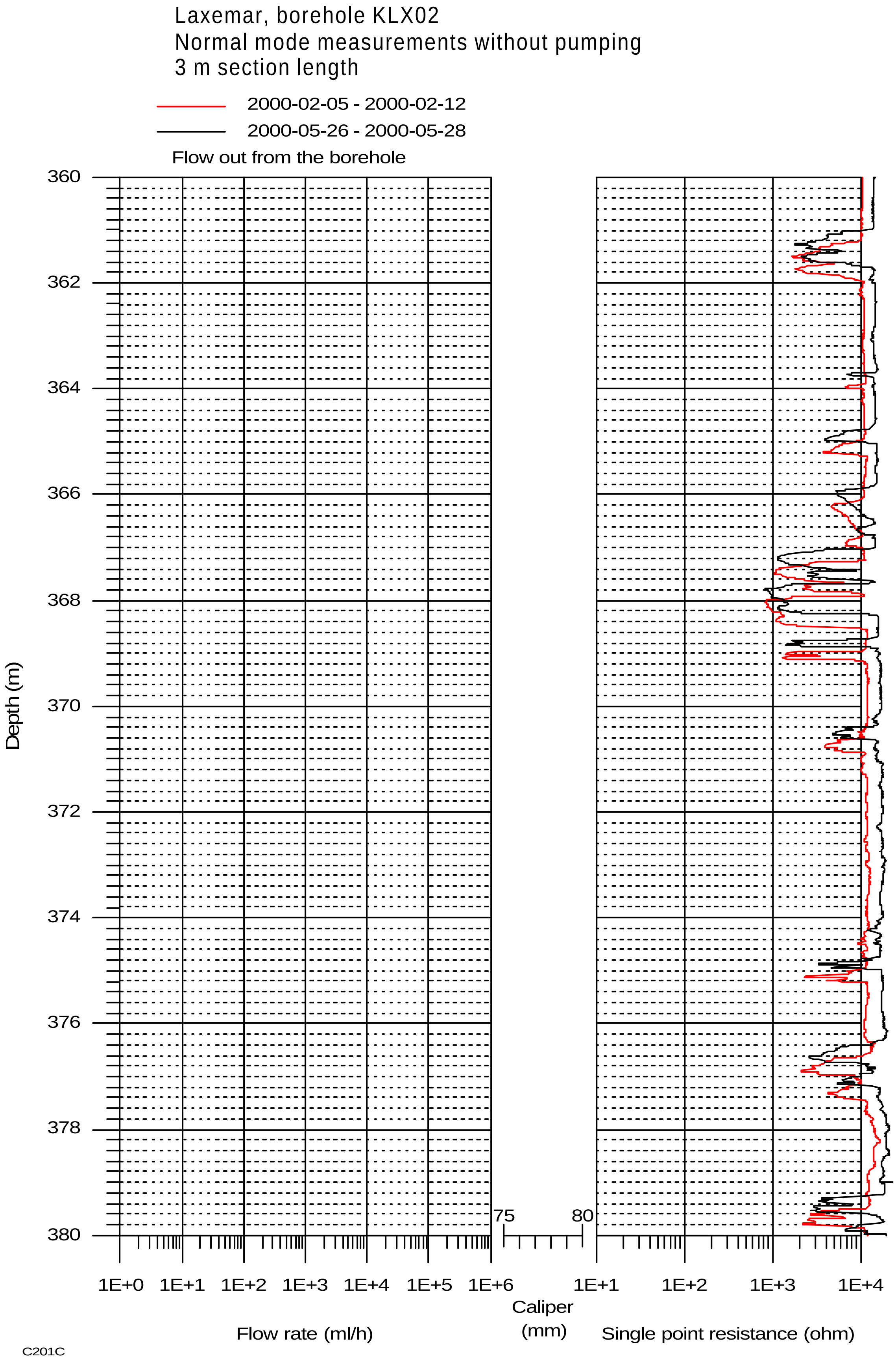

Laxemar, borehole KLX02
Normal mode measurements without pumping
3 m section length
2000-02-05 - 2000-02-12
2000-05-26 - 2000-05-28
Flow out from the borehole
Depth (m)
300
302
304
306
308
310
312
314
316
318
320
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper (mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C201C

Laxemar, borehole KLX02
Normal mode measurements without pumping
3 m section length

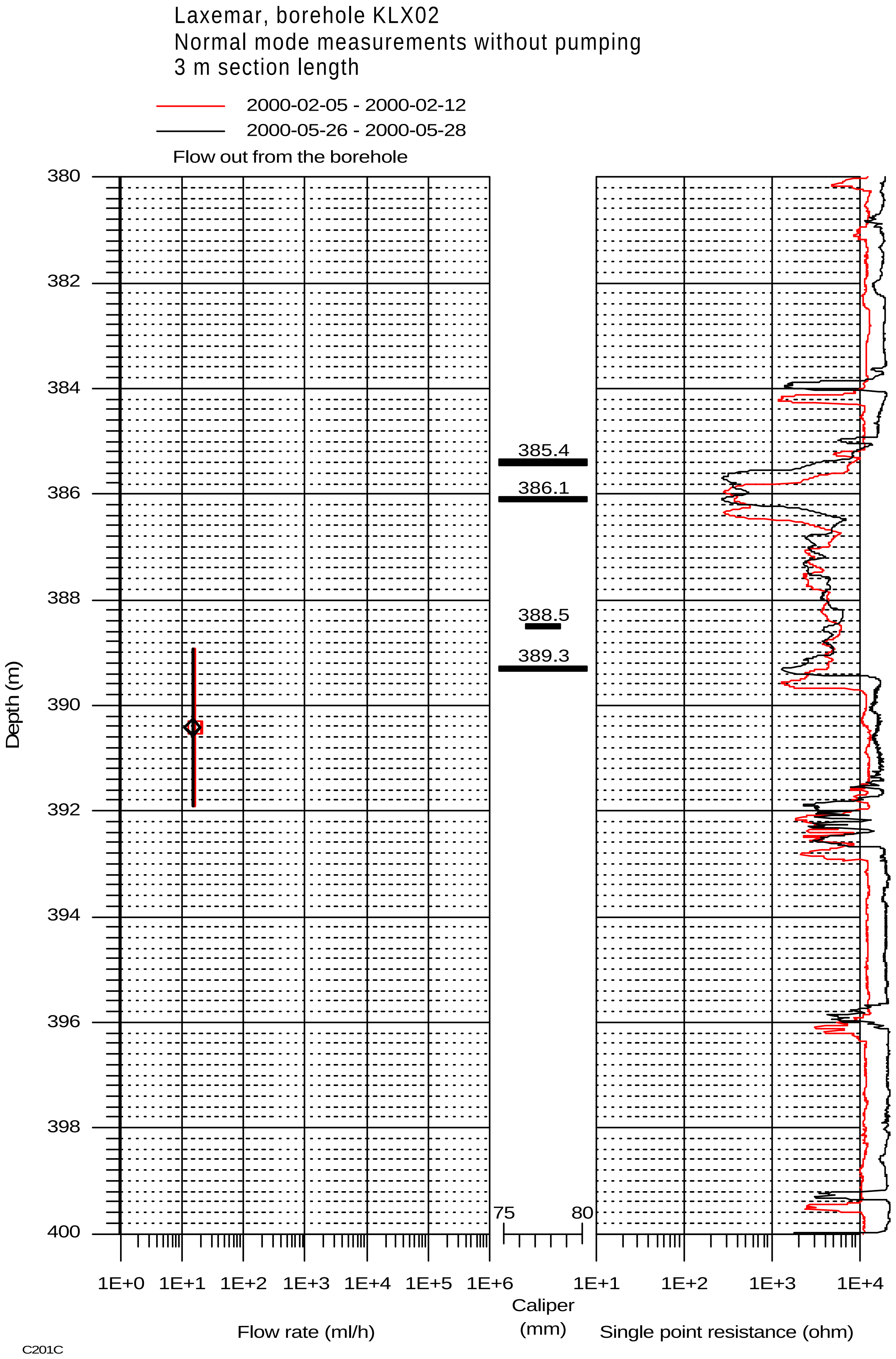


C201C


Laxemar, borehole KLX02
Normal mode measurements without pumping
3 m section length
2000-02-05 - 2000-02-12
2000-05-26 - 2000-05-28
Flow out from the borehole
Depth (m)
340
342
344
346
348
350
352
354
356
358
360
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C201C

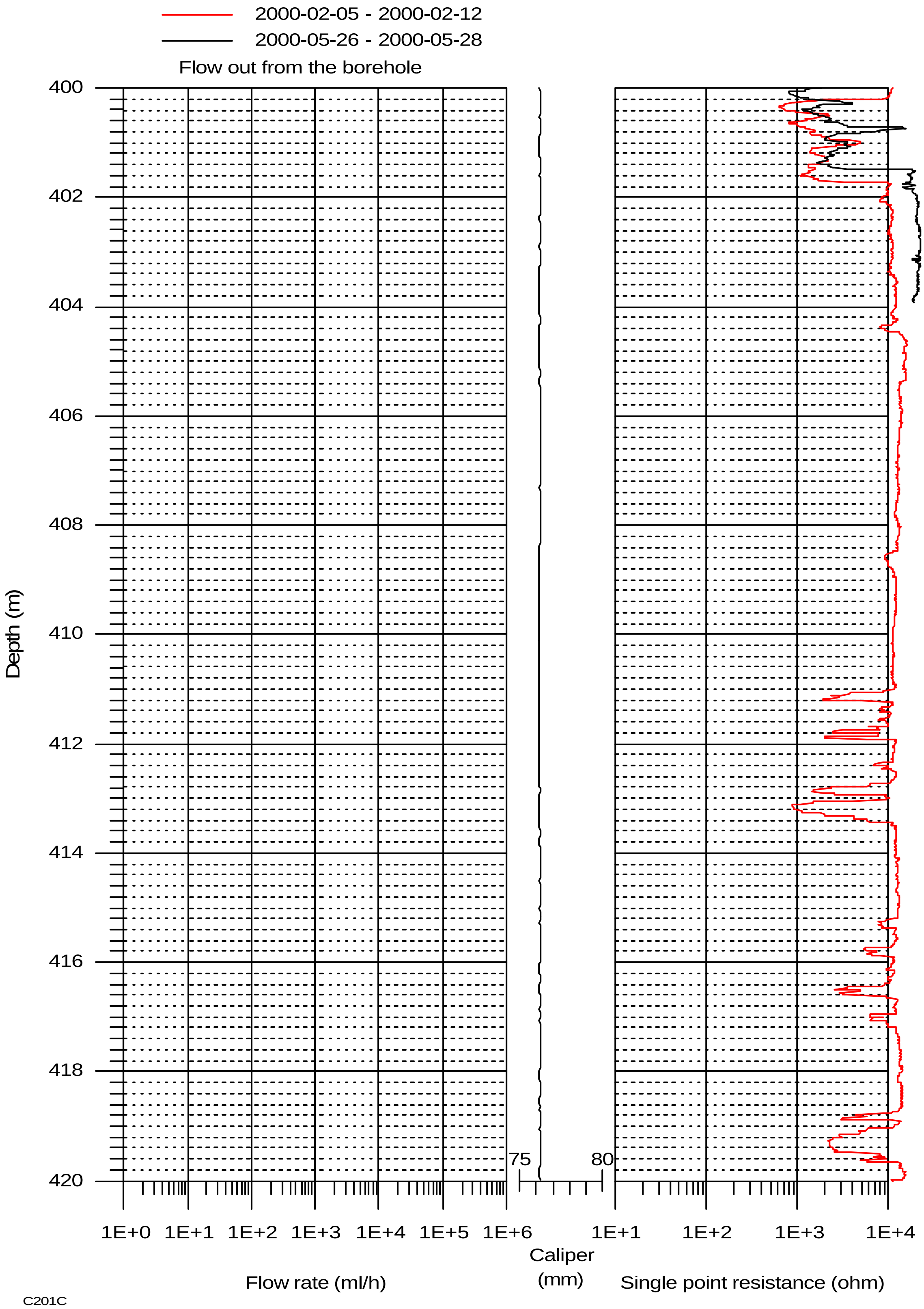


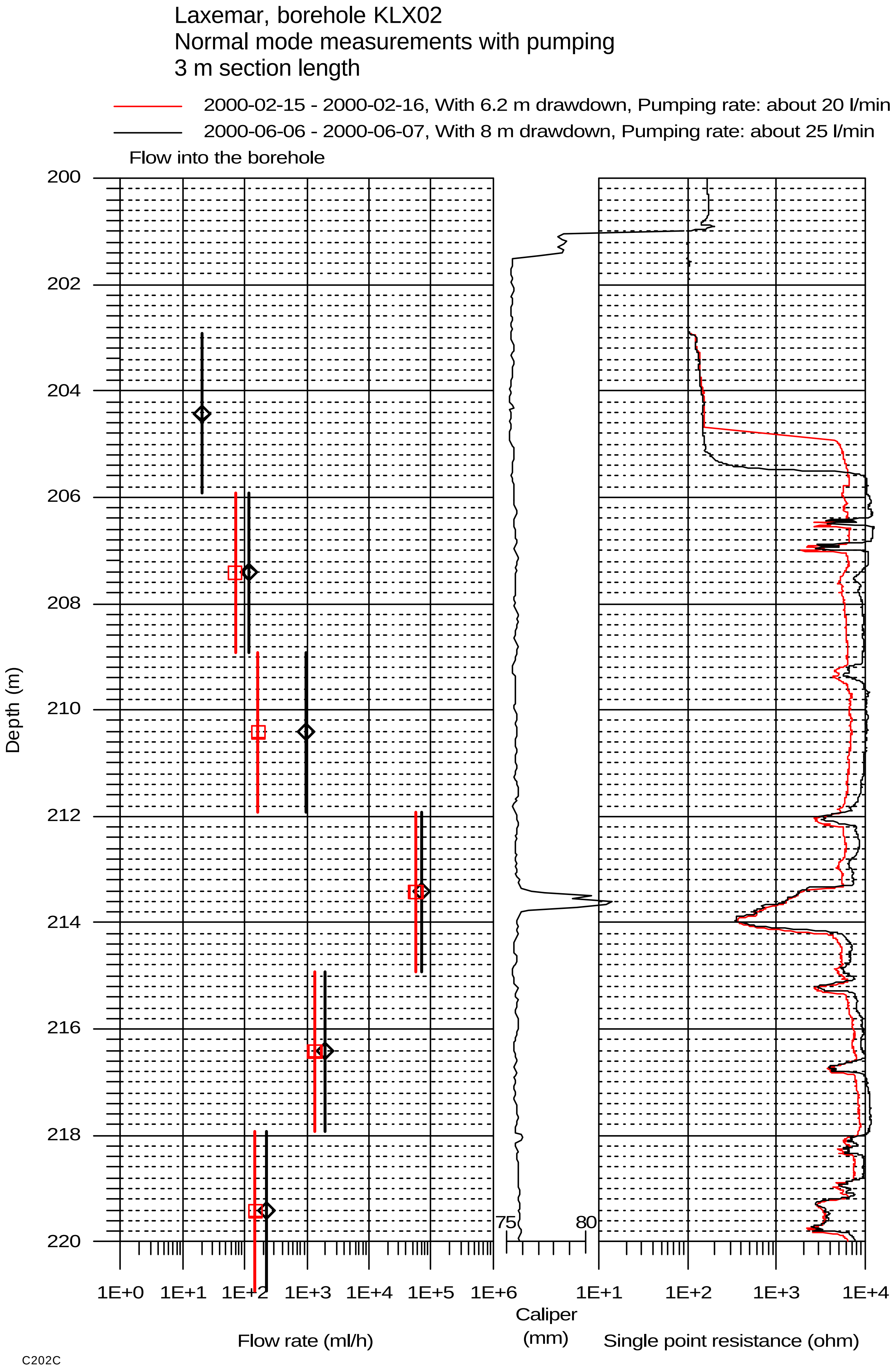
Laxemar, borehole KLX02
Normal mode measurements without pumping
3 m section length
2000-02-05 - 2000-02-12
2000-05-26 - 2000-05-28
Flow out from the borehole
Depth (m)
360
362
364
366
368
370
372
374
376
378
380
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Flow rate (ml/h)
Single point resistance (ohm)
C201C



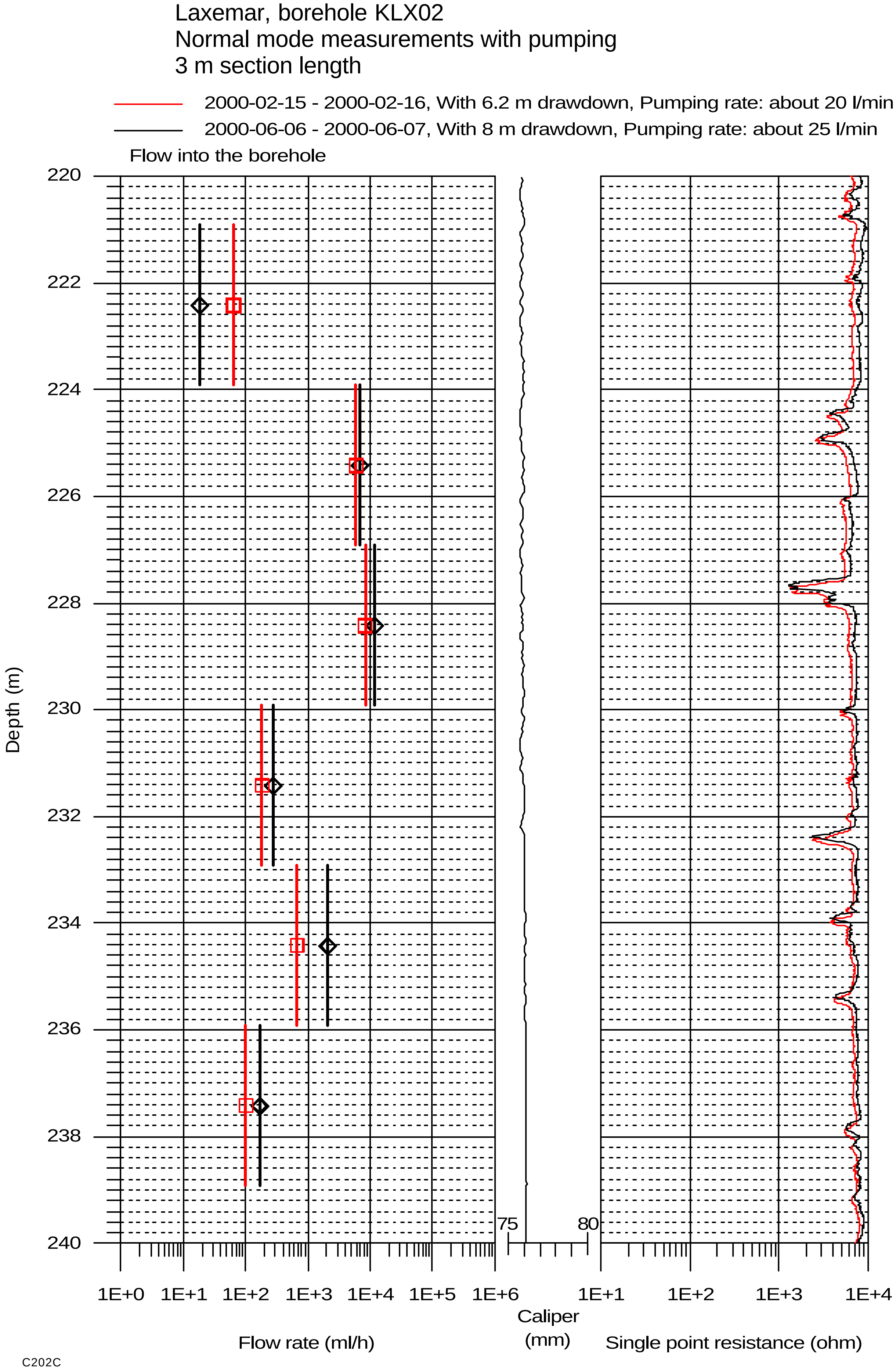
Laxemar, borehole KLX02
Normal mode measurements without pumping
3 m section length
2000-02-05 - 2000-02-12
2000-05-26 - 2000-05-28
Flow out from the borehole
Depth (m)
380
382
384
386
388
390
392
394
396
398
400
385.4
386.1
388.5
389.3
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
C201C

Laxemar, borehole KLX02
Normal mode measurements without pumping
3 m section length



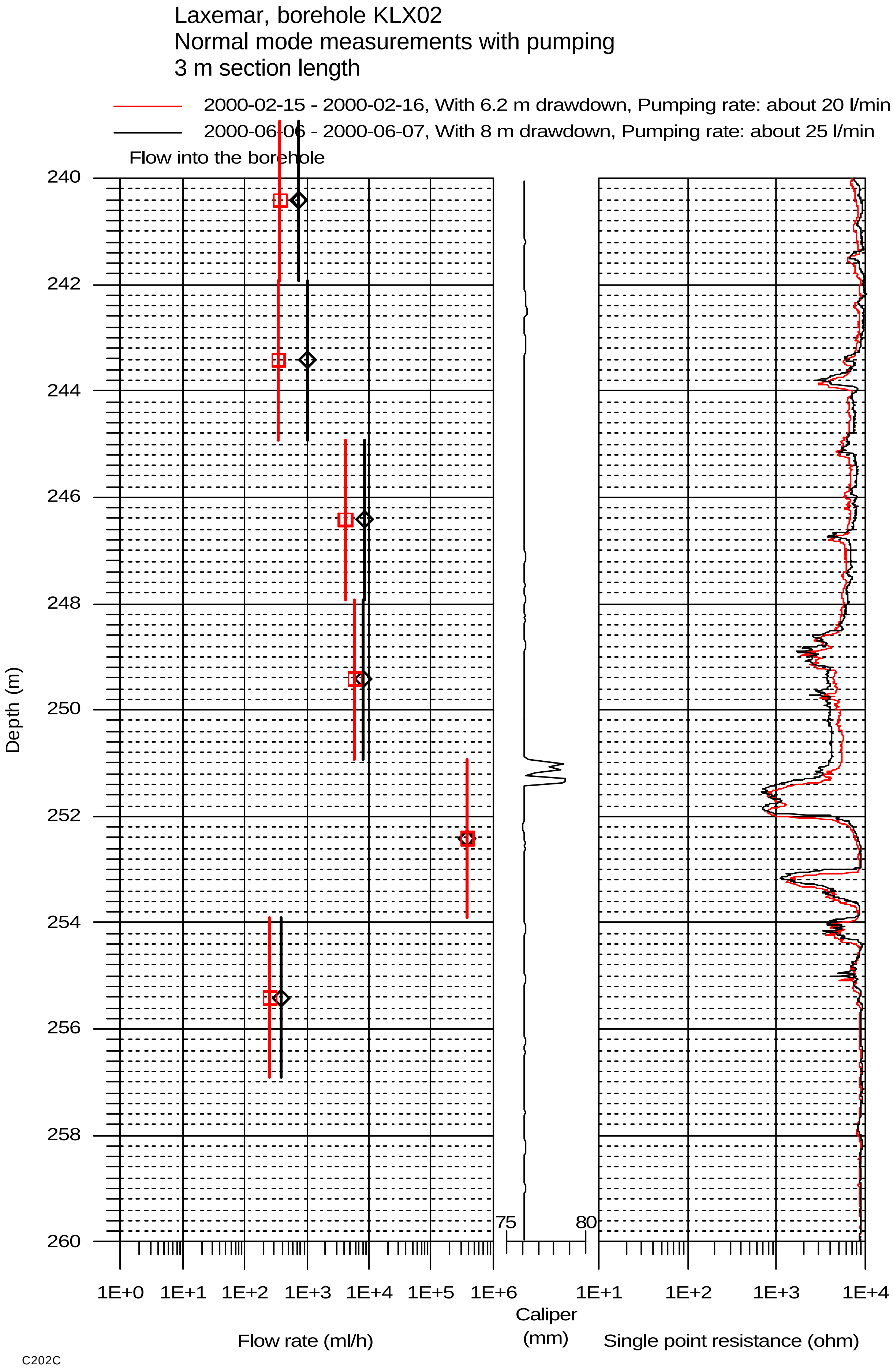


Laxemar, borehole KLX02
Normal mode measurements with pumping
3 m section length
2000-02-15 - 2000-02-16, With 6.2 m drawdown, Pumping rate: about 20 l/min
2000-06-06 - 2000-06-07, With 8 m drawdown, Pumping rate: about 25 l/min
Flow into the borehole
Depth (m)
200
202
204
206
208
210
212
214
216
218
220
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C202C

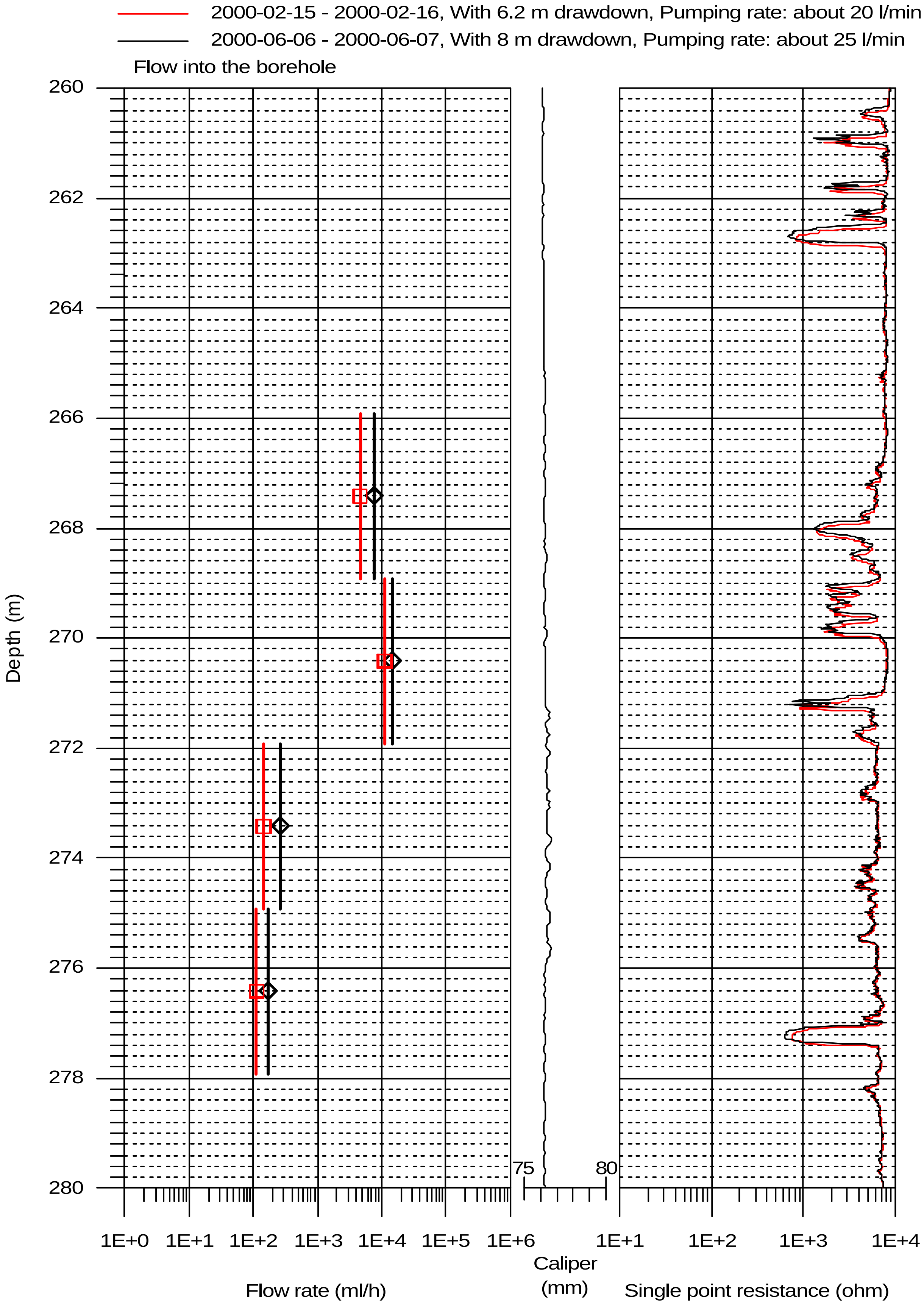


Laxemar, borehole KLX02
Normal mode measurements with pumping
3 m section length
2000-02-15 - 2000-02-16, With 6.2 m drawdown, Pumping rate: about 20 l/min
2000-06-06 - 2000-06-07, With 8 m drawdown, Pumping rate: about 25 l/min
Flow into the borehole
Depth (m)
220
222
224
226
228
230
232
234
236
238
240
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Flow rate (ml/h)
Single point resistance (ohm)

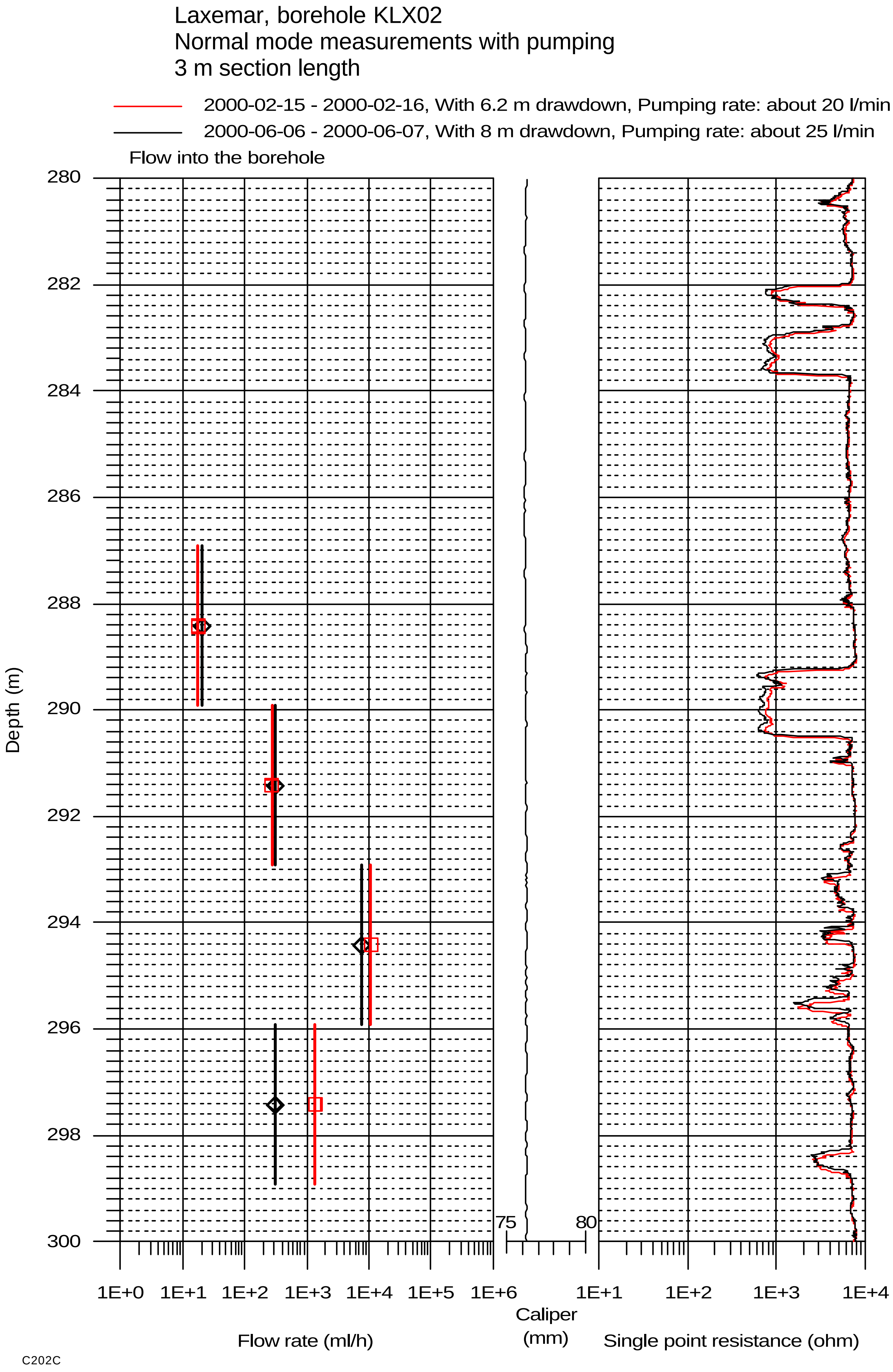
C202C


Laxemar, borehole KLX02
Normal mode measurements with pumping
3 m section length
2000-02-15 - 2000-02-16, With 6.2 m drawdown, Pumping rate: about 20 l/min
2000-06-06 - 2000-06-07, With 8 m drawdown, Pumping rate: about 25 l/min
Flow into the borehole
Depth (m)
240
242
244
246
248
250
252
254
256
258
260
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C202C

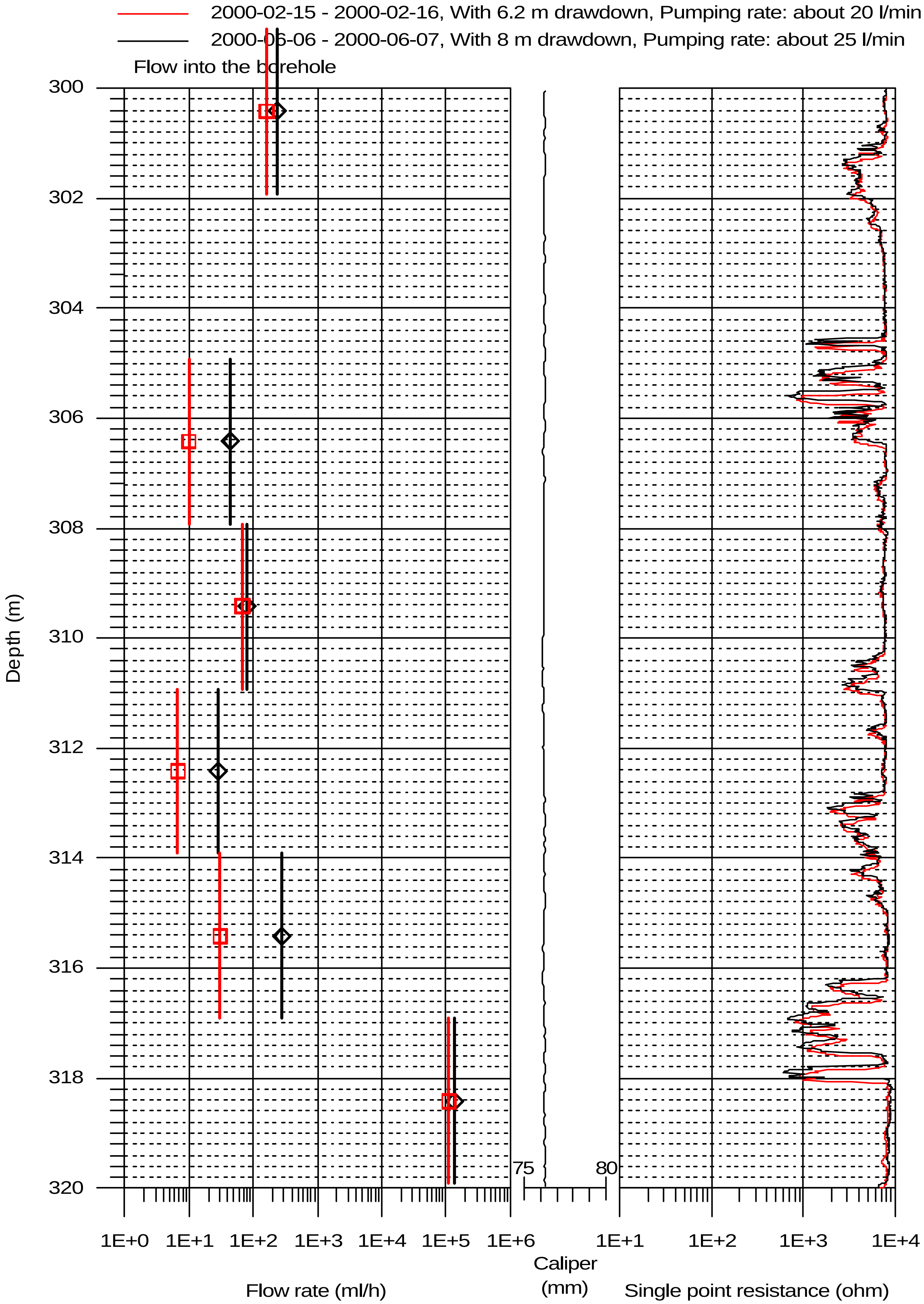
Laxemar, borehole KLX02
Normal mode measurements with pumping
3 m section length



C202C

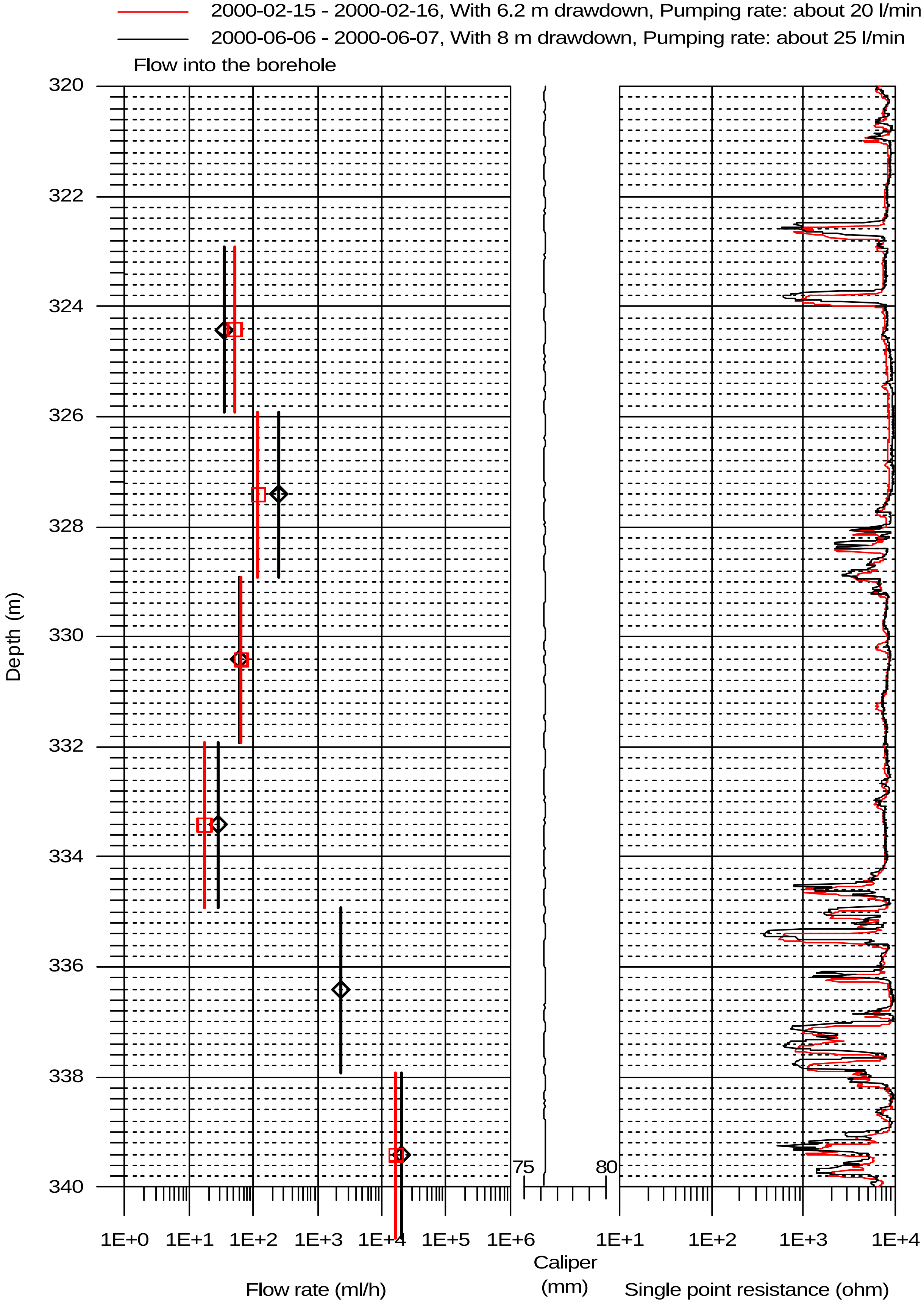

Laxemar, borehole KLX02
Normal mode measurements with pumping
3 m section length
2000-02-15 - 2000-02-16, With 6.2 m drawdown, Pumping rate: about 20 l/min
2000-06-06 - 2000-06-07, With 8 m drawdown, Pumping rate: about 25 l/min
Flow into the borehole
Depth (m)
280
282
284
286
288
290
292
294
296
298
300
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C202C

Laxemar, borehole KLX02
Normal mode measurements with pumping
3 m section length



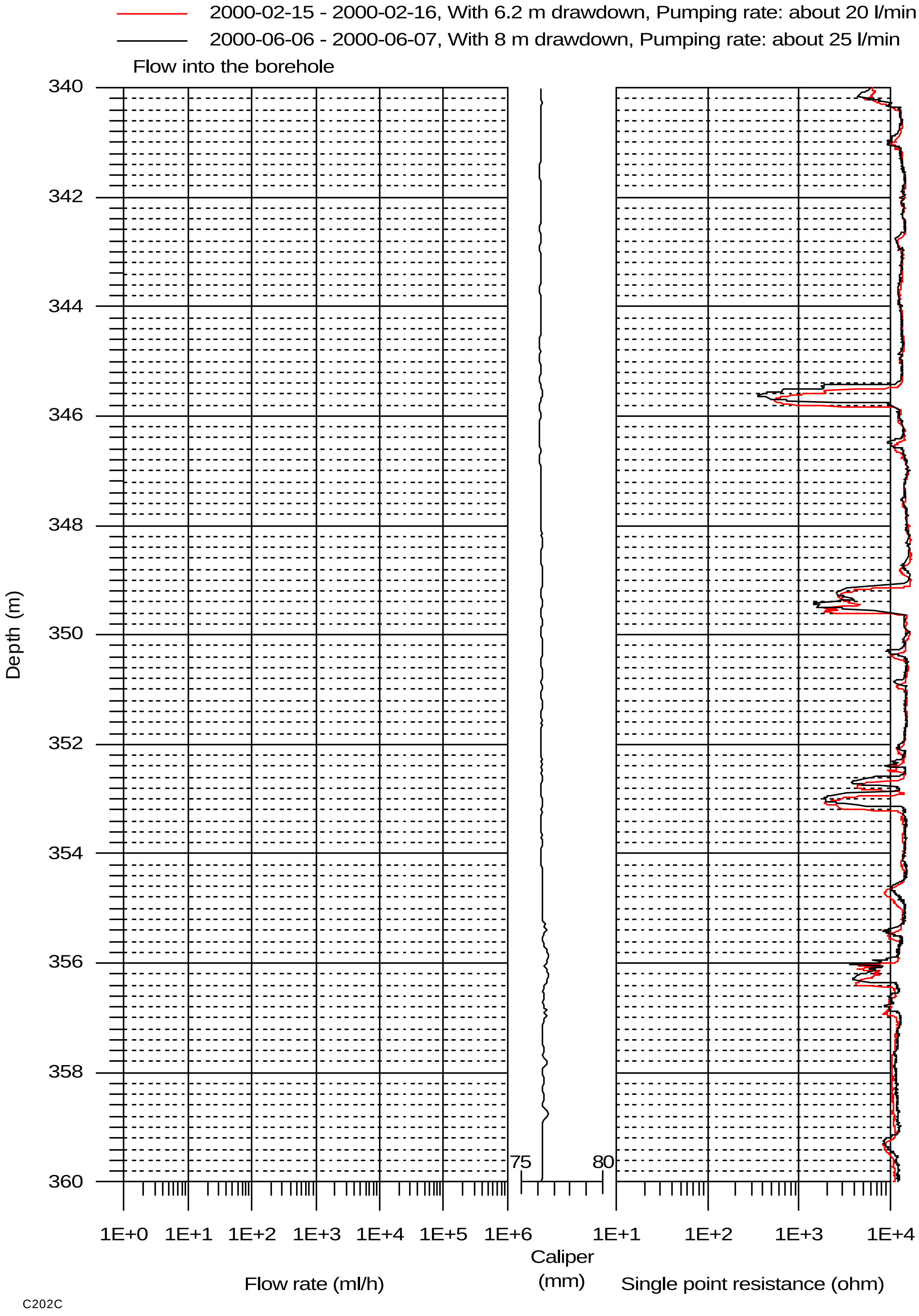
C202C

Laxemar, borehole KLX02
Normal mode measurements with pumping
3 m section length

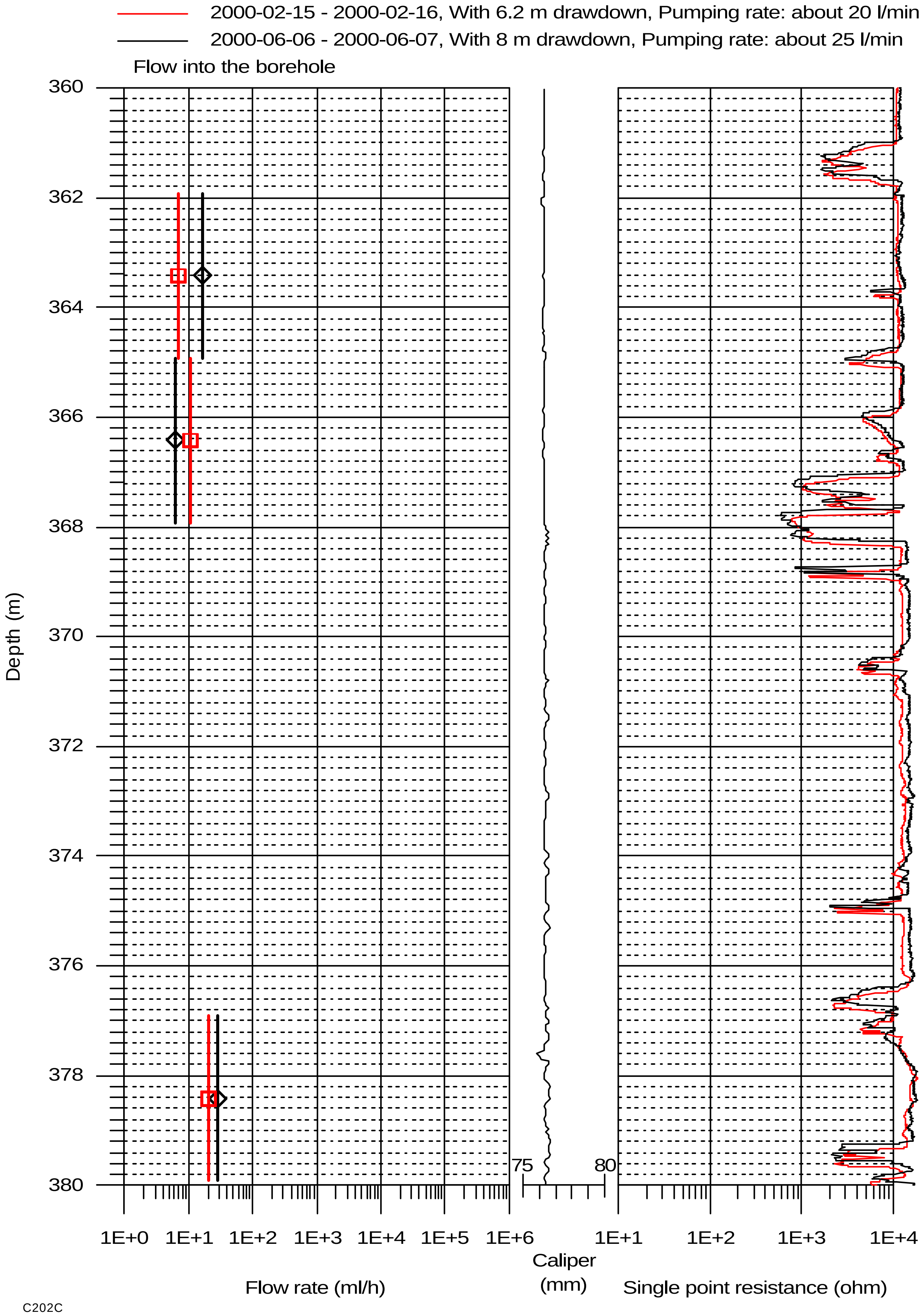


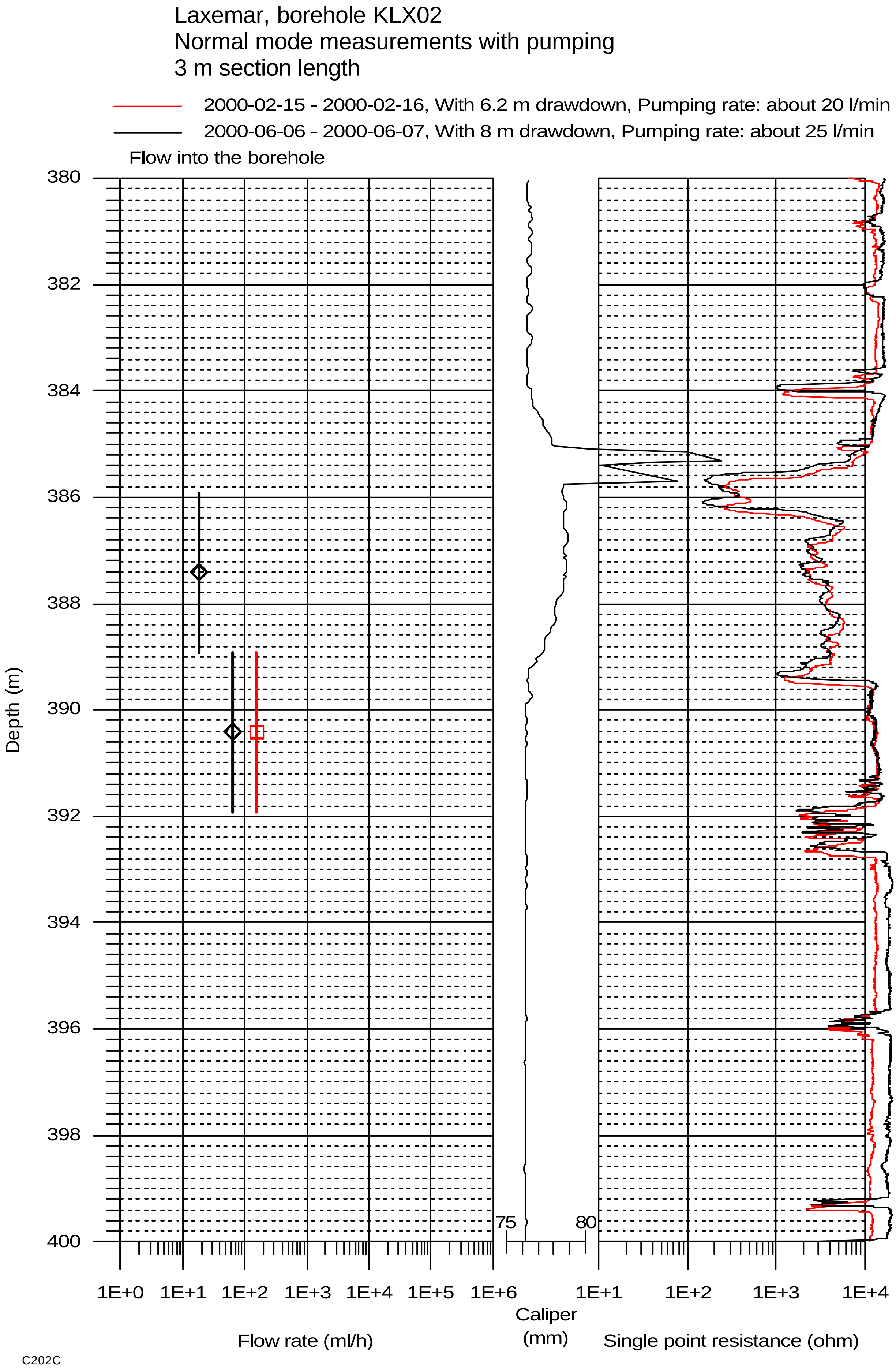
C202C

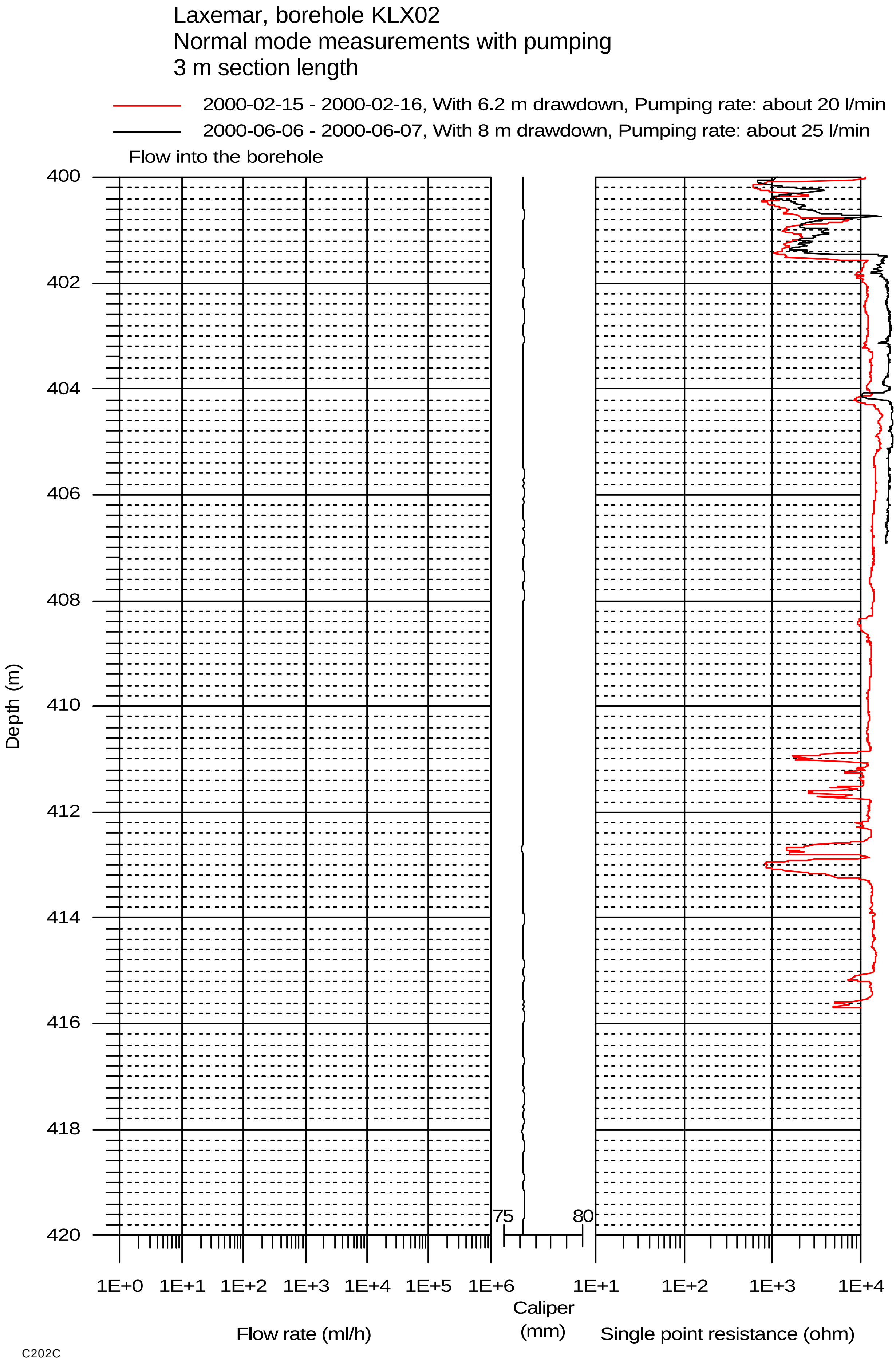
Laxemar, borehole KLX02
Normal mode measurements with pumping
3 m section length



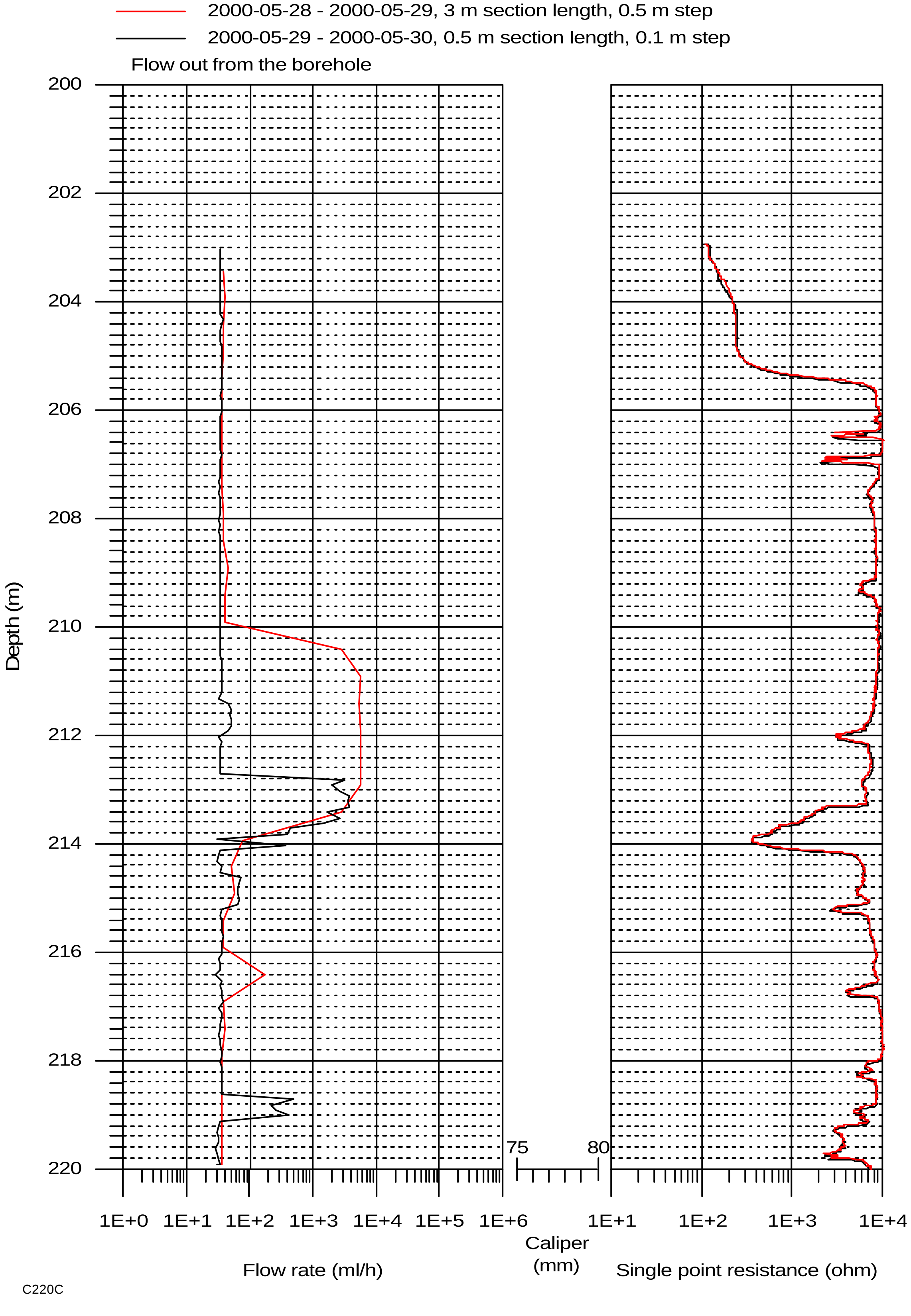
Laxemar, borehole KLX02
Normal mode measurements with pumping
3 m section length



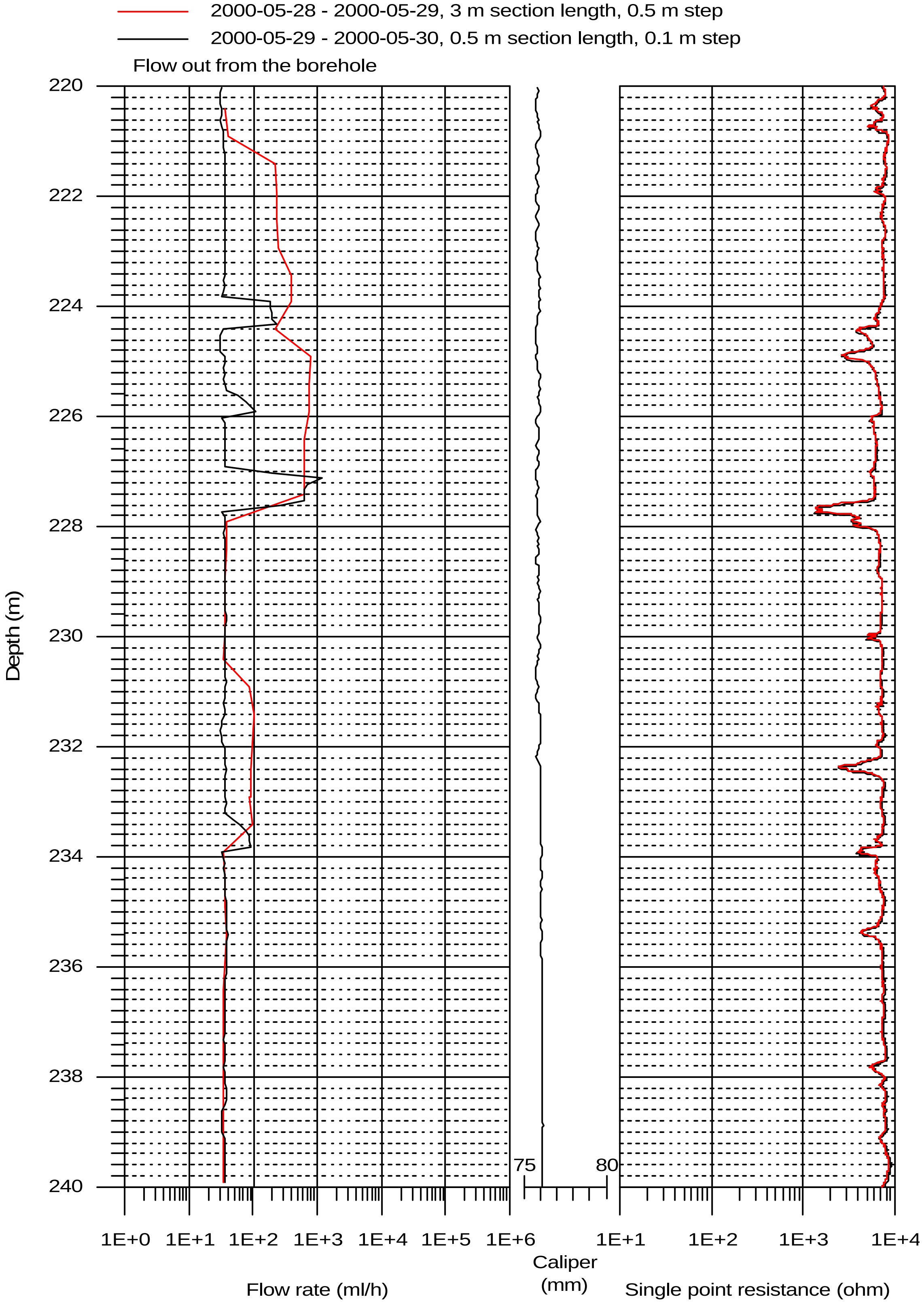

Laxemar, borehole KLX02
Normal mode measurements with pumping
3 m section length
2000-02-15 - 2000-02-16, With 6.2 m drawdown, Pumping rate: about 20 l/min
2000-06-06 - 2000-06-07, With 8 m drawdown, Pumping rate: about 25 l/min
Flow into the borehole
Depth (m)
380
382
384
386
388
390
392
394
396
398
400
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C202C


Laxemar, borehole KLX02
Normal mode measurements with pumping
3 m section length
2000-02-15 - 2000-02-16, With 6.2 m drawdown, Pumping rate: about 20 l/min
2000-06-06 - 2000-06-07, With 8 m drawdown, Pumping rate: about 25 l/min
Flow into the borehole
Depth (m)
400
402
404
406
408
410
412
414
416
418
420
75
80
1E+0 1E+1 1E+2 1E+3 1E+4 1E+5 1E+6
1E+1 1E+2 1E+3 1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
C202C

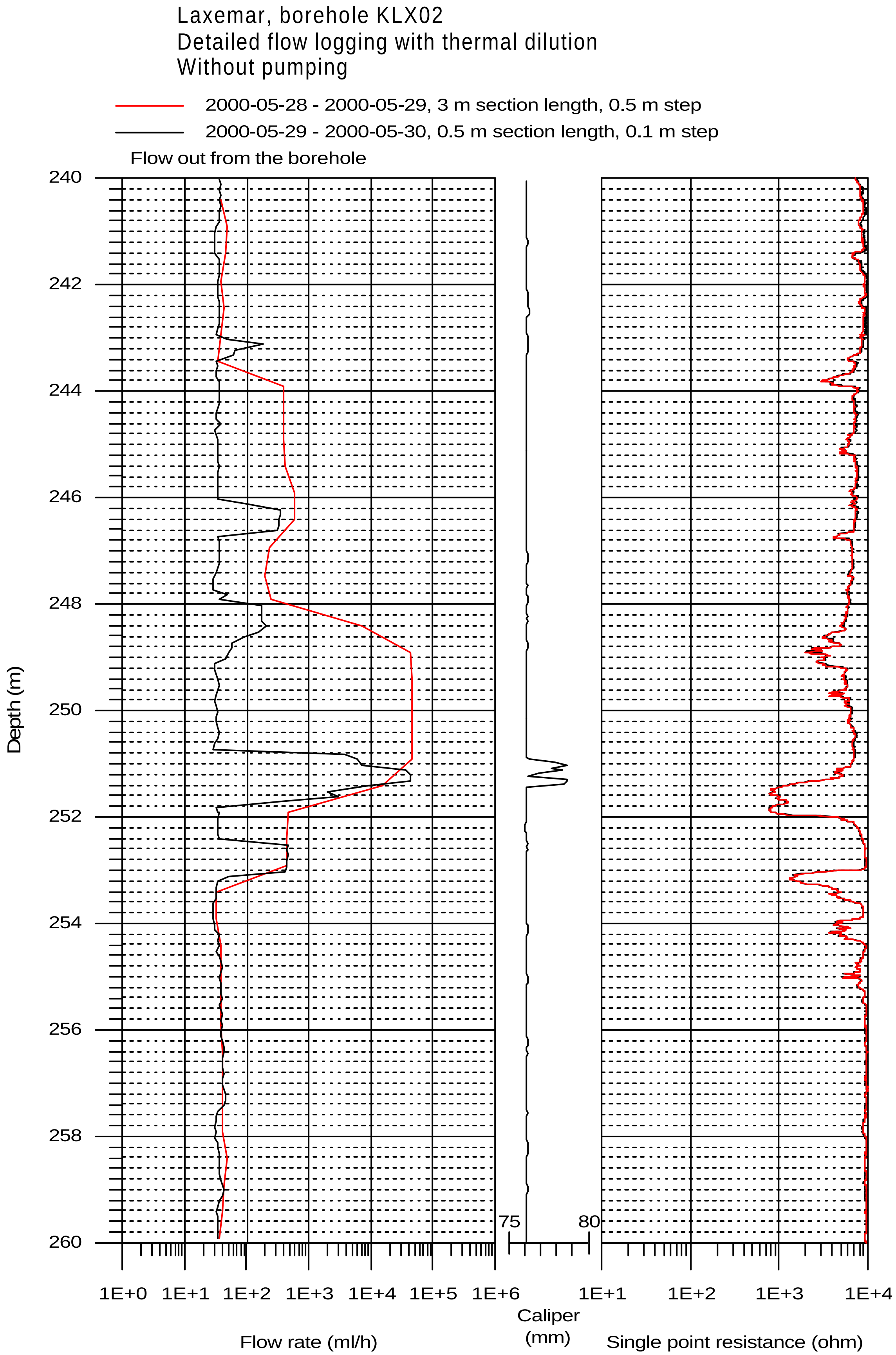
Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
Without pumping



Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
Without pumping

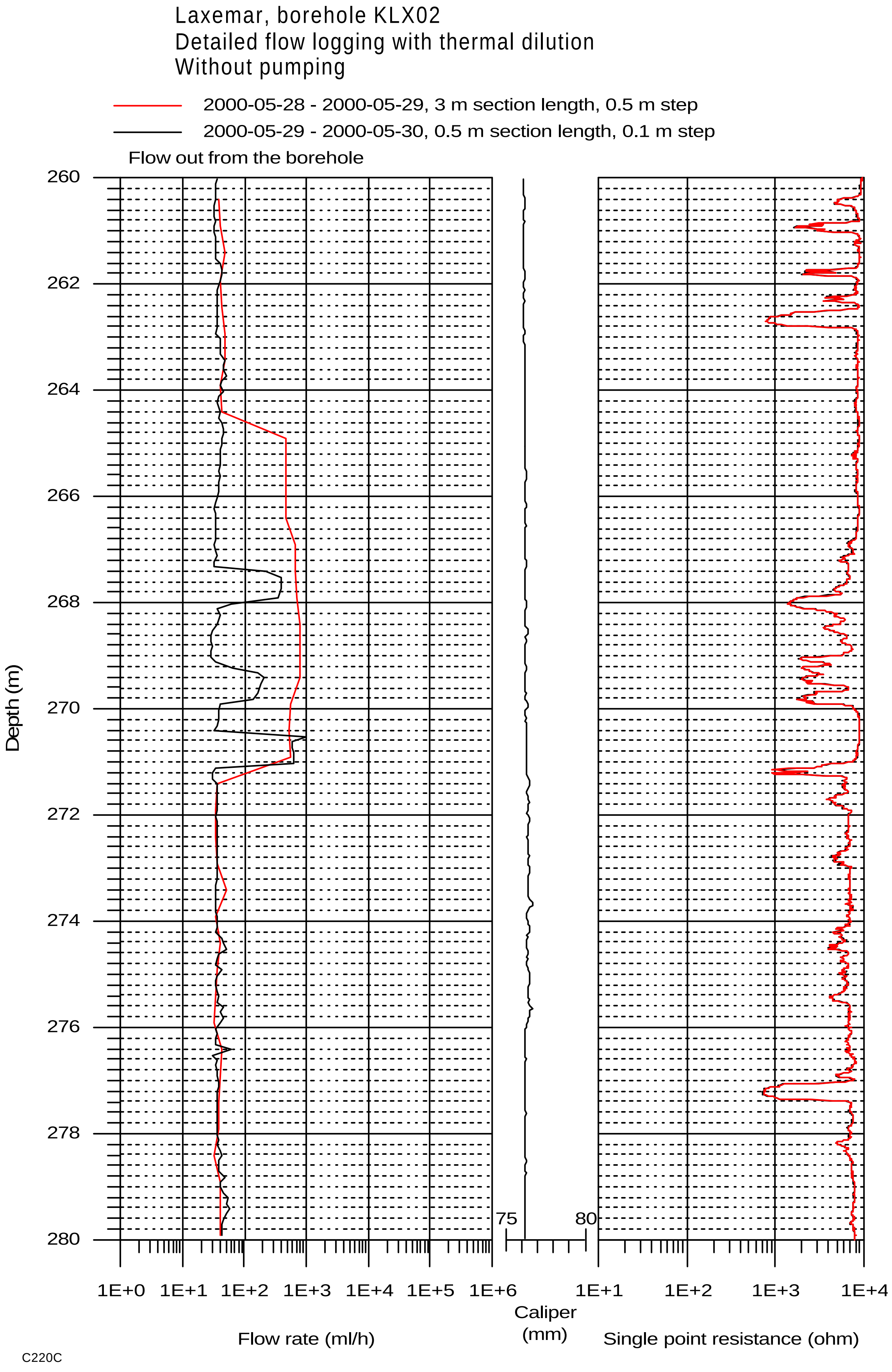


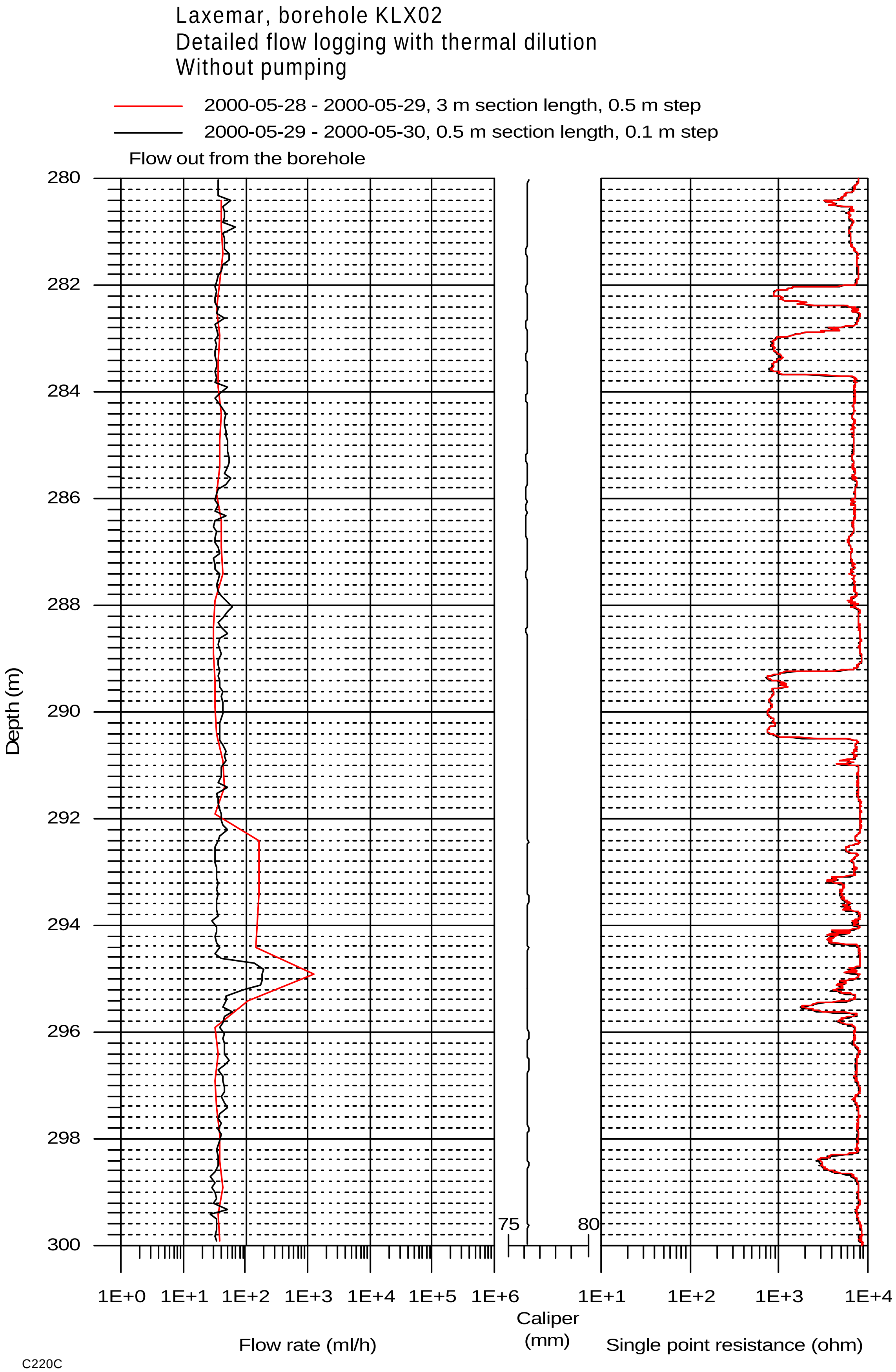
C220C

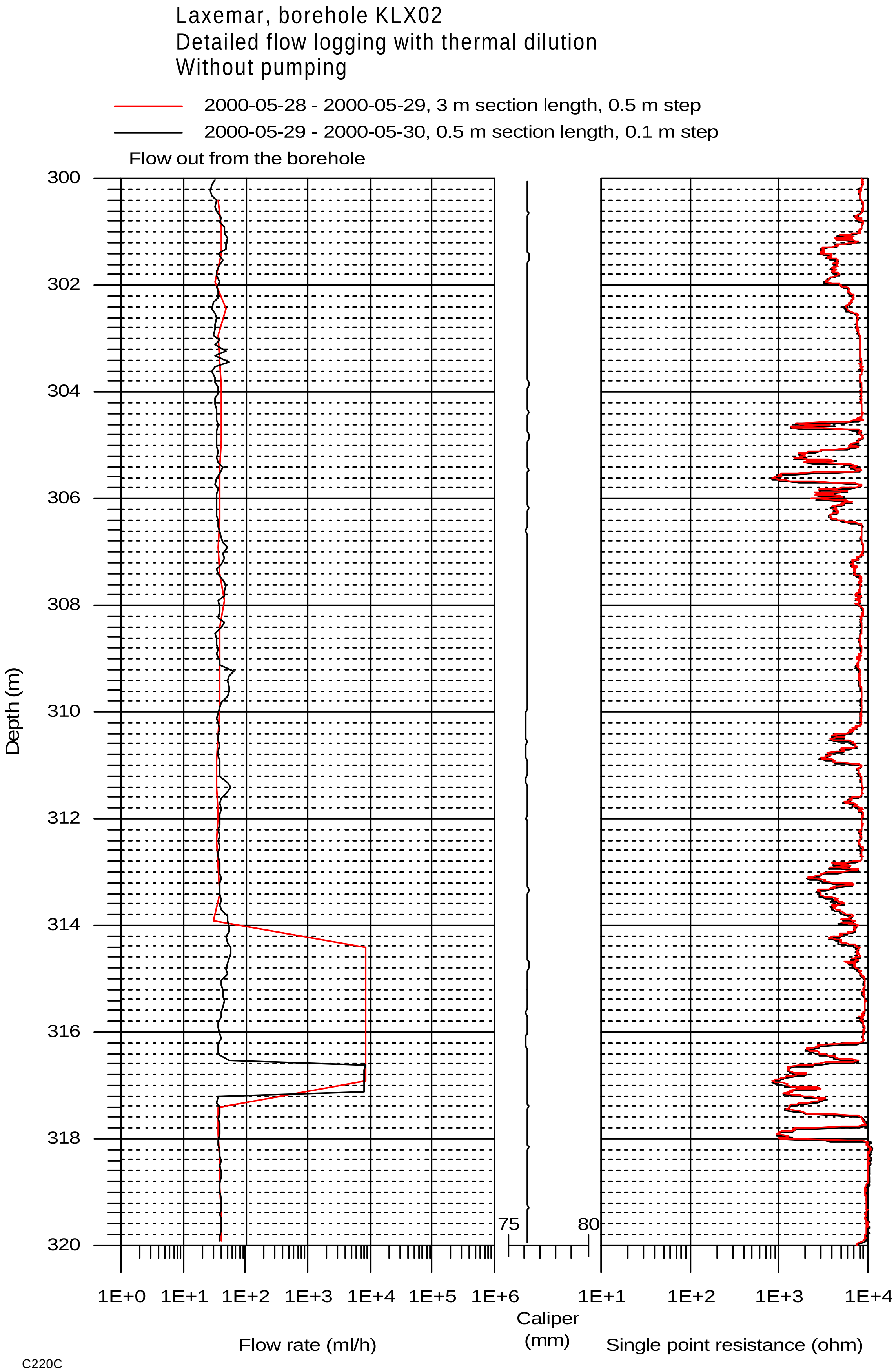


Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
Without pumping
2000-05-28 - 2000-05-29, 3 m section length, 0.5 m step
2000-05-29 - 2000-05-30, 0.5 m section length, 0.1 m step
Flow out from the borehole
240
242
244
246
248
250
252
254
256
258
260
Depth (m)
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)

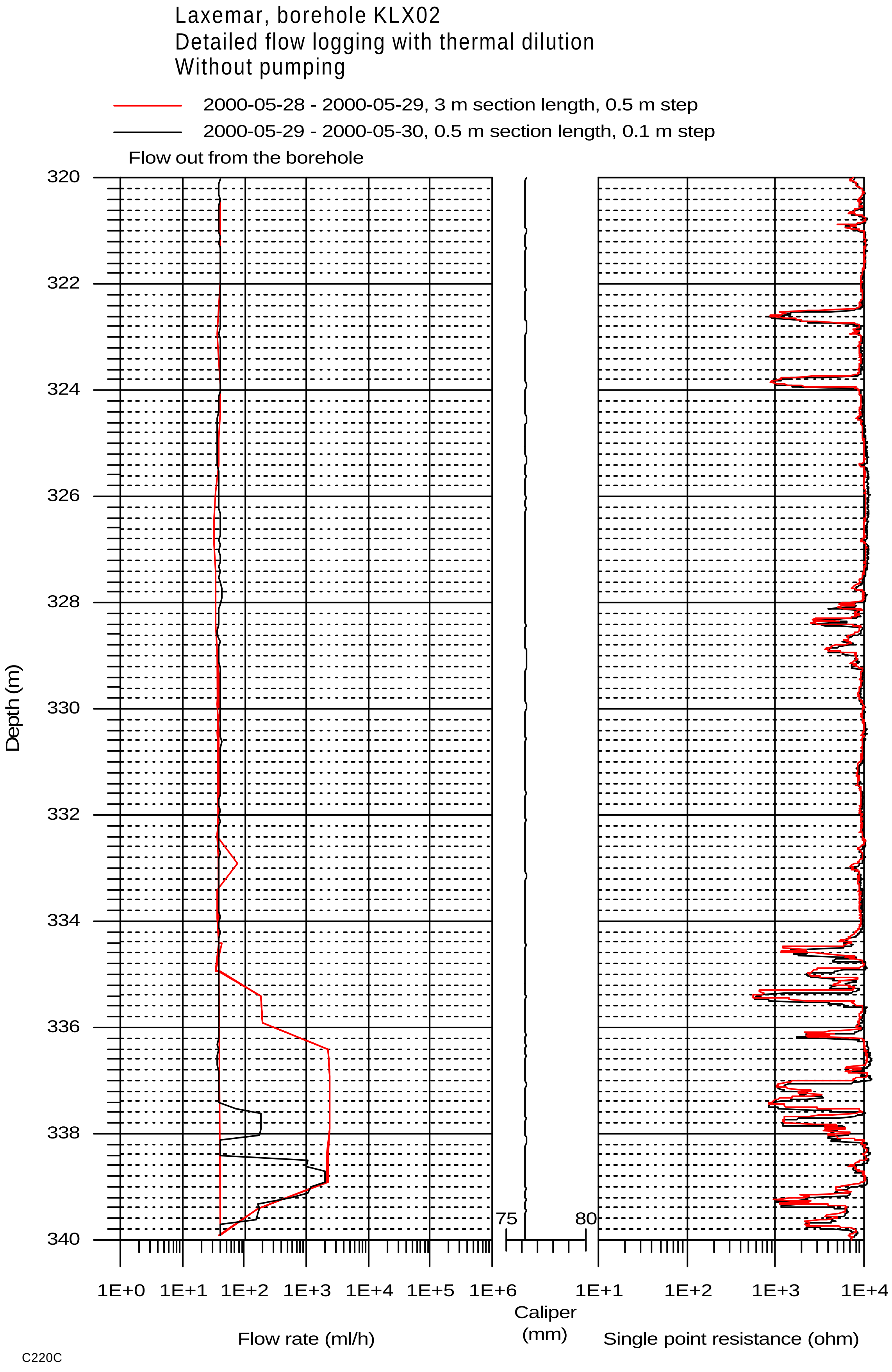
C220C

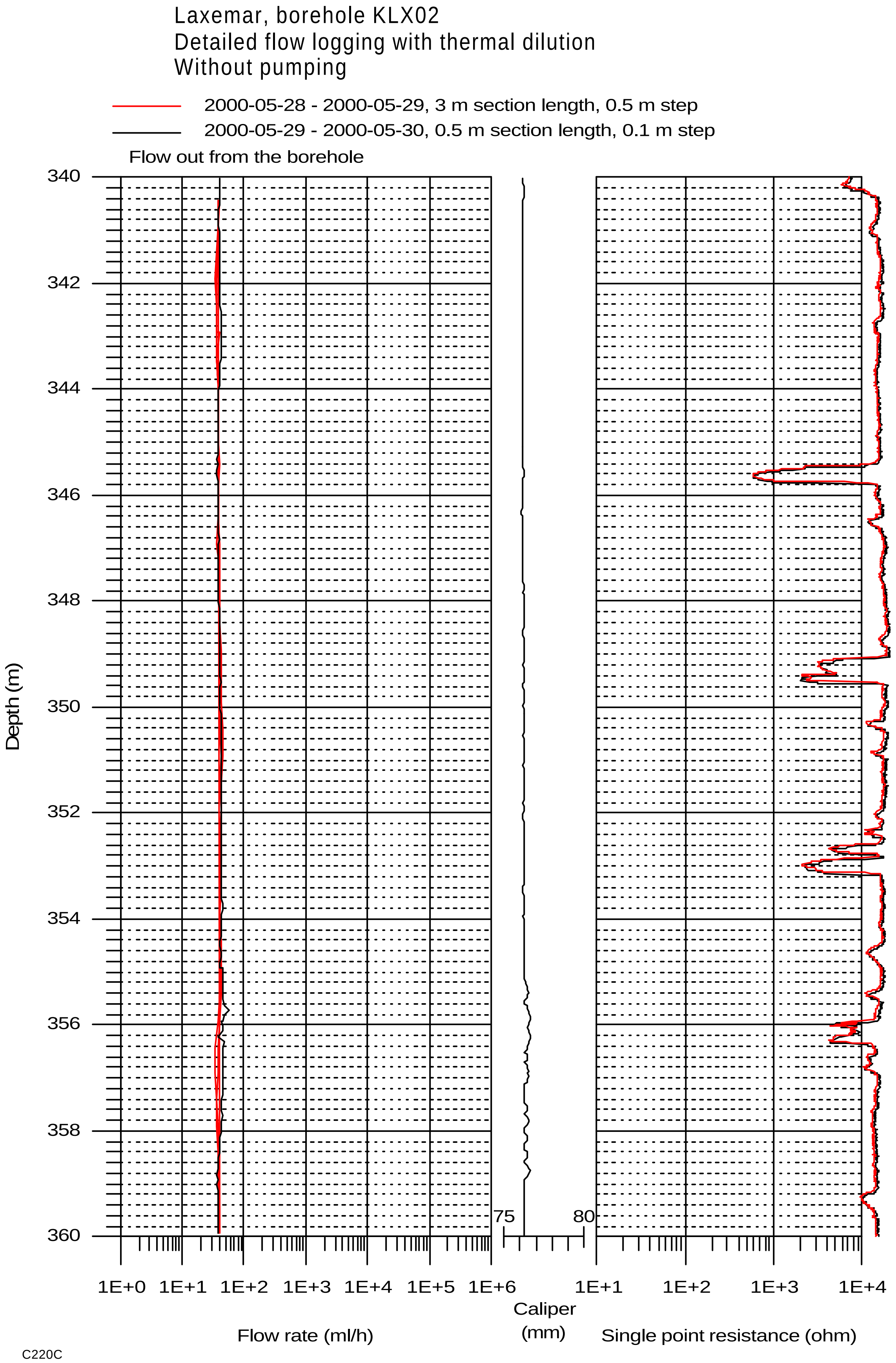

Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
Without pumping
2000-05-28 - 2000-05-29, 3 m section length, 0.5 m step
2000-05-29 - 2000-05-30, 0.5 m section length, 0.1 m step
Flow out from the borehole
Depth (m)
260
262
264
266
268
270
272
274
276
278
280
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C220C


Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
Without pumping
2000-05-28 - 2000-05-29, 3 m section length, 0.5 m step
2000-05-29 - 2000-05-30, 0.5 m section length, 0.1 m step
Flow out from the borehole
280
282
284
286
288
290
292
294
296
298
300
Depth (m)
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C220C

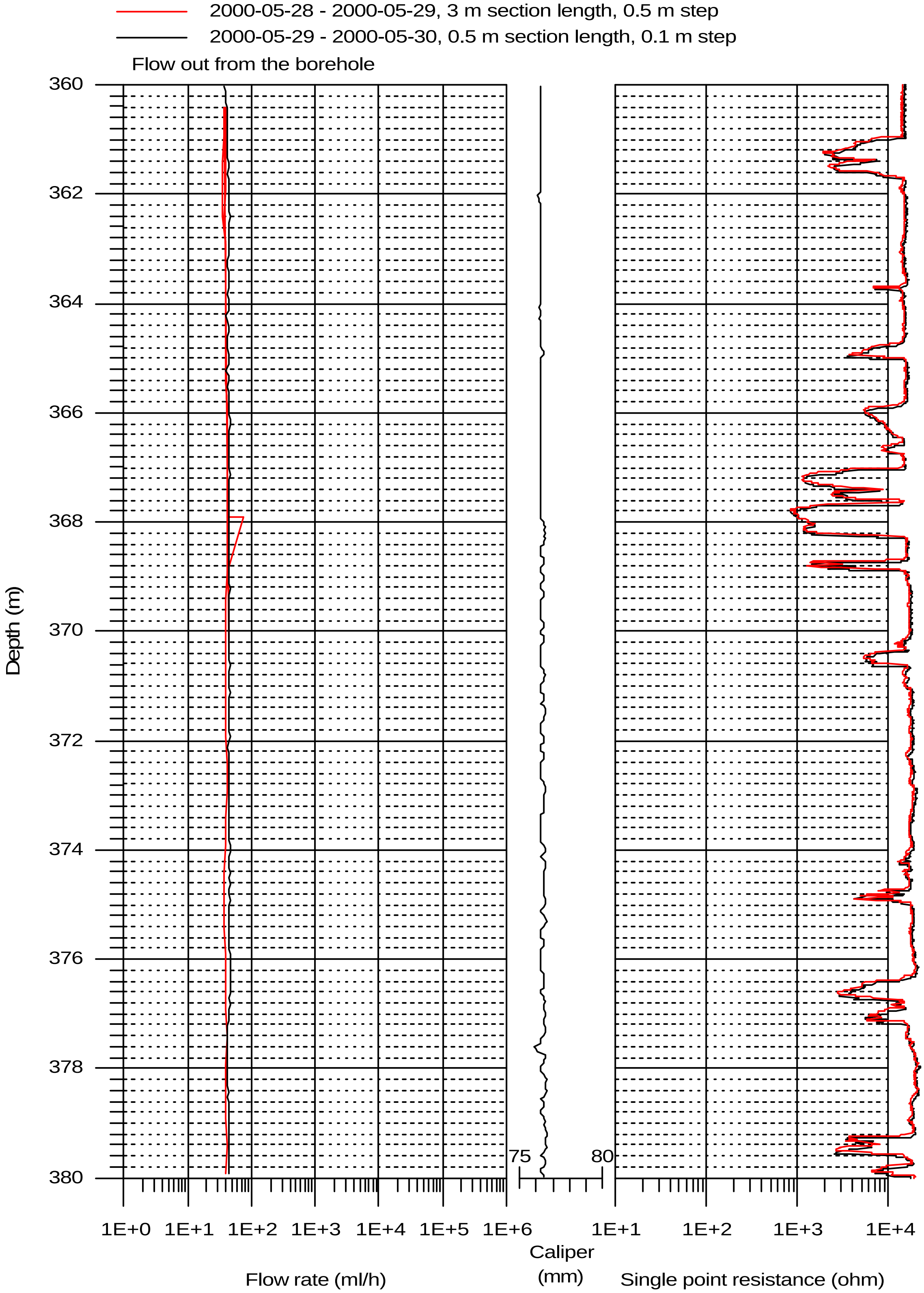


Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
Without pumping
2000-05-28 - 2000-05-29, 3 m section length, 0.5 m step
2000-05-29 - 2000-05-30, 0.5 m section length, 0.1 m step
Flow out from the borehole
Depth (m)
300
302
304
306
308
310
312
314
316
318
320
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C220C


Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
Without pumping
2000-05-28 - 2000-05-29, 3 m section length, 0.5 m step
2000-05-29 - 2000-05-30, 0.5 m section length, 0.1 m step
Flow out from the borehole
Depth (m)
320
322
324
326
328
330
332
334
336
338
340
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
75
80
Caliper (mm)
1E+1
1E+2
1E+3
1E+4
Flow rate (ml/h)
Single point resistance (ohm)
C220C

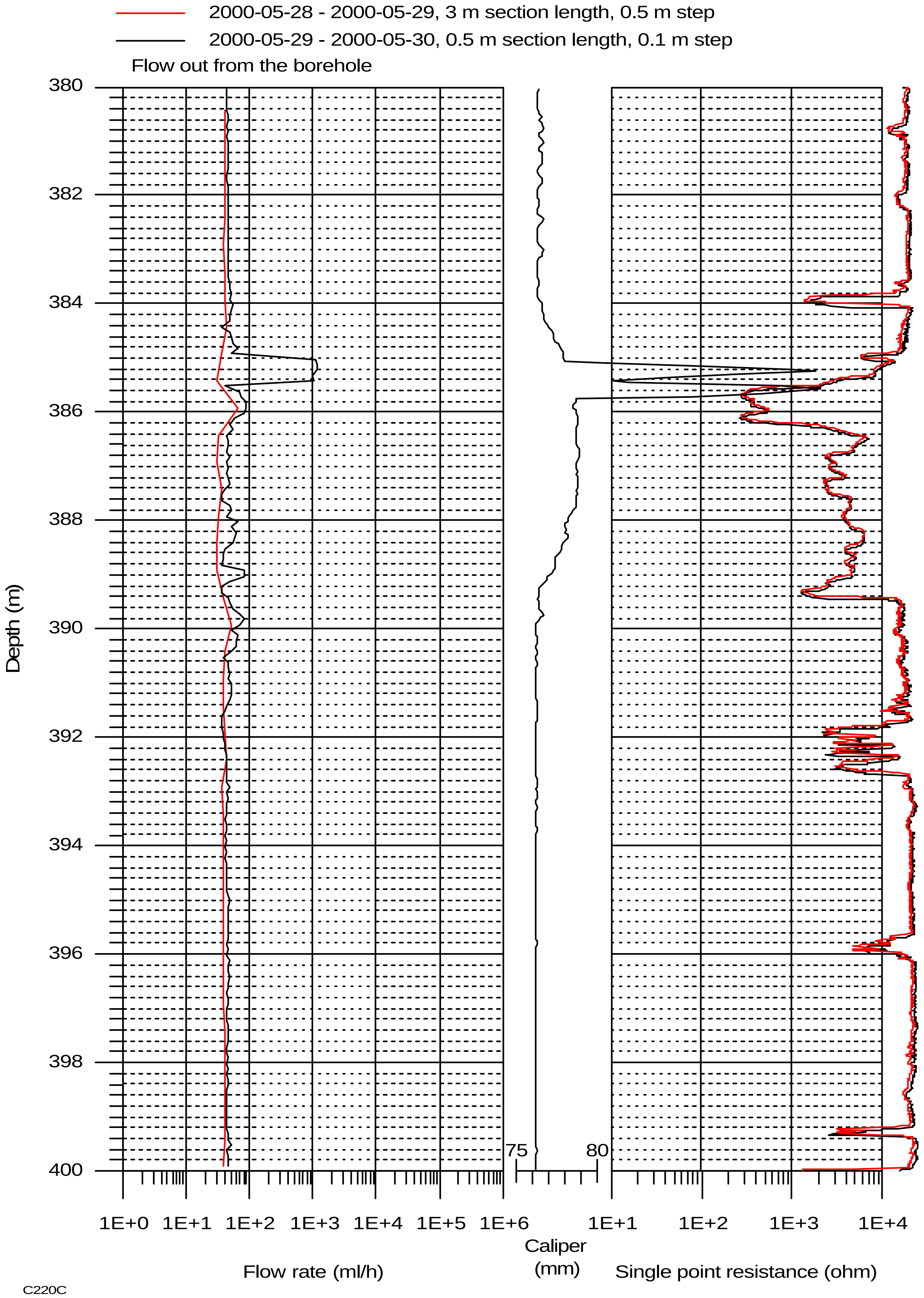

Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
Without pumping
2000-05-28 - 2000-05-29, 3 m section length, 0.5 m step
2000-05-29 - 2000-05-30, 0.5 m section length, 0.1 m step
Flow out from the borehole
Depth (m)
340
342
344
346
348
350
352
354
356
358
360
1E+0 1E+1 1E+2 1E+3 1E+4 1E+5 1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1 1E+2 1E+3 1E+4
Single point resistance (ohm)
C220C

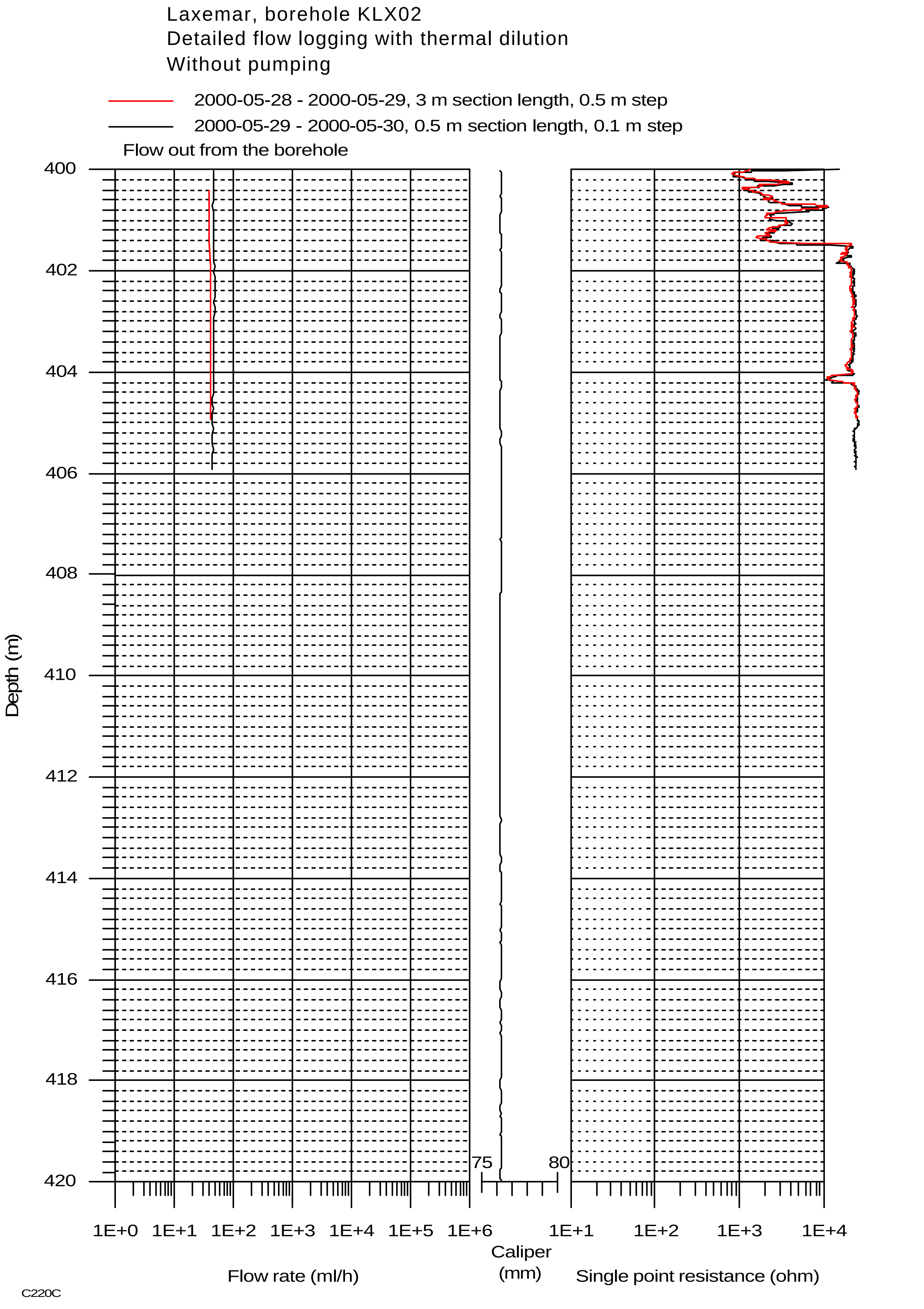
Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
Without pumping



C220C

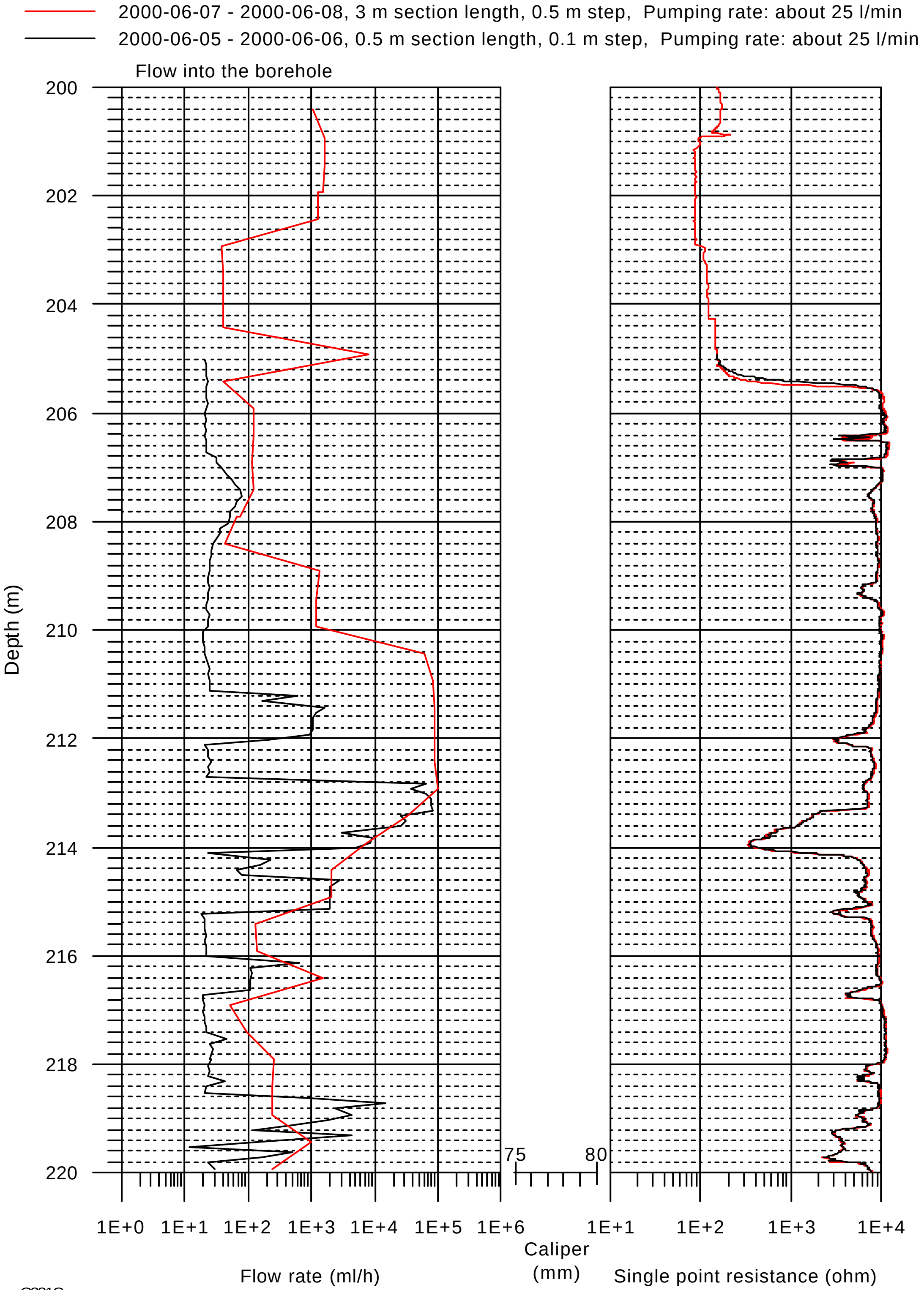
Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
Without pumping





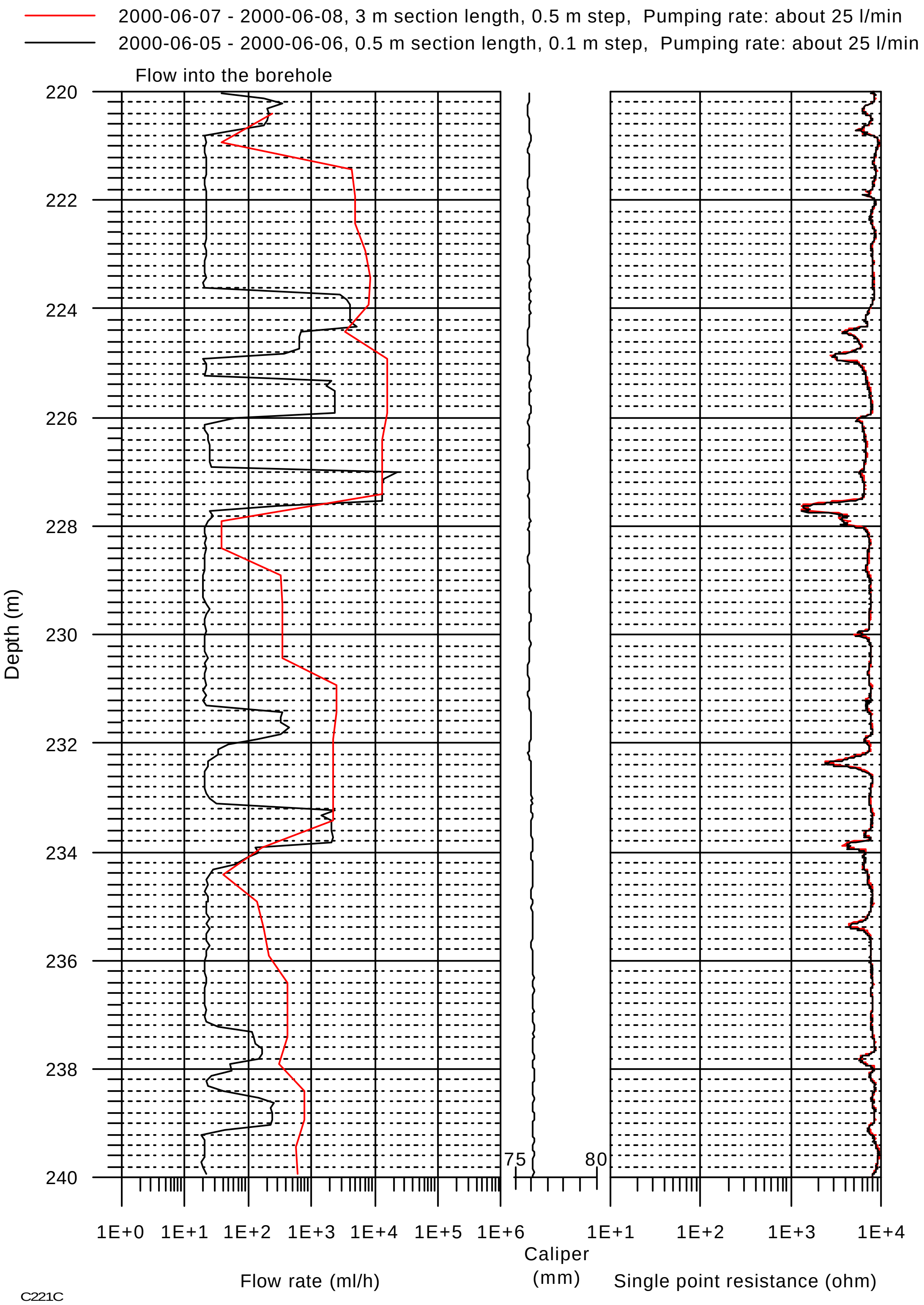
Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
Without pumping
2000-05-28 - 2000-05-29, 3 m section length, 0.5 m step
2000-05-29 - 2000-05-30, 0.5 m section length, 0.1 m step
Flow out from the borehole
400
402
404
406
408
410
412
414
416
418
420
Depth (m)
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
C220C

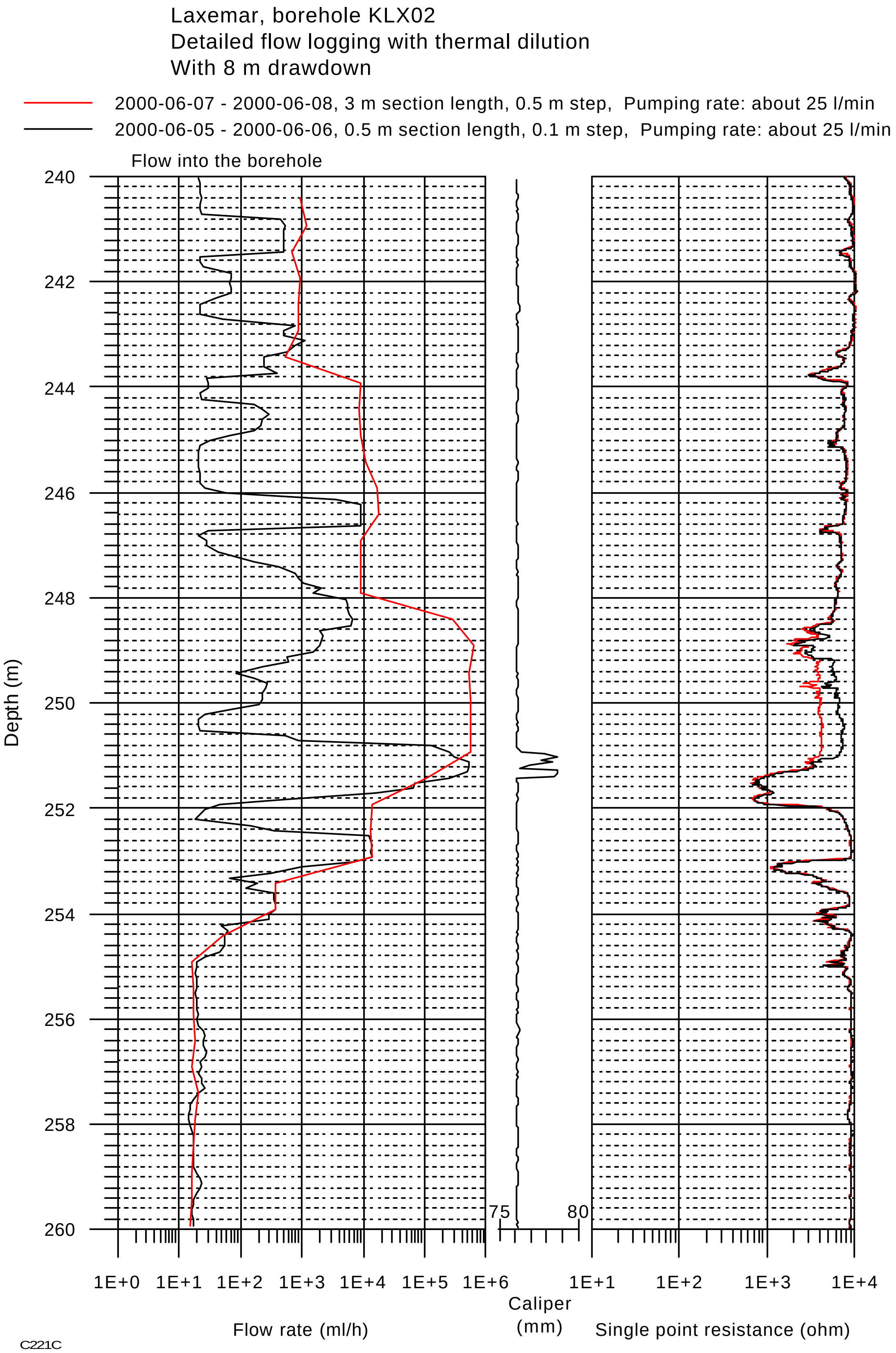
Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
With 8 m drawdown

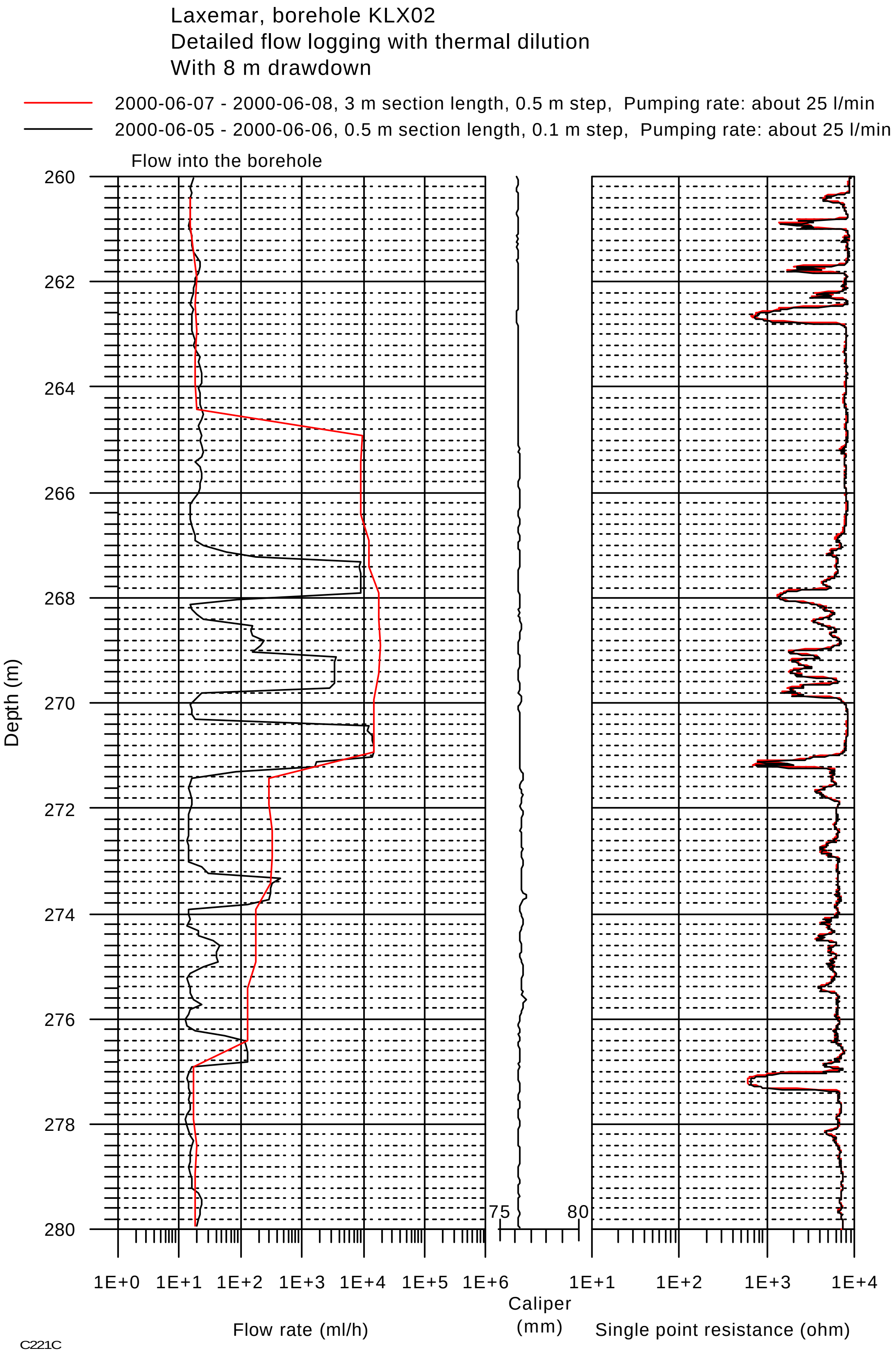


C221C

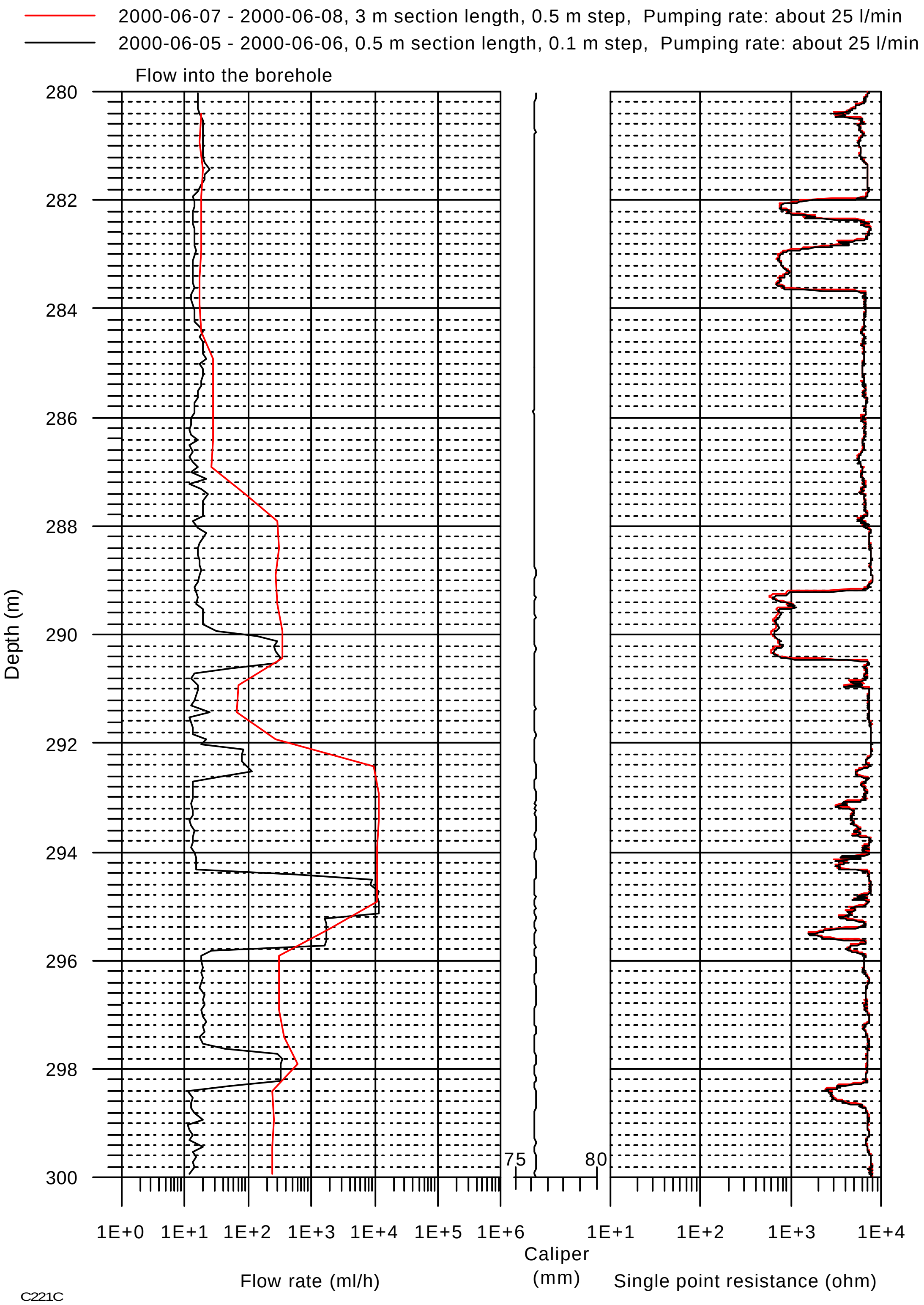
Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
With 8 m drawdown

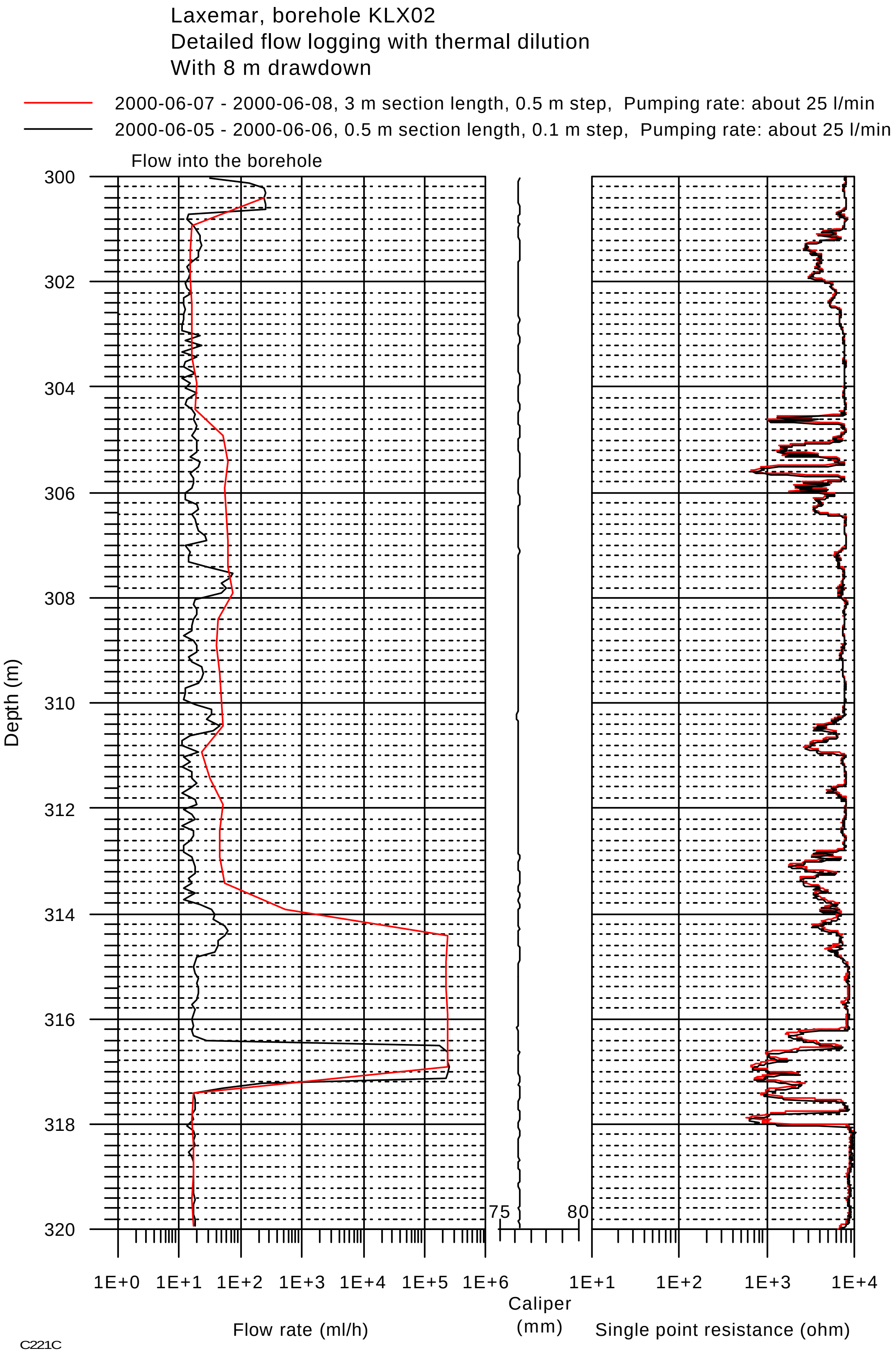



Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
With 8 m drawdown
2000-06-07 - 2000-06-08, 3 m section length, 0.5 m step, Pumping rate: about 25 l/min
2000-06-05 - 2000-06-06, 0.5 m section length, 0.1 m step, Pumping rate: about 25 l/min
Flow into the borehole
Depth (m)
240
242
244
246
248
250
252
254
256
258
260
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
C221C


Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
With 8 m drawdown
2000-06-07 - 2000-06-08, 3 m section length, 0.5 m step, Pumping rate: about 25 l/min
2000-06-05 - 2000-06-06, 0.5 m section length, 0.1 m step, Pumping rate: about 25 l/min
Flow into the borehole
Depth (m)
260
262
264
266
268
270
272
274
276
278
280
1E+0 1E+1 1E+2 1E+3 1E+4 1E+5 1E+6
Flow rate (ml/h)
75 80
Caliper (mm)
1E+1 1E+2 1E+3 1E+4
Single point resistance (ohm)
C221C

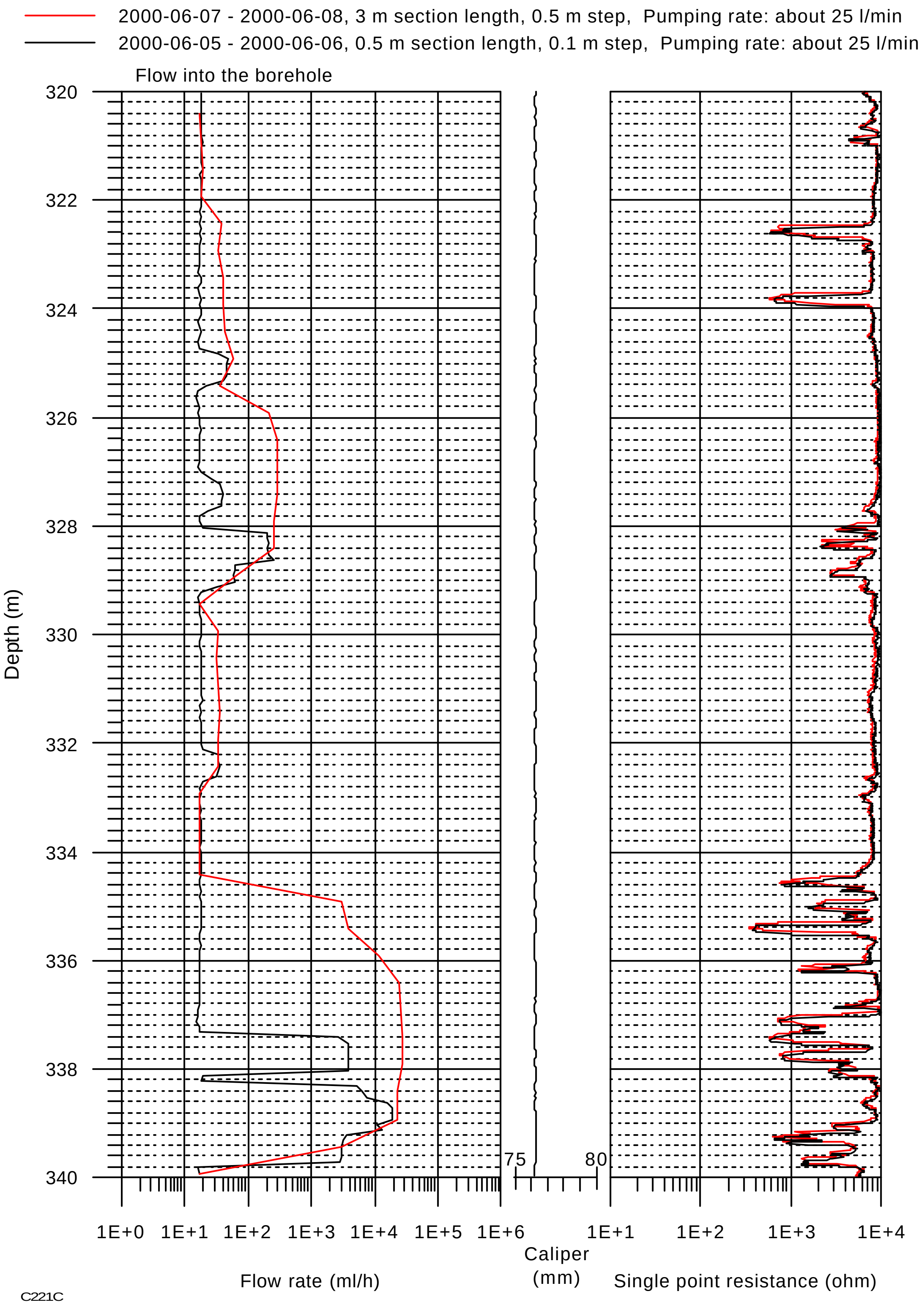
Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
With 8 m drawdown

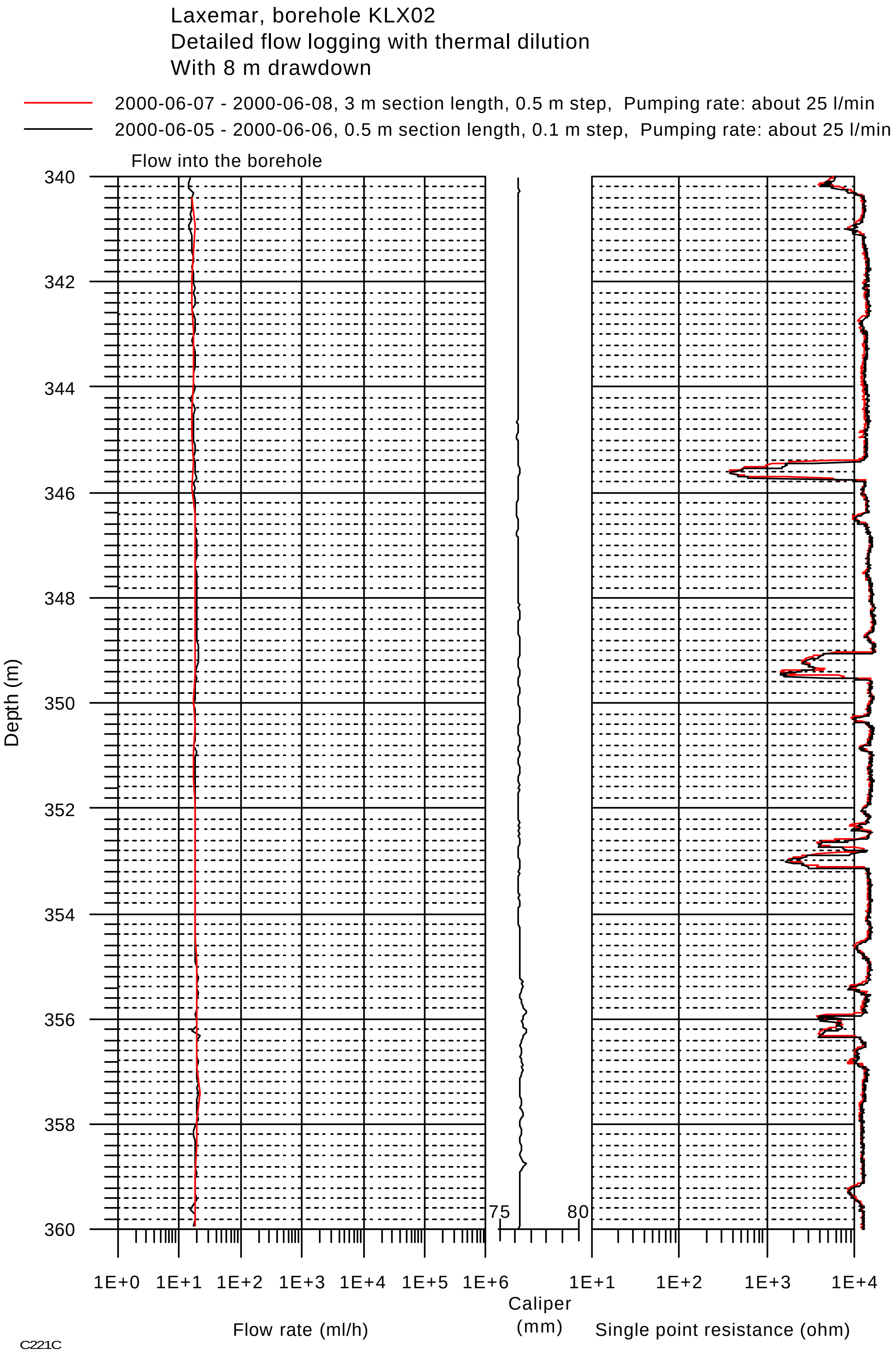




Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
With 8 m drawdown
2000-06-07 - 2000-06-08, 3 m section length, 0.5 m step, Pumping rate: about 25 l/min
2000-06-05 - 2000-06-06, 0.5 m section length, 0.1 m step, Pumping rate: about 25 l/min
Flow into the borehole
Depth (m)
300
302
304
306
308
310
312
314
316
318
320
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper (mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C221C

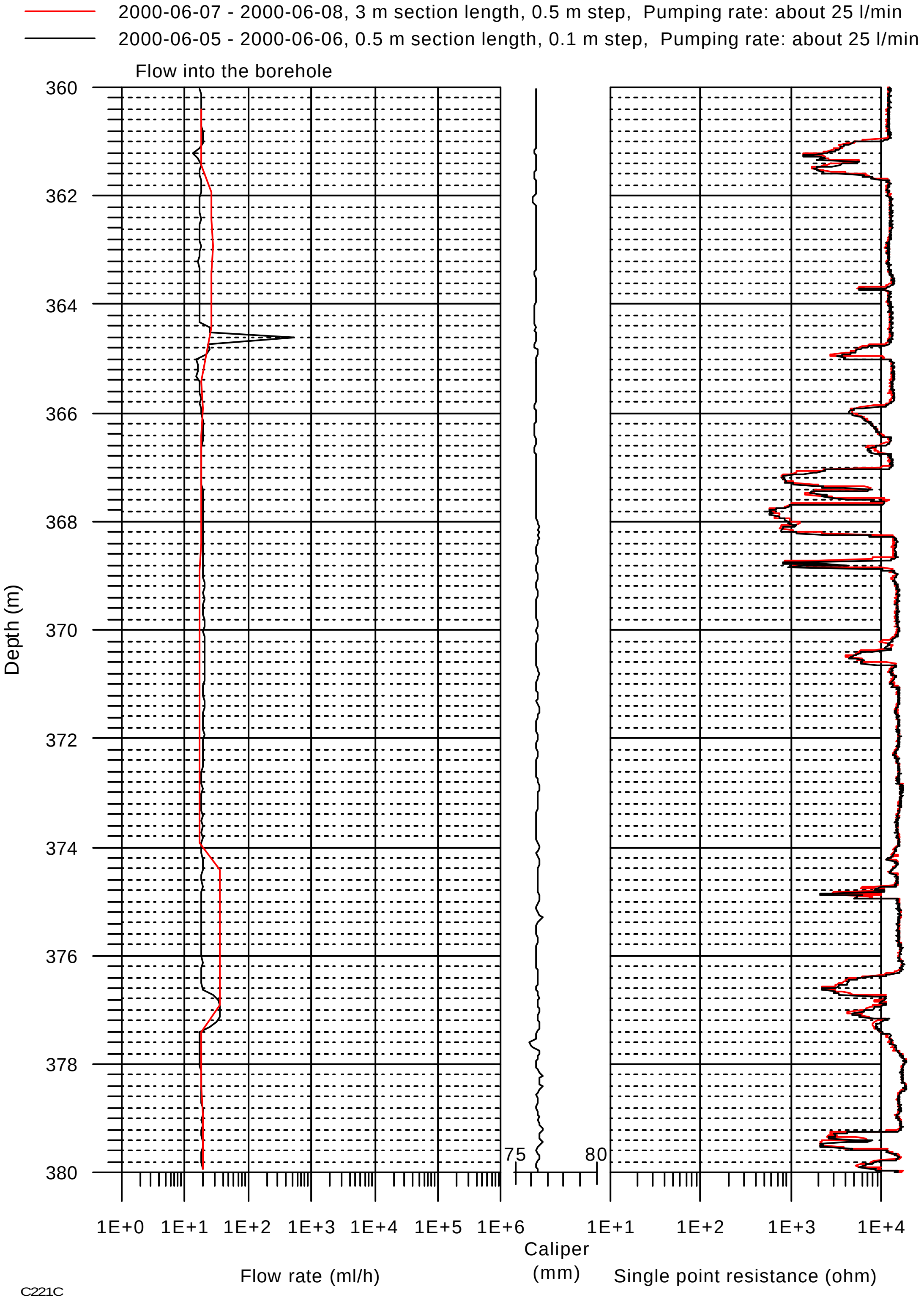
Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
With 8 m drawdown



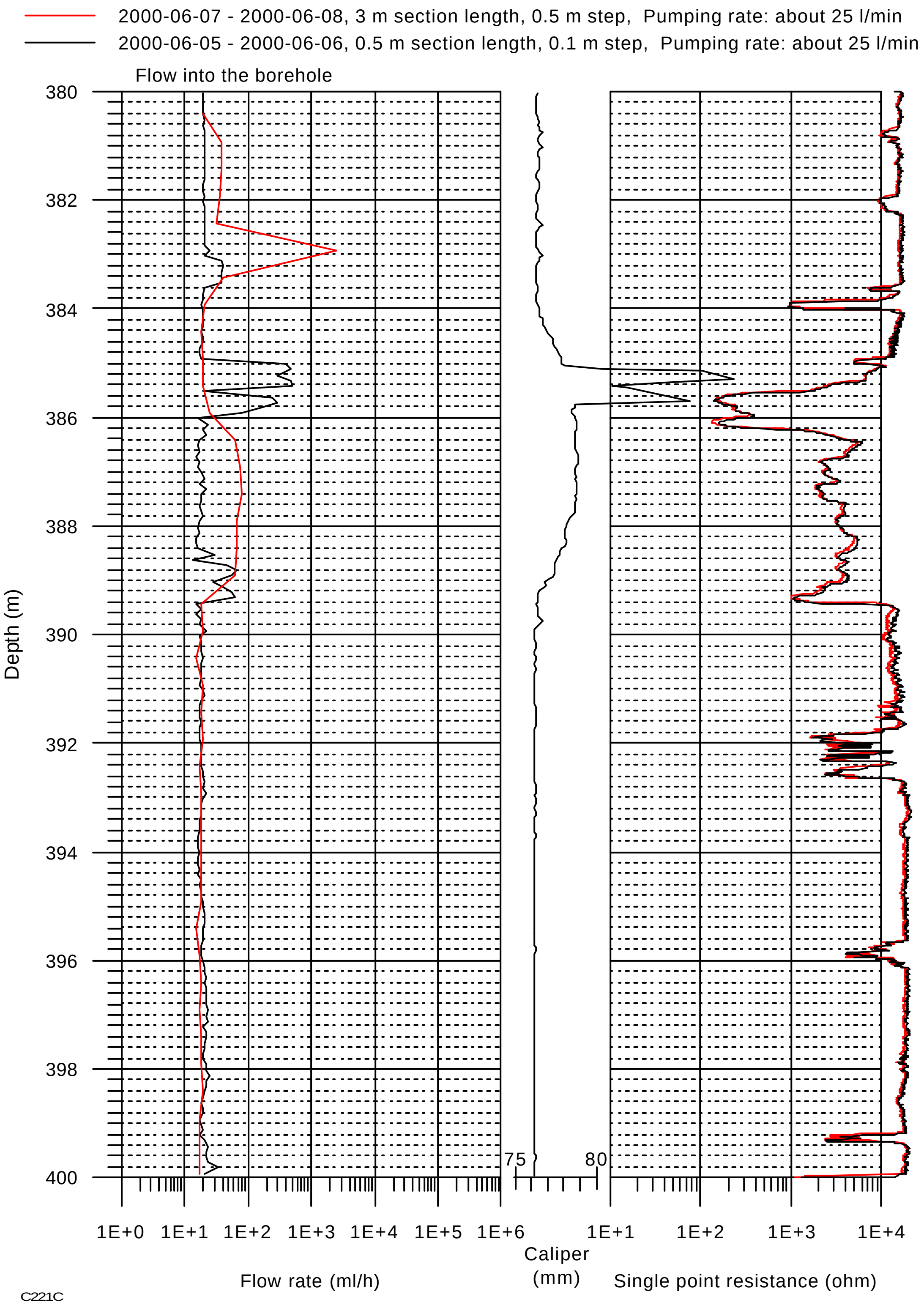


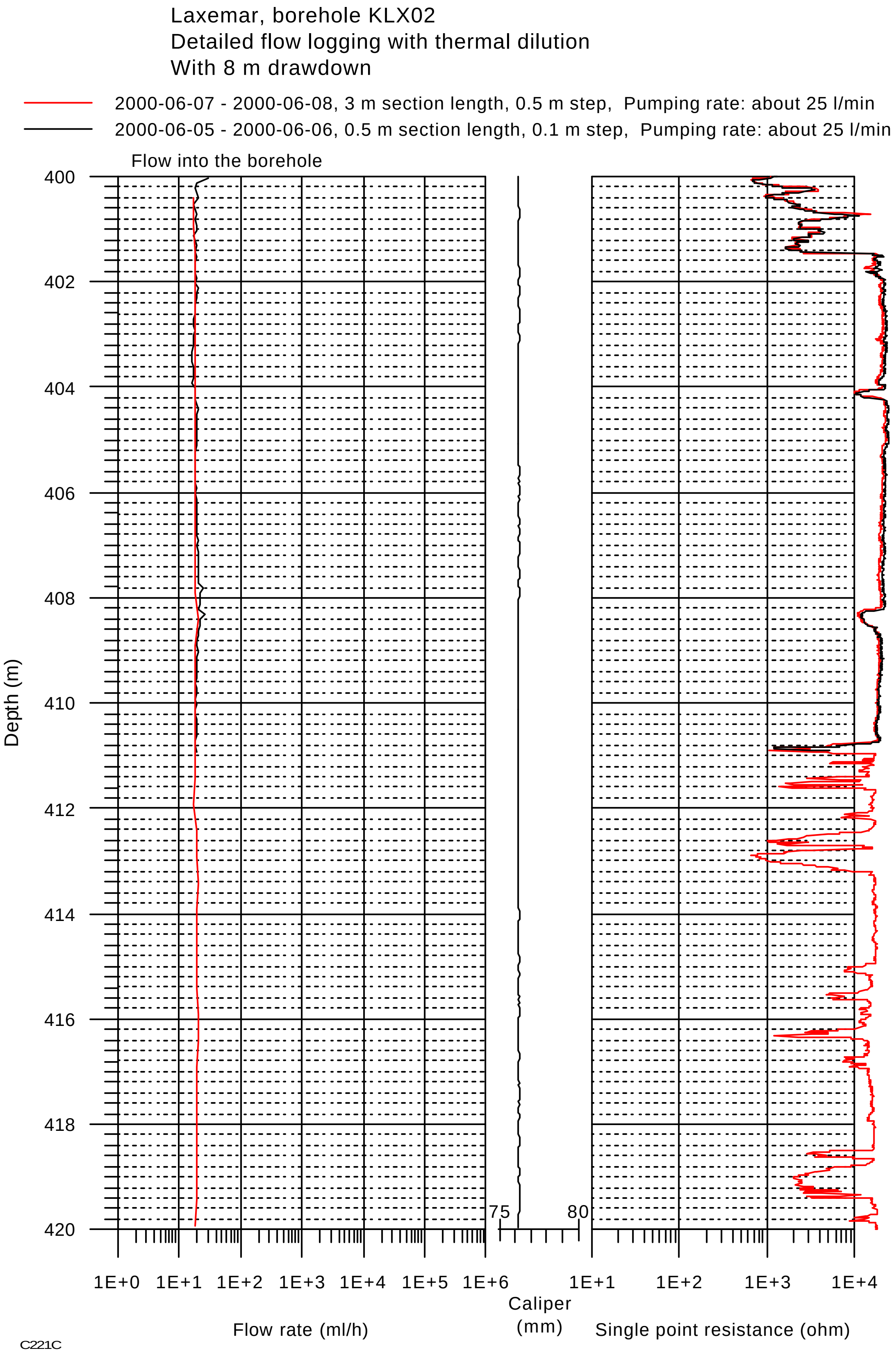
Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
With 8 m drawdown
2000-06-07 - 2000-06-08, 3 m section length, 0.5 m step, Pumping rate: about 25 l/min
2000-06-05 - 2000-06-06, 0.5 m section length, 0.1 m step, Pumping rate: about 25 l/min
Flow into the borehole
Depth (m)
340
342
344
346
348
350
352
354
356
358
360
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper (mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C221C

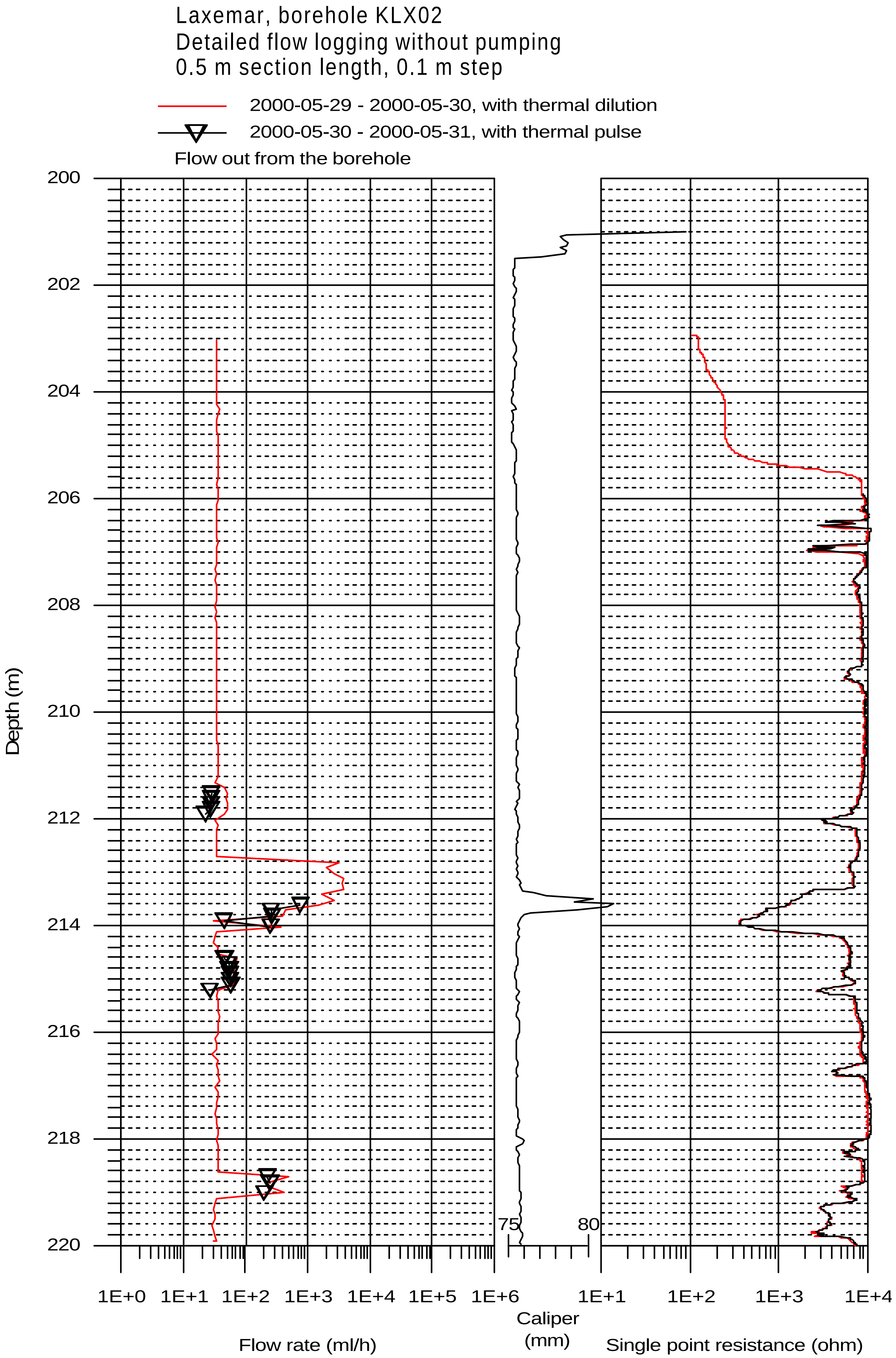
Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
With 8 m drawdown



Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
With 8 m drawdown

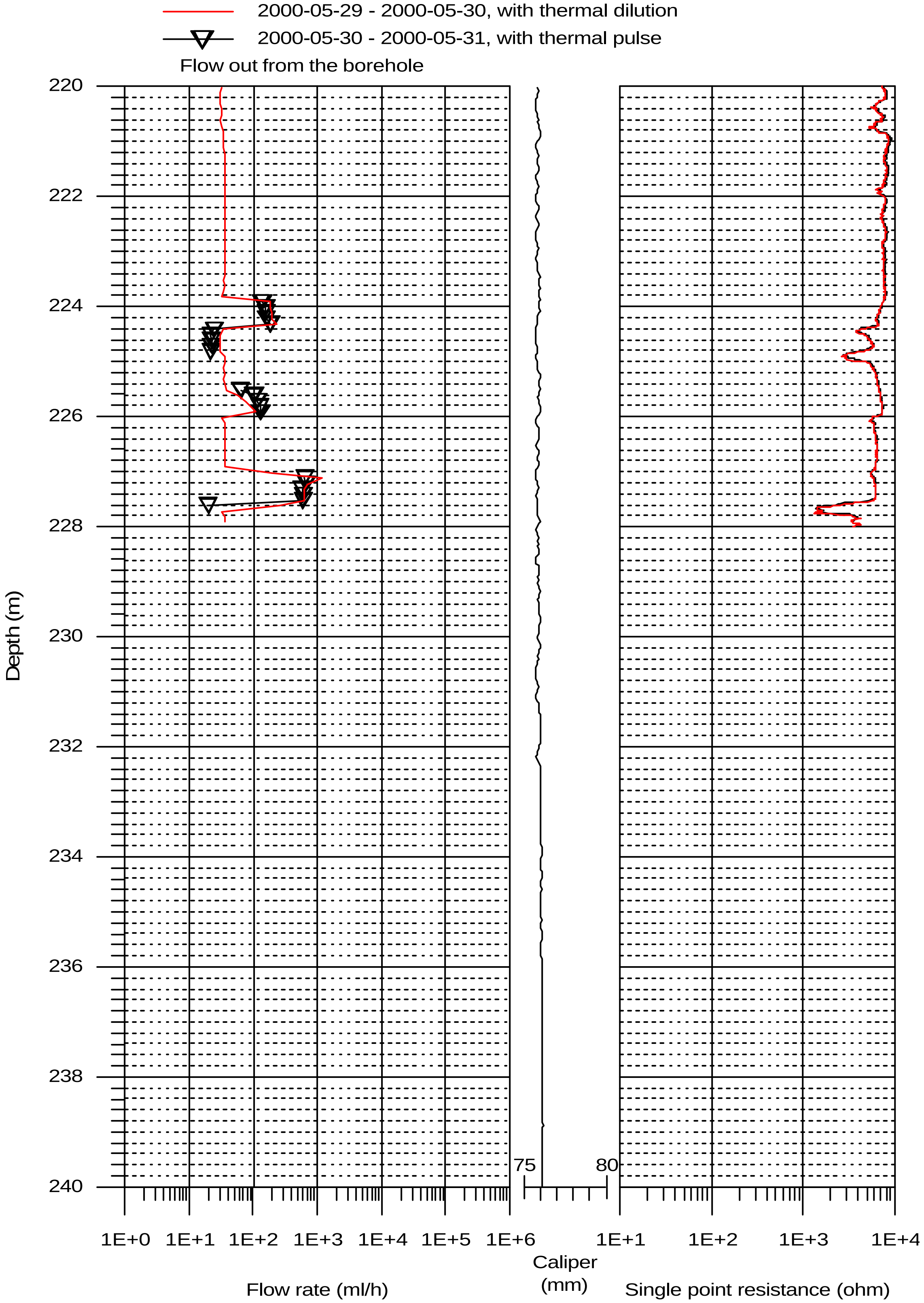



Laxemar, borehole KLX02
Detailed flow logging with thermal dilution
With 8 m drawdown
2000-06-07 - 2000-06-08, 3 m section length, 0.5 m step, Pumping rate: about 25 l/min
2000-06-05 - 2000-06-06, 0.5 m section length, 0.1 m step, Pumping rate: about 25 l/min
Flow into the borehole
Depth (m)
400
402
404
406
408
410
412
414
416
418
420
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C221C


Laxemar, borehole KLX02
Detailed flow logging without pumping
0.5 m section length, 0.1 m step
2000-05-29 - 2000-05-30, with thermal dilution
2000-05-30 - 2000-05-31, with thermal pulse
Flow out from the borehole
Depth (m)
200
202
204
206
208
210
212
214
216
218
220
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)

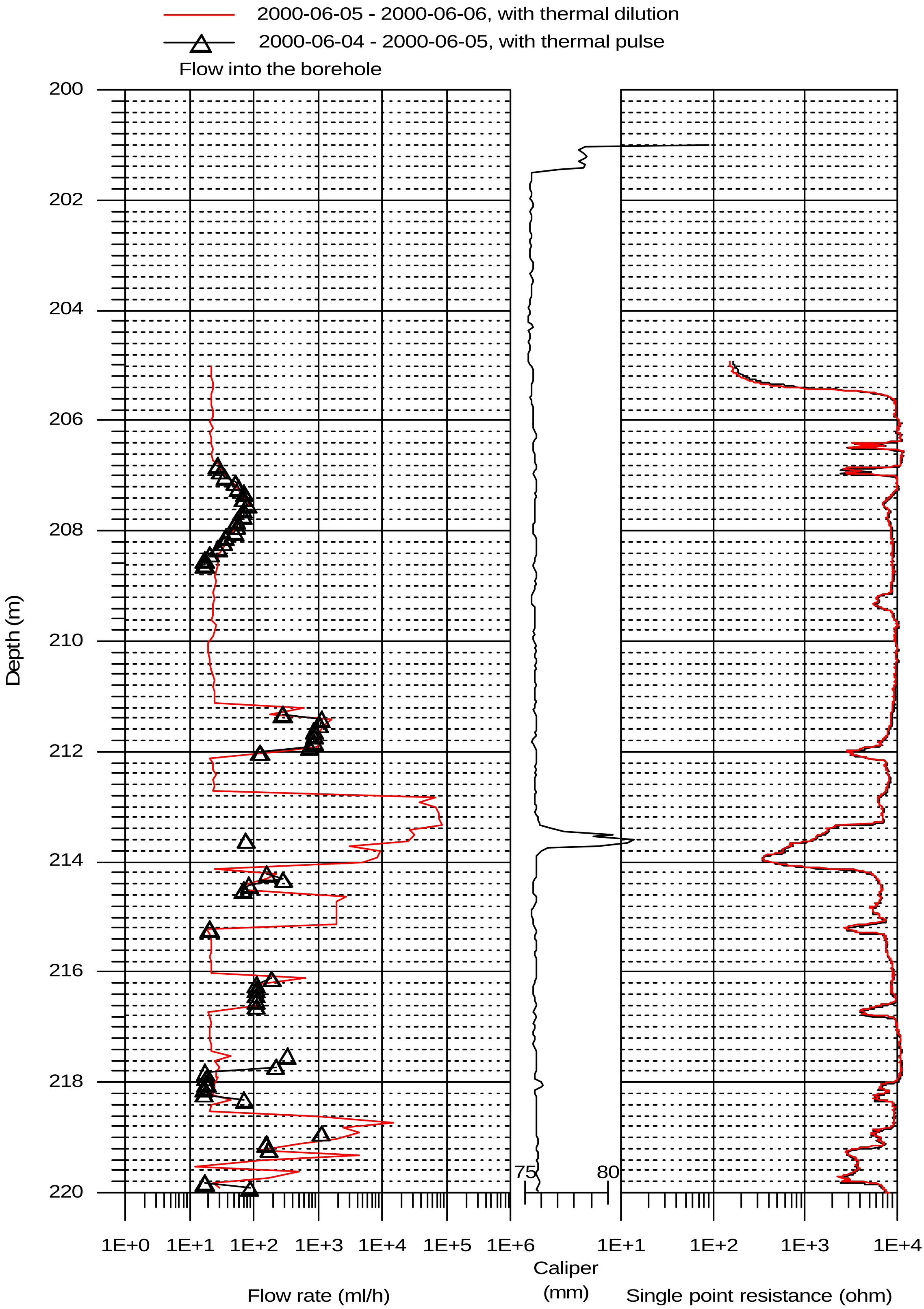
C223C

Laxemar, borehole KLX02
Detailed flow logging without pumping
0.5 m section length, 0.1 m step



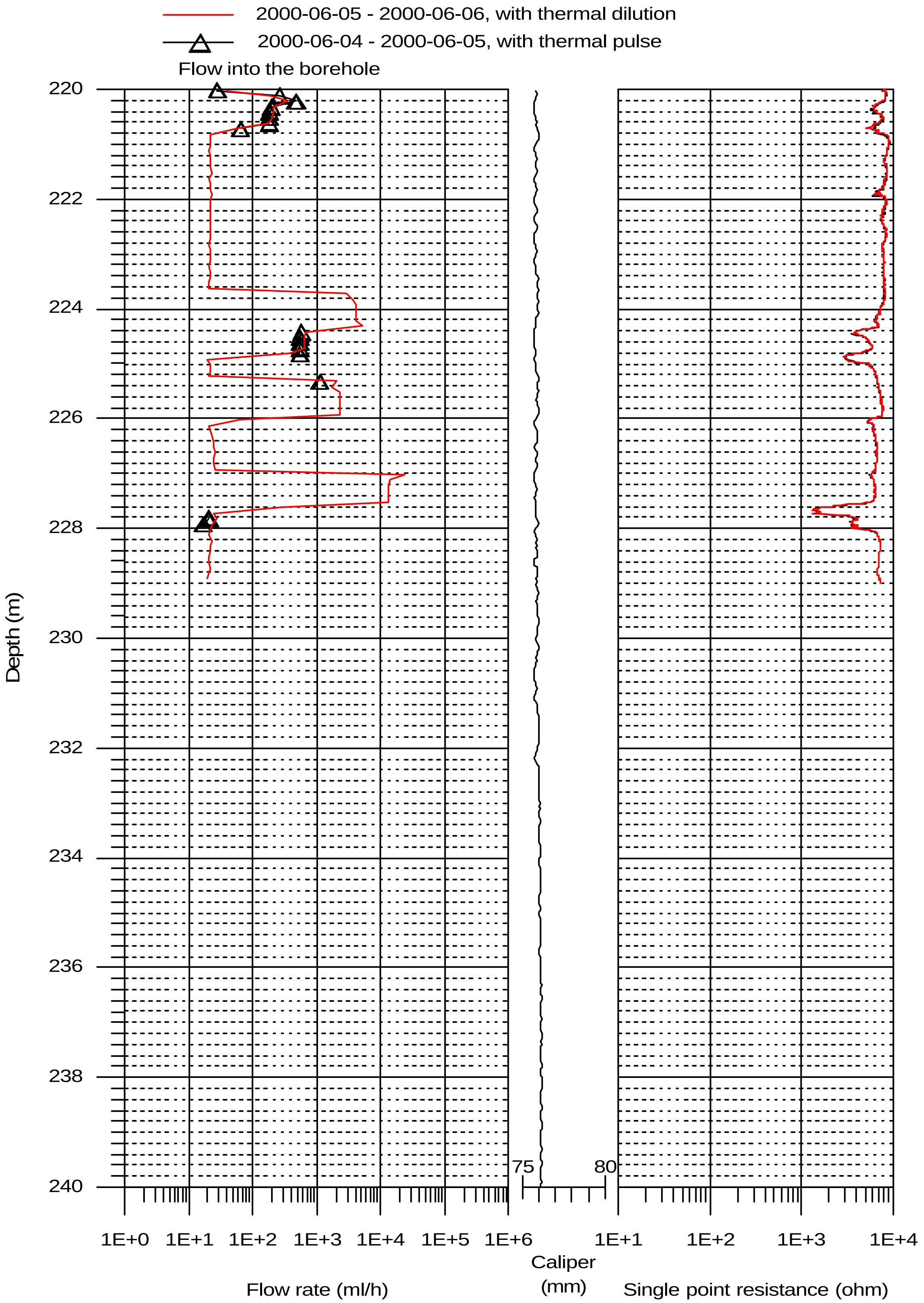
C223C

Laxemar, borehole KLX02
Detailed flow logging with 8 m drawdown, pumping rate about 25 l/min
0.5 m section length, 0.1 m step



C224C

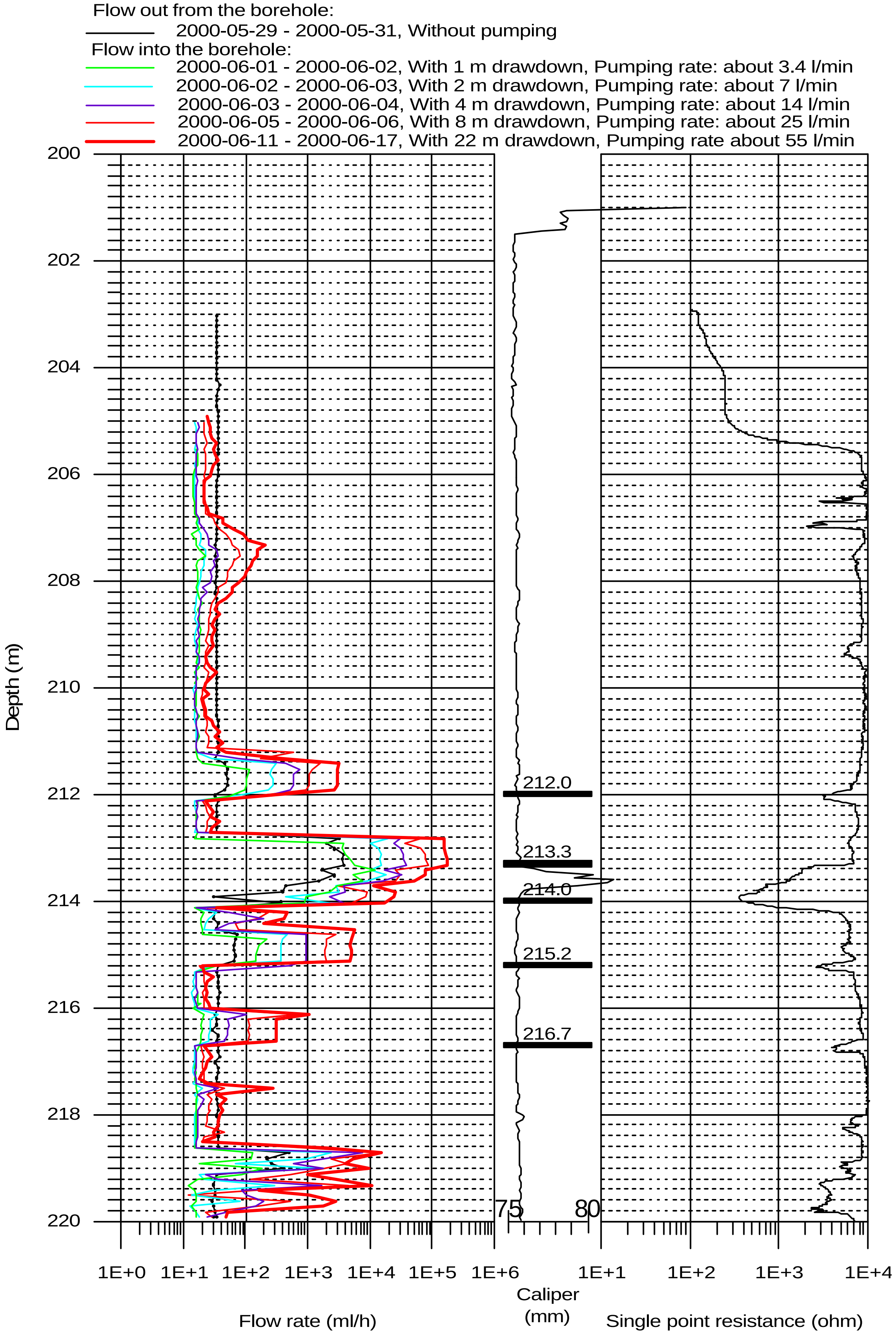
Laxemar, borehole KLX02
Detailed flow logging with 8 m drawdown, pumping rate about 25 l/min
0.5 m section length, 0.1 m step



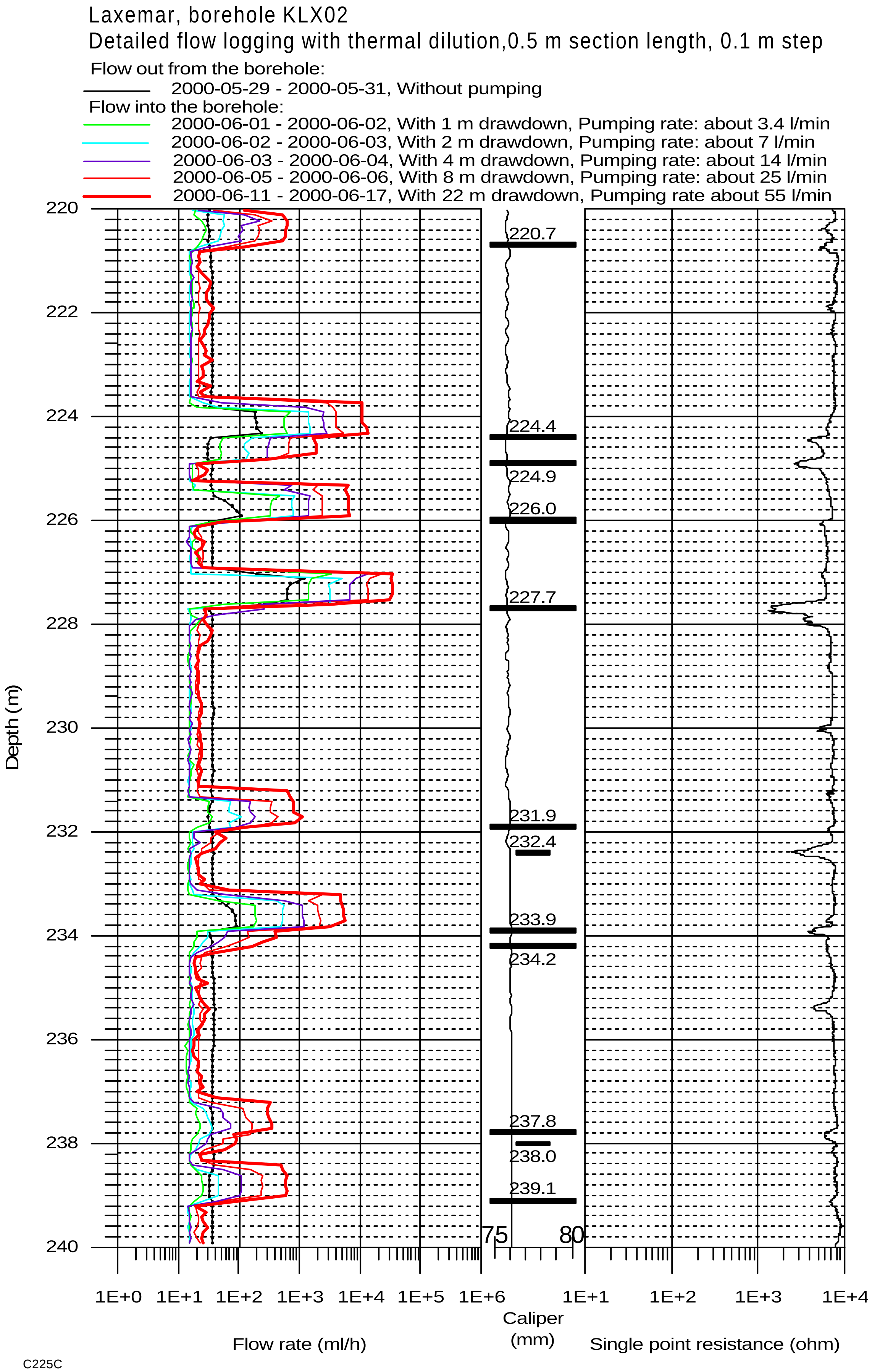
C224C

Laxemar, borehole KLX02

Detailed flow logging with thermal dilution,0.5 m section length, 0.1 m step

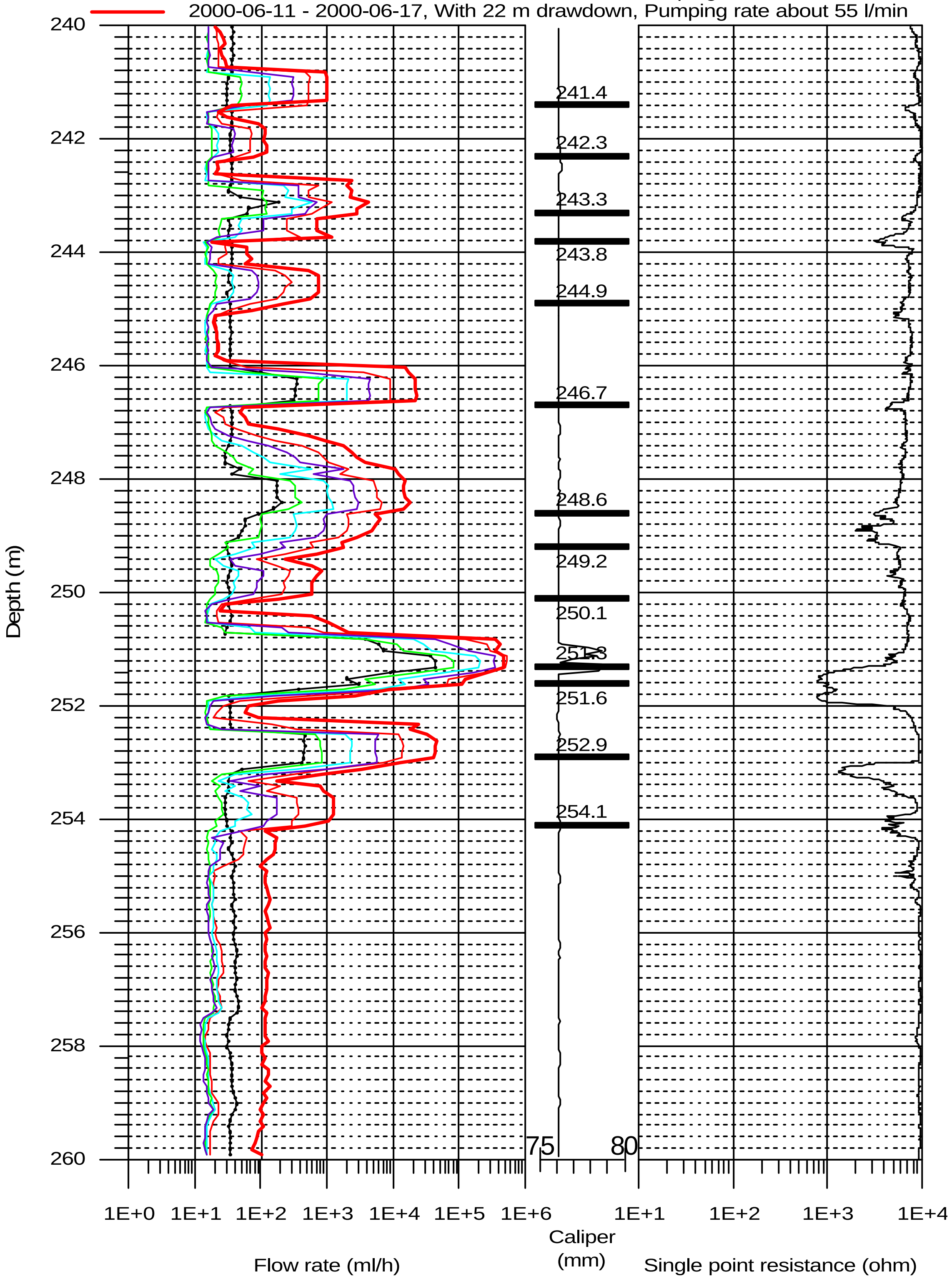


C225C


Laxemar, borehole KLX02
Detailed flow logging with thermal dilution,0.5 m section length, 0.1 m step
Flow out from the borehole:
2000-05-29 - 2000-05-31, Without pumping
Flow into the borehole:
2000-06-01 - 2000-06-02, With 1 m drawdown, Pumping rate: about 3.4 l/min
2000-06-02 - 2000-06-03, With 2 m drawdown, Pumping rate: about 7 l/min
2000-06-03 - 2000-06-04, With 4 m drawdown, Pumping rate: about 14 l/min
2000-06-05 - 2000-06-06, With 8 m drawdown, Pumping rate: about 25 l/min
2000-06-11 - 2000-06-17, With 22 m drawdown, Pumping rate about 55 l/min
Depth (m)
220
222
224
226
228
230
232
234
236
238
240
220.7
224.4
224.9
226.0
227.7
231.9
232.4
233.9
234.2
237.8
238.0
239.1
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
C225C

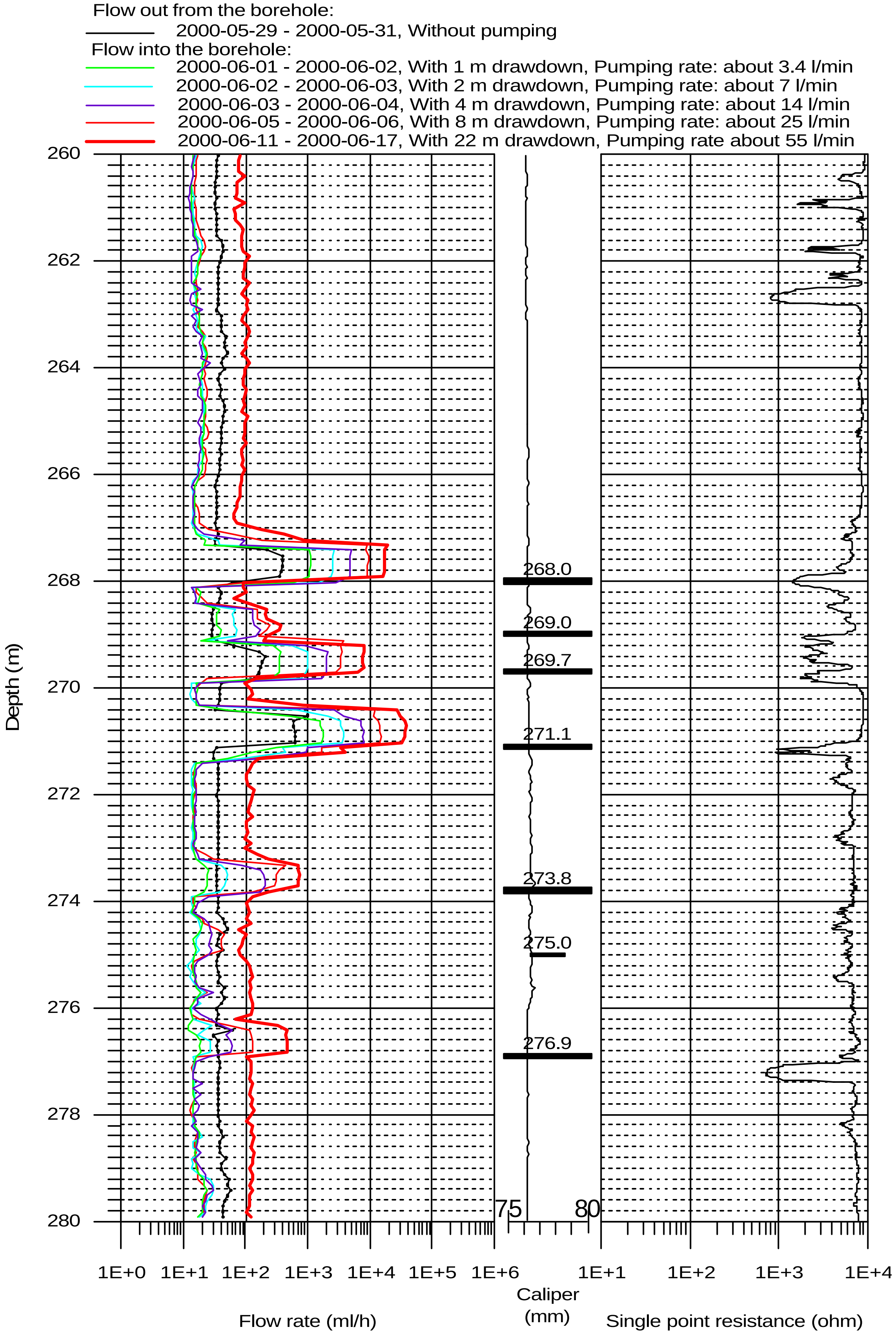
Laxemar, borehole KLX02
Detailed flow logging with thermal dilution,0.5 m section length, 0.1 m step

Flow out from the borehole:
2000-05-29 - 2000-05-31, Without pumping
Flow into the borehole:
2000-06-01 - 2000-06-02, With 1 m drawdown, Pumping rate: about 3.4 l/min
2000-06-02 - 2000-06-03, With 2 m drawdown, Pumping rate: about 7 l/min
2000-06-03 - 2000-06-04, With 4 m drawdown, Pumping rate: about 14 l/min
2000-06-05 - 2000-06-06, With 8 m drawdown, Pumping rate: about 25 l/min
2000-06-11 - 2000-06-17, With 22 m drawdown, Pumping rate about 55 l/min

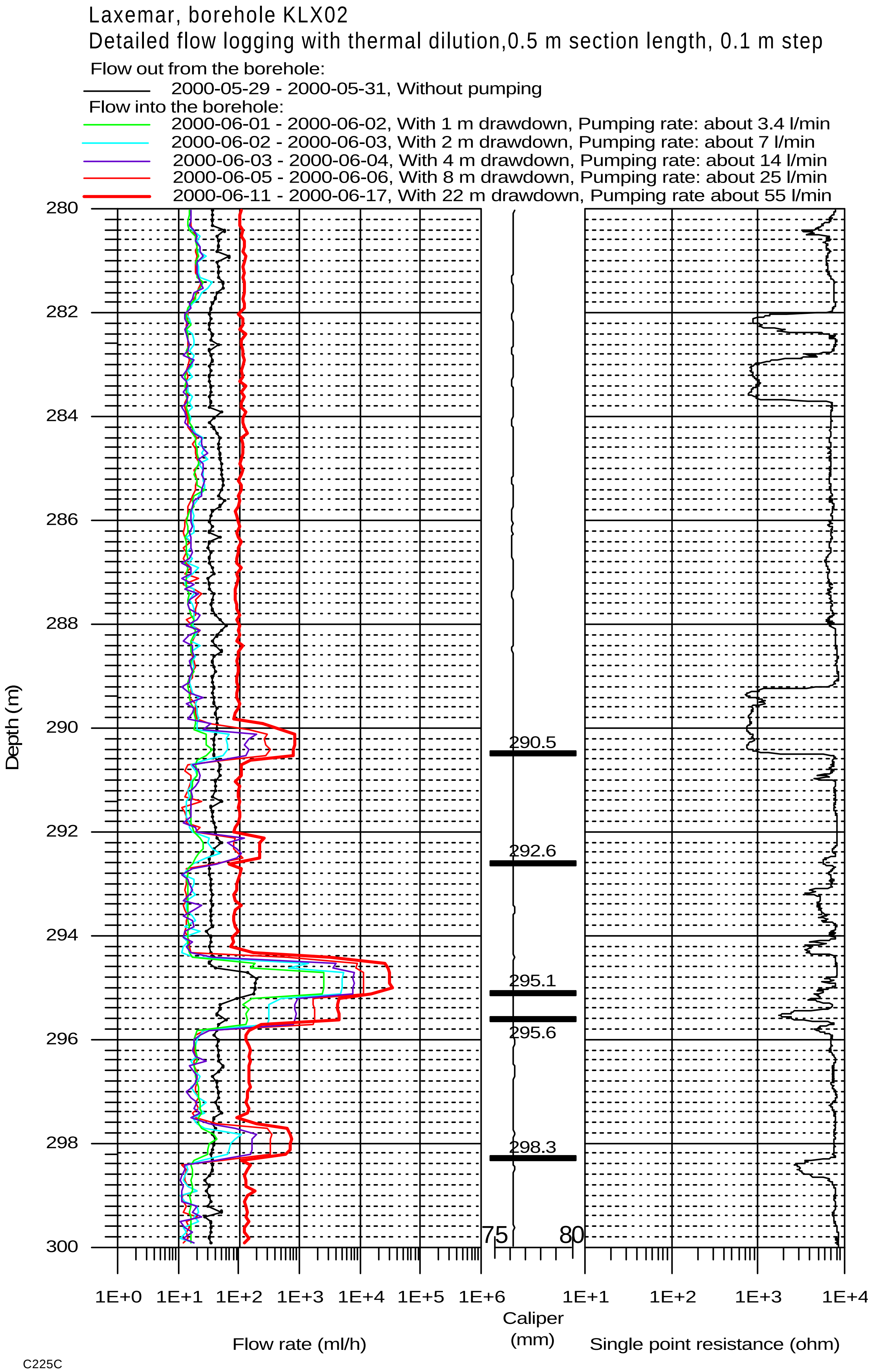


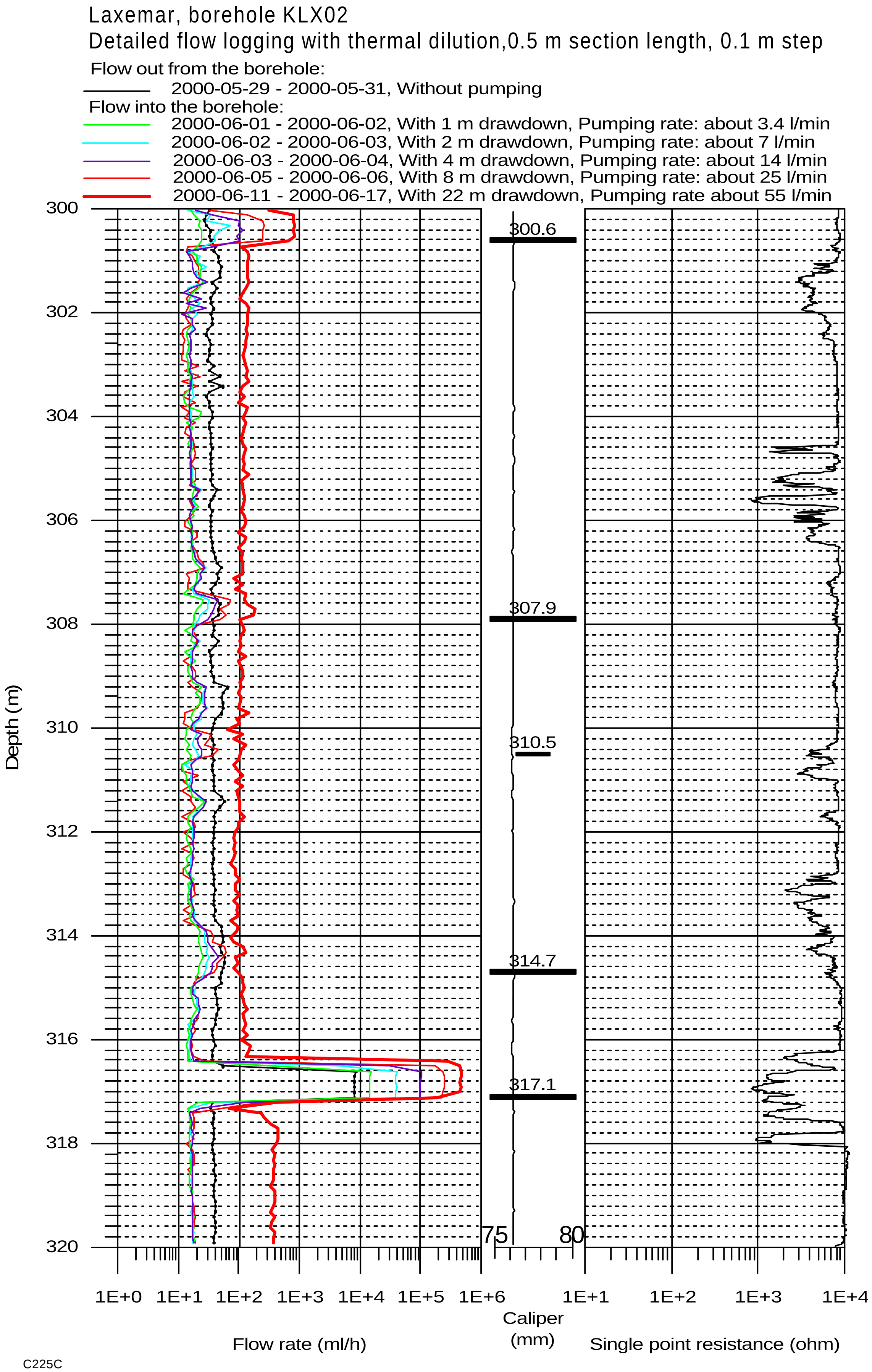
C225C

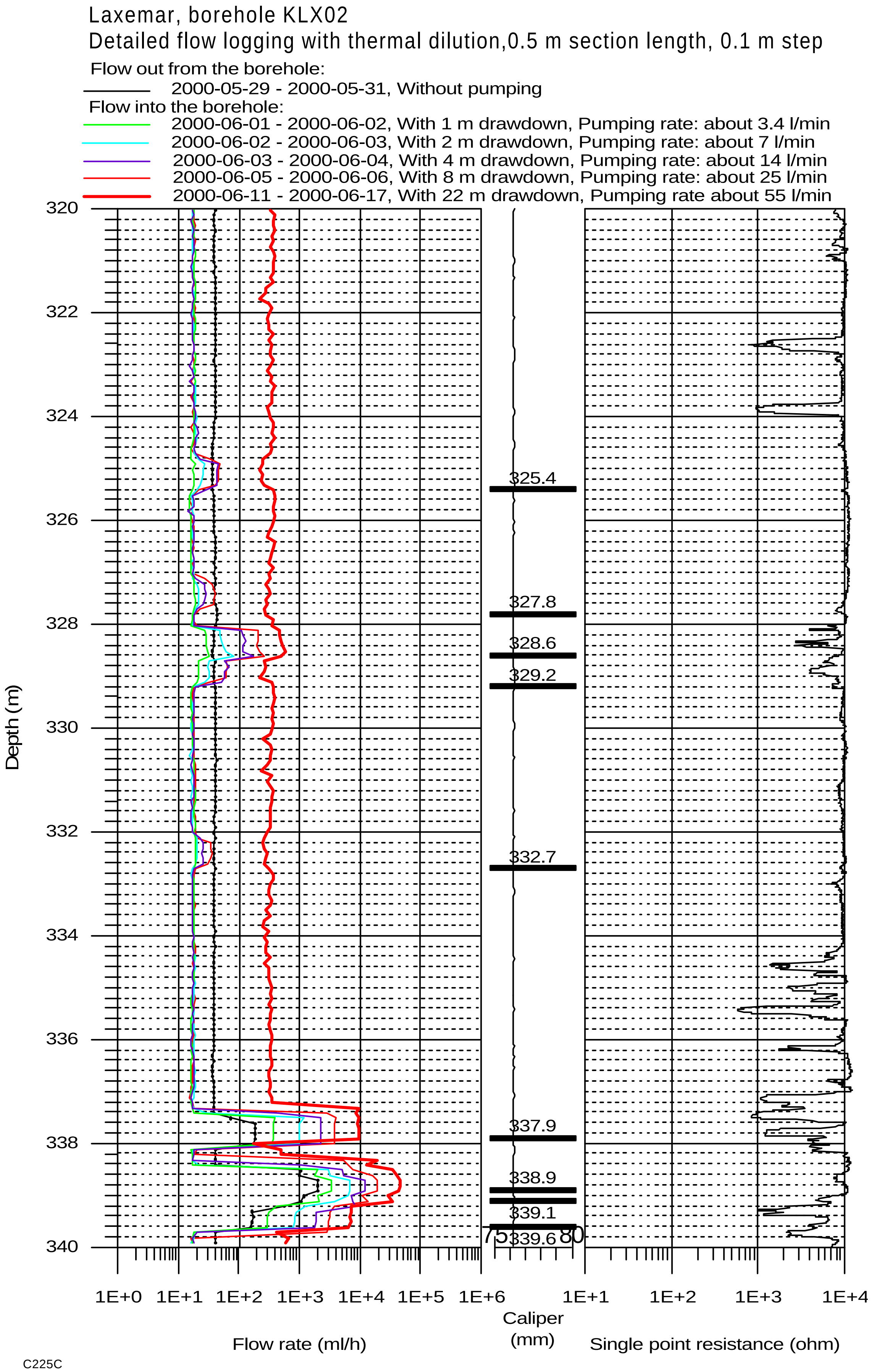
Laxemar, borehole KLX02
Detailed flow logging with thermal dilution,0.5 m section length, 0.1 m step



C225C


Laxemar, borehole KLX02
Detailed flow logging with thermal dilution,0.5 m section length, 0.1 m step
Flow out from the borehole:
2000-05-29 - 2000-05-31, Without pumping
Flow into the borehole:
2000-06-01 - 2000-06-02, With 1 m drawdown, Pumping rate: about 3.4 l/min
2000-06-02 - 2000-06-03, With 2 m drawdown, Pumping rate: about 7 l/min
2000-06-03 - 2000-06-04, With 4 m drawdown, Pumping rate: about 14 l/min
2000-06-05 - 2000-06-06, With 8 m drawdown, Pumping rate: about 25 l/min
2000-06-11 - 2000-06-17, With 22 m drawdown, Pumping rate about 55 l/min
Depth (m)
280
282
284
286
288
290
292
294
296
298
300
290.5
292.6
295.1
295.6
298.3
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Flow rate (ml/h)
Caliper
(mm)
Single point resistance (ohm)
C225C

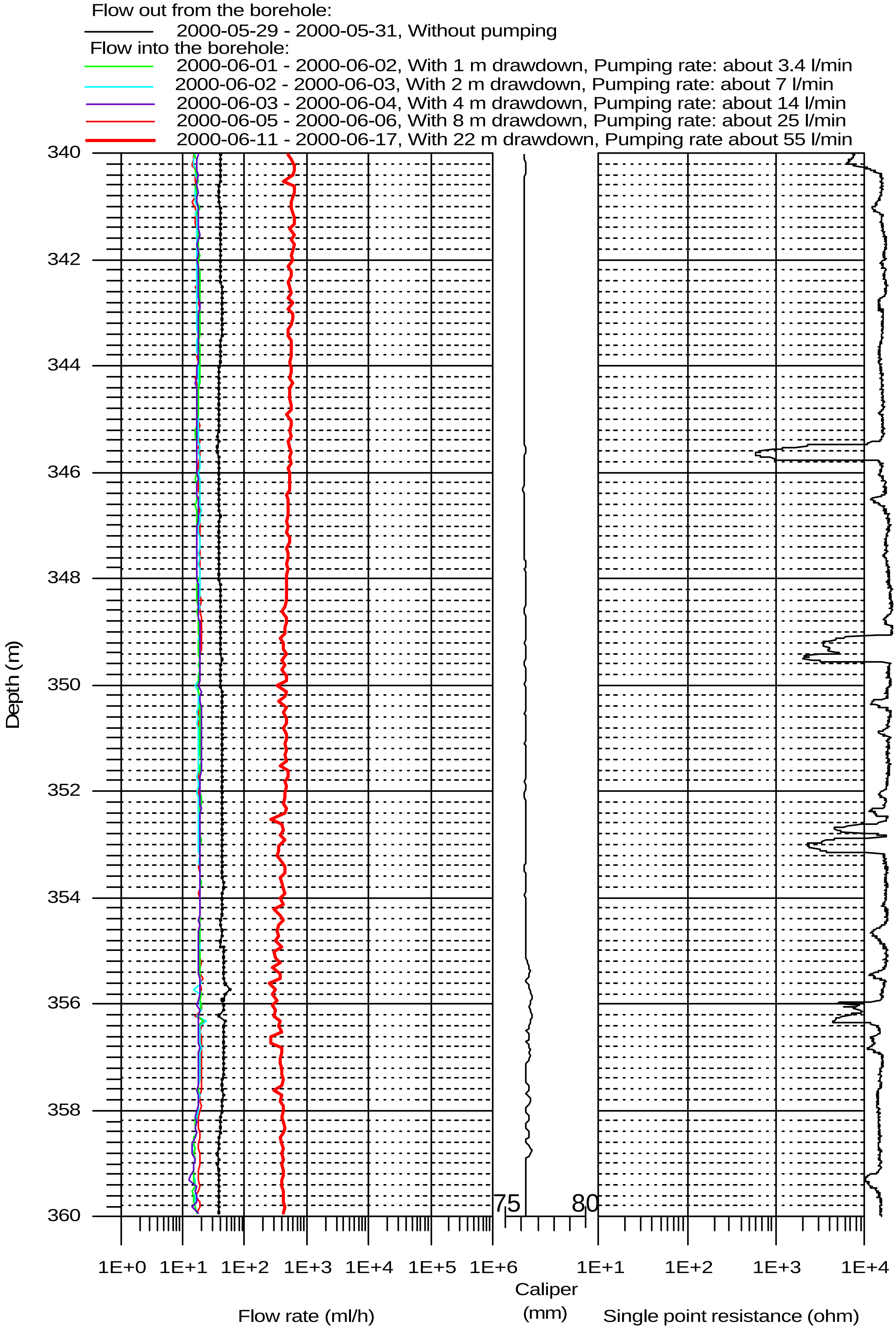

Laxemar, borehole KLX02
Detailed flow logging with thermal dilution,0.5 m section length, 0.1 m step
Flow out from the borehole:
2000-05-29 - 2000-05-31, Without pumping
Flow into the borehole:
2000-06-01 - 2000-06-02, With 1 m drawdown, Pumping rate: about 3.4 l/min
2000-06-02 - 2000-06-03, With 2 m drawdown, Pumping rate: about 7 l/min
2000-06-03 - 2000-06-04, With 4 m drawdown, Pumping rate: about 14 l/min
2000-06-05 - 2000-06-06, With 8 m drawdown, Pumping rate: about 25 l/min
2000-06-11 - 2000-06-17, With 22 m drawdown, Pumping rate about 55 l/min
Depth (m)
300
302
304
306
308
310
312
314
316
318
320
300.6
307.9
310.5
314.7
317.1
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
Caliper (mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
C225C



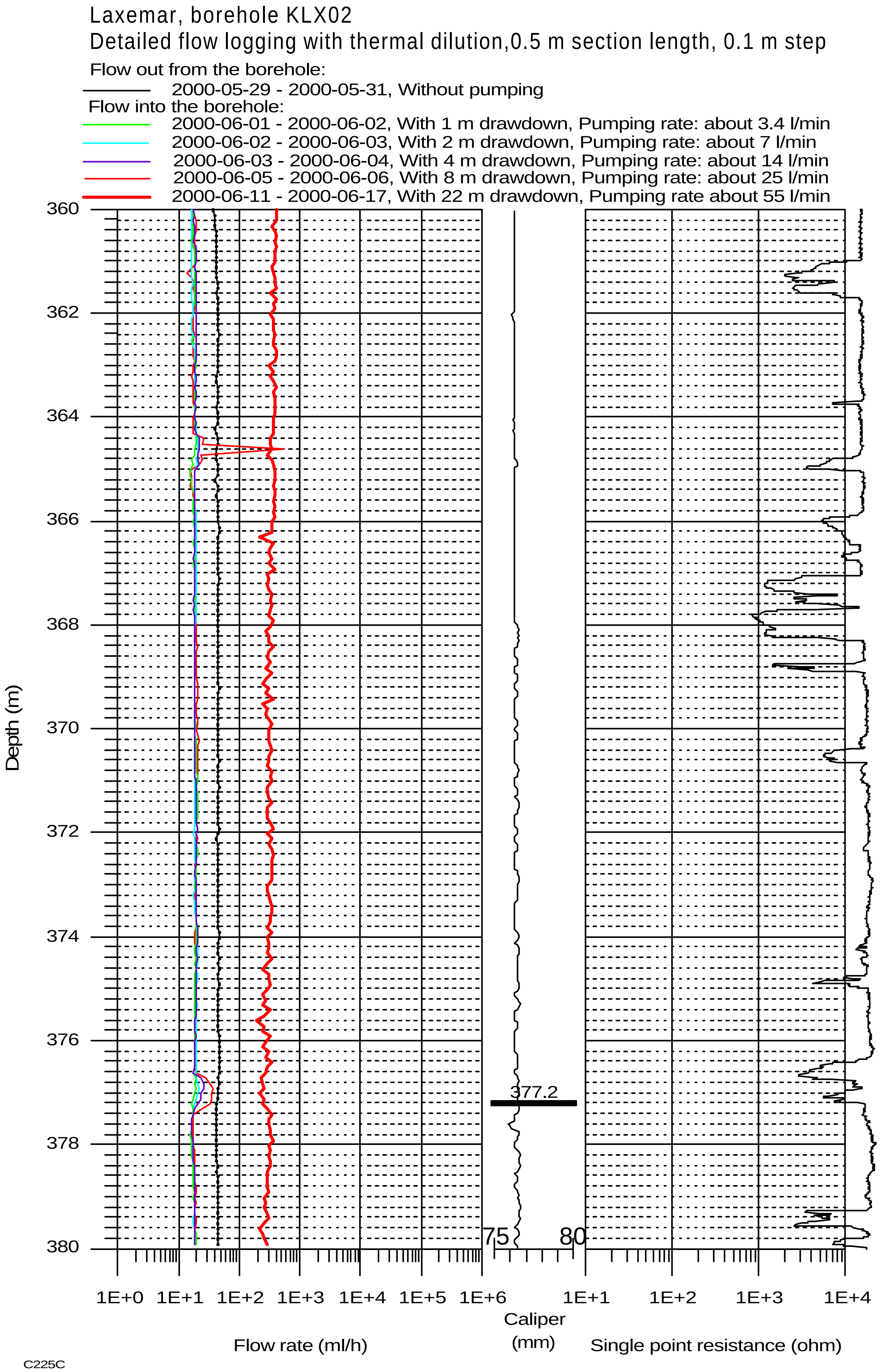
Laxemar, borehole KLX02
Detailed flow logging with thermal dilution,0.5 m section length, 0.1 m step
Flow out from the borehole:
2000-05-29 - 2000-05-31, Without pumping
Flow into the borehole:
2000-06-01 - 2000-06-02, With 1 m drawdown, Pumping rate: about 3.4 l/min
2000-06-02 - 2000-06-03, With 2 m drawdown, Pumping rate: about 7 l/min
2000-06-03 - 2000-06-04, With 4 m drawdown, Pumping rate: about 14 l/min
2000-06-05 - 2000-06-06, With 8 m drawdown, Pumping rate: about 25 l/min
2000-06-11 - 2000-06-17, With 22 m drawdown, Pumping rate about 55 l/min
Depth (m)
320
322
324
326
328
330
332
334
336
338
340
325.4
327.8
328.6
329.2
332.7
337.9
338.9
339.1
339.6
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
C225C

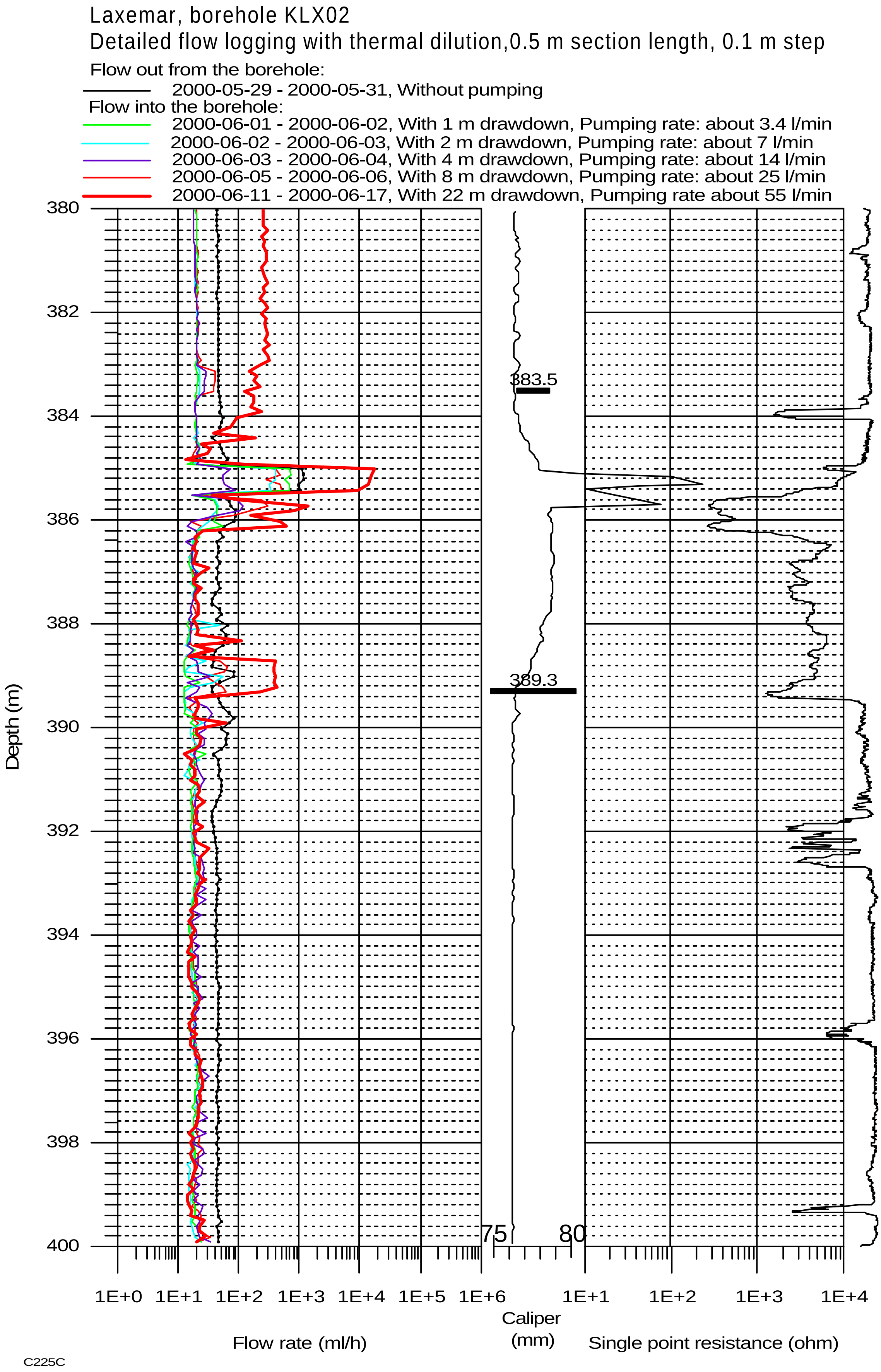
Laxemar, borehole KLX02

Detailed flow logging with thermal dilution,0.5 m section length, 0.1 m step



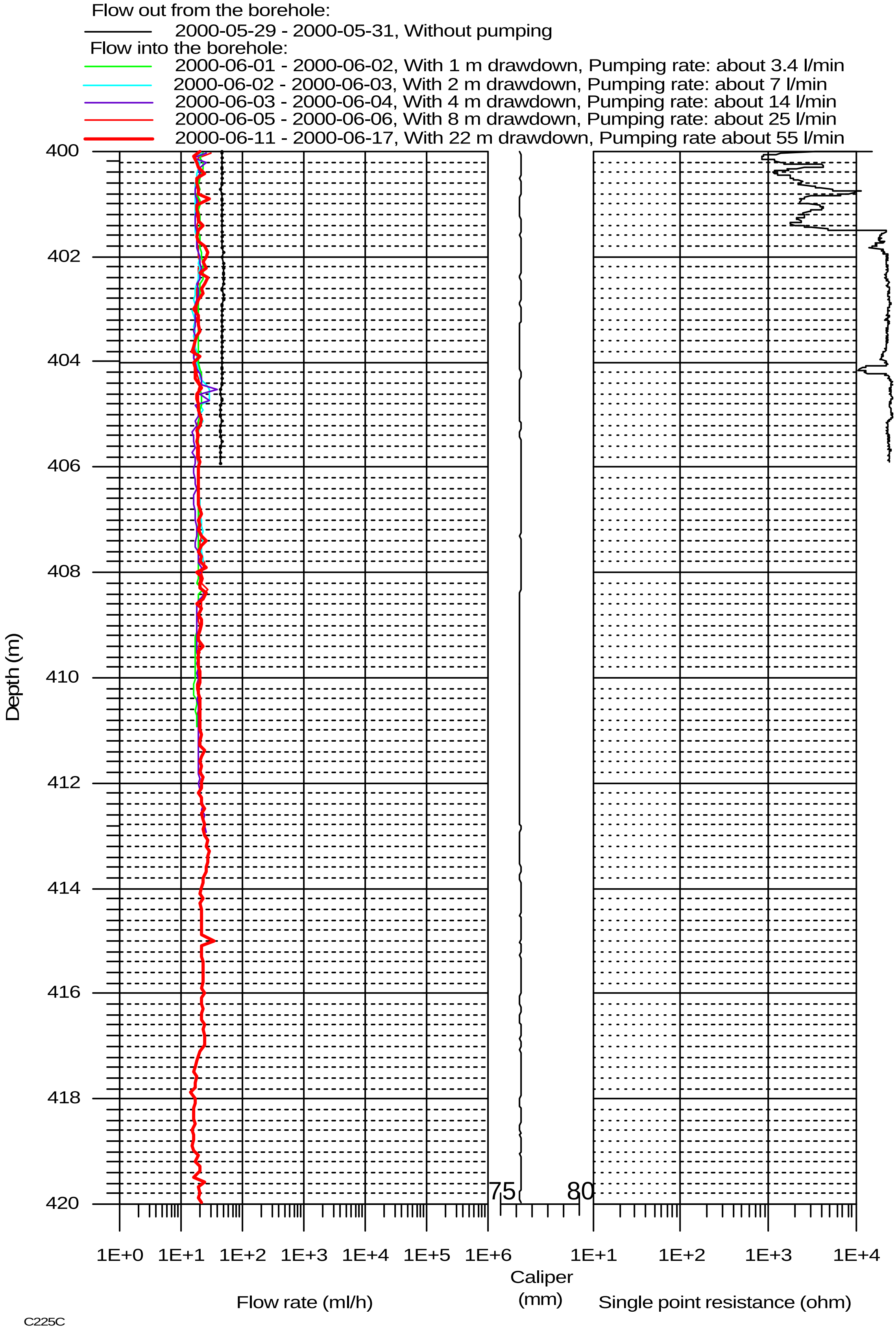
C225C

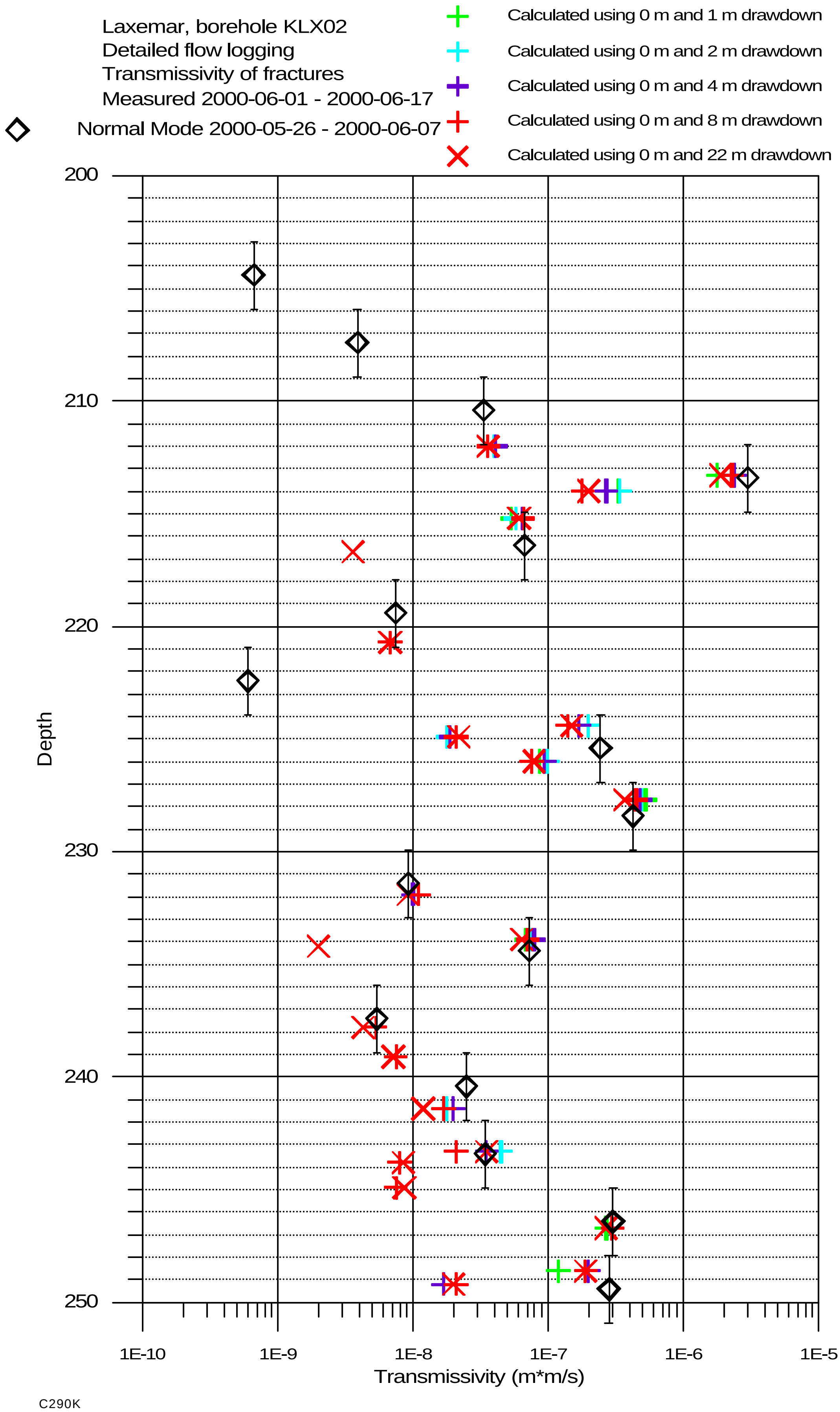

Laxemar, borehole KLX02
Detailed flow logging with thermal dilution,0.5 m section length, 0.1 m step
Flow out from the borehole:
2000-05-29 - 2000-05-31, Without pumping
Flow into the borehole:
2000-06-01 - 2000-06-02, With 1 m drawdown, Pumping rate: about 3.4 l/min
2000-06-02 - 2000-06-03, With 2 m drawdown, Pumping rate: about 7 l/min
2000-06-03 - 2000-06-04, With 4 m drawdown, Pumping rate: about 14 l/min
2000-06-05 - 2000-06-06, With 8 m drawdown, Pumping rate: about 25 l/min
2000-06-11 - 2000-06-17, With 22 m drawdown, Pumping rate about 55 l/min
Depth (m)
360
362
364
366
368
370
372
374
376
377.2
378
380
75
80
1E+0 1E+1 1E+2 1E+3 1E+4 1E+5 1E+6
1E+1 1E+2 1E+3 1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
C225C

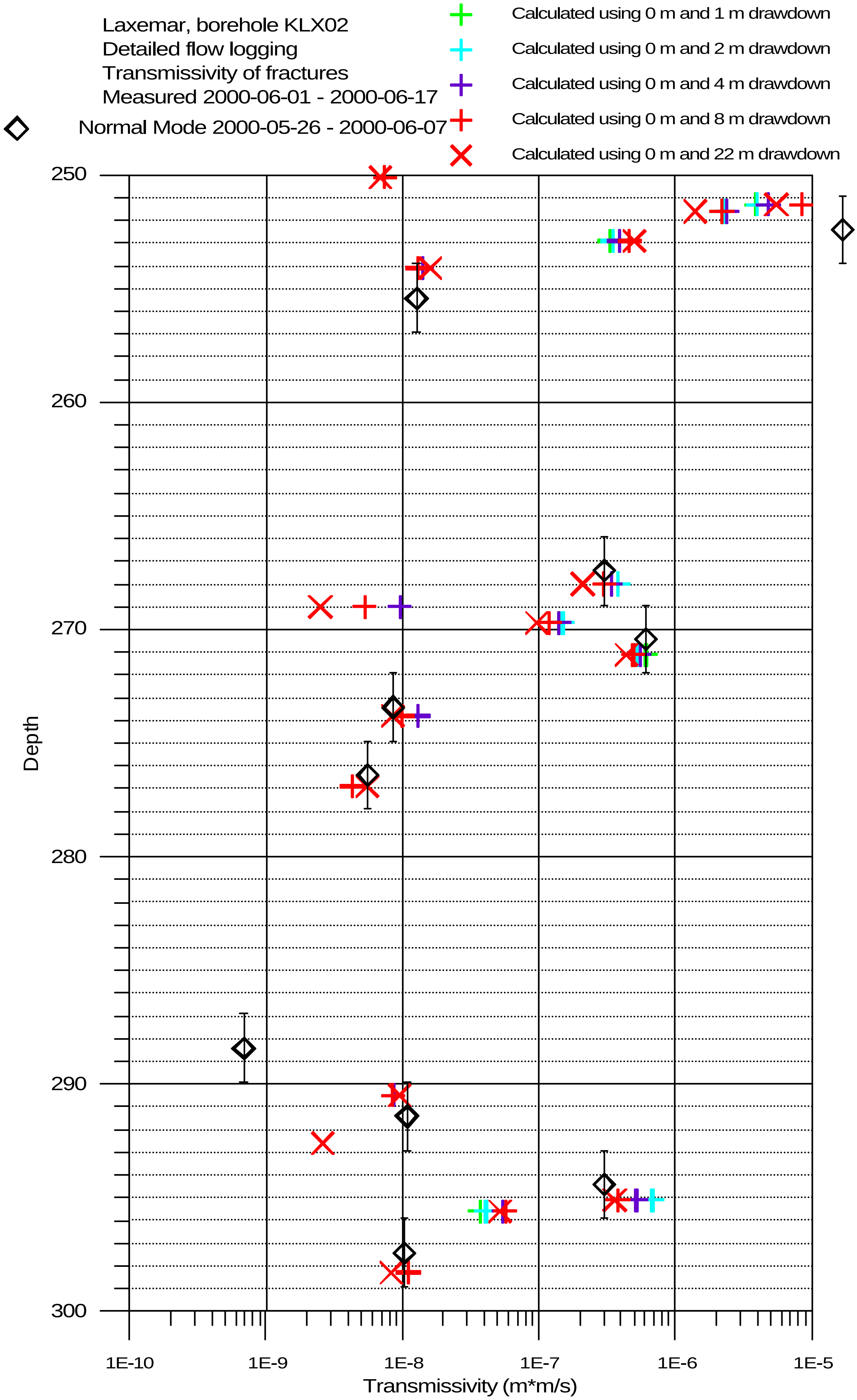


Laxemar, borehole KLX02
Detailed flow logging with thermal dilution,0.5 m section length, 0.1 m step
Flow out from the borehole:
2000-05-29 - 2000-05-31, Without pumping
Flow into the borehole:
2000-06-01 - 2000-06-02, With 1 m drawdown, Pumping rate: about 3.4 l/min
2000-06-02 - 2000-06-03, With 2 m drawdown, Pumping rate: about 7 l/min
2000-06-03 - 2000-06-04, With 4 m drawdown, Pumping rate: about 14 l/min
2000-06-05 - 2000-06-06, With 8 m drawdown, Pumping rate: about 25 l/min
2000-06-11 - 2000-06-17, With 22 m drawdown, Pumping rate about 55 l/min
Depth (m)
380
382
384
386
388
390
392
394
396
398
400
383.5
389.3
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Flow rate (ml/h)
Caliper (mm)
Single point resistance (ohm)
C225C

Laxemar, borehole KLX02
Detailed flow logging with thermal dilution,0.5 m section length, 0.1 m step

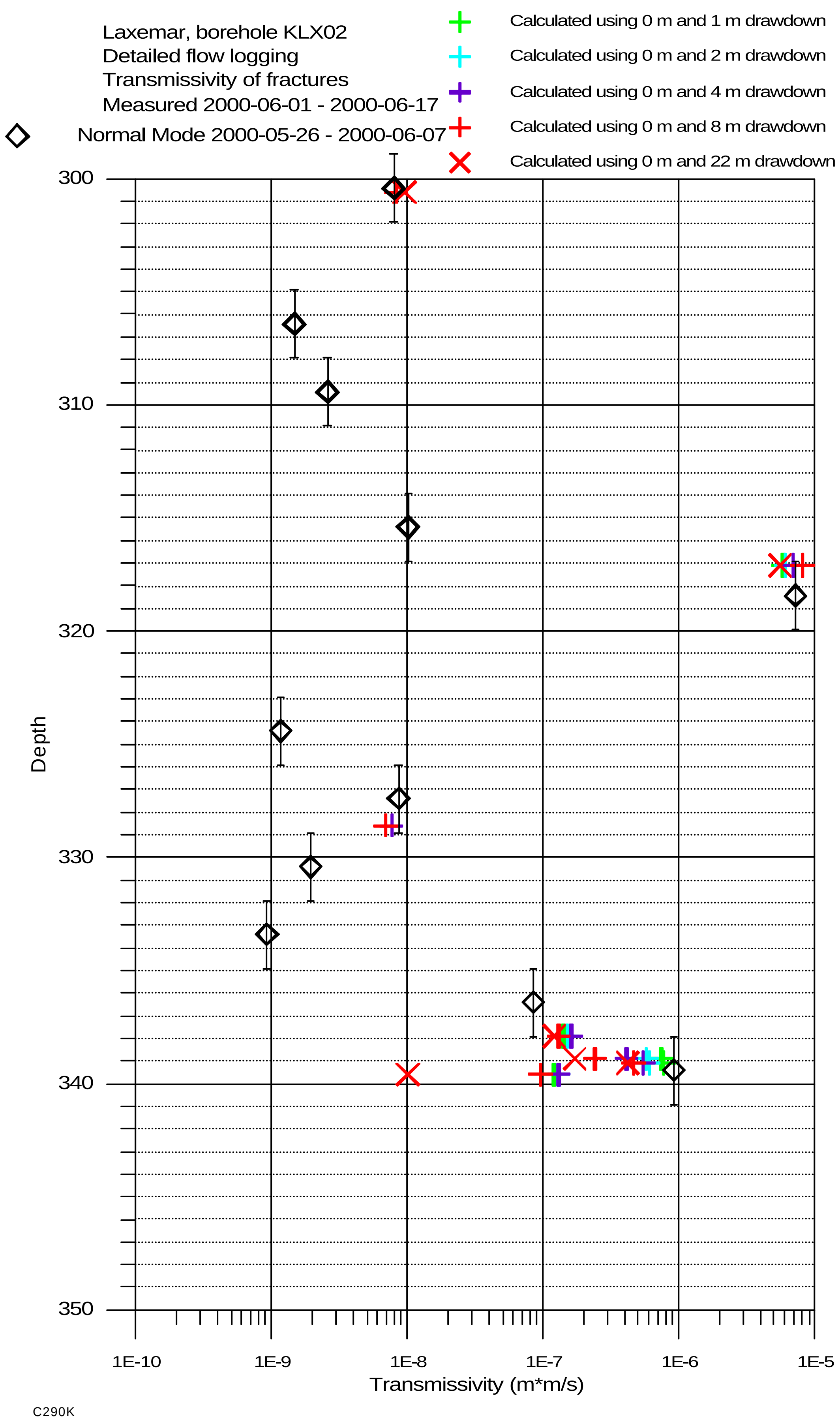


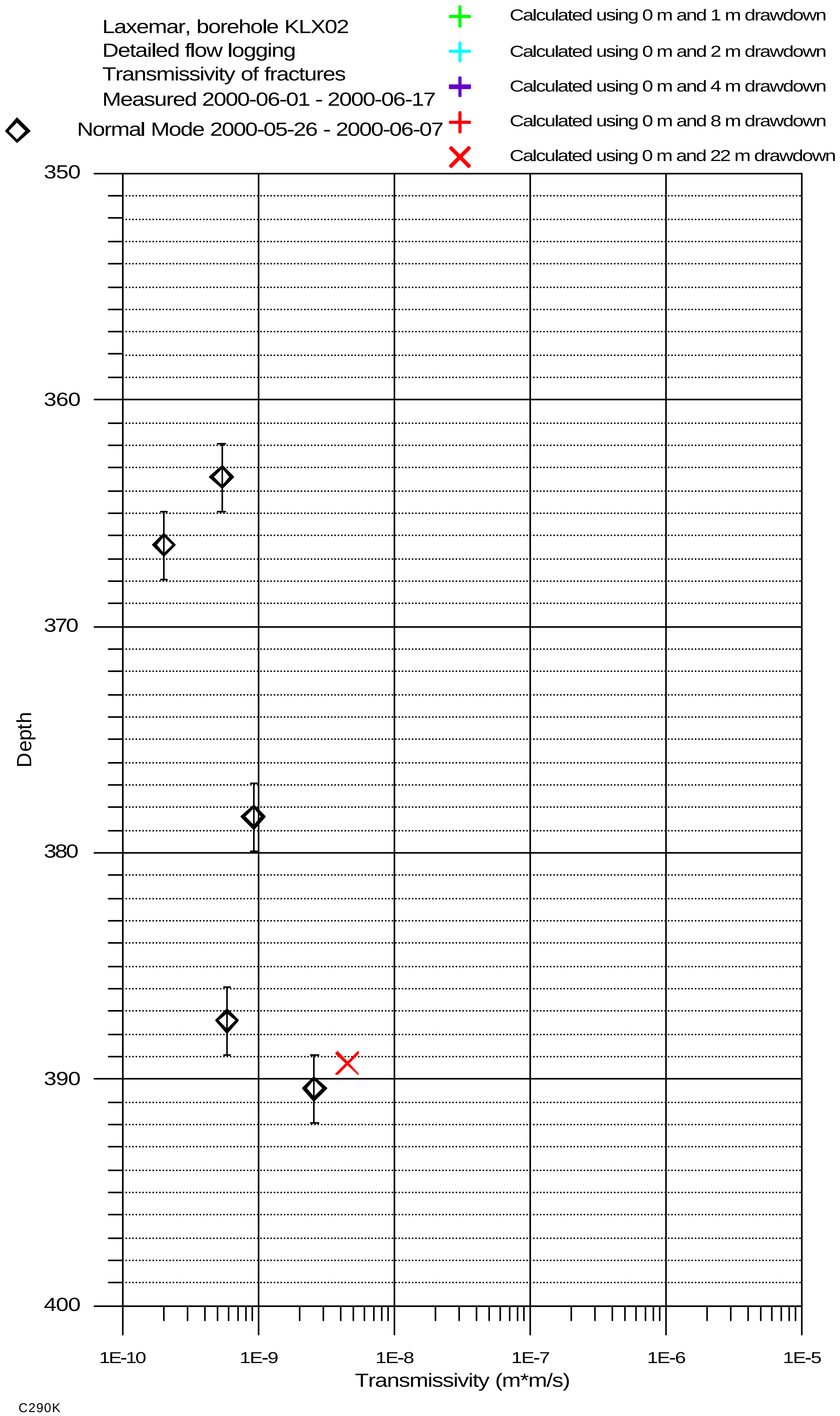

Laxemar, borehole KLX02
Detailed flow logging
Transmissivity of fractures
Measured 2000-06-01 - 2000-06-17
Normal Mode 2000-05-26 - 2000-06-07
Calculated using 0 m and 1 m drawdown
Calculated using 0 m and 2 m drawdown
Calculated using 0 m and 4 m drawdown
Calculated using 0 m and 8 m drawdown
Calculated using 0 m and 22 m drawdown
Depth
200
210
220
230
240
250
1E-10
1E-9
1E-8
1E-7
1E-6
1E-5
Transmissivity (m*m/s)
C290K

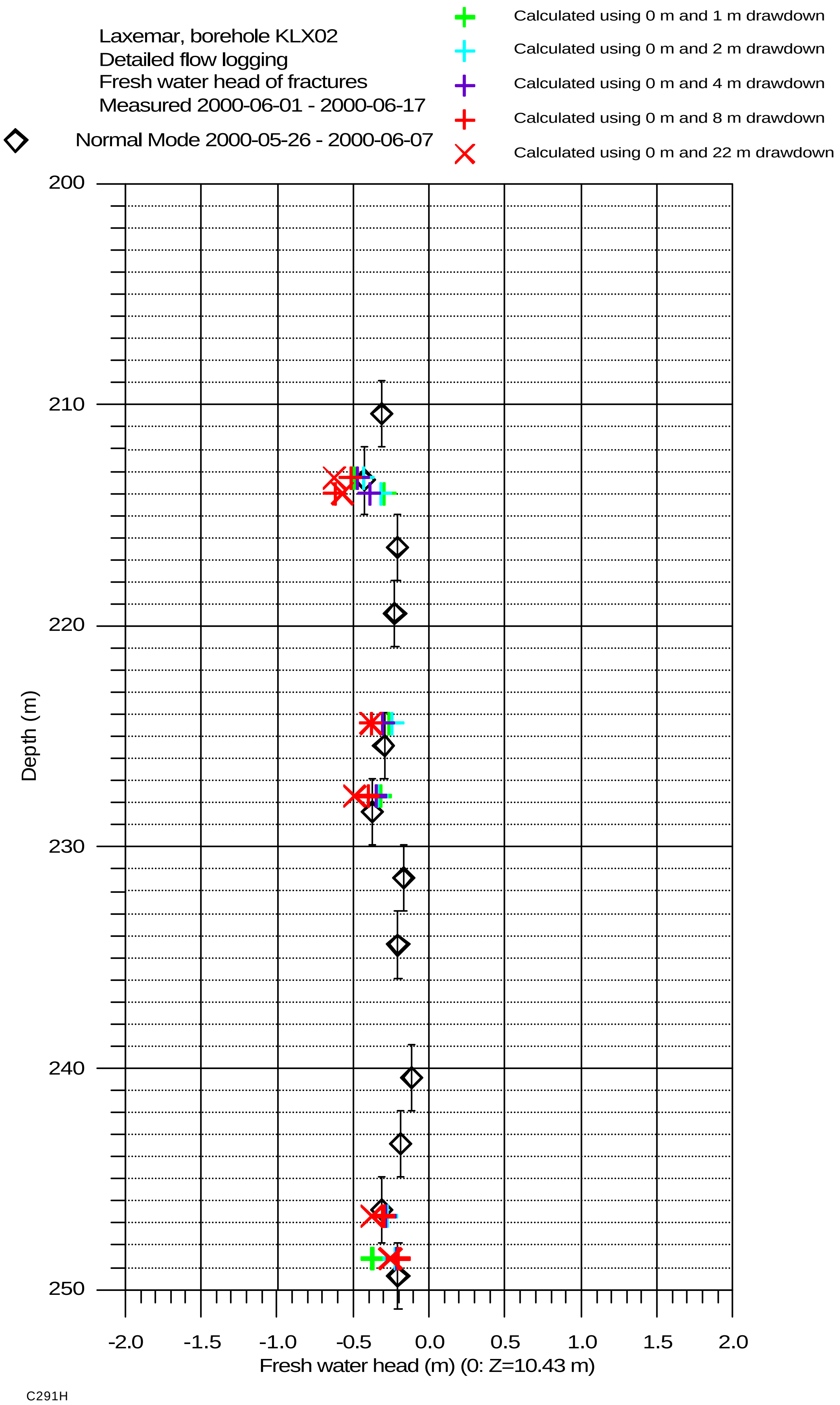


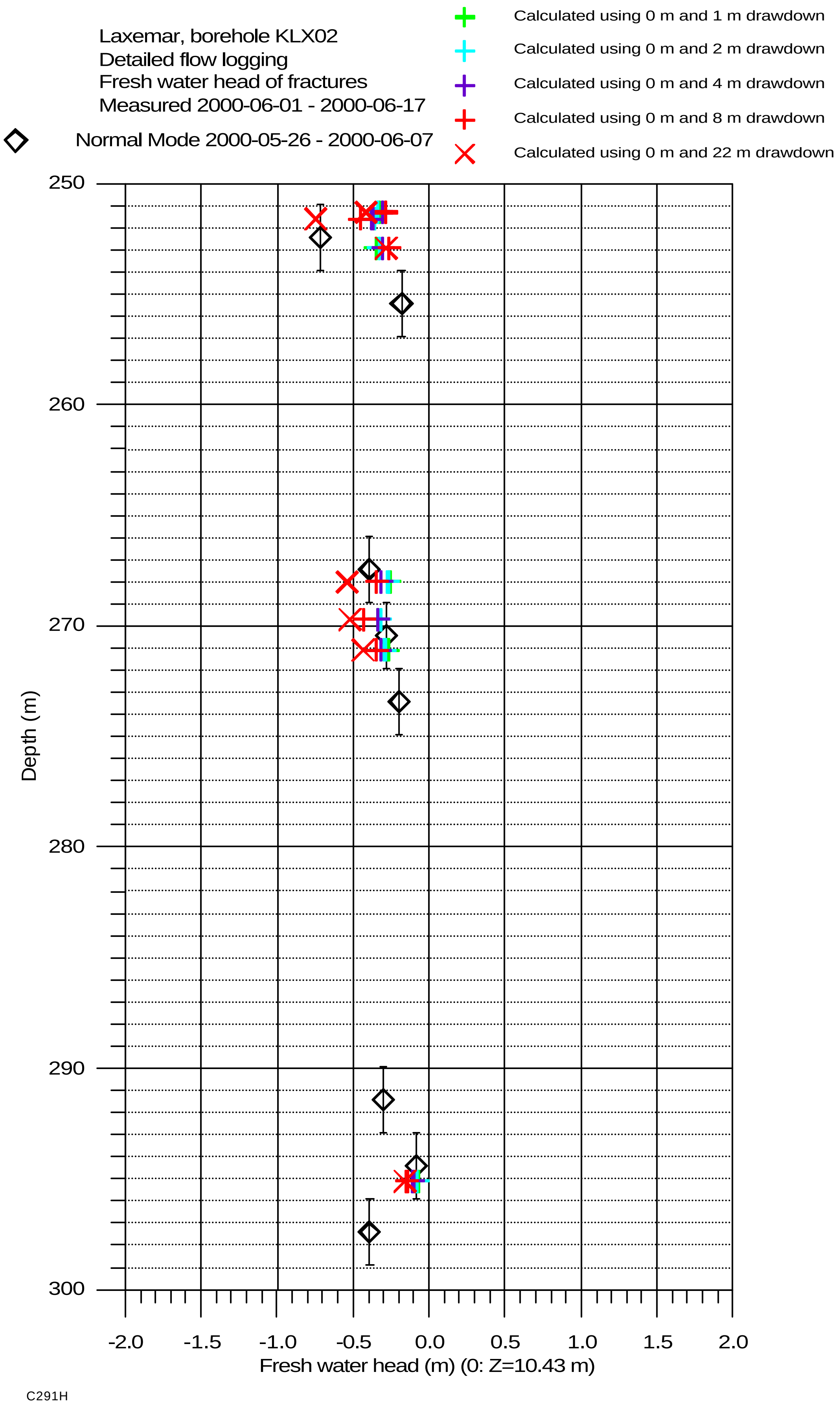
Laxemar, borehole KLX02
Detailed flow logging
Transmissivity of fractures
Measured 2000-06-01 - 2000-06-17
Normal Mode 2000-05-26 - 2000-06-07
Calculated using 0 m and 1 m drawdown
Calculated using 0 m and 2 m drawdown
Calculated using 0 m and 4 m drawdown
Calculated using 0 m and 8 m drawdown
Calculated using 0 m and 22 m drawdown
250
260
270
280
290
300
Depth
1E-10
1E-9
1E-8
1E-7
1E-6
1E-5
Transmissivity (m*m/s)

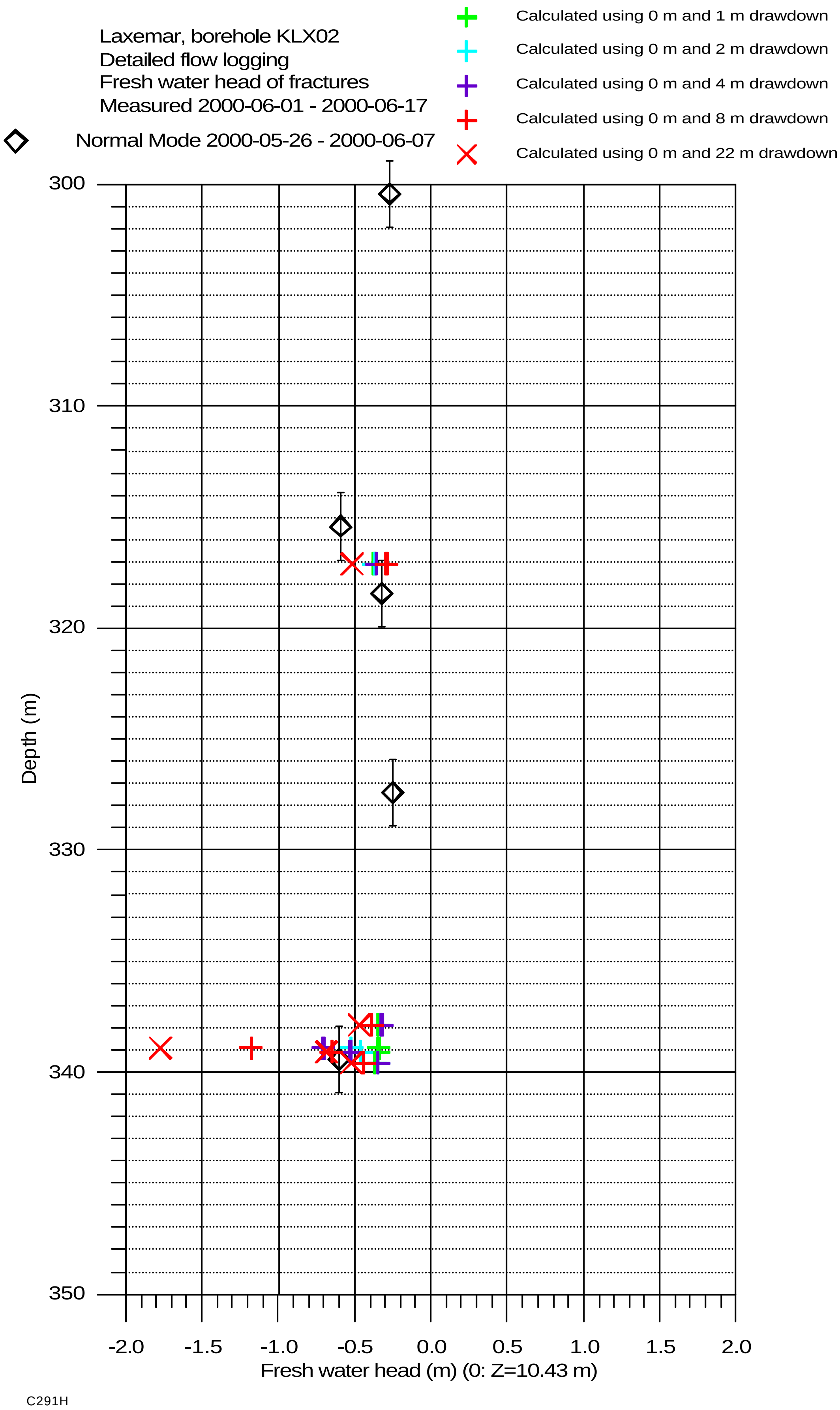
C290K

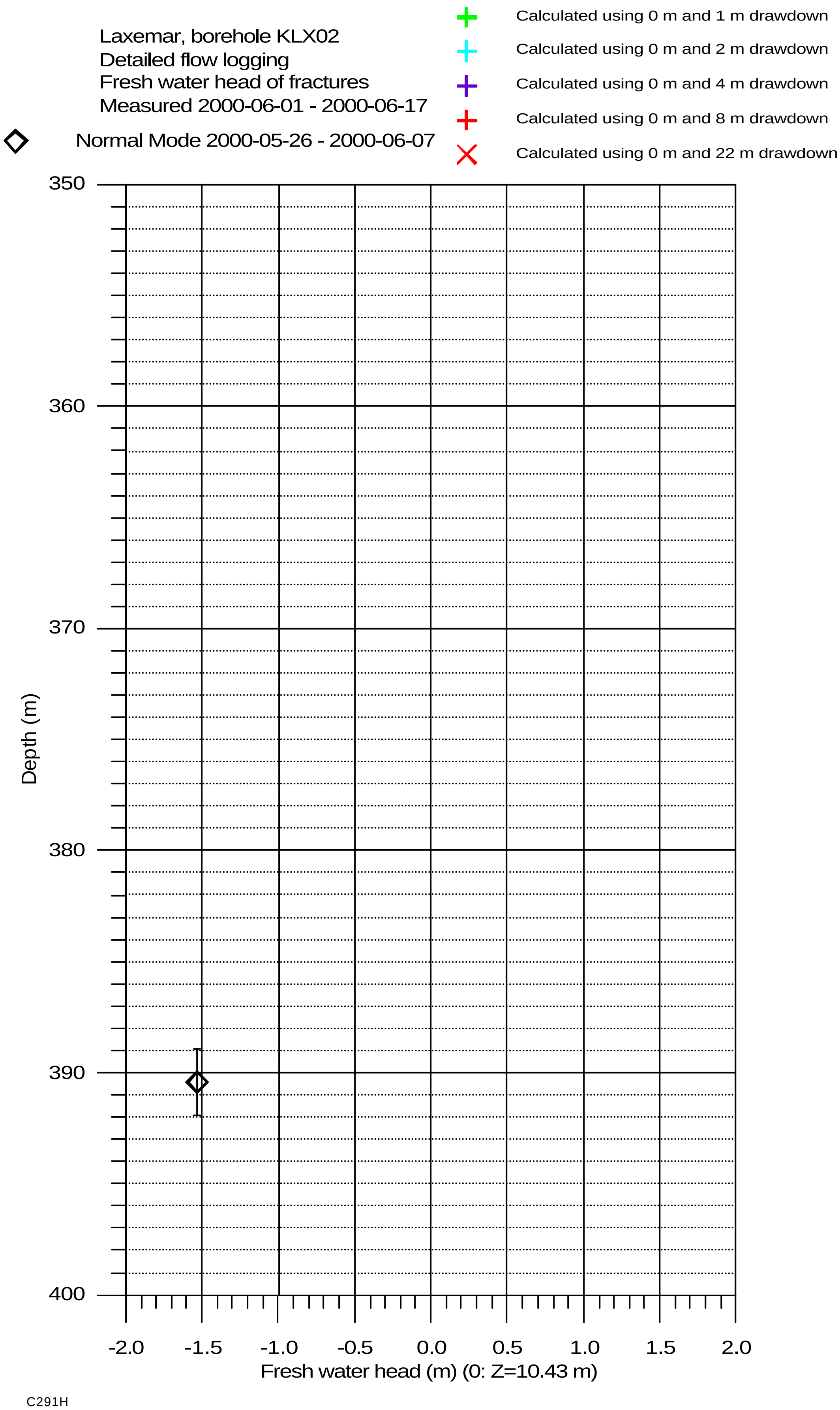

Laxemar, borehole KLX02
Detailed flow logging
Transmissivity of fractures
Measured 2000-06-01 - 2000-06-17
Normal Mode 2000-05-26 - 2000-06-07
Calculated using 0 m and 1 m drawdown
Calculated using 0 m and 2 m drawdown
Calculated using 0 m and 4 m drawdown
Calculated using 0 m and 8 m drawdown
Calculated using 0 m and 22 m drawdown
Depth
300
310
320
330
340
350
1E-10
1E-9
1E-8
1E-7
1E-6
1E-5
Transmissivity (m*m/s)
C290K


Laxemar, borehole KLX02
Detailed flow logging
Transmissivity of fractures
Measured 2000-06-01 - 2000-06-17
Normal Mode 2000-05-26 - 2000-06-07
Calculated using 0 m and 1 m drawdown
Calculated using 0 m and 2 m drawdown
Calculated using 0 m and 4 m drawdown
Calculated using 0 m and 8 m drawdown
Calculated using 0 m and 22 m drawdown
350
360
370
380
390
400
Depth
1E-10
1E-9
1E-8
1E-7
1E-6
1E-5
Transmissivity (m*m/s)
C290K

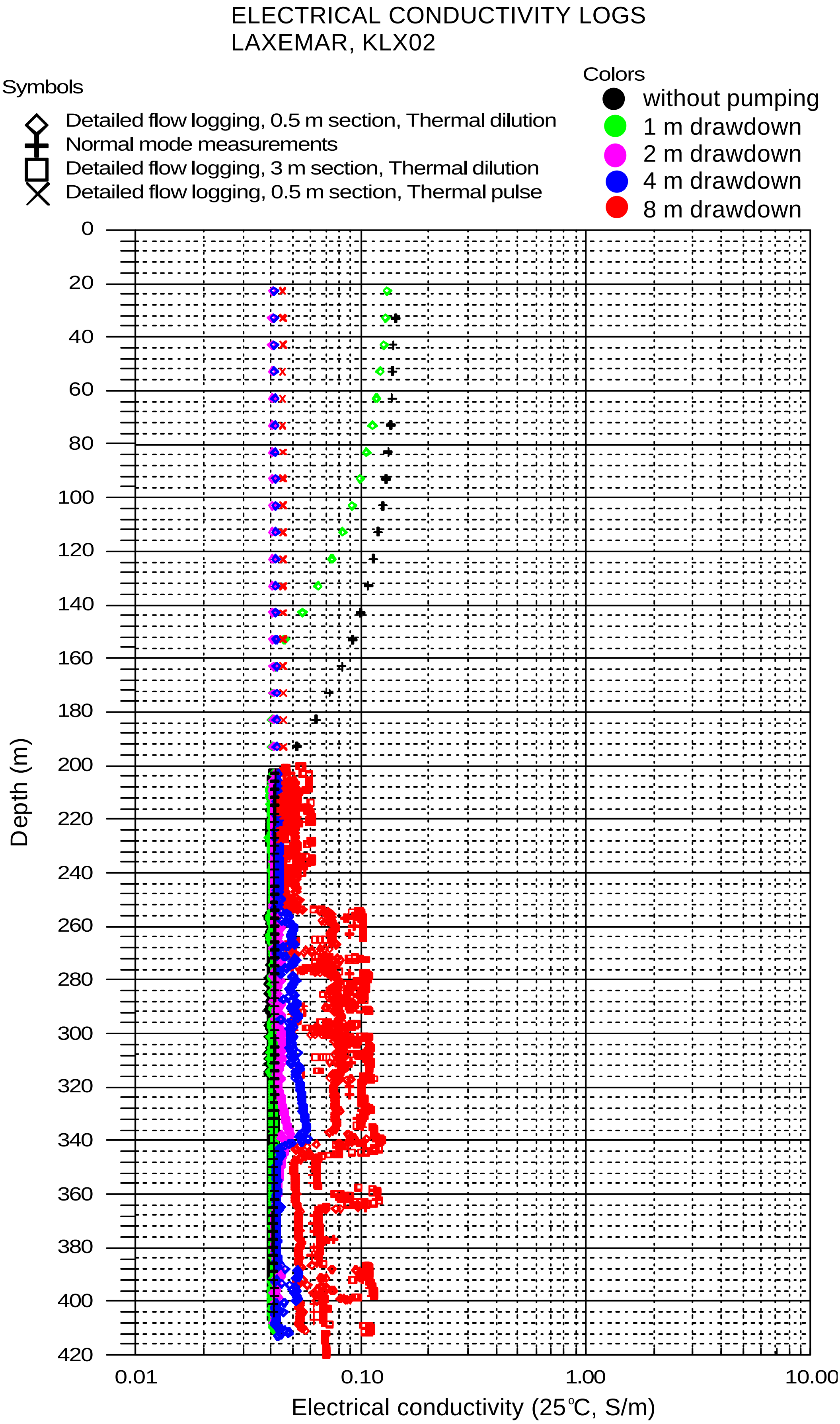

Laxemar, borehole KLX02
Detailed flow logging
Fresh water head of fractures
Measured 2000-06-01 - 2000-06-17
Normal Mode 2000-05-26 - 2000-06-07
Calculated using 0 m and 1 m drawdown
Calculated using 0 m and 2 m drawdown
Calculated using 0 m and 4 m drawdown
Calculated using 0 m and 8 m drawdown
Calculated using 0 m and 22 m drawdown
Depth (m)
200
210
220
230
240
250
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Fresh water head (m) (0: Z=10.43 m)
C291H


Laxemar, borehole KLX02
Detailed flow logging
Fresh water head of fractures
Measured 2000-06-01 - 2000-06-17
Normal Mode 2000-05-26 - 2000-06-07
Calculated using 0 m and 1 m drawdown
Calculated using 0 m and 2 m drawdown
Calculated using 0 m and 4 m drawdown
Calculated using 0 m and 8 m drawdown
Calculated using 0 m and 22 m drawdown
Depth (m)
250
260
270
280
290
300
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Fresh water head (m) (0: Z=10.43 m)
C291H


Laxemar, borehole KLX02
Detailed flow logging
Fresh water head of fractures
Measured 2000-06-01 - 2000-06-17
Normal Mode 2000-05-26 - 2000-06-07
Calculated using 0 m and 1 m drawdown
Calculated using 0 m and 2 m drawdown
Calculated using 0 m and 4 m drawdown
Calculated using 0 m and 8 m drawdown
Calculated using 0 m and 22 m drawdown
300
310
320
330
340
350
Depth (m)
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Fresh water head (m) (0: Z=10.43 m)
C291H

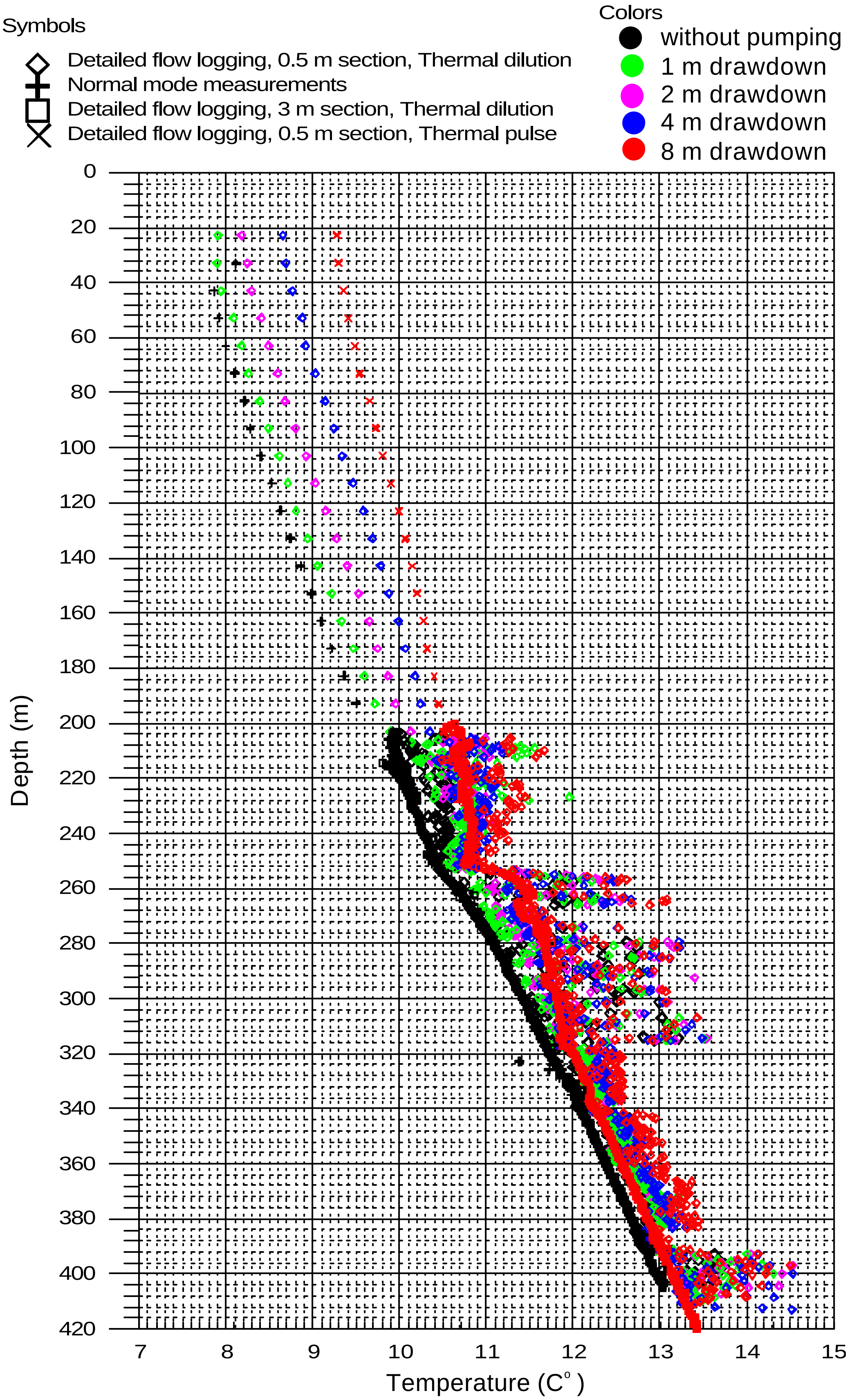


Laxemar, borehole KLX02
Detailed flow logging
Fresh water head of fractures
Measured 2000-06-01 - 2000-06-17
Normal Mode 2000-05-26 - 2000-06-07
Calculated using 0 m and 1 m drawdown
Calculated using 0 m and 2 m drawdown
Calculated using 0 m and 4 m drawdown
Calculated using 0 m and 8 m drawdown
Calculated using 0 m and 22 m drawdown
Depth (m)
350
360
370
380
390
400
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
Fresh water head (m) (0: Z=10.43 m)
C291H

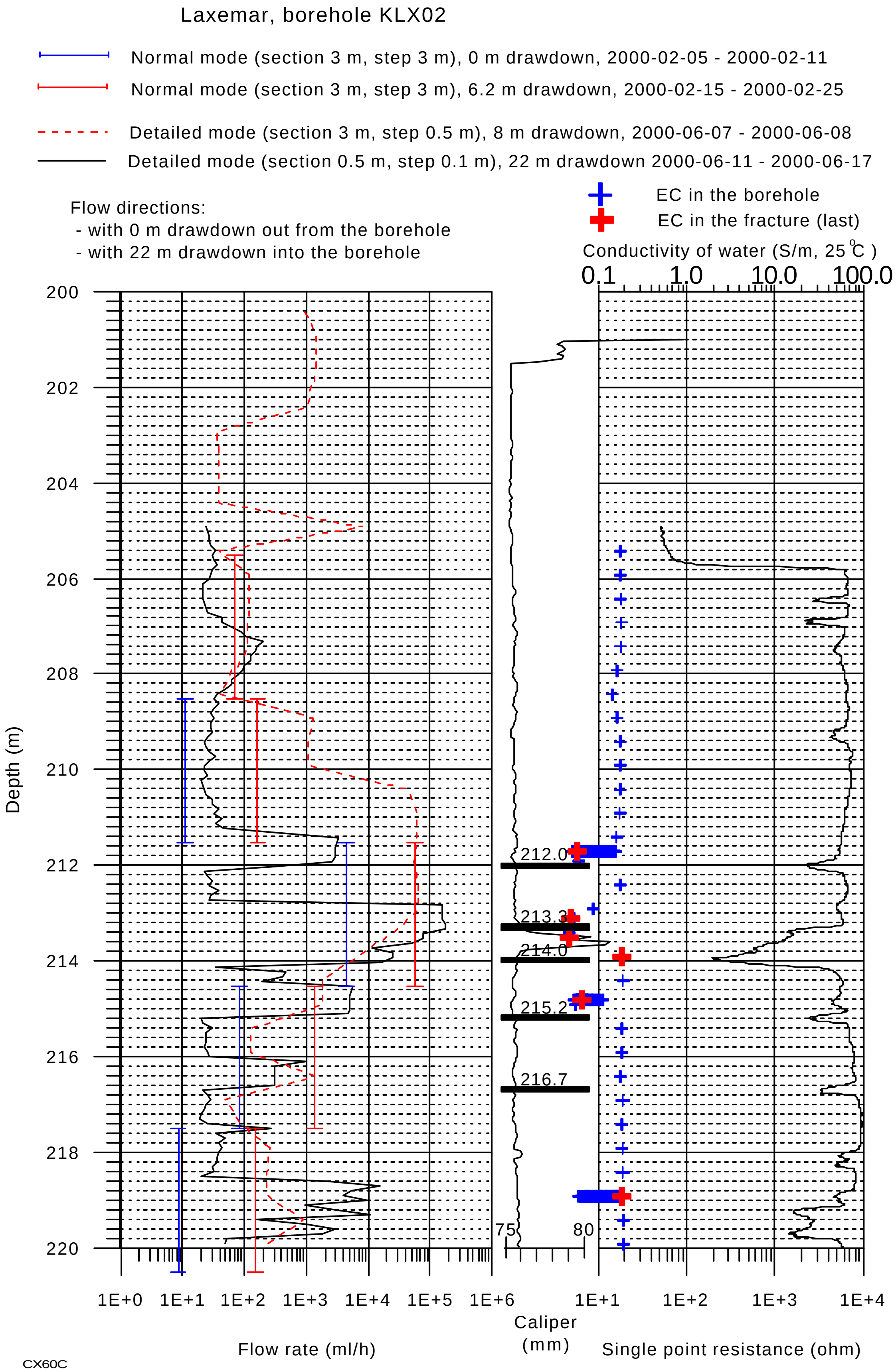

ELECTRICAL CONDUCTIVITY LOGS
LAXEMAR, KLX02
Symbols
Detailed flow logging, 0.5 m section, Thermal dilution
Normal mode measurements
Detailed flow logging, 3 m section, Thermal dilution
Detailed flow logging, 0.5 m section, Thermal pulse
Colors
without pumping
1 m drawdown
2 m drawdown
4 m drawdown
8 m drawdown
Depth (m)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
0.01
0.10
1.00
10.00
Electrical conductivity (25℃, S/m)

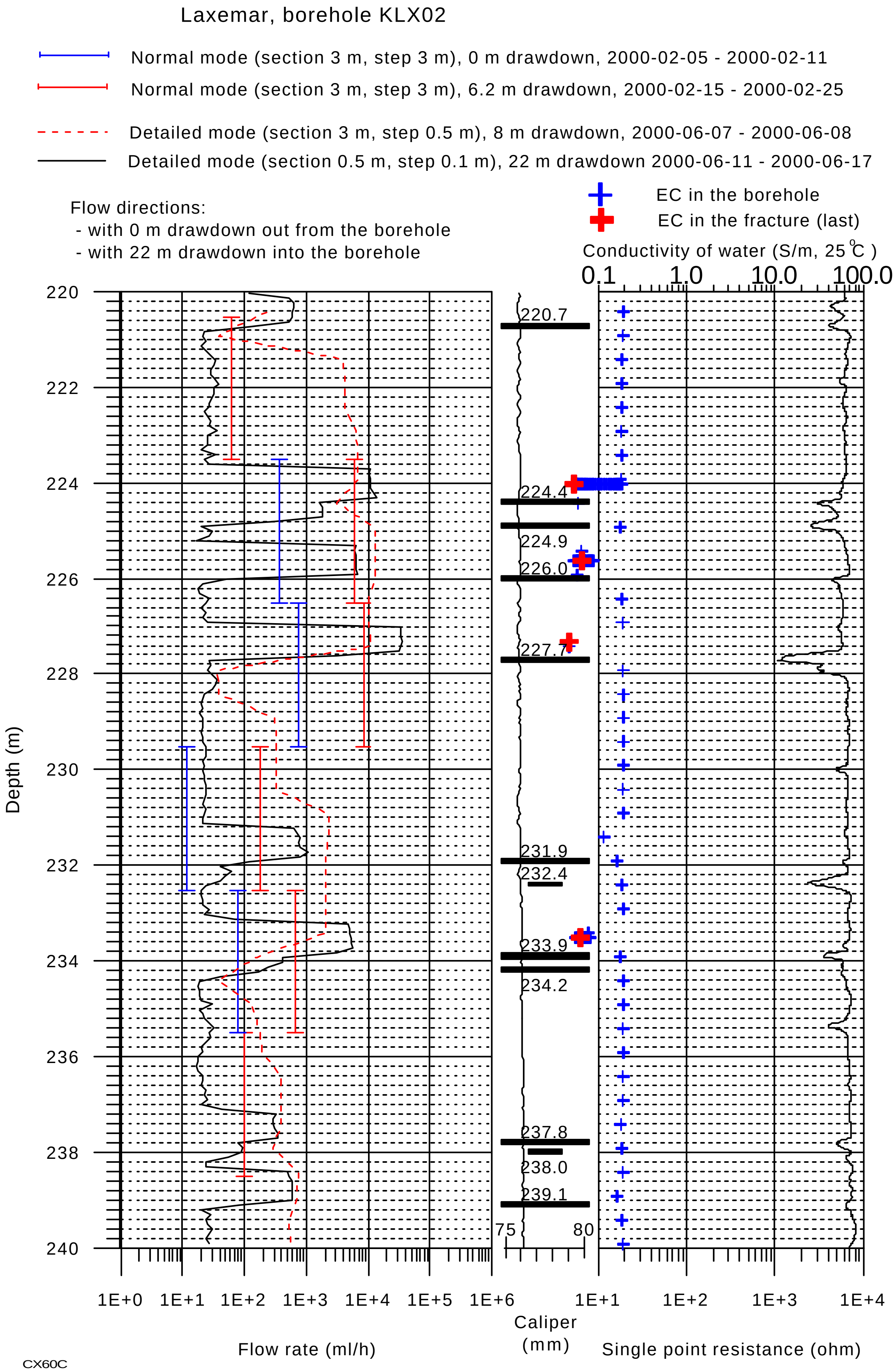
C240E

TEMPERATURE OF BOREHOLE WATER
LAXEMAR, KLX02

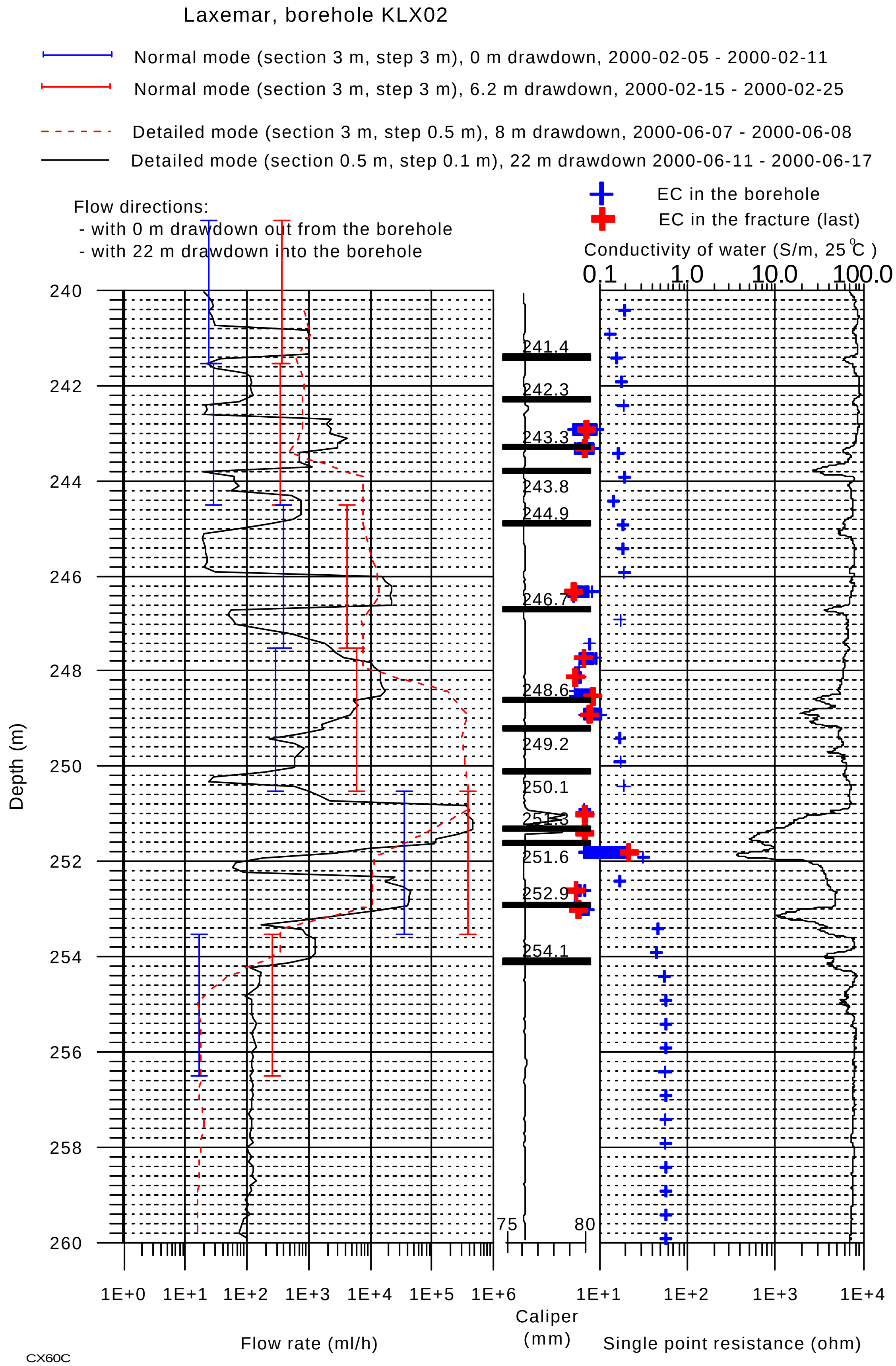


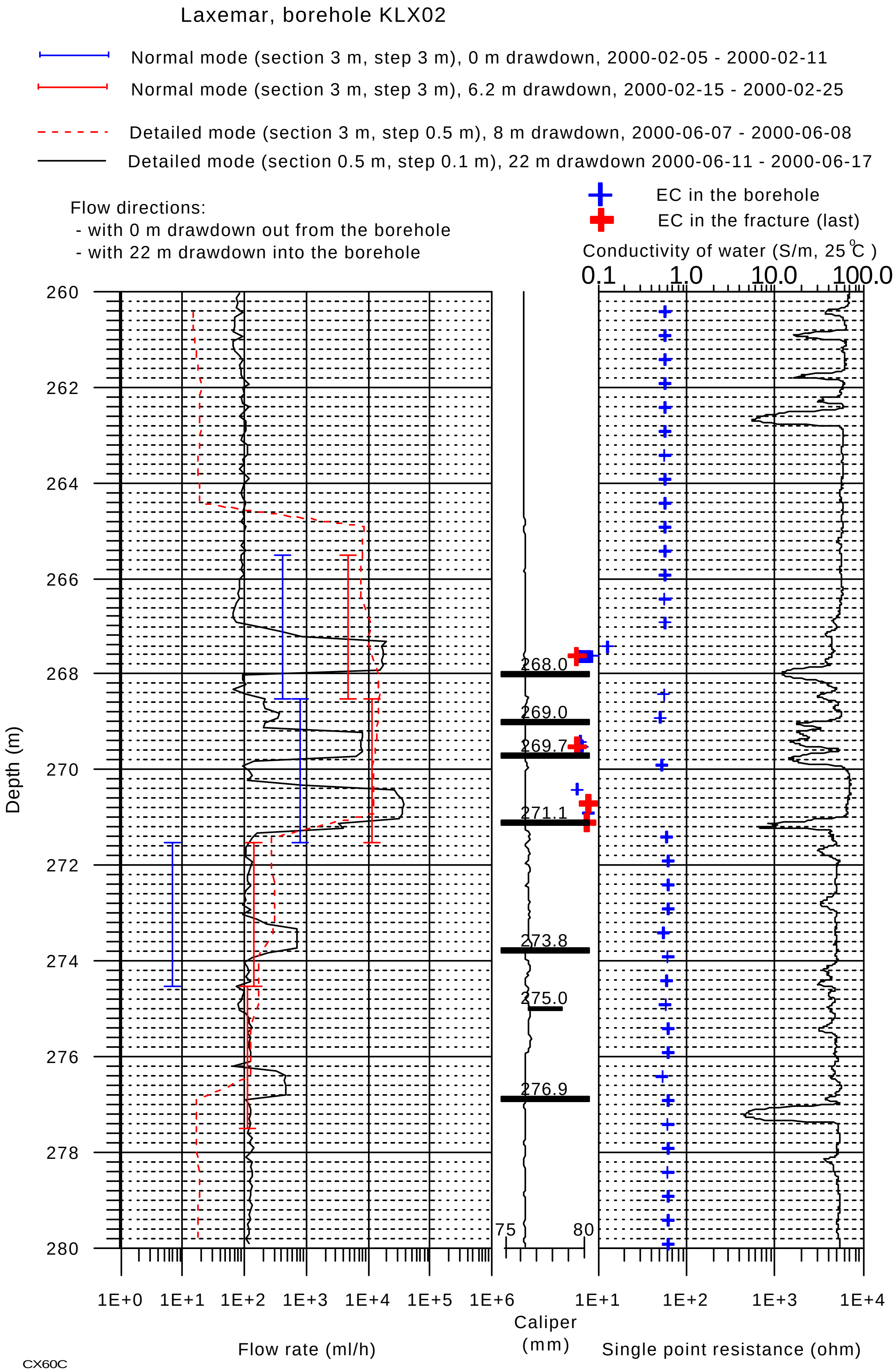
C250T

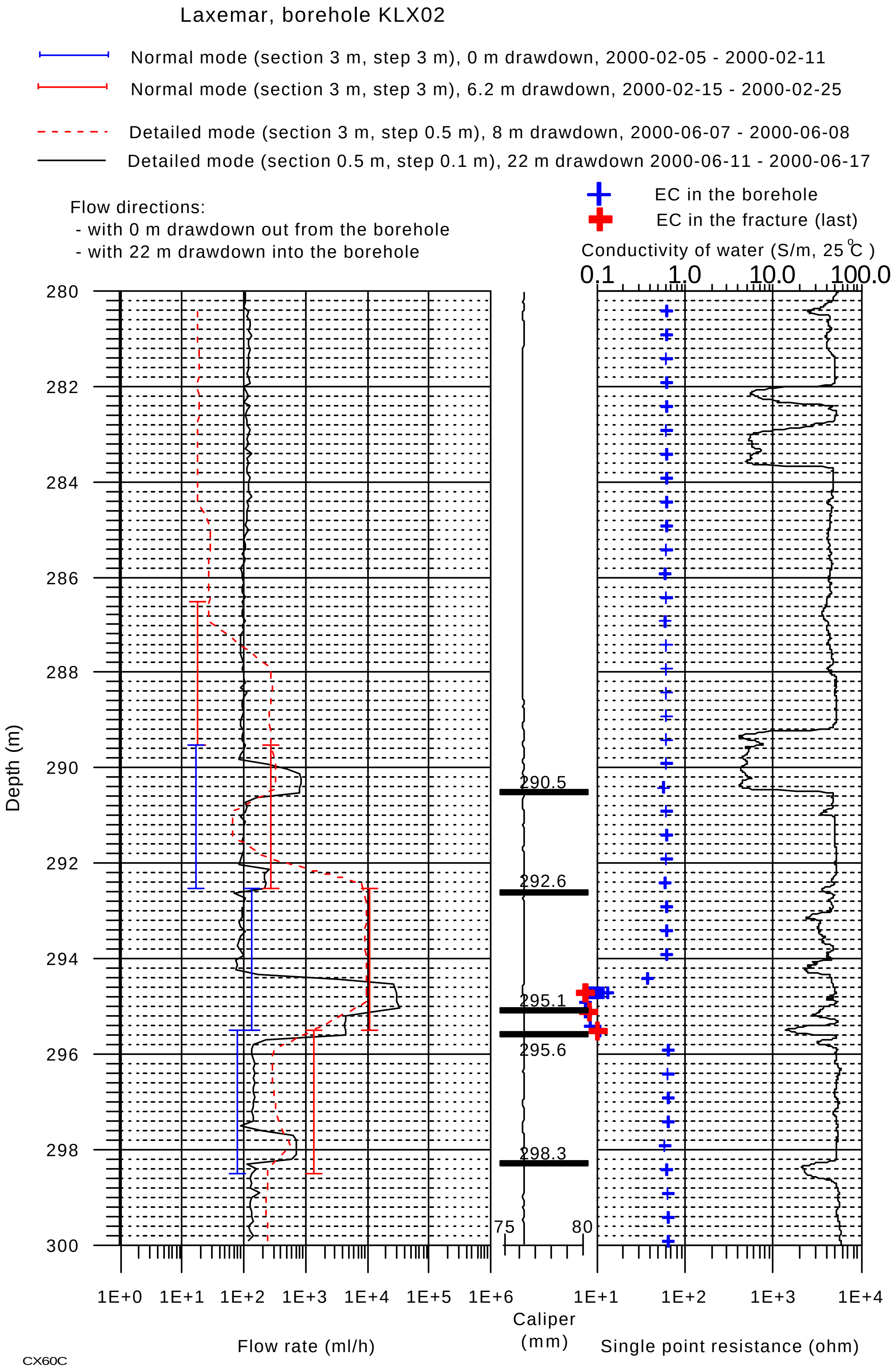

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 6.2 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 8 m drawdown, 2000-06-07 - 2000-06-08
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
200
202
204
206
208
210
212
214
216
218
220
212.0
213.3
214.0
215.2
216.7
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

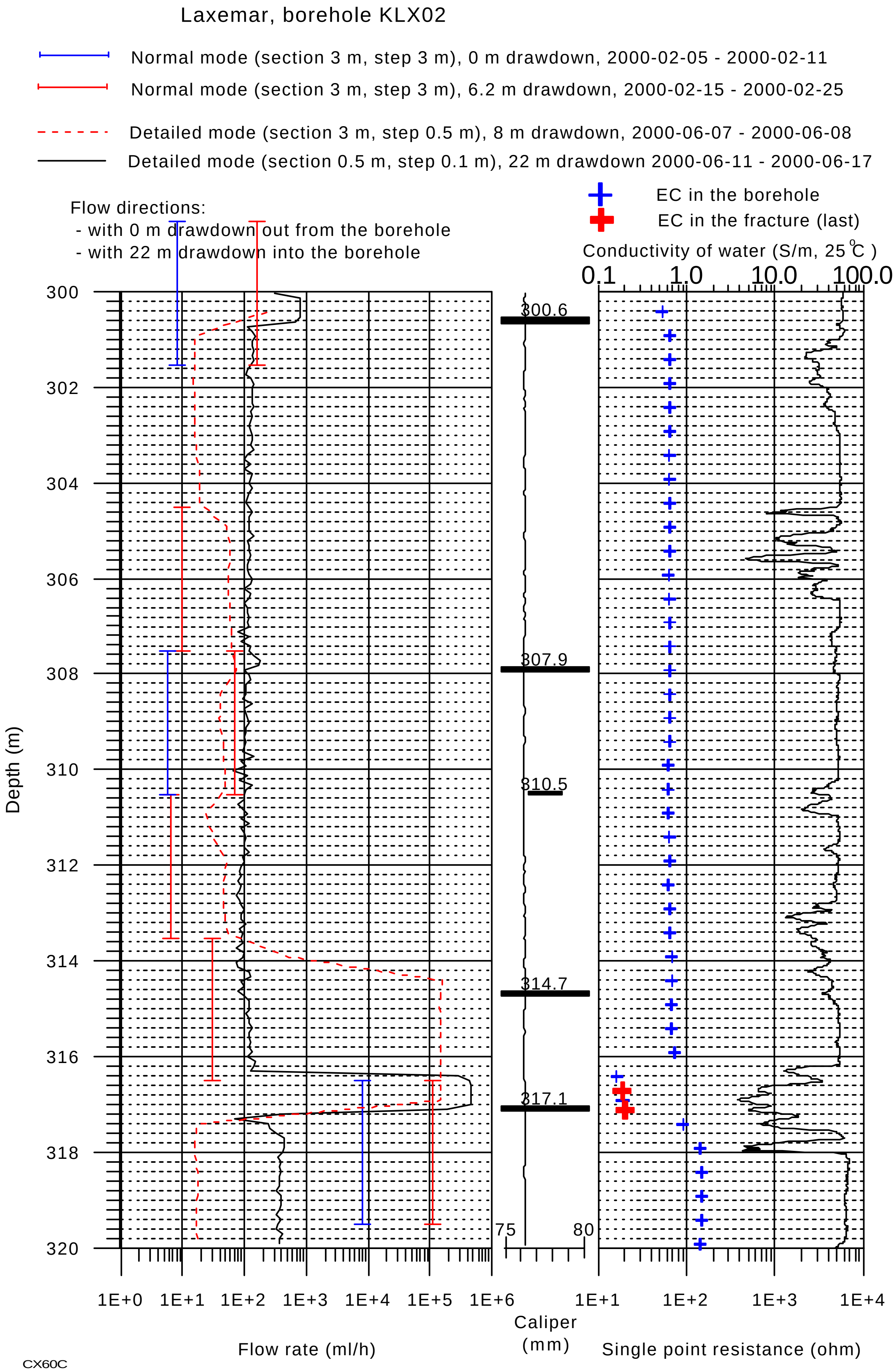


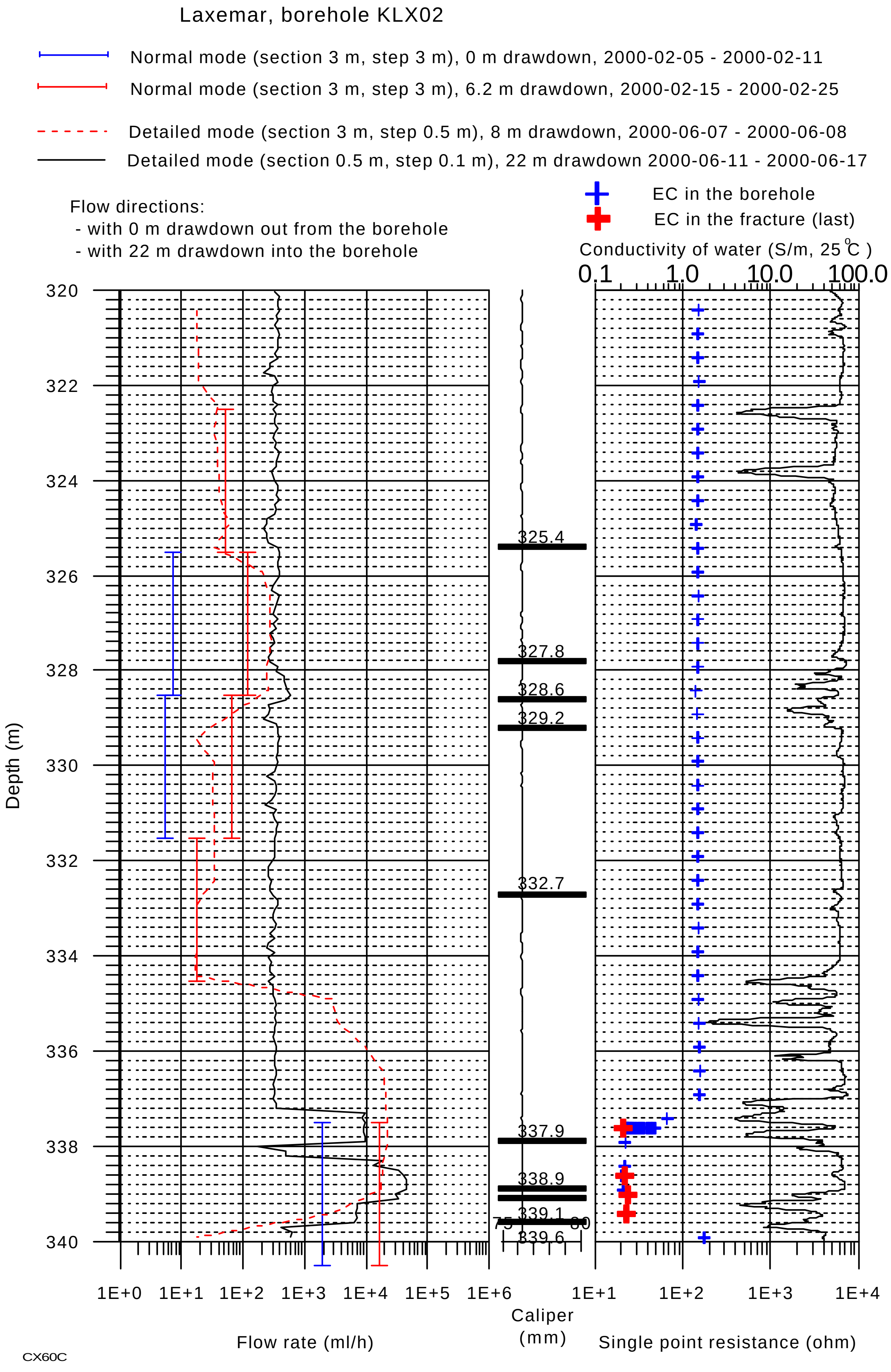
Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 6.2 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 8 m drawdown, 2000-06-07 - 2000-06-08
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
220
222
224
226
228
230
232
234
236
238
240
220.7
224.4
224.9
226.0
227.7
231.9
232.4
233.9
234.2
237.8
238.0
239.1
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C


Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 6.2 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 8 m drawdown, 2000-06-07 - 2000-06-08
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 ℃)
0.1
1.0
10.0
100.0
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
Depth (m)
240
242
244
246
248
250
252
254
256
258
260
241.4
242.3
243.3
243.8
244.9
246.7
248.6
249.2
250.1
251.3
251.6
252.9
254.1
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
CX60C

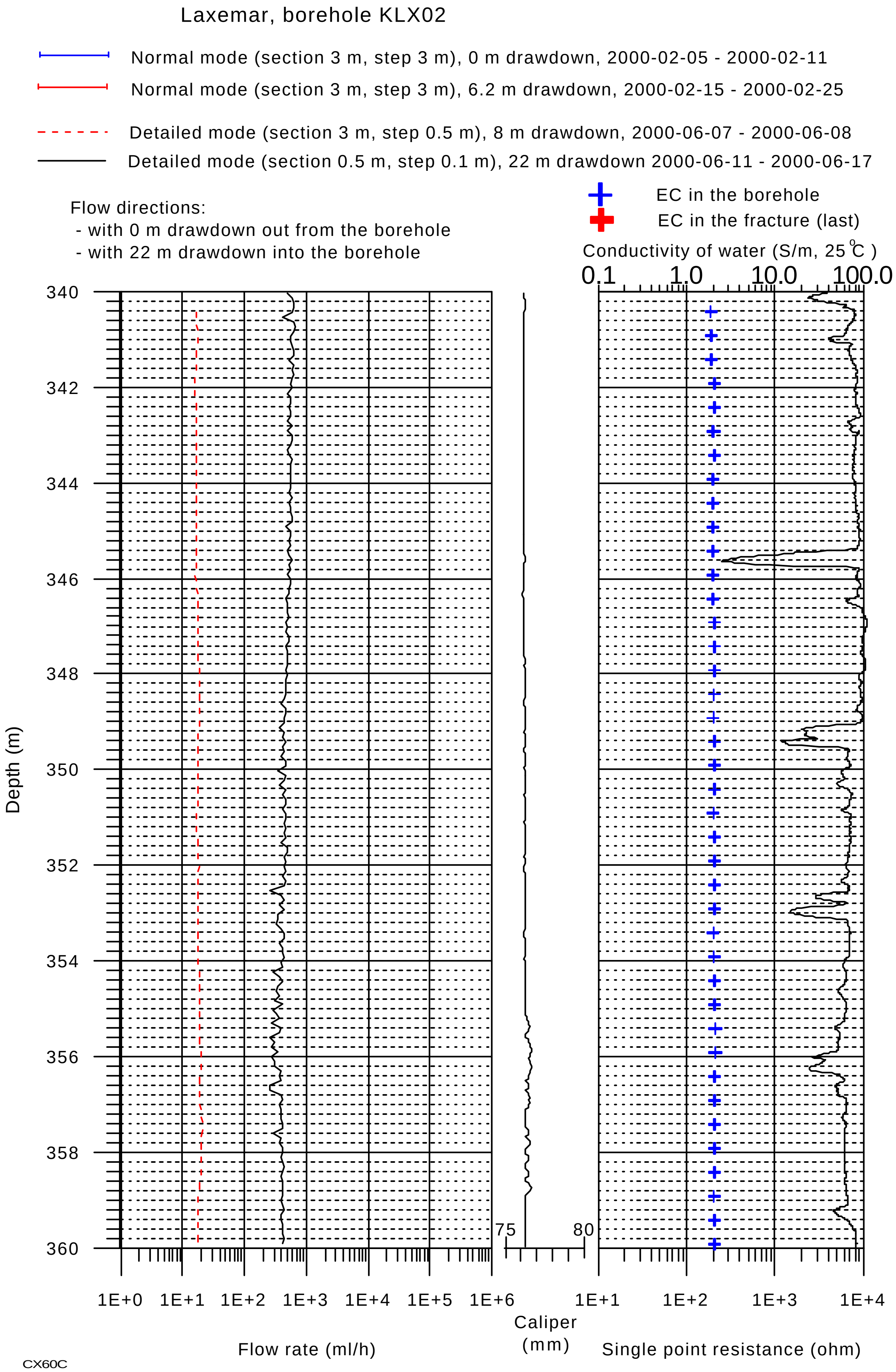

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 6.2 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 8 m drawdown, 2000-06-07 - 2000-06-08
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
260
262
264
266
268
270
272
274
276
278
280
268.0
269.0
269.7
271.1
273.8
275.0
276.9
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

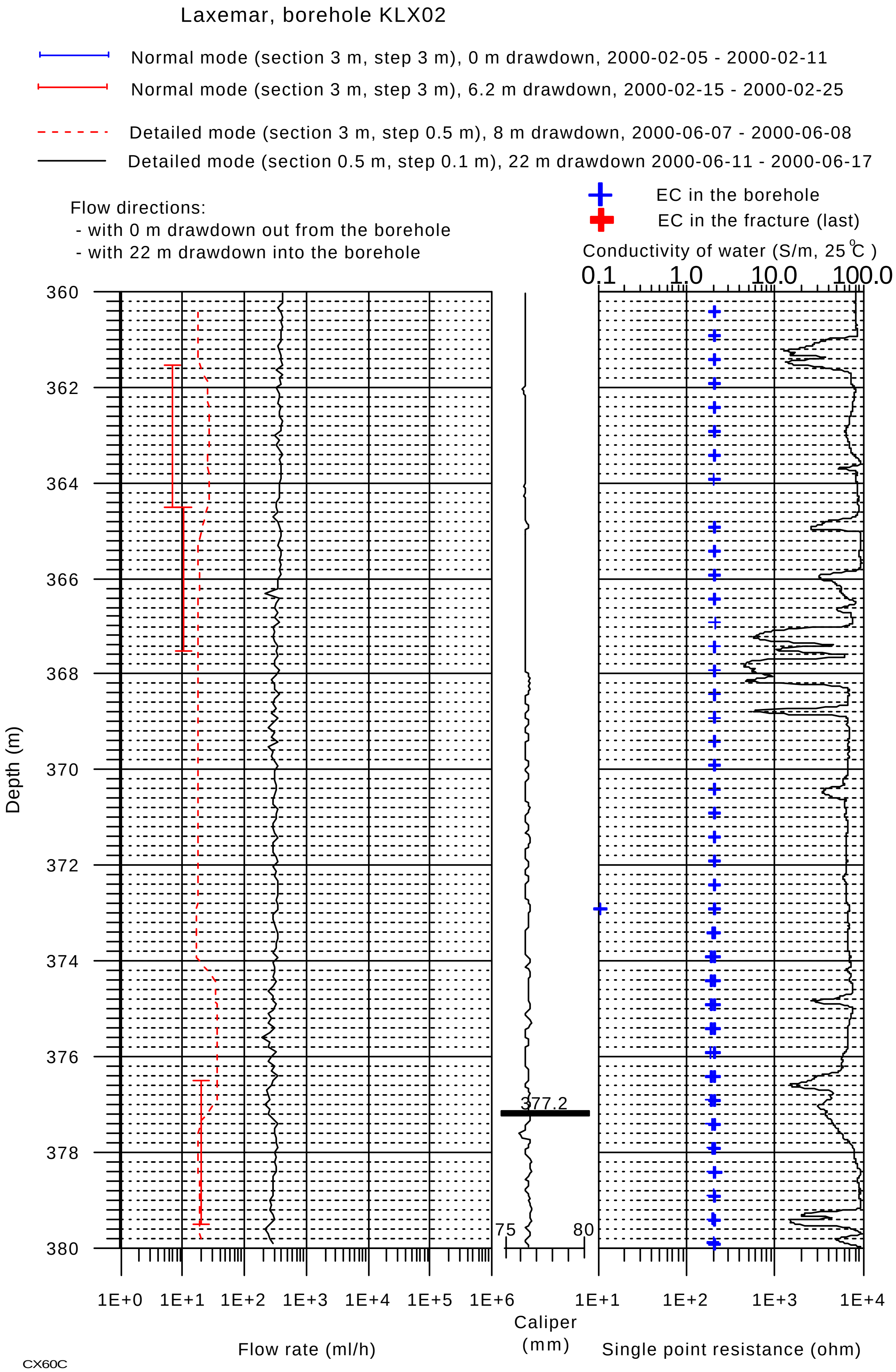

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 6.2 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 8 m drawdown, 2000-06-07 - 2000-06-08
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
280
282
284
286
288
290
292
294
296
298
300
290.5
292.6
295.1
295.6
298.3
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Flow rate (ml/h)
Caliper
(mm)
Single point resistance (ohm)
CX60C

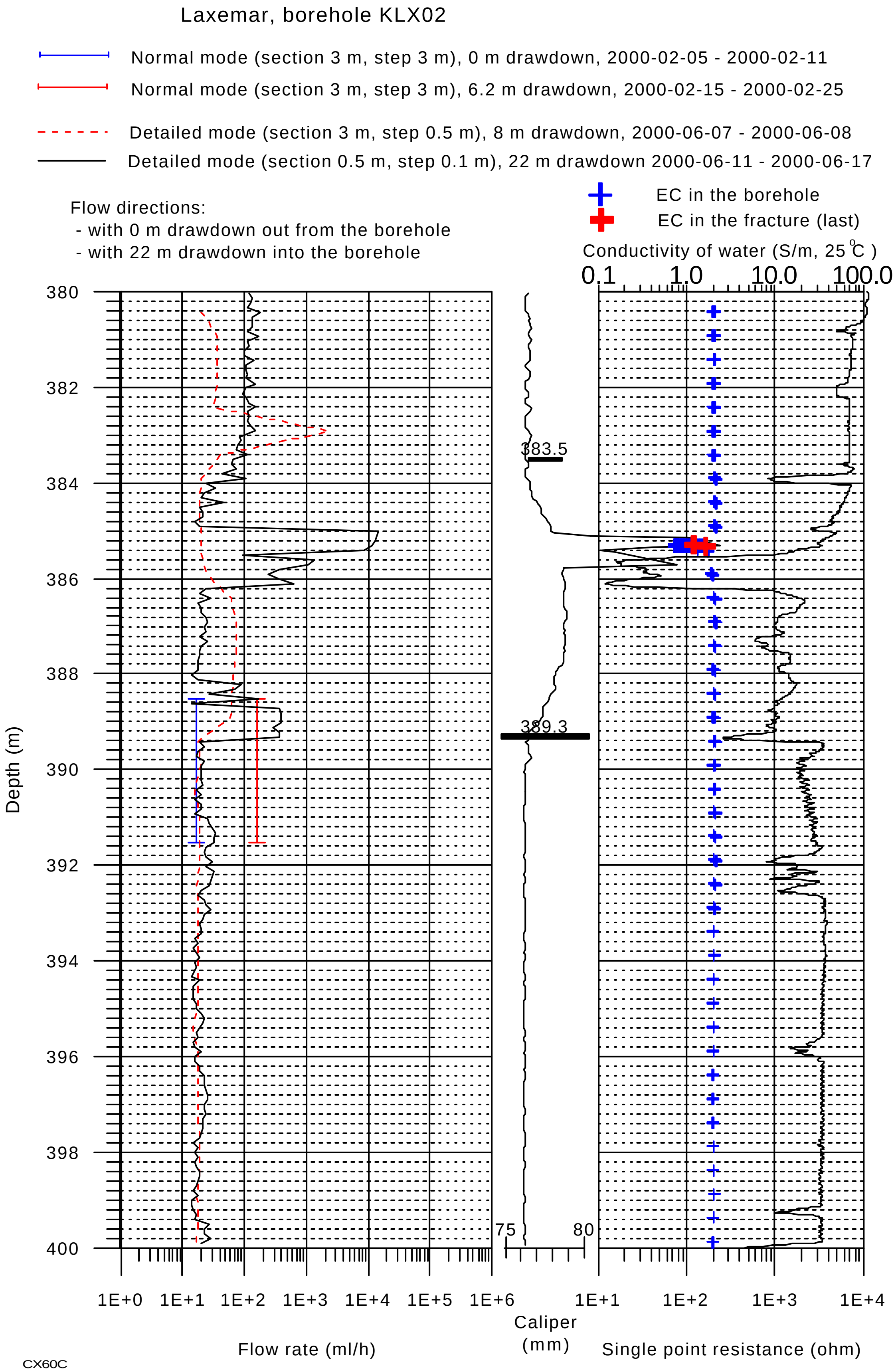

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 6.2 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 8 m drawdown, 2000-06-07 - 2000-06-08
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
300
302
304
306
308
310
312
314
316
318
320
300.6
307.9
310.5
314.7
317.1
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C



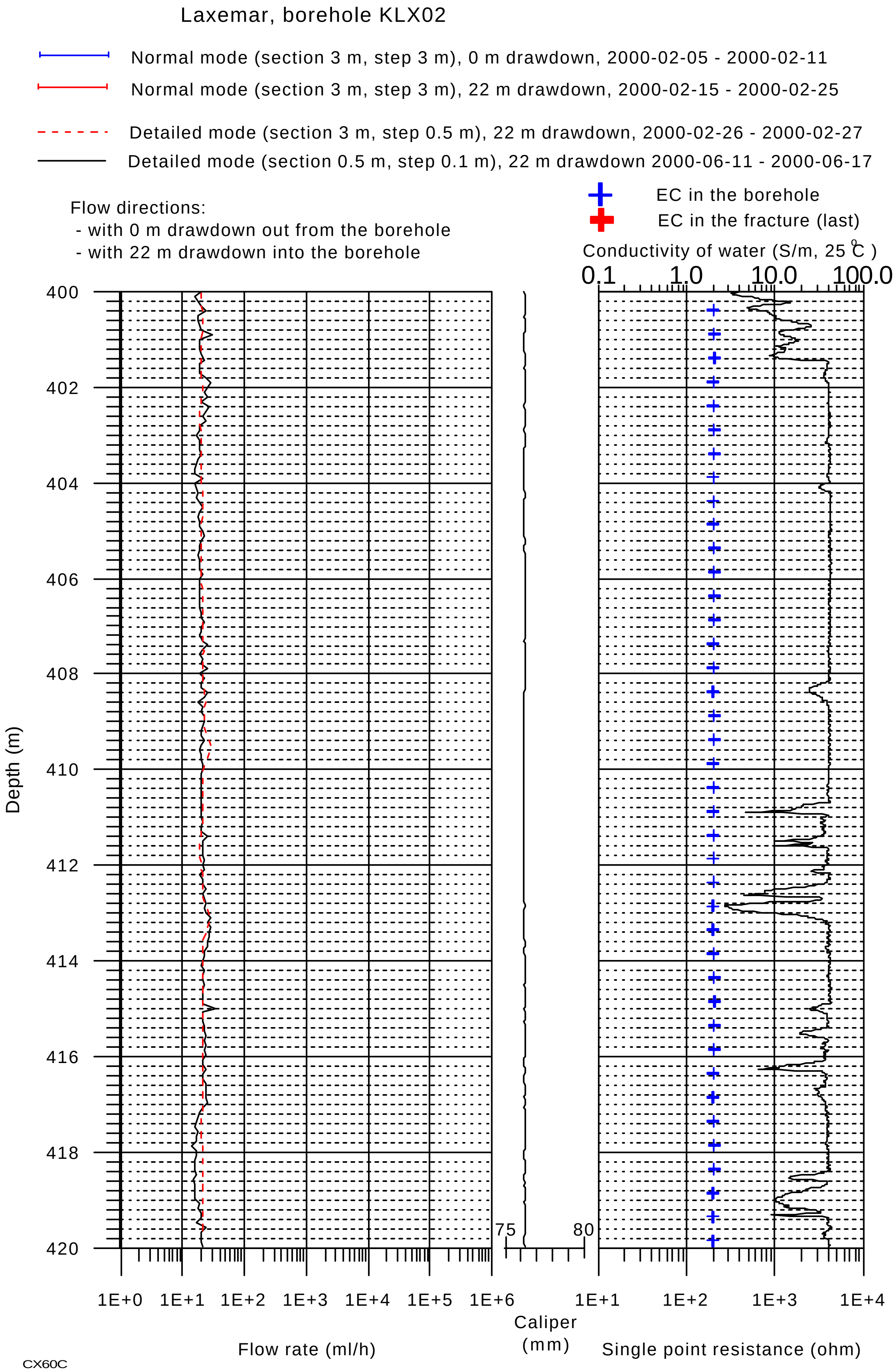
Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 6.2 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 8 m drawdown, 2000-06-07 - 2000-06-08
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
320
322
324
326
328
330
332
334
336
338
340
Depth (m)
325.4
327.8
328.6
329.2
332.7
337.9
338.9
339.1
339.6
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

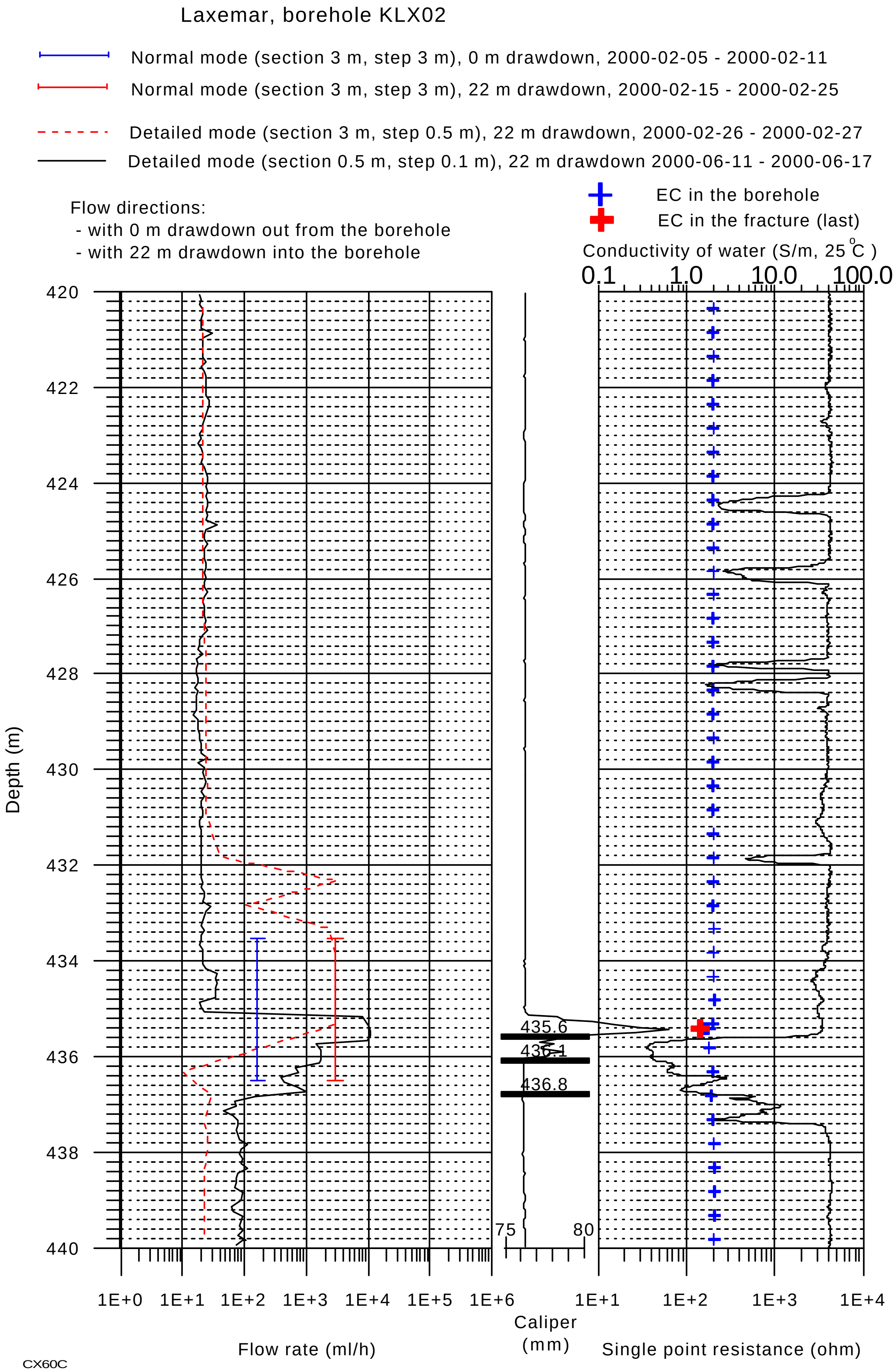

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 6.2 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 8 m drawdown, 2000-06-07 - 2000-06-08
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
340
342
344
346
348
350
352
354
356
358
360
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

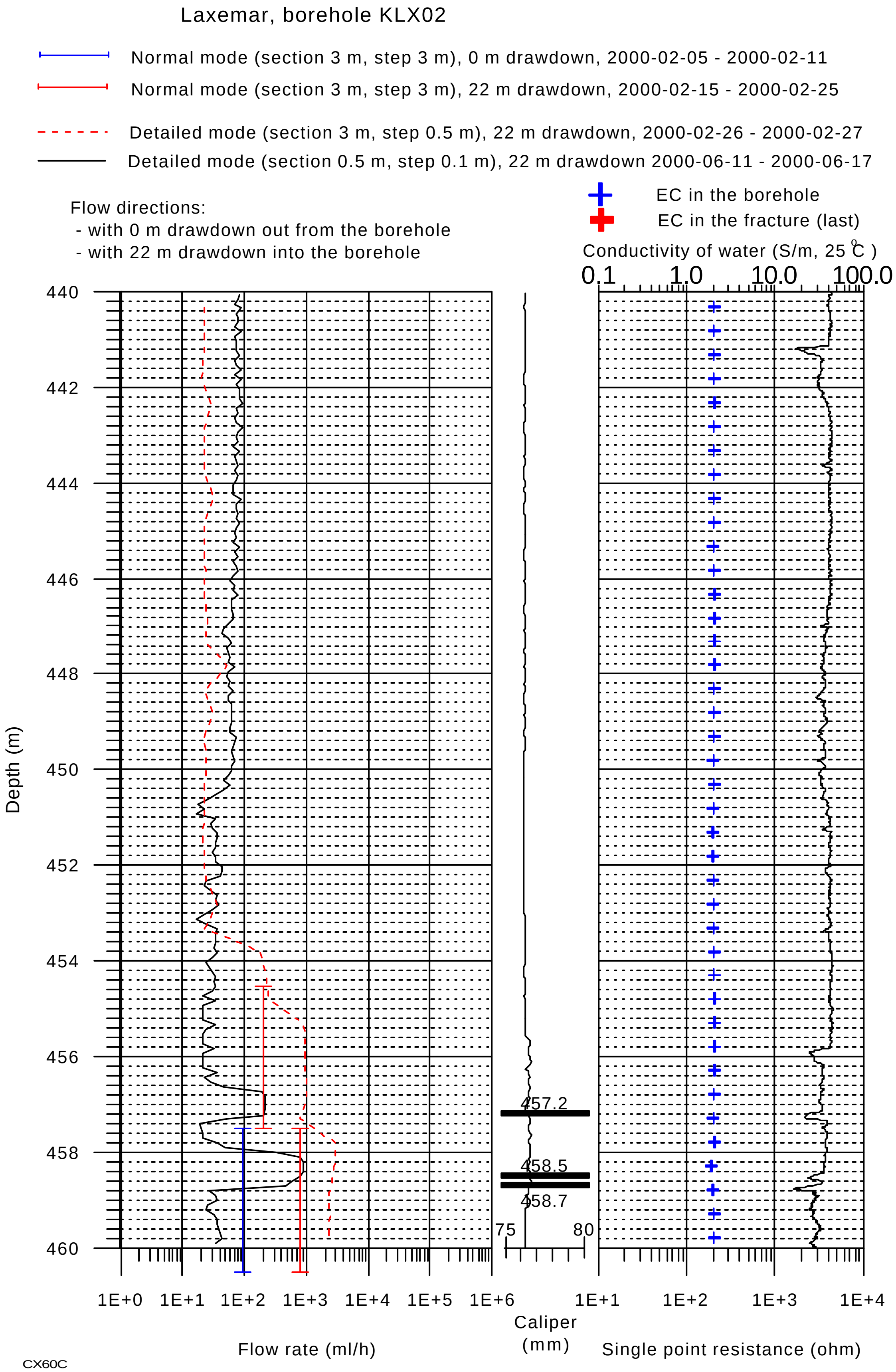

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 6.2 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 8 m drawdown, 2000-06-07 - 2000-06-08
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
360
362
364
366
368
370
372
374
376
378
380
377.2
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

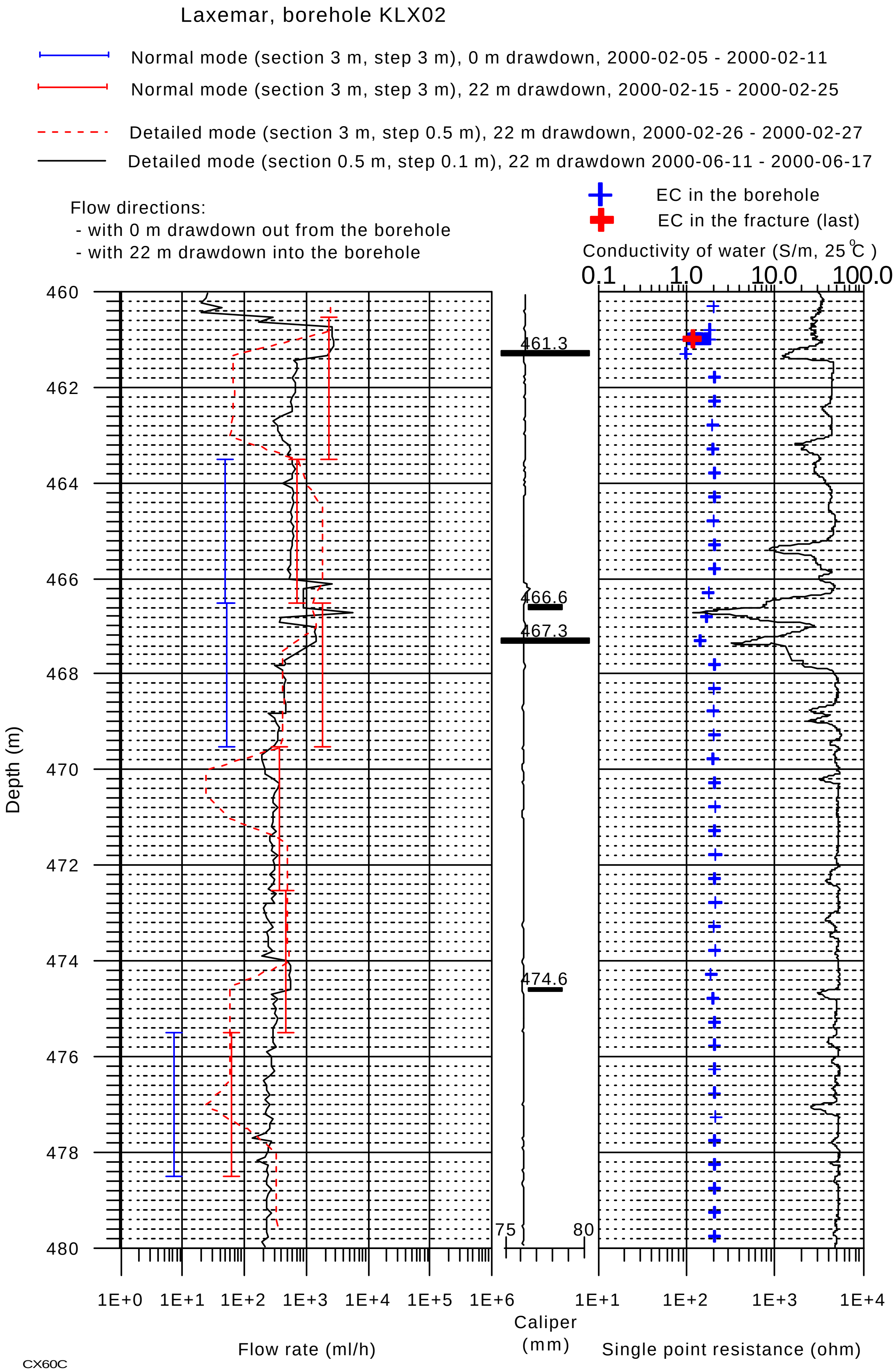


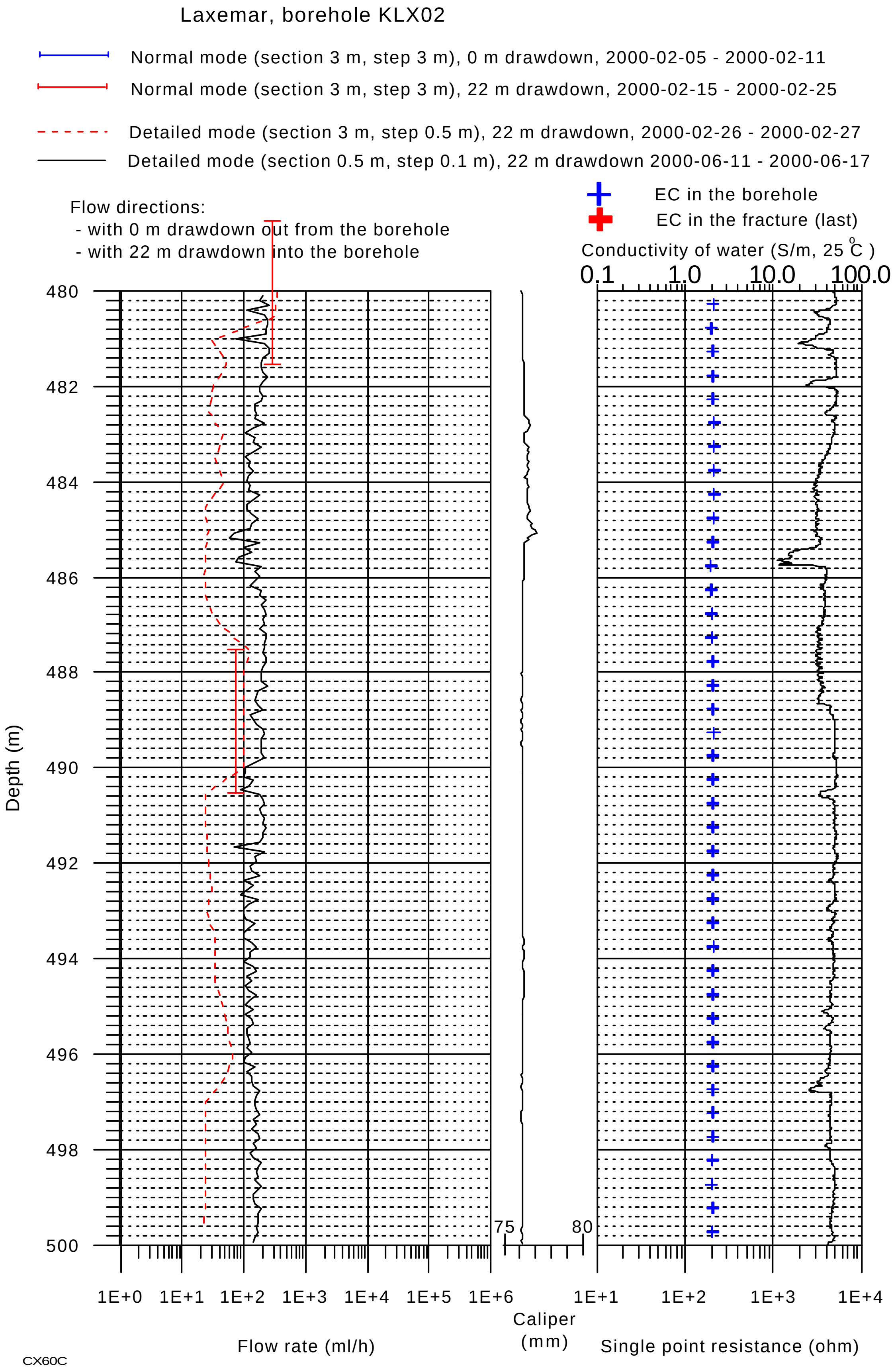
Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 6.2 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 8 m drawdown, 2000-06-07 - 2000-06-08
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
380
382
384
386
388
390
392
394
396
398
400
383.5
389.3
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

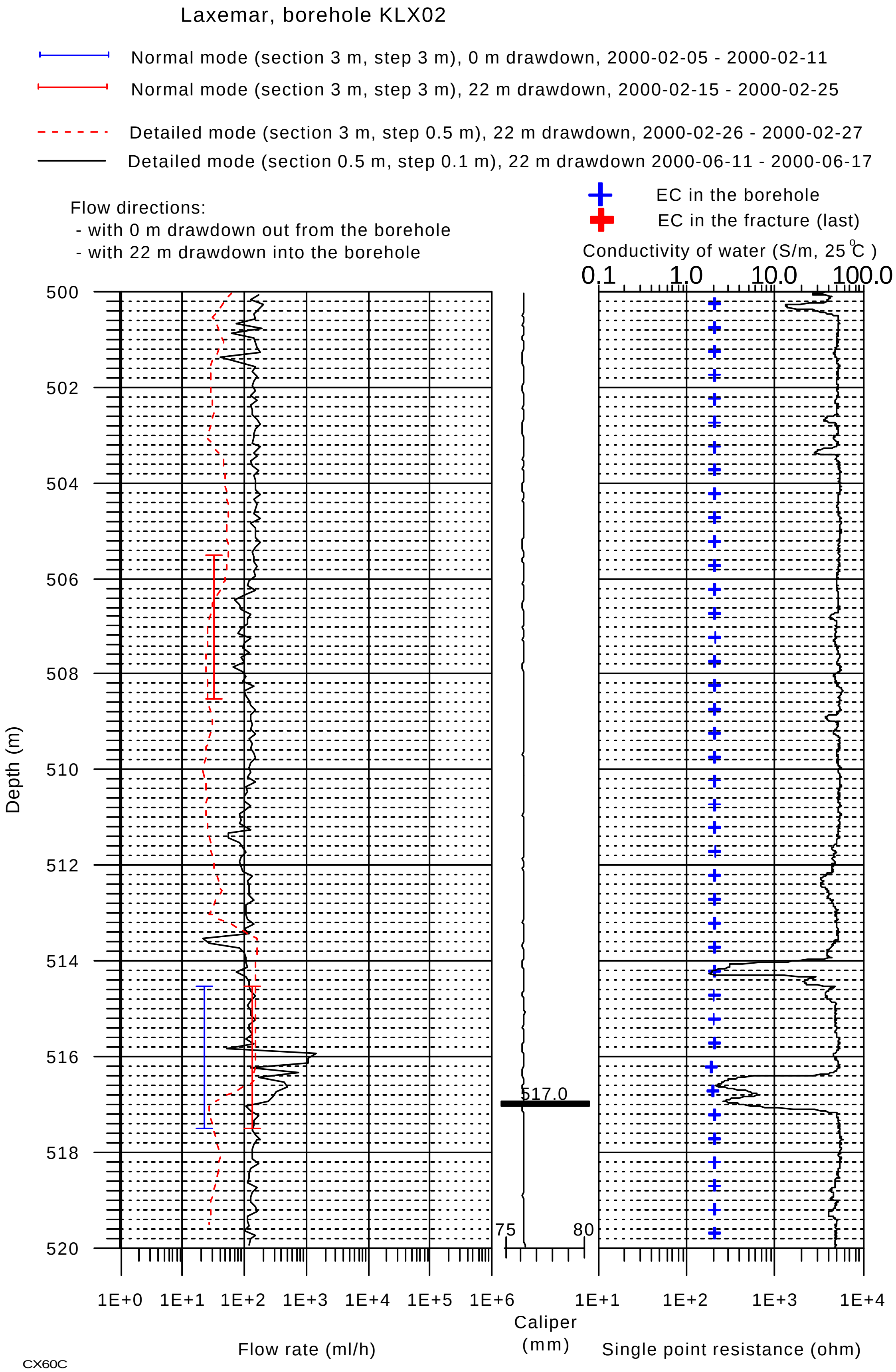

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
400
402
404
406
408
410
412
414
416
418
420
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper (mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
CX60C

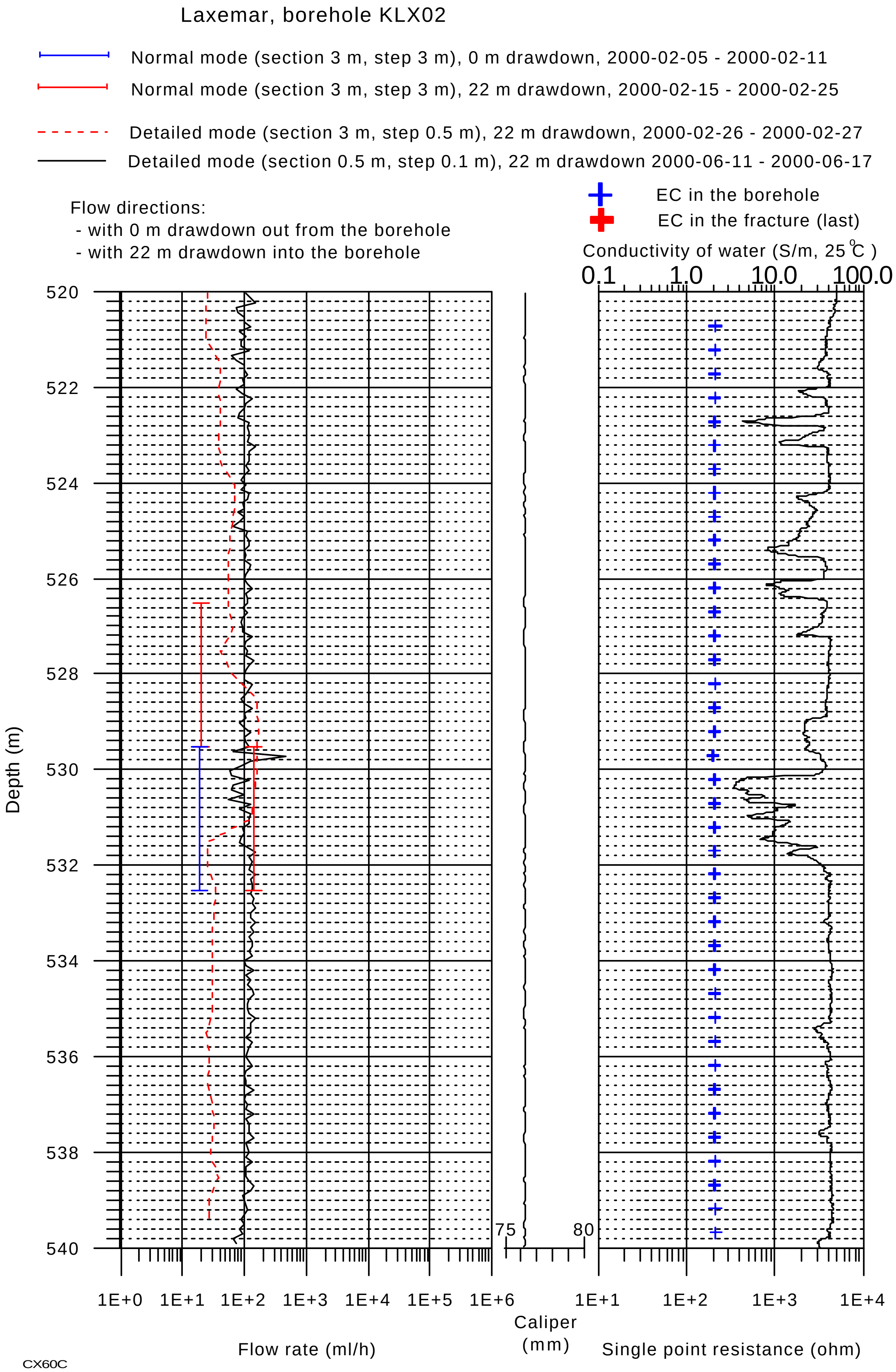

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
420
422
424
426
428
430
432
434
436
438
440
435.6
436.1
436.8
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C


Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
440
442
444
446
448
450
452
454
456
458
460
457.2
458.5
458.7
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C


Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
461.3
466.6
467.3
474.6
75
80
Depth (m)
460
462
464
466
468
470
472
474
476
478
480
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

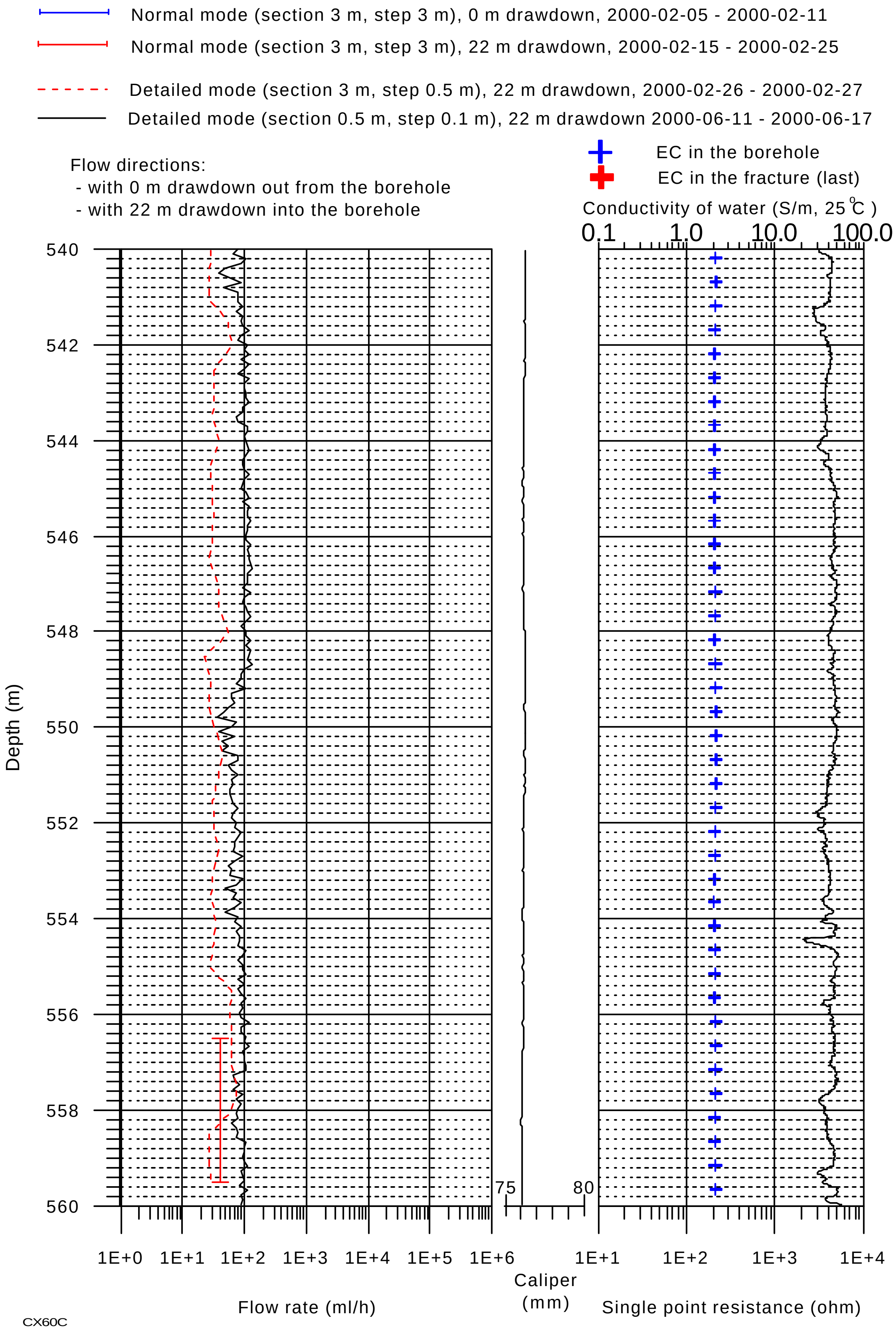

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
EC in the borehole
EC in the fracture (last)
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
480
482
484
486
488
490
492
494
496
498
500
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

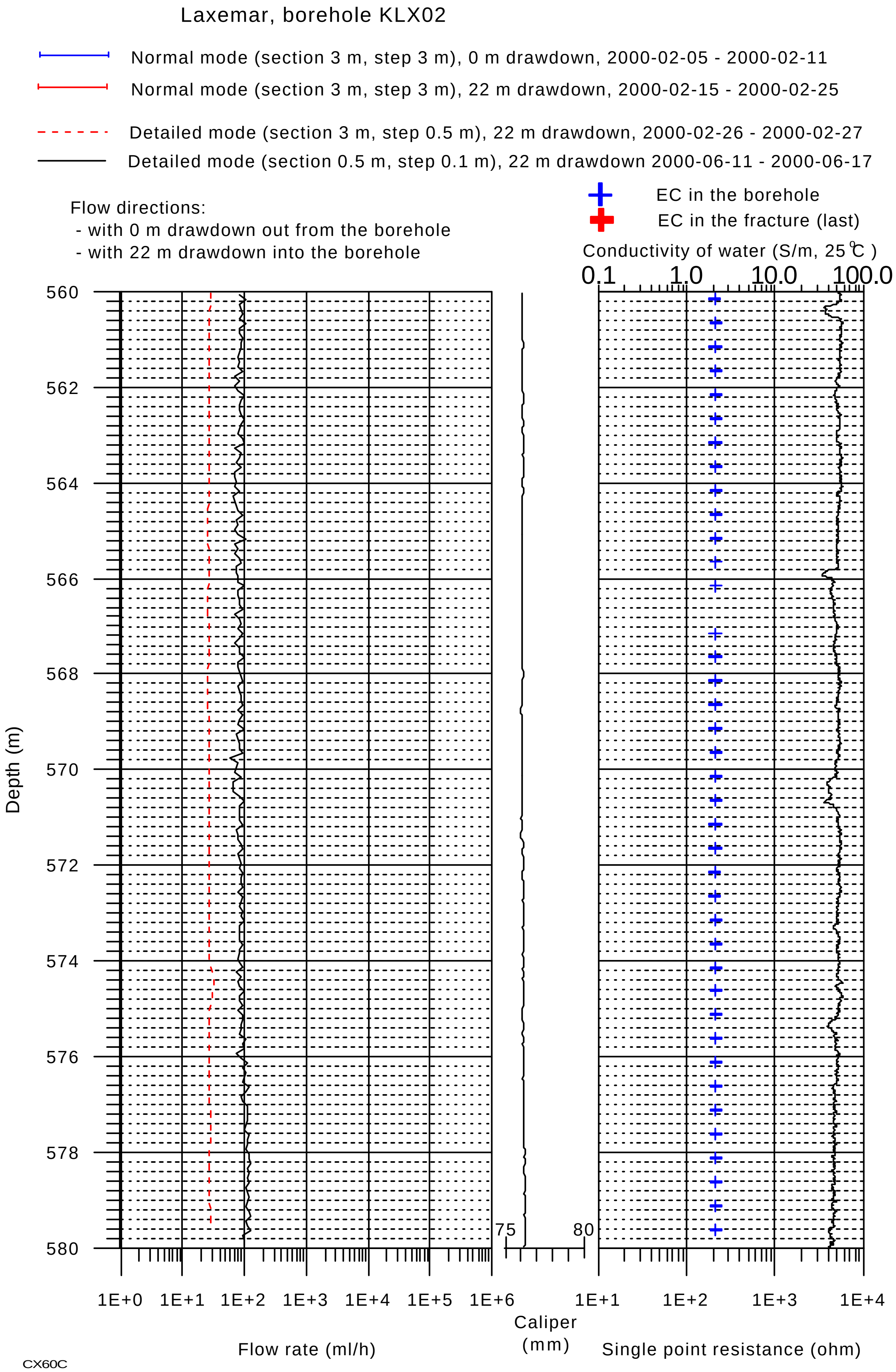

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
500
502
504
506
508
510
512
514
516
518
520
517.0
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
CX60C



Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
520
522
524
526
528
530
532
534
536
538
540
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Flow rate (ml/h)
Caliper (mm)
Single point resistance (ohm)
CX60C

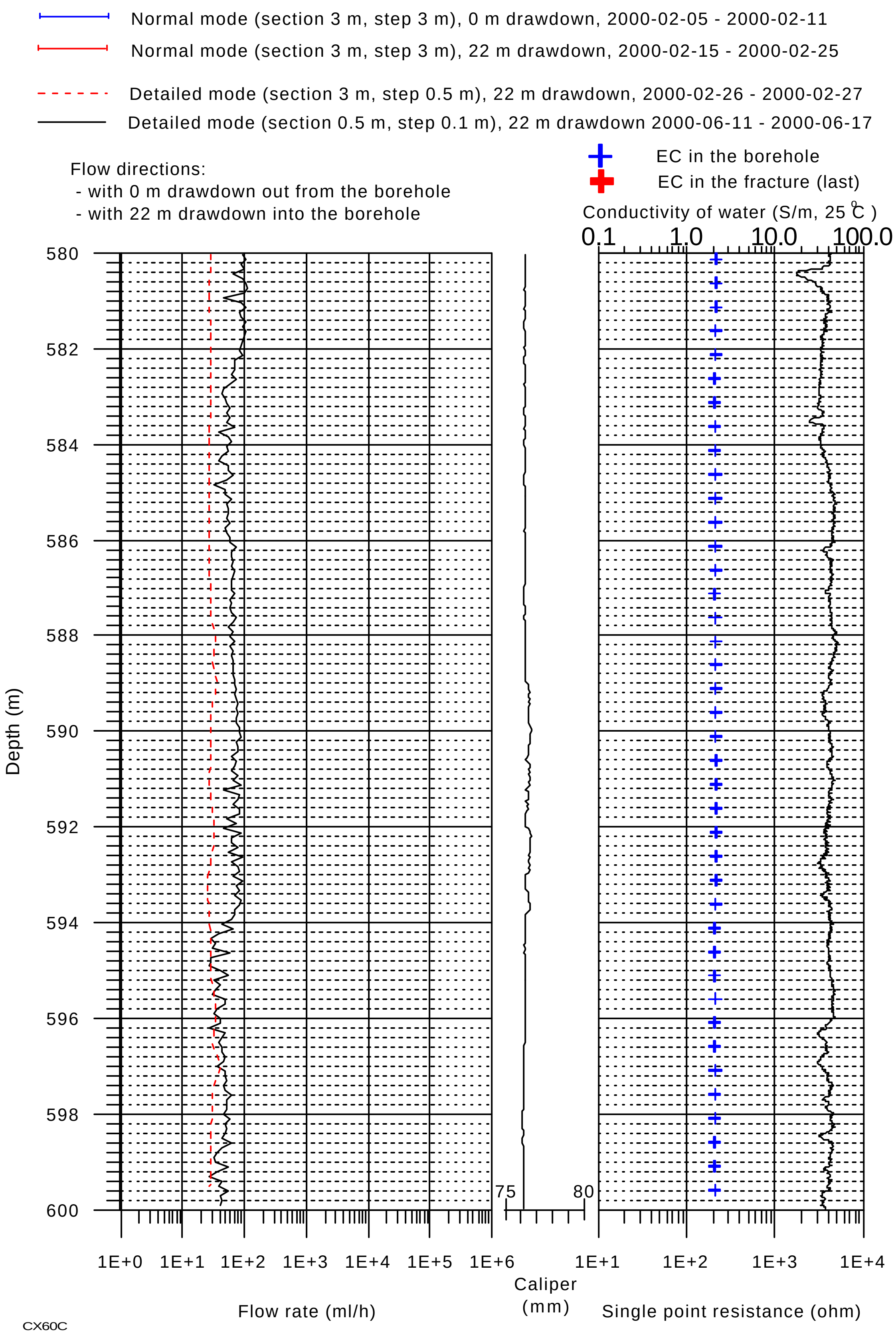
Laxemar, borehole KLX02

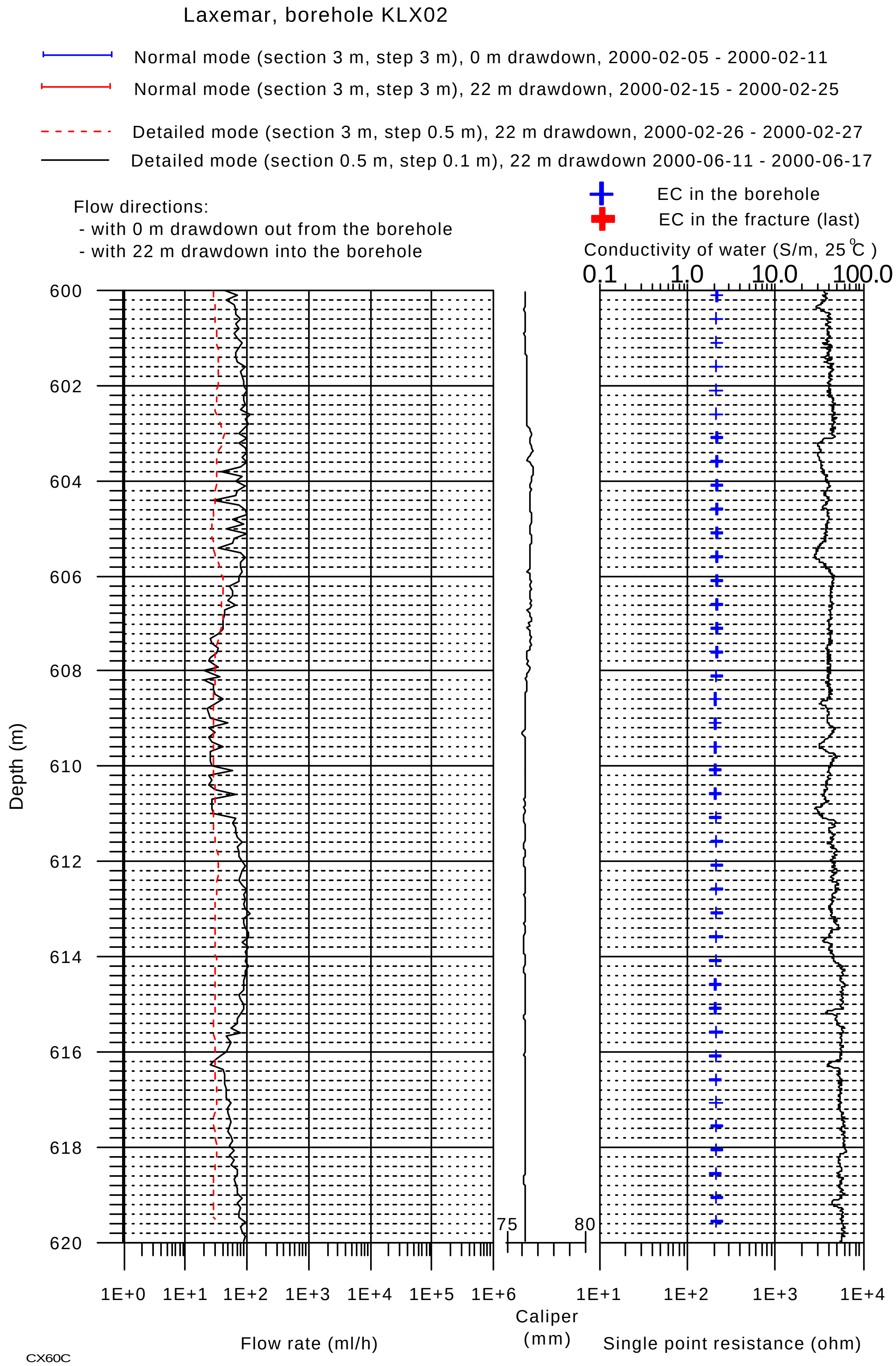




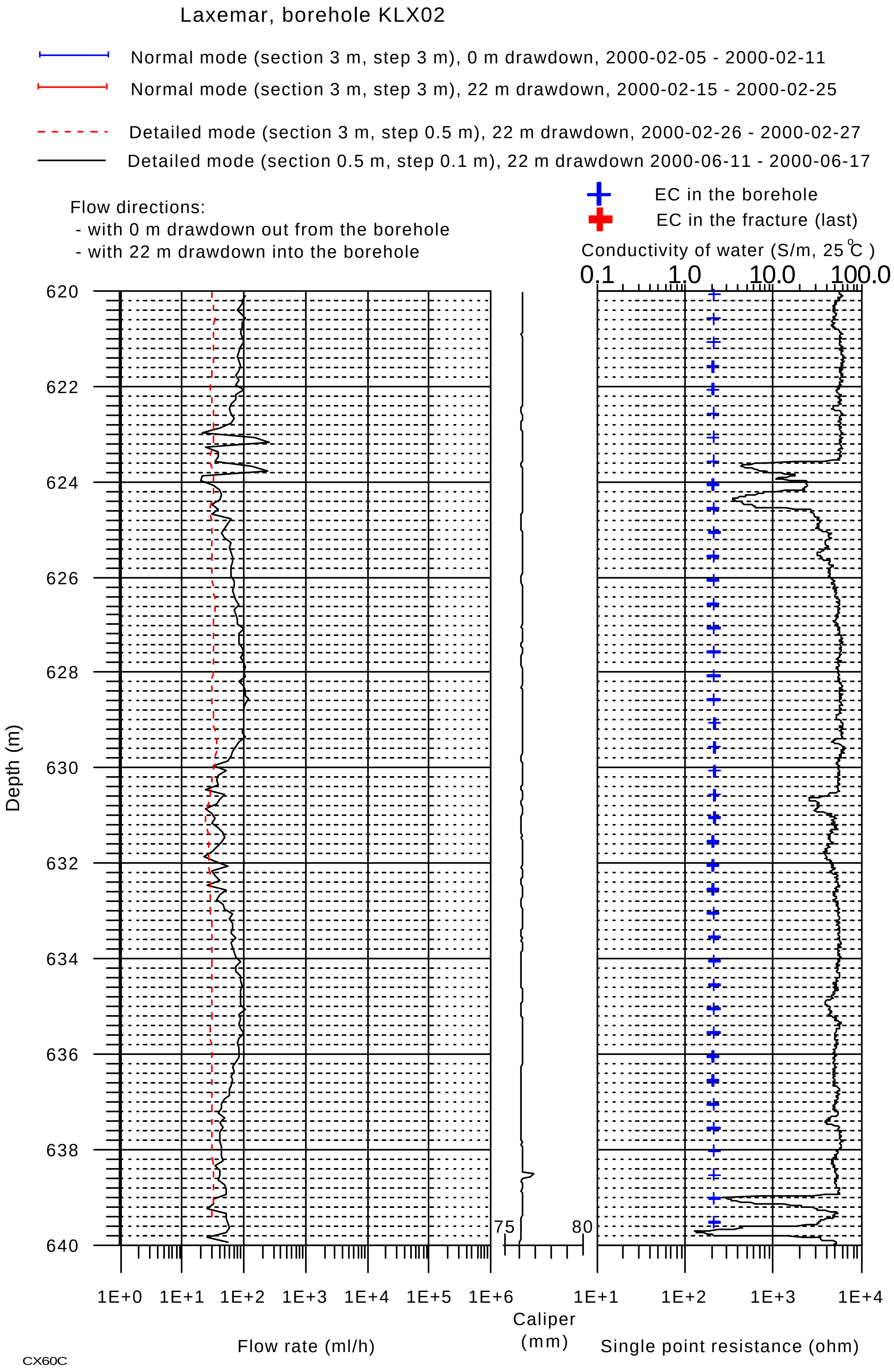
Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 ℃)
0.1
1.0
10.0
100.0
560
562
564
566
568
570
572
574
576
578
580
Depth (m)
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

Laxemar, borehole KLX02

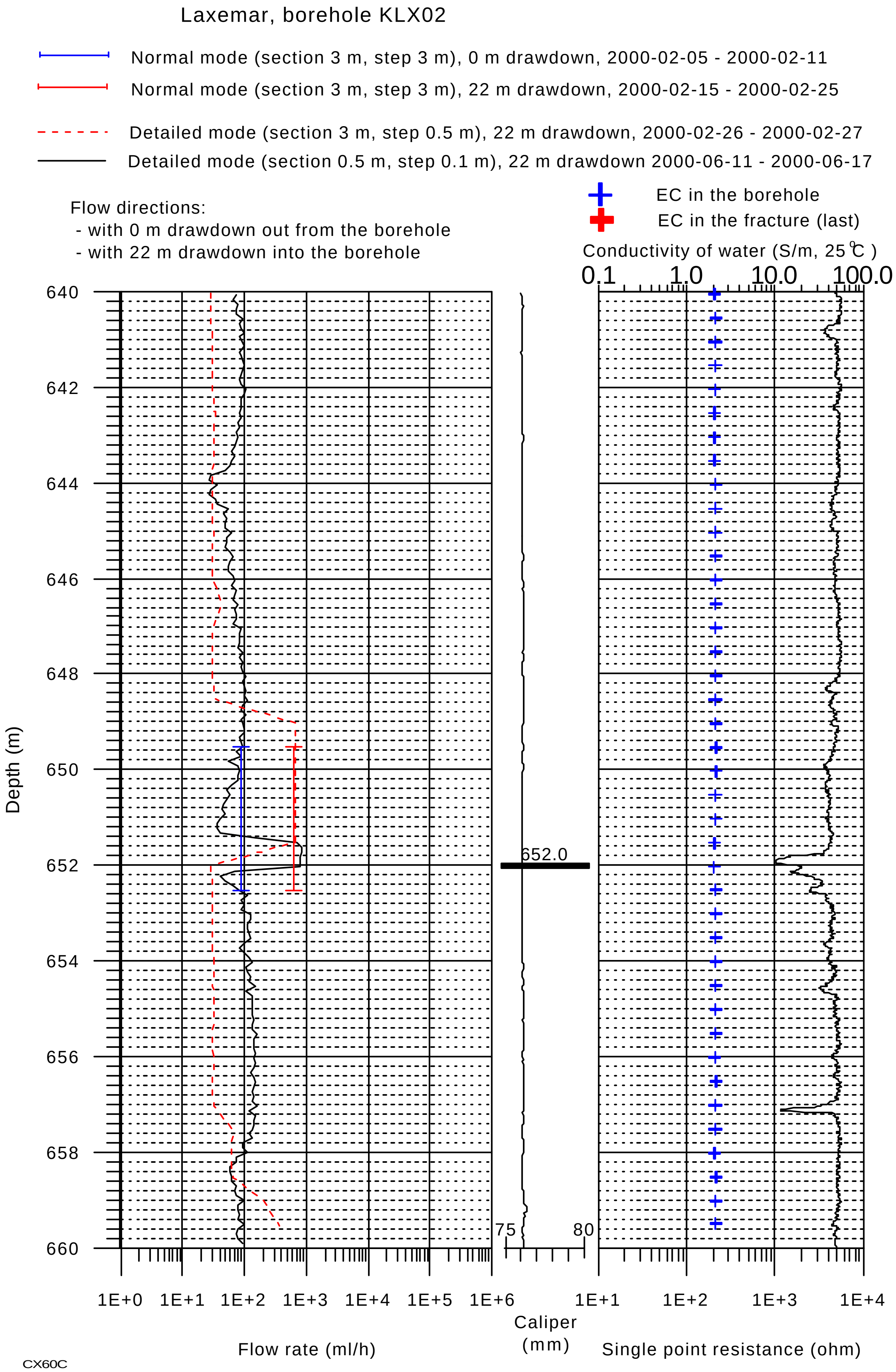




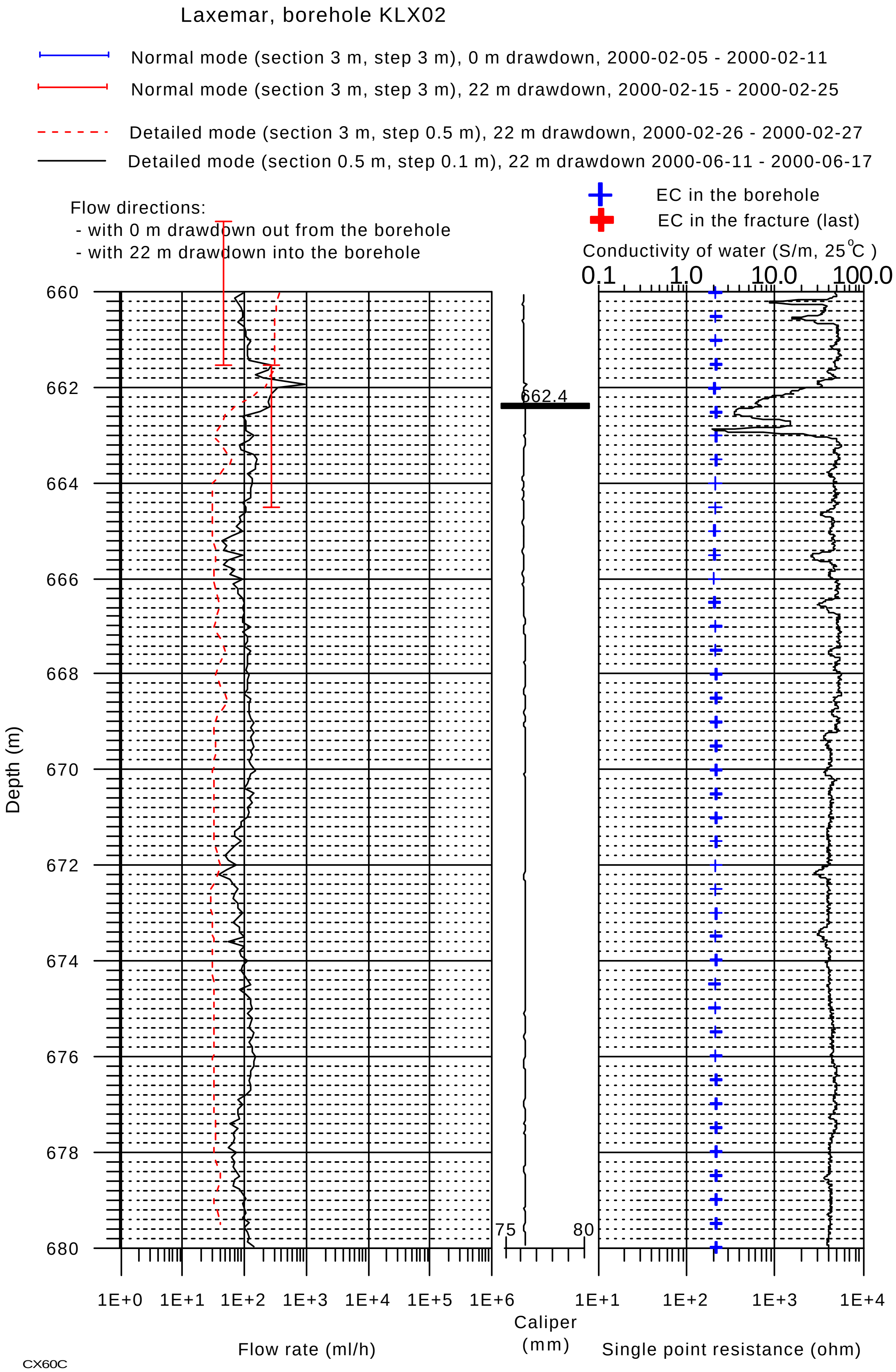
Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
EC in the borehole
EC in the fracture (last)
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
600
602
604
606
608
610
612
614
616
618
620
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

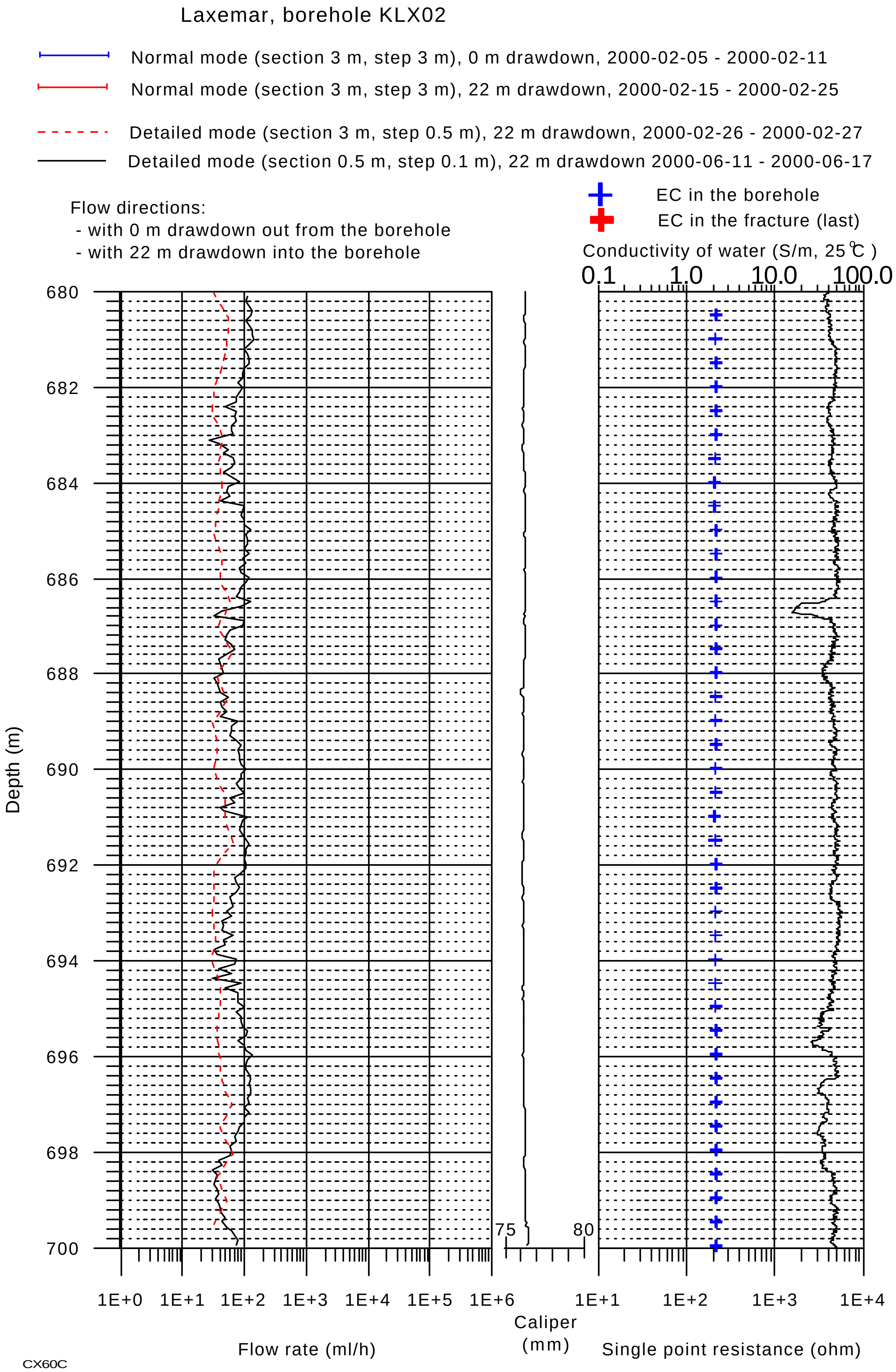


Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
620
622
624
626
628
630
632
634
636
638
640
Depth (m)
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

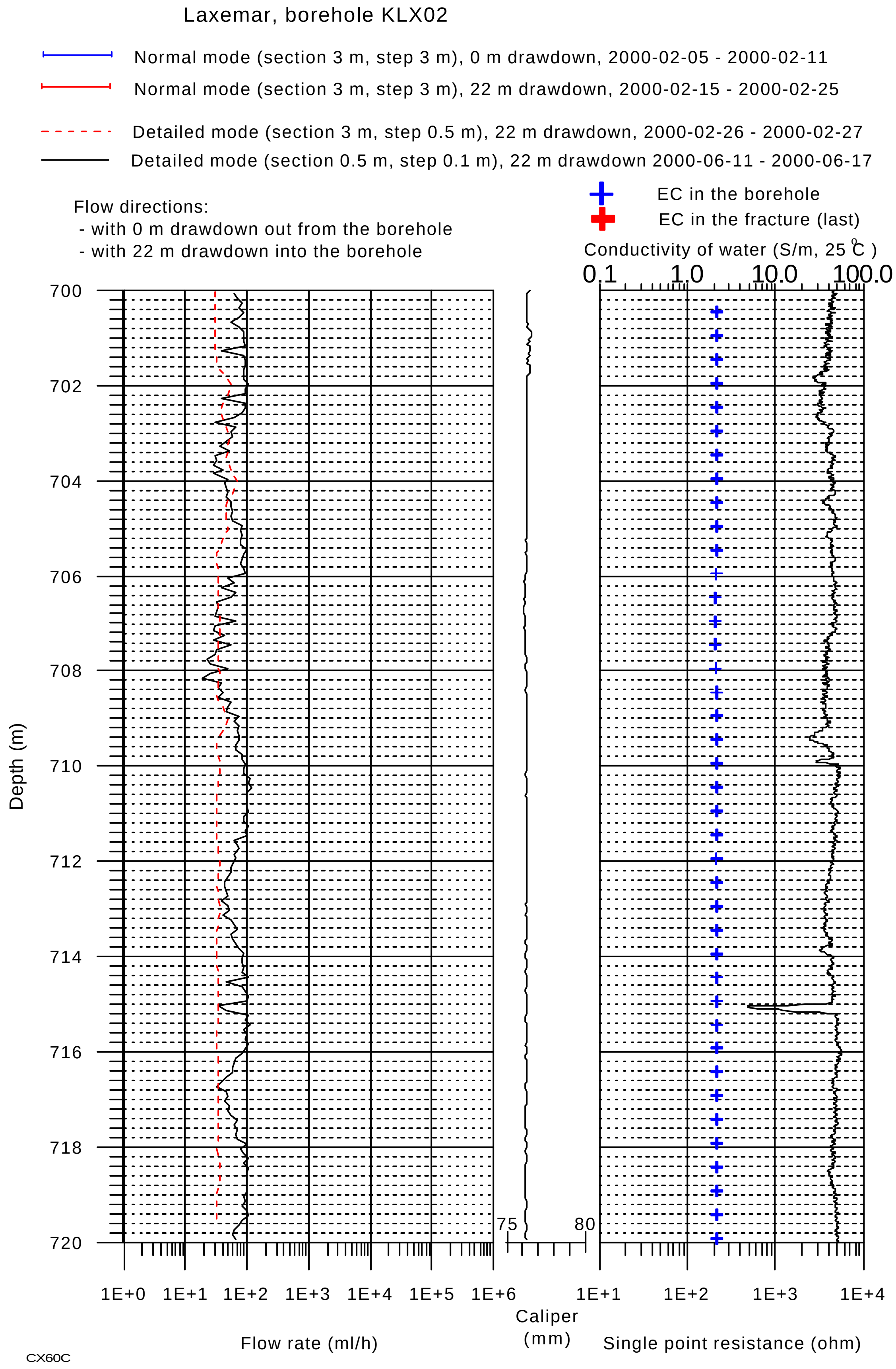


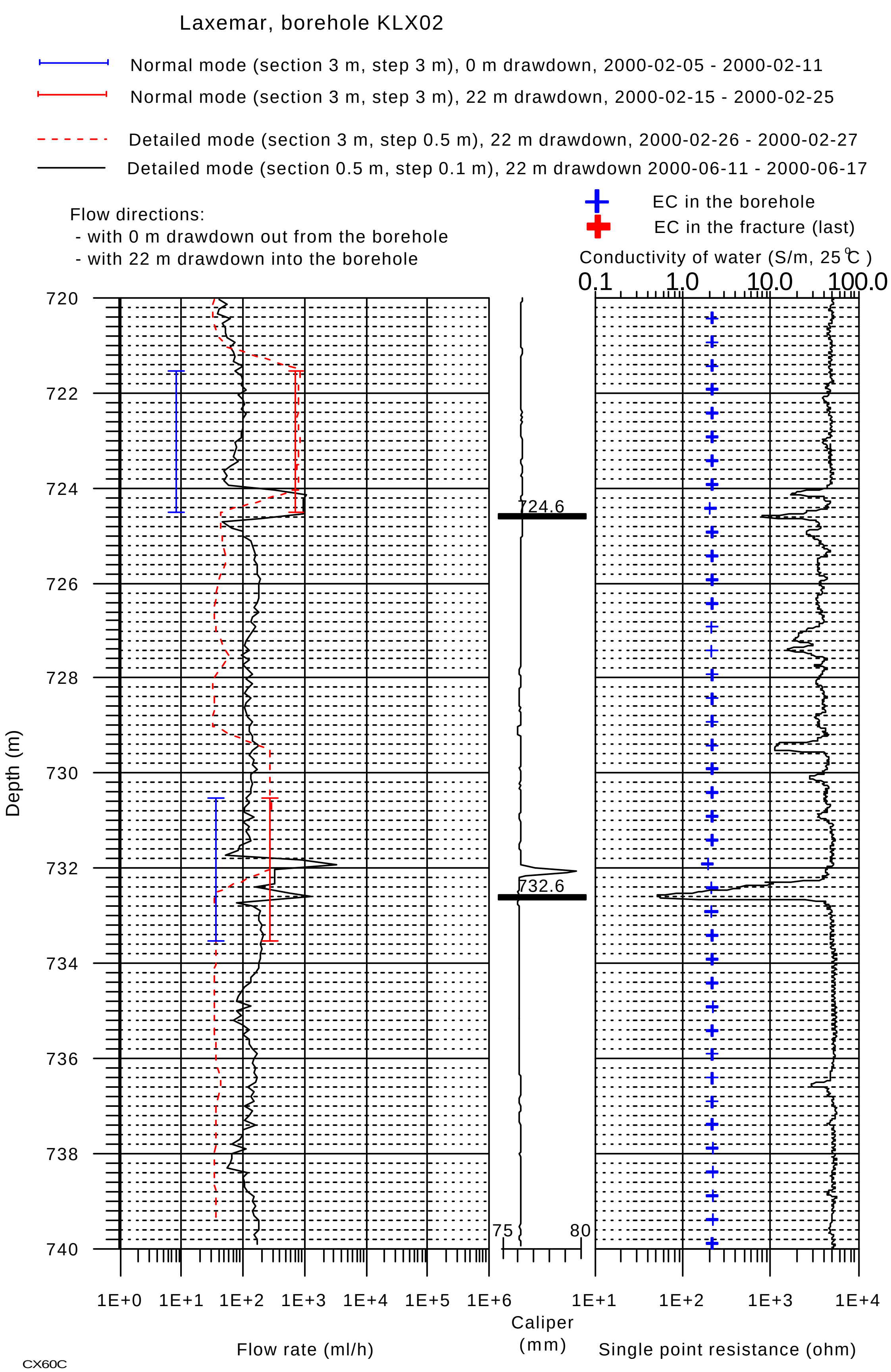
Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
640
642
644
646
648
650
652
654
656
658
660
652.0
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C


Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25°C)
0.1
1.0
10.0
100.0
Depth (m)
660
662
664
666
668
670
672
674
676
678
680
662.4
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

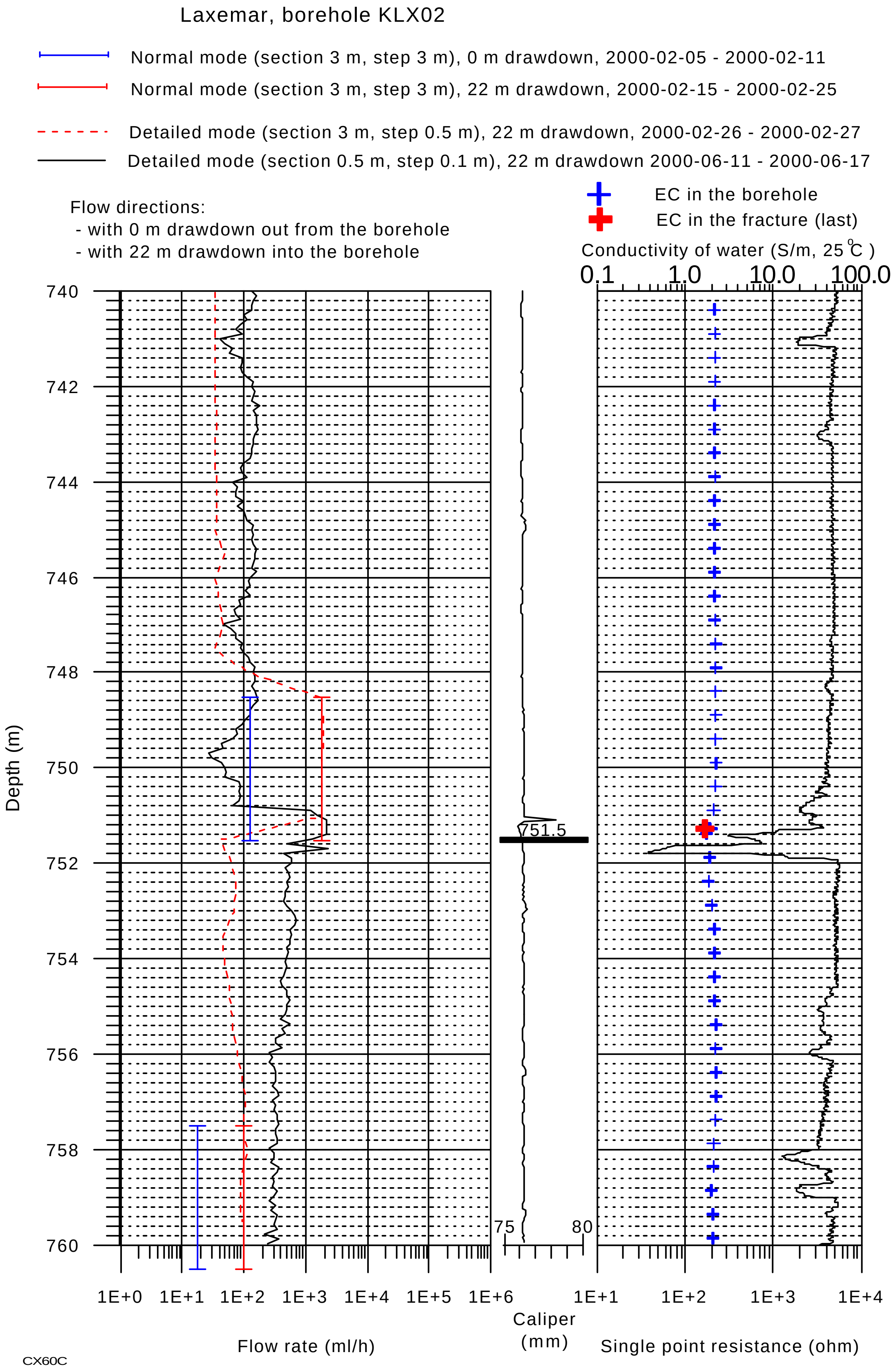


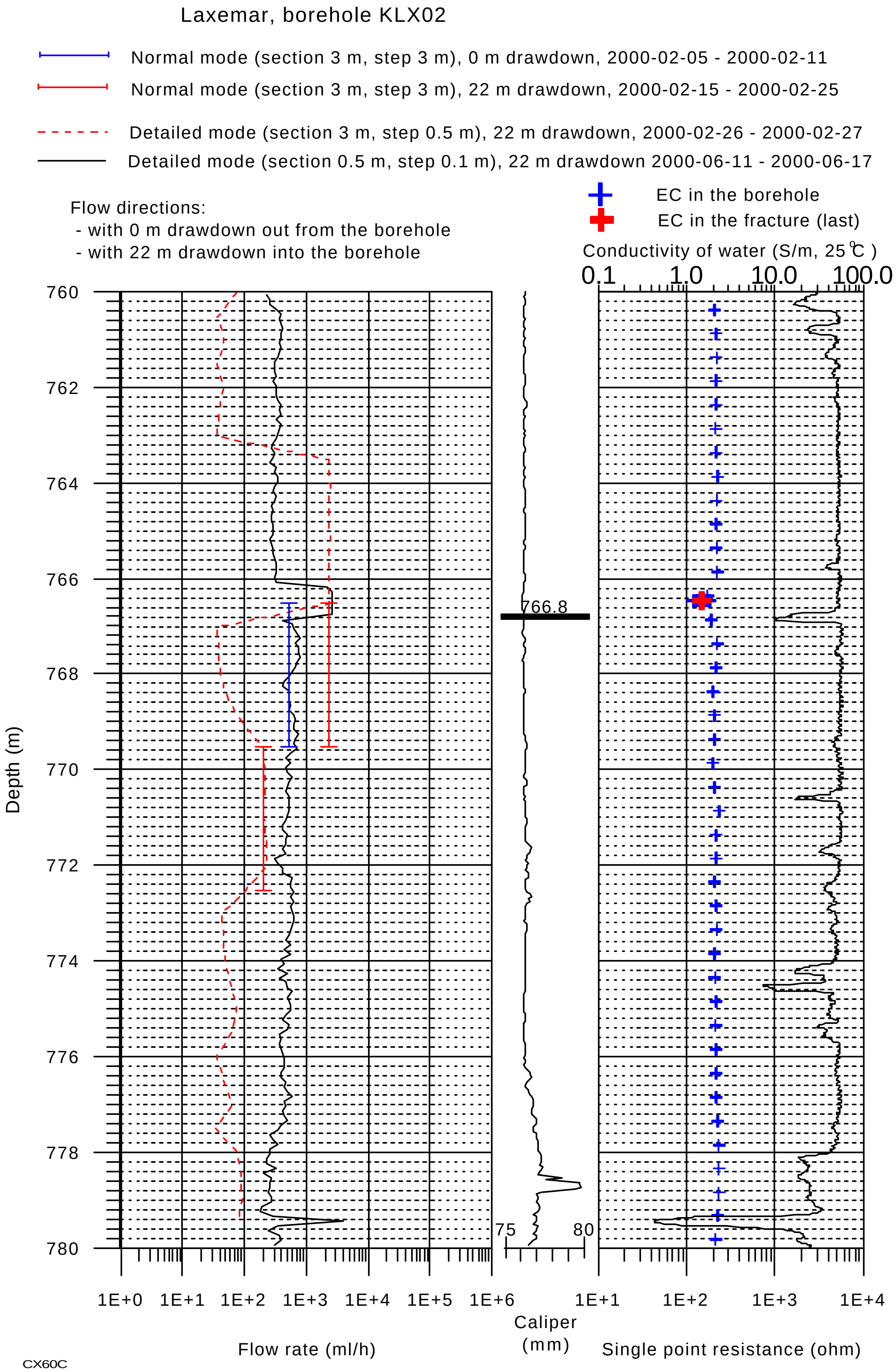
Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 ℃)
0.1
1.0
10.0
100.0
680
682
684
686
688
690
692
694
696
698
700
Depth (m)
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
Caliper (mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
CX60C

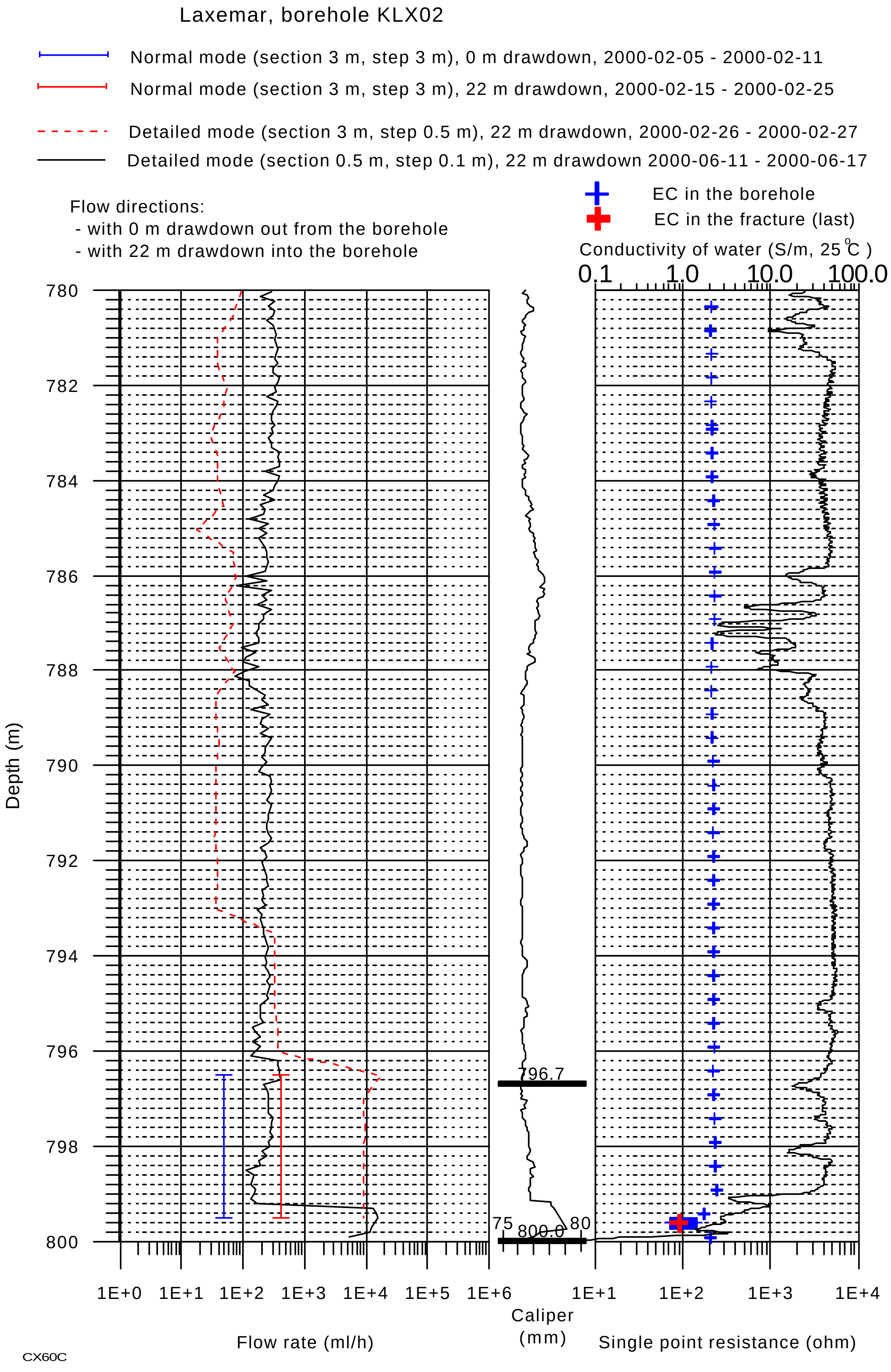

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
700
702
704
706
708
710
712
714
716
718
720
Depth (m)
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C



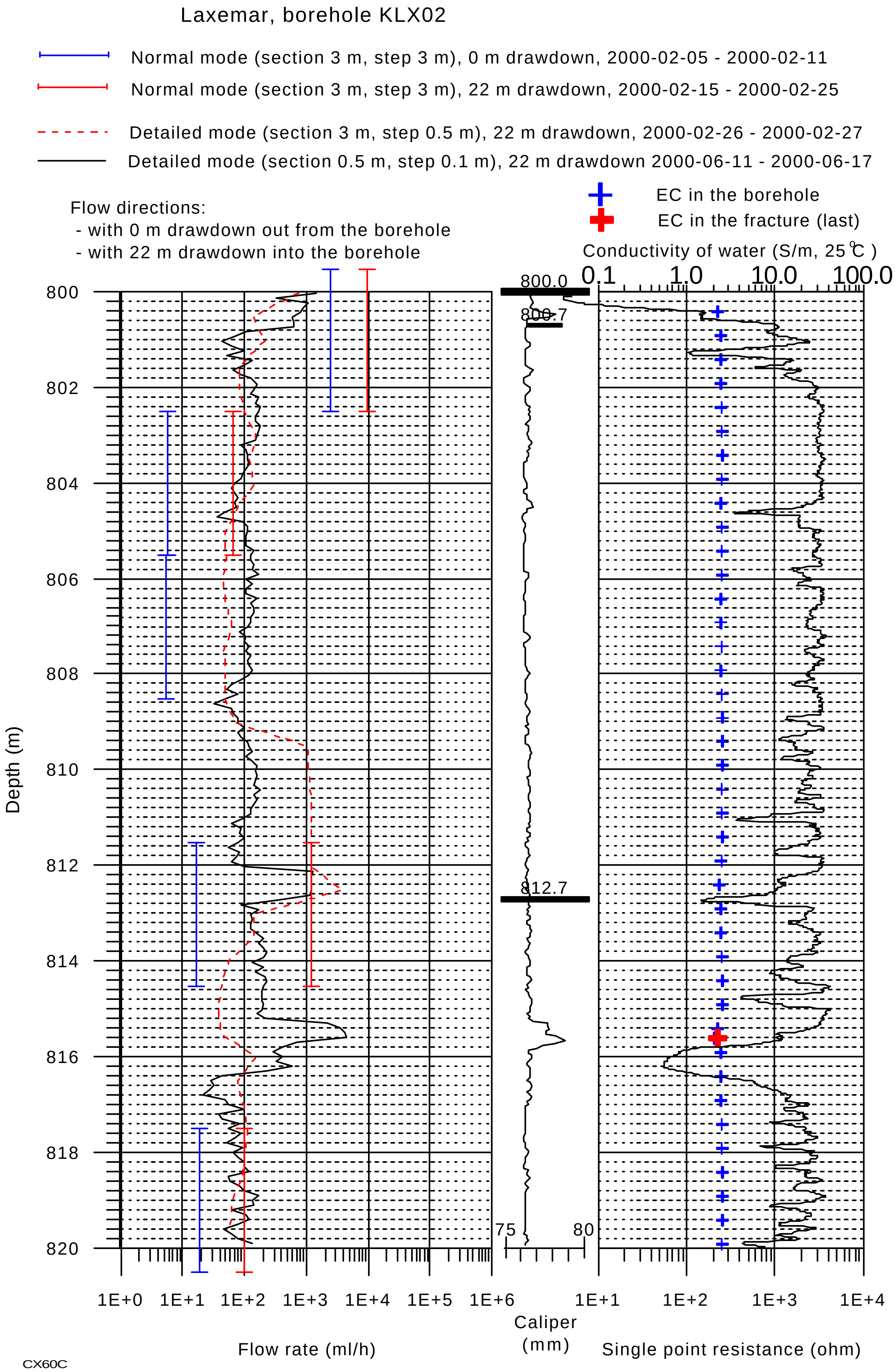
Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 ℃)
0.1
1.0
10.0
100.0
Depth (m)
720
722
724
726
728
730
732
734
736
738
740
724.6
732.6
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

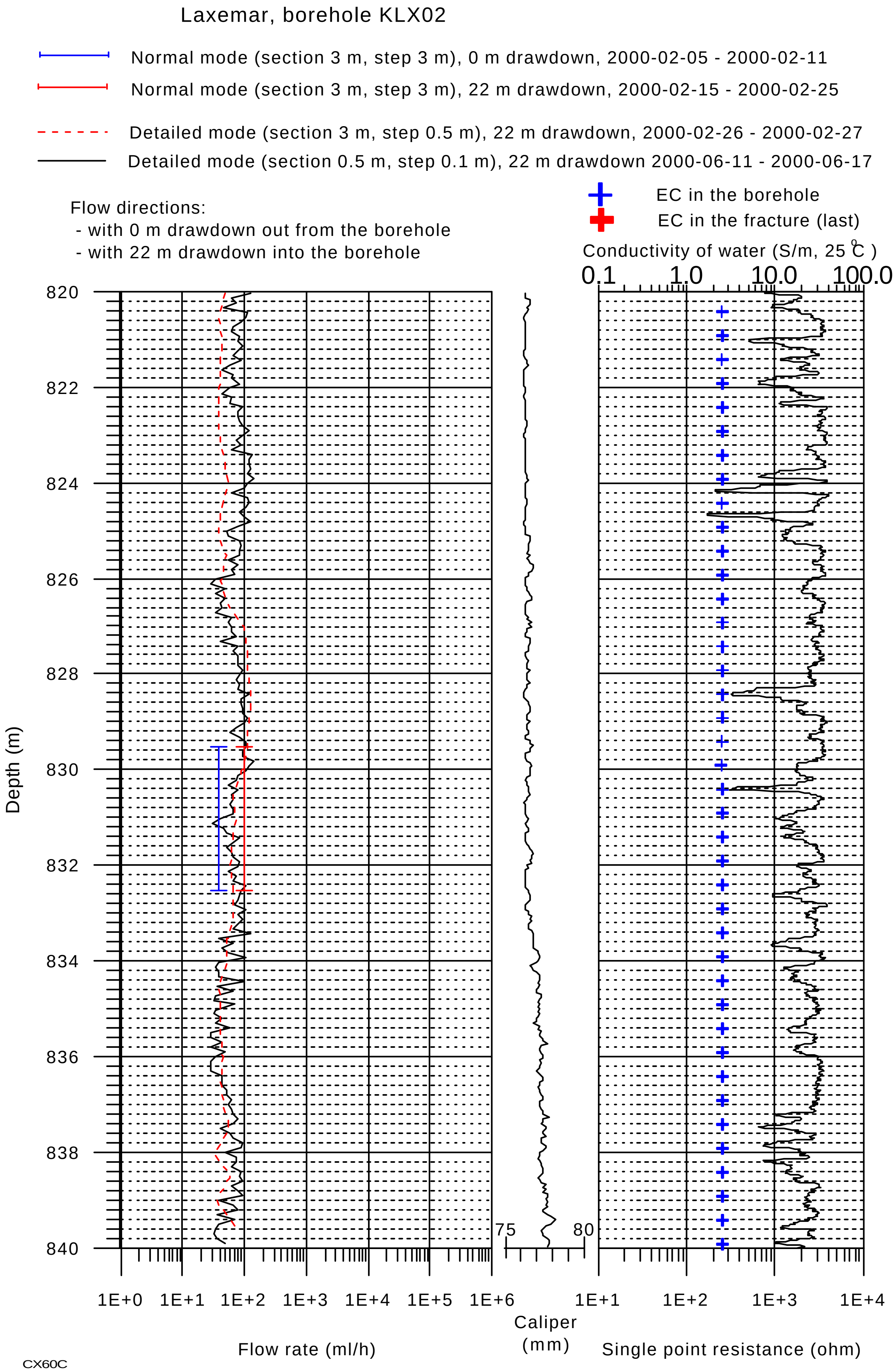

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
740
742
744
746
748
750
752
754
756
758
760
Depth (m)
751.5
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

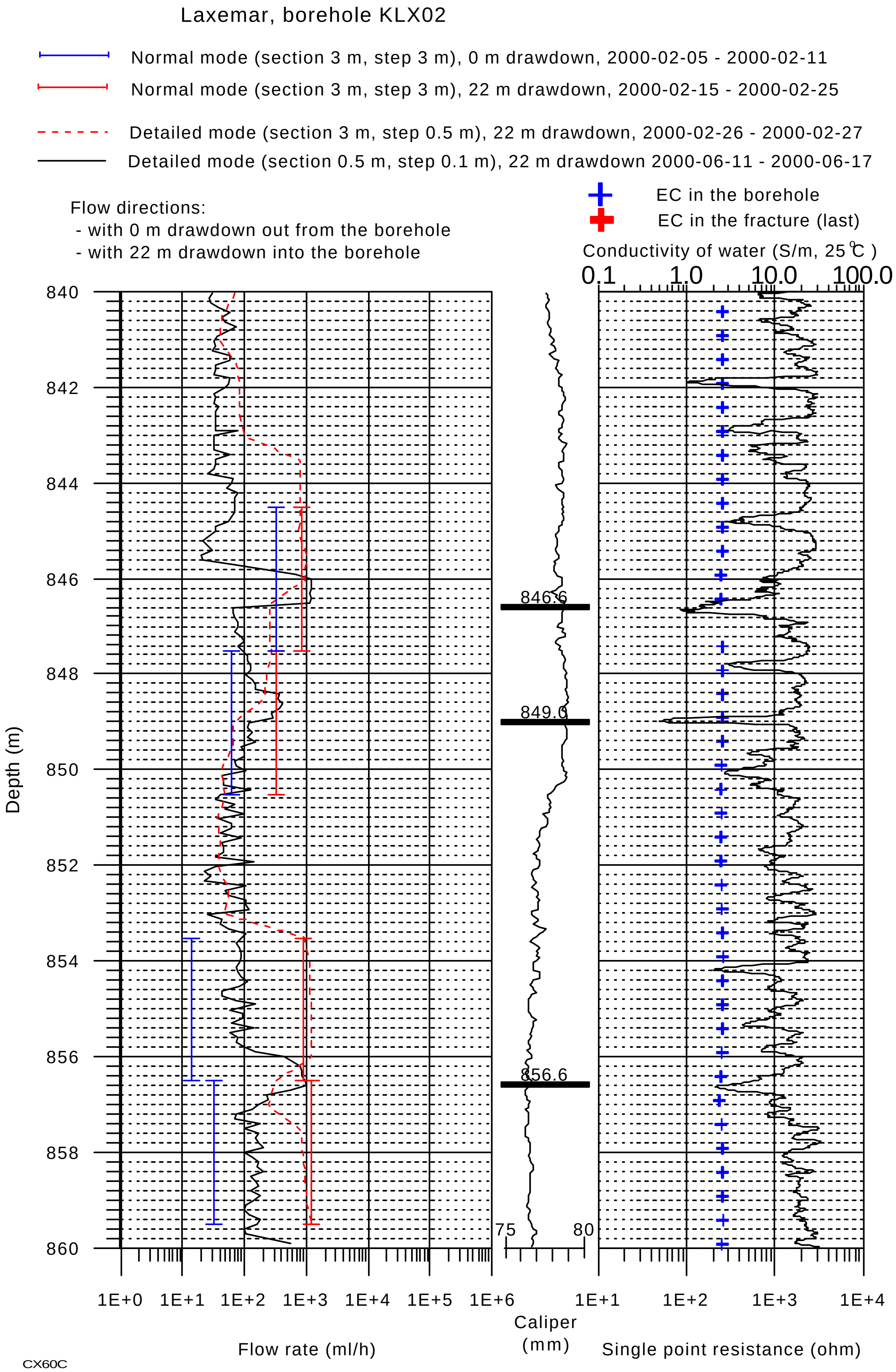

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 ℃)
0.1
1.0
10.0
100.0
760
762
764
766
768
770
772
774
776
778
780
Depth (m)
766.8
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C



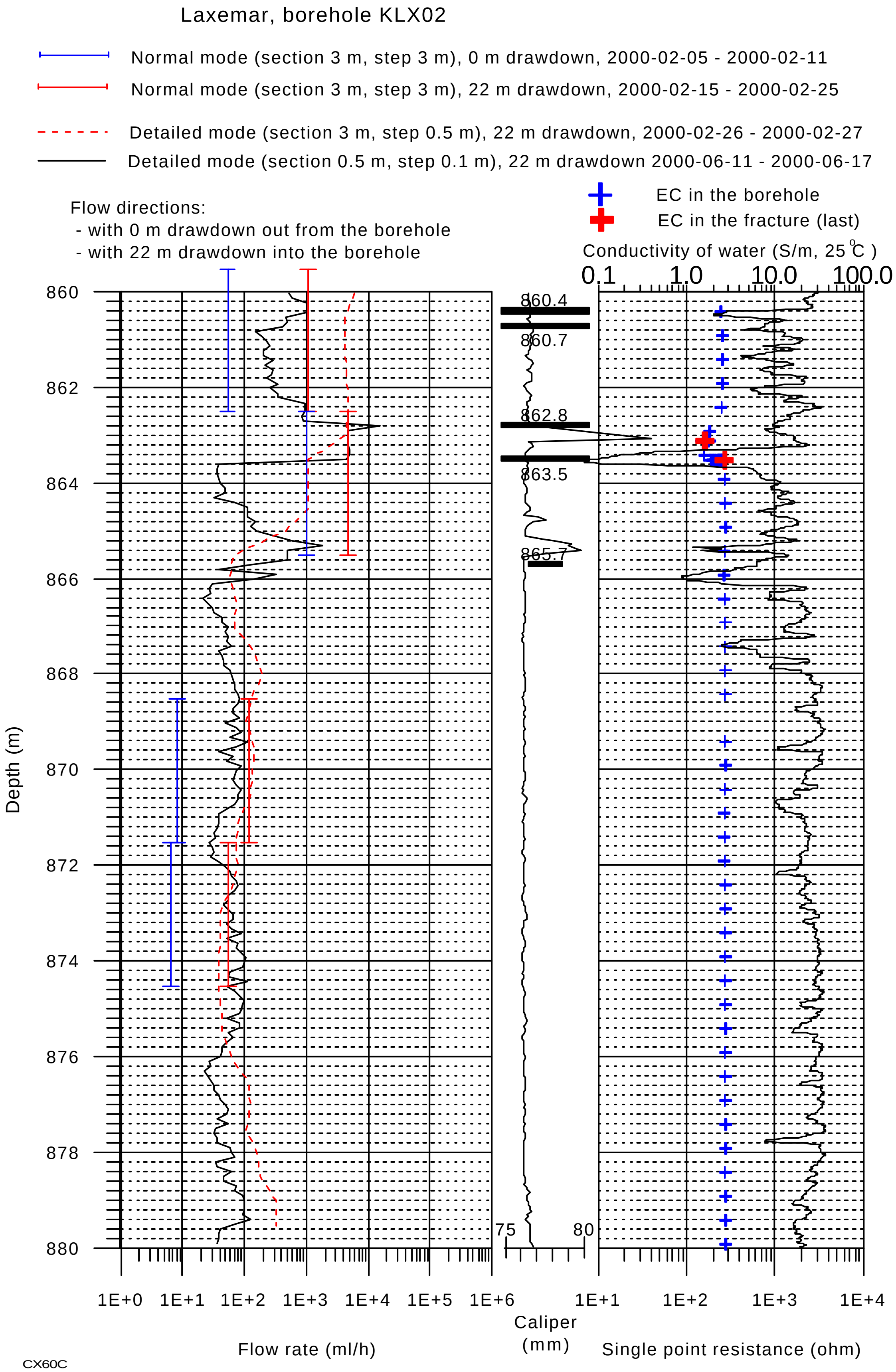
Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
780
782
784
786
788
790
792
794
796
798
800
Depth (m)
796.7
800.0
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C


Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 ℃)
0.1
1.0
10.0
100.0
800.0
800.7
812.7
800
802
804
806
808
810
812
814
816
818
820
Depth (m)
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

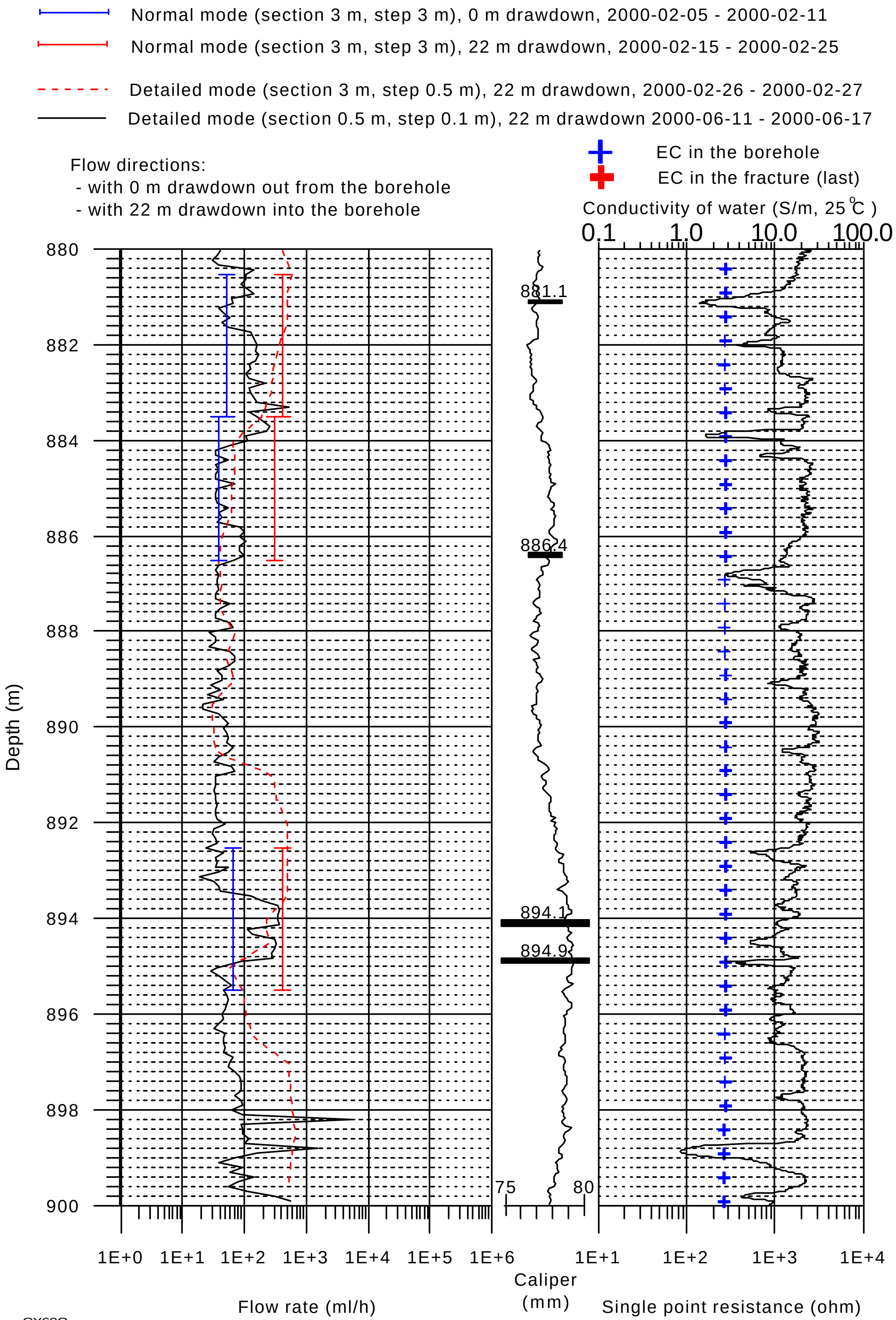

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 ℃)
0.1
1.0
10.0
100.0
Depth (m)
820
822
824
826
828
830
832
834
836
838
840
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
CX60C



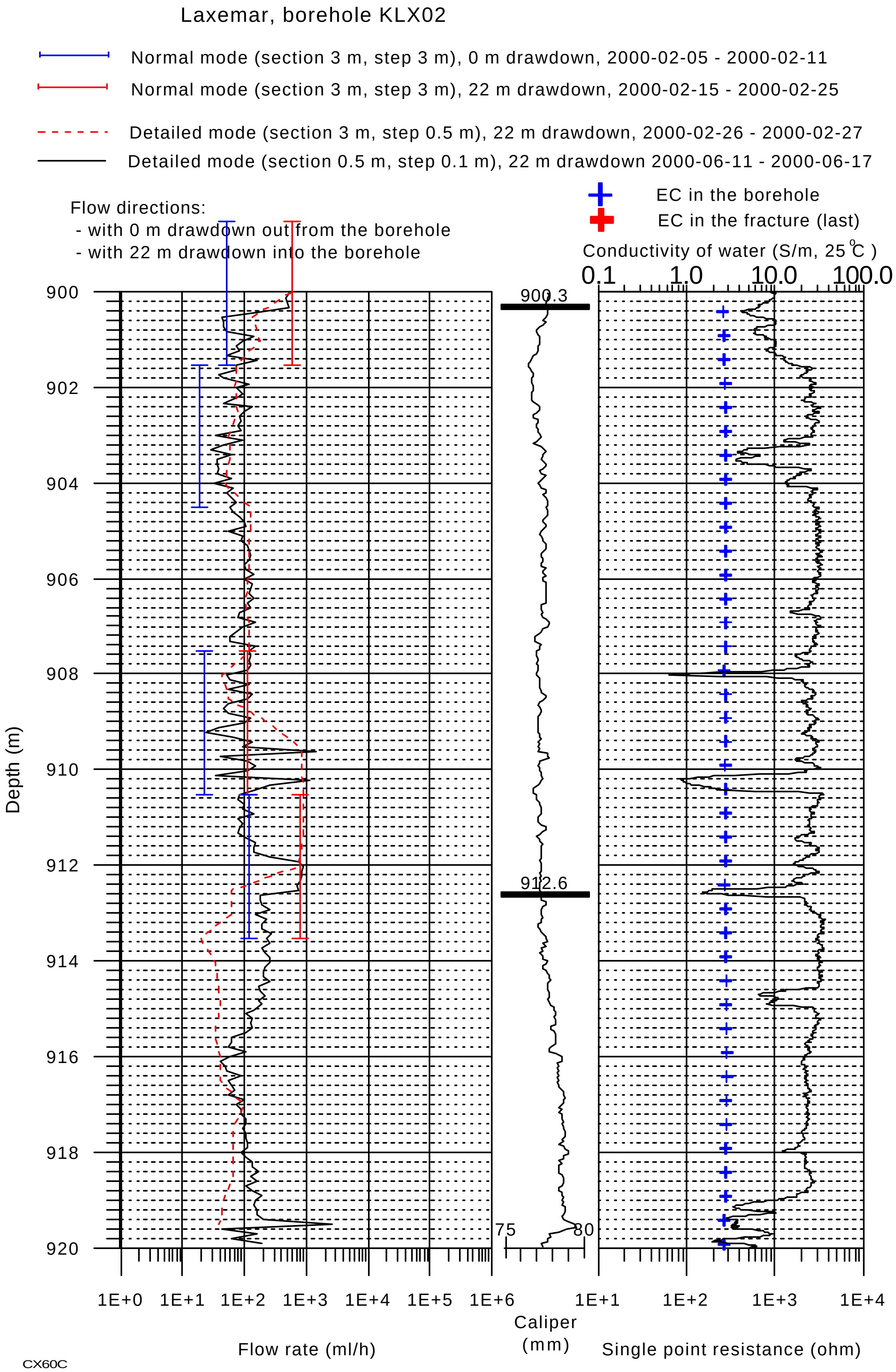
Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 ℃)
0.1
1.0
10.0
100.0
Depth (m)
840
842
844
846
848
850
852
854
856
858
860
846.6
849.0
856.6
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Flow rate (ml/h)
Caliper
(mm)
Single point resistance (ohm)
CX60C


Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
EC in the borehole
EC in the fracture (last)
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
860
862
864
866
868
870
872
874
876
878
880
860.4
860.7
862.8
863.5
865.7
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

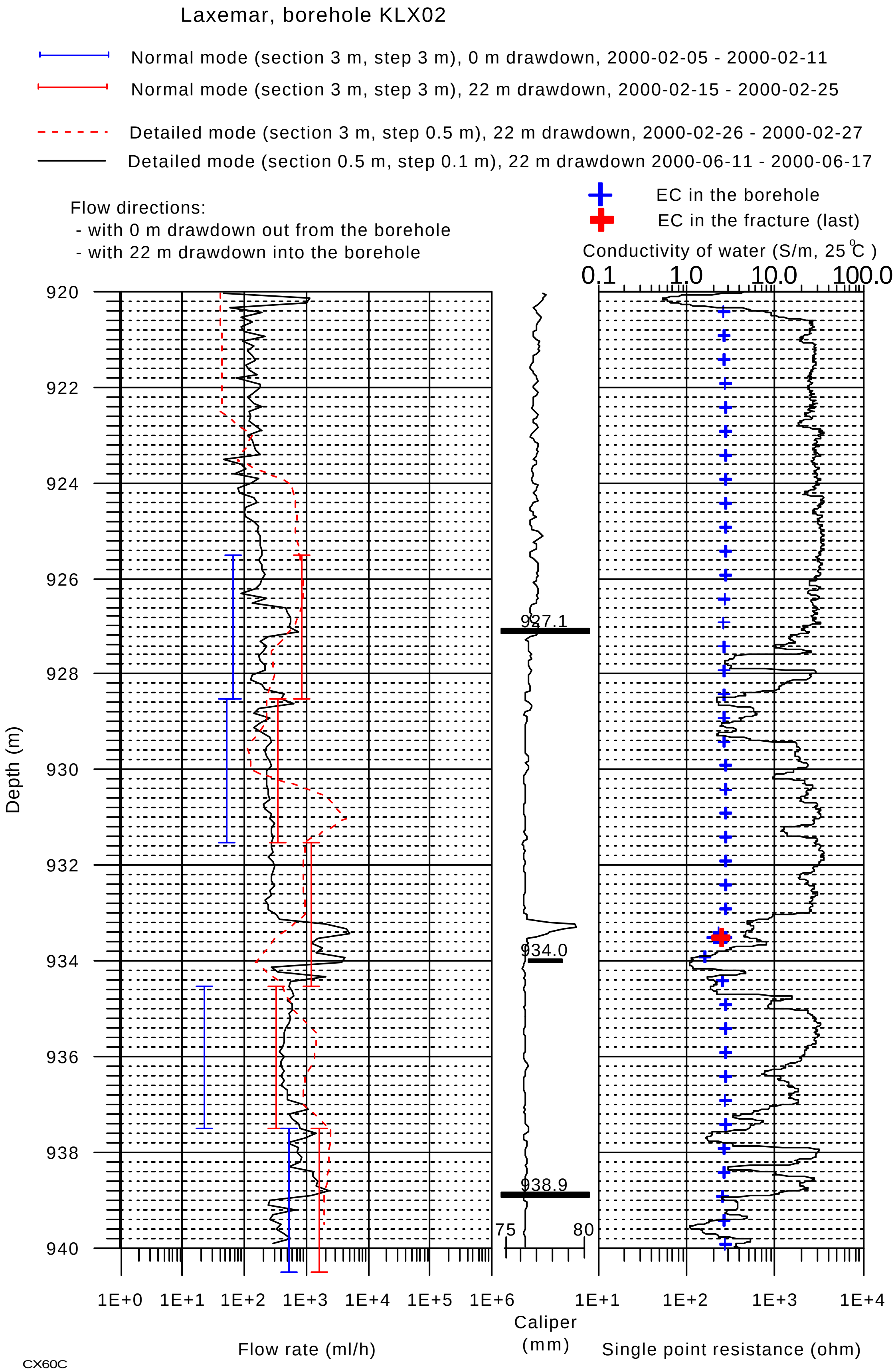
Laxemar, borehole KLX02



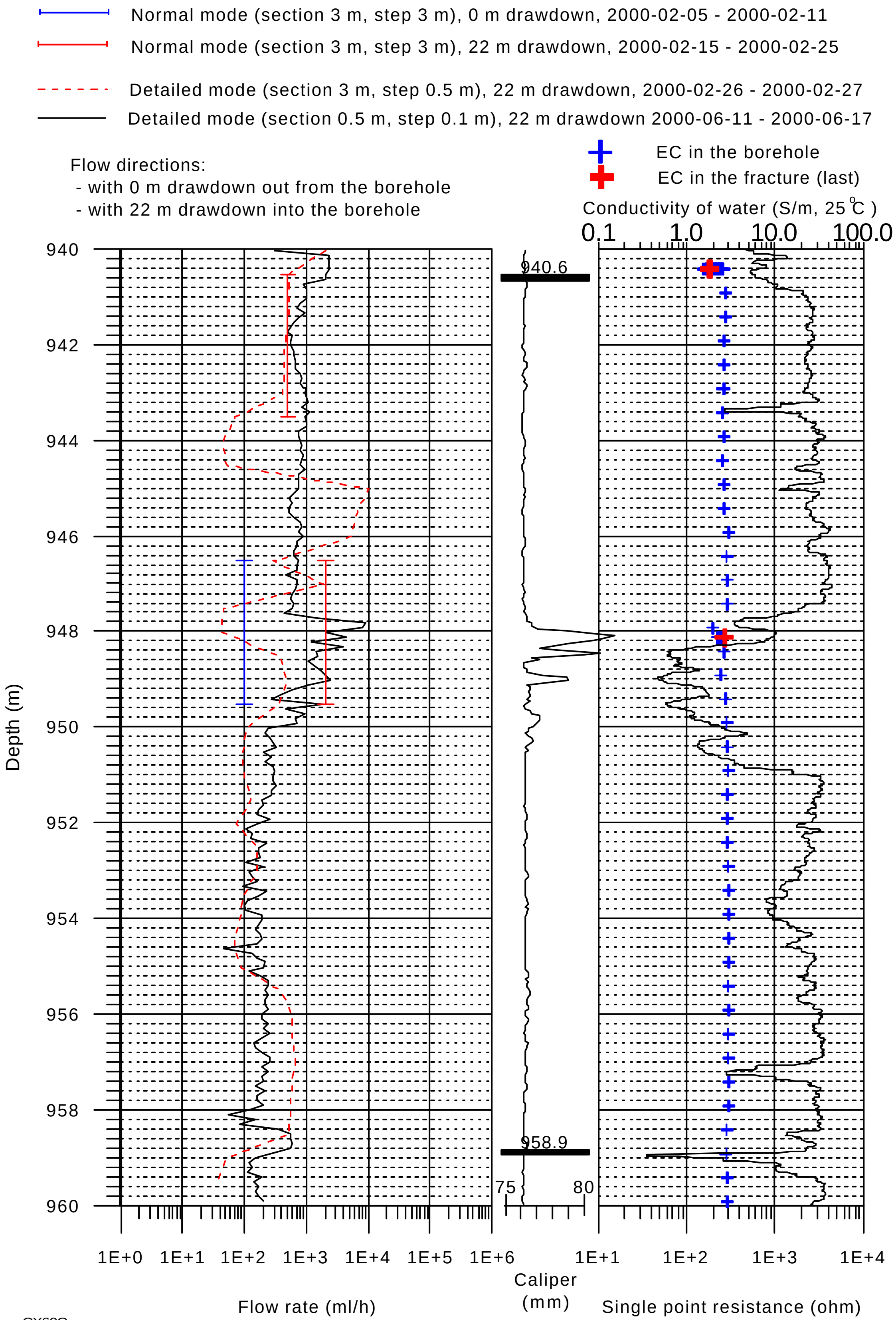
CX60C



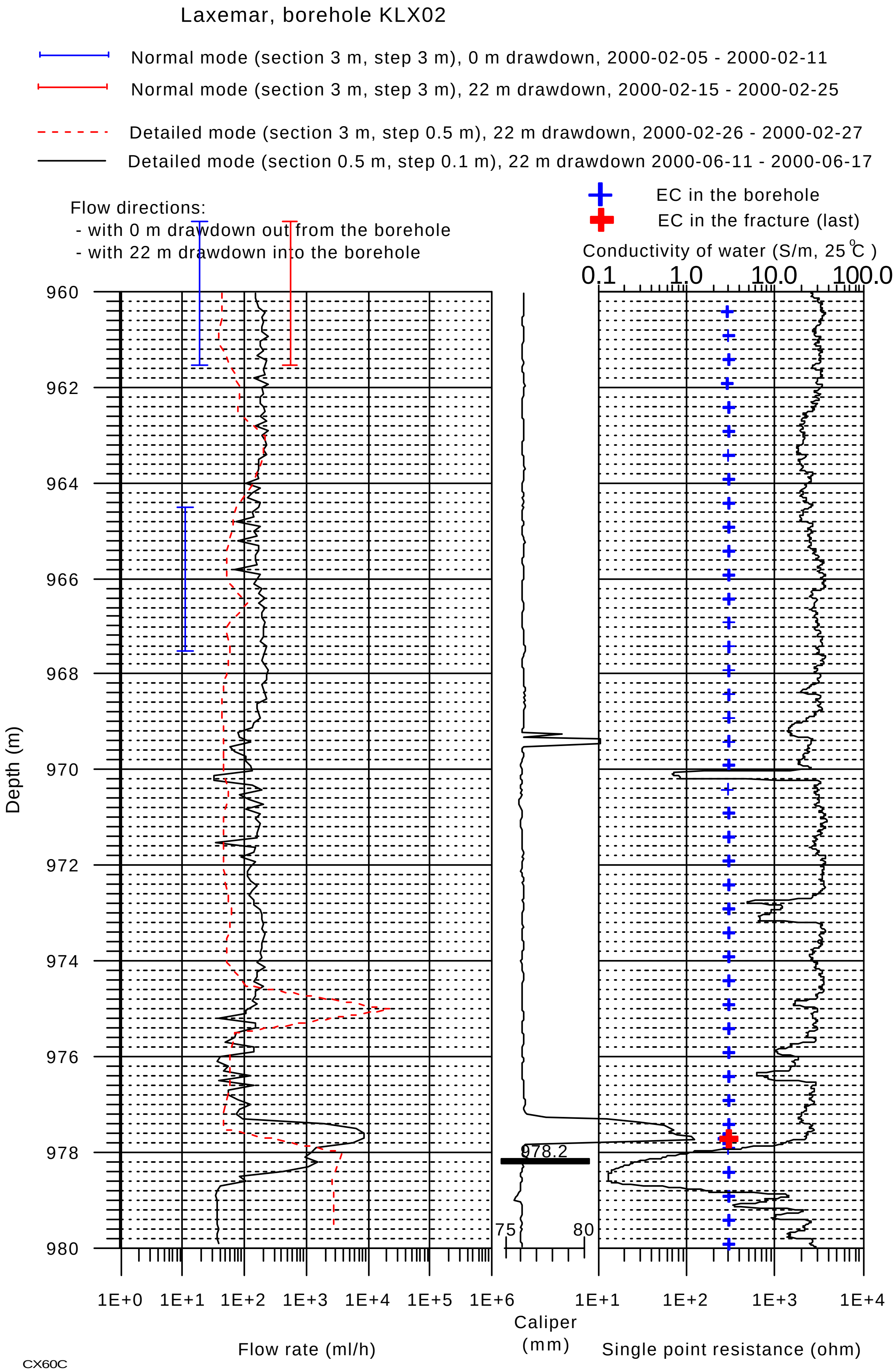
Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 ℃)
0.1
1.0
10.0
100.0
900.3
912.6
Depth (m)
900
902
904
906
908
910
912
914
916
918
920
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

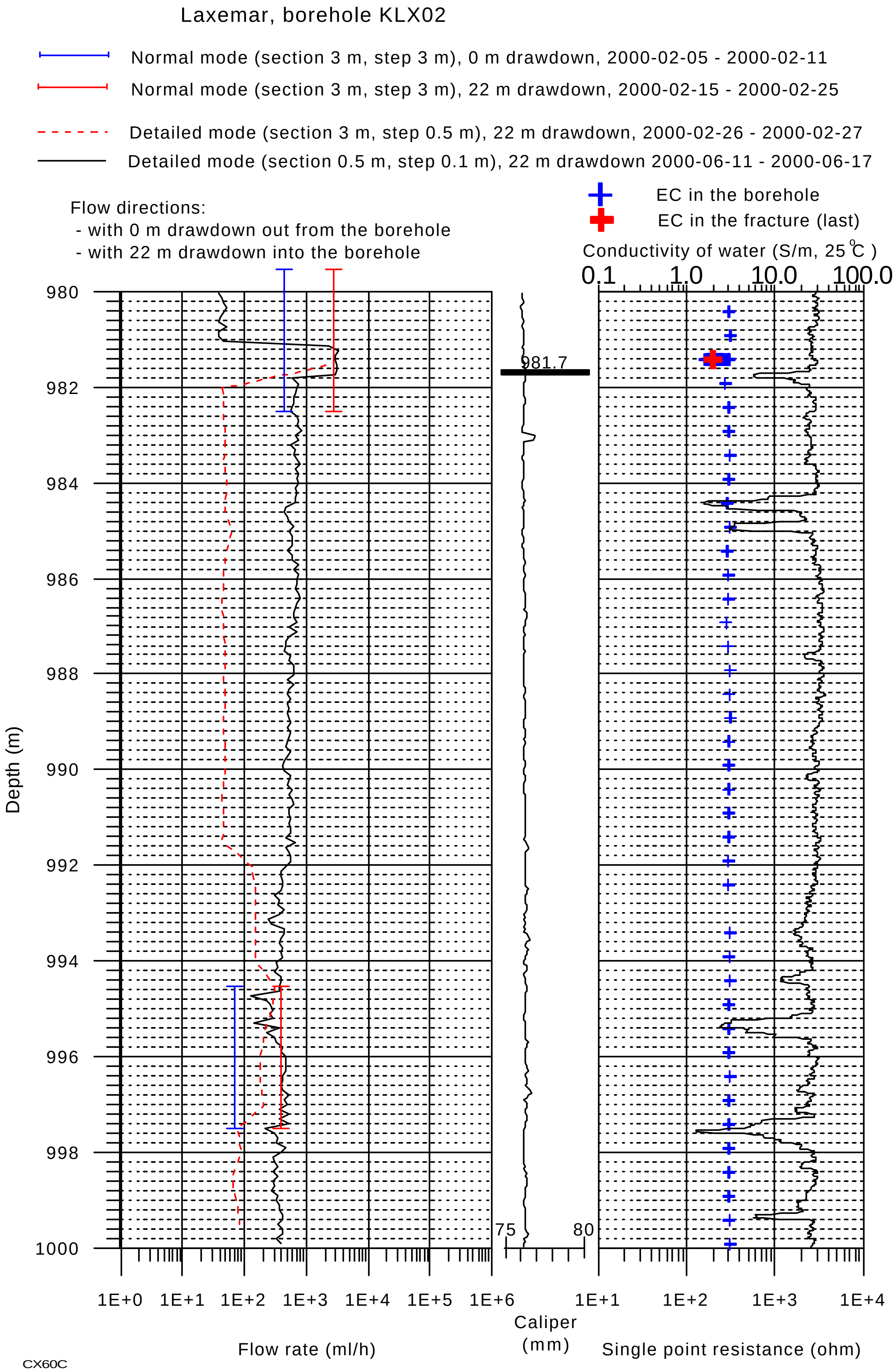

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
920
922
924
926
928
930
932
934
936
938
940
927.1
934.0
938.9
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

Laxemar, borehole KLX02



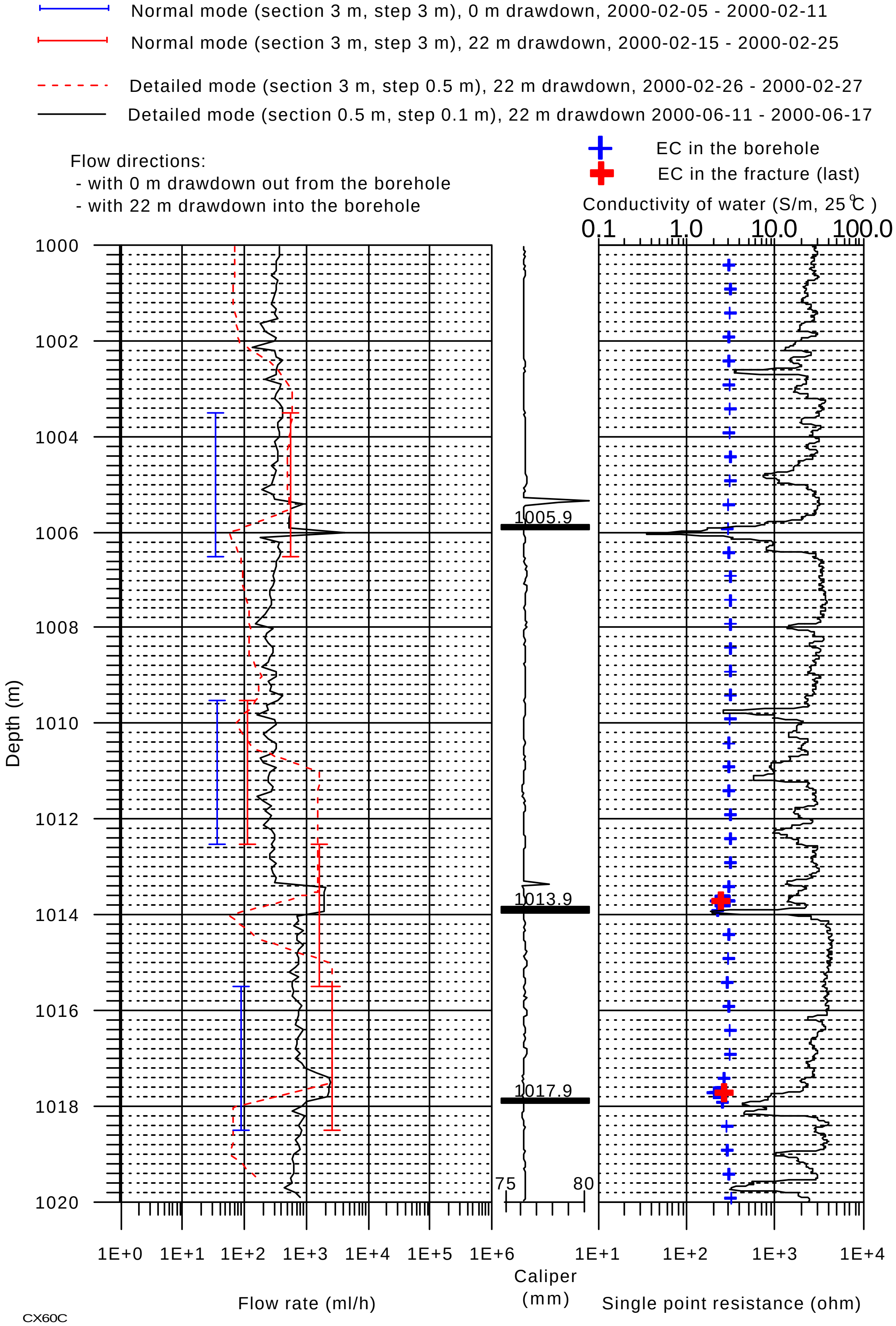
CX60C

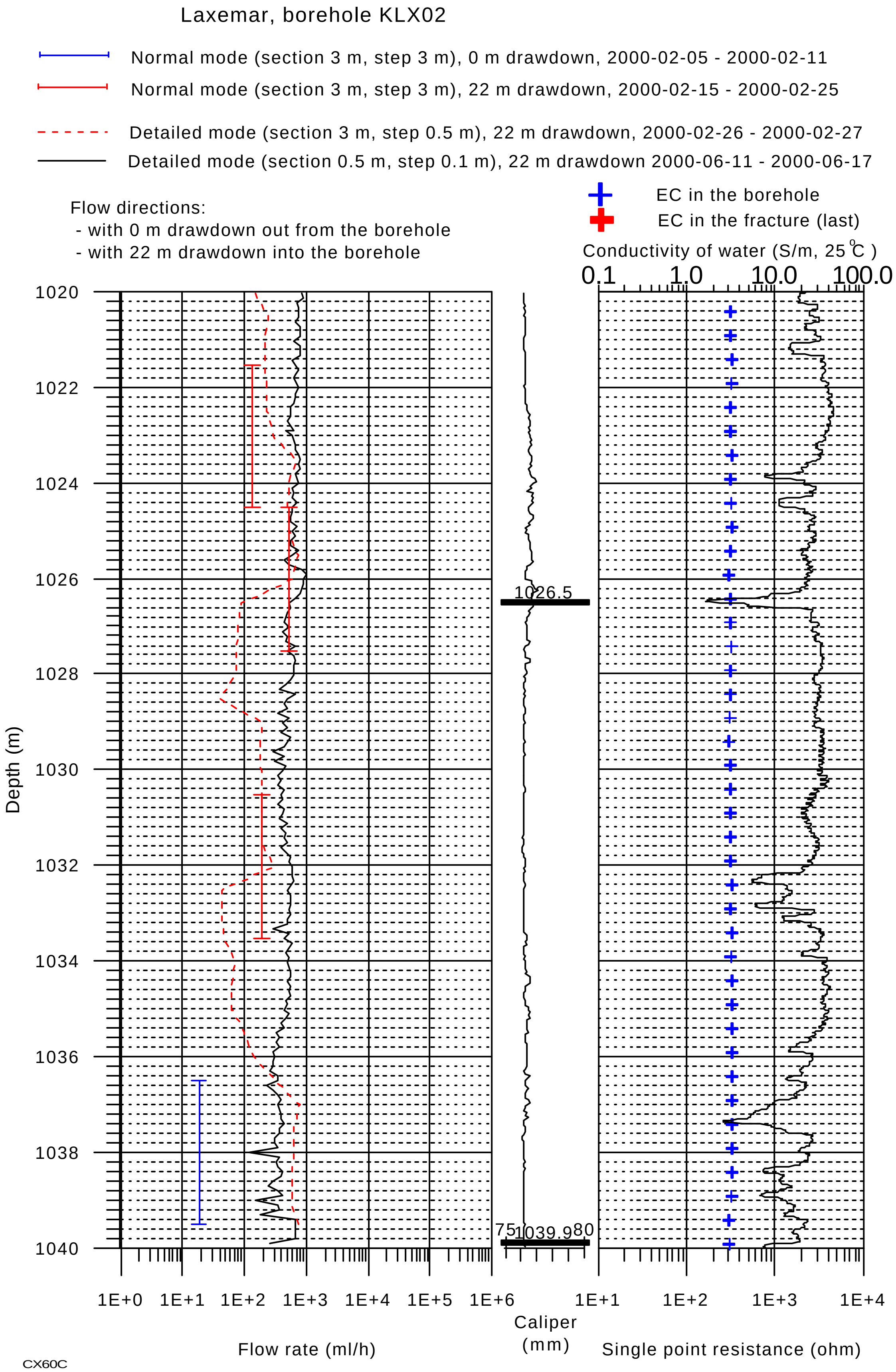

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
960
962
964
966
968
970
972
974
976
978
980
Depth (m)
978.2
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

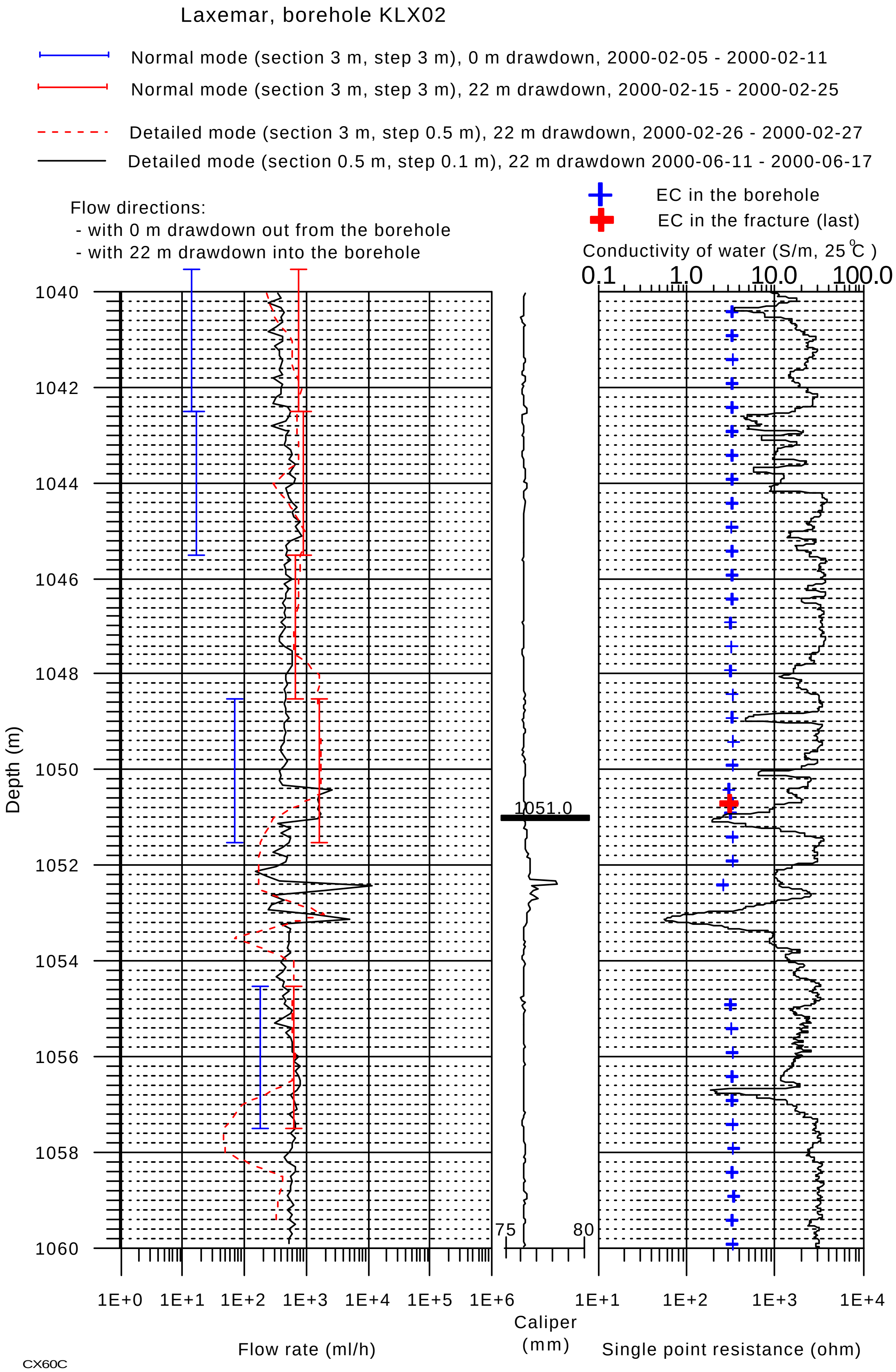


Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
980
982
984
986
988
990
992
994
996
998
1000
Depth (m)
981.7
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

Laxemar, borehole KLX02

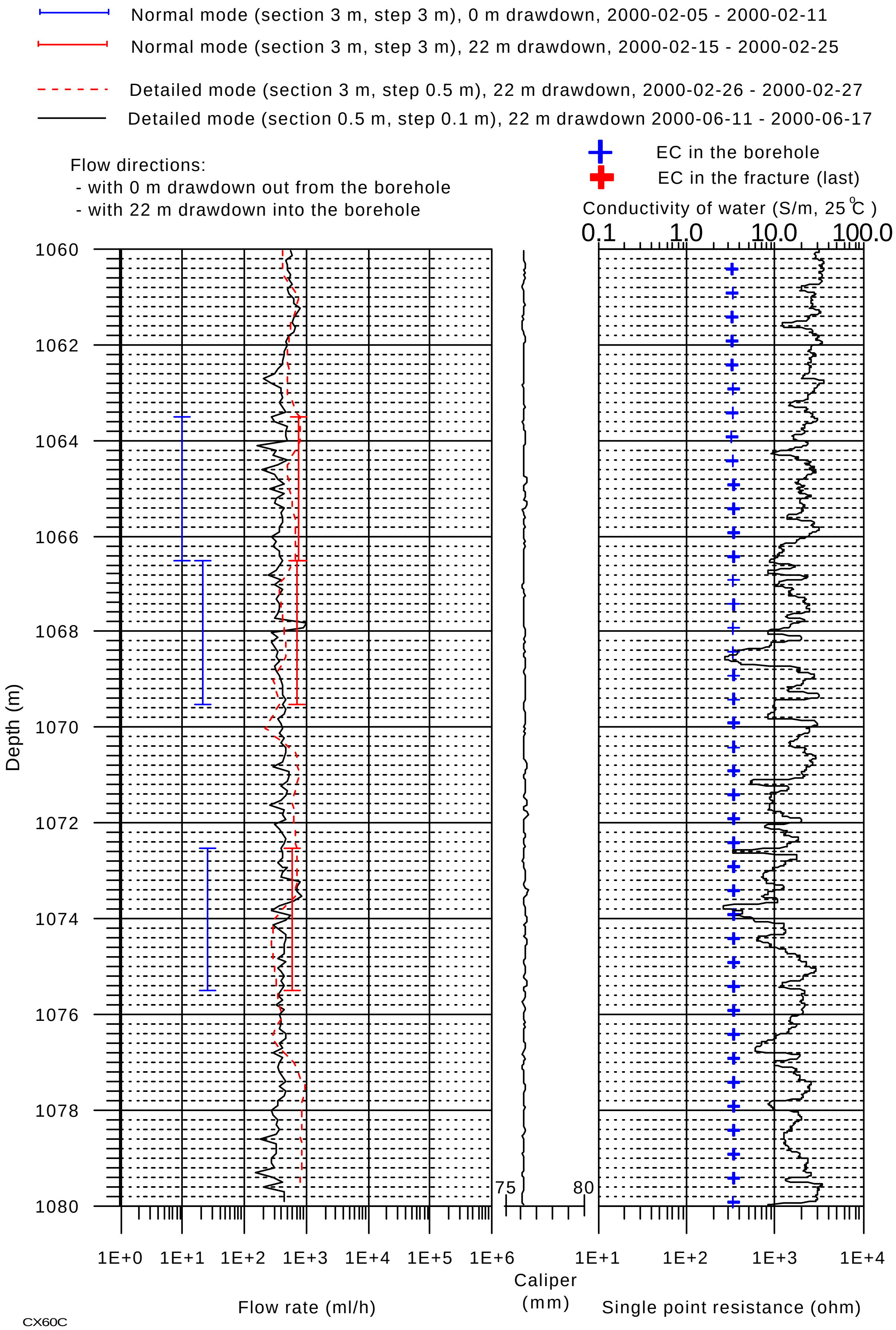


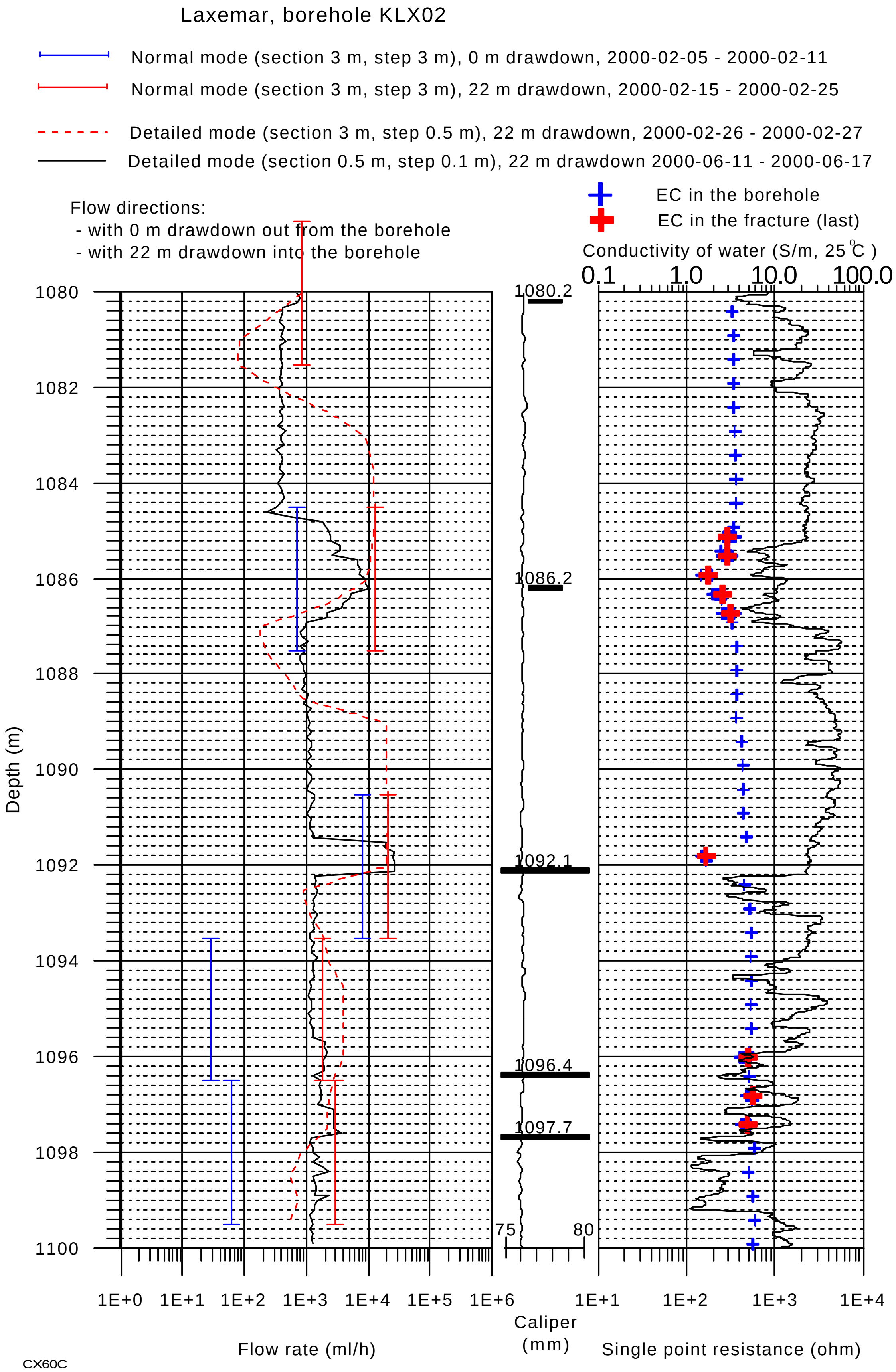

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
1020
1022
1024
1026
1028
1030
1032
1034
1036
1038
1040
Depth (m)
1026.5
75
1039.9
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

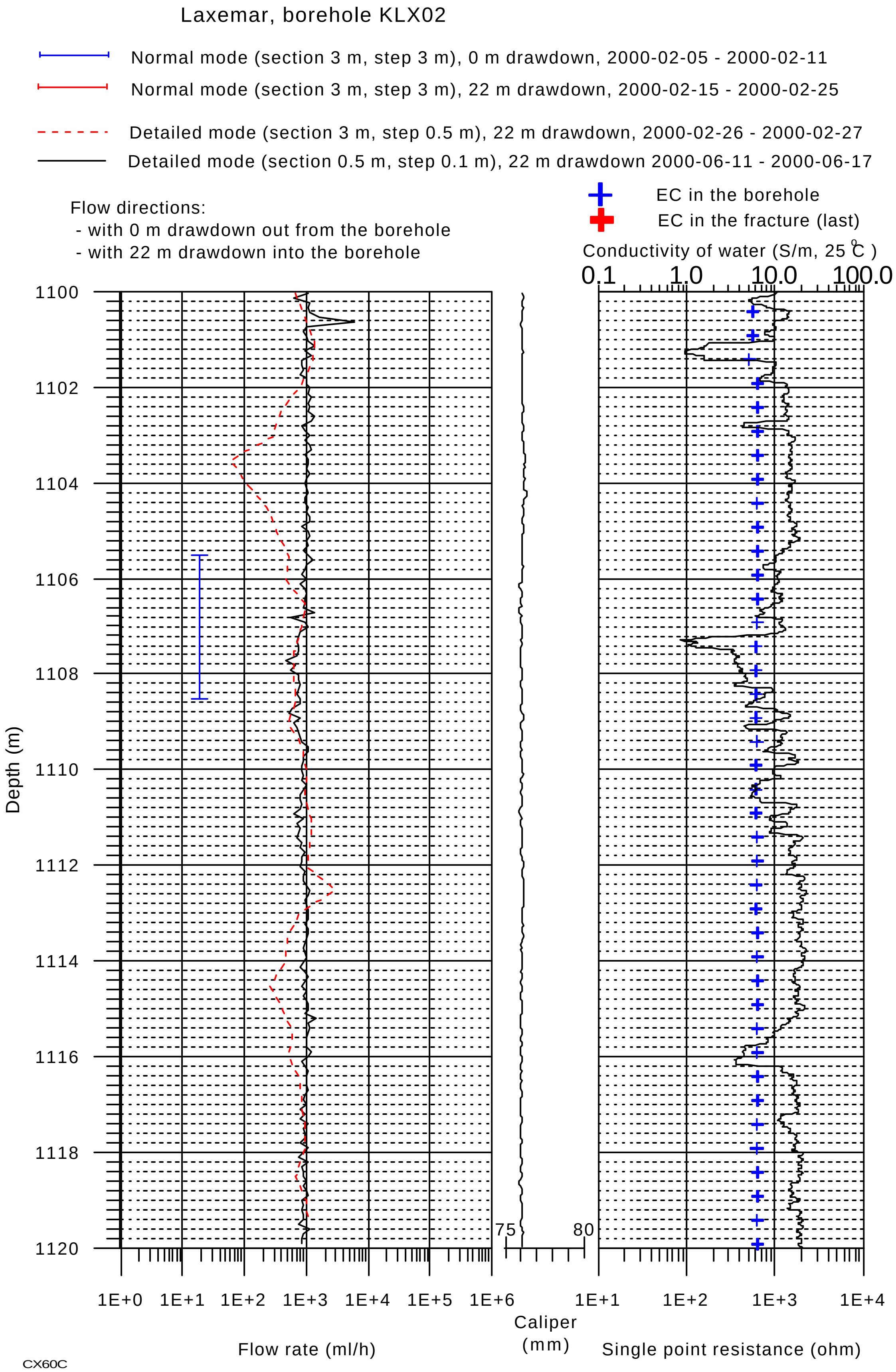


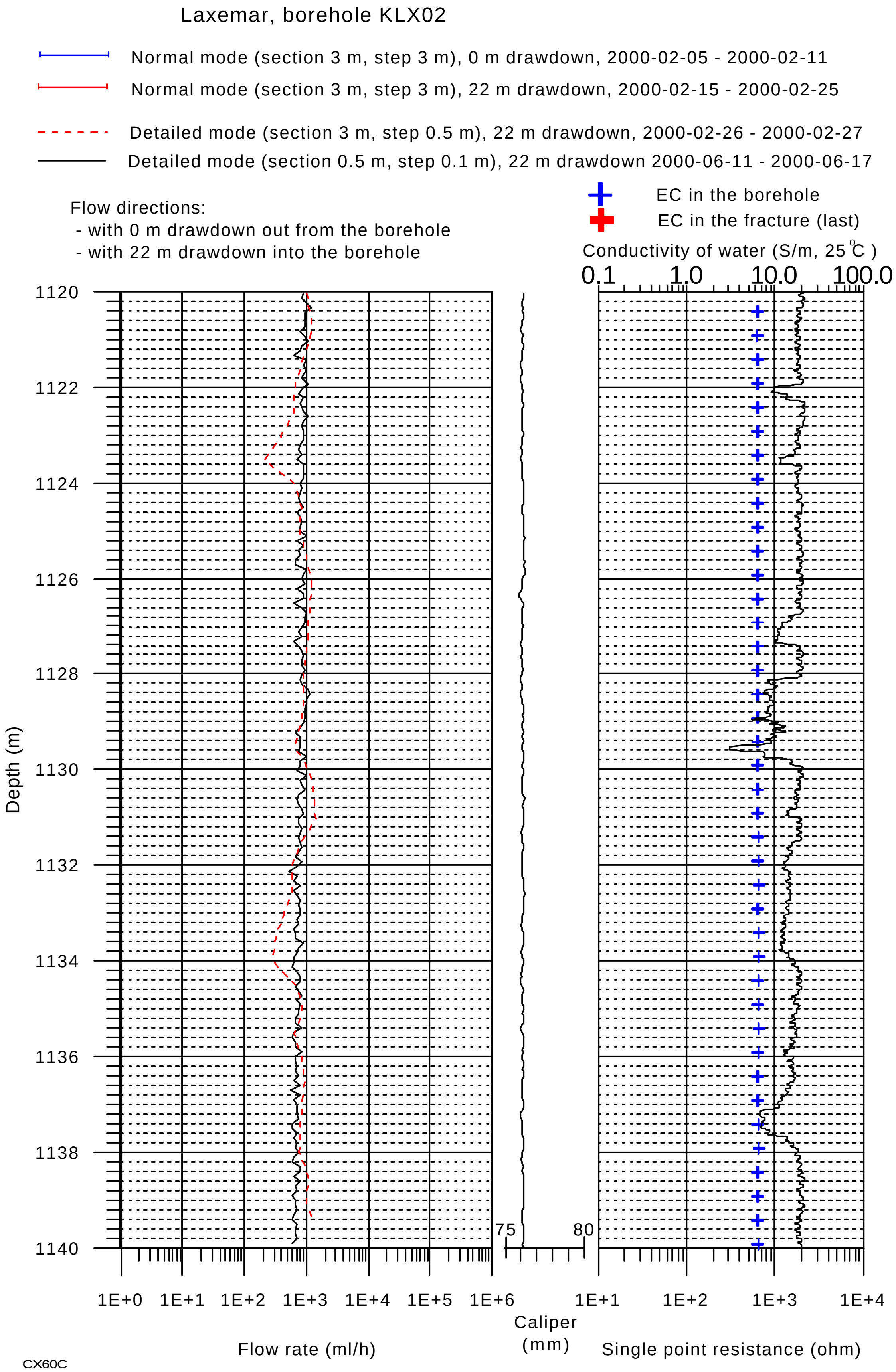
Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
1040
1042
1044
1046
1048
1050
1052
1054
1056
1058
1060
Depth (m)
1051.0
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

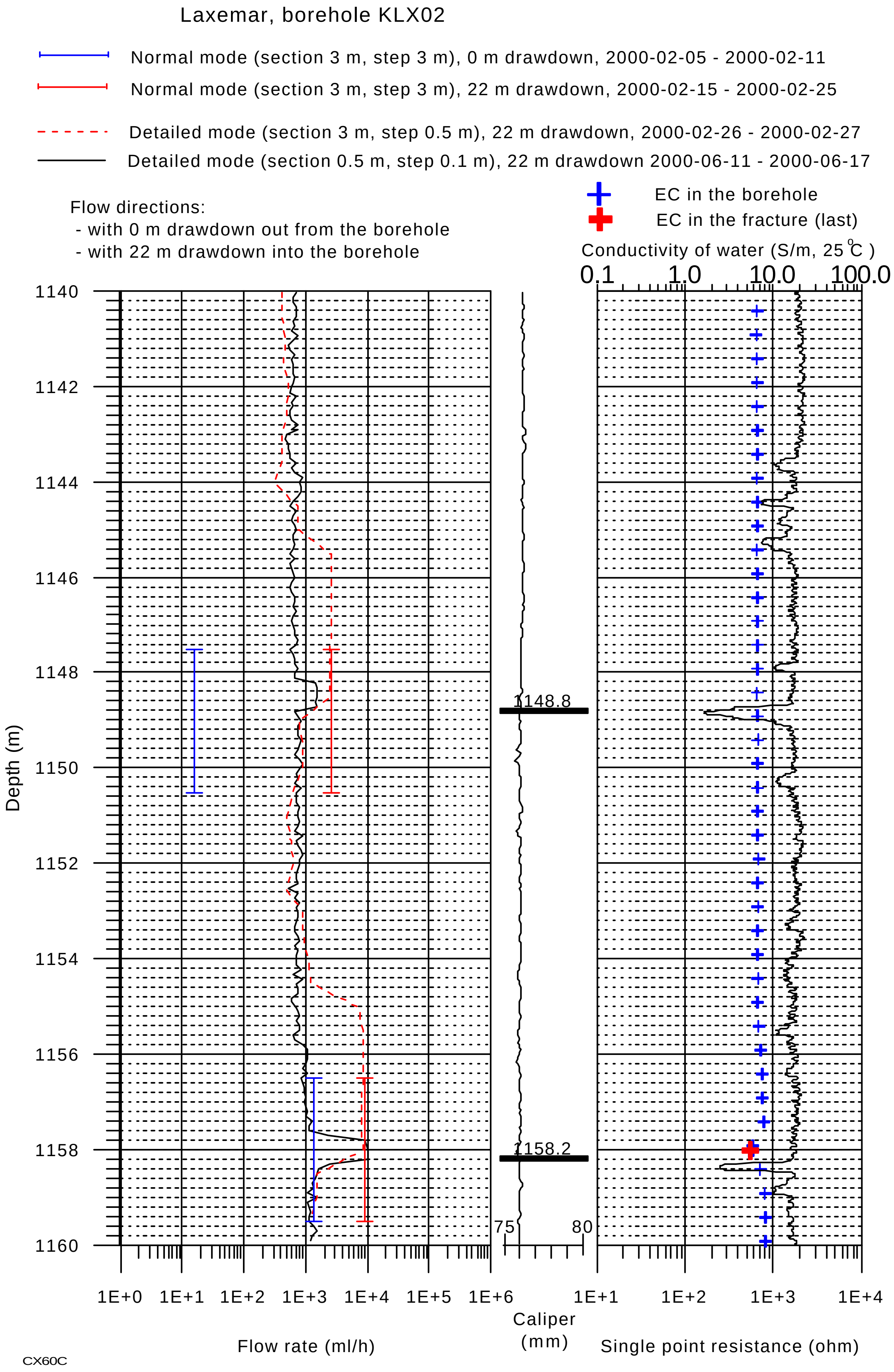
Laxemar, borehole KLX02

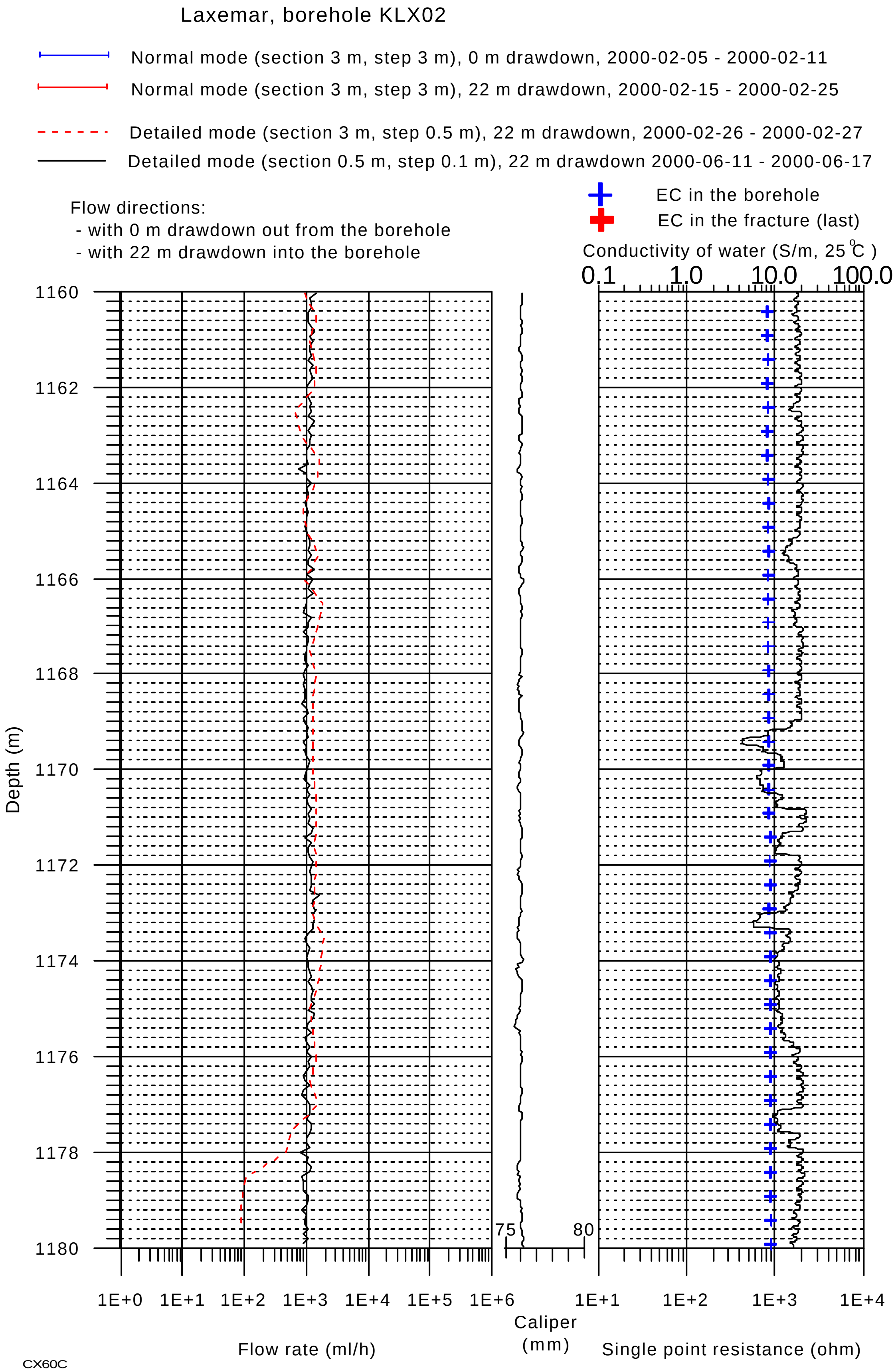


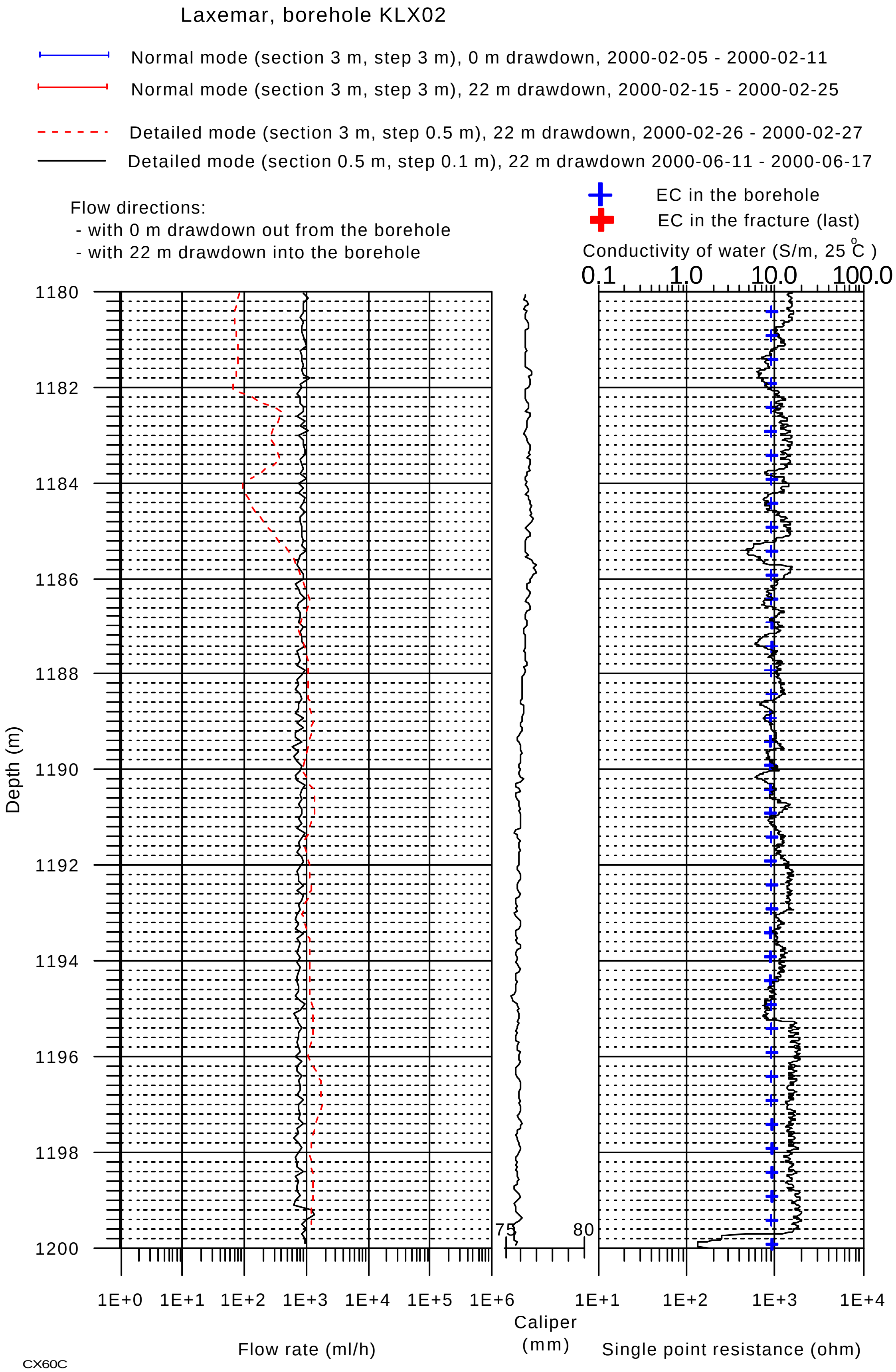

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
1080
1082
1084
1086
1088
1090
1092
1094
1096
1098
1100
1080.2
1086.2
1092.1
1096.4
1097.7
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

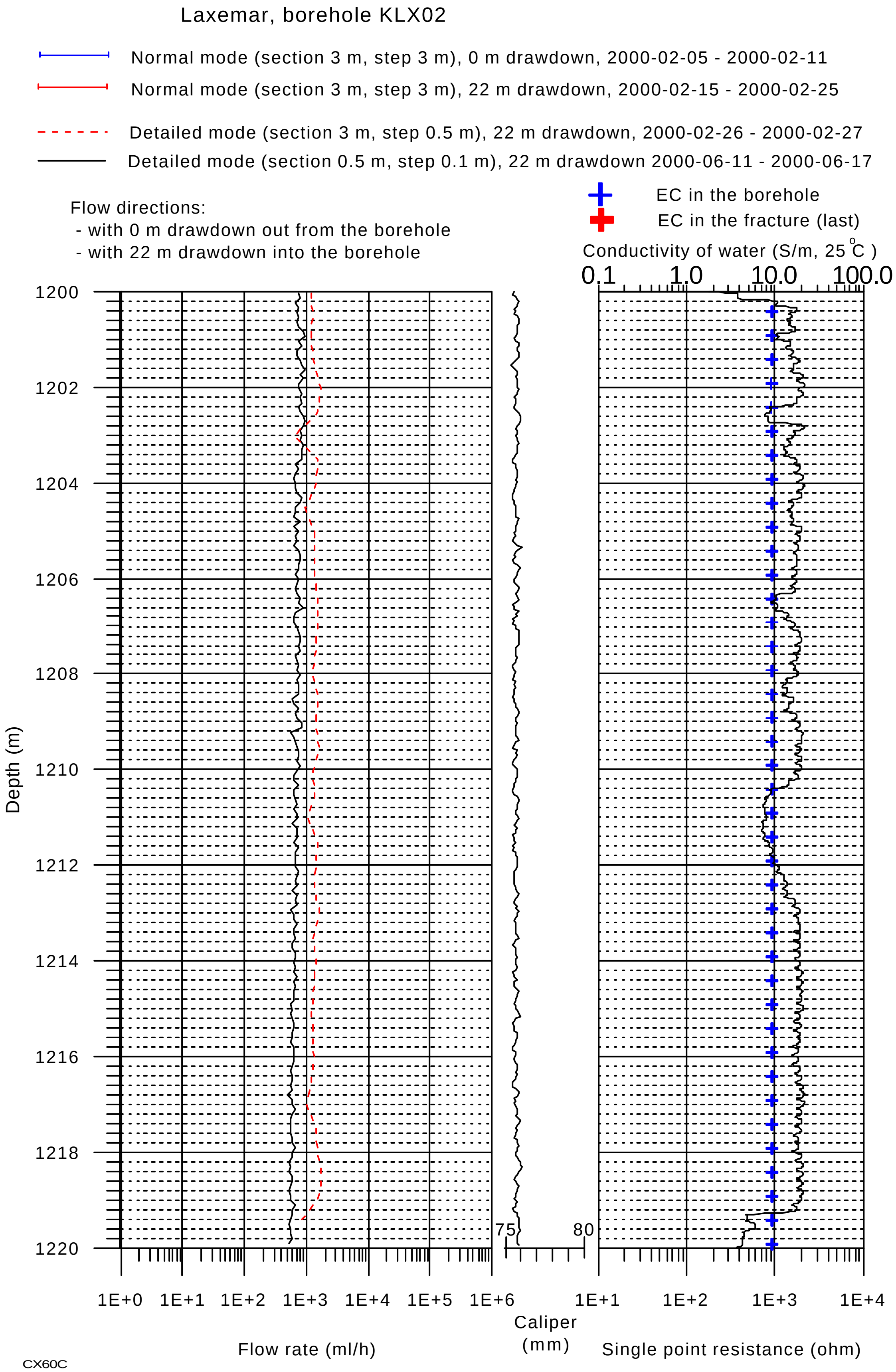

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
1100
1102
1104
1106
1108
1110
1112
1114
1116
1118
1120
Depth (m)
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper (mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
CX60C

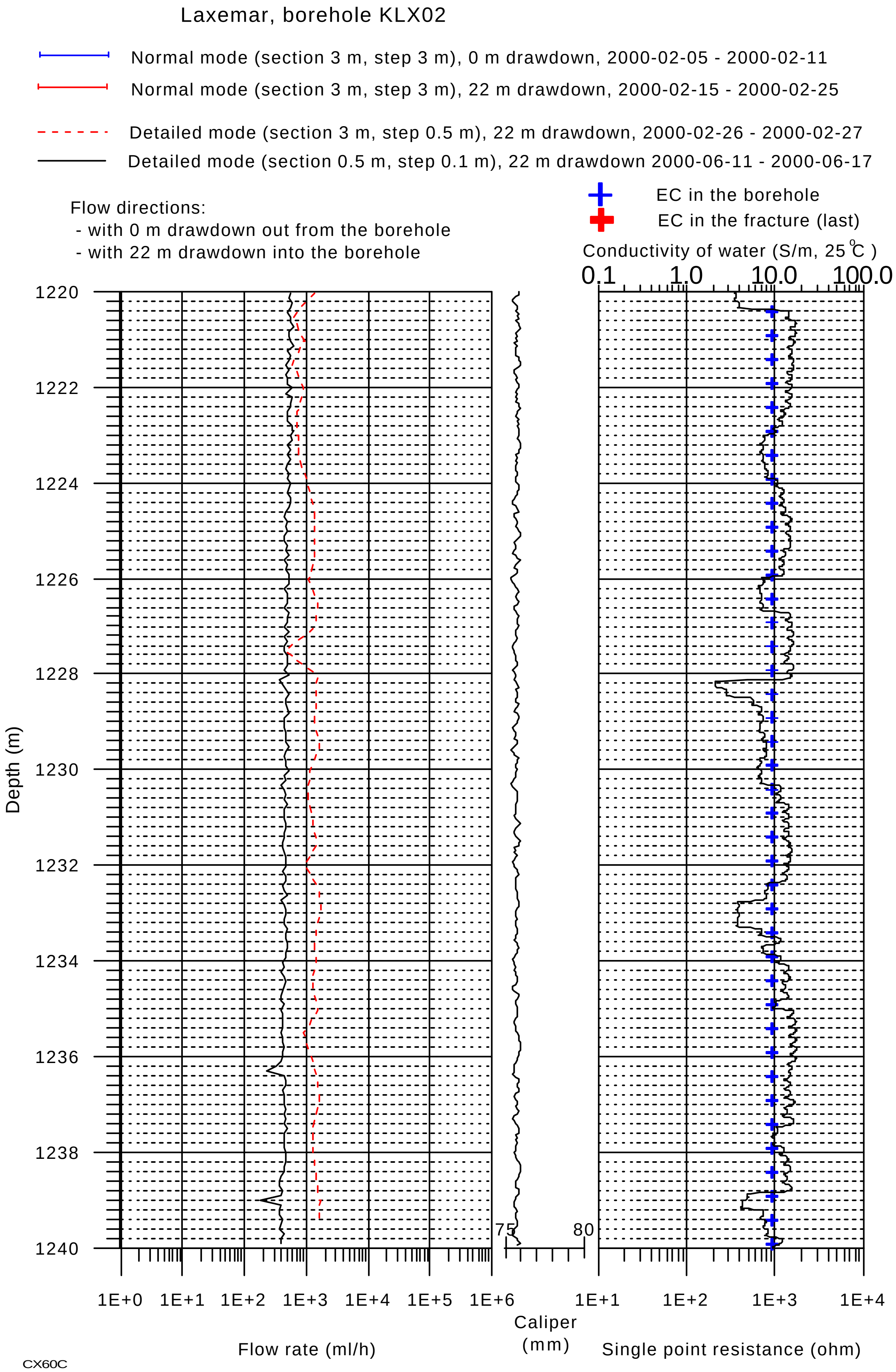

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
1120
1122
1124
1126
1128
1130
1132
1134
1136
1138
1140
Depth (m)
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

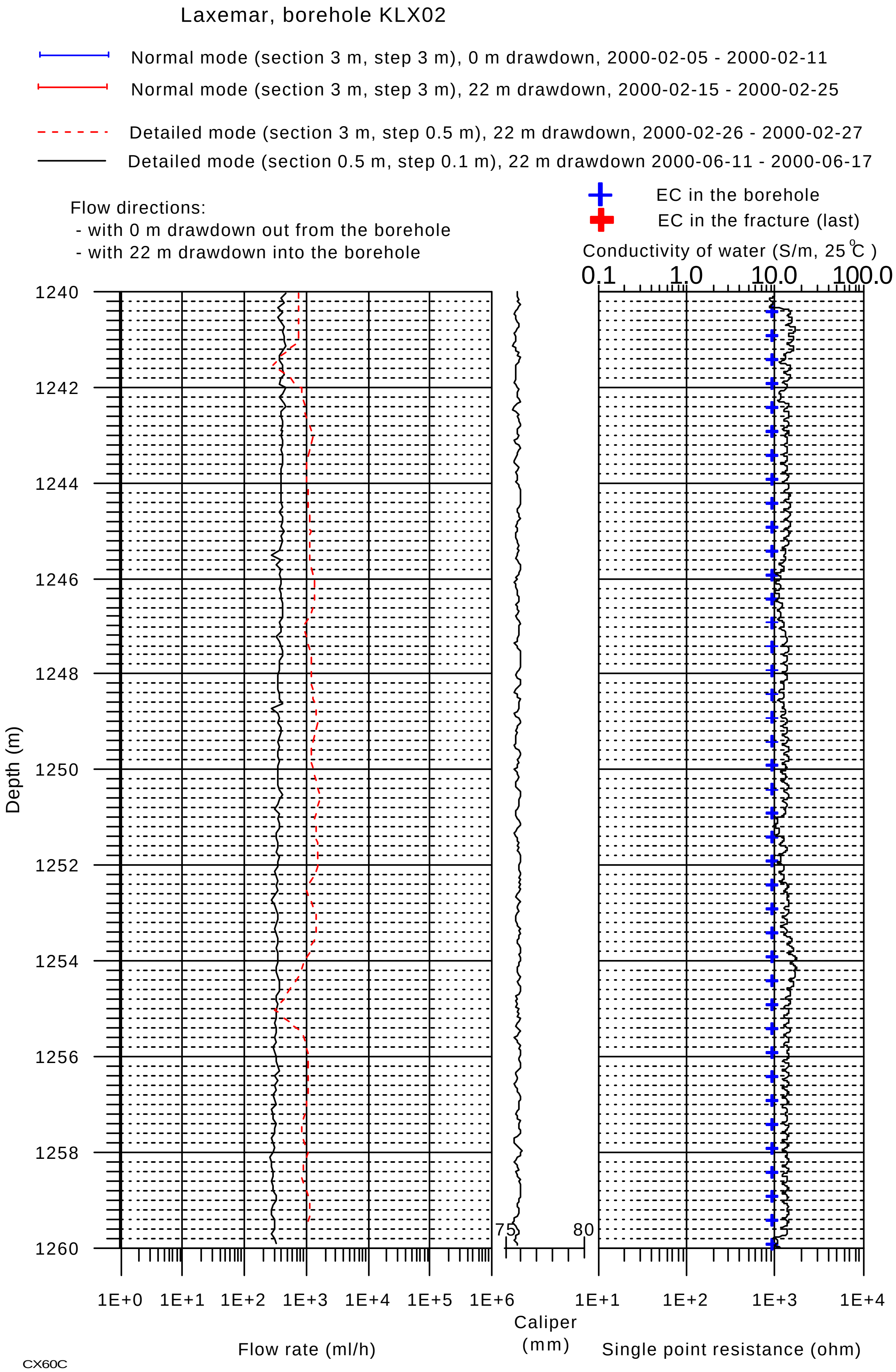

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
1140
1142
1144
1146
1148
1150
1152
1154
1156
1158
1160
1148.8
1158.2
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

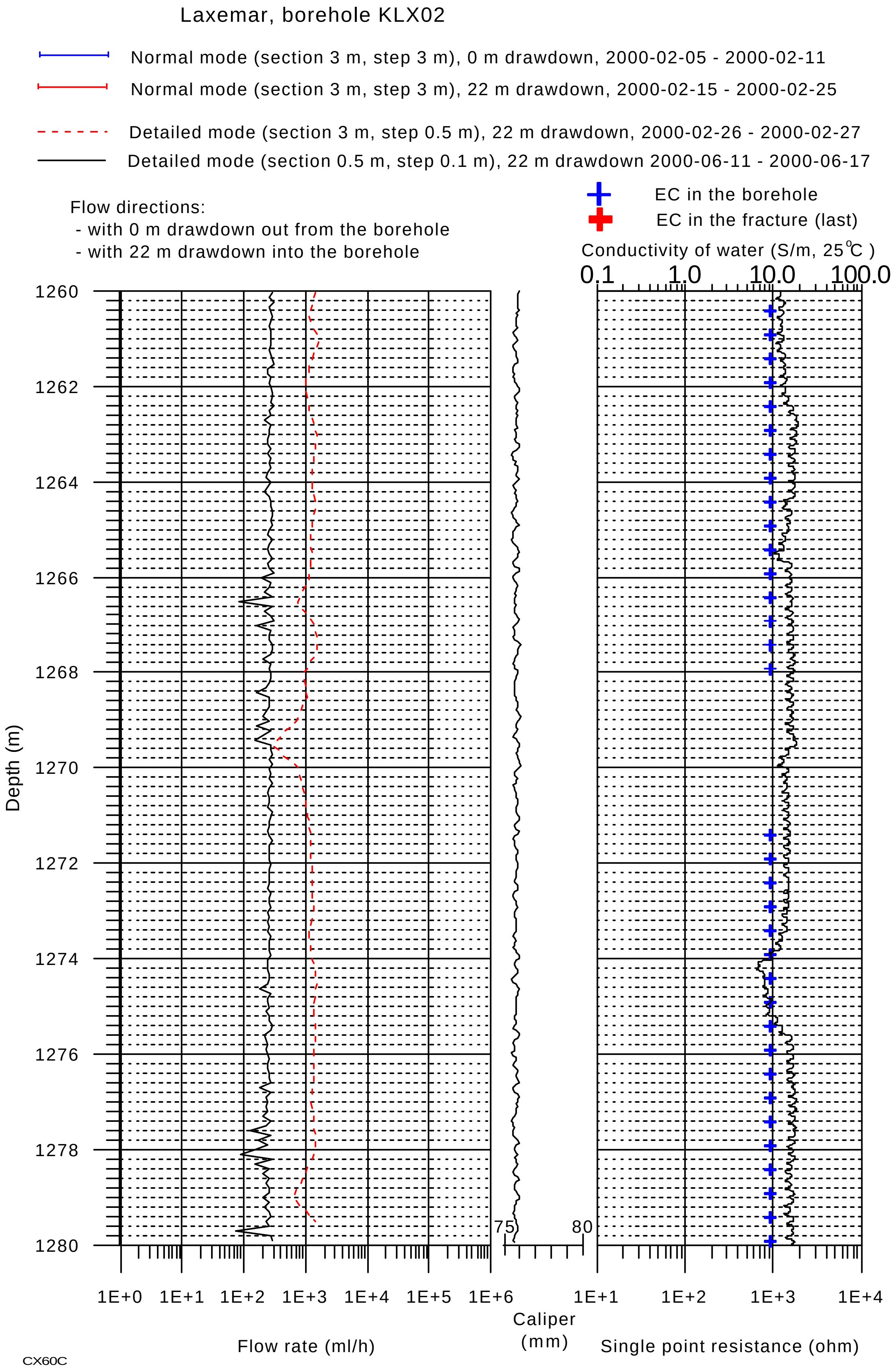

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
1160
1162
1164
1166
1168
1170
1172
1174
1176
1178
1180
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
Flow rate (ml/h)
75
80
Caliper
(mm)
1E+1
1E+2
1E+3
1E+4
Single point resistance (ohm)
CX60C

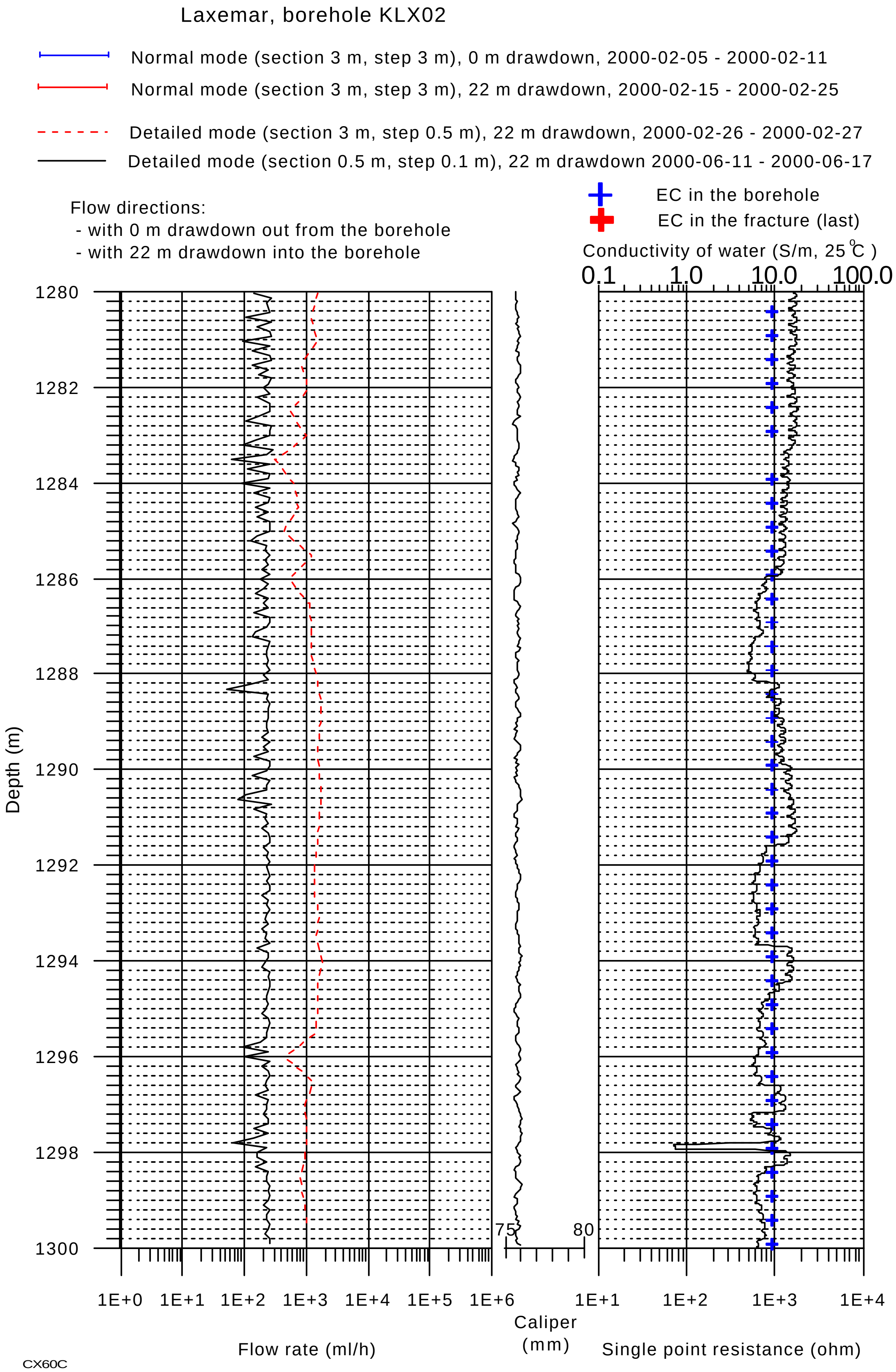

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
1180
1182
1184
1186
1188
1190
1192
1194
1196
1198
1200
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

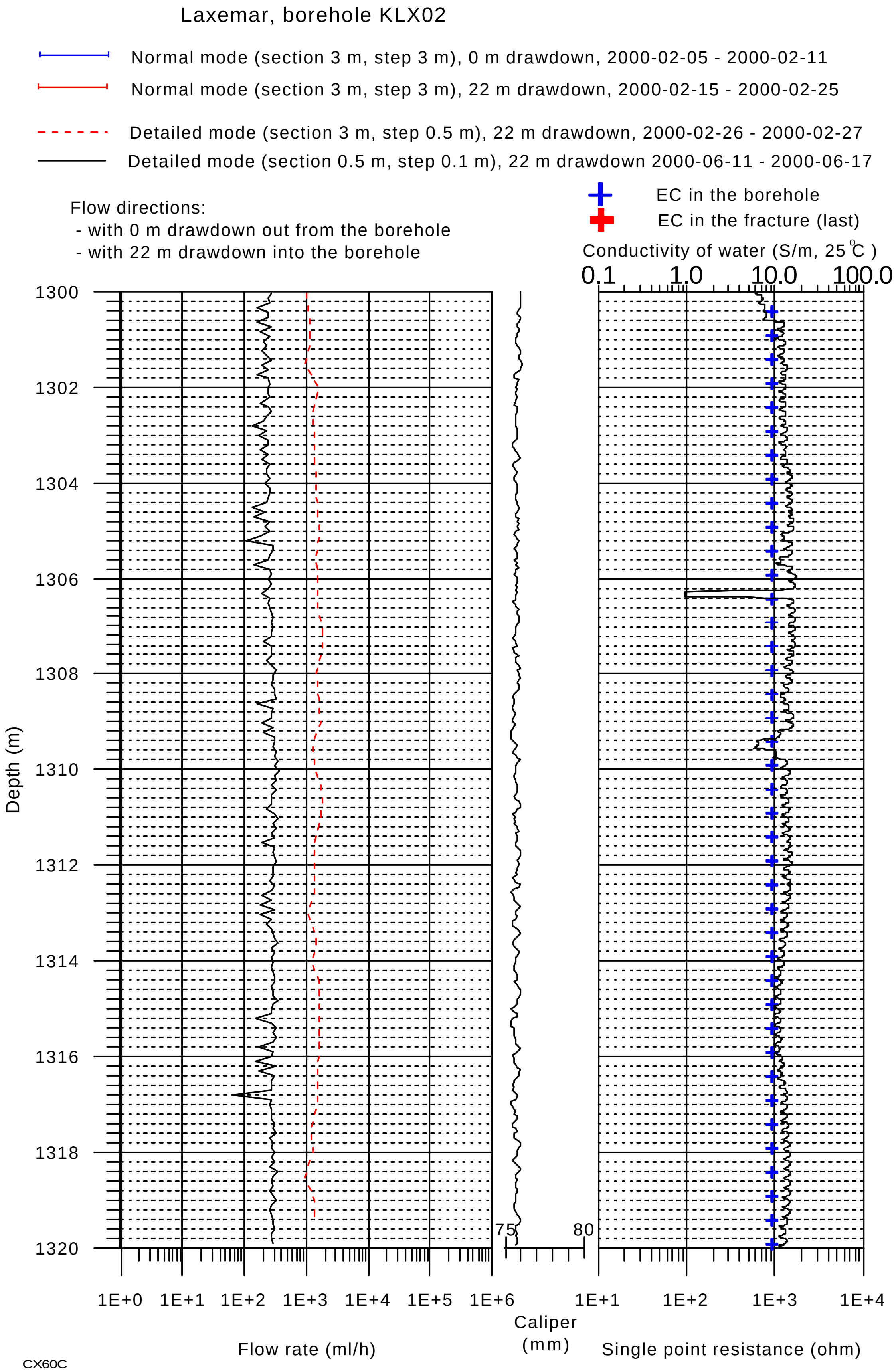

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
1200
1202
1204
1206
1208
1210
1212
1214
1216
1218
1220
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

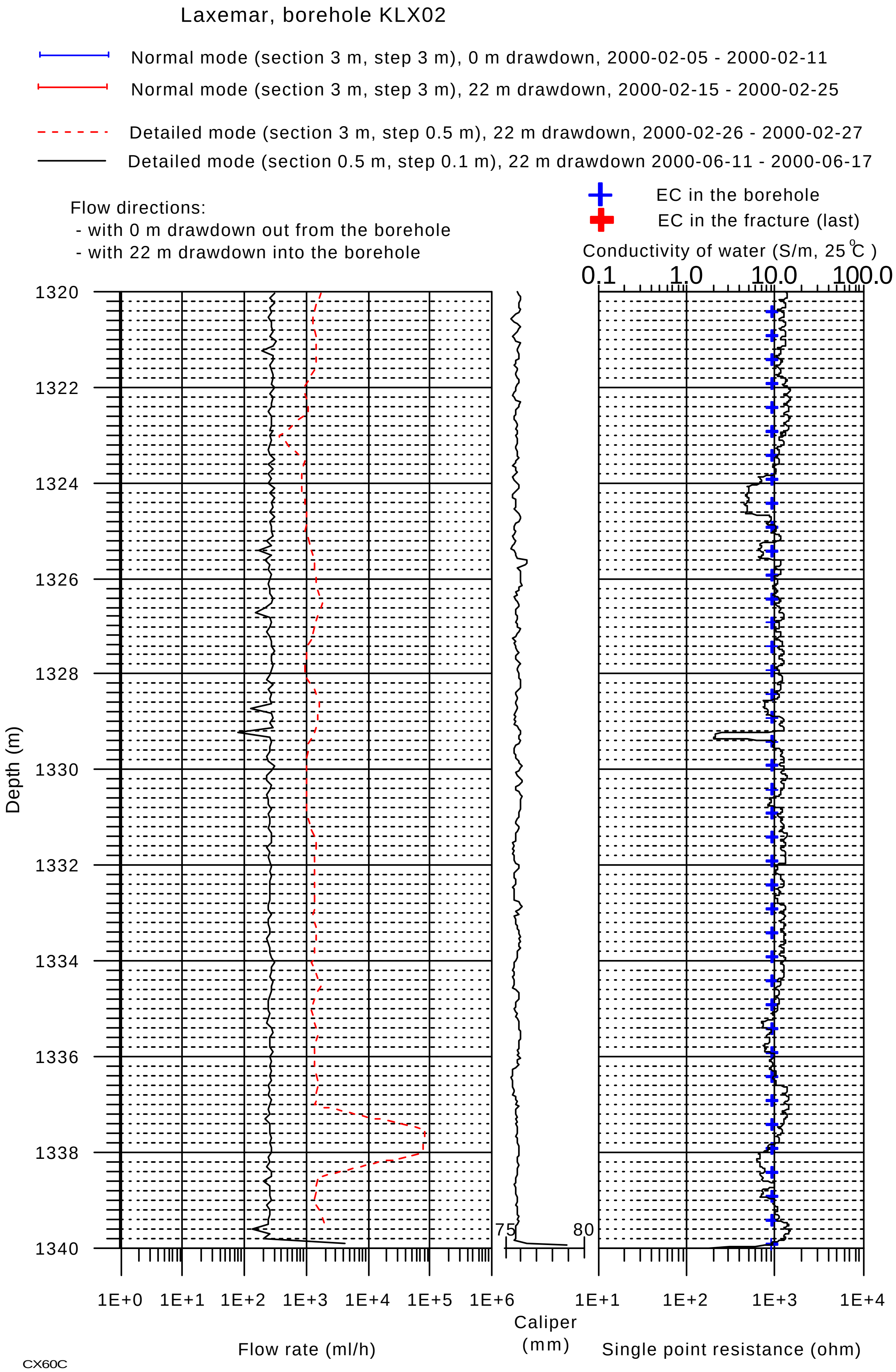

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
1220
1222
1224
1226
1228
1230
1232
1234
1236
1238
1240
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C


Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
1240
1242
1244
1246
1248
1250
1252
1254
1256
1258
1260
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

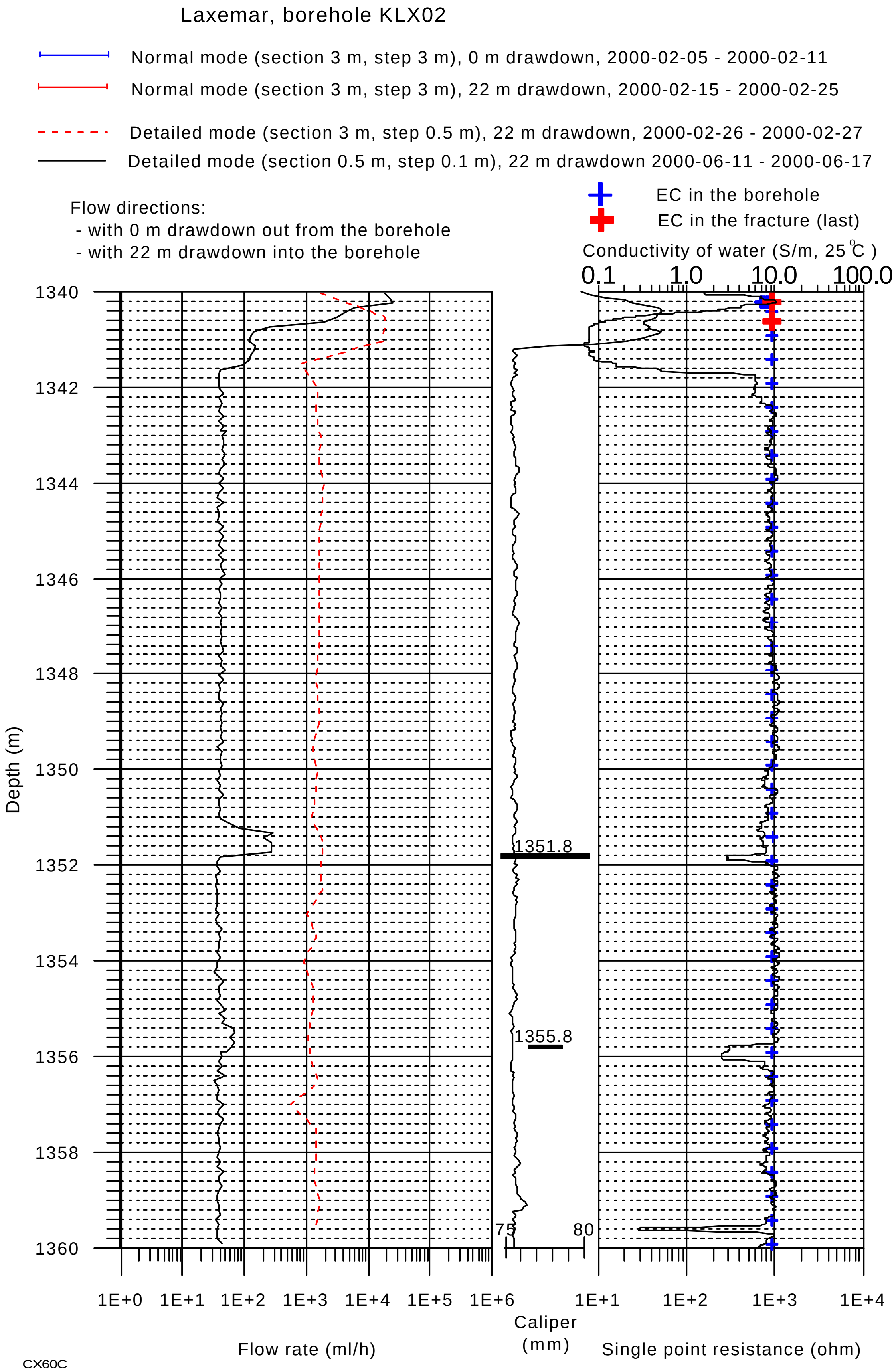

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25°C)
0.1
1.0
10.0
100.0
Depth (m)
1260
1262
1264
1266
1268
1270
1272
1274
1276
1278
1280
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

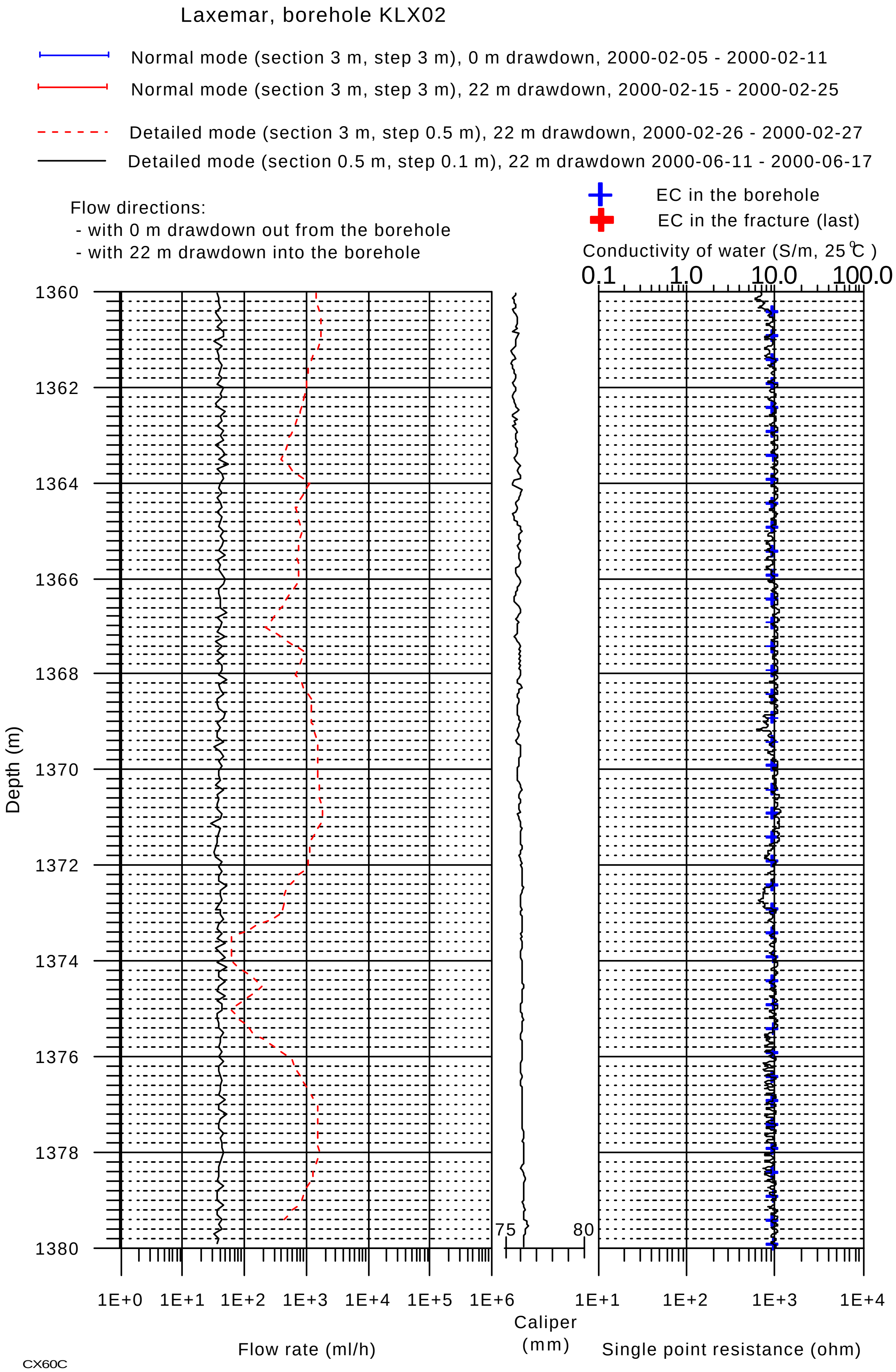

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
1280
1282
1284
1286
1288
1290
1292
1294
1296
1298
1300
Depth (m)
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

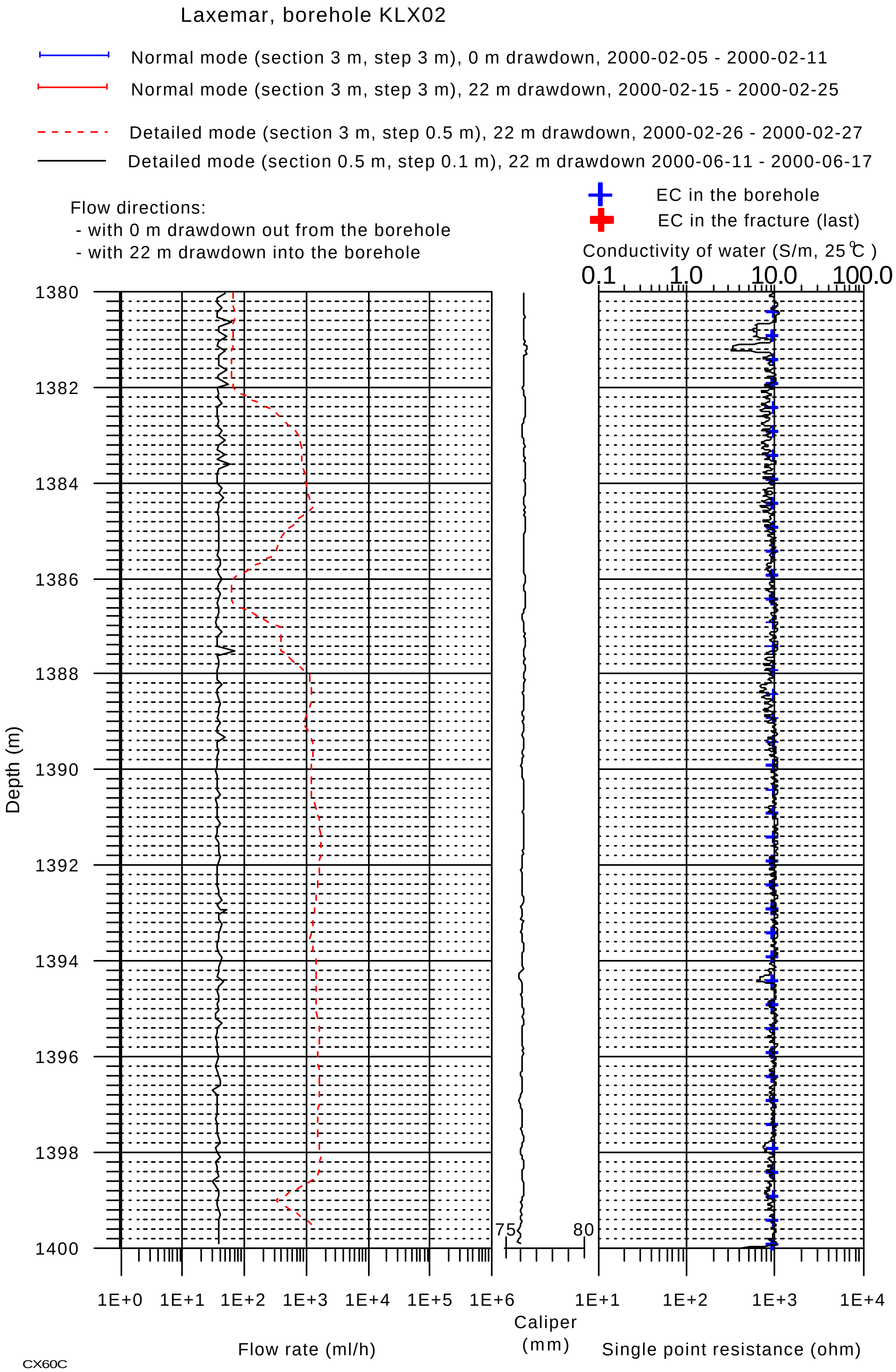

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
1300
1302
1304
1306
1308
1310
1312
1314
1316
1318
1320
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C



Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
1320
1322
1324
1326
1328
1330
1332
1334
1336
1338
1340
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C

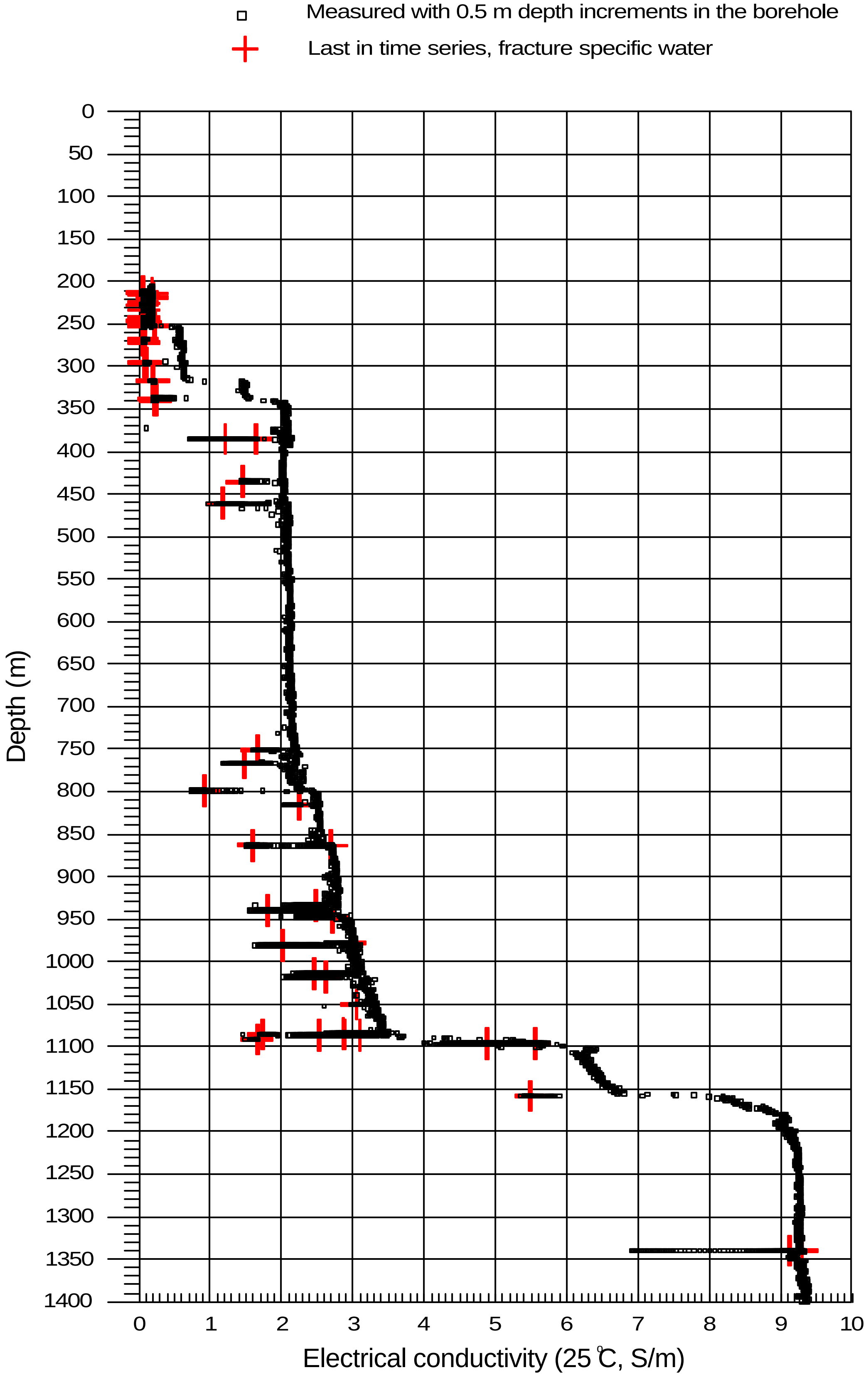

Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 °C)
0.1
1.0
10.0
100.0
Depth (m)
1340
1342
1344
1346
1348
1350
1352
1354
1356
1358
1360
1351.8
1355.8
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C


Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 ℃)
0.1
1.0
10.0
100.0
1360
1362
1364
1366
1368
1370
1372
1374
1376
1378
1380
Depth (m)
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
CX60C



Laxemar, borehole KLX02
Normal mode (section 3 m, step 3 m), 0 m drawdown, 2000-02-05 - 2000-02-11
Normal mode (section 3 m, step 3 m), 22 m drawdown, 2000-02-15 - 2000-02-25
Detailed mode (section 3 m, step 0.5 m), 22 m drawdown, 2000-02-26 - 2000-02-27
Detailed mode (section 0.5 m, step 0.1 m), 22 m drawdown 2000-06-11 - 2000-06-17
Flow directions:
- with 0 m drawdown out from the borehole
- with 22 m drawdown into the borehole
EC in the borehole
EC in the fracture (last)
Conductivity of water (S/m, 25 ℃)
0.1
1.0
10.0
100.0
1380
1382
1384
1386
1388
1390
1392
1394
1396
1398
1400
Depth (m)
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Flow rate (ml/h)
Caliper (mm)
Single point resistance (ohm)
CX60C

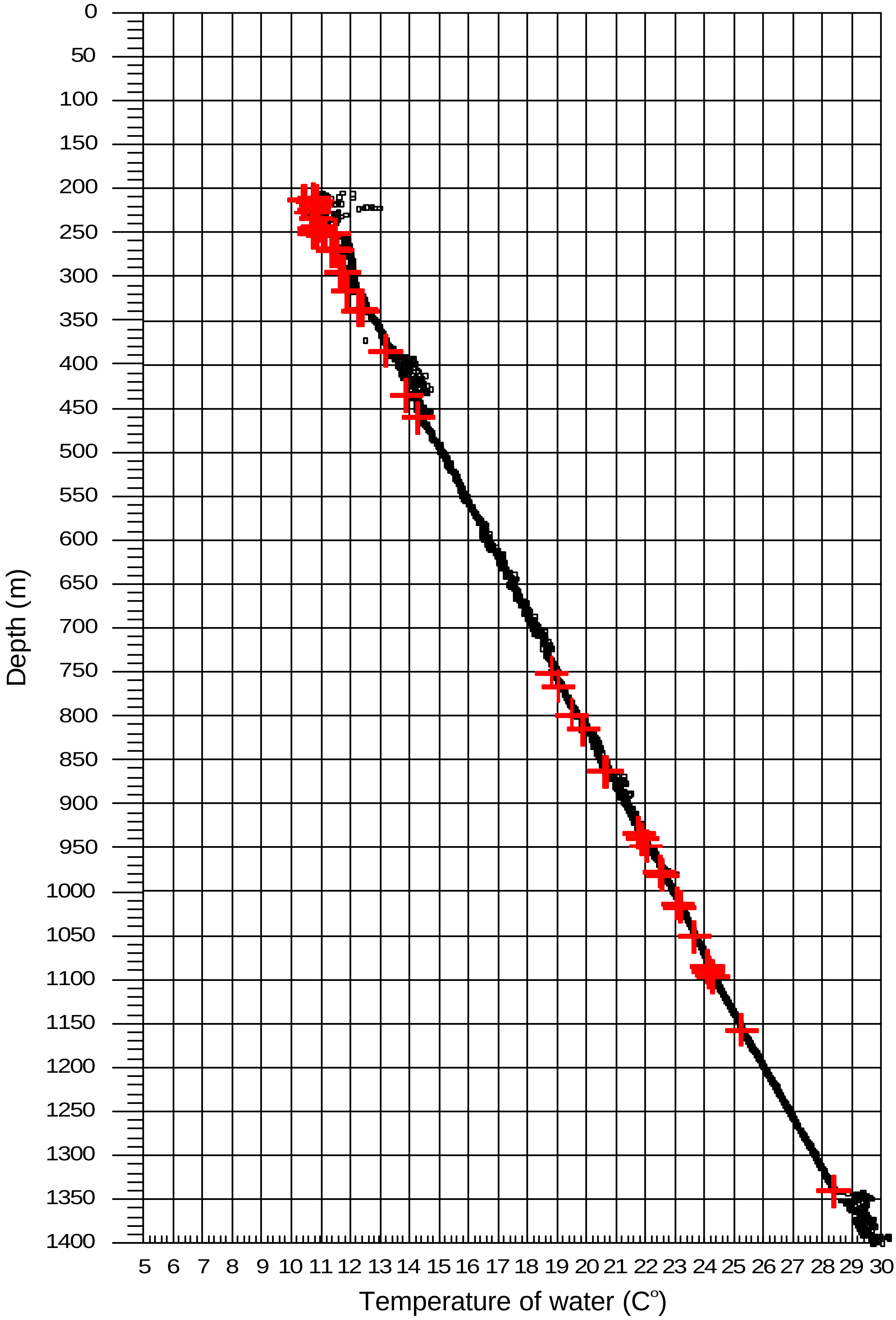
ELECTRICAL CONDUCTIVITY LOGS
LAXEMAR, KLX02, 22 M DRAWDOWN
2000-06-11 - 2000-06-17



C270E

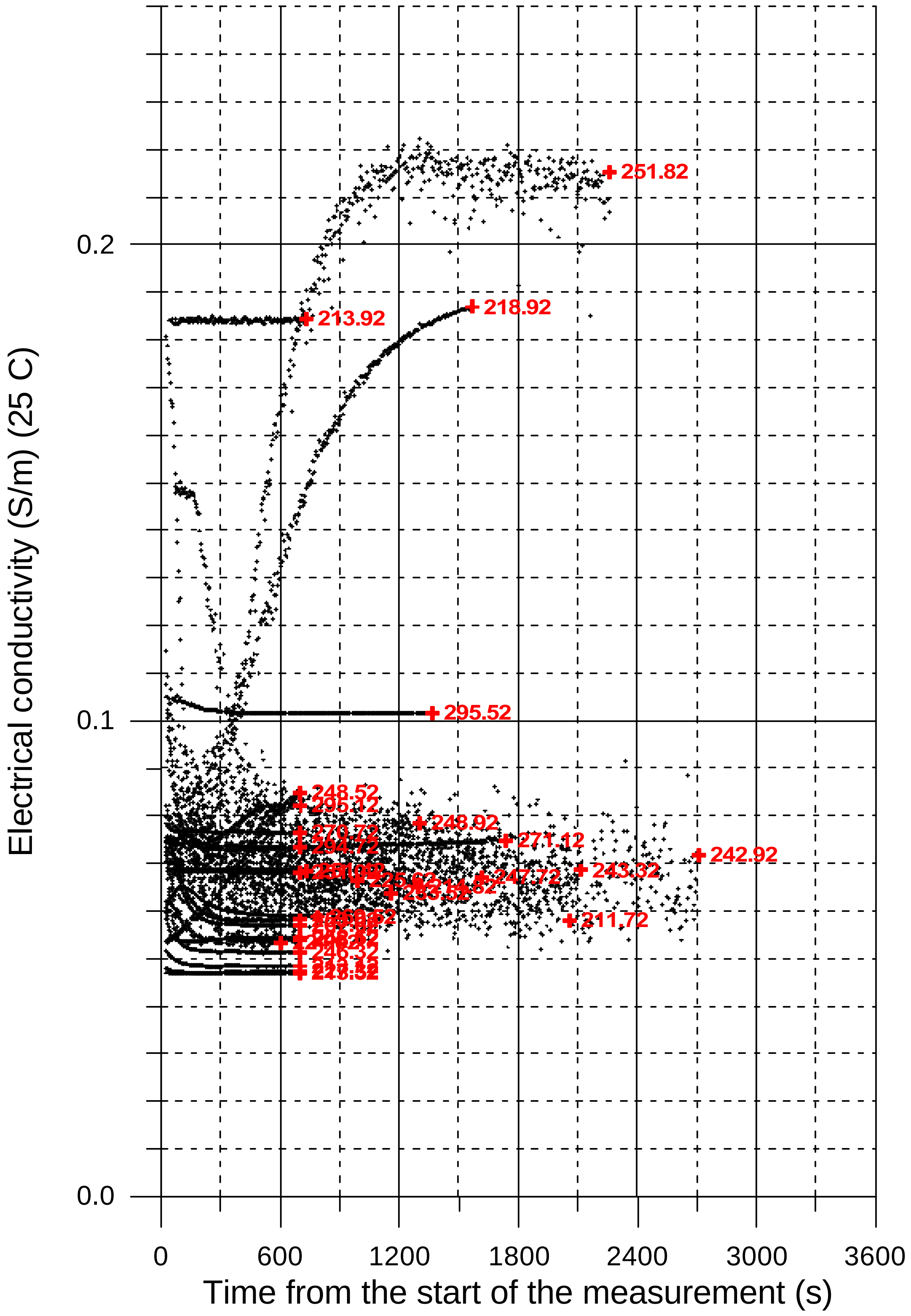
TEMPERATURE OF WATER
LAXEMAR, KLX02, 22 M DRAWDOWN
2000-06-11 - 2000-06-17

Measured with 0.5 m depth increments in the borehole
Last in time series, fracture specific water



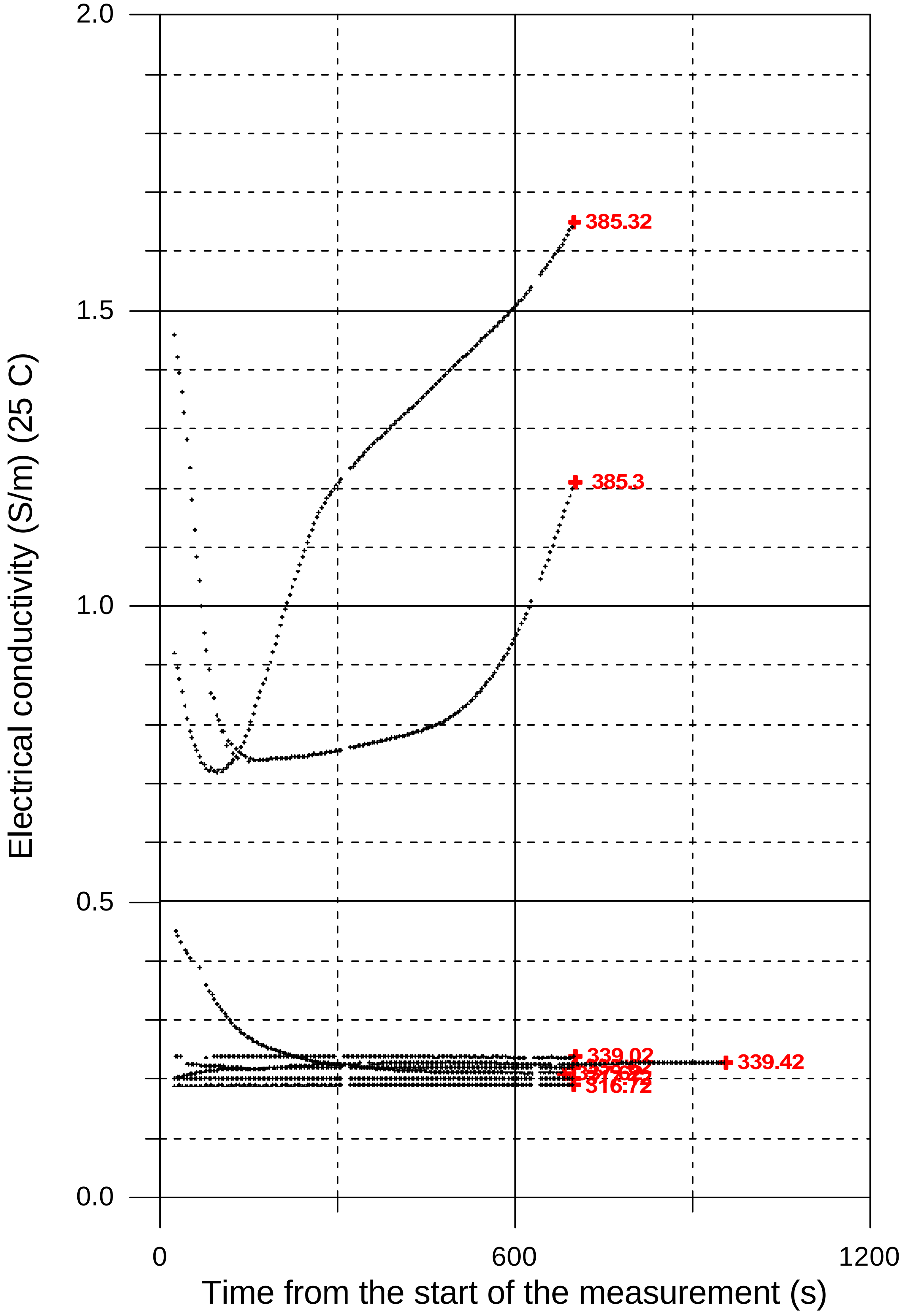
C271T

TIME SERIES OF ELECTRICAL CONDUCTIVITY
LAXEMAR, KLX02, DEPTHS BETWEEN 200 AND 300 M
2000-06-11 - 2000-06-17



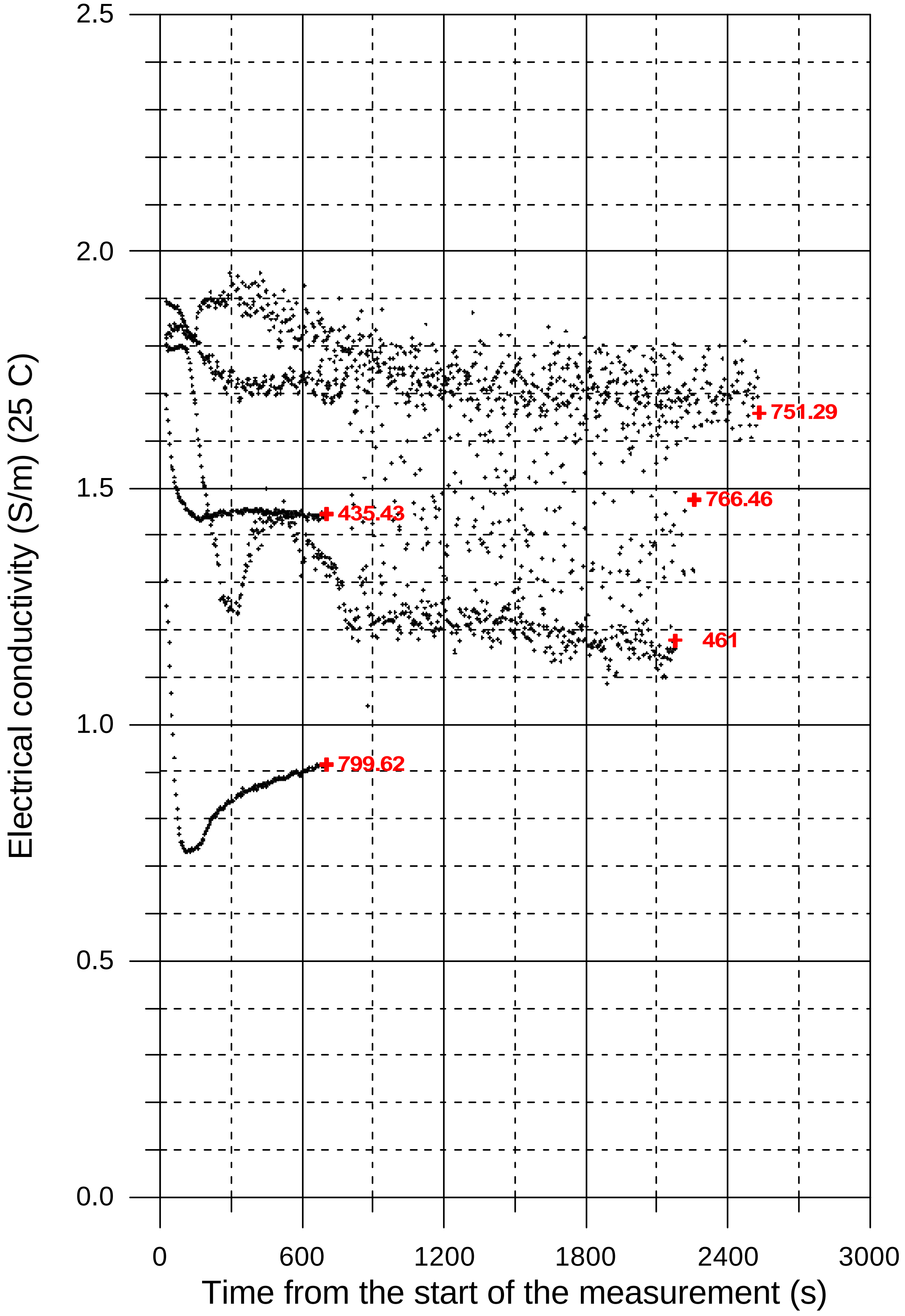
C280E

TIME SERIES OF ELECTRICAL CONDUCTIVITY
LAXEMAR, KLX02, DEPTHS BETWEEN 300 AND 400 M
2000-06-11 - 2000-06-17



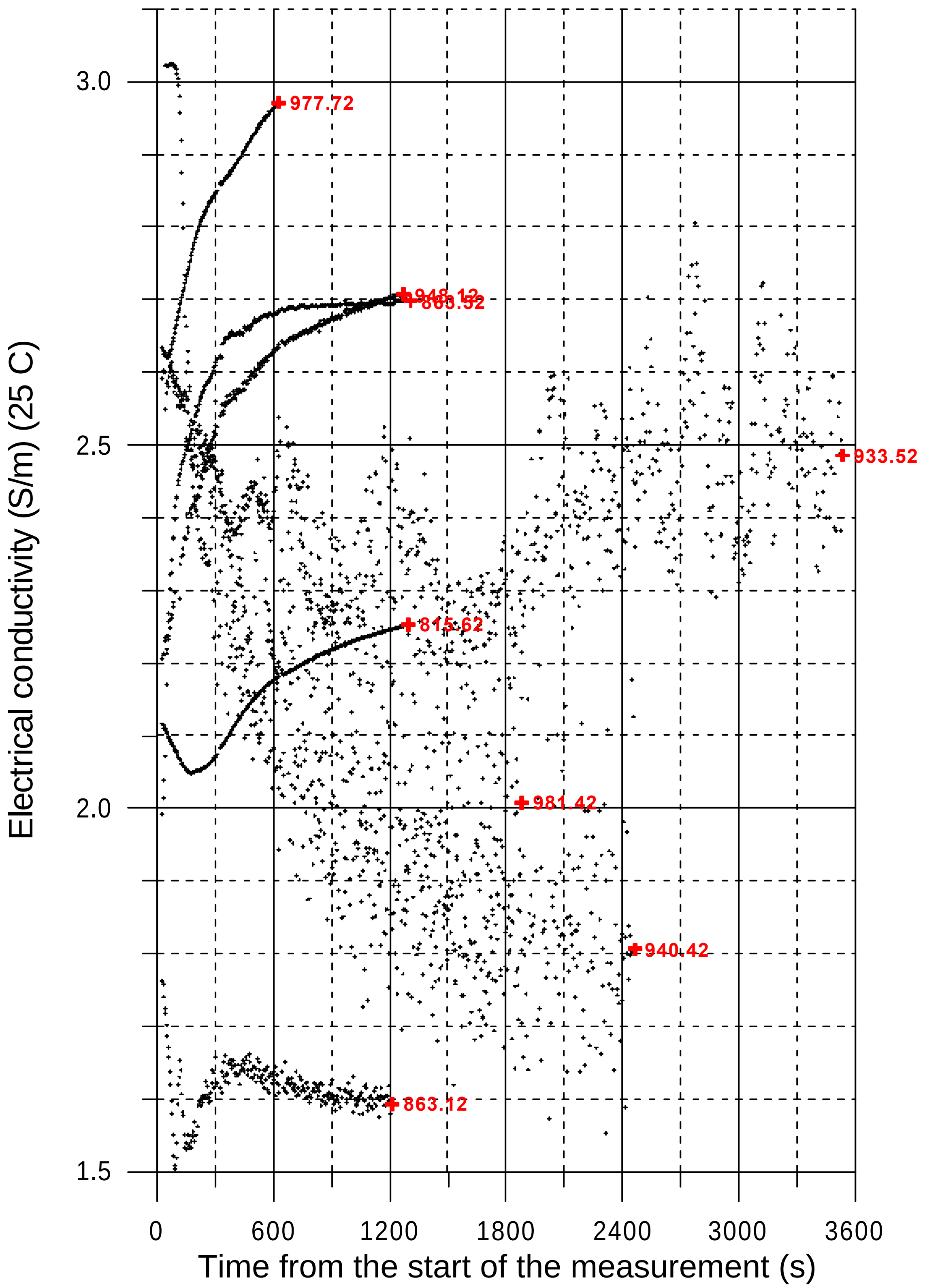
C280E

TIME SERIES OF ELECTRICAL CONDUCTIVITY
LAXEMAR, KLX02, DEPTHS BETWEEN 400 AND 800 M
2000-06-11 - 2000-06-17



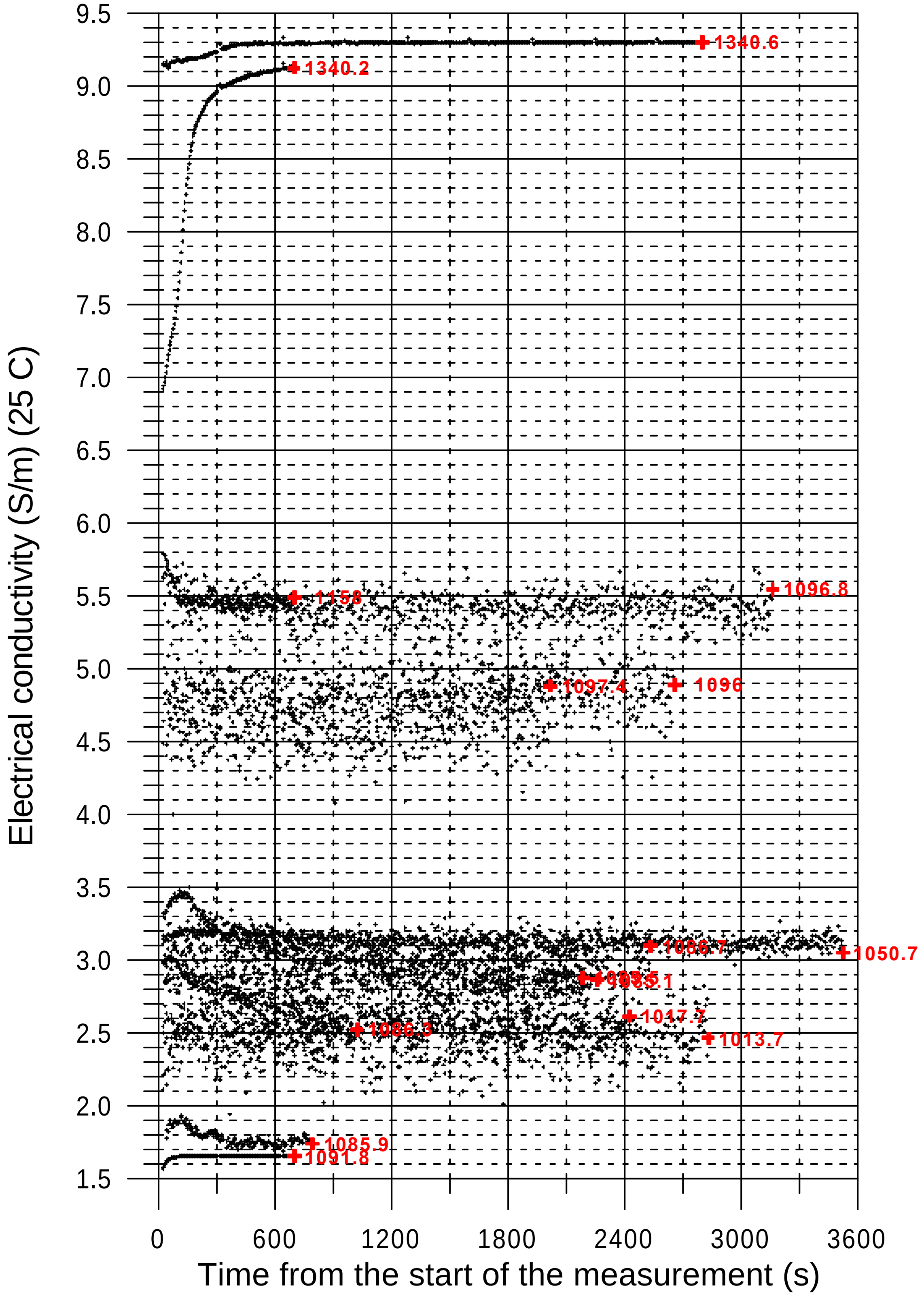
C280E

TIME SERIES OF ELECTRICAL CONDUCTIVITY
LAXEMAR, KLX02, DEPTHS BETWEEN 800 AND 1000 M
2000-06-11 - 2000-06-17

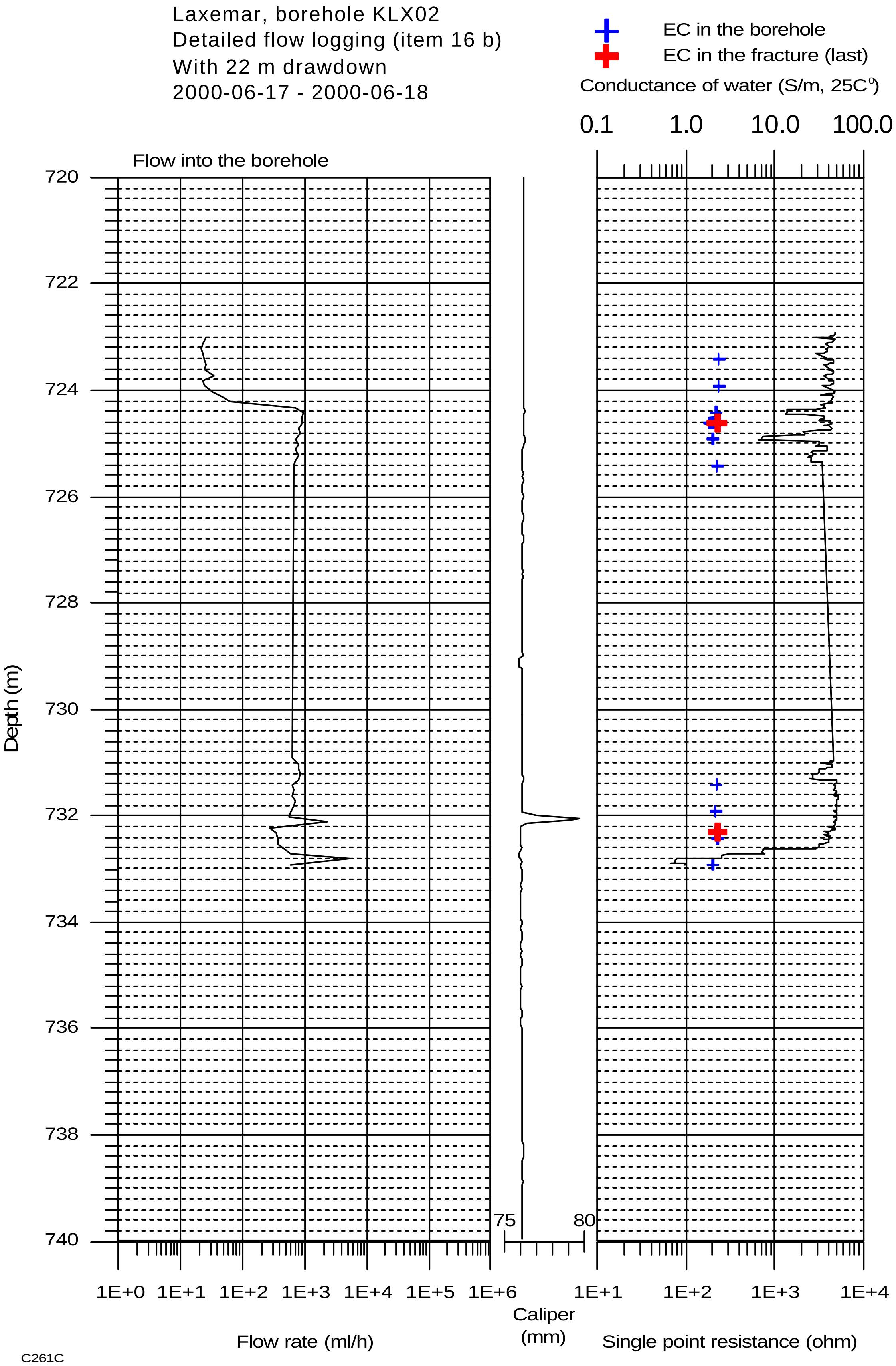


C280E

TIME SERIES OF ELECTRICAL CONDUCTIVITY
LAXEMAR, KLX02, DEPTHS BETWEEN 1000 AND 1400 M
2000-06-11 - 2000-06-17

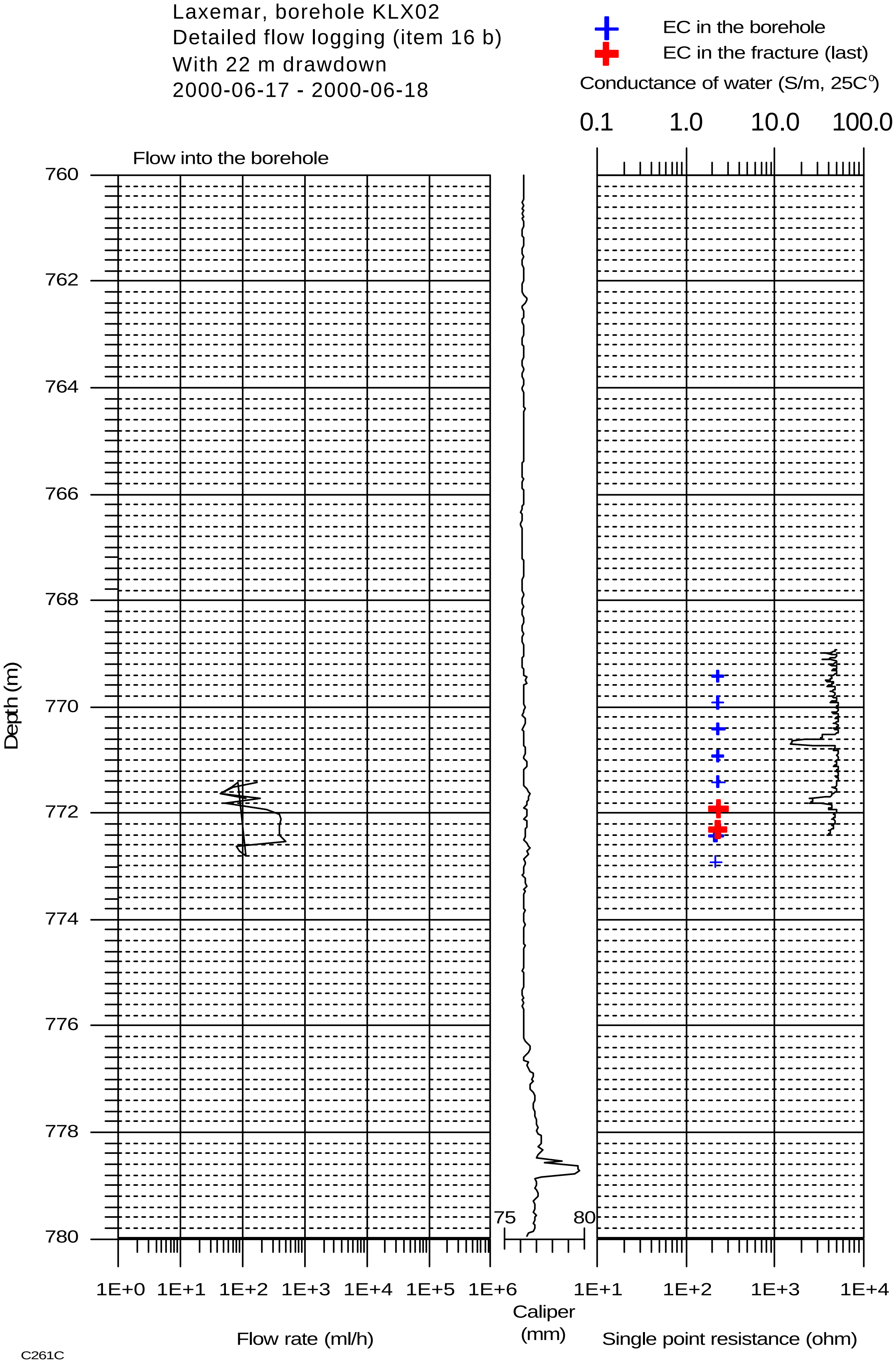


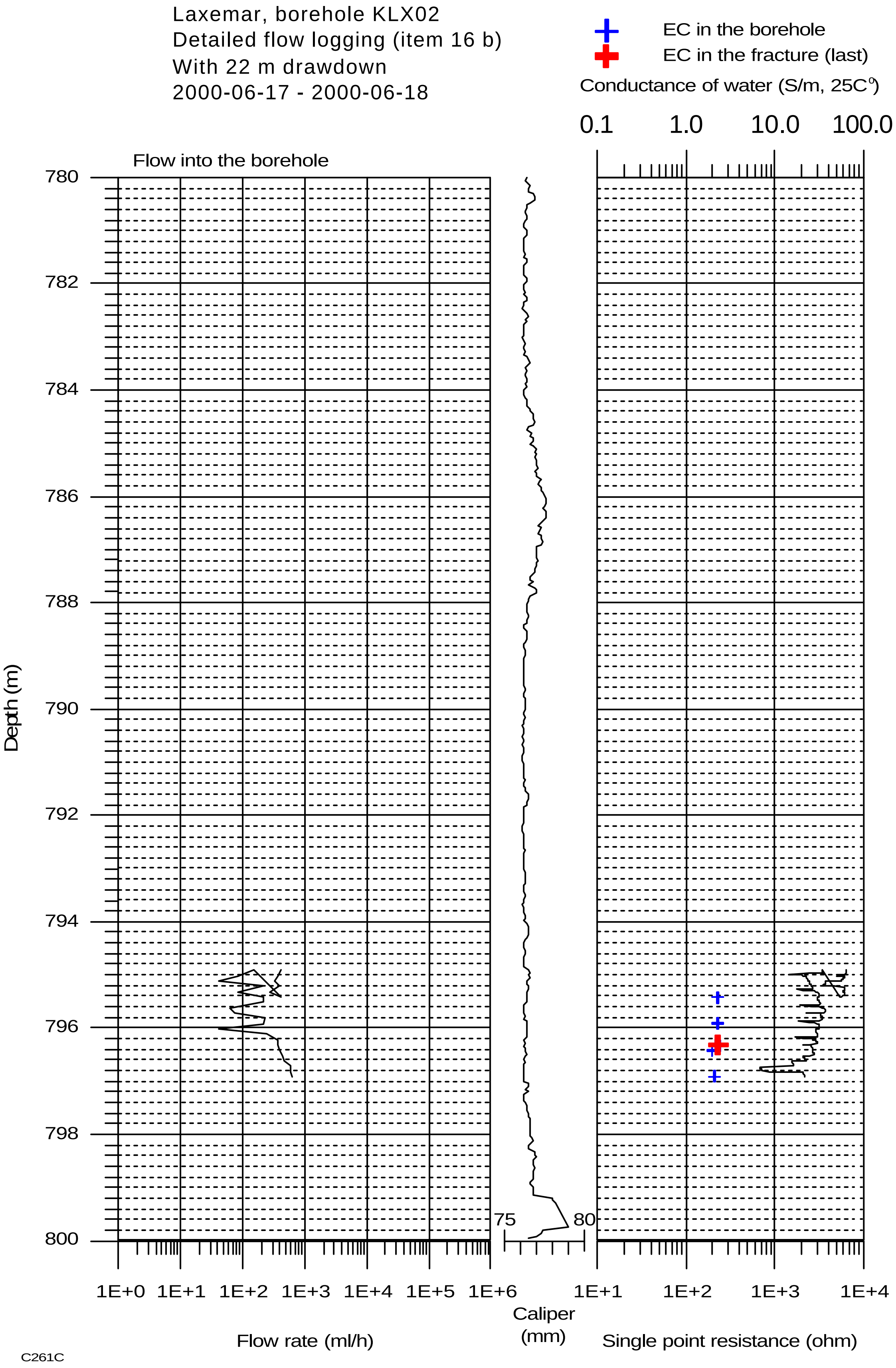
C280E

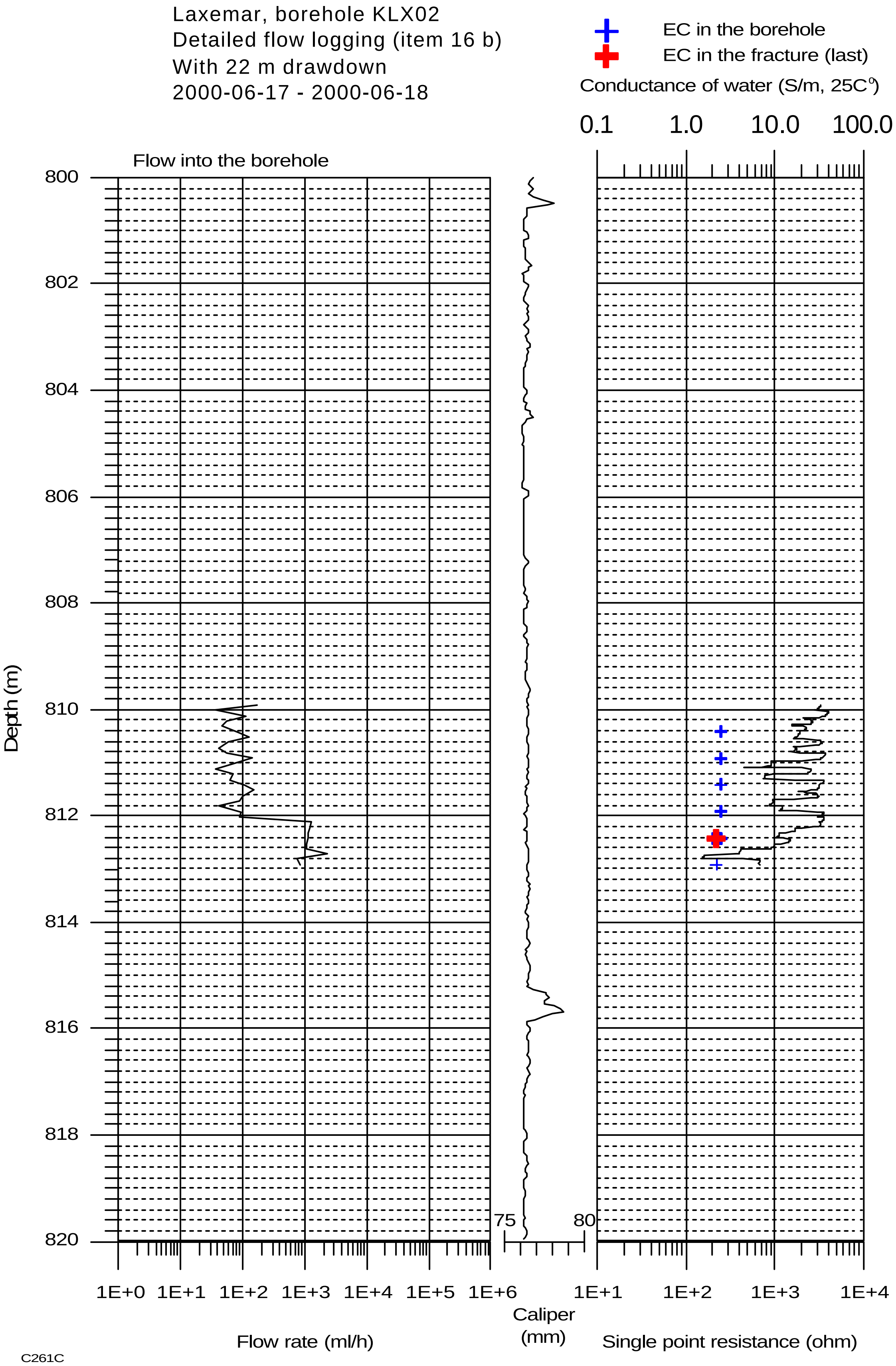


Laxemar, borehole KLX02
Detailed flow logging (item 16 b)
With 22 m drawdown
2000-06-17 - 2000-06-18
EC in the borehole
EC in the fracture (last)
Conductance of water (S/m, 25C°)
0.1
1.0
10.0
100.0
Flow into the borehole
Depth (m)
720
722
724
726
728
730
732
734
736
738
740
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
C261C

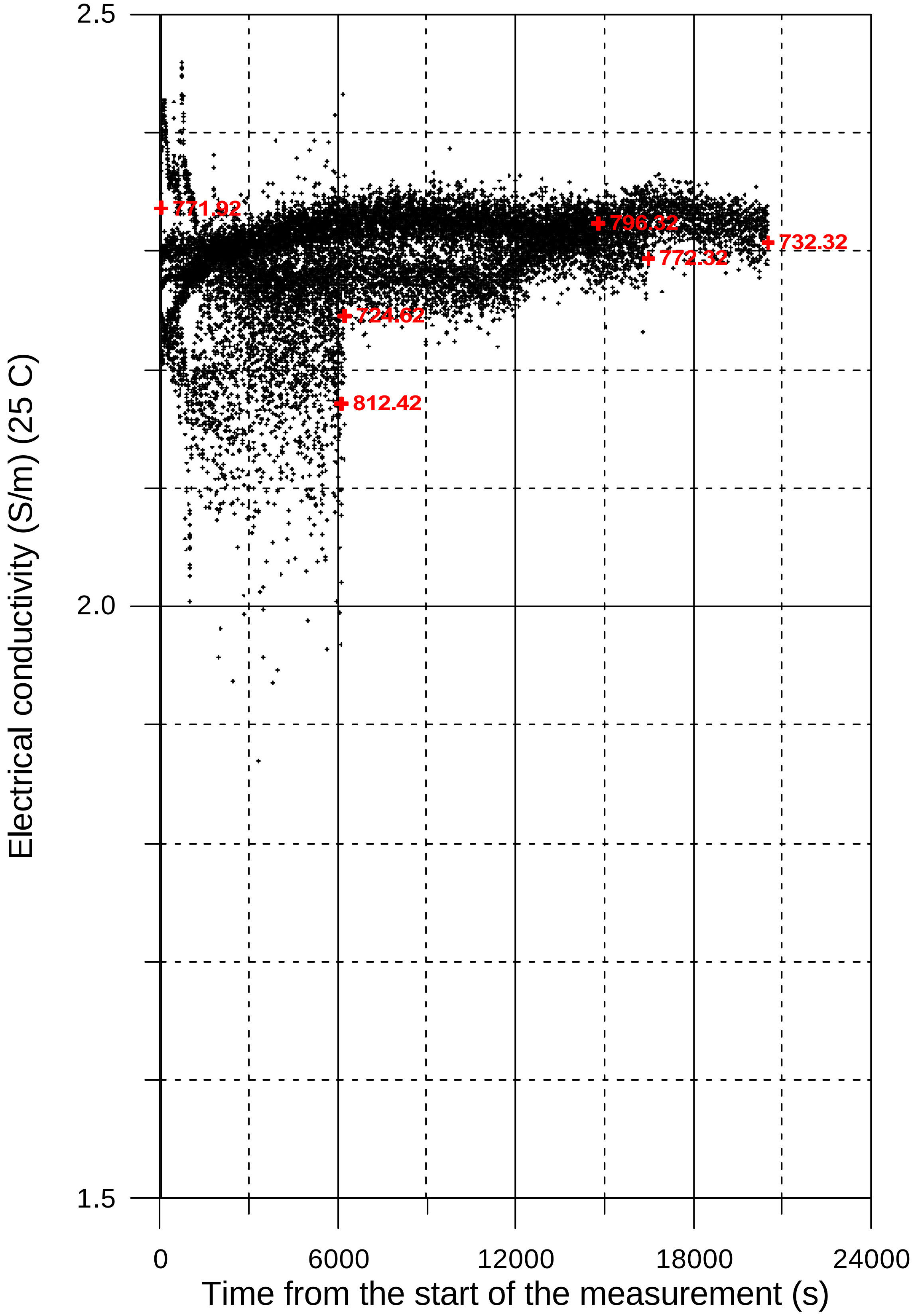
Laxemar, borehole KLX02
Detailed flow logging (item 16 b)
With 22 m drawdown
2000-06-17 - 2000-06-18




Laxemar, borehole KLX02
Detailed flow logging (item 16 b)
With 22 m drawdown
2000-06-17 - 2000-06-18
EC in the borehole
EC in the fracture (last)
Conductance of water (S/m, 25C°)
0.1
1.0
10.0
100.0
Flow into the borehole
780
782
784
786
788
790
792
794
796
798
800
Depth (m)
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper (mm)
Flow rate (ml/h)
Single point resistance (ohm)
C261C


Laxemar, borehole KLX02
Detailed flow logging (item 16 b)
With 22 m drawdown
2000-06-17 - 2000-06-18
EC in the borehole
EC in the fracture (last)
Conductance of water (S/m, 25C°)
0.1
1.0
10.0
100.0
Flow into the borehole
Depth (m)
800
802
804
806
808
810
812
814
816
818
820
75
80
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
1E+6
1E+1
1E+2
1E+3
1E+4
Caliper
(mm)
Flow rate (ml/h)
Single point resistance (ohm)
C261C

TIME SERIES OF ELECTRICAL CONDUCTIVITY
LAXEMAR, KLX02
2000-06-17 - 2000-06-18 (item 16 b)



C281E