P-06-199

Supplement 1

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Oskarshamn site investigation

Difference flow logging of boreholes KLX09B–F

Subarea Laxemar

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Description

In the present Supplement 1 to SKB P-06-199 Difference flowlogging of boreholes KLX09B–F, all groundwater head calculations for KLX09F have been redone on revised borehole elevation data (Z-coordinates).

The borehole coordinates that formed the basis for this revision of groundwater head data were retrieved from SKB Sicada 2007-03-07 EG154 (provided by SKB in file Krökdata_korrigerade_ 070307_KLX03-KLX29 utom KLX15, HLX13,15,26-28,32,36-38,43.xls) /Stenberg and Håkansson 2007/.

Some comments have been added to the fracture frequency tables and a displacement error in the fracture frequency graphs has also been fixed.

Specifically the following appendices are revised and included in this supplement;

Revised appendices	**Appendix number**
Conductive fracture frequency	Appendix B.9
Plotted conductive fracture frequency	Appendix B.10
Conductive fracture frequency	Appendix C.9
Plotted conductive fracture frequency	Appendix C.10
Conductive fracture frequency	Appendix D.9
Plotted conductive fracture frequency	Appendix D.10
Conductive fracture frequency	Appendix E.9
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Transmissivity and head of 5 m sections	Appendix F.3.2
Transmissivity and head of detected fractures	Appendix F.4
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Inferred flow anomalies from overlapping flow logging	Appendix F.7
Conductive fracture frequency	Appendix F.9
Plotted conductive fracture frequency	Appendix F.10
Comparison between section transmissivity and fracture transmissivity	Appendix F.11
Head in the borehole during flowlogging	Appendix F.12.1
Air pressure, water level in borehole and pumping rate during flow logging	Appendix F.12.2
Groundwater recovery after pumping	Appendix F.12.3
Flow logging with smaller injection	Appendices F.13.1–F.13.2

Reference

Stenberg L, Håkansson N, 2007. Revision of borehole deviation measurements in Oskarshamn. Svensk Kärnbränslehantering AB (in preparation).

Appendix B.9

Calculation of conductive fracture frequency

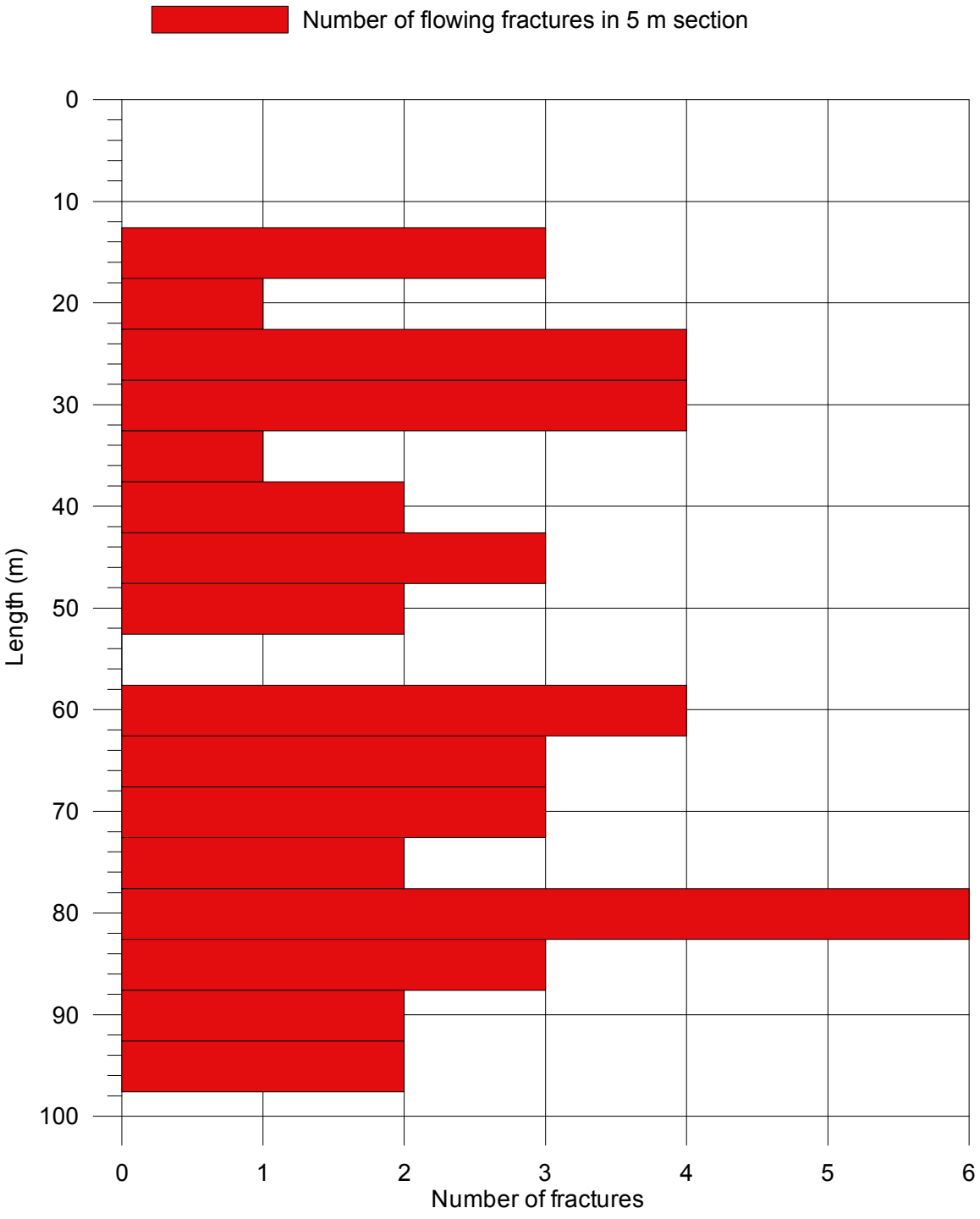
Borehole ID	Secup (m)	Seclow (m)	Number of fractures, total	Number of fractures 10–100 (ml/h)	Number of fractures 100–1,000 (ml/h)	Number of fractures 1,000–10,000 (ml/h)	Number of fractures 10,000–100,000 (ml/h)	Number of fractures 100,000–1,000,000 (ml/h)
KLX09B	12.6	17.6	3**,***	–	–	–	–	–
KLX09B	17.6	22.6	1**	–	–	–	–	–
KLX09B	22.6	27.6	4**	–	1	–	–	–
KLX09B	27.6	32.6	4	1	1	1	1	–
KLX09B	32.6	37.6	–	–	–	–	–	–
KLX09B	37.6	42.6	2	–	–	2	–	–
KLX09B	42.6	47.6	3	1	1	1	–	–
KLX09B	47.6	52.6	2	–	–	1	1	–
KLX09B	52.6	57.6	–	–	–	–	–	–
KLX09B	57.6	62.6	4	–	–	–	4	–
KLX09B	62.6	67.6	3	–	–	1	1	1
KLX09B	67.6	72.6	3	–	–	2	1	–
KLX09B	72.6	77.6	2	–	1	1	–	–
KLX09B	77.6	82.6	6	–	–	3	3	–
KLX09B	82.6	87.6	3	1	1	1	–	–
KLX09B	87.6	92.6	2	2	–	–	–	–
KLX09B	92.6	97.6	2	–	–	2	–	–

** Some fractures were detected during the injection measurements, but have been omitted because they are not comparable to the 1 m section pumping measurement.

*** Some fractures were not detected in the single-hole test.

Appendix B.10

Laxemar, borehole KLX09B
Calculation of conductive fracture frequency



Appendix C.9

Calculation of conductive fracture frequency

Borehole ID	Secup (m)	Seclow (m)	Number of fractures, total	Number of fractures 10–100 (ml/h)	Number of fractures 100–1,000 (ml/h)	Number of fractures 1,000–10,000 (ml/h)	Number of fractures 10,000–100,000 (ml/h)	Number of fractures 100,000–1,000,000 (ml/h)
KLX09C	16.36	21.36	2**,***	–	–	–	–	–
KLX09C	21.36	26.36	3***	–	–	–	1	–
KLX09C	26.36	31.36	3***	–	–	–	–	–
KLX09C	31.36	36.36	1	–	–	1	–	–
KLX09C	36.36	41.36	3***	–	–	1	–	–
KLX09C	41.36	46.36	2***	–	–	1	–	–
KLX09C	46.36	51.36	1***	–	–	–	–	–
KLX09C	51.36	56.36	2	–	–	1	1	–
KLX09C	56.36	61.36	1***	–	–	–	–	–
KLX09C	61.36	66.36	3	–	–	3	–	–
KLX09C	66.36	71.36	2***	–	–	1	–	–
KLX09C	71.36	76.36	2****	–	–	–	–	1
KLX09C	76.36	81.36	2***	–	–	1	–	–
KLX09C	81.36	86.36	4***	–	–	2	1	–
KLX09C	86.36	91.36	–	–	–	–	–	–
KLX09C	91.36	96.36	–	–	–	–	–	–
KLX09C	96.36	101.36	1	–	–	1	–	–
KLX09C	101.36	106.36	–	–	–	–	–	–
KLX09C	106.36	111.36	1	–	–	–	–	1
KLX09C	111.36	116.36	1	–	–	–	1	–

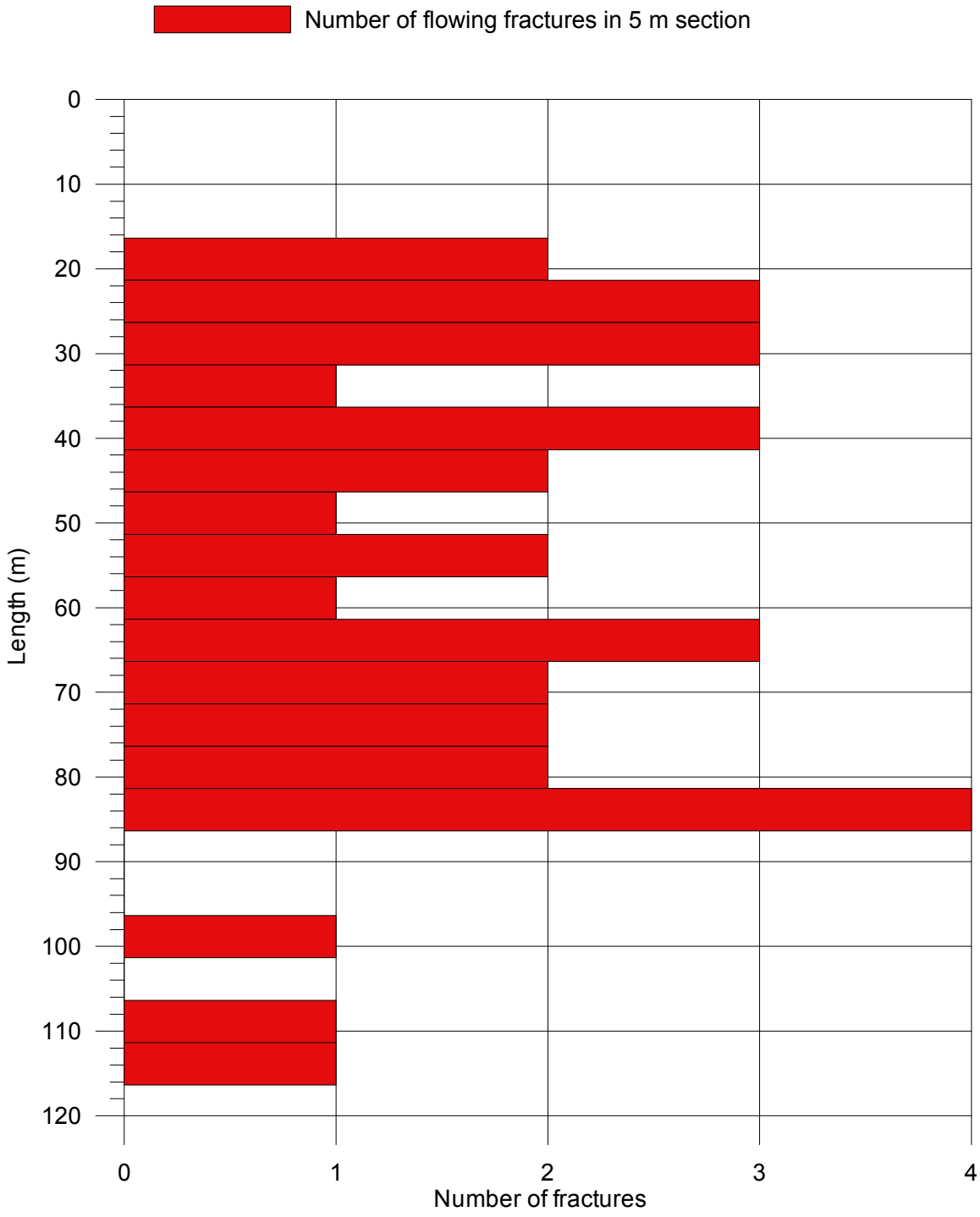
** Some fractures were detected during the injection measurements, but have been omitted because they are not comparable to the 1 m section pumping measurement.

*** Some fractures were not detected in the single-hole test.

**** Some fractures were detected during the smaller injection measurements, but have been omitted because they are not comparable to the 1 m section pumping measurement.

Appendix C.10

Laxemar, borehole KLX09C
Calculation of conductive fracture frequency



Appendix D.9

Calculation of conductive fracture frequency

Borehole ID	Secup (m)	Seclow (m)	Number of fractures, total	Number of fractures 10–100 (ml/h)	Number of fractures 100–1,000 (ml/h)	Number of fractures 1,000–10,000 (ml/h)	Number of fractures 10,000–100,000 (ml/h)	Number of fractures 100,000–1,000,000 (ml/h)
KLX09D	12.91	17.91	1**	–	–	–	–	–
KLX09D	17.91	22.91	3**	–	–	–	–	–
KLX09D	22.91	27.91	3**,***	–	–	1	–	–
KLX09D	27.91	32.91	2	–	1	–	1	–
KLX09D	32.91	37.91	2	–	2	–	–	–
KLX09D	37.91	42.91	1	–	–	1	–	–
KLX09D	42.91	47.91	1	–	1	–	–	–
KLX09D	47.91	52.91	2	–	–	1	1	–
KLX09D	52.91	57.91	3	–	–	2	1	–
KLX09D	57.91	62.91	–	–	–	–	–	–
KLX09D	62.91	67.91	4****	–	–	–	3	–
KLX09D	67.91	72.91	1	–	–	1	–	–
KLX09D	72.91	77.91	2****	–	1	–	–	–
KLX09D	77.91	82.91	2	–	1	1	–	–
KLX09D	82.91	87.91	7	–	2	3	2	–
KLX09D	87.91	92.91	–	–	–	–	–	–
KLX09D	92.91	97.91	1	–	–	1	–	–
KLX09D	97.91	102.91	2	–	1	1	–	–
KLX09D	102.91	107.91	–	–	–	–	–	–
KLX09D	107.91	112.91	2	–	2	–	–	–
KLX09D	112.91	117.91	2	–	1	1	–	–

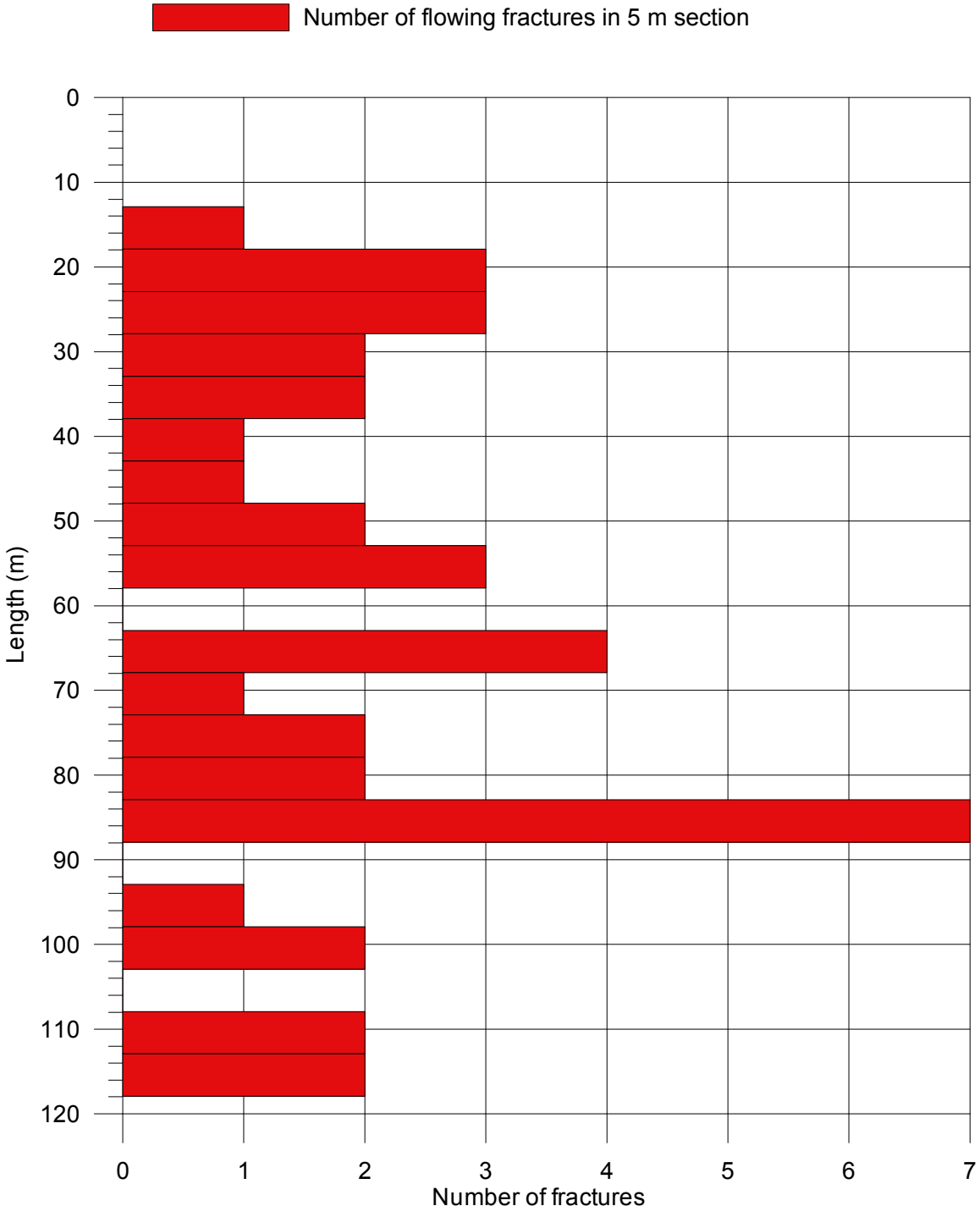
** Some fractures were detected during the injection measurements, but have been omitted because they are not comparable to the 1 m section pumping measurement.

*** Some fractures were not detected in the single-hole test.

**** Some fractures were detected during the smaller injection measurements, but have been omitted because they are not comparable to the 1 m section pumping measurement.

Appendix D.10

Laxemar, borehole KLX09D
Calculation of conductive fracture frequency



Appendix E.9

Calculation of conductive fracture frequency

Borehole ID	Secup (m)	Seclow (m)	Number of fractures, total	Number of fractures 10–100 (ml/h)	Number of fractures 100–1,000 (ml/h)	Number of fractures 1,000–10,000 (ml/h)	Number of fractures 10,000–100,000 (ml/h)	Number of fractures 100,000–1,000,000 (ml/h)
KLX09E	13.87	18.87	1**,***	–	–	–	–	–
KLX09E	18.87	23.87	1**, ***	–	–	–	–	–
KLX09E	23.87	28.87	2***	–	–	1	–	–
KLX09E	28.87	33.87	1***	–	–	–	–	–
KLX09E	33.87	38.87	2***	–	–	1	–	–
KLX09E	38.87	43.87	1***	–	–	–	–	–
KLX09E	43.87	48.87	2	–	1	1	–	–
KLX09E	48.87	53.87	1	–	–	1	–	–
KLX09E	53.87	58.87	1	–	–	1	–	–
KLX09E	58.87	63.87	1	–	–	1	–	–
KLX09E	63.87	68.87	2	–	–	1	1	–
KLX09E	68.87	73.87	4***	–	–	2	1	–
KLX09E	73.87	78.87	2***	–	–	–	–	–
KLX09E	78.87	83.87	2	–	–	1	1	–
KLX09E	83.87	88.87	1	–	–	–	1	–
KLX09E	88.87	93.87	1	–	–	1	–	–
KLX09E	93.87	98.87	3****	–	–	–	2	–
KLX09E	98.87	103.87	2	–	–	2	–	–
KLX09E	103.87	108.87	2	–	1	1	–	–
KLX09E	108.87	113.87	1****	–	–	–	–	–

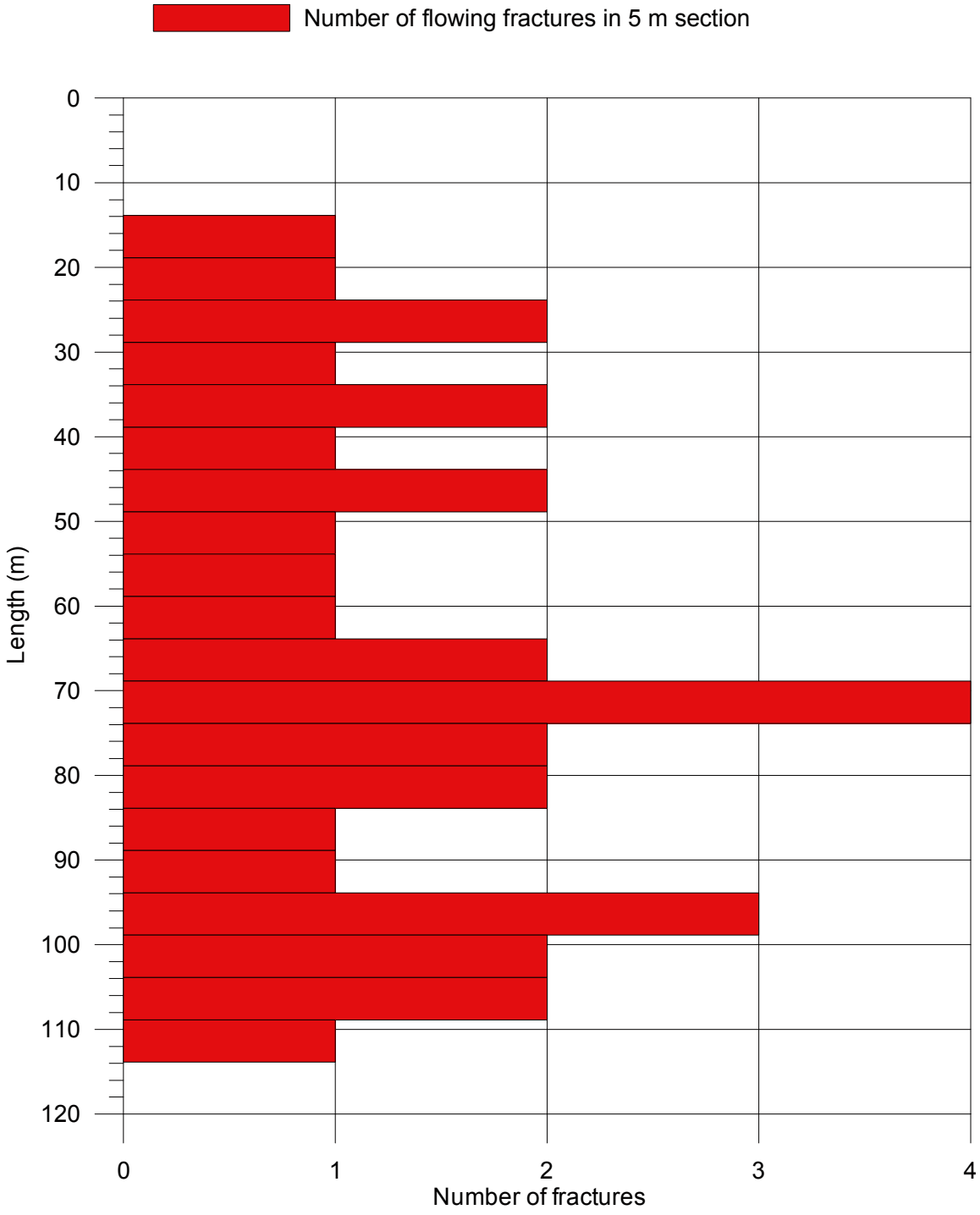
** Some fractures were detected during the injection measurements, but have been omitted because they are not comparable to the 1 m section pumping measurement.

*** Some fractures were not detected in the single-hole test.

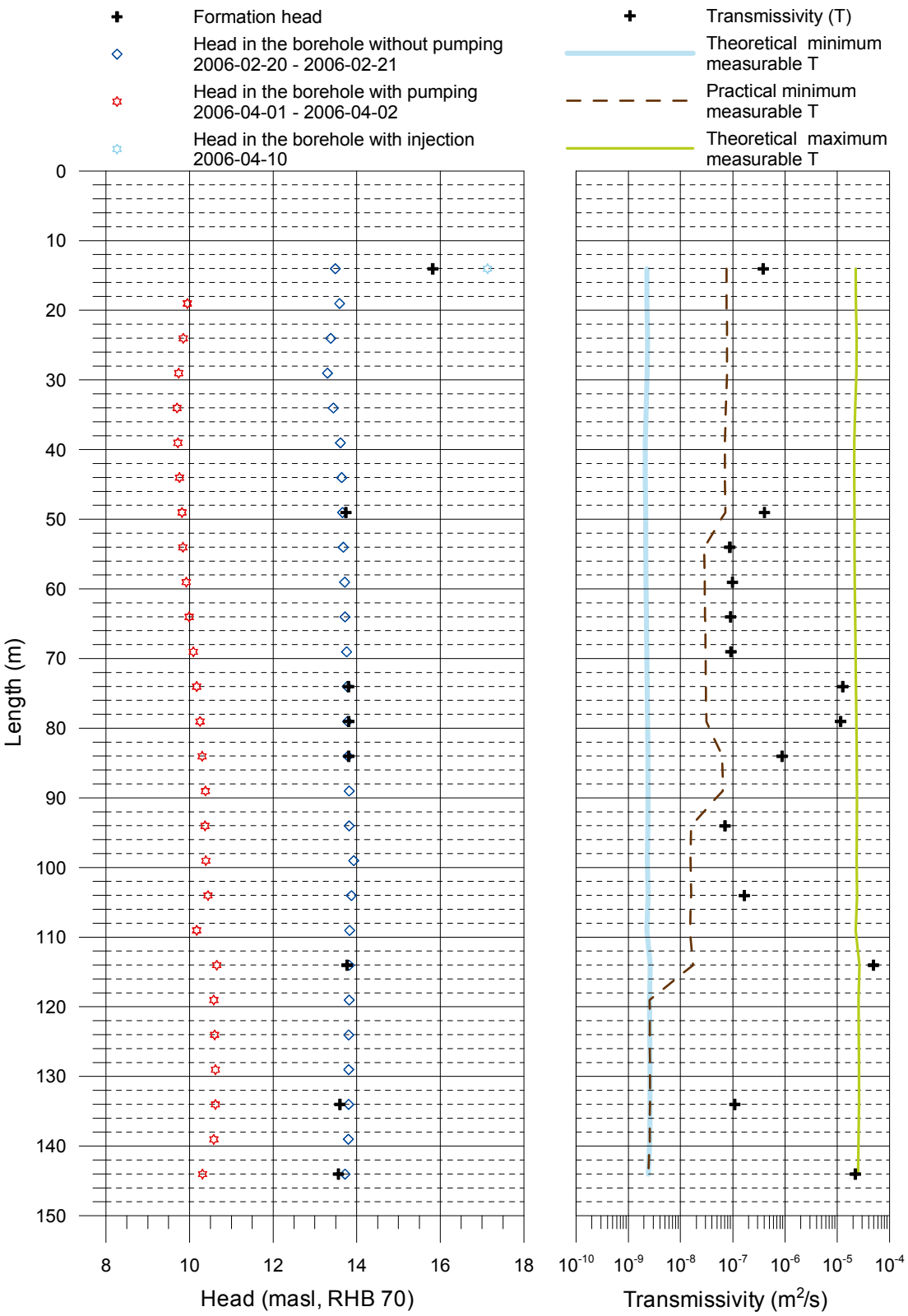
**** Some fractures were detected during the smaller injection measurements, but have been omitted because they are not comparable to the 1 m section pumping measurement.

Appendix E.10

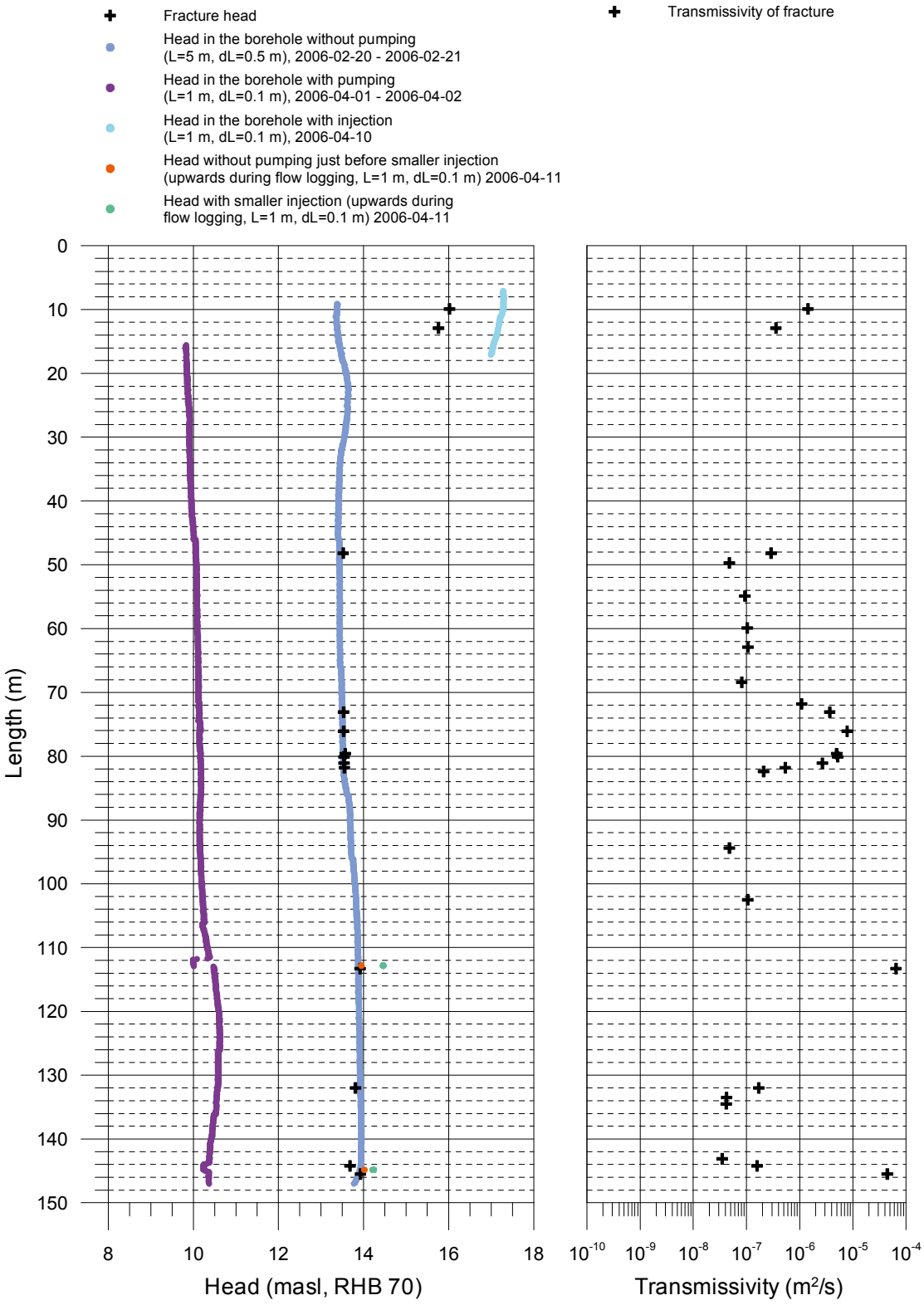
Laxemar, borehole KLX09E
Calculation of conductive fracture frequency



Laxemar, borehole KLX09F
Transmissivity and head of 5 m sections



Laxemar, borehole KLX09F
Transmissivity and head of detected fractures



Appendix F.6

Difference flow logging – Sequential flow logging

Borehole ID	Secup L (m)	Seclow L (m)	L_w (m)	Q_0 (m^3/s)	h_{0FW} (m.a.s.l.)	Q_1 (m^3/s)	h_{1FW} (m.a.s.l.)	T_D (m^2/s)	h_i (m.a.s.l.)	Q-lower limit P (mL/h)	TD-measl$_{LT}$ (m^2/s)	TD-measl$_{LP}$ (m^2/s)	TD-measl$_U$ (m^2/s)	Comments
KLX09F	11.53	16.53	5	9.00E–07	13.49	–5.06E–07	17.13	3.8E–07	15.8	1,000	2.3E–09	7.6E–08	2.2E–05	**
KLX09F	16.53	21.53	5	6.11E–08	13.59	–	9.95	–	–	1,000	2.3E–09	7.6E–08	2.3E–05	
KLX09F	21.53	26.53	5	–	13.38	–	9.85	–	–	1,000	2.3E–09	7.8E–08	2.3E–05	
KLX09F	26.53	31.53	5	4.17E–09	13.30	–	9.74	–	–	1,000	2.3E–09	7.7E–08	2.3E–05	
KLX09F	31.53	36.53	5	–	13.44	–	9.70	–	–	1,000	2.2E–09	7.4E–08	2.2E–05	
KLX09F	36.53	41.53	5	2.78E–09	13.61	–	9.72	–	–	1,000	2.1E–09	7.1E–08	2.1E–05	
KLX09F	41.53	46.53	5	–	13.64	–	9.76	–	–	1,000	2.1E–09	7.1E–08	2.1E–05	
KLX09F	46.53	51.53	5	3.42E–08	13.66	1.59E–06	9.82	4.0E–07	13.7	1,000	2.2E–09	7.2E–08	2.2E–05	
KLX09F	51.53	56.53	5	–	13.68	3.42E–07	9.84	8.8E–08	–	400	2.2E–09	2.9E–08	2.2E–05	
KLX09F	56.53	61.53	5	–	13.71	3.78E–07	9.92	9.9E–08	–	400	2.2E–09	2.9E–08	2.2E–05	
KLX09F	61.53	66.53	5	–	13.72	3.42E–07	9.99	9.1E–08	–	400	2.2E–09	3.0E–08	2.2E–05	
KLX09F	66.53	71.53	5	–	13.76	3.42E–07	10.09	9.2E–08	–	400	2.3E–09	3.0E–08	2.3E–05	
KLX09F	71.53	76.53	5	4.36E–07	13.77	4.69E–05	10.17	1.3E–05	13.8	400	2.3E–09	3.1E–08	2.3E–05	
KLX09F	76.53	81.53	5	3.89E–07	13.78	4.19E–05	10.25	1.2E–05	13.8	400	2.3E–09	3.1E–08	2.3E–05	
KLX09F	81.53	86.53	5	1.89E–08	13.79	3.14E–06	10.30	8.8E–07	13.8	800	2.4E–09	6.3E–08	2.4E–05	
KLX09F	86.53	91.53	5	–	13.82	–	10.38	–	–	800	2.4E–09	6.4E–08	2.4E–05	
KLX09F	91.53	96.53	5	–	13.82	2.47E–07	10.37	7.1E–08	–	200	2.4E–09	1.6E–08	2.4E–05	
KLX09F	96.53	101.53	5	–	13.93	–	10.39	–	–	200	2.3E–09	1.6E–08	2.3E–05	
KLX09F	101.53	106.53	5	–	13.87	5.75E–07	10.44	1.7E–07	–	200	2.4E–09	1.6E–08	2.4E–05	
KLX09F	106.53	111.53	5	–	13.83	–	10.17	–	–	200	2.3E–09	1.5E–08	2.3E–05	
KLX09F	111.53	116.53	5	–2.28E–06	13.82	1.56E–04	10.65	4.9E–05	13.8	200	2.6E–09	1.7E–08	2.7E–05	
KLX09F	116.53	121.53	5	–	13.82	–	10.58	–	–	30	2.5E–09	2.5E–09	2.5E–05	
KLX09F	121.53	126.53	5	–	13.81	–	10.60	–	–	30	2.6E–09	2.6E–09	2.6E–05	
KLX09F	126.53	131.53	5	–	13.81	–	10.62	–	–	30	2.6E–09	2.6E–09	2.6E–05	
KLX09F	131.53	136.53	5	–2.36E–08	13.81	3.28E–07	10.62	1.1E–07	13.6	30	2.6E–09	2.6E–09	2.6E–05	
KLX09F	136.53	141.53	5	–	13.80	–	10.58	–	–	30	2.6E–09	2.6E–09	2.6E–05	
KLX09F	141.53	146.53	5	–3.56E–06	13.72	7.33E–05	10.31	2.2E–05	13.6	30	2.4E–09	2.4E–09	2.5E–05	

** Values from the measurement with injection.

Appendix F.7

PFL – Difference flow logging – Inferred flow anomalies from overlapping flow logging

Borehole ID	Length to flow anom. L (m)	L_w (m)	dL (m)	Q_0 (m^3/s)	h_{0FW} (m.a.s.l.)	Q_1 (m^3/s)	h_{1FW} (m.a.s.l.)	T_D (m^2/s)	h_I (m.a.s.l.)	Comments
KLX09F	9.9	1	0.1	3.83E–06	13.38	–1.82E–06	17.28	1.4E–06	16.0	*, **
KLX09F	11.5	1	0.1	5.56E–09	13.37	–	17.21		–	**, ***
KLX09F	12.9	1	0.1	8.64E–07	13.38	–5.11E–07	17.17	3.6E–07	15.8	**
KLX09F	16.7	1	0.1	–	13.47	–	9.83		–	*, ***
KLX09F	17.2	1	0.1	5.28E–08	13.48	–	9.84		–	***
KLX09F	18.6	1	0.1	–	13.55	–	9.84		–	*, ***
KLX09F	24.0	1	0.1	–	13.63	–	9.88		–	***
KLX09F	30.7	1	0.1	4.17E–09	13.53	–	9.90		–	***
KLX09F	31.7	1	0.1	–	13.49	–	9.91		–	***
KLX09F	33.2	1	0.1	–	13.46	–	9.91		–	***
KLX09F	33.7	1	0.1	–	13.45	–	9.92		–	*, ***
KLX09F	35.5	1	0.1	–	13.44	–	9.92		–	***
KLX09F	38.5	1	0.1	3.89E–09	13.43	–	9.94		–	***
KLX09F	42.1	1	0.1	–	13.39	–	9.97		–	***
KLX09F	43.1	1	0.1	–	13.39	–	9.98		–	***
KLX09F	45.6	1	0.1	–	13.40	–	10.01		–	***
KLX09F	46.9	1	0.1	7.22E–09	13.43	–	10.05		–	***
KLX09F	48.2	1	0.1	2.31E–08	13.44	1.02E–06	10.06	2.9E–07	13.5	
KLX09F	49.7	1	0.1	–	13.43	1.61E–07	10.07	4.7E–08	–	
KLX09F	54.0	1	0.1	–	13.44	–	10.08		–	***
KLX09F	54.9	1	0.1	–	13.44	3.17E–07	10.08	9.3E–08	–	
KLX09F	59.9	1	0.1	–	13.44	3.47E–07	10.09	1.0E–07	–	
KLX09F	61.3	1	0.1	–	13.44	–	10.10		–	*, ***
KLX09F	62.9	1	0.1	–	13.44	3.61E–07	10.10	1.1E–07	–	
KLX09F	67.0	1	0.1	–	13.48	–	10.12		–	*, ***
KLX09F	68.4	1	0.1	–	13.49	2.78E–07	10.12	8.2E–08	–	
KLX09F	71.8	1	0.1	–	13.49	3.69E–06	10.14	1.1E–06	–	
KLX09F	73.1	1	0.1	1.58E–07	13.49	1.26E–05	10.14	3.7E–06	13.5	
KLX09F	76.1	1	0.1	2.66E–07	13.50	2.64E–05	10.17	7.8E–06	13.5	
KLX09F	79.6	1	0.1	2.61E–07	13.52	1.71E–05	10.17	5.0E–06	13.6	
KLX09F	80.1	1	0.1	1.33E–07	13.51	1.78E–05	10.16	5.2E–06	13.5	
KLX09F	81.1	1	0.1	4.89E–08	13.52	9.17E–06	10.17	2.7E–06	13.5	
KLX09F	81.8	1	0.1	1.17E–08	13.53	1.83E–06	10.17	5.4E–07	13.6	
KLX09F	82.4	1	0.1	–	13.53	7.11E–07	10.18	2.1E–07	–	
KLX09F	94.4	1	0.1	–	13.71	1.71E–07	10.16	4.8E–08	–	*
KLX09F	102.5	1	0.1	–	13.82	3.83E–07	10.22	1.1E–07	–	
KLX09F	113.3	1	0.1	–1.74E–06	13.95	–3.58E–05	14.47	6.5E–05	13.9	****
KLX09F	132.0	1	0.1	–1.89E–08	13.92	5.58E–07	10.57	1.7E–07	13.8	
KLX09F	133.5	1	0.1	–	13.93	1.44E–07	10.55	4.2E–08	–	*
KLX09F	134.5	1	0.1	–	13.94	1.43E–07	10.54	4.2E–08	–	
KLX09F	143.1	1	0.1	–	13.94	1.26E–07	10.38	3.5E–08	–	
KLX09F	144.2	1	0.1	–4.14E–08	13.94	5.50E–07	10.24	1.6E–07	13.7	
KLX09F	145.5	1	0.1	–4.19E–06	14.02	–1.36E–05	14.23	4.4E–05	13.9	****

* Uncertain = The flow rate is less than 30 mL/h or the flow anomalies are overlapping or they are unclear because of noise.

** Values from the measurement with injection.

*** Fracture not detected with pumping in single hole test.

**** Values from the measurement with smaller injection, water level used instead of Head for pressure difference.

Appendix F.9

Calculation of conductive fracture frequency

Borehole ID	Secup (m)	Seclow (m)	Number of fractures, total	Number of fractures 10–100 (ml/h)	Number of fractures 100–1,000 (ml/h)	Number of fractures 1,000–10,000 (ml/h)	Number of fractures 10,000–100,000 (ml/h)	Number of fractures 100,000–1,000,000 (ml/h)
KLX09F	6.53	11.53	2**,***	–	–	–	–	–
KLX09F	11.53	16.53	1**	–	–	–	–	–
KLX09F	16.53	21.53	3***	–	–	–	–	–
KLX09F	21.53	26.53	1***	–	–	–	–	–
KLX09F	26.53	31.53	1***	–	–	–	–	–
KLX09F	31.53	36.53	4***	–	–	–	–	–
KLX09F	36.53	41.53	1***	–	–	–	–	–
KLX09F	41.53	46.53	3***	–	–	–	–	–
KLX09F	46.53	51.53	3***	–	1	1	–	–
KLX09F	51.53	56.53	2***	–	–	1	–	–
KLX09F	56.53	61.53	2***	–	–	1	–	–
KLX09F	61.53	66.53	1	–	–	1	–	–
KLX09F	66.53	71.53	2***	–	1	–	–	–
KLX09F	71.53	76.53	3	–	–	–	3	–
KLX09F	76.53	81.53	3	–	–	–	3	–
KLX09F	81.53	86.53	2	–	–	2	–	–
KLX09F	86.53	91.53	–	–	–	–	–	–
KLX09F	91.53	96.53	1	–	1	–	–	–
KLX09F	96.53	101.53	–	–	–	–	–	–
KLX09F	101.53	106.53	1	–	–	1	–	–
KLX09F	106.53	111.53	–	–	–	–	–	–
KLX09F	111.53	116.53	1****	–	–	–	–	–
KLX09F	116.53	121.53	–	–	–	–	–	–
KLX09F	121.53	126.53	–	–	–	–	–	–
KLX09F	126.53	131.53	–	–	–	–	–	–
KLX09F	131.53	136.53	3	–	2	1	–	–
KLX09F	136.53	141.53	–	–	–	–	–	–
KLX09F	141.53	146.53	3****	–	1	1	–	–

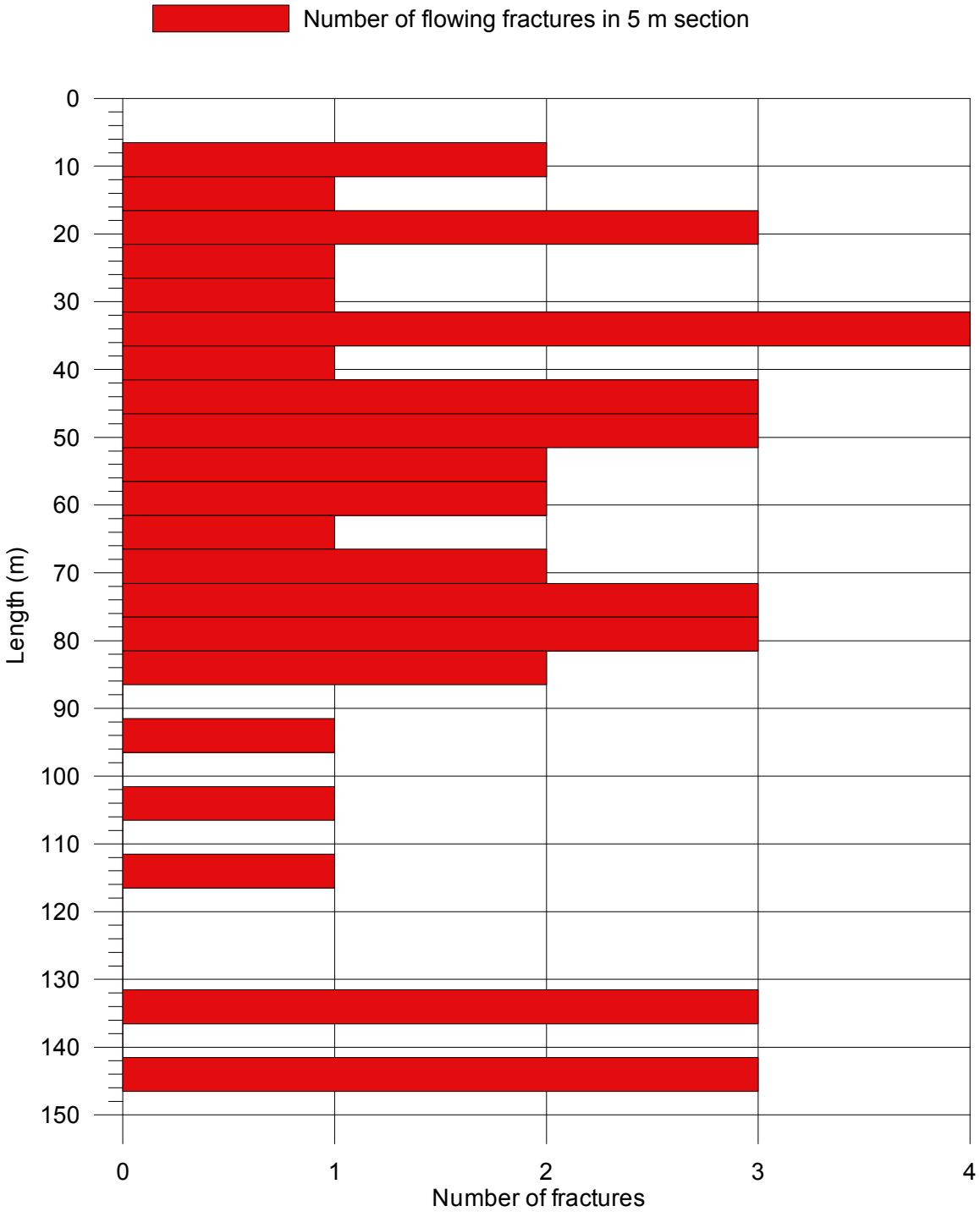
** Some fractures were detected during the injection measurements, but have been omitted because they are not comparable to the 1 m section pumping measurement.

*** Some fractures were not detected in the single-hole test.

**** Some fractures were detected during the smaller injection measurements, but have been omitted because they are not comparable to the 1 m section pumping measurement.

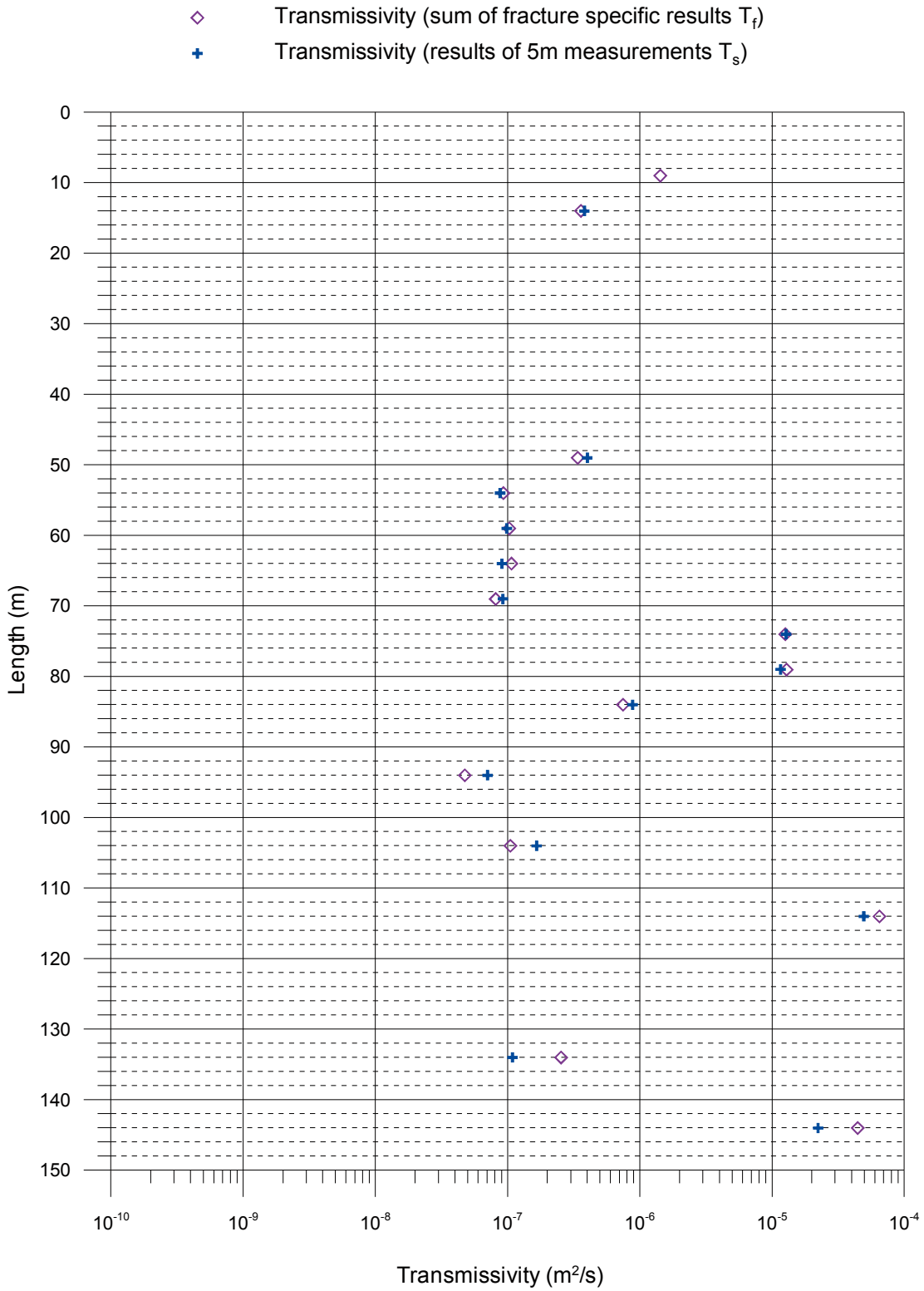
Appendix F.10

Laxemar, borehole KLX09F
Calculation of conductive fracture frequency



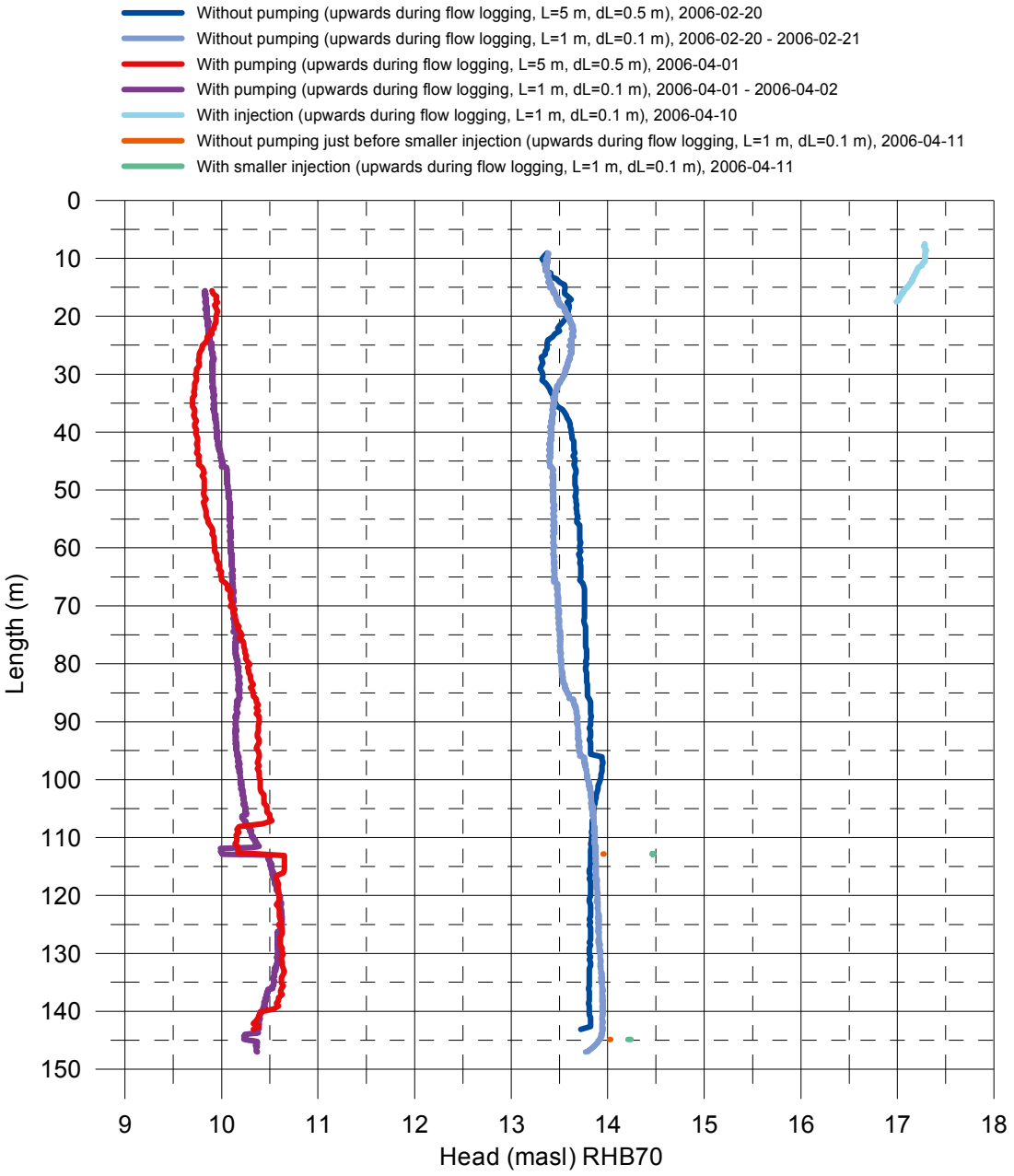
Appendix F.11

Laxemar, borehole KLX09F
Comparison between section transmissivity and fracture transmissivity

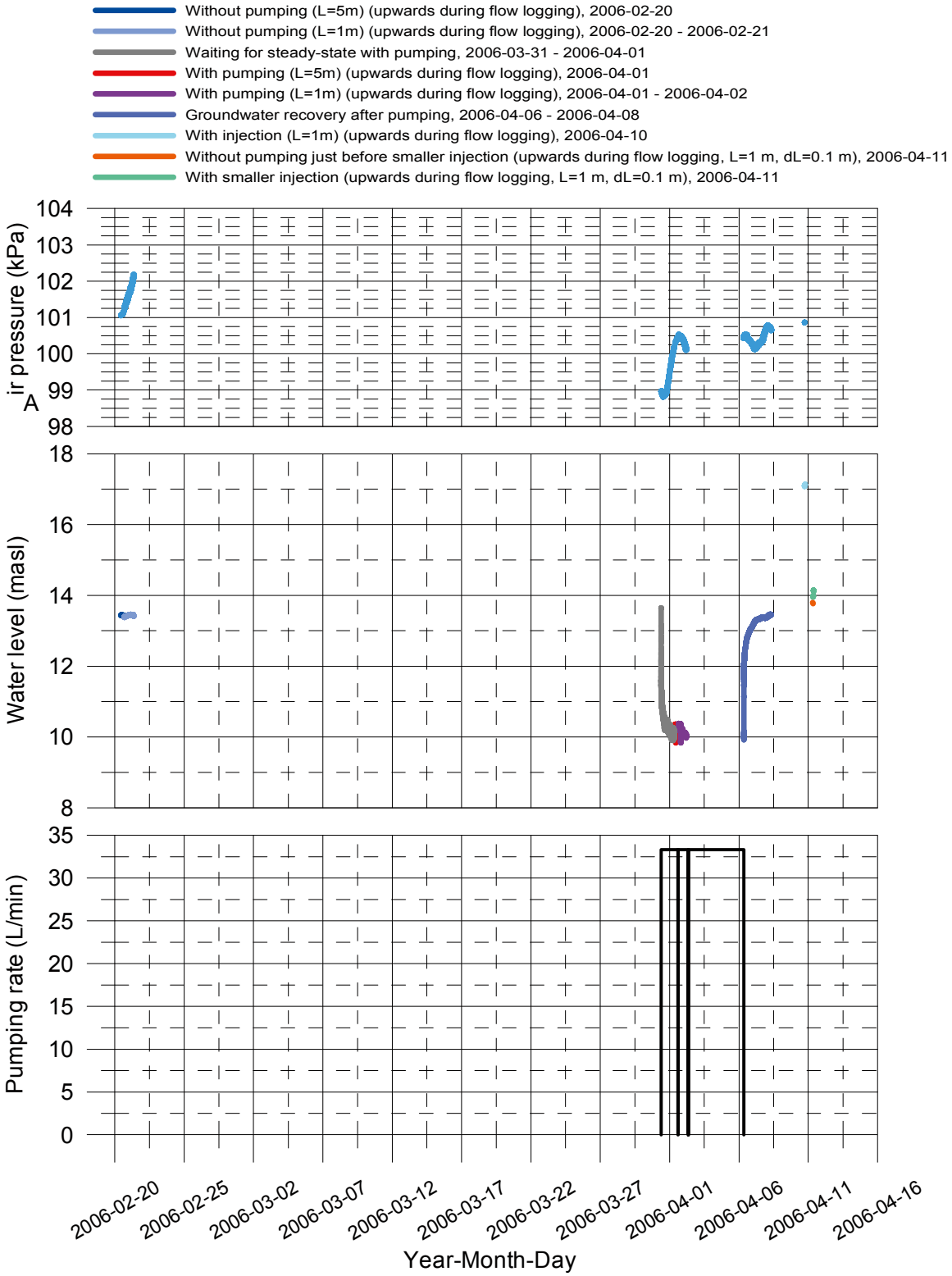


Laxemar, borehole KLX09F
Head in the borehole during flow logging

Head(masl)= (Absolute pressure (Pa) - Airpressure (Pa) + Offset) /(1000 kg/m^3 * 9.80665 m/s^2) + Elevation (m)
Offset = 2460 Pa (Correction for absolut pressure sensor)



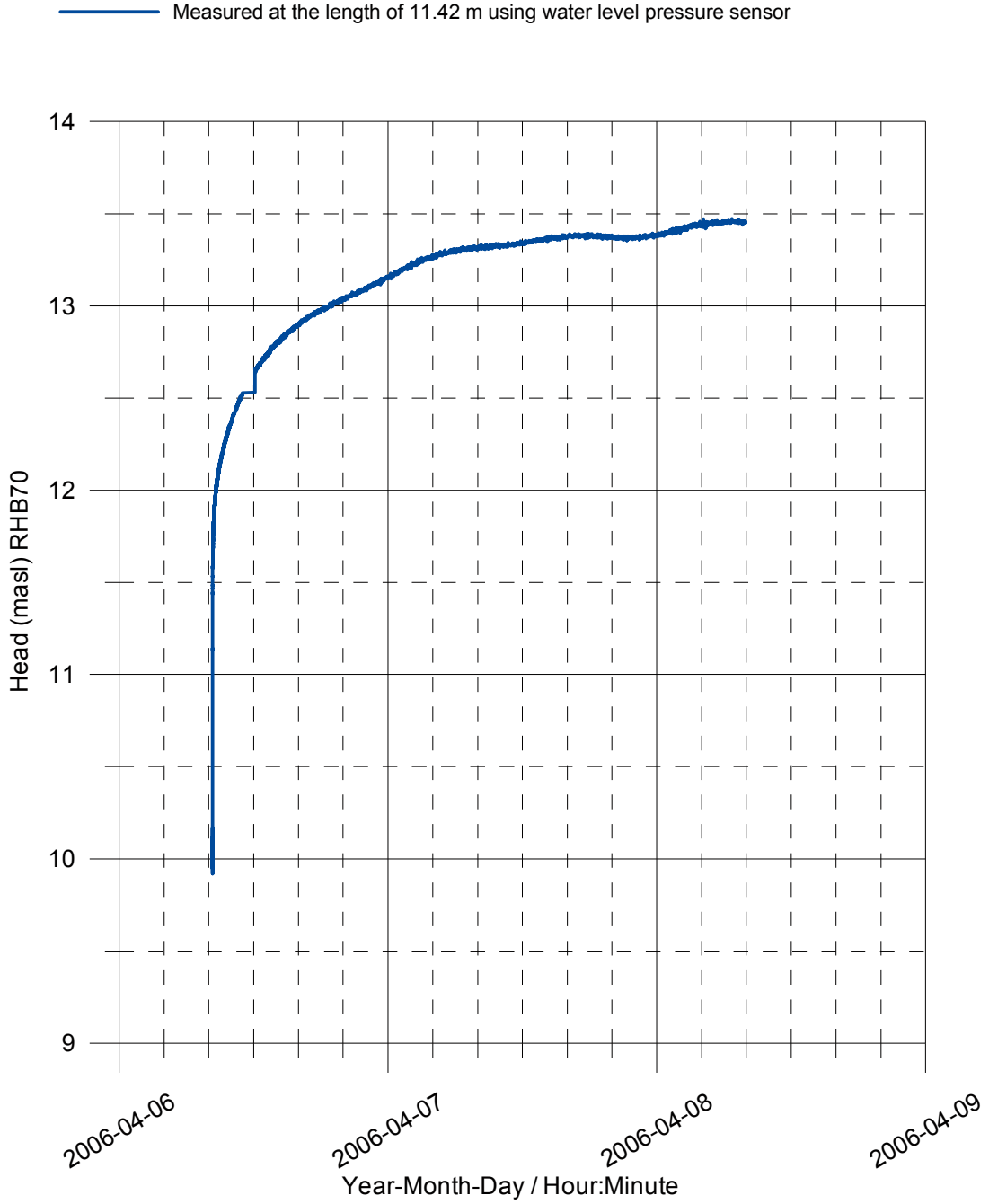
Laxemar, borehole KLX09F
Air pressure, water level in the borehole and pumping rate during flow logging



Appendix F.12.3

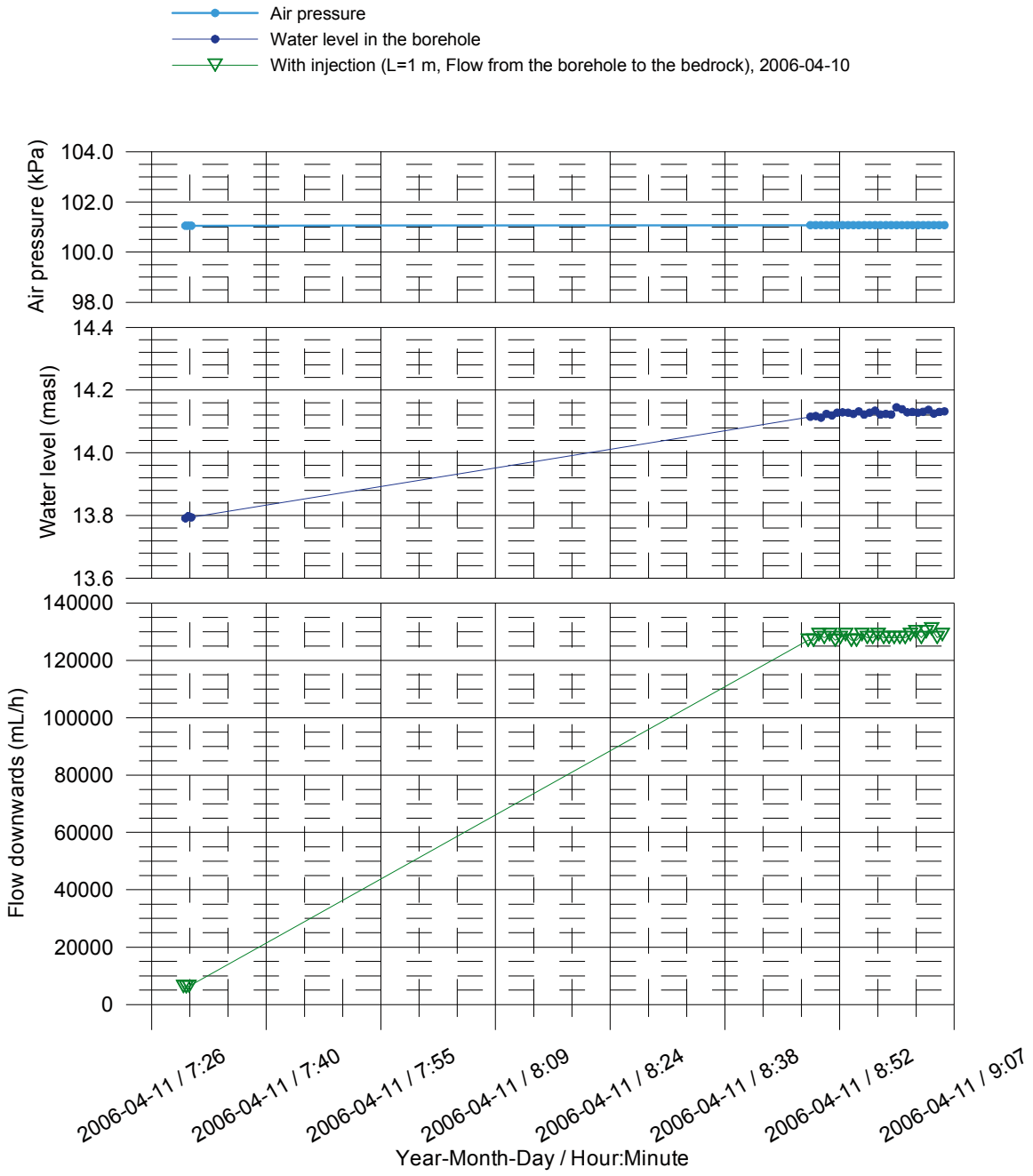
Laxemar, borehole KLX09F
Groundwater recovery after pumping

Head(masl)= (Absolute pressure (Pa) - Airpressure (Pa) + Offset) /(1000 kg/m^3 * 9.80665 m/s^2) + Elevation (m)
Offset = 2460 Pa (Correction for absolut pressure sensor)



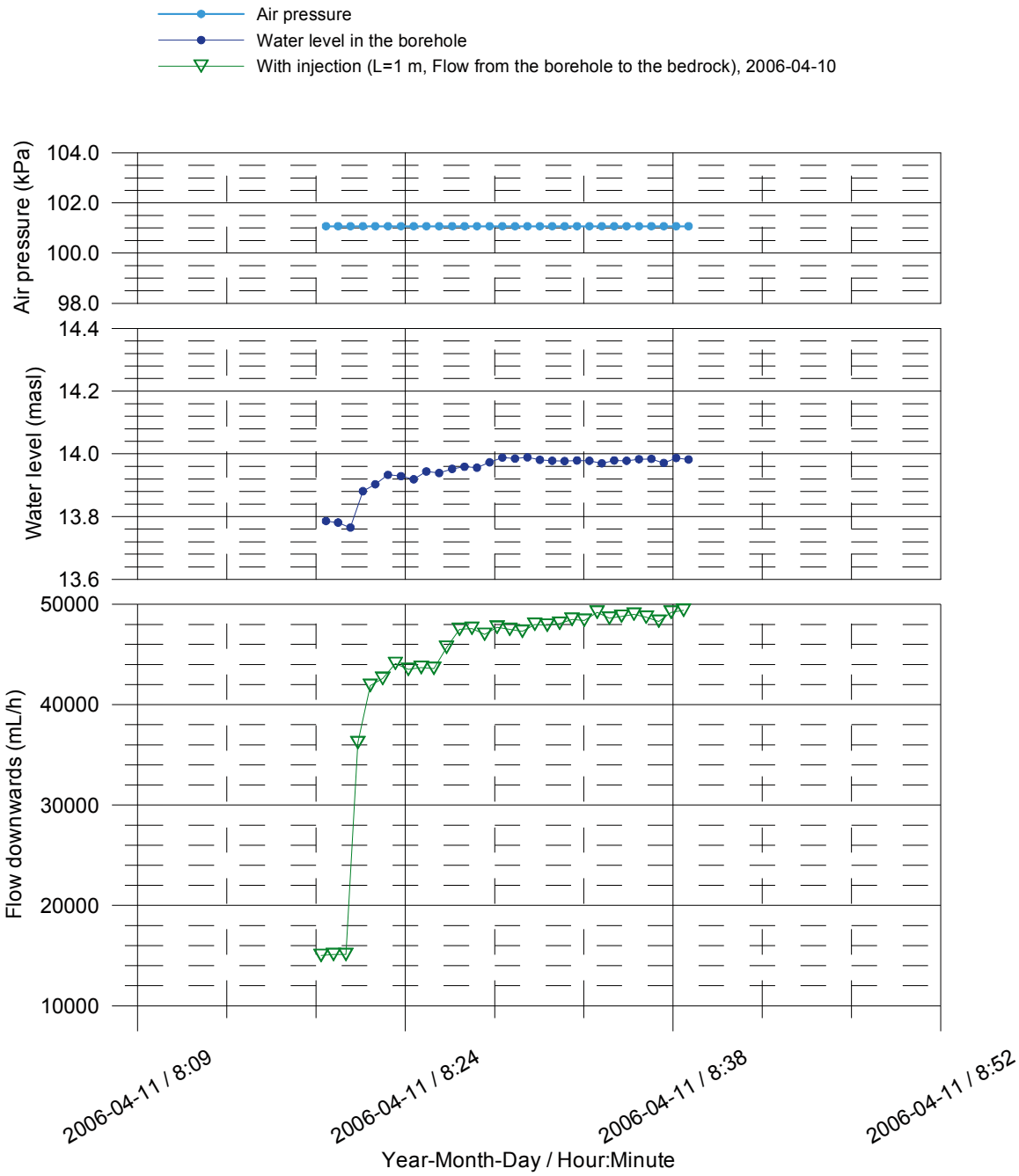
Appendix F.13.1

Laxemar, borehole KLX09F
Flow logging with injection at the length 112.8 m



Appendix F.13.2

Laxemar, borehole KLX09F
Flow logging with injection at the length 144.8 m



CM Gruppen AB, Bromma, 2008