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Oskarshamn site investigation

Hydraulic interference tests of HLX27, HLX28, HLX32 and single hole pumping test of KLX27A

Subarea Laxemar

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Abstract

This report documents the results from 4 interference tests performed in the Laxemar subarea between November 2004 and June 2007. The active boreholes used for pumping are HLX27, HLX28 and HLX32. Pumping borehole HLX27 was used for two different interference tests, November 2004 and May/June 2007. At each interference test the pressure responses in a number of observation boreholes were monitored and evaluated.

The report also include the evaluation of the single pumping test of the upper percussion drilled part, down to 75 m of KLX27A

The main purposes of the interference tests were to document how different fracture zones of the rock are connected hydraulically, to quantify their hydraulic properties and to clarify whether there are any hydraulic boundaries in the area.

The interference tests were performed by pumping and creating a drawdown in the pumping borehole while registering the pressure responses in some adjacent observation sections. The pressure was monitored in totally 60 sections in 20 observation boreholes during the interference tests.

The flow period of the interference tests lasted from about 4 h to 8 days and several responses were detected. All observation sections with a detected response as well as the pumping boreholes were evaluated quantitatively using methods for transient evaluation. Due to occasionally long distances and/or relatively bad hydraulic connection to the pumping borehole the results from the transient evaluation of the observation sections may be uncertain. It is possible that the evaluated transmissivity values more reflect the hydraulic conditions close to the pumping borehole rather than the conditions adjacent to the evaluated observation boreholes in such cases. Most of the estimated hydraulic diffusivity based on the response times for the selected sections was in rather good agreement with the corresponding estimates from the transient analysis.

Several observation sections were influenced by tidal effects, and probably to some extent also by changes of the sea level. Primarily due to the tidal effects the pressure data from certain observation sections exhibit an oscillating behaviour.

Sammanfattning

Denna rapport innehåller resultaten från 4 interferenstest som har genomförts i Laxemarområdet mellan november 2004 och juni 2007. De borrhål som använts som pumphål är HLX27, HLX28 and HLX32. Pumphål HLX27 användes för två olika interferenstest, dels i november 2004 dels i månadsskiftet maj/juni 2007. Vid varje interferenstest har responsen i ett antal observationshål mätts och utvärderats.

Rapporten inkluderar även en utvärdering av den övre hammarborrade delen till 75 av KLX27A.

Huvudsyftet med de utförda interferenstesterna var att dokumentera hur spricksystemen i berget hänger ihop hydrauliskt, kvantifiera bergets hydrauliska egenskaper samt att klargöra om det finns några hydrauliska gränser inom området.

Interferenstesterna utfördes genom att en tryckavsänkning skapades genom pumpning i pumphålet samtidigt som tryckresponser registrerades i olika observationssektioner i ett flertal omgivande borrhål. Trycket registrerades i sammanlagt 60 observationssektioner i 20 borrhål under interfenstesterna.

Flödesperioden pågick i mellan cirka 4 timmar och 8 dagar för de olika pumpningarna och ett flertal responser detekterades. Alla pumphål samt de observationssektioner där respons detekterades har utvärderats kvantitativt med metoder för transient utvärdering. Resultaten från den transienta utvärderingen av observationshålen kan vara osäkra på grund av de emellanåt långa avstånden till, och/eller den relativt dåliga hydrauliska kontakten med pumphålet. I dessa fall är det möjligt att de utvärderade transmissiviteterna återspeglar de hydrauliska förhållandena i närheten av pumphålet snarare än förhållandena runt de utvärderade observationshålen. Likväl stämde de flesta av de utifrån responstiden beräknade hydrauliska diffusiviteterna relativt väl överens med motsvarande hydrauliska diffusivitet beräknad utifrån den transienta analysen.

Många observationssektioner är påverkade av tidaleffekter, samt troligen även av effekter orsakade av ändrat vattenstånd i havet. Vissa berörda sektioner uppvisar ett oscillerande beteende beroende på framförallt tidaleffekterna.

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1 Introduction

This report documents the results from 4 hydraulic interference tests performed within the site investigation in the subarea Laxemar at Oskarshamn. Interference tests are performed in order to study how different fracture zones are connected hydraulically, to quantify their hydraulic properties and to clarify whether there are any major hydraulic boundaries in the area. The locations of the boreholes involved in the interference tests are shown in Figure 1-1. The tests were carried out in between November 2004 and June 2007.

The interference tests and the evaluation of the tests have been made according to the activity plans and method descriptions listed in Table 1-1. Both the activity plans and method descriptions are internal controlling documents of SKB.

The 4 boreholes used as pumping boreholes and the surrounding boreholes which served as observation boreholes are listed in Table 1-2. There are two pumping tests made in bore hole HLX27, one that started 041118 and one at 070530. The one started in 2004-11-18 is further on denoted HLX27 (2004) and the one started 2007-05-30 is denoted HLX27 (2007). The times referred to in Table 1-2 are the chosen start and stop times of the flow period.

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

Pumping borehole	Activity plan number (execution)	Activity plan number (evaluation)
HLX27 (2004)	AP PS 400-04-105	AP PS 400-04-105
HLX27 (2007)	AP PS 400-07-52	AP PS 400-07-25
HLX28	AP PS 400-07-48	AP PS 400-07-25
HLX32	AP PS 400-04-105	AP PS 400-04-105
Kärnborrning KLX27A	AP PS 400-07-58	AP PS 400-07-58
Method documents	**Number**	**Version**
Instruktion för analys av injektions- och enhålspumptester	SKB MD 320.004	1.0
Metodbeskrivning av hydrauliska enhålspumptester	SKB MD 321.003	1.0
Metodbeskrivning för interferenstester	SKB MD 330.003	1.0

Table 1-2. Tests performed.

Pumping borehole	Observation borehole	Test start date and time (YYYY-MM-DD tt:mm)	Test stop date and time (YYYY-MM-DD tt:mm)
HLX27 (2004)	HLX15, HLX26, HLX28	2004-11-18 10:59	2004-11-26 11:50
HLX27 (2007)	KLX15A, HLX26, HLX38, HLX42, KLX19A, KLX05A, KLX03	2007-05-30 11:17	2007-06-02 12:02
HLX28	KLX19A, KLX20A, KLX14A, HLX32, HLX36, HLX37, HLX38	2007-04-05 14:52	2007-04-10 08:51
HLX32	HLX26, HLX27, HLX28	2005-04-05 10:40	2005-04-05 14:25
KLX27A	–	2007-08-22 18:10	2007-08-23 06:05

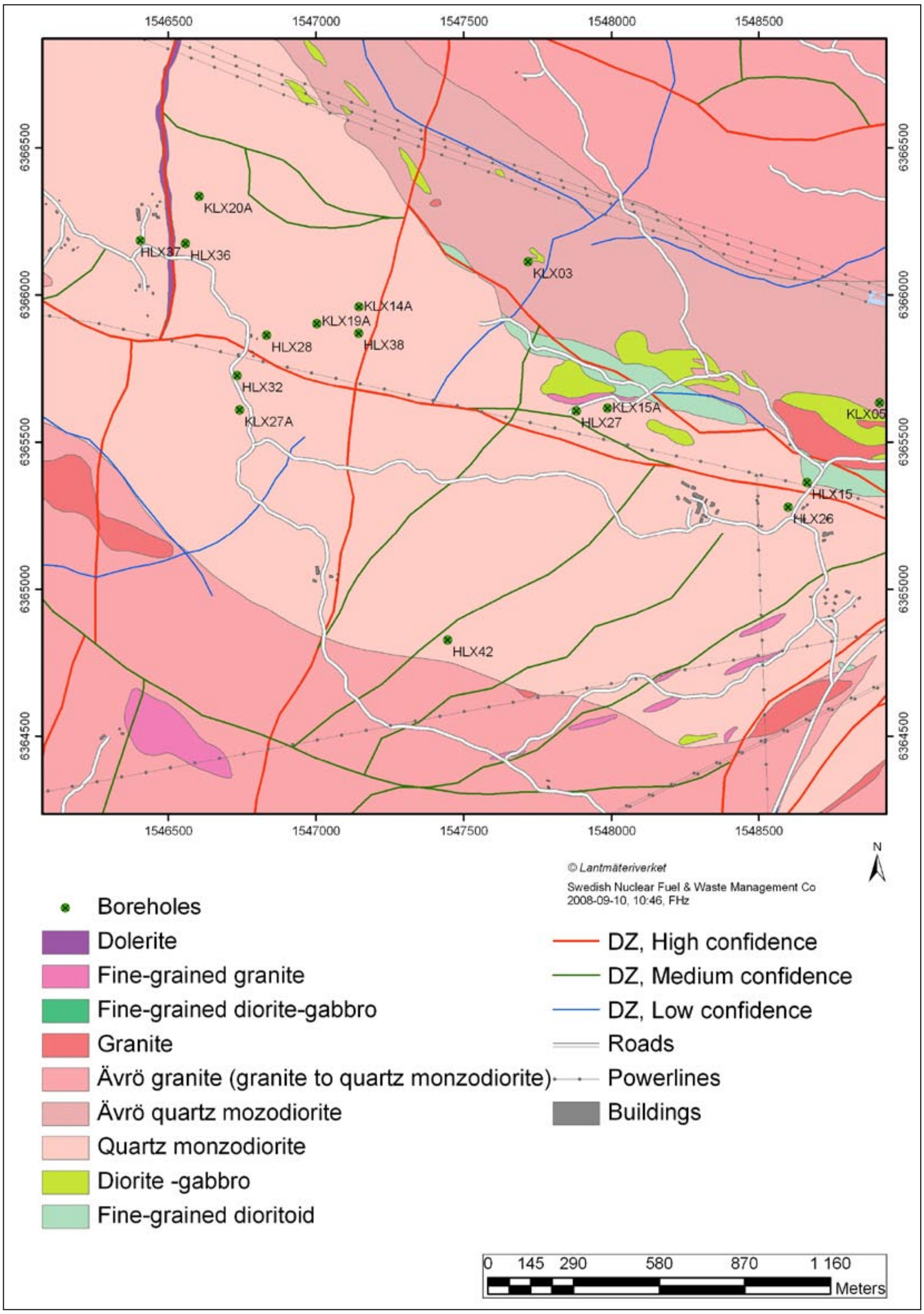


Figure 1-1. *The positions of the boreholes included in the tests in subarea Laxemar.*

2 Objectives

The main aim of hydraulic interference tests is to get support for interpretations of geologic structures in regard to their hydraulic and geometric properties deduced from single-hole tests. Furthermore, interference tests may provide information about the hydraulic connectivity and hydraulic boundary conditions within the tested area. Finally, interference tests make up the basis for calibration of numerical models of the area.

The interference tests were performed by pumping in altering boreholes and monitoring pressure responses in different observation sections in surrounding boreholes. All boreholes monitored for responses are part of the HMS, the Hydro Monitoring System at Oskarshamn. In total, 60 sections in 20 observation boreholes were included in the interference tests.

3 Scope

3.1 Boreholes tested

Technical data of the boreholes included in the interference tests are presented in Table 3-1. Some of the boreholes that, according to the Activity Plans, were intended to be included in the interference tests did not supply any pressure data during some of the tests and were therefore excluded from these tests. These boreholes are listed in Section 5.6.

The reference point in the boreholes is always top of casing (ToC). The Swedish National coordinate system (RT90 2.5 gon V) is used in the x-y-direction together with RHB70 in the z-direction. The coordinates of the boreholes at ground surface are shown in Table 3-2. All section positions are given as length along the borehole (not vertical distance from ToC). All times presented are Swedish summer times, i.e. when appropriate; adjustment for daylight saving time has been made for all reported times.

Table 3-1. Pertinent technical data of the boreholes included in the four interference tests. (From Sicada).

Borehole data							
Bh ID	Elevation of top of casing (ToC) (m.a.s.l.)	Borehole interval from ToC (m)	Casing (inner)/ Bh-diam. (m)	Inclination-top of bh (from horizontal plane) (º)	Dip-direction-top of bore-hole (from local N) (º)	Remarks	Drilling finished Date (YYYY-MM-DD)
KLX03	18.49	0.10–11.95	0.347	–74.93	199.04	Borehole	2004-09-07
		11.95–100.35	0.253			Borehole	
		100.35–101.40	0.086			Borehole	
		101.40–1,000.42	0.076			Borehole	
		0.00–100.00	0.200			Casing ID	
		0.10–11.65	0.311			Casing ID	
		100.00–100.05	0.170			Casing ID	
KLX05	17.63	0.00.12.60	0.343	–65.12	189.72	Borehole	2005-01-22
		12.60–15.00	0.250			Borehole	
		15.00–75.10	0.195			Borehole	
		75.10–108.01	0.086			Borehole	
		108.01–1,000.16	0.076			Borehole	
		0.00–15.00	0.200			Casing ID	
		0.10–12.60	0.310			Casing ID	
KLX14A	16.35	0.30–3.20	0.116	–49.96	111.95	Borehole	2006-09-04
		3.20–6.45	0.096			Borehole	
		6.45–176.27	0.076			Borehole	
		0.00–6.45	0.077			Casing ID	
KLX15A	14.59	0.30–6.00	0.341	–54.42	198.83	Borehole	2007-02-25
		6.00–11.65	0.233			Borehole	
		11.65–76.03	0.198			Borehole	
		76.03–76.13	0.165			Borehole	
		76.13–76.71	0.086			Borehole	
		76.71–77.58	0.086			Borehole	
		77.58–1,000.43	0.076			Borehole	
		0.00–11.65	0.210			Casing ID	
		0.30–6.00	0.310			Casing ID	

Borehole data							
Bh ID	**Elevation of top of casing (ToC)** (m.a.s.l.)	**Borehole interval from ToC** (m)	**Casing (inner)/ Bh-diam.** (m)	**Inclination-top of bh (from horizontal plane)** (º)	**Dip-direction-top of bore-hole (from local N)** (º)	**Remarks**	**Drilling finished** Date (YYYY-MM-DD)
KLX19A	16.87	0.20–6.30	0.339	–57.78	197.13	Borehole	2006-09-20
		6.30–70.00	0.254			Borehole	
		70.00–99.33	0.253			Borehole	
		99.33–100.73	0.086			Borehole	
		100.73–800.07	0.076			Borehole	
		520.30–522.50	0.084			Borehole	
		0.00–92.75	0.200			Casing ID	
		0.20–6.20	0.310			Casing ID	
		6.20–6.30	0.280			Casing ID	
		92.75–98.70	0.200			Casing ID	
		98.70–98.75	0.170			Casing ID	
		520.40–522.40	0.076			Casing ID	
KLX20A	27.24	0.3–6.0	0.340	–49.81	270.61	Borehole	2006-03-25
		6.0–99.90	0.253			Borehole	
		99.90–99.91	0.162			Borehole	
		99.91–100.9	0.086			Borehole	
		100.9–457.92	0.076			Borehole	
		0.0–99.47	0.208			Casing ID	
		0.3–6.0	0.323			Casing ID	
		99.47–99.50	0.208			Casing ID	
HLX15	4.81	0.00–12.24	0.190	–58.37	184.65	Borehole	2004-04-29
		12.24–151.90	0.137			Borehole	
		0.00–11.95	0.160			Casing ID	
		11.95–12.04	0.147			Casing ID	
HLX26	6.48	0.00–9.10	0.190	–60.42	12.37	Borehole	2004-09-28
		9.10–151.20	0.137			Borehole	
		0.00–8.94	0.160			Casing ID	
		8.94–9.03	0.147			Casing ID	
HLX27	8.25	0.00–6.10	0.190	–59.41	191.00	Borehole	2004-09-22
		6.10–164.70	0.137			Borehole	
		0.00–5.94	0.160			Casing ID	
		5.94–6.03	0.147			Casing ID	
HLX28	13.42	0.00–6.10	0.190	–59.49	201.38	Borehole	2004-10-02
		6.10–154.20	0.136			Borehole	
		0.00–5.94	0.160			Casing ID	
		5.94–6.03	0.147			Casing ID	
HLX32	10.84	0.0–12.30	0.191	–58.67	28.59	Borehole	2005-01-11
		12.30–162.6	0.140			Borehole	
		0.0–12.21	0.160			Casing ID	
		12.21–12.30	0.147			Casing ID	
HLX36	15.56	0.00–6.10	0.190	–59.30	270.61	Borehole	2005-09-22
		6.10–121.50	0.140			Borehole	
		121.50–199.80	0.140			Borehole	
		0.00–5.94	0.160			Casing ID	
		5.94–6.03	0.142			Casing ID	

Borehole data							
Bh ID	Elevation of top of casing (ToC) (m.a.s.l.)	Borehole interval from ToC (m)	Casing (inner)/ Bh-diam. (m)	Inclination-top of bh (from horizontal plane) (º)	Dip-direction-top of borehole (from local N) (º)	Remarks	Drilling finished Date (YYYY-MM-DD)
HLX37	15.19	0.0–12.10	0.190	–59.25	86.18	Borehole	2005-09-28
		12.10–121.50	0.140			Borehole	
		121.5–199.8	0.139			Borehole	
		0.0–11.94	0.160			Casing ID	
		11.94–12.03	0.142			Casing ID	
HLX38	11.53	0.00–15.10	0.190	–59.39	110.04	Borehole	2004-04-24
		15.10–103.20	0.140			Borehole	
		103.20–199.50	0.139			Borehole	
		0.00–14.93	0.160			Casing ID	
		14.93–15.02	0.143			Casing ID	
HLX42	12.88	0.30–9.10	0.180	–57.11	321.51	Borehole	2006-11-16
		9.10–152.60	0.139			Borehole	
		0.00–9.01	0.160			Casing ID	
		9.01–9.10	0.143			Casing ID	
KLX27A	16.98	0.16–9.20	0.310	–65.37	0.73	Casing ID	2007-08-27
		9.20–75.60	0.160			Borehole	

Table 3-2. Coordinates at the ground surface of the boreholes included in the interference tests. (From SICADA).

Borehole data		
Bh ID	Northing (m)	Easting (m)
KLX03	6366112.59	1547718.9
KLX05	6365633.34	1548909.41
KLX14A	6365959.69	1547146.87
KLX15A	6365614.17	1547987.47
KLX19A	6365901.42	1547004.62
KLX20A	6366334.57	1546604.89
HLX15	6365361.97	1548664.02
HLX26	6365278.71	1548600.52
HLX27	6365605.07	1547882.69
HLX28	6365861.70	1546834.47
HLX32	6365725.79	1546734.36
HLX36	6366172.93	1546558.45
HLX37	6366183.66	1546406.21
HLX38	6365868.86	1547146.08
HLX42	6364827.04	1547446.73
KLX27A	6365608.29	1546742.63

3.2 Tests performed

Four separate hydraulic interference tests were performed and the results are presented in this report. All borehole sections involved in the interference tests are listed in Table 3-3 to Table 3-10. The amount of data extracted from HMS (Hydro Monitoring System) from the observation boreholes was chosen to provide adequate information about the pressure conditions prior to as well as during and after the interference tests. HMS is registering pressure continuously at a pre-selected scanning frequency.

The column "Test section" in the tables below reports the hydraulically active section lengths. In most boreholes the upper part of the upper section is cased to some depth and the casing length is thus not included in the "Test section". The casing length of each borehole can be found in Table 3-1.

The interpreted points of application, calculated as explained below, and lengths of the borehole sections involved in the interference tests together with the distances between the pumping borehole and the observation borehole sections are shown in the tables below. The distances are calculated as the distance between the points of application in the pumping borehole and the points of application in respective observation section using a special routine in the Sicada database.

The points of application in the pumping borehole and in the different observation borehole sections respectively were in general selected as the midpoints of the section. This is true for all boreholes except the pumping boreholes HLX32 and HLX27 (2004) and the associated observation boreholes HLX15, 26, 27 and 28. In these boreholes the point of application is based on the position of the flow anomaly assumed to contribute to the major part of the transmissivity in each section. If several parts of the section have comparable values of transmissivity a point of balance calculation was made to estimate the point of application.

3.2.1 Interference test 1 in HLX27 (2004)

Table 3-3. Borehole sections involved in the interference test in HLX27 (2004). For borehole locations see Figure 1-1.

Bh ID	Test section (m)	Test type[1]	Test configuration
HLX27	6.0–164.70	1B	Open borehole
HLX15	12.04–151.90	2	Open borehole
HLX26:1	11.0–151.2	2	Below packer
HLX28	6.0–154.2	2	Open borehole

[1] 1B: Pumping test-submersible pump, 2: Interference test.

Table 3-4. Points of application, lengths of the test sections and calculated spherical distances to the pumping borehole in interference test 1 in HLX27 (2004).

Bh ID	Test section (m)	Point of application (m below TOC)	Section length (m)	Distance to HLX27 (m)
HLX27	6.0–164.70	85.5	159.0	0
HLX15	12.04–151.90	81.97	139.86	824
HLX26:1	11.0–151.2	81.1	140.20	772
HLX28	6.0–154.2	80.10	148.2	1,088

3.2.2 Interference test 2 in HLX27 (2007)

Table 3-5. Borehole sections involved in interference test 2 in HLX27 (2007). For borehole locations, see Figure 1-1.

Bh ID	Test section (m)	Test type[1]	Test configuration
HLX27	6.0–164.70	1B	Open borehole
KLX03A:1	965.5–971.5	2	Below packer
KLX03A:2	830.5–964.5	2	Between packers
KLX03A:3	752.5–829.5	2	Between packers
KLX03A:4	729.5–751.5	2	Between packers
KLX03A:5	652.5–728.5	2	Between packers
KLX03A:6	465.5–651.5	2	Between packers
KLX03A:7	349.5–464.5	2	Between packers
KLX03A:8	199.5–348.5	2	Between packers
KLX03A:9	193.5–198.5	2	Between packers
KLX03A:10	100.1–194.5	2	Above packer
KLX05A:1	721.0–1,000.16	2	Below packer
KLX05A:2	634.0–720.0	2	Between packers
KLX05A:3	625.0–633.0	2	Between packers
KLX05A:4	501.0–624.0	2	Between packers
KLX05A:5	361.0–500.0	2	Between packers
KLX05A:6	256.0–360.0	2	Between packers
KLX05A:7	241.0–255.0	2	Between packers
KLX05A:8	220.0–240.0	2	Between packers
KLX05A:9	128.0–219.0	2	Between packers
KLX05A:10	15.0–127.0	2	Above packer
KLX15A:1	421.0–1,000.43	2	Below packer
KLX15A:2	189.0–420.0	2	Between packers
KLX15A:3	188.0–11.7	2	Above packer
KLX19A:1	661.0–800.07	2	Below packer
KLX19A:2	518.0–660.0	2	Between packers
KLX19A:3	509.0–517.0	2	Between packers
KLX19A:4	481.5–508.0	2	Between packers
KLX19A:5	311.0–480.5	2	Between packers
KLX19A:6	291.0–310.0	2	Between packers
KLX19A:7	136.0–290.0	2	Between packers
KLX19A:8	6.3–135.0	2	Above packer
:			
HLX26:1	11.0–151.2	2	Below packer
HLX38	15.0–199.5	2	Open borehole
HLX42:1	30.0–152.6	2	Below packer
HLX42:2	9.1–29.0	2	Above packer

[1] 1B: Pumping test-submersible pump, 2: Interference test.

Table 3-6. Points of application, lengths of the test sections and calculated spherical distances to the pumping borehole in interference test 2 in HLX27 (2007).

Bh ID	Test section (m)	Point of application (m below TOC)	Section length (m)	Distance to HLX27 (m)
HLX27	6.0–164.70	85.5	158.70	0
KLX03A:1	965.5–971.5	968.50	6.00	983
KLX03A:2	830.5–964.5	897.50	134.00	922
KLX03A:3	752.5–829.5	791.00	77.00	834
KLX03A:4	729.5–751.5	740.50	22.00	796
KLX03A:5	652.5–728.5	690.50	76.00	755
KLX03A:6	465.5–651.5	558.50	186.00	672
KLX03A:7	349.5–464.5	407.00	115.00	594
KLX03A:8	199.5–348.5	274.00	149.00	552
KLX03A:9	193.5–198.5	196.00	5.00	544
KLX03A:10	100.1–194.5	146.30	92.40	546
KLX05A:1	721.0–1,000.16	860.50	279.16	1,135
KLX05A:2	634.0–720.0	677.00	86.00	1,078
KLX05A:3	625.0–633.0	629.00	8.00	1,065
KLX05A:4	501.0–624.0	562.50	123.00	1,052
KLX05A:5	361.0–500.0	430.50	139.00	1,034
KLX05A:6	256.0–360.0	308.00	104.00	1,026
KLX05A:7	241.0–255.0	248.00	14.00	1,024
KLX05A:8	220.0–240.0	230.00	20.00	1,024
KLX05A:9	128.0–219.0	173.50	91.00	1,024
KLX05A:10	15.0–127.0	71.00	112.00	1,031
KLX15A:1	421.0–1,000.43	710.70	579.40	611
KLX15A:2	189.0–420.0	304.50	231.00	219
KLX15A:3	188.0–11.7	99.85	176.30	96
KLX19A:1	661.0–800.07	730.55	139.07	1,118
KLX19A:2	518.0–660.0	589.00	142.00	1,048
KLX19A:3	509.0–517.0	513.00	8.00	1,015
KLX19A:4	481.5–508.0	494.75	26.50	1,008
KLX19A:5	311.0–480.5	395.75	169.50	975
KLX19A:6	291.0–310.0	300.50	19.00	950
KLX19A:7	136.0–290.0	213.00	154.00	936
KLX19A:8	98.75–135.0	70.65	36.25	930
HLX26:1	11.0–151.2	80.1	140.20	772
HLX38	15.0–199.5	107.25	184.50	734
HLX42:1	30.0–152.6	91.3	122.60	144
HLX42:2	9.1–29.0	19.05	19.90	187

3.2.3 Interference test in HLX28

Table 3-7. Borehole sections involved in the interference test in HLX28. For borehole locations, see Figure 1-1.

Bh ID	Test section (m)	Test type[1]	Test configuration
HLX28	6.0–154.2	1B	Open borehole
KLX14A:1	120.0–176.27	2	Below packer
KLX14A:2	73.0–119.0	2	Between packers
KLX14A:3	6.5–72.0	2	Above packer

Bh ID	Test section (m)	Test type[1]	Test configuration
KLX19A:1	661.0–800.07	2	Below packer
KLX19A:2	518.0–660.0	2	Between packers
KLX19A:3	509.0–517.0	2	Between packers
KLX19A:4	481.5–508.0	2	Between packers
KLX19A:5	311.0–480.5	2	Between packers
KLX19A:6	291.0–310.0	2	Between packers
KLX19A:7	136.0–290.0	2	Between packers
KLX19A:8	98.75–135.0	2	Above packer
KLX20A	6.0–457.92	2	Open borehole
HLX32:1	16.0–162.6	2	Below packer
HLX36:1	50.0–199.8	2	Below packer
HLX36:2	6.03–49.0	2	Above packer
HLX37:1	149.0–199.8	2	Below packer
HLX37:2	118.0–148.0	2	Between packers
HLX37:3	12.03–117.0	2	Above packer
HLX38	15.0–199.5	2	Open borehole

[1] 1B: Pumping test-submersible pump, 2: Interference test.

Table 3-8. Points of application, lengths of the test sections and calculated spherical distances to the pumping borehole during the interference test in HLX28.

Bh ID	Test section (m)	Point of application (m below TOC)	Section length (m)	Distance to HLX28 (m)
HLX28	6.0–154.2	80.10	148.2	0
KLX14A:1	120.0–176.3	148.15	56.30	433
KLX14A:2	73.0–119.0	96.00	46.00	402
KLX14A:3	6.5–72.0	39.25	65.50	372
KLX19A:1	661.0–800.07	730.50	139.00	631
KLX19A:2	518.0–660.0	589.00	142.00	504
KLX19A:3	509.0–517.0	513.00	8.00	425
KLX19A:4	481.5–508.0	494.50	27.00	408
KLX19A:5	311.0–480.5	395.75	169.50	321
KLX19A:6	291.0–310.0	300.50	19.00	246
KLX19A:7	136.0–290.0	213.00	154.00	193
KLX19A:8	6.3–135.0	116.90	36.20	172
KLX20A	6.0–457.92	232.0	451.9	611.6
HLX32:1	16.0–162.6	72.5	150.3	92.9
HLX36:1	50.0–199.8	124.90	149.80	485
HLX36:2	6.03–49.0	27.50	43.00	449
HLX37:1	149.0–199.8	174.4	50.8	486.1
HLX37:2	118.0–148.0	133	30.0	498.3
HLX37:3	12.03–117.0	64.5	104.97	525.0
HLX38	15.0–199.5	107.25	184.5	381

3.2.4 Interference test in HLX32

Table 3-9. Borehole sections involved in the interference test in HLX32. For borehole locations, see Figure 1-1.

Bh ID	Test section (m)	Test type[1]	Test configuration
HLX32	12.3–162.6	1B	Open borehole
HLX26:1	11.0–151.2	2	Below packer
HLX27	6.0–165.0	2	Open borehole
HLX28	6.0–154.2	2	Open borehole

[1] 1B: Pumping test-submersible pump, 2: Interference test

Table 3-10. Points of application, lengths of the test sections and calculated spherical distances to the pumping borehole during the interference test in HLX32.

Bh ID	Test section (m)	Point of application (m below TOC)	Section length (m)	Distance to HLX32 (m)
HLX32	12.3–162.6	87.5	150.30	
HLX26:1	11.0–151.2	81.1	140.20	1,901
HLX27	6.0–165.0	85.5	159.0	1,134
HLX28	6.0–154.2	80.10	148.2	81

4 Description of equipment

4.1 Overview

The equipment consisted of the pumped hole units described in 4.2 and 4.3 below and of the observation hole instrumentation described in 4.3.

4.2 Equipment when testing boreholes HLX27 (2004)

The pumping test was performed the following basic equipment

- submersible pump: Grundfoss, range is about 5–100 L/min,
- absolute pressure transducer: MiniTroll 300 PSIA, ± 0.1% accuracy,
- water level dipper,
- 35 L container and chronometer for flow measurement.

4.3 Equipment when testing boreholes HLX27 (2007), HLX28, HLX32 and KLX27A

The pumping and interference test was performed with an integrated field unit consisting of a container at the pumped borehole housing a

- submersible pump: Grundfoss SPE5-70, range is about 5–100 L/min,
- absolute pressure transducer: Druck PTX1830, 10bar range and ± 0.1% accuracy,
- water level dipper,
- flow gauge: Krohne IFM1010 electromagnetic, 0–150 L/min, except for HLX27 test in 2004 where flow was measured with a 35 L container and a chronometer.

4.4 Observation hole equipment

All the observation sections included in the interference test are part of the SKB hydro monitoring system (HMS), where pressure is recorded continuously.

Utilised pressure gauges/logger are

when pumping HLX27 (2004)

- HLX15, HLX26 and HLX28 : MiniTroll 30PSIA, with accuracy ± 0.1% over full temperature

when pumping HLX27 (2007).

- HLX26 and KLX15A: MiniTroll 30PSIA, with accuracy ± 0.1% FS
- HLX38 and HLX42: LevelTroll 30PSIA, with accuracy ± 0.1% FS
- KLX03, KLX05 and KLX19A: Druck PTX1830, 0–600 kPa range and accuracy ± 0.1% FS and Datataker logger

when pumping HLX28

- HLX32, HLX36, HLX37, HLX38 and KLX20A: MiniTroll 30PSIA, with accuracy ± 0.1% FS
- KLX14: LevelTroll 30PSIA, with accuracy ± 0.1% FS
- KLX19A: Druck PTX1830, 0–600 kPa range and accuracy ± 0.1% FS and Datataker logger

when pumping HLX32

- HLX26, HLX27 and HLX28: MiniTroll 30PSIA, with accuracy ± 0.1% FS.

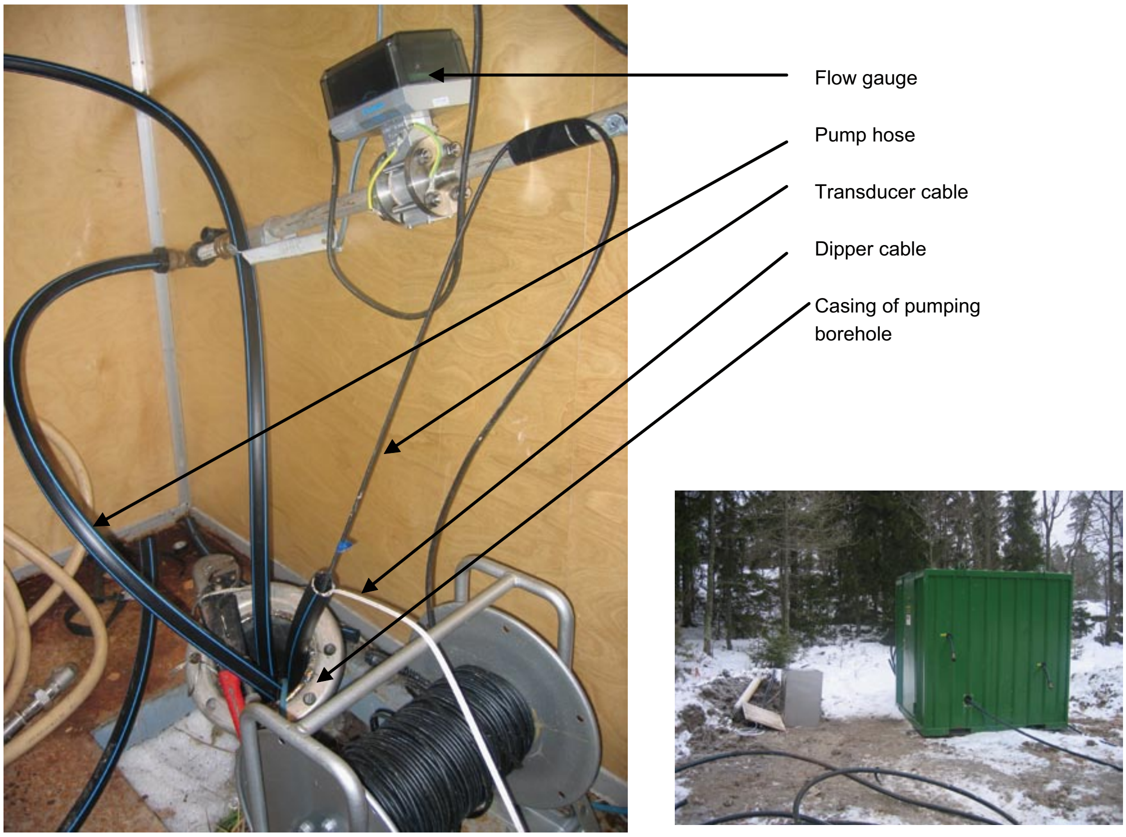


Figure 4-1. Container housing the testing equipment (right) and instrumentation inside (left) in borehole.

5 Execution

5.1 Preparations

Generally the equipment was installed down the hole at least one day ahead of pump start and logging of water groundwater head was initiated.

5.2 Procedure

During the tests the pressure interference was recorded in totally 60 sections in 4 observation boreholes, both cored and percussion drilled, using the HMS (Hydro Monitoring System). The boreholes connected to the HMS are fitted with stationary equipment for measuring pressure in the different sections. In some of the observation boreholes the stationary installations were set to log more frequently than the default long term monitoring frequency.

5.3 Data handling

Data from all pressure gauges was corrected with respect to atmospheric pressure and for the observation boreholes converted to groundwater head expressed in metre above sea level in the RT90-RHB70 national grid elevation system. All data and filed protocols of flow and water level are stored in the site characterisation database (SICADA)

The pressure and flow data from the pumping boreholes were collected from the HMS or received from the activity leader in form of .csv, .dat or .txt files.

5.4 Transient analysis and interpretation

5.4.1 General

When possible, both qualitative and quantitative analyses have been carried out in accordance with the methodology descriptions for interference tests, SKB MD 330.003. Standard methods for constant-flow rate tests in an equivalent porous medium were used by the transient analyses and interpretation of the tests.

Transient evaluation of all responding observation sections was performed, both for the flow and recovery period, respectively. All responding observation sections are also included in the response analysis. In the transient evaluation of the responses in the pumping borehole and selected observation sections the models described in /4/, /5/ and /7/ respectively was used. The responses in the pumping boreholes were evaluated as single-hole pumping tests according to the methods described in /1/.

In the primary qualitative analyses, data from all observation sections included in each interference test were studied in linear time versus pressure diagrams to deduce the responding sections. Linear diagrams of pressure versus time are presented in Chapter 6 for each borehole included in the interference tests.

The qualitative evaluation of the dominating transient flow regimes (pseudo-linear, pseudo-radial and pseudo-spherical flow, respectively) and possible outer boundary conditions was mainly based on the drawdown and recovery responses in logarithmic diagrams. In particular, pseudo-radial flow is reflected by a constant (horizontal) derivative in the diagrams, whereas no-flow- and constant head boundaries are characterized by a rapid increase and decrease of the derivative, respectively. Based on the qualitative evaluation relevant models were selected for the quantitative transient evaluation.

In the drawdown and recovery diagrams different values on the filter coefficient (step length) by the calculation of the pressure derivative were applied to investigate the effect on the pressure derivative. It is desired to achieve maximum smoothing of the derivative without altering the original shape of the test data.

The quantitative transient analysis was performed by the test analysis software AQTESOLV /8/ that enables both visual and automatic type curve matching. The transient evaluation was carried out as an iterative process of type curve matching and automatic non-linear regression. The transient interpretation of the hydraulic test parameters is in most cases based on the identified pseudo-radial flow regime appearing during the tests and plotted in log-log and lin-log data diagrams.

The analysis from pumping tests in HLX32 and HLX27 (2004) were made by SKB utilising Saphir v4 /9/.

5.4.2 Pumping boreholes

For the single-hole pumping tests the storativity was calculated using, see Equation (5-1), from SKB (2006) /2/. Firstly, the transmissivity and skin factor were obtained by type curve matching using a fixed storativity value of 10^{-6} according to the instruction SKB MD 320.004. The storativity was then re-calculated from an empirical regression relationship between storativity and transmissivity according to Equation (5-1). The type curve matching was then repeated. In most cases the change of storativity does not significantly alter the transmissivity value in the new type curve matching, but only the estimated skin factor is altered correspondingly. This described way of estimating the storativity is true for boreholes HLX27 (2007) and HLX28 while pumping borehole HLX27 (2004) and HLX32 were evaluated based on the storativity obtained from the observation hole response.

$$S=0.0007 \cdot T^{0.5} \qquad (5\text{-}1)$$

S = storativity (–)
T = transmissivity (m^2/s)

For the transient analysis of KLX27A a storativity of $2.4 \cdot 10^{-5}$ was assumed. In addition to the transient analysis, an interpretation based on the assumption of stationary conditions in the pumping boreholes was performed as described by Moye (1967).

The wellbore storage coefficient (C) in the pumping borehole section can be obtained from the parameter estimation of a fictive casing radius, r(c) in an equivalent open test system according to Equation (5-2).

$$C = \frac{\pi \cdot r(c)^2}{\rho \cdot g} \qquad (5\text{-}2)$$

The radius of influence at a certain time during the test may be estimated from Jacob's approximation of the Theis' well function according to Equation (5-3):

$$r_i = \sqrt{\frac{2.25 \cdot T \cdot t}{S}} \qquad (5\text{-}3)$$

T = representative transmissivity from the test (m^2/s)
S = storativity estimated from Equation (5-1)
r_i = radius of influence at time t (m)
t = time after start of pumping (s).

Furthermore, a r_i-index (–1, 0 or 1) is defined to characterize the hydraulic conditions by the end of the test. The r_i-index is defined as shown below. It is assumed that a certain time interval of PRF can be identified between t_1 and t_2 during the test.

- r_i-index = 0: The transient response indicates that the size of the hydraulic feature tested is greater than the radius of influence based on the actual test time (t_2=t_p), i.e. the PRF is continuing at stop of the test. This fact is reflected by a flat derivative at this time.
- r_i-index = 1: The transient response indicates that the hydraulic feature tested is connected to a hydraulic feature with lower transmissivity or an apparent barrier boundary (NFB). This fact is reflected by an increase of the derivative. The size of the hydraulic feature tested is estimated as the radius of influence based on t_2.
- r_i-index = –1: The transient response indicates that the hydraulic feature tested is connected to a hydraulic feature with higher transmissivity or an apparent constant head boundary (CHB). This fact is reflected by a decrease of the derivative. The size of the hydraulic feature tested is estimated as the radius of influence based on t_2.

If a certain time interval of PRF cannot be identified during the test, the r_i-indices –1 and 1 are defined as above. In such cases the radius of influence is estimated using the flow time t_p in Equation (5-3).

5.5 Response analysis and estimation of the hydraulic diffusivity

5.5.1 Response analysis

Calculation of the response indices

In responding observation sections the response time (dt_L) and the maximum drawdown (s_p) were calculated. The response time is defined as the time lag after start of pumping until a drawdown response of 0.1 m was observed in the actual observation section. The maximum drawdown does not always occur at stop of pumping, e.g. due to heavy precipitation by the end of the flow period. In such cases the transient analysis is based on the response prior to the disturbance. Response parameters were only calculated for observation sections with a final drawdown of 0.1 m or more. Sections with a lower drawdown were regarded as non-responding to the pumping.

The 3D (spherical) distances between the point of application in the pumping borehole and in the observation borehole sections (r_s) were calculated. These parameters combined with the pumping flow rate (Q_p) are the variables used to calculate the response indices, which characterize the hydraulic connectivity between the pumping and the observation section. The calculated hydraulic connectivity parameters are shown in the tables in Chapter 6. The response indices are calculated as follows:

Index 1:

r_s^2/dt_L(s=0.1 m) = normalised squared distance r_s with respect to the response time lag at s=0.1 m (m^2/s).

Index 2:

s_p/Q_p = normalised drawdown s_p with respect to the pumping rate (s/m^2).

Additionally, a third index was calculated including drawdown and distance. This index is calculated as follows:

Index 2 new:

$(s_p/Q_p)*\ln(r_s/r_0)$ assuming r_0=1. For the pumped borehole $r_s=e^1$ (i.e. a fictive borehole radius of 2.718).

The classification based on the response indices is given as follows:

Index 1 (r_s^2/dt_L) at s=0.1 m		**Colour code**
$r_s^2/dt_L > 100$ m²/s	Excellent	
$10 < r_s^2/dt_L \leq 100$ m²/s	High	
$1 < r_s^2/dt_L \leq 10$ m²/s	Medium	
$r_s^2/dt_L \leq 1$ m²/s	Low	

Index 2 (s_p/Q_p)		**Colour code**
$s_p/Q_p > 1\cdot10^5$ s/m²	Excellent	
$3\cdot10^4 < s_p/Q_p \leq 1\cdot10^5$ s/m²	High	
$1\cdot10^4 < s_p/Q_p \leq 3\cdot10^4$ s/m²	Medium	
$s_p/Q_p \leq 1\cdot10^4$ s/m²	Low	
$s_p < 0.1$ m	No response	

Index 2 new (s_p/Q_p) · ln(r_s/r_0)		**Colour code**
$(s_p/Q_p)\cdot\ln(r_s/r_0) > 5\cdot10^5$ s/m²	Excellent	
$5\cdot10^4 < (s_p/Q_p)\cdot\ln(r_s/r_0) \leq 5\cdot10^5$ s/m²	High	
$5\cdot10^3 < (s_p/Q_p)\cdot\ln(r_s/r_0) \leq 5\cdot10^4$ s/m²	Medium	
$(s_p/Q_p)\cdot\ln(r_s/r_0) \leq 5\cdot10^3$ s/m²	Low	
$s_p < 0.1$ m	No response	

In some cases it is not clear if the section responds to the pumping or if the drawdown is based on natural processes solely. In uncertain cases, the data sets were regarded all together to better differentiate between these effects. By looking at the pressure responses before and after the pumping period, it may be possible to distinguish between natural fluctuations and those induced by pumping. Furthermore, it should be pointed out, that some of the responses could be caused by the drawdown in adjacent sections above or below the measured section in the same observation borehole.

All observation data are influenced by natural fluctuations of the groundwater level such as tidal effects and long term trends. The pressure changes due to tidal effects are different for the observation boreholes.

5.5.2 Estimation of hydraulic diffusivity

The distances r_s between the pumping borehole and the different observation sections have been calculated as the spherical distance using the co-ordinates for the midpoint of each section as described in Section 3.2. The calculation of the hydraulic diffusivity is based on radial flow according to /6/.

$$T / S = r_s^2 / [4 \cdot dt_L \cdot (1 + dt_L / tp) \cdot \ln(1 + tp / dt_L)] \qquad (5\text{-}4)$$

The time lag dt_L is here defined as the time when the pressure response in an observation section is 0.01 m. The pumping time is included as tp. The estimates of the hydraulic diffusivity according to above should be seen as approximate values of the hydraulic diffusivity to be compared with the ratio of T/S from the transient test analysis.

5.6 Nonconformities

- Three of the observation boreholes that, according to the activity plan, originally were intended to be included in the interference test did for various reasons not provide any pressure data and were therefore excluded from the interference test. These sections are:
  - Observation borehole HLX28 during the interference test in HLX27 (2007).
  - Observation borehole HLX27 during the interference test in HLX28.
  - Observation borehole HLX15 during the interference test in HLX32.
- The upper observation sections in boreholes HLX26 and HLX32 (HLX26:2 and HLX32:2) are not monitored by HMS and thus not part of the interference tests.

6 Results

6.1 General comments and assumptions

All pressure data for the observation boreholes presented in this report have been corrected for atmospheric pressure changes by subtraction from the measured (absolute) pressure. The pressure in several of the observation sections included in the interference test was displaying an oscillating behaviour. This is naturally caused by so called tidal fluctuations or earth tides in combination with changes of the sea water level. These phenomena have, to some extent, been investigated previously at Forsmark in /3/. It should be observed that no further corrections of the measured drawdown have been made for these interference test, e.g. due to natural trends, precipitation or tidal effects.

The transient evaluation of the interference tests was generally based on variable flow rate tests. The nomenclature and symbols used for the results of the single-hole and interference test are according to the Instruction for analysis of single-hole injection and pumping tests (SKB MD 320.004) and the methodology description for interference tests (SKB MD 330.003), respectively (both are SKB internal controlling documents). Additional symbols used are explained in the text.

Linear plots of pressure versus time for the pumping and observation sections are presented in Figures 6-1 through 6-20. The measured drawdown (s_p) at the end of the flow period and the estimated response time lags (dt_L) in responding observation sections are shown in Tables 6-31 and 6-32, respectively. Test summary sheets for all responding observation sections are presented in Appendix 1. Transient, quantitative evaluation of the drawdown and recovery period is shown in log-log and lin-log diagram in Appendix 2. The results are also summarized in Tables 6-33 to 6-36. The locations of all boreholes are shown in Figure 1-1. Abbreviations of flow regimes and hydraulic boundaries that may appear in the text below are listed below.

WBS = Wellbore storage
PRF = Pseudo-radial flow regime
PLF = Pseudo-linear flow regime
PSF = Pseudo-spherical flow regime (including leaky flow)
PSS = Pseudo-stationary flow regime
NFB = No-flow boundary
CHB = Constant-head boundary

6.2 Interference test 1 in HLX27 (2004)

6.2.1 Pumping borehole HLX27 (2004)

General test data for the pumping test in HLX27 (2004) are presented in Table 6-1. The borehole is cased to 6.03 m. The uncased interval of this section is thus c. 6.0–164.7 m. The locations of the observation bore holes as well as their degree of response is seen in Figure 6-1. The Rock types and deformation zones is also seen in this figure. A plot of the pressure in HLX27 (2004) during the test together with a graph of the flow rate pumped are seen in Figure 6-2.

On 23rd November the discharge hose connected to the test container accidentally got loose which caused a disruption in the drawdown. After repair the flow stabilized somewhat lower than previously, 80 instead of 87 L/min, and consequently this also caused a lower drawdown after the disruption. An effect of counteracting the drawdown was compounded even more by the large precipitation that took place during the flow period, when an excess of 60 mm fell of which it may be assumed that part of it recharged the aquifer The dip in the derivative of recovery phase is believed to be due to this, see Figure 6-2.

Table 6-1. General test data for interference test 1 in HLX27 (2004) (6.0–164.7 m).

General test data			
Pumping borehole	HLX27		
Test type[1)]	Constant Drawdown and recovery test		
Test section (open borehole/packed-off section):	open borehole		
Test No	1		
Field crew	SKB		
Test equipment system			
General comment	Interference test		
	Nomen-clature	**Unit**	**Value**
Borehole length	L	m	164.7
Casing length	L_c	m	6.03
Test section – secup	Secup	m	6.03
Test section – seclow	Seclow	m	164.7
Test section length	L_w	m	158.67
Test section diameter[2)]	$2 \cdot r_w$	mm	137
Test start (start of flow period)		yymmdd hh:mm	041118 11:00
Packer expanded		yymmdd hh:mm:ss	
Start of flow period		yymmdd hh:mm:ss	041118 11:00
Stop of flow period		yymmdd hh:mm:ss	041126 11:50:00
Test stop (stop of flow period)		yymmdd hh:mm	041126 11:50:00
Total flow time	t_p	min	11,570
Total recovery time	t_F	min	
Pressure data			
Relative pressure in test section before start of flow period	p_i	m	6.82
Relative pressure in test section before stop of flow period	p_p	m	–13.13
Relative pressure in test section at stop of recovery period	p_F	m	
Pressure change during flow period ($p_i - p_p$)	dp_p	m	19.95
Flow data			
Flow rate from test section just before stop of flow period	Q_p	m^3/s	0.001417
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	
Total volume discharged during flow period	V_p	m^3	

1) Constant Head injection and recovery, Constant Rate withdrawal and recovery or Constant Drawdown and recovery.

2) Nominal diameter.

Flow regime and calculated parameters

The diagnostic derivative plot show a slight radial composite behaviour, $T_{inner\ zone} = 2 \cdot T_{outer\ zone}$, and constant head at the end of pumping. Consistent flow regime and tranmsissivity are obtained between drawdown and recovery phase. Note that the outer zone migt be an artefact of the recharge event explained above.

Selected representative parameters

The representative parameters were selected from the drawdown period. The selected representative transmissivity is $9.0 \cdot 10^{-5}$ m²/s and for the storativity $4.7 \cdot 10^{-5}$.

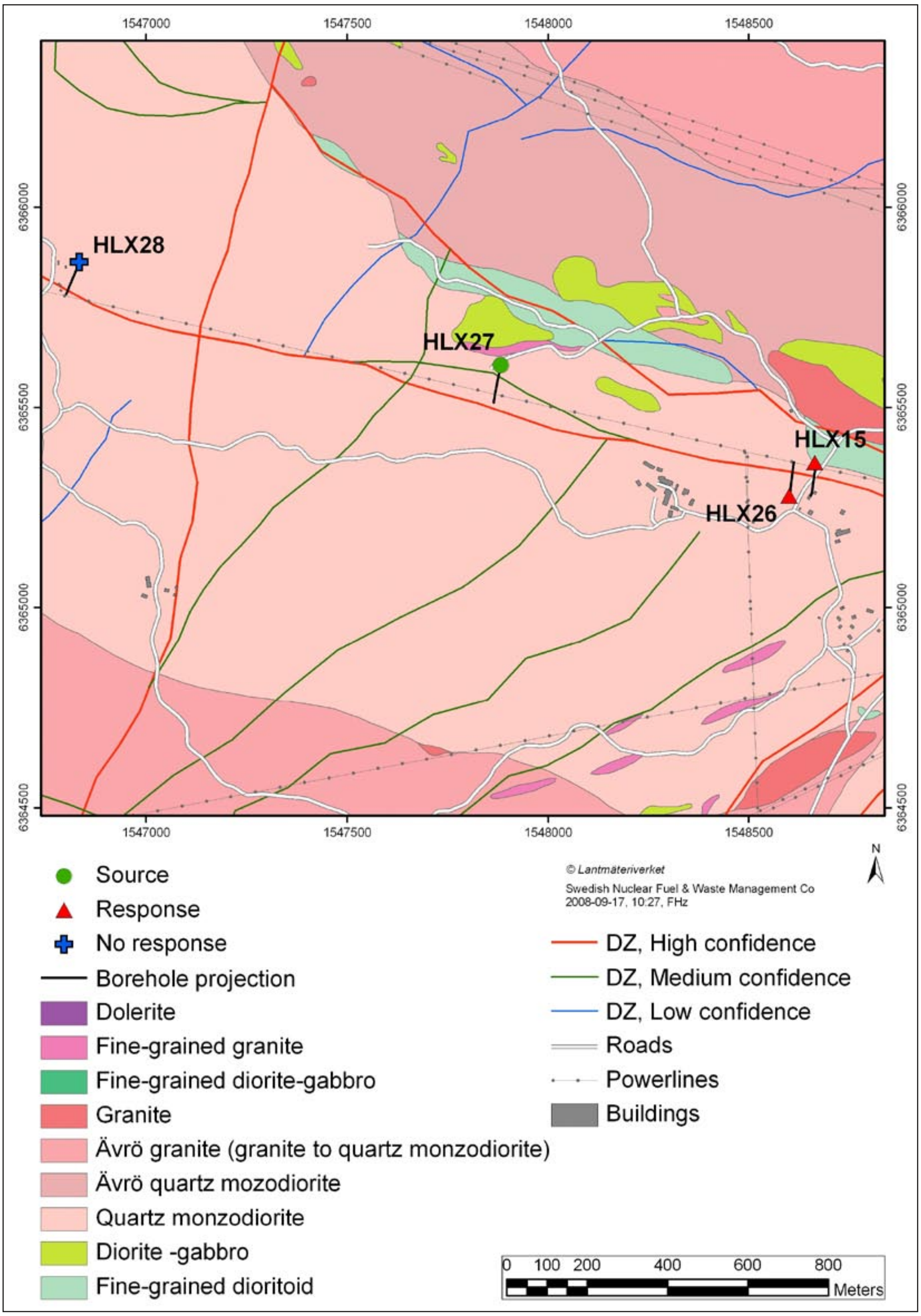


Figure 6-1. *Borehole response map for the observation boreholes when pumping in HLX27 in 2004.*

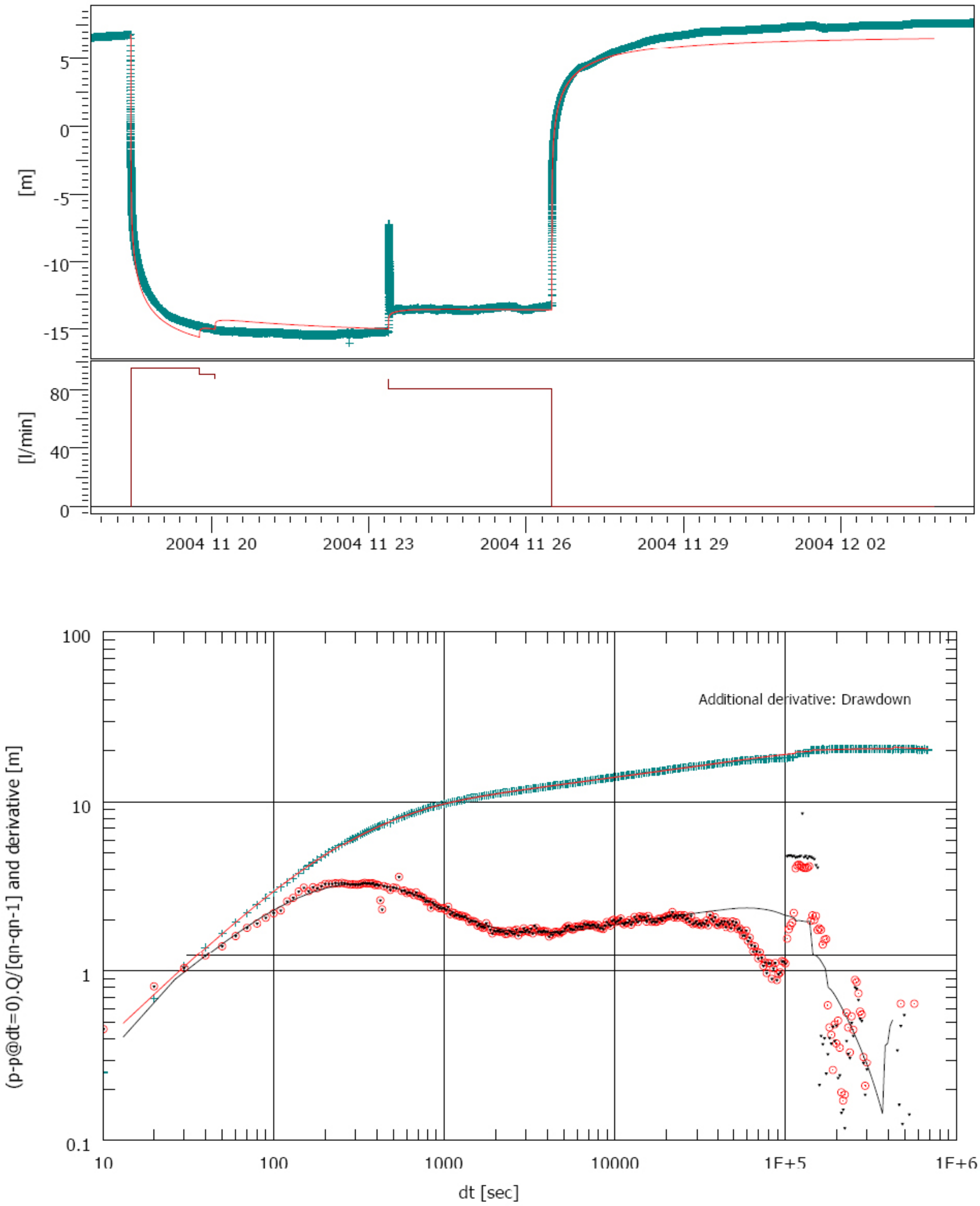


***Figure 6-2.** Linear plot of flow rate and pressure versus time in the pumping borehole HLX27 (2004) above and log-log diagnostic plot of the recovery phase below.*

6.2.2 Observation borehole HLX15

In Figure 6-3 an overview of the head responses in observation borehole HLX15 is shown. The evaluation plots are given in Appendix 6. The borehole is intermittently under artisian conditions, as is the case during this test. As such it was fitted with a 1.5 m standpipe on top of the casing to prevent it from overflowing. The response curve in Figure 6-3 show a sharp increase in head (a spike) after 4 days of pumping followed by a slower decrease to a steady level after 1.5 days. The recovery after pumpstop keep increasing to above the initial pre-pumping head. The borehole shows a head response due to the pumping in HLX27 (2004). The interpretation is however complicated by the considerable amount of precipitation that fell during the test, see Appendix 7. It is believed that the precipitation affect the head in HLX15 in that it causes recharge to the aquifer during the drawdown period, thus counteracting the drawdown so that a stabilization of head of established. It is also affecting the recovery since the head after pumpstop reaches levels well above the pre-pumping head, 5.77 m.a.s.l. vs 6.00 m.a.s.l. (and still increasing when measurement was discontinued).

The reason for the spike is the same as explained for the pumping hole HLX27 when the discharge hose connected to the test container accidentally got loose which caused a disruption in the drawdown, see 6.2.1.

The evaluation of the tests was only done for drawdown phase prior to the spike in order to avoid incurring complicating recharge events in the evaluationmodel. This show that the recharge effect caused the drawdown at the end of the flowperiod to be is 0.6 m less than it otherwise would have been.

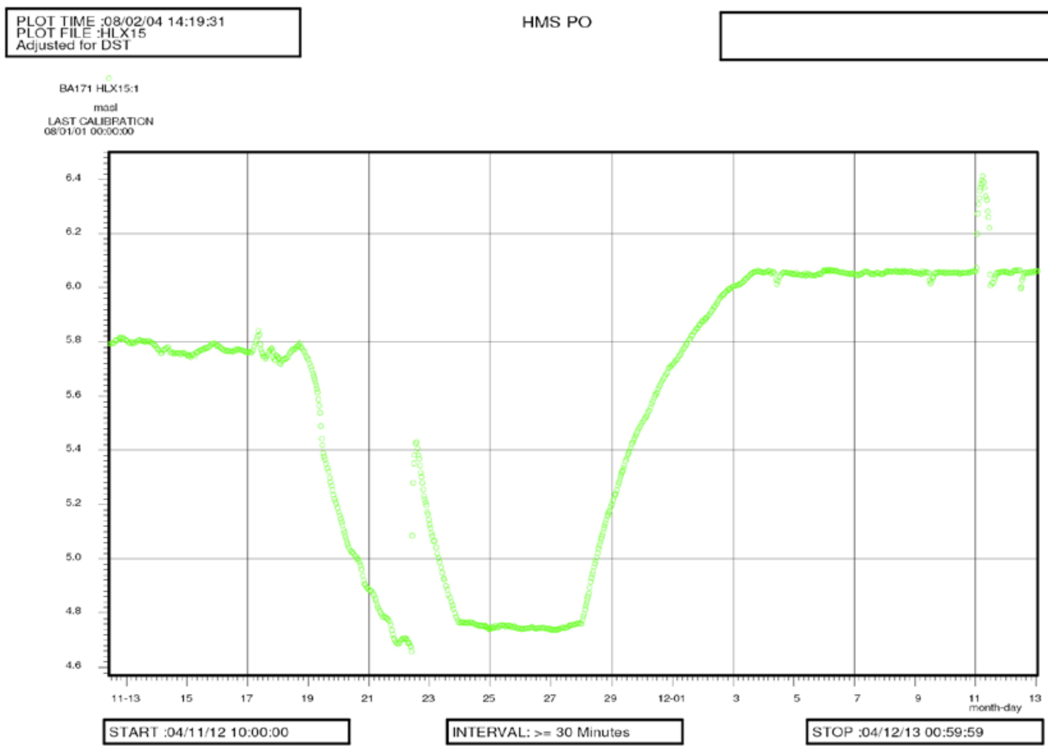


Figure 6-3. *Linear plot of head versus time in the observation borehole section HLX15 during interference test 1 in borehole HLX27 (2004).*

Selected representative parameters

The representative parameters were selected from the drawdwon period. The selected representative transmissivity is $1.2 \cdot 10^{-4}$ m^2/s and the storativity $5.1 \cdot 10^{-5}$.

6.2.3 Observation borehole HLX26

In Figure 6-4 an overview of the head responses in observation section HLX26:1 is shown. Section HLX26:2 between 9.1–10.0 m are not registered by HMS and hence not part of the test. General test data from the observation section HLX26:1 (11.0–151.2 m) are presented in Table 6-2.

Table 6-2. General test data from the observation section HLX26:1 (11.0–151.2 m) during interference test 1 in HLX27 (2004).

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	3.85
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	3.48
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	
Hydraulic head change during flow period ($h_i - h_p$)	dh_p	m	0.37

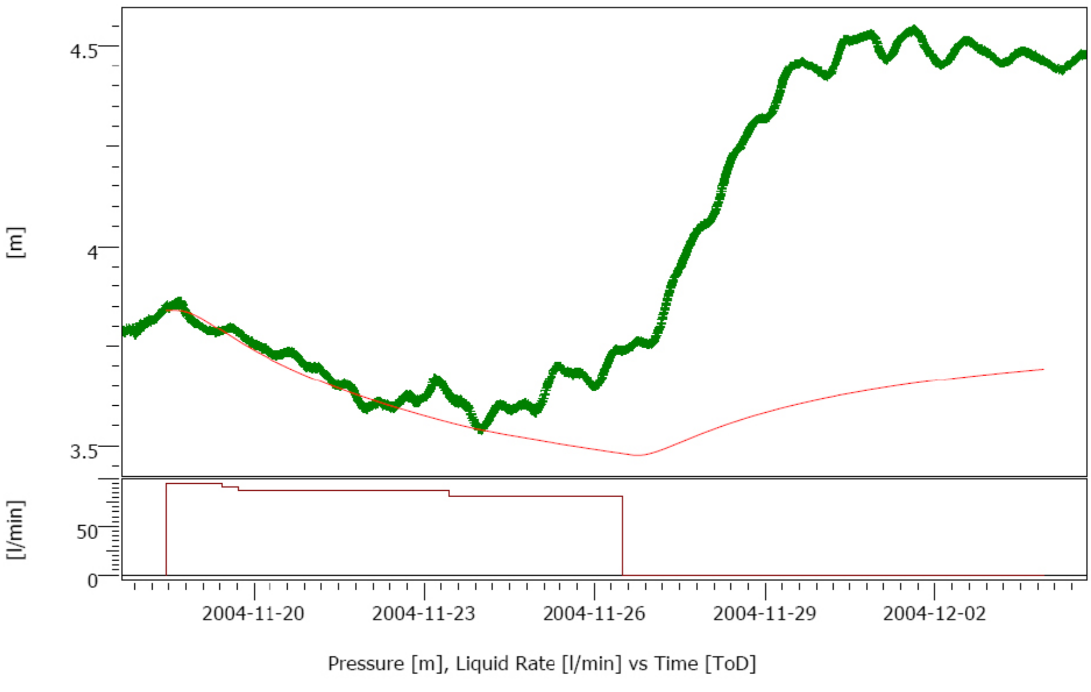


Figure 6-4. *Linear plot of head versus time in the observation borehole section HLX26:1 during interference test 1 in borehole HLX27 (2004).*

Selected representative parameters

The representative parameters were selected from the recovery period. The selected representative transmissivity is $4.99 \cdot 10^{-4}$ m²/s and the estimated storativity $2.92 \cdot 10^{-4}$.

6.2.4 Observation borehole HLX28

Observation borehole HLX28 is unaffected by the pumping in HLX27 (2004), as seen in Figure 6-5, hence no evaluations are made for this period. The borehole is cased to 6.03 m and the uncased interval of the upper section of this borehole is thus c. 6.0–154.2 m.

6.3 Interference test 2 in HLX27 (2007)

6.3.1 Pumping borehole HLX27 (2007)

General test data for interference test 2 in HLX27 (2007), conducted between 070530 and 070602, are presented in Table 6-3. The borehole is cased to 6.0 m. The uncased interval of the borehole is thus c. 6.0–164.7 m. The electrical conductivity of the pumped water was monitored as well as the EC of the stream receiving the discharged water, see Appendix 4. The locations of the observation bore holes as well as their degree of response is seen in Figure 6-6. The Rock types and deformation zones is also seen in this figure.

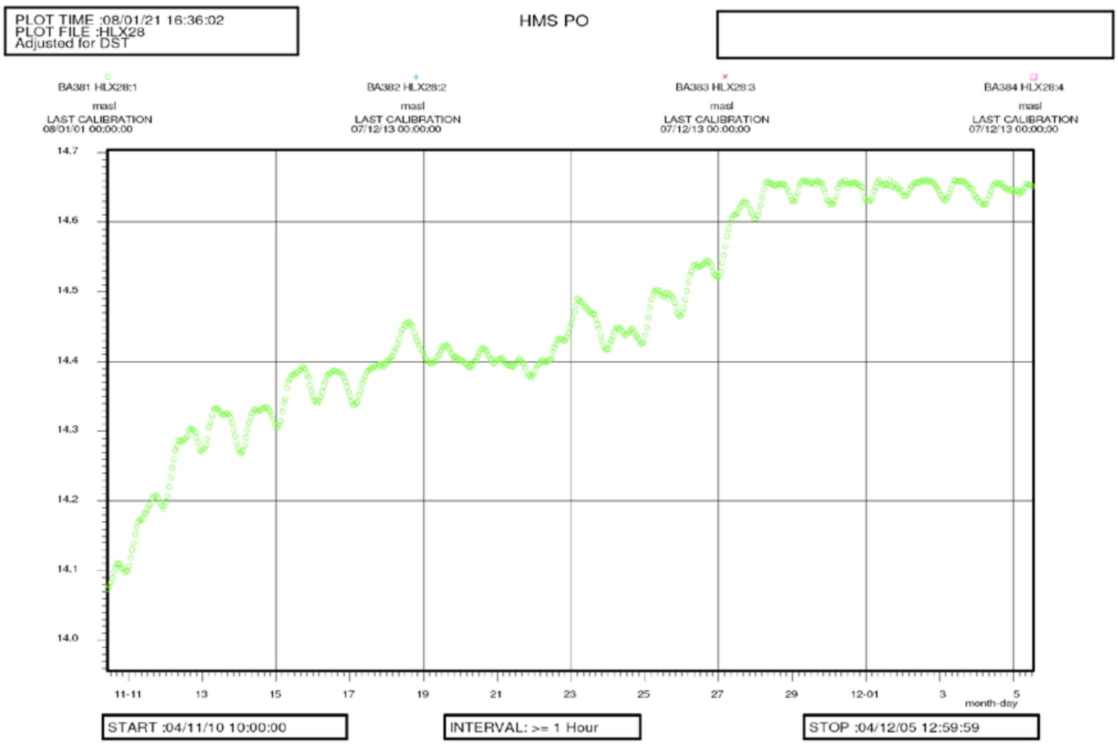


Figure 6-5. *Linear plot of ground water level in the observation borehole HLX28 during pumping in borehole HLX27 (2004). The figure shows that the variations of the ground water level in HLX28 seem to be unaffected by the pumping in HLX27 (2004), performed 2004-11-18 to 04-11-26.*

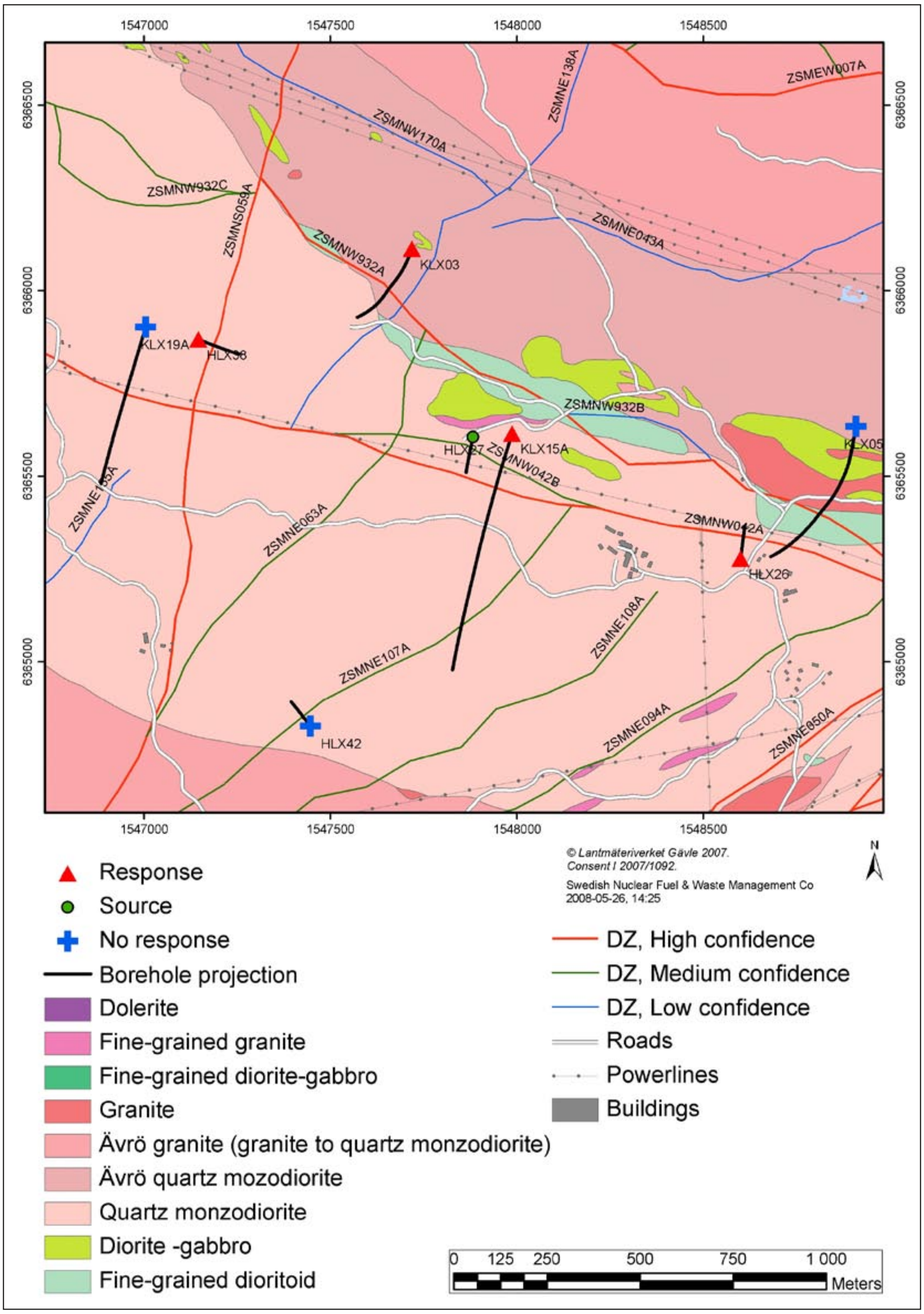


***Figure 6-6.** Borehole response map for the observation boreholes when pumping in HLX27 in 2007.*

Table 6-3. General test data for interference test 2 in HLX27 (2007) (6.0–164.7 m).

General test data			
Pumping borehole	HLX27		
Test type[1)]	Constant Rate withdrawal and recovery test		
Test section (open borehole/packed-off section):	open borehole		
Test No	1		
Field crew	SKB		
Test equipment system			
General comment	Interference test		
	Nomen-clature	**Unit**	**Value**
Borehole length	L	m	164.7
Casing length	L_c	m	6.03
Test section – secup	Secup	m	6.03
Test section – seclow	Seclow	m	164.7
Test section length	L_w	m	158.67
Test section diameter[2)]	$2 \cdot r_w$	mm	137
Test start (start of flow period)		yymmdd hh:mm	070530 11:17
Packer expanded		yymmdd hh:mm:ss	
Start of flow period		yymmdd hh:mm:ss	070530 11:17:00
Stop of flow period		yymmdd hh:mm:ss	070602 12:02:00
Test stop (stop of flow period)		yymmdd hh:mm	070602 12:02:00
Total flow time	t_p	min	4,365
Total recovery time	t_F	min	7,130
Pressure data			
Relative pressure in test section before start of flow period	p_i	m	78.6
Relative pressure in test section before stop of flow period	p_p	m	55.0
Relative pressure in test section at stop of recovery period	p_F	m	78.6
Pressure change during flow period (p_i – p_p)	dp_p	m	23.6
Flow data			
Flow rate from test section just before stop of flow period	Q_p	m^3/s	0.001517
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	0.00152
Total volume discharged during flow period	V_p	m^3	397

1) Constant Head injection and recovery, Constant Rate withdrawal and recovery or Constant Drawdown and recovery.

2) Nominal diameter.

Comments on the test

The test was performed as a constant flow rate pumping test with only slightly decreasing flow rate. The mean flow rate was c. 95 L/min and the duration of the flow period was c. 3 days (cf. Figure 6-7). A total drawdown during the flow period of 23.6 m and a total recovery at the end of the recovery period about the same was observed. A large set of flow rate data are available. A short increase of the flow rate is seen between about 12:30 and 13:05 on the first day of pumping, visible as a hatch in the pressure curve.

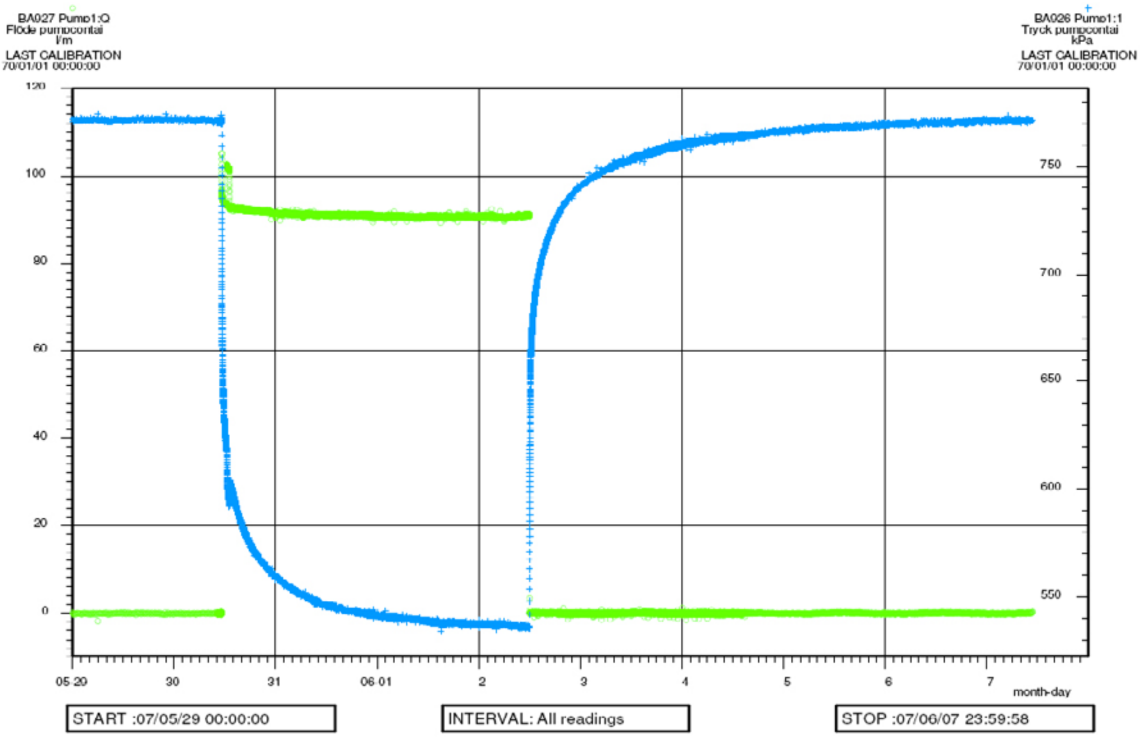


***Figure 6-7.** Linear plot of flow rate and pressure versus time in the pumping borehole HLX27 (2007).*

Flow regime and calculated parameters

During both the flow and recovery period, initial wellbore storage effects are followed by dominating pseudo-radial flow transitioning to pseudo-spherical (leaky) flow by the end. The responses during the flow and recovery period are very similar. After initial WBS during the first c. 2 min of the flow period a period of approximate PRF was developed between c. 20–50 min. At c. 50 min the flow rate was shortly increased as described earlier. The PRF is then re-established between c. 200 and 600 min. The flow then makes a transition into a PSF that continues for the rest of the flow period. The recovery displays the same flow pattern, after initial WBS the flow turns to a PRF after about 20 min until about 1,000 min when a PSF is observed.

The transient evaluation was based on variable flow rate. The evaluation was performed by applying the Moench' (Case 1) model for a leaky aquifer both for the flow and recovery periods. The agreement in evaluated parameter values between the flow and recovery period is very good.

Selected representative parameters

The representative parameters were selected from the recovery period. The selected representative transmissivity is $2.2 \cdot 10^{-5}$ m^2/s and the estimated storativity $3.3 \cdot 10^{-6}$.

6.3.2 Observation borehole KLX03

In Figure 6-8 an overview of the observed head versus time in the sections in observation borehole KLX03 is shown. The interpretation of responses in this borehole is uncertain. Some of the responses may be secondary, i.e. transmitted along the borehole. There are assumed responses in sections 1–4 and 8–10 while sections 5, 6 and 7 display virtually no responses to the pumping in HLX27 (2007). The most distinct responses occur in sections 9 and 8 while the other responses are much delayed, particularly at stop of pumping. Clear responses were also observed in sections 2 and 10. All sections in observation borehole KLX03 are affected by tidal oscillations as described earlier in the report.

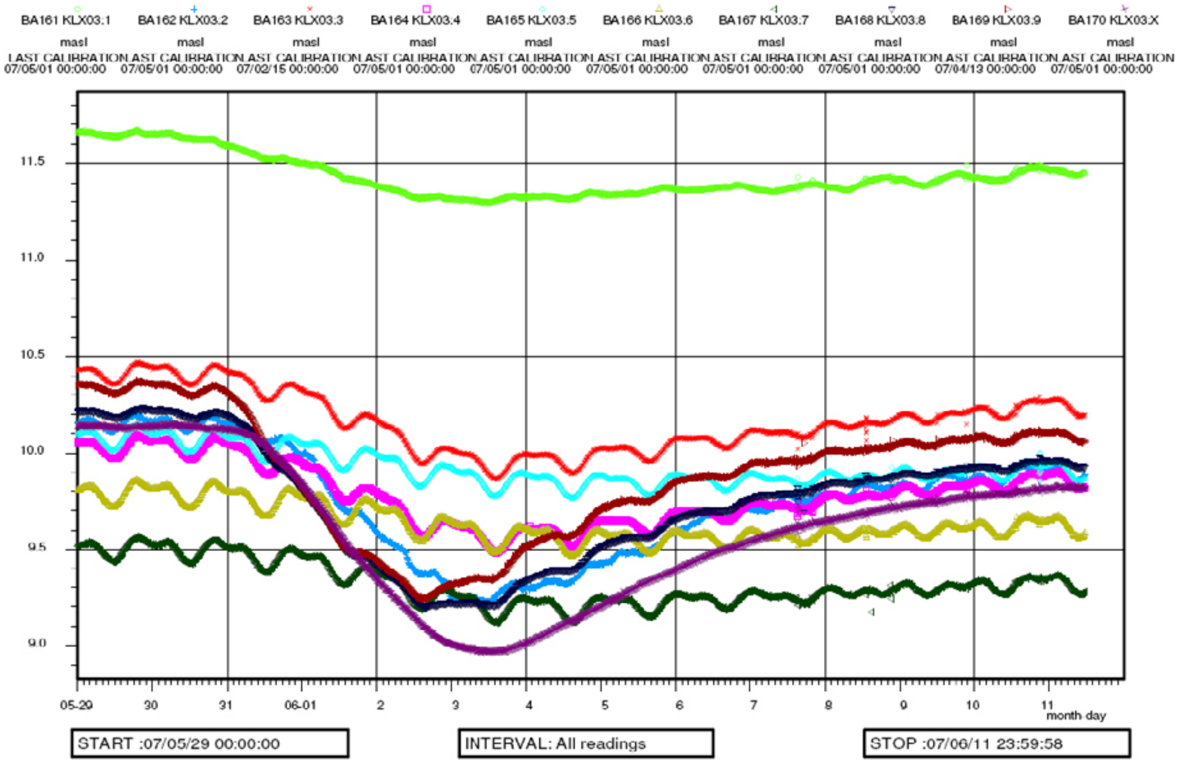


Figure 6-8. *Linear plot of head versus time for all ten sections in the observation borehole KLX03 during interference test 2 in borehole HLX27 (2007).*

Observation section KLX03:1

In Figure 6-8 an overview of the head responses in observation borehole KLX03 is shown. General test data from the observation section KLX03:1 (965.5–971.5 m) are presented in Table 6-4.

Comments on the test

A small response was obtained in this section during the flow and recovery period in this section as seen in Figure 6-8. The time lag to a response of 0.1 m was about 23 h during the flow period. A total drawdown of 0.31 m and a total recovery at the end of the recovery period of 0.11 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "high", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "low".

Table 6-4. General test data from the observation section KLX03:1 (965.5–971.5 m) during interference test 2 in HLX27 (2007).

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	11.63
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	11.32
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	11.44
Hydraulic head change during flow period ($h_i - h_p$)	dh_p	m	0.31

Flow regime and calculated parameters

The data are quite scattered and the evaluation of the recovery is considered as uncertain. During both the flow period and the recovery a transition towards a possible pseudo-radial flow regime occurred. Transient evaluation was based on variable flow rate by the Theis' model for confined aquifers. The evaluation of both periods is considered as uncertain.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $3.7 \cdot 10^{-4}$ m^2/s and the estimated storativity is $1.3 \cdot 10^{-4}$. Both values are considered as very uncertain due to the long distance from the pumping borehole and the small, uncertain response.

Observation section KLX03:2

In Figure 6-8 an overview of the head responses in observation borehole KLX03 is shown. General test data from the observation section KLX03:2 (830.5–964.5 m) are presented in Table 6-5.

Comments on the test

A clear response was obtained in this section during the flow and recovery period during interference test 2 in HLX27 (2007). A total drawdown of c. 0.7 m and a total recovery at the end of the recovery period of 0.48 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "medium", Index 2 (s_p/Q_p) as "low" and the new Index 2 $(s_p/Q_p) \cdot \ln(r_s/r_0)$ as "low".

Flow regime and calculated parameters

The data are quite scattered and the evaluation of both the flow and recovery period is considered as uncertain. During both periods a transition to a possible pseudo-radial flow regime occurred. Transient evaluation was based on variable flow rate by the Theis' model for confined aquifers.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $3.2 \cdot 10^{-5}$ m^2/s and the estimated storativity is $4.3 \cdot 10^{-5}$.

Observation section KLX03:3

In Figure 6-8 an overview of the head responses in observation borehole KLX03 is shown. General test data from the observation section KLX03:3 (752.5–829.5 m) are presented in Table 6-6.

Table 6-5. General test data from the observation section KLX03:2 (830.5–964.5 m) during interference test 2 in HLX27 (2007).

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	10.1
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	9.4
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	9.88
Hydraulic head change during flow period ($h_i - h_p$)	dh_p	m	0.72

Table 6-6. General test data from the observation section KLX03:3 (752.5–829.5 m) during interference test 2 in HLX27 (2007).

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	10.35
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	9.98
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	10.19
Hydraulic head change during flow period (h_i – h_p)	dh_p	m	0.38

Comments on the test

A small response was obtained in this section during the flow and recovery period during interference test 2 in HLX27 (2007). A total drawdown of 0.37 m and a total recovery at the end of the recovery period of 0.21 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "medium", Index 2 (s_p/Q_p) as "low" and the new Index 2 $(s_p/Q_p)\cdot\ln(r_s/r_0)$ as "low".

Flow regime and calculated parameters

The data are quite scattered and the transient evaluation of both the flow and recovery period is considered as uncertain. During both periods a transition to a possible pseudo-radial flow occurred. Transient evaluation was based on variable flow rate by the Theis' model for confined aquifers.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $7.3\cdot10^{-5}$ m^2/s and the estimated storativity $1.2\cdot10^{-4}$.

Observation section KLX03:4

In Figure 6-8 an overview of the head responses in observation borehole KLX03 is shown. General test data from the observation section KLX03:4 (729.5–751.5 m) are presented in Table 6-7.

Comments on the test

A small response was obtained in this section during the flow and recovery period during interference test 2 in HLX27 (2007). A total drawdown of 0.39 m and a total recovery at the end of the recovery period of 0.21 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "medium", Index 2 (s_p/Q_p) as "low" and the new Index 2 $(s_p/Q_p)\cdot\ln(r_s/r_0)$ as "low".

Table 6-7. General test data from the observation section KLX03:4 (729.5–751.5 m) during interference test 2 in HLX27 (2007).

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	9.98
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	9.59
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	9.80
Hydraulic head change during flow period (h_i – h_p)	dh_p	m	0.39

Flow regime and calculated parameters

The data are quite scattered and the transient evaluation of both the flow and recovery period is considered as uncertain. During both periods a transition to a possible pseudo-radial flow regime occurred. Transient evaluation was based on variable flow rate by the Theis' model for confined aquifers.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $6.6 \cdot 10^{-5}$ m^2/s and the estimated storativity $1.3 \cdot 10^{-4}$.

Observation section KLX03:8

In Figure 6-8 an overview of the head responses in observation borehole KLX03 is shown. General test data from the observation section KLX03:8 (199.5–348.5 m) are presented in Table 6-8.

Comments on the test

A clear response was obtained in this section during the flow and recovery period during interference test 2 in HLX27 (2007). A total drawdown of 0.95 m and a total recovery at the end of the recovery period of 0.7 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "medium", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "low".

Flow regime and calculated parameters

A rather distinct response was observed in this section. However, the transient evaluation of both the flow and recovery period is considered as uncertain. During both periods a transition to a possible pseudo-radial flow occurred. Transient evaluation was based on variable flow rate by the Theis' model for confined aquifers.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $7.1 \cdot 10^{-5}$ m^2/s and the estimated storativity $1.2 \cdot 10^{-4}$.

Observation section KLX03:9

In Figure 6-8 an overview of the head responses in observation borehole KLX03 is shown. General test data from the observation section KLX03:9 (193.5–198.5 m) are presented in Table 6-9.

Table 6-8. General test data from the observation section KLX03:8 (199.5–348.5 m) during interference test 2 in HLX27 (2007).

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	10.18
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	9.23
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	9.93
Hydraulic head change during flow period (h_i – h_p)	dh_p	m	0.95

Table 6-9. General test data from the observation section KLX03:9 (193.5–198.5 m) during interference test 2 in HLX27 (2007).

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	10.30
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	9.26
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	10.06
Hydraulic head change during flow period ($h_i – h_p$)	dh_p	m	1.04

Comments on the test

A clear response was obtained in this section during the flow and recovery period during interference test 2 in HLX27 (2007). A total drawdown of c. 1 m and a total recovery at the end of the recovery period of 0.8 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "medium", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "low".

Flow regime and calculated parameters

A rather distinct response was observed in this section. However, the transient evaluation of both the flow and recovery period is considered as uncertain. During both periods a transition to a possible pseudo-radial flow occurred. Transient evaluation was based on variable flow rate by the Theis' model for confined aquifers.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $7.9 \cdot 10^{-5}$ m²/s and the estimated storativity $1.1 \cdot 10^{-4}$.

Observation section KLX03:10

In Figure 6-8 an overview of the head responses in observation borehole KLX03 is shown. General test data from the observation section KLX03:10 (100.1–192.5 m) are presented in Table 6-10.

Comments on the test

A clear response was obtained in this section during the flow and recovery period during interference test 2 in HLX27 (2007). A total drawdown of 0.98 m and a total recovery at the end of the recovery period of 0.65 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "medium", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "low".

Table 6-10. General test data from the observation section KLX03:10 (100.1–192.5 m) during interference test 2 in HLX27 (2007).

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	10.13
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	9.15
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	9.8
Hydraulic head change during flow period ($h_i – h_p$)	dh_p	m	0.98

Flow regime and calculated parameters

A rather distinct response was observed in this section. However, the transient evaluation of both the flow and recovery period is considered as uncertain. During both periods a transition to a possible pseudo-radial flow occurred. Transient evaluation was based on variable flow rate by the Theis' model for confined aquifers.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $3.9 \cdot 10^{-5}$ m^2/s and the estimated storativity $1.1 \cdot 10^{-4}$.

6.3.3 Observation borehole KLX15A

In Figure 6-9 an overview of the observed head versus time in the sections in observation borehole KLX15A is shown. Distinct responses were observed in sections 2 and 3. Section 1 also shows a clear response. The head in observation sections KLX15A:2 and :3 decreased to a level where the pressure transducers only measured the air pressure, seen in Figure 6-9 as the flat part of their curves at the bottom.

Observation section KLX15A:1

In Figure 6-9 an overview of the head responses in observation borehole KLX15A is shown. General test data from the observation section KLX15A:1 (421.0–1,000.4 m) are presented in Table 6-11.

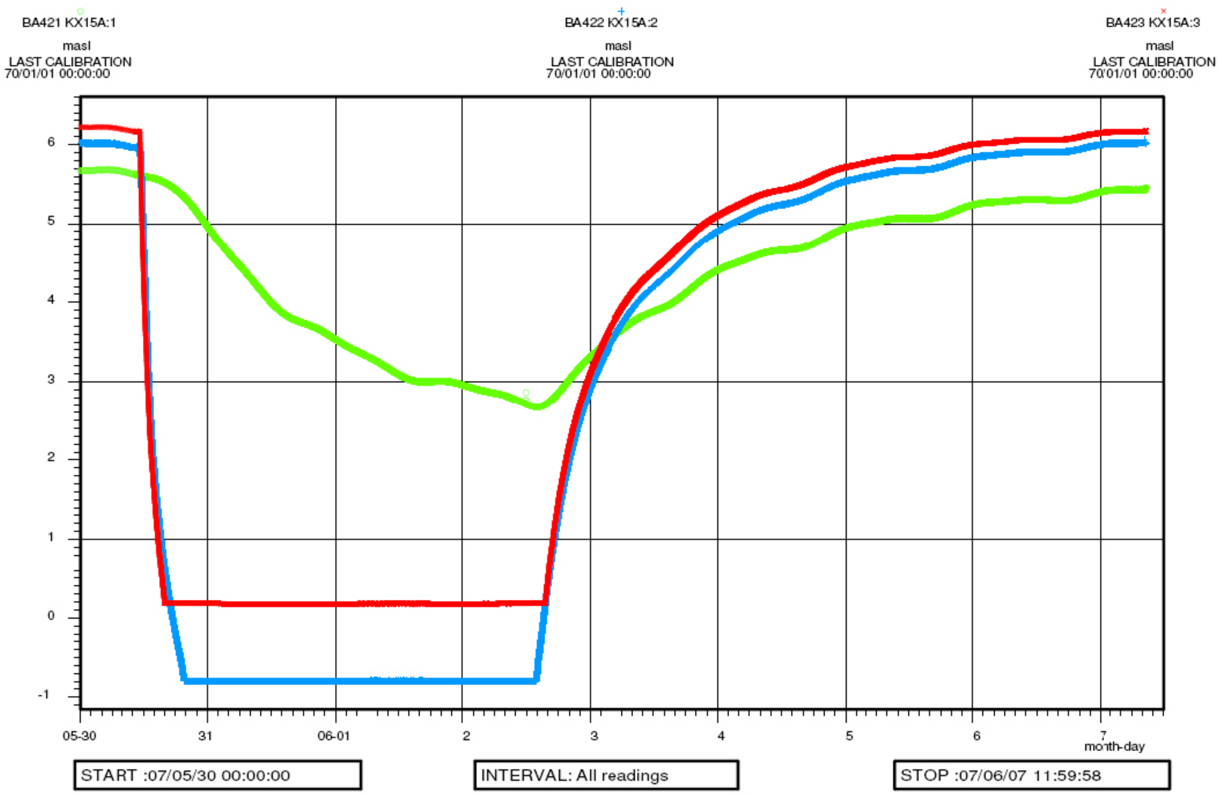


Figure 6-9. *Linear plot of head versus time for all three sections in the observation borehole KLX15A during interference test 2 in borehole HLX27 (2007).*

Table 6-11. General test data from the observation section KLX15A:1 (421.0–1,000.4 m) during interference test 2 in HLX27 (2007).

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	5.6
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	2.7
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	5.45
Hydraulic head change during flow period ($h_i – h_p$)	dh_p	m	2.9

Comments on the test

A distinct response was obtained during the flow and recovery period in this section. The time lag for a response of 0.1 m was much longer than for the other two sections as seen in Figure 6-9. A total drawdown of 2.9 m and a total recovery at the end of the recovery period of 2.75 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "high", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "medium".

Flow regime and calculated parameters

The flow and recovery period both starts with a transition towards a possible pseudo-radial flow regime at the end of the periods. Transient evaluation was based on variable flow rate by the Theis' model for confined aquifers. Consistent results were obtained from the flow and recovery period respectively.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $7.2 \cdot 10^{-5}$ m^2/s and the estimated storativity is $2.1 \cdot 10^{-5}$.

Observation section KLX15A:2

In Figure 6-9 an overview of the head responses in observation borehole KLX15A is shown. General test data from the observation section KLX15A:2 (189.0–420.0 m) are presented in Table 6-12.

Table 6-12. General test data from the observation section KLX15A:2 (189.0–420.0 m) during interference test 2 in HLX27 (2007).

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	5.56
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	–0.79
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	6.01
Hydraulic head change during flow period ($h_i – h_p$)	dh_p	m	6.75

Comments on the test

A very distinct response was obtained in this section during the flow and recovery period during interference test 2 in HLX27 (2007). After approximately 500 min the pressure flattens out to a constant level indicating that the transducer is above the water level. When the pump was shut off the water level rapidly raised putting the transducer below water again. The total drawdown during the first phase of the flow period of 6.35 m and a total recovery at the end of the recovery period of 6.8 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "high", Index 2 (s_p/Q_p) as "low" and the new Index 2 ($s_p/Q_p)\cdot\ln(r_s/r_0$) as "medium".

Flow regime and calculated parameters

During the flow period a transition to a pseudo-radial flow regime occurred after about 100 min. During the recovery period a pseudo-radial flow regime occurs, followed by a transition to pseudo-spherical (leaky) flow after about 500 min. The transient evaluation of the flow period was only conducted on the data when the pressure transducer was below the water surface making the evaluated flow period rather short. The transient evaluation was based on variable flow rate by the Theis' model for the flow period and the Hantush' model for leaky aquifers on the recovery period. Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $4.3\cdot10^{-5}$ m^2/s and the estimated storativity is $6.0\cdot10^{-6}$.

Observation section KLX15A:3

In Figure 6-9 an overview of the head responses in observation borehole KLX15A is shown. General test data from the observation section KLX15A:3 (11.7–188.0 m) are presented in Table 6-13.

Comments on the test

A very distinct response was obtained in this section during the flow and recovery period during interference test 2 in HLX27 (2007). After approximately 280 min the pressure flattens out to a constant level indicating that the pressure transducer is above the water level. When the pump was shut off the water level rapidly raised putting the transducer below water again. The total drawdown during the first phase of the flow period and the total recovery at the end of the recovery period was c. 6 m. The calculated Index 1 (r_s^2/dt_L) is rated as "high", Index 2 (s_p/Q_p) as "low" and the new Index 2 ($s_p/Q_p)\cdot\ln(r_s/r_0$) as "medium".

Table 6-13. General test data from the observation section KLX15A:3 (11.7–188.0 m) during interference test 2 in HLX27 (2007).

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	6.15
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	0.18
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	6.18
Hydraulic head change during flow period (h_i – h_p)	dh_p	m	5.97

Flow regime and calculated parameters

The evaluation of the flow period is only conducted on the data when the pressure transducer was situated below the water surface making the evaluated part of the flow period rather short. During the flow period a transition to pseudo-radial flow occurred. During the recovery period pseudo-radial flow transitioning to pseudo-spherical (leaky) flow occurred. Transient evaluation was based on variable flow rate by the Theis' model for the flow period and the Hantush' model for leaky aquifers on the recovery period

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $4.6 \cdot 10^{-5}$ m^2/s and the estimated storativity is $2.3 \cdot 10^{-5}$.

6.3.4 Observation borehole HLX26

Observation borehole HLX26 had two sections separated by a packer at 10.0–11.0 m. Only the lower one, HLX26:1 (11.0–151.2 m) was monitored by HMS and included in interference test 2 while the upper section was left out.

Observation section HLX26:1

In Figure 6-10 an overview of the head response in observation borehole section HLX26:1 is shown. The borehole is cased to 9.0 m and a packer is installed between 10 and 11 m. The interval of this section is thus c. 11.0–151.2 m. General test data from the observation section HLX26:1 is presented in Table 6-14.

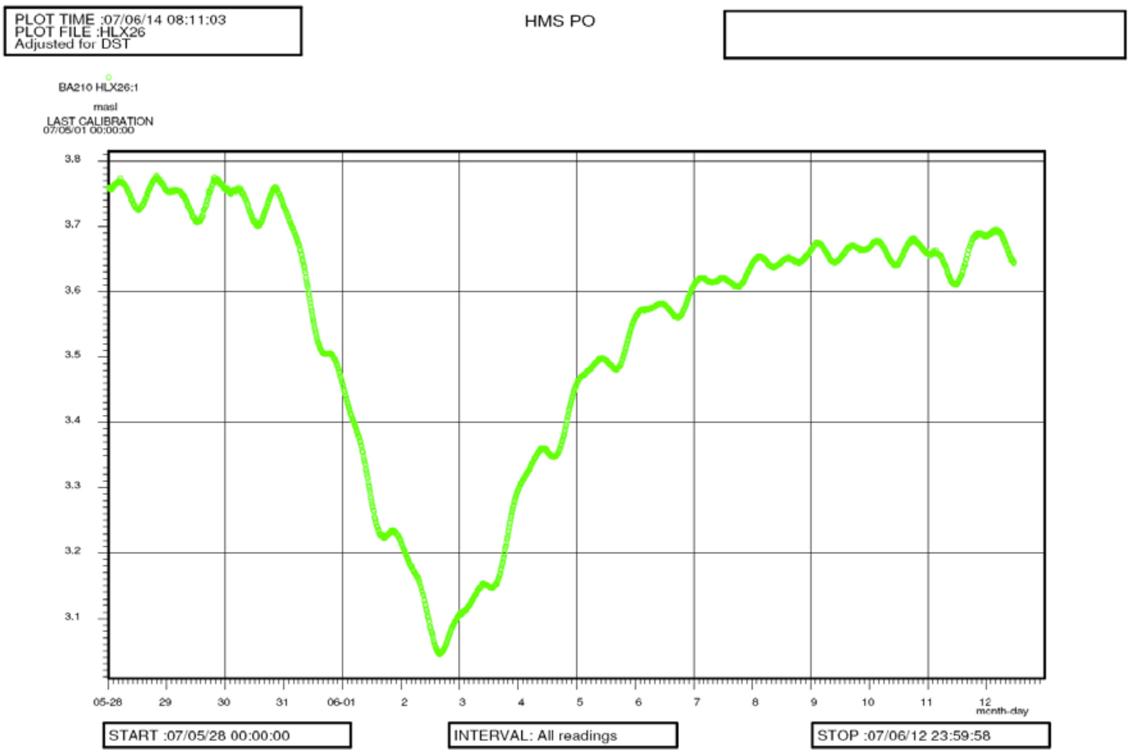


Figure 6-10. *Linear plot of head versus time in the observation borehole section HLX26:1 during interference test 2 in borehole HLX27 (2007).*

Table 6-14. General test data from the observation section HLX26 (11.0–151.2 m) during interference test 2 in HLX27 (2007).

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	3.71
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	3.09
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	3.65
Hydraulic head change during flow period (h_i – h_p)	dh_p	m	0.62

Comments on the test

A clear but small response to the pumping in HLX27 was observed in borehole HLX26. The variations of the flow rate in the pumping section can clearly be seen in the head data in the observation section. The time lag to a drawdown of 0.1 m after start of pumping was about 21 hours in HLX26:1. A total drawdown during the flow period of 0.62 m was observed. The pressure at the end of the recovery period was almost the same as at start of pumping. The calculated Index 1 (r_s^2/dt_L) is rated as "medium", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "low".

Flow regime and calculated parameters

During both the flow and recovery period a transition to a short period of pseudo-radial flow occurred by the end. The responses during the flow and recovery period are similar. Transient evaluation was based on variable flow rate by the Theis' model for confined aquifers.

The agreement in evaluated parameter values between the flow and recovery period is very good.

Selected representative parameters

The transient evaluation of the flow period is selected as representative for the test. The selected representative transmissivity is $1.3 \cdot 10^{-4}$ m^2/s and the estimated storativity is $9.6 \cdot 10^{-5}$.

6.3.5 Observation borehole HLX38

In Figure 6-11 an overview of the head response in observation borehole HLX38 is shown. General test data from the observation borehole HLX38 are presented in Table 6-15. The borehole is cased to 15.0 m. The uncased interval of this section is thus c. 15.0–199.5 m.

Table 6-15. General test data from the observation section HLX38 (15.0–199.5 m) during interference test 2 in HLX27 (2007).

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	5.59
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	5.27
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	5.52
Hydraulic head change during flow period (h_i – h_p)	dh_p	m	0.32

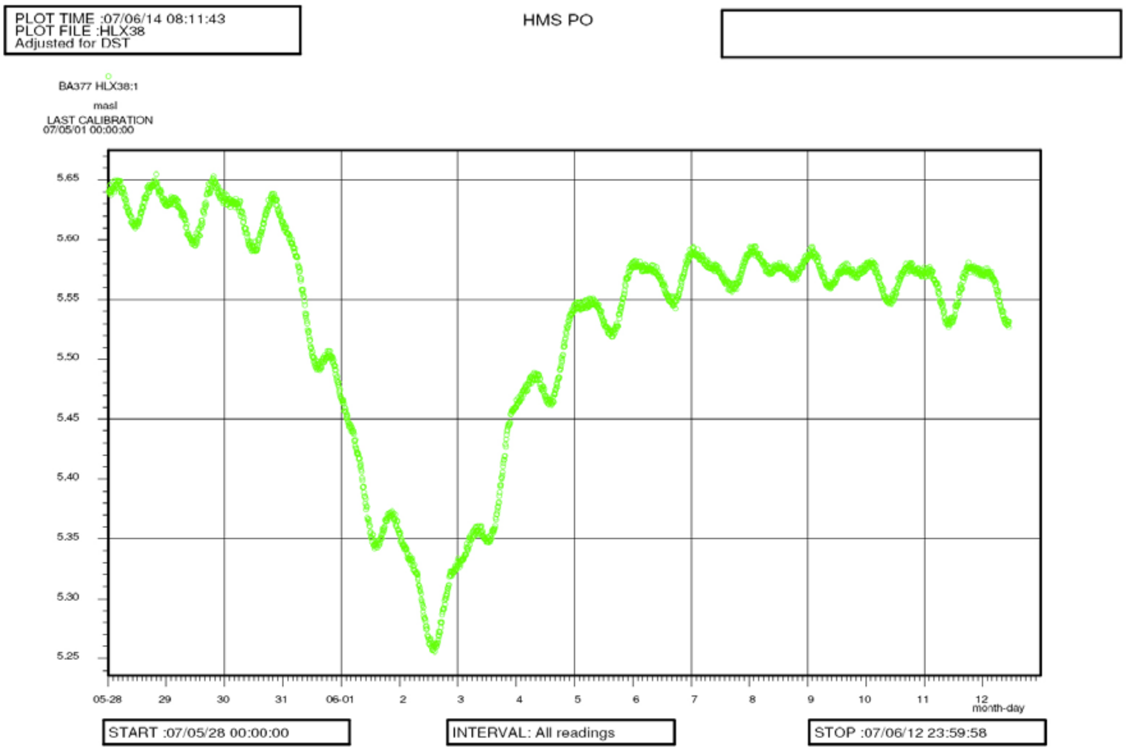


Figure 6-11. *Linear plot of head versus time in the observation borehole HLX38 during interference test 2 in borehole HLX27 (2007).*

Comments on the test

A clear but small response to the pumping in HLX27 was observed in borehole HLX38. The variations of the flow rate in the pumping section can clearly be seen in the pressure data for the observation section. The time lag to a drawdown of 0.1 m after start of pumping was about 27 hours in HLX38. A total drawdown of 0.32 m was observed. The pressure at the end of the recovery period was almost the same as at the start of the pumping. The calculated Index 1 (r_s^2/dt_L) is rated as "medium", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "low".

Flow regime and calculated parameters

During the flow period a transition to a possible pseudo-radial flow regime occurred. During the recovery period a short period of pseudo-radial flow transitioning to pseudo-spherical (leaky) flow occurred. The transient evaluation was based on variable flow rate and performed by the Theis' model for the flow period and the Hantush' model for leaky aquifers on the recovery period respectively.

Selected representative parameters

The transient evaluation of the recovery period is selected as representative for the test. The selected representative transmissivity is $9.8 \cdot 10^{-5}$ m^2/s and the estimated storativity is $5.3 \cdot 10^{-5}$.

6.3.6 Observation borehole HLX42

Observation borehole HLX42 had two sections separated by a packer at 29.0–30.0 m. The borehole is about 152.6 m long and cased to about 9.1 m. An overview of the head response in observation borehole HLX42 is shown in Figure 6-12. The upper section HLX42:2 (9.1–29.0 m) is, as seen in Figure 6-10, unaffected by the pumping in HLX27 (2007). The lower section, HLX42:1, may possibly show a small response but concerning the natural head trend in the borehole, the precipitation during the period and the delay in the observed head recovery at stop of pumping, the response is highly uncertain and not evaluated.

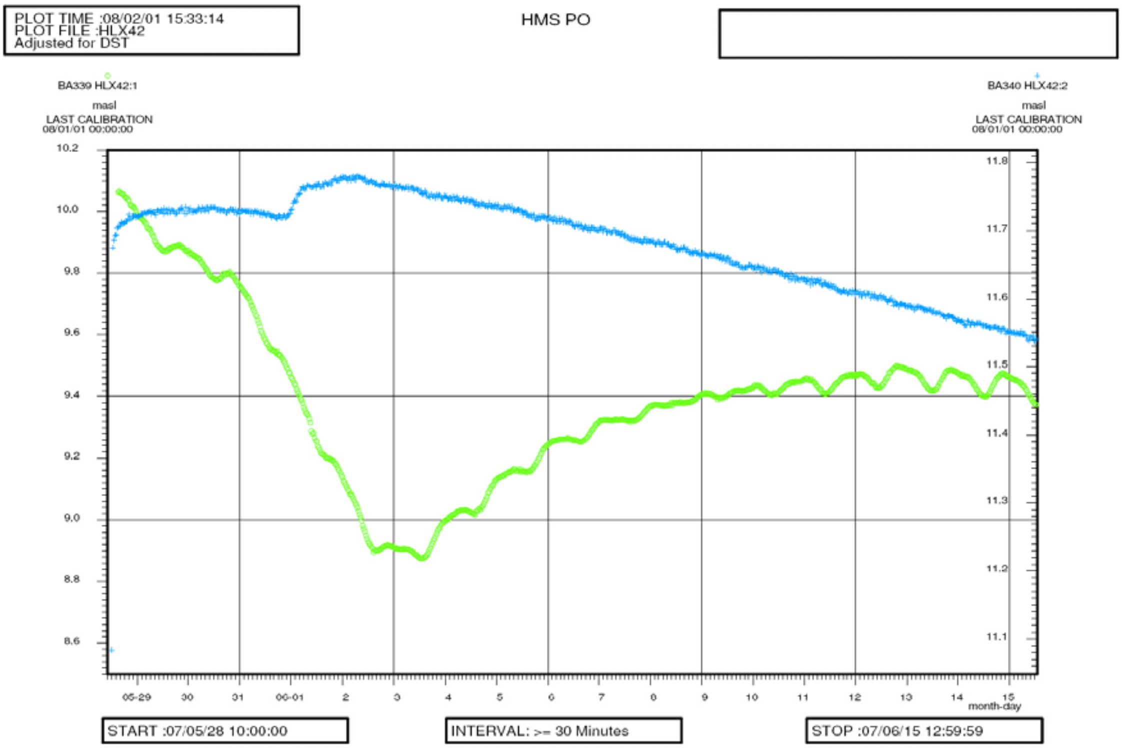


Figure 6-12. *Linear plot of head versus time in the observation borehole HLX42 during interference test 2 in borehole HLX27 (2007).*

6.4 Interference test in HLX28

6.4.1 Pumping borehole HLX28

General test data for the interference test in HLX28 are presented in Table 6-16. The borehole is cased to 6.0 m. The uncased interval of this section is thus c. 6.0–154.2 m.

The locations of the observation bore holes as well as their degree of response is seen in Figure 6-13. The Rock types and deformation zones is also seen in this figure.

Table 6-16. General test data for the pumping test in HLX28: 6.0–154.2 m.

General test data			
Pumping borehole	HLX28		
Test type[1)]	Constant Rate withdrawal and recovery test		
Test section (open borehole/packed-off section):	open borehole		
Test No	1		
Field crew	SKB		
Test equipment system			
General comment	Interference test		
	Nomen-clature	**Unit**	**Value**
Borehole length	L	m	154.2
Casing length	L_c	m	6.03
Test section – secup	Secup	m	6.03
Test section – seclow	Seclow	m	154.2
Test section length	L_w	m	148.17
Test section diameter[2)]	$2 \cdot r_w$	mm	136
Test start (start of flow period)		yymmdd hh:mm	070405 14:52
Packer expanded		yymmdd hh:mm:ss	
Start of flow period		yymmdd hh:mm:ss	070405 14:52:00
Stop of flow period		yymmdd hh:mm:ss	070410 08:51:00
Test stop (stop of flow period)		yymmdd hh:mm	070410 08:51
Total flow time	t_p	min	6,839
Total recovery time	t_F	min	8,616
Pressure data			
Relative pressure in test section before start of flow period	p_i	m	57.9
Relative pressure in test section before stop of flow period	p_p	m	46.8
Relative pressure in test section at stop of recovery period	p_F	m	58.2
Pressure change during flow period (p_i – p_p)	dp_p	m	11.1
Flow data			
Flow rate from test section just before stop of flow period	Q_p	m^3/s	0.0016
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	0.00161
Total volume discharged during flow period	V_p	m^3	660.6

[1)] Constant Head injection and recovery, Constant Rate withdrawal and recovery or Constant Drawdown and recovery.

[2)] Nominal diameter.

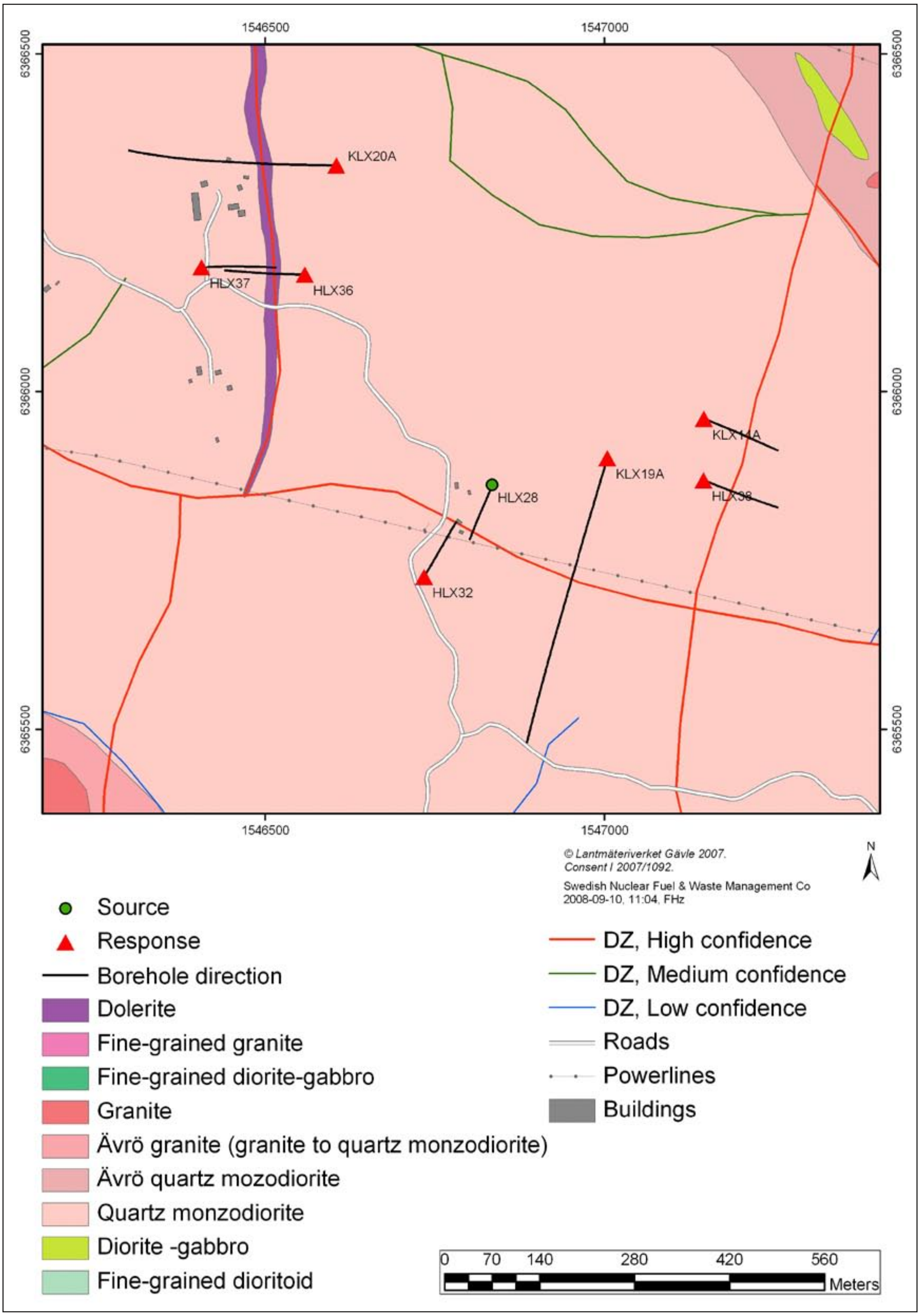


Figure 6-13. *Borehole response map for the observation boreholes when pumping in HLX28.*

Comments on the test

The pressure and flow during the test are showed in Figure 6-14. The test was performed as a constant flow rate pumping test with slightly decreasing flow rate. The mean flow rate was c. 96.6 L/min and the duration of the flow period was c. 4 days and 18 h. A total drawdown of 11.1 m and a total recovery at the end of the recovery period of 11.4 m was observed.

Flow regime and calculated parameters

The responses during both the flow and recovery period clearly indicate a double-permeability system with an early, short PRF followed by a transition to a second PRF with lower transmissivity. The first PRF is assumed to represent a high-transmissive feature of limited extension close to the borehole, intersected by a less transmissive fracture network at longer distances from the borehole. By the end of the flow period a PSF is shown which is only weakly developed during the recovery period. The evaluation shown in Appendix 1 represents the late time response. The evaluation of the early response is shown in the Test Diagrams in Appendix 2.

The transient evaluation of the early time responses of both the flow and recovery period was performed by applying the model by Dougherty-Babu for a confined aquifer. The late time responses were evaluated by the model by Moench (Case 1) for a leaky aquifer. Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively, both for the early and late time evaluations.

Selected representative parameters

For the interference test in HLX28, the parameter values estimated from the long time evaluation of the flow period are selected as the most representative for the pumping borehole. The selected representative transmissivity is $3.6 \cdot 10^{-5}$ m^2/s and the estimated storativity is $4.2 \cdot 10^{-6}$.

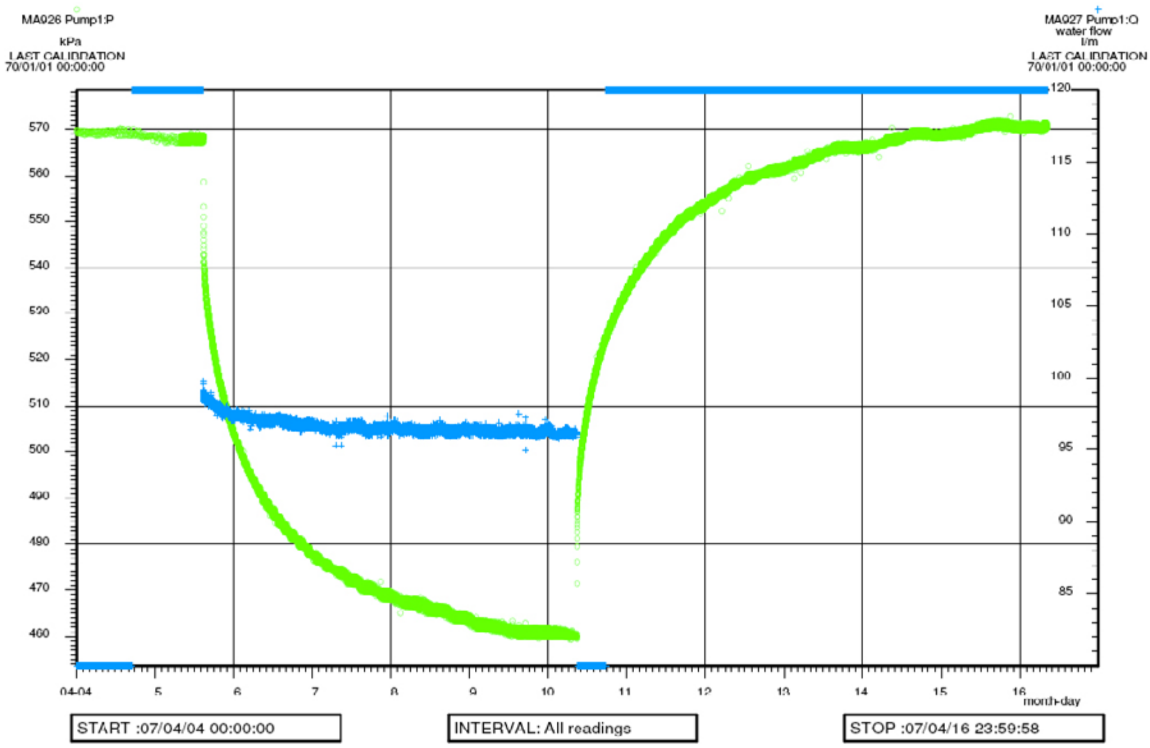


Figure 6-14. *Linear plot of flow rate and pressure versus time in the pumping borehole HLX28.*

6.4.2 Observation borehole KLX14A

In Figure 6-15 an overview of the head responses in observation borehole KLX14A is shown. A head response was only obtained in section 3 (the top section) during the interference test in HLX28. The length of borehole hole KLX14 A is 176.3 General test data from the observation section KLX14A:3 (6.5–72.0 m) are presented in Table 6-17. The borehole is cased to 6.5 m.

Comments on the test

A clear response is seen during the flow period in this section. The other two sections in the borehole only showed signs of tidal effects. A total drawdown of c. 4.1 m and a total recovery at the end of the recovery period of less than 4.5 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "high", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "medium".

Flow regime and calculated parameters

Consistent responses were obtained during the flow and recovery period. After a short period of nearly pseudo-radial flow a transition to pseudo-spherical (leaky) flow occurred by the end. Both periods were evaluated with the Hantush-Jacob's model for a leaky confined aquifer. Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively.

Table 6-17. General test data from the observation section KLX14A:3 (6.5–72.0 m) during the interference test in HLX28.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	11.54
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	7.46
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	11.96
Hydraulic head change during flow period ($h_i - h_p$)	dh_p	m	4.08

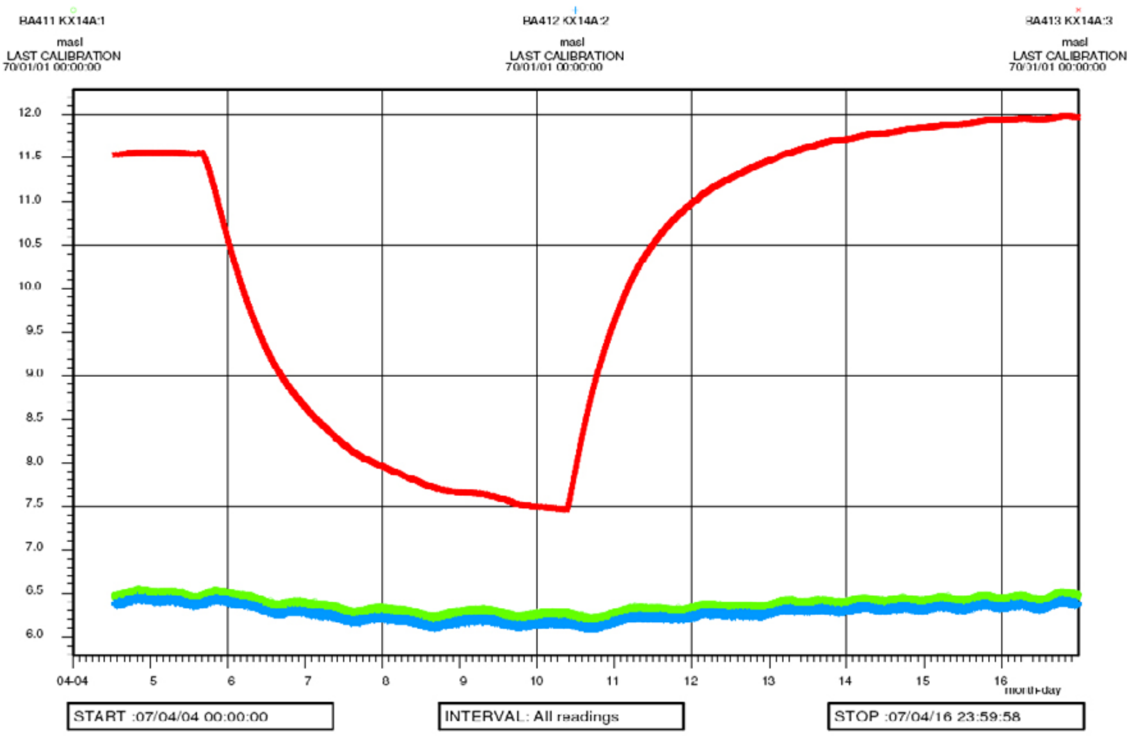


Figure 6-15. Linear plot of head versus time in the observation borehole KLX14A during the interference test in borehole HLX28.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative. The selected representative transmissivity is $4.1 \cdot 10^{-5}$ m²/s and the estimated storativity is $2.9 \cdot 10^{-5}$.

6.4.3 Observation borehole KLX19A

In Figure 6-16 an overview of the observed head versus time in the sections in observation borehole KLX19A is shown. There are responses in sections 3–8, while sections 1 and 2 display no responses on the pumping in HLX28.

Observation section KLX19A:3

General test data from the observation section KLX19A:3 (509.0–517.0 m) are presented in Table 6-18.

Table 6-18. General test data from the observation section KLX19A:3 (509.0–517.0 m) during the interference test in HLX28.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	13.1
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	6.7
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	12.7
Hydraulic head change during flow period ($h_i - h_p$)	dh_p	m	6.4

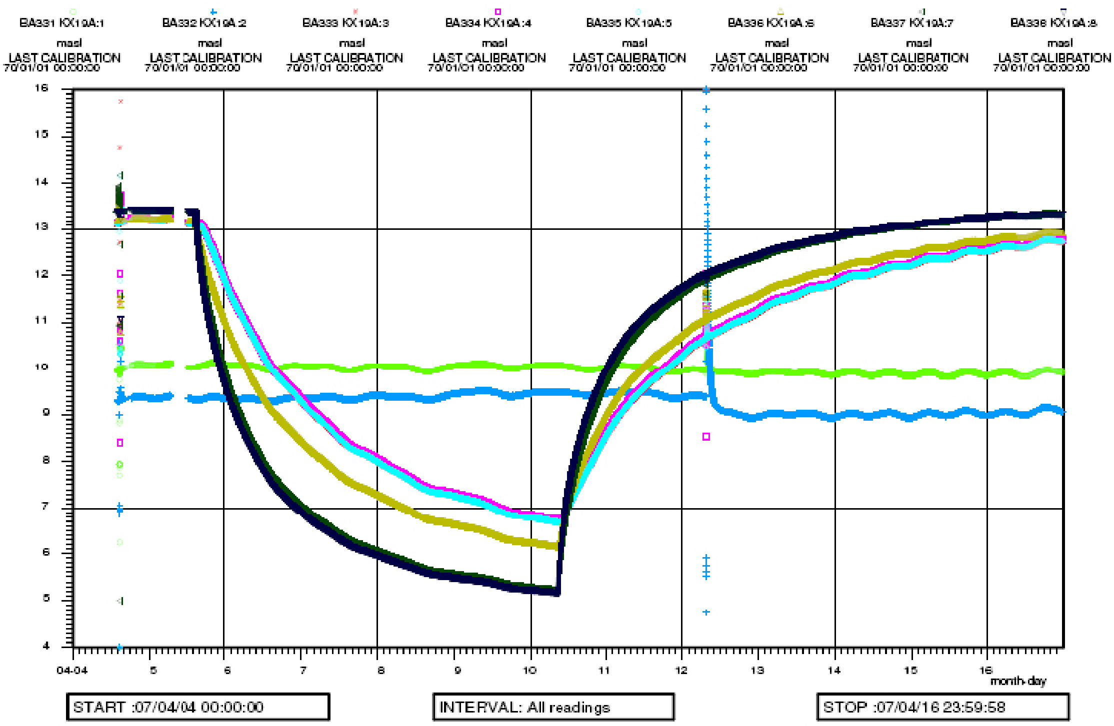


Figure 6-16. Linear plot of pressure versus time for all eight sections in the observation borehole KLX19A during pumping in borehole HLX28.

Comments on the test

Distinct responses were obtained during both the flow and recovery period in this section as seen in Figure 6-16. The time lag for a response of 0.1 m was about 2 h. A total drawdown of 6.4 m and a total recovery at the end of the recovery period of 6.0 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "high", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "medium".

Flow regime and calculated parameters

The flow period is dominated by nearly pseudo-radial flow transitioning to pseudo-spherical (leaky) flow. During the recovery period a transition to pseudo-radial flow occurred. Both periods were evaluated with the Hantush-Jacob's model for a leaky confined aquifer. Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $3.5\cdot10^{-5}$ m²/s and the estimated storativity is $2.0\cdot10^{-5}$.

Observation section KLX19A:4

In Figure 6-16 an overview of the head responses in observation borehole KLX19A is shown. General test data from the observation section KLX19A:4 (481.0–508.0 m) are presented in Table 6-19.

Comments on the test

Distinct responses were obtained during both the flow and recovery period during the interference test in HLX28. A total drawdown of 6.5 m and a total recovery at the end of the recovery period of 6.1 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "high", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "medium".

Flow regime and calculated parameters

The flow period is dominated by nearly pseudo-radial flow transitioning to pseudo-spherical (leaky) flow. During the recovery period a transition to pseudo-radial flow occurred. Both periods were evaluated with the Hantush-Jacob's model for a leaky confined aquifer. Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively.

Table 6-19. General test data from the observation section KLX19A:4 (481.0–508.0 m) during the interference test in HLX28.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	13.2
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	6.7
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	12.8
Hydraulic head change during flow period (h_i – h_p)	dh_p	m	6.5

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $3.5 \cdot 10^{-5}$ m^2/s and the estimated storativity is $2.0 \cdot 10^{-5}$.

Observation section KLX19A:5

In Figure 6-16 an overview of the head responses in observation borehole KLX19A is shown. General test data from the observation section KLX19A:5 (311.0–480.5 m) are presented in Table 6-20.

Comments on the test

Distinct responses were obtained during both the flow and recovery period during the interference test in HLX28. A total drawdown of 6.4 m and a total recovery at the end of the recovery period of 6.0 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "high", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "medium".

Flow regime and calculated parameters

The flow period is dominated by nearly pseudo-radial flow transitioning to pseudo-spherical (leaky) flow. During the recovery period a transition to pseudo-radial flow occurred. Both periods were evaluated with the Hantush-Jacob's model for a leaky confined aquifer. Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $3.5 \cdot 10^{-5}$ m^2/s and the estimated storativity is$3.5 \cdot 10^{-5}$.

Observation section KLX19A:6

In Figure 6-16 an overview of the head responses in observation borehole KLX19A is shown. General test data from the observation section KLX19A:6 (291.0–310.0 m) are presented in Table 6-21.

Table 6-20. General test data from the observation section KLX19A:5 (311.0–480.5 m) during the interference test in HLX28.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	13.1
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	6.7
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	12.7
Hydraulic head change during flow period ($h_i - h_p$)	dh_p	m	6.4

Table 6-21. General test data from the observation section KLX19A:6 (291.0–310.0 m) during the interference test in HLX28.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	13.2
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	6.1
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	12.9
Hydraulic head change during flow period (h_i – h_p)	dh_p	m	7.1

Comments on the test

Distinct responses were obtained both during the flow and recovery period during the interference test in HLX28. A total drawdown of 7.1 m and a total recovery at the end of the recovery period of 6.8 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "high", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "medium".

Flow regime and calculated parameters

During both periods, the responses indicate a double-permeability system with early and late responses separated by an apparent NFB. The early response is assumed to represent a flow feature with higher transmissivity of presumed limited extension intersected by a less transmissive fracture network outside. By the end of the flow period a PSF is shown which is only weakly developed during the recovery period.

The early response was evaluated by the Theis' model for a confined aquifer and the late response by the Hantush-Jacob's model for a leaky confined aquifer, c.f. Appendix 2. Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively.

Selected representative parameters

The parameter values estimated from the late time response during the flow period are selected as the most representative for the test section. The selected representative transmissivity is $4.8·10^{-5}$ m^2/s and the estimated storativity is $3.5·10^{-5}$.

Observation section KLX19A:7

In Figure 6-16 an overview of the head responses in observation borehole KLX19A is shown. General test data from the observation section KLX19A:7 (136.0–290.0 m) are presented in Table 6-22.

Table 6-22. General test data from the observation section KLX19A:7 (136.0–290.0 m) during the interference test in HLX28.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	13.4
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	5.2
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	13.3
Hydraulic head change during flow period (h_i – h_p)	dh_p	m	8.2

Comments on the test

Distinct and rather large responses were obtained during both the flow and recovery period during the interference test in HLX28. A total drawdown of 8.2 m and a total recovery at the end of the recovery period of c. 8 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "high", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "medium".

Flow regime and calculated parameters

During both periods, the responses indicate a double-permeability system with early and late responses separated by an apparent NFB. The early response is assumed to represent a flow feature with higher transmissivity of presumed limited extension intersected by a less transmissive fracture network outside. By the end of the flow period a PSF is shown which is only weakly developed during the recovery period.

The early response was evaluated by the Theis' model for a confined aquifer and the late response by the Hantush-Jacob's model for a leaky confined aquifer, c.f. Appendix 2. Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively.

Selected representative parameters

The parameter values estimated from the late time response during the flow period are selected as the most representative for the test section. The selected representative transmissivity is $4.5 \cdot 10^{-5}$ m²/s for an estimated storativity of $2.9 \cdot 10^{-5}$.

Observation section KLX19A:8

In Figure 6-16 an overview of the head responses in observation borehole KLX03 is shown. General test data from the observation section KLX19A:8 (98.75–135.0 m) are presented in Table 6-23.

Comments on the test

Distinct and rather large responses were obtained during both the flow and recovery period during the interference test in HLX28. A total drawdown of 8.2 m and a total recovery at the end of the recovery period of 8.1 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "high", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "medium".

Flow regime and calculated parameters

During both periods, the responses indicate a double-permeability system with early and late responses separated by an apparent NFB. The early response is assumed to represent a flow feature with higher transmissivity of presumed limited extension intersected by a less transmissive fracture network outside. By the end of the flow period a PSF is shown which is only weakly developed during the recovery period.

Table 6-23. General test data from the observation section KLX03 KLX19A:8 (98.8–135.0 m) during the interference test in HLX28.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	13.4
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	5.2
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	13.3
Hydraulic head change during flow period (h_i – h_p)	dh_p	m	8.2

The early response was evaluated by the Theis' model for a confined aquifer and the late response by the Hantush-Jacob's model for a leaky confined aquifer, c.f. Appendix 2. Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively.

Selected representative parameters

The parameter values estimated from the late time response during the flow period are selected as the most representative for the test section. The selected representative transmissivity is $5.3 \cdot 10^{-5}$ m^2/s and the estimated storativity is $2.8 \cdot 10^{-5}$.

6.4.4 Observation borehole KLX20A

In Figure 6-17 an overview of the observed head versus time in observation borehole KLX20A during the interference test in HLX28 is shown. General test data from the observation borehole section KLX20A:100.9–457.92 m is presented in Table 6-24.

Table 6-24. General test data from the observation section KLX20A:100.9–457.92 m during the interference test in HLX28.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	15.42
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	12.80
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	15.15
Hydraulic head change during flow period ($h_i - h_p$)	dh_p	m	2.62

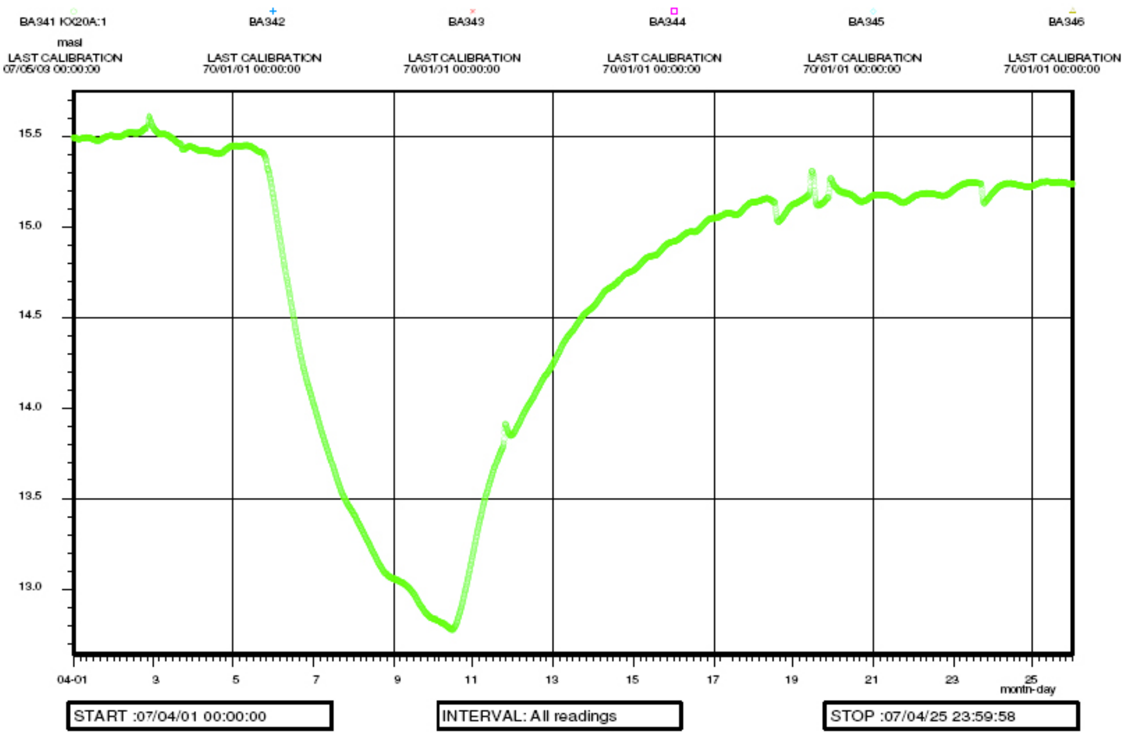


***Figure 6-17.** Linear plot of head versus time in the observation borehole KLX20A during the interference test in borehole HLX28.*

Comments on the test

Distinct responses were obtained during both the flow and recovery period during the interference test in HLX28. A total drawdown of 2.6 m and a total recovery at the end of the recovery period in the same magnitude was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "high", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "medium".

Flow regime and calculated parameters

During the flow period a short period of approximate pseudo-radial flow occurred transitioning to pseudo-spherical (leaky) flow. During the recovery period a pseudo-radial flow dominated by the end. Both periods were evaluated with the Hantush-Jacob's model for a leaky confined aquifer. Consistent results of evaluated hydraulic parameter values are obtained from the flow and recovery period respectively.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative. The selected representative transmissivity is $5.4 \cdot 10^{-5}$ m²/s and the estimated storativity is $2.7 \cdot 10^{-5}$.

6.4.5 Observation borehole HLX32

In Figure 6-18 an overview of the observed head versus time in the sections in observation borehole HLX32 during the interference test in HLX28 is shown. Borehole HLX32 had at the time of the test (2007-04-05 to 2007-04-10) two sections. Section HLX32:1 (16.0–152.6 m) showed a clear response while HLX32:2 (12.3–15.0 m) were not monitored by HMS.

Observation section HLX32:1

General test data from the observation section HLX32:1 (16.0–152.60 m) are presented in Table 6-25.

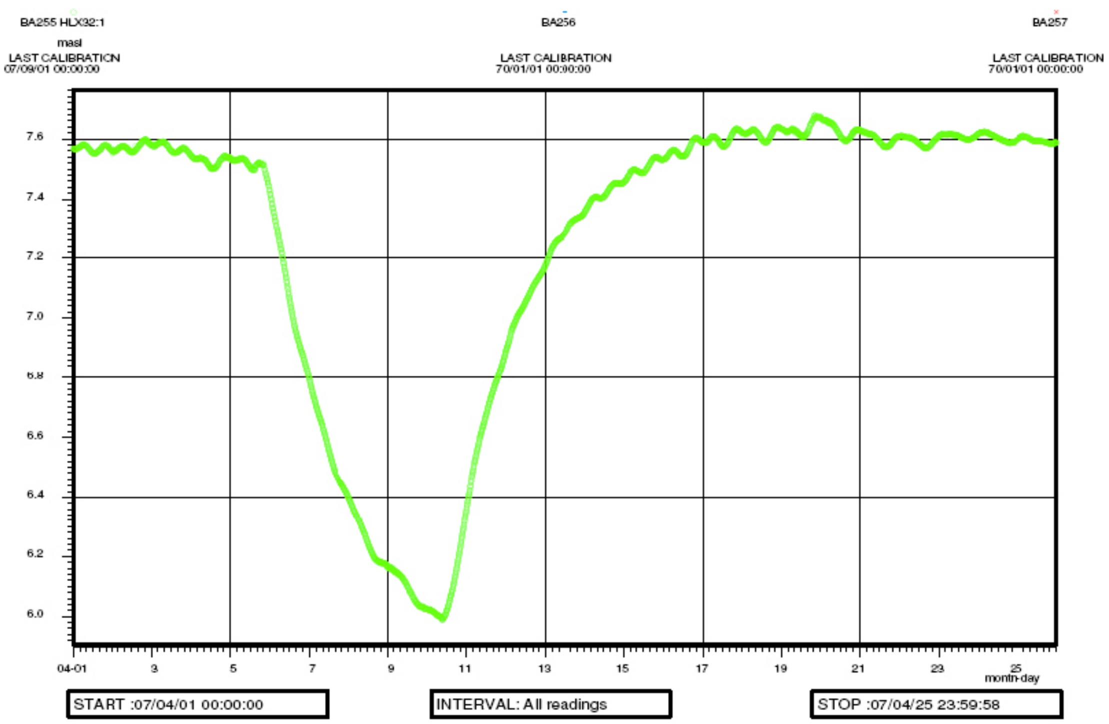


Figure 6-18. *Linear plot of head versus time in the observation section HLX32:1 during the interference test in borehole HLX28.*

Table 6-25. General test data from the observation section HLX32:1 (16.0–152.6 m) during the interference test in HLX28.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	7.5
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	5.99
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	7.5
Hydraulic head change during flow period (h_i – h_p)	dh_p	m	1.51

Comments on the test

Distinct and rather large responses were obtained during both the flow and recovery period during the interference test in HLX28. A total drawdown of 1.5 m and a total recovery at the end of the recovery period in the same magnitude was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "low", Index 2 (s_p/Q_p) as "low" and the new
Index 2 (s_p/Q_p)·ln(r_s/r_0) as "low".

Flow regime and calculated parameters

During both the flow and recovery period a short period of approximate pseudo-radial flow occurred transitioning to pseudo-spherical (leaky) flow. Both periods were evaluated with the Hantush-Jacob's model for a leaky confined aquifer. Consistent results of evaluated hydraulic parameter values are obtained from the flow and recovery period respectively.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for this test. The selected representative transmissivity is $7.5 \cdot 10^{-5}$ m^2/s and the estimated storativity is $2.2 \cdot 10^{-3}$.

6.4.6 Observation borehole HLX36

In Figure 6-19 an overview of the observed head versus time in the sections in observation borehole HLX36 is shown. Responses were observed in section 1, while section 2 displays no response on the pumping in HLX28.

Observation section HLX36:1

General test data from the observation section HLX36:1 (50.0–199.8 m) are presented in Table 6-26.

Table 6-26. General test data from the observation section HLX36:1: 50.0–199.8 m during the interference test in HLX28.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	14.2
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	11.2
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	14.2
Hydraulic head change during flow period (h_i – h_p)	dh_p	m	3.0

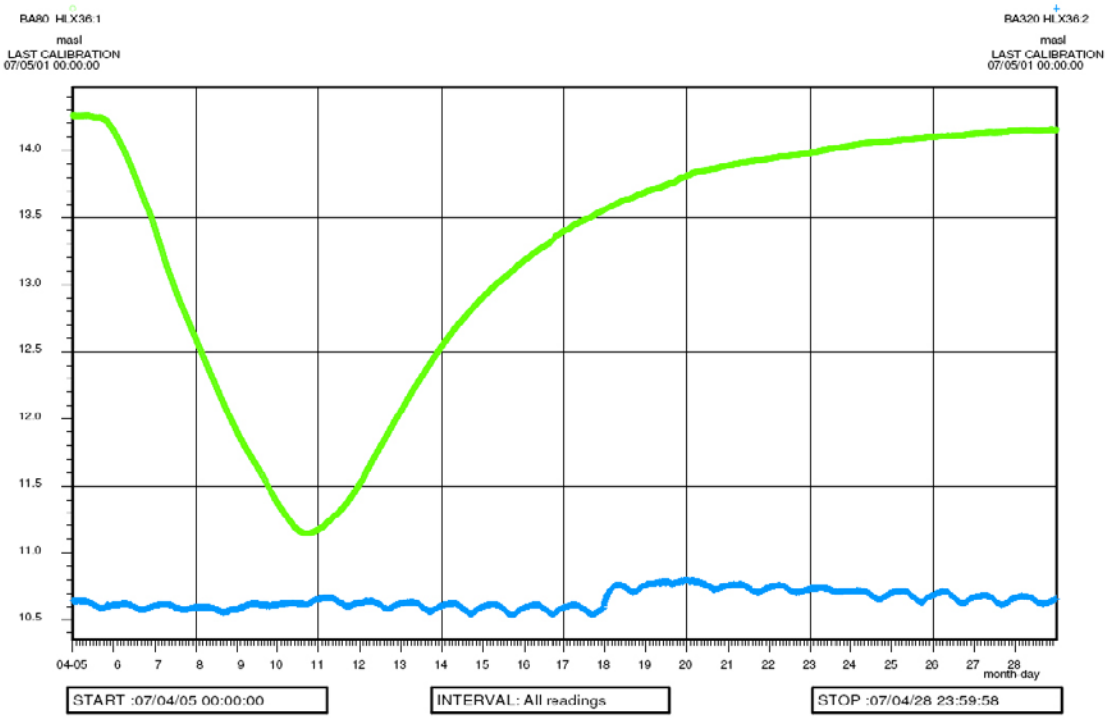


Figure 6-19. *Linear plot of head versus time in the observation borehole HLX36 during the interference test in borehole HLX28.*

Comments on the test

Distinct and rather large responses were obtained during both the flow and recovery period during the interference test in HLX28. A total drawdown of 3.0 m and a total recovery at the end of the recovery period in the same magnitude was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "medium", Index 2 (s_p/Q_p) as "low" and the new Index 2 (s_p/Q_p)·ln(r_s/r_0) as "medium".

Flow regime and calculated parameters

The flow period is dominated by pseudo-radial flow. During the recovery period pseudo-radial flow transitioning to slightly leaky flow occurred. Both periods were evaluated with the Hantush-Jacob's model for a leaky confined aquifer. Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative. The selected representative transmissivity is $4.6 \cdot 10^{-5}$ m^2/s and the estimated storativity is $7.5 \cdot 10^{-5}$.

6.4.7 Observation borehole HLX37

In Figure 6-20 an overview of the observed head versus time in the sections in observation borehole HLX37 is shown. Responses were observed in sections 1 and 2, while section 3 displays no response on the pumping in HLX28.

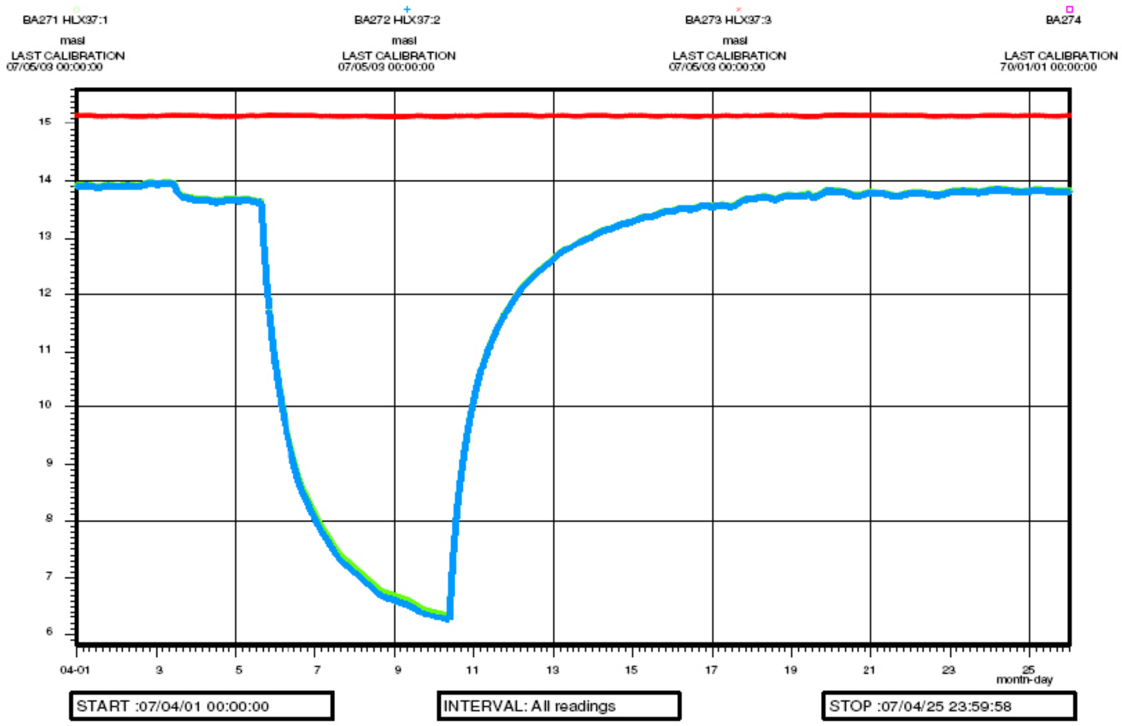


Figure 6-20. *Linear plot of head versus time for all three sections in the observation borehole HLX37 during the interference test in borehole HLX28.*

Observation section HLX37:1

In Figure 6-20 an overview of the head responses in observation borehole HLX37 is shown. General test data from the observation section HLX37:1 (149.0–199.8 m) are presented in Table 6-27.

Comments on the test

A distinct and fast response was obtained during the flow and recovery period in this section as seen in Figure 6-20. A total drawdown of 7.3 m and a total recovery at the end of the recovery period of the same magnitude was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "excellent", Index 2 (s_p/Q_p) as "low" and the new Index 2 $(s_p/Q_p)\cdot\ln(r_s/r_0)$ as "medium".

Flow regime and calculated parameters

During both the flow and recovery period a short period of approximate pseudo-radial flow occurred transitioning to pseudo-spherical (leaky) flow. Both periods were evaluated with the Hantush-Jacob's model for a leaky confined aquifer. Consistent results of evaluated hydraulic parameter values are obtained from the flow and recovery period respectively.

Table 6-27. General test data from the observation section HLX37:1 (149.0–199.8 m) during the interference test in HLX28.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	13.65
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	6.34
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	13.65
Hydraulic head change during flow period ($h_i - h_p$)	dh_p	m	7.31

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test. The selected representative transmissivity is $4.9 \cdot 10^{-5}$ m²/s and the estimated storativity is $5.9 \cdot 10^{-6}$.

Observation section HLX37:2

In Figure 6-20 an overview of the head responses in observation borehole HLX37 is shown. General test data from the observation section HLX37:2 (118.0–148.0 m) are presented in Table 6-28.

Comments on the test

A distinct response was observed during the flow and recovery period during pumping in HLX28. A total drawdown of 7.4 m was observed. The pressure recovered completely during the recovery period. The calculated Index 1 (r_s^2/dt_L) is rated as "excellent", Index 2 (s_p/Q_p) as "low" and the new Index 2 $(s_p/Q_p) \cdot \ln(r_s/r_0)$ as "medium".

Flow regime and calculated parameters

During both the flow and recovery period a short period of approximate pseudo-radial flow occurred transitioning to pseudo-spherical (leaky) flow. Both periods were evaluated with the Hantush-Jacob's model for a leaky confined aquifer. Consistent results of evaluated hydraulic parameter values are obtained from the flow and recovery period respectively.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative for the test section. The selected representative transmissivity is $4.8 \cdot 10^{-5}$ m²/s and the estimated storativity is $5.6 \cdot 10^{-6}$.

6.4.8 Observation borehole HLX38

In Figure 6-21 an overview of the head responses in observation borehole HLX38 is shown. General test data from the observation borehole interval HLX38 (15.0–199.5 m) are presented in Table 6-29. The borehole is cased to 15.0 m.

Comments on the test

Only a small, but clear, response is deduced in this section and thus, the tidal effects can clearly be seen in Figure 6-21. A total drawdown of c. 0.16 m and a total recovery at the end of the recovery period of 0.17 m was observed. The calculated Index 1 (r_s^2/dt_L) is rated as "low", Index 2 (s_p/Q_p) as "low" and the new Index 2 $(s_p/Q_p) \cdot \ln(r_s/r_0)$ as "low".

Table 6-28. General test data from the observation section HLX37:2: 118.0–148.0 m during the interference test in HLX28.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	13.63
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	6.26
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	13.63
Hydraulic head change during flow period ($h_i - h_p$)	dh_p	m	7.37

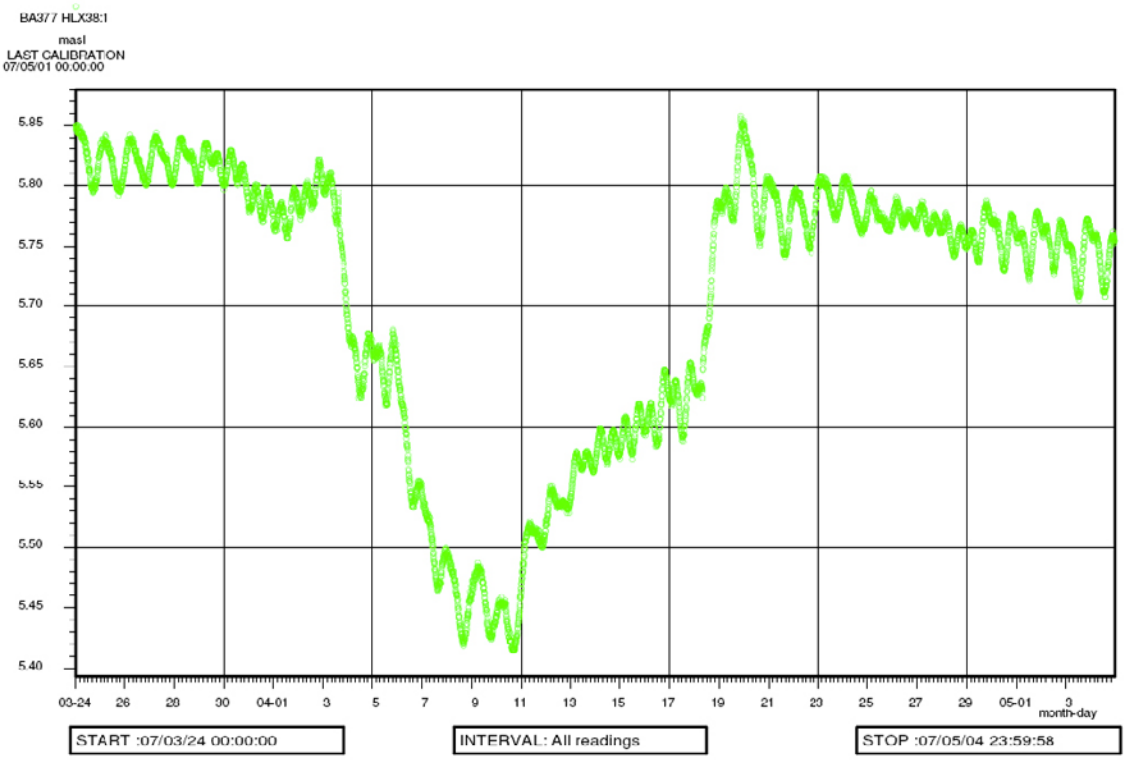


Figure 6-21. *Linear plot of head versus time in the observation borehole HLX38 during the interference test in borehole HLX28.*

Table 6-29. General test data from the observation borehole interval HLX38 (15.0–199.5 m) during the interference test in HLX28.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	5.61
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	5.45
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	5.62
Hydraulic head change during flow period (h_i – h_p)	dh_p	m	0.16

Flow regime and calculated parameters

During the flow period a transition to pseudo-spherical (leaky) flow occurred. During the recovery period a transition towards possible pseudo-radial flow occurred. However, the response during the latter period is considered as uncertain due to natural pressure fluctuations. Both periods were evaluated with the Hantush-Jacob's model for a leaky confined aquifer. The transient evaluation of particularly the recovery period is considered as very uncertain.

Selected representative parameters

The parameter values estimated from the flow period are selected as the most representative. The selected representative transmissivity is $8.3 \cdot 10^{-5}$ m^2/s and the estimated storativity is $3.5 \cdot 10^{-4}$.

6.5 Interference test in HLX32

6.5.1 Pumping borehole HLX32

General test data for the interference test in HLX32 are presented in Table 6-30. The borehole is cased to 12.3 m. The uncased interval of this section is thus c. 12.3–162.6 m. The interference test in HLX32 was performed during c. 3.5 h on 2005-04-05. A plot of the flow and pressure is seen in Figure 6-23 below. The locations of the observation bore holes as well as their degree of response is seen in Figure 6-22. The Rock types and deformation zones is also seen in this figure.

Table 6-30. General test data for the interference test in HLX32: 12.3–162.6 m.

General test data			
Pumping borehole	HLX32		
Test type[1)]	Constant Rate withdrawal and recovery test		
Test section (open borehole/packed-off section):	open borehole		
Test No	1		
Field crew	SKB		
Test equipment system			
General comment	Interference test		
	Nomen-clature	**Unit**	**Value**
Borehole length	L	m	162.6
Casing length	L_c	m	12.3
Test section – secup	Secup	m	12.3
Test section – seclow	Seclow	m	162.6
Test section length	L_w	m	150.3
Test section diameter[2)]	$2 \cdot r_w$	mm	140
Test start (start of flow period)		yymmdd hh:mm	050405 10:40
Packer expanded		yymmdd hh:mm:ss	
Start of flow period		yymmdd hh:mm:ss	050405 10:40:00
Stop of flow period		yymmdd hh:mm:ss	050405 14:25:00
Test stop (stop of flow period)		yymmdd hh:mm	050405 14:25:
Total flow time	t_p	min	225
Total recovery time	t_F	min	
Pressure data			
Relative pressure in test section before start of flow period	p_i	m	40.6
Relative pressure in test section before stop of flow period	p_p	m	34.2
Relative pressure in test section at stop of recovery period	p_F	m	
Pressure change during flow period (p_i – p_p)	dp_p	m	6.41
Flow data			
Flow rate from test section just before stop of flow period	Q_p	m^3/s	0.00015
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	
Total volume discharged during flow period	V_p	m^3	

1) Constant Head injection and recovery, Constant Rate withdrawal and recovery or Constant Drawdown and recovery.

2) Nominal diameter.

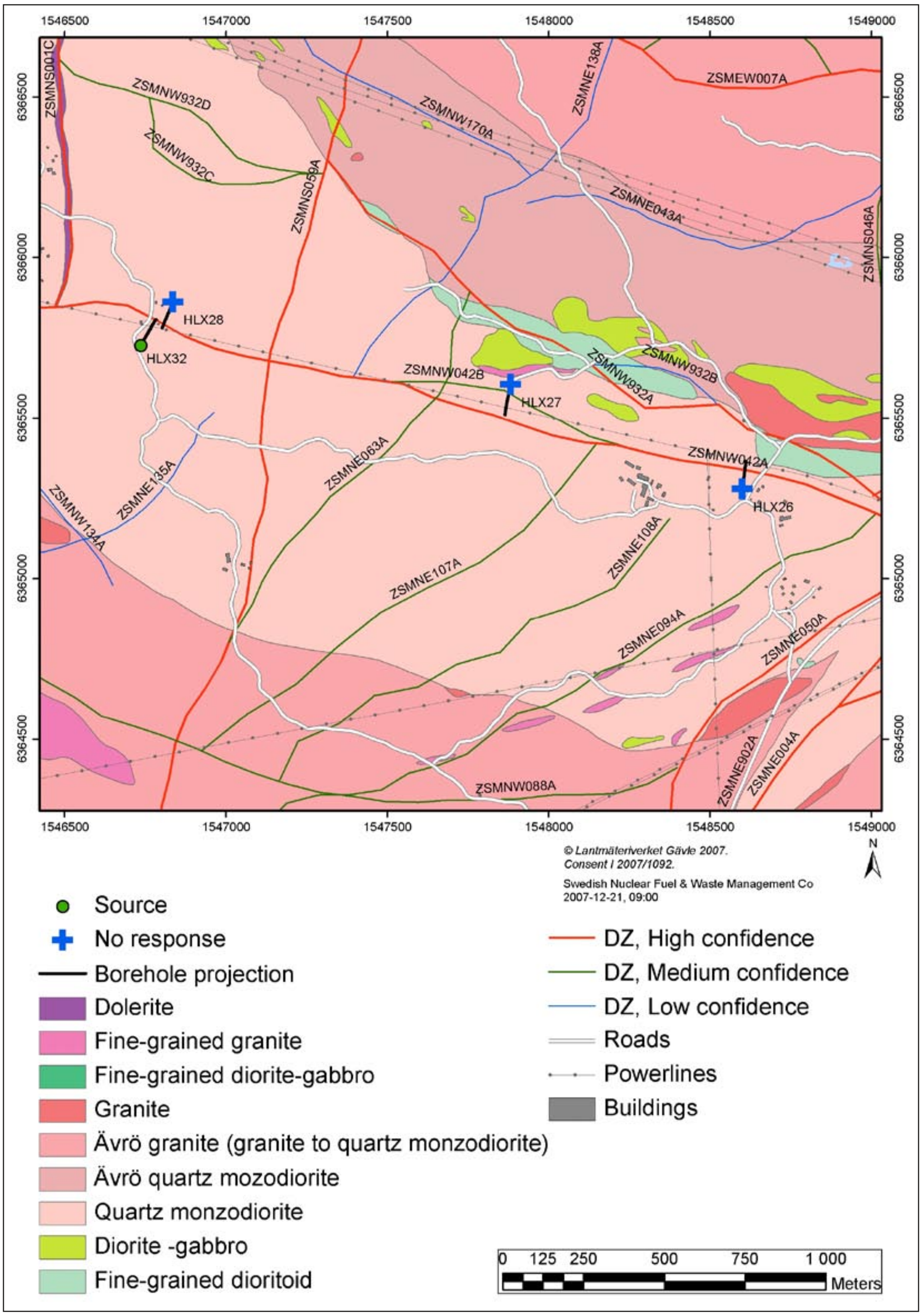


Figure 6-22. *Borehole response map for the observation boreholes when pumping in HLX32.*

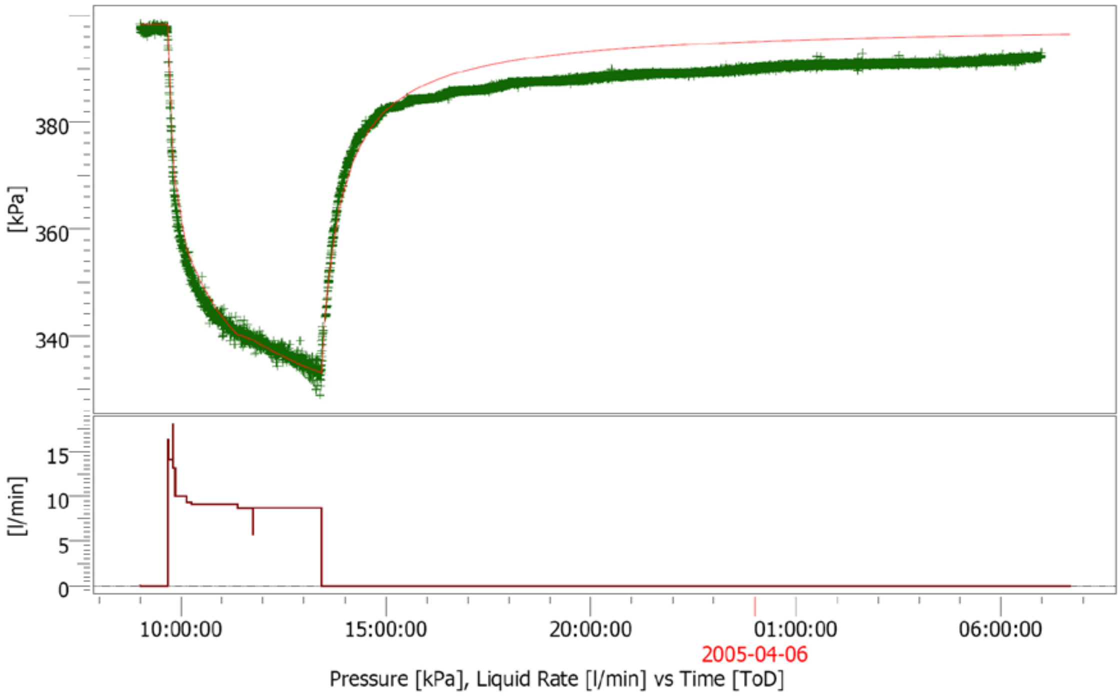


Figure 6-23. *Linear plot of flow rate and pressure versus time in the pumping borehole HLX32.*

Flow regime and selected representative parameters

Consistent flow regimes and transmissivities were obtained for the drawdown and recovery phases. A WBS and IARF were seen but recovery also shows a no flow boundary further away. T_{moye} was chosen as representative for this test and the value of T_M was $1.3 \cdot 10^{-05}$.

6.5.2 Observation borehole HLX26

The borehole HLX26 is cased to 9.0 m and there is one packer placed at 10.0–11.0 m. The uncased interval of the upper section, HLX26:2, of this borehole is thus c. 9.0–10.0 m while section HLX26:1 is located between 11.0–151.2 m. Observation borehole section HLX26:1 is unaffected by the pumping in HLX32, as seen in Figure 6-24. Hence, no evaluation is made for this section. In section HLX26:2 no registrations in HMS were performed.

6.5.3 Observation borehole HLX27

Observation borehole HLX27 is unaffected by the pumping in HLX32, as seen in Figure 6-25, hence no evaluation is made for this borehole. The borehole is cased to 6.0 m and the uncased interval of the upper section of this borehole is thus c. 6.0–164.7 m.

6.5.4 Observation borehole HLX28

Observation borehole HLX28 is unaffected by the pumping in HLX32, as seen in Figure 6-26, hence no evaluation is made for this period. The borehole is cased to 6.0 m and the uncased interval of the upper section of this borehole is thus c. 6.0–154.2 m.

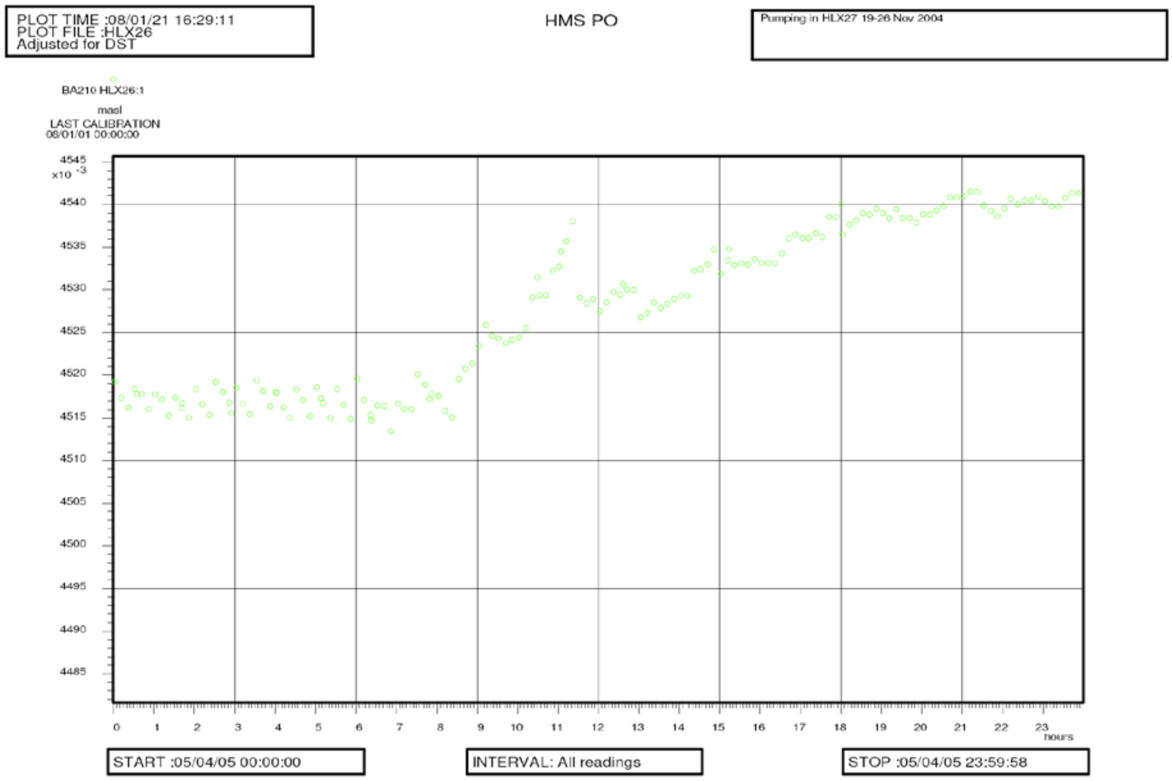


Figure 6-24. *Linear plot of the head in the observation borehole HLX26 during the interference test in borehole HLX32. The figure shows that the level variations in HLX26:1 seems to be unaffected by the pumping in HLX32, performed 2005-04-05 between 11:40 and 14:25.*

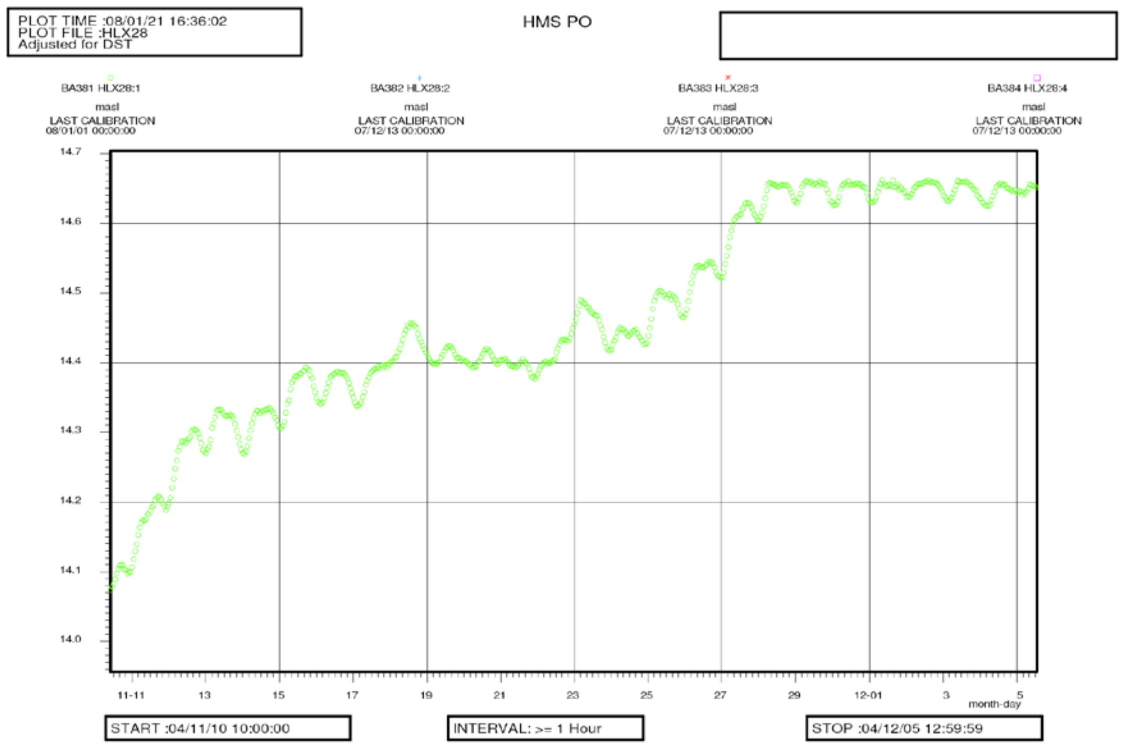


Figure 6-25. *Linear plot of the head in the observation borehole HLX27 during the interference test in borehole HLX32. The figure shows that the level variations in HLX27 seems to be unaffected by the pumping in HLX32, performed 2005-04-05 between 11:40 and 14:25.*

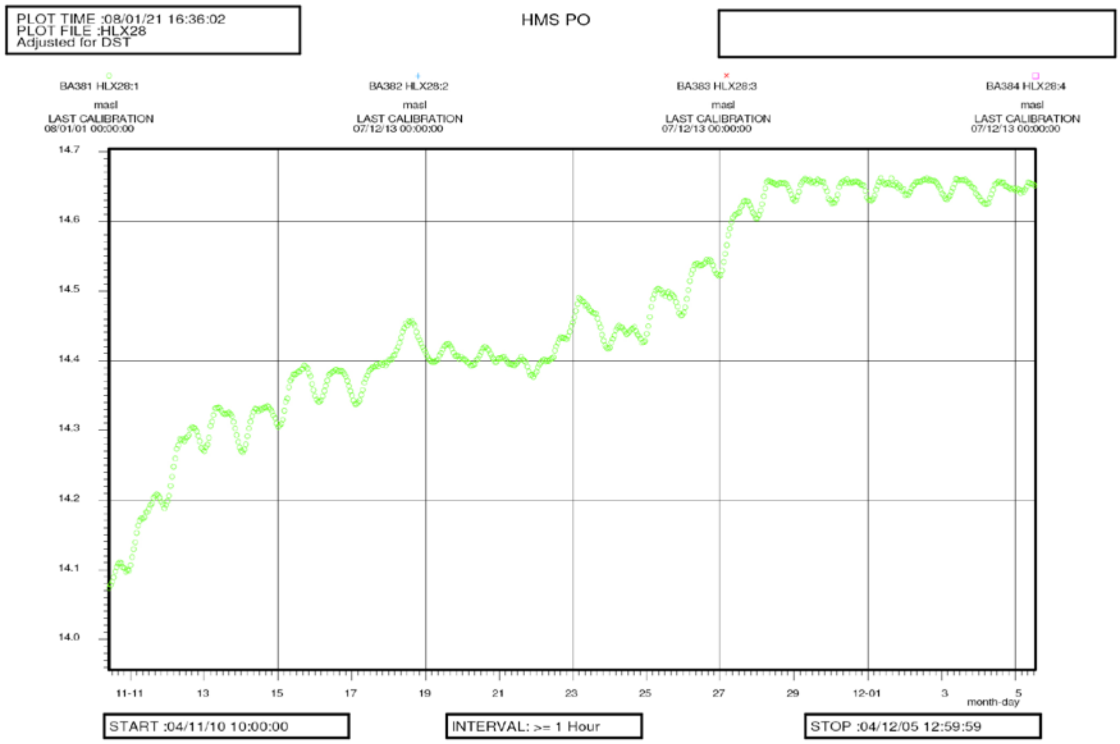


Figure 6-26. *Linear plot of the head in the observation borehole HLX28 during the interference test in borehole HLX32. The figure shows that the level variations in HLX28 seems to be unaffected by the pumping in HLX32, performed 2005-04-05 between 11:40 and 14:25.*

6.6 Response analysis

Response analysis including a response matrix (Appendix 3) according to the methodology description for interference tests was made. The estimated response time lags (dt_L) in the responding observation sections during the different interference tests are shown in Table 6-31. The lag times were derived from the drawdown curves in the observation borehole sections at an actual drawdown of 0.1 m. No corrections of the drawdown for natural trends caused by e.g. drought or precipitation have been made. Because of the oscillating behaviour of the measured pressure in some of the observation sections, it was sometimes difficult to determine the exact time to reach a 0.1 m drawdown. It was possible, however, to make an approximate estimate from the drawdown curves.

Only observation sections with a presumed, relatively clear, pressure response are included in the response analysis. In Table 6-31 all observation sections are presented.

The normalized distance squared with respect to the time lag was calculated. This parameter is directly related to the hydraulic diffusivity (T/S) of the formation. In addition, the normalized drawdown with respect to the flow rate was calculated (see Table 6-31). From these parameters different response indices were calculated according to Section 5.5.1.

In the figures below, response diagrams showing the distributions of the presumptive responding observation sections are presented. In the diagrams, Index 1 has been plotted versus Index 2-new as defined in Section 5.5.1. Clearly, sections located towards the upper right corner in the diagrams correspond to sections which are well connected to the pumping borehole with high hydraulic diffusivities and distinct responses. On the other hand, sections with delayed and small responses, poorly connected to the pumping sections, with lower hydraulic diffusivity are located towards the lower left corner. For the index classification of the responses, see Section 5.5.1.

Table 6-31. Calculated response lag times and normalized distances squared for the observation sections included in the interference tests.

Pumping borehole	Observation borehole	Section (m)	dt_L[s=0.1 m] (s)	r_s (m)	Flow rate Q_p (m^3/s)	s_p (m)	r_s^2/dt_L[s=0.1 m] (m^2/s) Index 1	s_p/Q_p (s/m^2) Index 2	$(s_p/Q_p)\cdot\ln(r_s/r_o)$ (s/m^2) Index 2new
HLX27 (2004)	KLX15A	12.04–151.90	64,260	824	1.42E–03	1.65	10.57	1,164.71	7,820.03
HLX27 (2004)	HLX26:1	11.0–151.2	140,191	772	1.42E–03	0.37	4.22	261.18	1,735.47
HLX27 (2004)	HLX28	6.0–154.2	–	–	–	–	0	0	0
HLX27 (2007)	KLX03A:1	965.5–971.5	84,000	983	1.52E–03	0.31	11.5	204.40	1,408.41
HLX27 (2007)	KLX03A:2	830.5–964.5	126,000	922	1.52E–03	0.72	6.75	474.73	3,240.73
HLX27 (2007)	KLX03A:3	752.5–829.5	162,000	834	1.52E–03	0.38	4.29	250.55	1,685.25
HLX27 (2007)	KLX03A:4	729.5–751.5	159,000	796	1.52E–03	0.39	3.99	250.55	1,673.57
HLX27 (2007)	KLX03A:5	652.5–728.5	–	–	–	–	0	0	0
HLX27 (2007)	KLX03A:6	465.5–651.5	–	–	–	–	0	0	0
HLX27 (2007)	KLX03A:7	349.5–464.5	–	–	–	–	0	0	0
HLX27 (2007)	KLX03A:8	199.5–348.5	78,000	552	1.52E–03	0.95	3.91	626.37	3,954.64
HLX27 (2007)	KLX03A:9	193.5–198.5	72,000	544	1.52E–03	1.04	4.11	685.71	4,319.28
HLX27 (2007)	KLX03A:10	100.1–194.5	91,200	546	1.52E–03	0.98	3.27	652.75	4,114.02
HLX27 (2007)	KLX05A:1	721.0–1,000.16	–	–	–	–	0	0	0
HLX27 (2007)	KLX05A:2	634.0–720.0	–	–	–	–	0	0	0
HLX27 (2007)	KLX05A:3	625.0–633.0	–	–	–	–	0	0	0
HLX27 (2007)	KLX05A:4	501.0–624.0	–	–	–	–	0	0	0
HLX27 (2007)	KLX05A:5	361.0–500.0	–	–	–	–	0	0	0
HLX27 (2007)	KLX05A:6	256.0–360.0	–	–	–	–	0	0	0
HLX27 (2007)	KLX05A:7	241.0–255.0	–	–	–	–	0	0	0
HLX27 (2007)	KLX05A:8	220.0–240.0	–	–	–	–	0	0	0
HLX27 (2007)	KLX05A:9	128.0–219.0	–	–	–	–	0	0	0
HLX27 (2007)	KLX05A:10	15.0–127.0	–	–	–	–	0	0	0
HLX27 (2007)	KLX15A:1	421.0–1,000.43	18,000	611	1.52E–03	2.9	20.7	1,912.09	12,266.23
HLX27 (2007)	KLX15A:2	189.0–420.0	660	219	1.52E–03	6.75	72.7	4,450.55	23,984.33
HLX27 (2007)	KLX15A:3	188.0–11.7	360	96	1.52E–03	5.97	25.6	3,936.26	17,966.48
HLX27 (2007)	KLX19A:1	661.0–800.07	–	–	–	–	0	0	0
HLX27 (2007)	KLX19A:2	518.0–660.0	–	–	–	–	0	0	0
HLX27 (2007)	KLX19A:3	509.0–517.0	–	–	–	–	0	0	0

Pumping borehole	Observation borehole	Section (m)	dt_L[s=0.1 m] (s)	r_s (m)	Flow rate Q_p (m^3/s)	s_p (m)	r_s^2/dt_L[s=0.1 m] (m^2/s) Index 1	s_p/Q_p (s/m^2) Index 2	$(s_p/Q_p)\cdot\ln(r_s/r_o)$ (s/m^2) Index 2new
HLX27 (2007)	KLX19A:4	481.5–508.0	–	–	–	–	0	0	0
HLX27 (2007)	KLX19A:5	311.0–480.5	–	–	–	–	0	0	0
HLX27 (2007)	KLX19A:6	291.0–310.0	–	–	–	–	0	0	0
HLX27 (2007)	KLX19A:7	136.0–290.0	–	–	–	–	0	0	0
HLX27 (2007)	KLX19A:8	98.75–135.0	–	–	–	–	0	0	0
HLX27 (2007)	HLX26:1	11.0–151.2	79,000	772	1.52E–03	0.62	7.54	415.38	2,761.89
HLX27 (2007)	HLX38	15.0–199.5	96,000	734	1.52E–03	0.32	5.61	217.58	1,435.72
HLX27 (2007)	HLX42:1	30.0–152.6	–	–	–	–	0	0	0
HLX27 (2007)	HLX42:2	9.1–29.0	–	–	–	–	0	0	0
HLX28	KLX14A:1	120.0–176.27	–	–	–	–	0	0	0
HLX28	KLX14A:2	73.0–119.0	–	–	–	–	0	0	0
HLX28	KLX14A:3	6.5–72.0	9,600	372	1.6E–03	4.08	14.4	2,544.70	15,061.80
HLX28	KLX19A:1	661.0–800.07	–	–	–	–	0	0	0
HLX28	KLX19A:2	518.0–660.0	–	–	–	–	0	0	0
HLX28	KLX19A:3	509.0–517.0	7,800	425	1.6E–03	6.4	23.2	4,004.16	24,233.52
HLX28	KLX19A:4	481.5–508.0	7,800	408	1.6E–03	6.45	21.3	4,004.16	24,070.06
HLX28	KLX19A:5	311.0–480.5	7,800	321	1.6E–03	6.4	13.2	4,016.63	23,181.76
HLX28	KLX19A:6	291.0–310.0	1,200	246	1.6E–03	7.1	50.4	4,390.85	24,173.10
HLX28	KLX19A:7	136.0–290.0	870	193	1.6E–03	8.2	42.8	5,089.40	26,783.92
HLX28	KLX19A:8	98.75–135.0	432	172	1.6E–03	8.2	68.5	5,133.06	26,422.38
HLX28	KLX20A	100.9–457.92	21,600	612	1.6E–03	2.62	17.3	1,634.10	10,485.55
HLX28	HLX32:1	16.0–132.6	36,000	93	1.6E–03	1.51	0.24	941.79	4,268.75
HLX28	HLX36:1	50.0–199.8	32,400	485	1.6E–03	3.0	7.26	1,896.05	11,725.45
HLX28	HLX36:2	6.03–49.0	–	–	–	–	0	0	0
HLX28	HLX37:1	149.0–199.8	2,040	486	1.6E–03	7.31	116	4,559.25	28,204.48
HLX28	HLX37:2	118.0–148.0	2,040	498	1.6E–03	7.37	121	4,596.67	28,548.10
HLX28	HLX37:3	12.03–117.0	–	–	–	–	0	0	0
HLX28	HLX38	15.0–199.5	150,000	381	1.6E–03	0.16	0.97	102.91	611.58
HLX32	HLX26:1	11.0–151.2	–	–	–	–	0	0	0
HLX32	HLX27	6.0–165.0	–	–	–	–	0	0	0
HLX32	HLX28	6.0–154.2	–	–	–	–	0	0	0

The following response parameters are used in Table 6-31 as well as in Figures 6-27 to 6-29:

r_s^2/dt_L[s=0.1 m]	=	normalized distance squared with respect to the time lag (m^2/s),
dt_L[s=0.1 m]	=	time lag after start of pumping (s) at a drawdown s=0.1 m in the observation section,
r_s	=	3D-(spherical) distance between the hydraulic point of application (hydr. p.a.) in the pumping borehole and observation borehole (m),
s_p/Q_p	=	normalized drawdown with respect to the pumping flow rate (s/m^2),
s_p	=	maximal drawdown in the actual observation borehole/section (m),
Q_p	=	pumping flow rate by the end of the flow period (m^3/s).

The normalized distances squared must be considered as rough estimates for many of the observation sections. The main reason is, as mentioned above, the difficulty to estimate the time lag due to oscillating pressures. Furthermore, the spherical distance may not always be representative of the true path way of flow between boreholes. The maximal drawdown is not always at stop of pumping, e.g. due to precipitation or other disturbances by the end of the tests. Furthermore, in some cases the drawdown must be corrected, e.g. due to natural pressure trends, e.g. during draught periods. However, for the actual interference tests no such corrections of the data have been made.

The response diagrams can be used to group observation sections by the strength and time lags of their responses. Observation sections with the most distinct responses can thus be identified. In some of the interference tests only one observation section responded to the pumping. These tests are also included in the figures below.

Figure 6-27 shows the response diagram during interference test 1 in HLX27 (2004). Only one response is indicated. The response is not very good, both rather small and rather slow.

Figure 6-28 shows the response diagram during interference test 2 in HLX27 (2007). Several observation sections responded to this pumping. In borehole KLX15A, sections 2 and 3 show distinct and fast responses. Section 1 also shows a distinct response. In KLX03, sections 1–4 and 8–10 show rather small and slow responses to the pumping while sections 5–7 show no visible response at all. Boreholes HLX26 and HLX38 also show small but clear responses.

Figure 6-29 shows the response diagram during the interference test in HLX28. Several observation sections responded to this pumping. The most distinct responses occurred in HLX37 and the uppermost part of KLX19A (sections 6–8). Distinct responses were also observed in sections 3–5 in KLX19A and in sections KLX14A:3, KLX20A and HLX36:1. Slow responses occurred in boreholes HLX32 and HLX38.

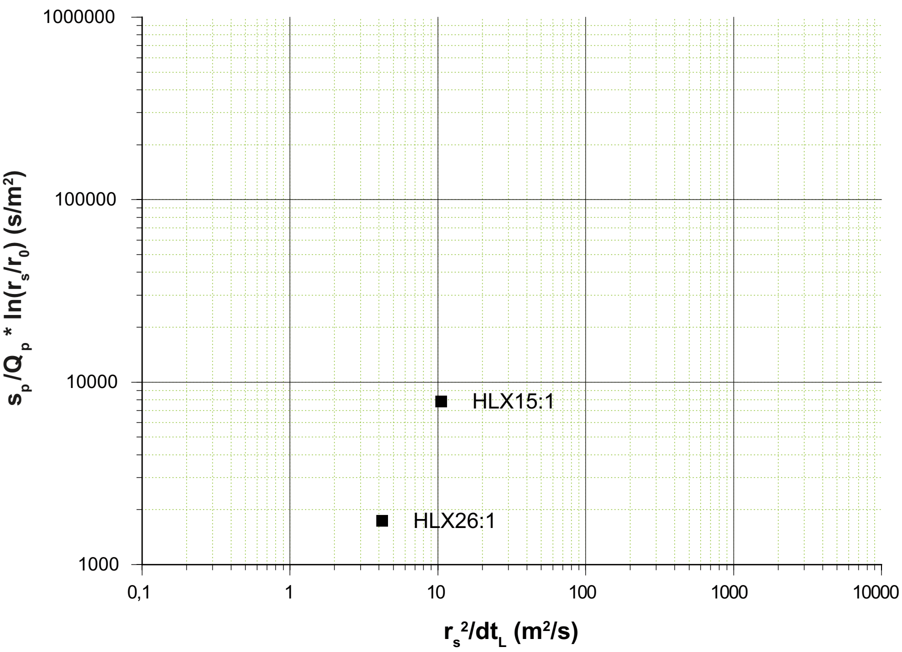


Figure 6-27. *Response diagram showing the responses in the responding observation section during interference test 1 in HLX27 (2004).*

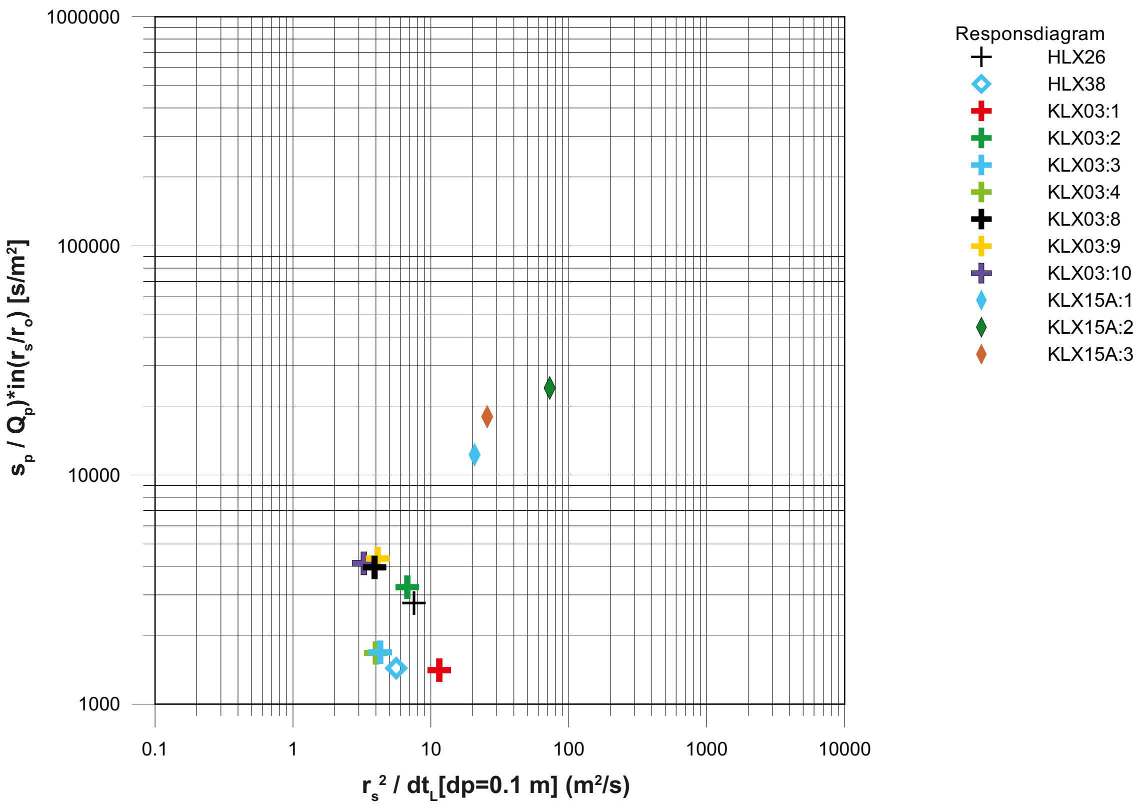


Figure 6-28. *Response diagram showing the responding observation sections during interference test 2 in HLX27 (2007).*

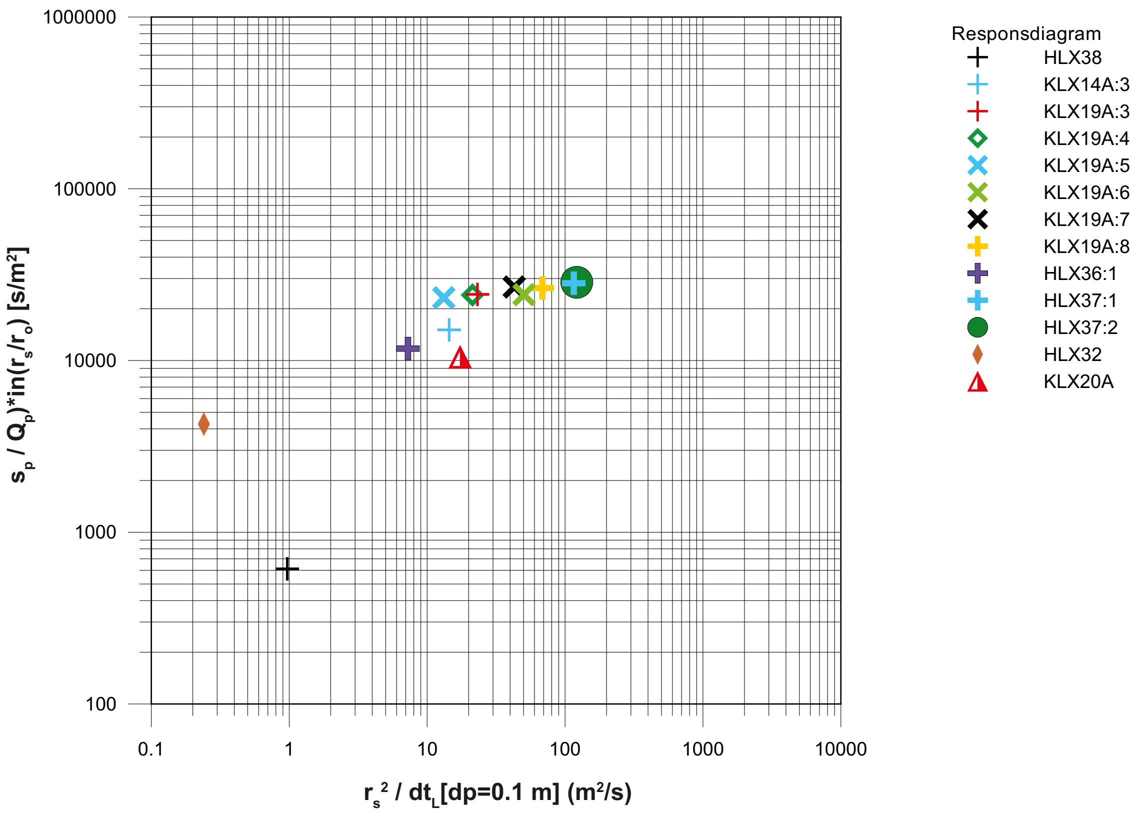


Figure 6-29. *Response diagram showing the responses in the responding observation sections during the interference test in HLX28.*

6.7 Estimation of the hydraulic diffusivity

The hydraulic diffusivity of the responding observation sections can be estimated from the observed response time lags in the observation sections according to Section 5.5.2. The time lag dt_L has been estimated for both a drawdown of 0.01 m and 0.1 m in the observation section respectively. The estimated time lags in the observation sections are shown in Table 6-32 together with the estimated hydraulic diffusivity T/S of the sections. For comparison, the ratio of the estimated transmissivity and storativity T_o/S_o from the transient evaluation of the responses in these sections during the interference tests are also presented.

Table 6-32 shows that the estimated hydraulic diffusivities from the time lags in general are higher compared to the ratio of T_o/S_o from the transient evaluation of the test sections.

Table 6-32 and Figure 6-30 and 6-31 show that there is a fair agreement between the estimated hydraulic diffusivity of the sections based on the response time lags and from the results of the transient evaluation, respectively, also at long distances from the pumping borehole. Results from pumping in borehole HLX27 (2007) and the pumping in HLX28 are similar. It is noted that the ratios $T/S_{0.1}$ (dt_L based on 0.1 m) and T_o/S_o have a better correlation than $T/S_{0.01}$ (dt_L based on 0.01 m) and T_o/S_o in opposite to other tests previously evaluated. The results from the response time lag are in general somewhat higher than the results from the transient evaluation.

Table 6-32. Estimated response lag times and hydraulic diffusivity for the responding observation sections during the interference tests.

Pumping borehole	Observation borehole	Section (m)	measured dt_L[s=0.01 m] (s)	r_s (m)	$T/S_{0.01}$ (m²/s)	$T/S_{0.1}$ (m²/s)	T_o/S_o (m²/s)
HLX27 (2004)[1)]	HLX15:1	12.04–151.90	10	824			2.39
HLX27 (2004)[1)]	HLX26:1	11.0–151.2	4	772		0.78	0.59
HLX27 (2007)	HLX26:1	11.0–151.2	6,000	772	22.84	1.31	1.35
HLX27 (2007)	HLX38	15.0–199.5	67,500	734	1.42	0.95	1.85
HLX27 (2007)	KLX15A:1	721.0–1,000.0	780	611	117.62	4.36	3.43
HLX27 (2007)	KLX15A:2	189.0–420.0	240	219	49.64	17.90	7.17
HLX27 (2007)	KLX15A:3	188.0–11.7	150	96	15.29	6.34	2.00
HLX27 (2007)	KLX03A:1	965.5–971.5	32,700	983	5.80	1.98	2.85
HLX27 (2007)	KLX03A:2	830.5–964.5	75,600	922	1.96	1.09	0.74
HLX27 (2007)	KLX03A:3	752.5–829.5	77,400	834	1.56	0.67	0.61
HLX27 (2007)	KLX03A:4	729.5–751.5	77,700	796	1.42	0.63	0.51
HLX27 (2007)	KLX03A:8	199.5–348.5	52,800	552	1.06	0.68	0.59
HLX27 (2007)	KLX03A:9	193.5–198.5	49,500	544	1.11	0.72	0.72
HLX27 (2007)	KLX03A:10	100.1–194.5	22,800	546	2.68	0.56	0.35
HLX28	KLX14A:3	6.5–72.0	6,300	372	5.16	3.31	1.41
HLX28	HLX38	15.0–199.5	59,100	381	0.47	0.16	0.24
HLX28	KLX19A:3	509.0–517.0	3,780	425	11.45	5.38	1.75
HLX28	KLX19A:4	481.5–508.0	3,900	408	10.22	4.96	1.67
HLX28	KLX19A:5	311.0–480.5	4,080	321	6.04	3.07	1.00
HLX28	KLX19A:6	291.0–310.0	360	246	41.77	12.40	1.37
HLX28	KLX19A:7	136.0–290.0	300	193	30.88	10.57	1.55
HLX28	KLX19A:8	6.3–135.0	180	172	40.95	17.00	1.89
HLX28	HLX36:1	50.0–199.8	9,900	485	5.45	1.50	0.61
HLX28	HLX37:1	149.0–199.8	900	486.1	64.77	28.21	8.31
HLX28	HLX37:2	118.0–148.0	1,080	498.3	56.59	29.65	8.57
HLX28	HLX32	12.3–132.6	22,500	92.9	0.08	0.05	0.03
HLX28	KLX20A	100.9–457.92	8,400	611.6	10.31	3.74	2.00

[1)] Evaluated by SKB and no results available on $dtL_{0.01}$ and $T/S_{0.01}$.

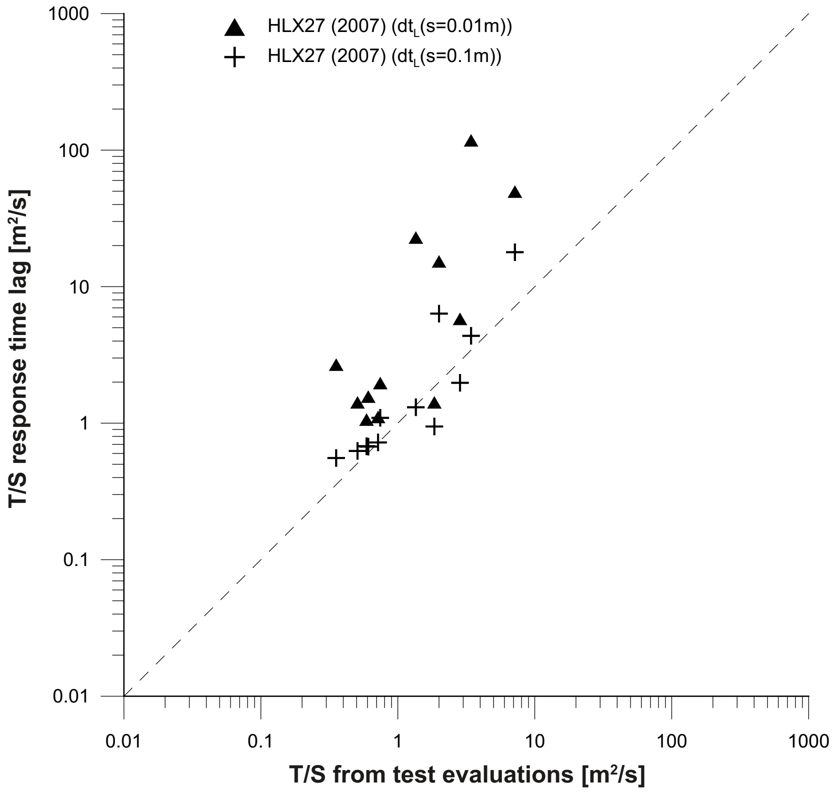


Figure 6-30. *Comparison of estimated hydraulic diffusivity of responding observation sections during interference test 2 in HLX27 (2007) at Laxemar.*

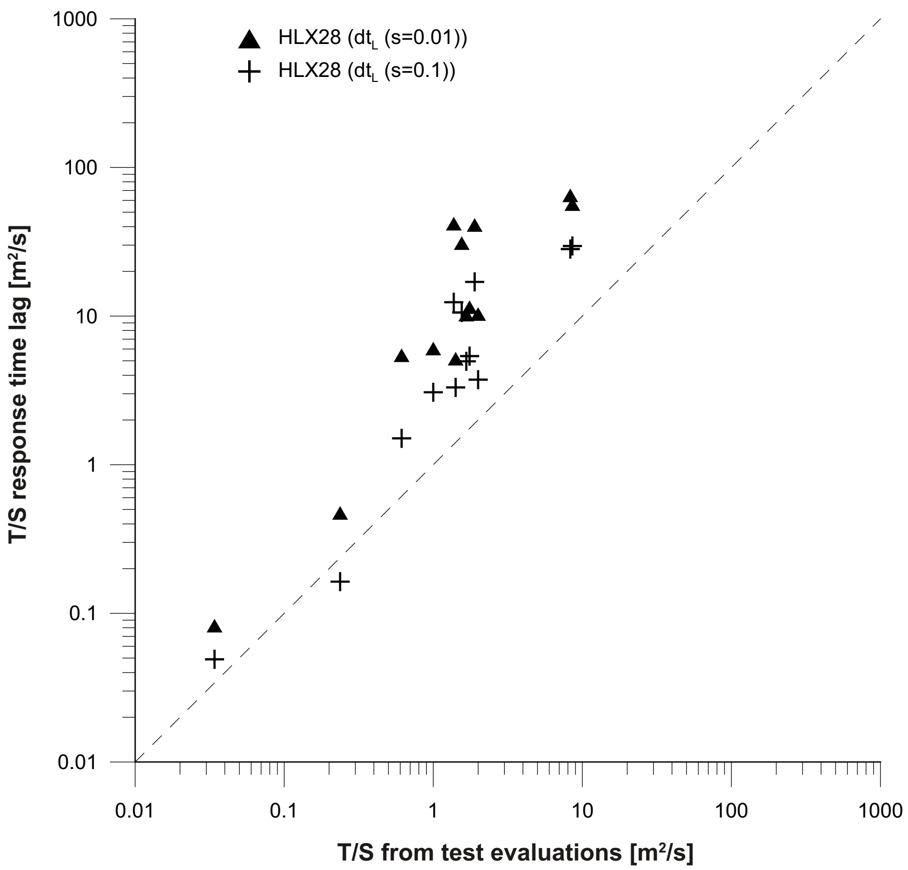


Figure 6-31. *Comparison of estimated hydraulic diffusivity of responding observation sections during the interference test in HLX28 at Laxemar.*

HLX32 has an apparent storativity much higher than expected at that short distance indicating bad hydraulic connection to the pumping borehole HLX28. A couple of sections in HLX37, 1 and 2 have a very short time lag for the pressure response despite a large distance to HLX28, indicating good hydraulic connection to this borehole.

6.8 Single hole pumping test KLX27A

A single hole pumping test was performed in KLX27A which is a core-drilled hole. The pumping was conducted in a section between 9.2 75.6 m.

The pumping started on 22nd August 2007 with a pumping rate of 80 L/min which turned out to be too high for the aquifer. The water level soon reached the pump intake at 65 m below TOC with a total drawdown of 36 m and the flow stabilised at 10.5 L/min throughout the test. The flow and pressure in the pumped borehole plotted against time is seen in Figure 6-32 below. Test summary sheet, test diagrams and analysis results are shown in Appendix 5.

Flow regime and calculated parameters

Drawdown is quite discontinuous, of the staccato type, which induced vary bad pressure derivative. Nevertheless, it was possible to obtain some kind of match between data and model. The recovery phase consists almost exclusively of wellbore storage effects and no good match was obtained.

A stationary T-value was calculated according to /10/. Table 6-33 show calculated parameters.

Selected representative parameters

The transmissivity derived from the stationary analysis, $T_{Moye} = 5.3 \cdot 10^{-6}$ m²/s, is considered most representative since the tests was largely conducted under stationary conditions.

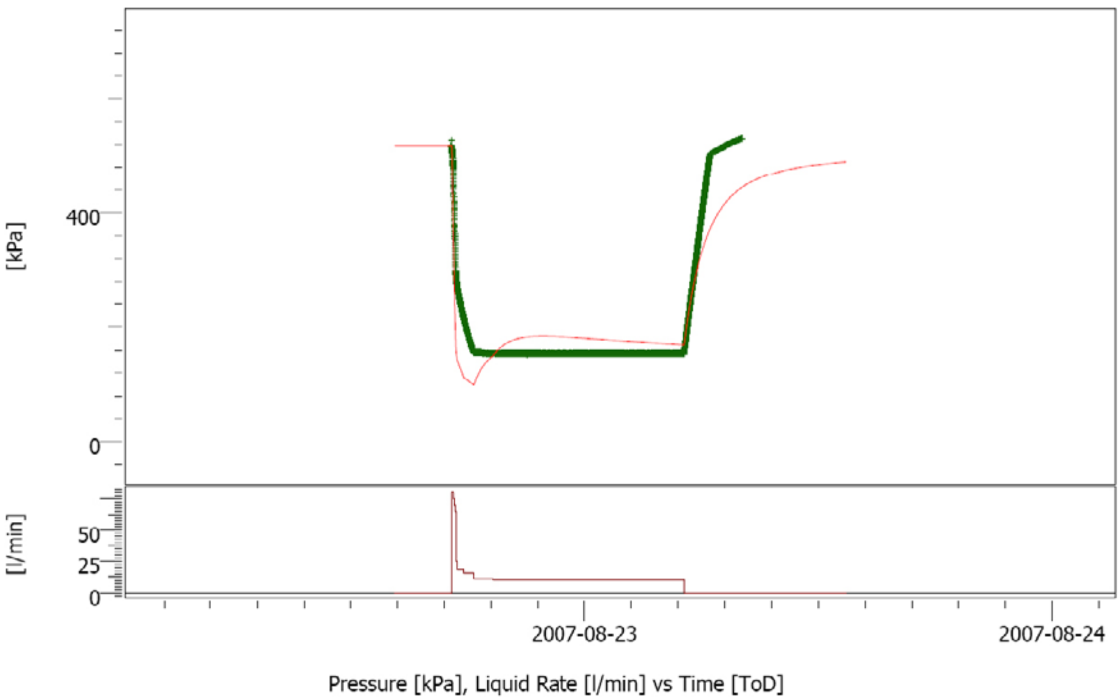


Figure 6-32. *Linear plot of flow rate and pressure versus time in the pumping borehole KLX27A.*

Table 6-33. Evaluated parameters from pumping test in KLX27A, 9.20–75.60 m. Boldfaced parameters are considered to be most representative.

Test phase	Pumping rate, Q_p [L/min]	Total draw-down, dh_p [m]	Transient trans-missivity, T_T [m²/s]	Stationary trans-missivity, T_{Moye} [m²/s]	Specific capacity, Q/s [m²/s]	skin [–]	comment
Drawdown	10.5	36.5	5.95E–6	5.3E–6	4.7E–6	0	
Recovery	0	–	5.55E–6	–		0	Bad fit

6.9 Summary of results of the interference and pumping tests

A compilation of measured test data from the interference tests is shown in Tables 6-34 and 6-35. In Tables 6-36 and 6-37 calculated hydraulic parameters for the pumping boreholes and the evaluated observation sections are presented.

Nomenclature used:

Q/s = specific flow for the pumping/injection borehole.
T_M = steady state transmissivity from Moye's equation.
T_T = transmissivity from transient evaluation of single-hole test.
T_o = transmissivity from transient evaluation of interference test.
S_o = storativity from transient evaluation of interference test.
T_o/S_o = hydraulic diffusivity (m²/s).
K'/b' = leakage coefficient from transient evaluation of interference test.
S* = assumed storativity by the estimation of the skin factor in single hole tests.
C = wellbore storage coefficient.
ξ = skin factor.

The estimated transmissivity of the observation sections may be more weighted towards the hydraulic properties close to the pumping borehole, particularly for observation boreholes at large distances from the pumping borehole. In addition, the estimated transmissivity may in some cases be overestimated from interference tests for observation sections with poor hydraulic connection to the pumping borehole.

The results of the interference tests show a fair agreement between the estimated hydraulic diffusivity of the sections based on the response time lags and from the results of the transient evaluation, respectively, also at long distances from the pumping borehole. The ratios T/S (dt_L based on 0.1 m) and T_o/S_o have a better correlation than T/S (dt_L based on 0.01 m) and T_o/S_o in this case.

Table 6-34. Summary of test data from the pumping boreholes during the interference tests.

Pumping borehole ID	Section (m)	Test type[1)]	h_i (m)	h_p (m)	h_F (m)	Q_p (m³/s)	Q_m (m³/s)	V_p (m³)
HLX27 (2004)	6.00–164.70	1B	6.82	–13.13		1.42E–03	1.42E–03	
HLX27 (2007)	6.00–164.70	1B	78.57	54.98	78.58	1.52E–03	1.52E–03	397.0
HLX28	6.00–154.20	1B	57.9	46.8	58.2	1.6E–03	1.61E–03	661.0
HLX32	12.30–162.60	1B	40.6	34.2		1.5E–04	1.5E–04	
KLX27A	9.20–75.60	1B				1.75E–04	1.75E–04	8.3

Table 6-35. Summary of test data from the observation sections involved in the interference tests.

Pumping borehole ID	Borehole ID	Section (m)	Test type[1)]	h_i (m.a.s.l.)	h_p (m.a.s.l.)	h_F (m.a.s.l.)
HLX27 (2004)	HLX15:1	12.04–159.90	2	5.77	4.12[2]	
HLX27 (2004)	HLX26:1	11.0–151.2	2	3.85	3.48[2]	
HLX27 (2007)	HLX26:1	11.0–151.2	2	3.71	3.09	3.65
HLX27 (2007)	HLX38	15.0–199.5	2	5.59	5.27	5.52
HLX27 (2007)	KLX15A:1	421.0–1,000.0	2	5.6	2.7	5.45
HLX27 (2007)	KLX15A:2	189.0–420.0	2	5.56	–0.79	6.01
HLX27 (2007)	KLX15A:3	188.0–11.7	2	6.15	0.18	6.18
HLX27 (2007)	KLX03A:1	965.5–971.5	2	11.63	11.32	11.44
HLX27 (2007)	KLX03A:2	830.5–964.5	2	10.1	9.4	9.88
HLX27 (2007)	KLX03A:3	752.5–829.5	2	10.35	9.98	10.19
HLX27 (2007)	KLX03A:4	729.5–751.5	2	9.98	9.59	9.80
HLX27 (2007)	KLX03A:8	199.5–348.5	2	10.18	9.23	9.93
HLX27 (2007)	KLX03A:9	193.5–198.5	2	10.30	9.26	10.06
HLX27 (2007)	KLX03A:10	100.1–194.5	2	10.13	9.15	9.8
HLX28	KLX14A:3	6.5–72.0	2	11.54	7.46	11.96
HLX28	HLX38	15.0–199.5	2	5.61	5.45	5.62
HLX28	KLX19A:3	509.0–517.0	2	13.1	6.7	12.7
HLX28	KLX19A:4	481.5–508.0	2	13.2	6.7	12.8
HLX28	KLX19A:5	311.0–480.5	2	13.1	6.7	12.7
HLX28	KLX19A:6	291.0–310.0	2	13.2	6.1	12.9
HLX28	KLX19A:7	136.0–290.0	2	13.4	5.2	13.3
HLX28	KLX19A:8	98.75–135.0	2	13.4	5.2	13.3
HLX28	HLX36:1	50.0–199.8	2	14.2	11.2	14.2
HLX28	HLX37:1	149.0–199.8	2	13.65	6.34	13.65
HLX28	HLX37:2	118.0–148.0	2	13.63	6.26	13.63
HLX28	HLX32:1	16.0–132.6	2	7.5	5.99	7.5
HLX28	KLX20A	100.9–457.92	2	15.42	12.80	15.15

[1)] 1B: Pumping test-submersible pump, 2: Interference test (observation borehole during pumping in another borehole).
[2)] Value taken from simulated drawdown, since actual waterlevel at this pumping stage was much affected by precipitation and there fore not representative.

Table 6-36. Summary of calculated hydraulic parameters from the single-hole tests.

Pumping borehole ID	Section (m)	Test type	Q/s (m^2/s)	T_M (m^2/s)	T_T (m^2/s)	ξ (–)	C (m^3/Pa)	S* (–)
HLX27 (2004)	6.0–164.7	1B		9.0E–05	8.7E–05	–2.0	2.0E–06	4.7E–05
HLX27 (2007)	6.0–164.7	1B	6.4E–05	8.2E–05	2.2E–05	–1.0	1.7E–06	3.3E–06
HLX28	6.0–154.2	1B	1.4E–04	2.0E–04	3.6E–05		3.2E–06	4.2E–06
HLX32	12.3–162.6	1B		1.3E–05	1.3E–05	–4.3	3.3E–06	x
KLX27A	9.2–75.6	1B	4.7E–06	5.3E–06	5.95E–06	0		2.4E–05

Table 6-37. Summary of calculated hydraulic parameters from the observation borehole sections during the interference tests.

Pumping borehole ID	Observation borehole ID	Section (m)	Test type	T_o (m^2/s)	S_o (–)	T_o/S_o (m^2/s)	K'/b' (s^{-1})
HLX27 (2004)	HLX15:1	12.04–159.90	2	1.22E–04	5.10E–05	2.39	
HLX27 (2004)	HLX26:1	11.0–151.2	2	4.99E–04	2.92E–04	0.59	
HLX27 (2007)	HLX26:1	11.0–151.2	2	1.30E–04	9.60E–05	1.35	
HLX27 (2007)	HLX38	15.0–199.5	2	9.80E–05	5.30E–05	1.85	
HLX27 (2007)	KLX15A:1	721.0–1,000.0	2	7.20E–05	2.10E–05	3.43	
HLX27 (2007)	KLX15A:2	189.0–420.0	2	4.30E–05	6.00E–06	7.17	1.70E–10
HLX27 (2007)	KLX15A:3	188.0–11.7	2	4.60E–05	2.30E–05	2.00	1.80E–09
HLX27 (2007)	KLX03A:1	965.5–971.5	2	3.70E–04	1.30E–04	2.85	
HLX27 (2007)	KLX03A:2	830.5–964.5	2	3.20E–05	4.30E–05	0.74	
HLX27 (2007)	KLX03A:3	752.5–829.5	2	7.30E–05	1.20E–04	0.61	
HLX27 (2007)	KLX03A:4	729.5–751.5	2	6.60E–05	1.30E–04	0.51	
HLX27 (2007)	KLX03A:8	199.5–348.5	2	7.10E–05	1.20E–04	0.59	
HLX27 (2007)	KLX03A:9	193.5–198.5	2	7.90E–05	1.10E–04	0.72	
HLX27 (2007)	KLX03A:10	100.1–194.5	2	3.90E–05	1.10E–04	0.35	
HLX28	KLX14A:3	6.5–72.0	2	4.10E–05	2.90E–05	1.41	1.40E–10
HLX28	HLX38	15.0–199.5	2	8.30E–05	3.50E–04	0.24	3.83E–09
HLX28	KLX19A:3	509.0–517.0	2	3.50E–05	2.00E–05	1.75	3.67E–11
HLX28	KLX19A:4	481.5–508.0	2	3.50E–05	2.10E–05	1.67	4.00E–11
HLX28	KLX19A:5	311.0–480.5	2	3.50E–05	3.50E–05	1.00	6.50E–11
HLX28	KLX19A:6	291.0–310.0	2	4.80E–05	3.50E–05	1.37	4.33E–11
HLX28	KLX19A:7	136.0–290.0	2	4.50E–05	2.90E–05	1.55	7.50E–11
HLX28	KLX19A:8	98.75–135.0	2	5.30E–05	2.80E–05	1.89	5.50E–11
HLX28	HLX36:1	50.0–199.8	2	4.60E–05	7.50E–05	0.61	7.17E–16
HLX28	HLX37:1	149.0–199.8	2	4.90E–05	5.90E–06	8.31	1.30E–11
HLX28	HLX37:2	118.0–148.0	2	4.80E–05	5.60E–06	8.57	1.27E–11
HLX28	HLX32:1	16.0–132.6	2	7.50E–05	2.20E–03	0.03	6.50E–09
HLX28	KLX20A	100.9–457.92	2	5.40E–05	2.70E–05	2.00	7.50E–11

7 References

/1/ **Ludvigson J-E, Hansson L, Hjerne C, 2007.** Method evaluation of single-hole hydraulic injection tests at site investigations in Forsmark. SKB P-07-80, Svensk Kärnbränslehantering AB.

/2/ **SKB, 2006**. Preliminary site description. Laxemar subarea – version 1.2. SKB R-06-10, Svensk Kärnbränslehantering AB.

/3/ **Ludvigson J-E, Jönsson S, Levén J, 2004.** Forsmark site investigation. Hydraulic evaluation of pumping activities prior to hydro-geochemical sampling in borehole KFM03A – Comparison with results from difference flow logging. SKB P-04-96, Svensk Kärnbränslehantering AB.

/4/ **Dougherty D E, Babu D K, 1984.** Flow to a partially penetrating well in a double-porosity reservoir. Water Resour. Res., 20 (8), 1116–1122.

/5/ **Hantush M S, 1955.** Nonsteady radial flow in an infinite leaky aquifer. Am. Geophys. Union Trans., v. 36, no 1, pp 95–100.

/6/ **Streltsova T D, 1988.** Well testing in heterogeneous formations. Exxon Monograph. John Wiley and sons.

/7/ **Moench A F, 1985.** Transient flow to a large-diameter well in an aquifer with storative semiconfining layers, Water Resources Research, vol. 21, no. 8, pp. 1121–1131.

/8/ Aqtesolv v4 by HydroSolve Inc, USA.

/9/ Saphir v 4 by Kappa Engineering, France.

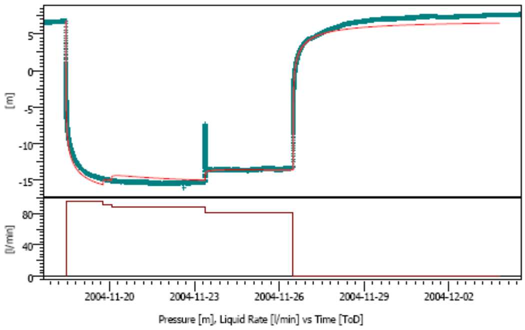
/10/ **Moye D G, 1967.** Diamond Drilling for Foundation Exploration. Civil Engineering Trans., April 1967, (2150), pp. 95–100.

Appendix 1

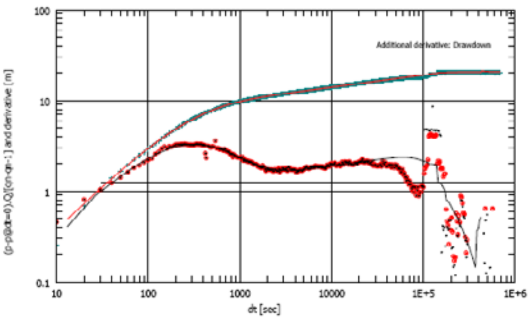
Test summary sheet

Test Summary Sheet – Pumping borehole HLX27 (2004)			
Project:	PLU	Test type:	1B
Area:	Oskarshamn	Test no:	1
Borehole ID:	HLX27	Test start:	2004-11-18 10:59:00
Test section (m):	6.0-164.7	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.137	Responsible for test evaluation:	SKB Mansueto Morosini

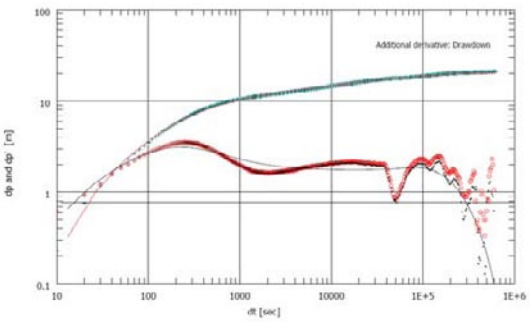
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (masl)			
p_i (masl)	6.82		
p_p(masl)	-13.13	p_F (masl)	
Q_p (m^3/s)	$1.42 \cdot 10^{-3}$		
t_p (min)	11570	t_F (min)	
S^* (-)	$1.5 \cdot 10^{-4}$	S^* (-)	
EC_w (mS/m)			
Te_w(^oC)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	0.0685	r (m)	0.0685
Results		**Results**	
Q/s (m^2/s)	$1.0 \cdot 10^{-4}$		
T_M (m^2/s)			
Flow regime:	WBS-> Radcomp.-> Const. head	Flow regime:	WBS-> Radcomp.-> Const. head
dt_1 (min)	2122	dt_1 (min)	
dt_2 (min)	4100	dt_2 (min)	
T (m^2/s)	$8.7 \cdot 10^{-5}$	T (m^2/s)	$1.4 \cdot 10^{-4}$
S (-)		S (-)	
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)	$3.45 \cdot 10^{-6}$	C (m^3/Pa)	$1.97 \cdot 10^{-6}$
C_D (-)		C_D (-)	
ξ (-)	-2.1	ξ (-)	-1.9
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Selected representative parameters.			
dt_1 (min)	2122	C (m^3/Pa)	$3.45 \cdot 10^{-6}$
dt_2 (min)	4100	C_D (-)	
T_T (m^2/s)	$9 \cdot 10^{-5}$	ξ (-)	-2
S* (-)	$1 \cdot 10^{-4}$		
K_s (m/s)			
S_s (1/m)			

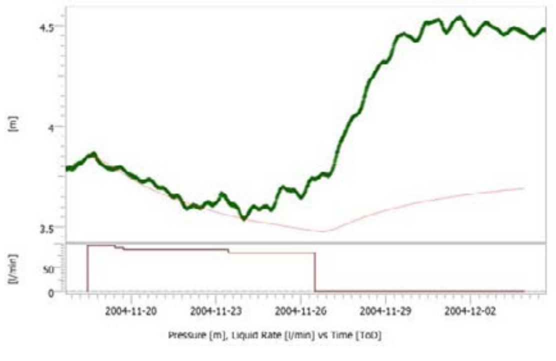
Comments:

The diagnostic derivative plot show a slight radial composite behaviour, $T_{inner\ zone} = 2 \cdot T_{outer\ zone}$, and constant head at the end of pumping. Consistent flow regime and tranmsissivity are obtained between drawdown and recovery phase

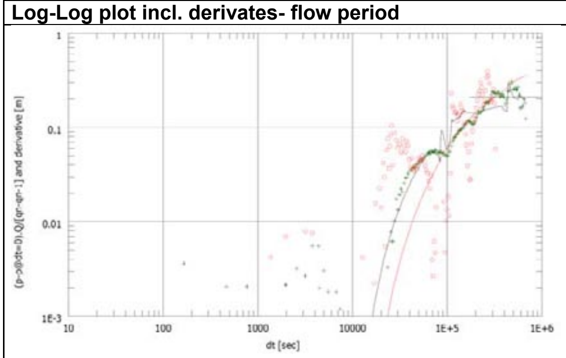
On 23rd November the discharge hose connected to the test container accidentally got loose which caused a disruption in the drawdown . After remediation the flow stabilized somewhat lower than previously, 80 instead of 87 L/min as a consequence this also caused a lower drawdown after the disruption. The dip in the derivative of recovery phase is believed to be due to this.

Test Summary Sheet – Observation borehole HLX26:1 (pumping borehole HLX27 (2004))			
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	HLX26:1	Test start:	2004-11-18 10:59:00
Test section (m):	11.0-151.0	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.137	Responsible for test evaluation:	SKB Mansueto Morosini

Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period

Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (masl)			
p_i (masl)	3.85		
p_p(masl)	3.48	p_F (masl)	
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.		Derivative fact.	
r (m)	772	r (m)	772
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	Line source ->IARF	Flow regime:	
dt_1 (min)		dt_1 (min)	
dt_2 (min)		dt_2 (min)	
T (m^2/s)	$4.99 \cdot 10^{-4}$	T (m^2/s)	
S (-)	$2.92 \cdot 10^{-4}$	S (-)	
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

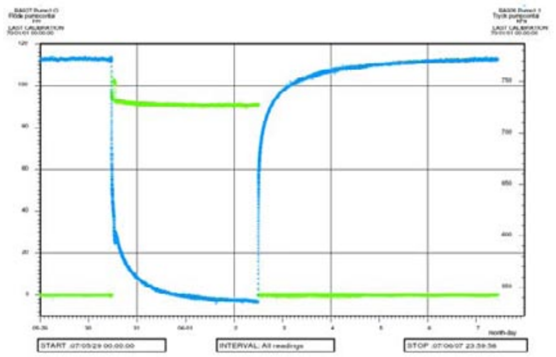
Selected representative parameters.			
dt_1 (min)		C (m^3/Pa)	
dt_2 (min)		C_D (-)	
T_T (m^2/s)	$4.99 \cdot 10^{-4}$	ξ (-)	
S (-)	$2.92 \cdot 10^{-4}$		
K_s (m/s)			
S_s (1/m)			

Comments:

Recovery was not evaluated due to disturbance from precipitation.

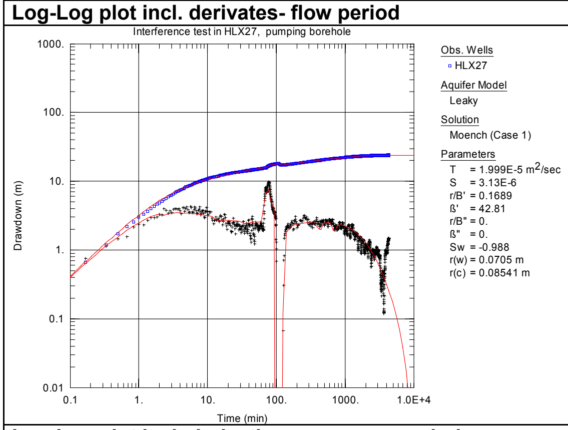
Test Summary Sheet – Pumping borehole HLX27 (2007)			
Project:	PLU	Test type:	1B
Area:	Oskarshamn	Test no:	1
Borehole ID:	HLX27	Test start:	2007-05-30 11:17:00
Test section (m):	6.0-164.7	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.137	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot Q and p

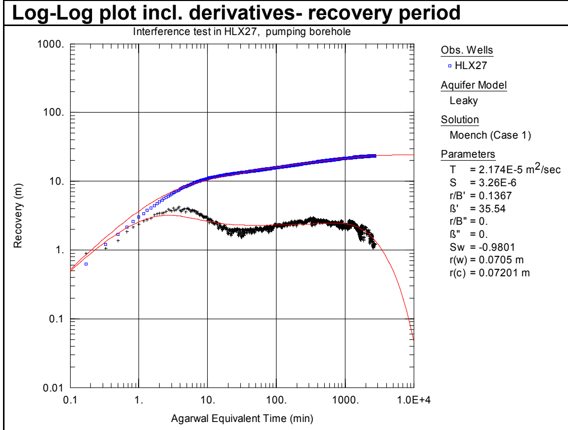


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	771.1		
p_p(kPa)	539.5	p_F (kPa)	771.2
Q_p (m^3/s)	$1.52 \cdot 10^{-3}$		
t_p (min)	4365	t_F (min)	7130
S^* (-)	$3.1 \cdot 10^{-6}$	S^* (-)	$3.3 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)		r (m)	
Results		**Results**	
Q/s (m^2/s)	$6.4 \cdot 10^{-5}$		
T_M (m^2/s)	$8.2 \cdot 10^{-5}$		
Flow regime:	WBS->PRF->PSF	Flow regime:	WBS->PRF->PSF
dt_1 (min)	20	dt_1 (min)	20
dt_2 (min)	600	dt_2 (min)	1000
T (m^2/s)	$2.0 \cdot 10^{-5}$	T (m^2/s)	$2.2 \cdot 10^{-5}$
S (-)		S (-)	
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)	$2.3 \cdot 10^{-6}$	C (m^3/Pa)	$1.7 \cdot 10^{-6}$
C_D (-)		C_D (-)	
ξ (-)	-1.0	ξ (-)	-1.0
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.			
dt_1 (min)	20	C (m^3/Pa)	$1.7 \cdot 10^{-6}$
dt_2 (min)	1000	C_D (-)	
T_T (m^2/s)	$2.2 \cdot 10^{-5}$	ξ (-)	-1.0
S* (-)	$3.3 \cdot 10^{-6}$		
K_s (m/s)			
S_s (1/m)			

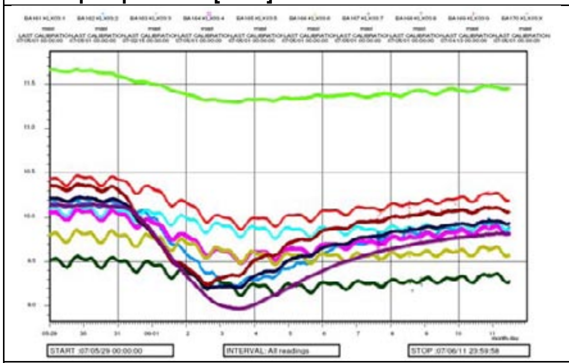
Comments:

During both the flow and recovery period, wellbore storage effects are followed by dominating pseudo-radial flow transitioning to pseudo-spherical flow by the end. The responses during the flow and recovery period are very similar. Transient evaluation was based on variable flow rate.

The agreement in evaluated parameter values between the flow and recovery period is very good. The parameter values from the recovery period are selected as the most representative.

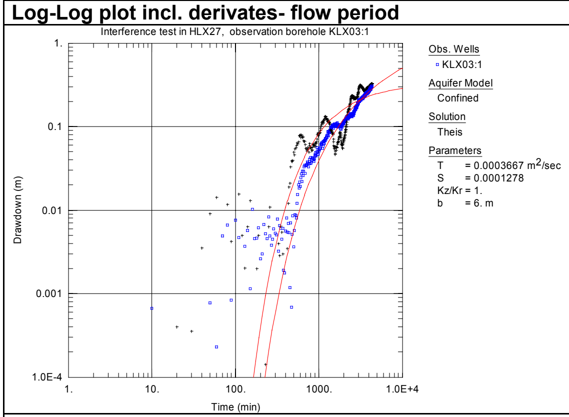
Test Summary Sheet –Observation borehole KLX03:1, pumping borehole HLX27 (2007)			
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX03:1	Test start:	2007-05-30 11:17:00
Test section (m):	965.5-971.5	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot pressure [masl]

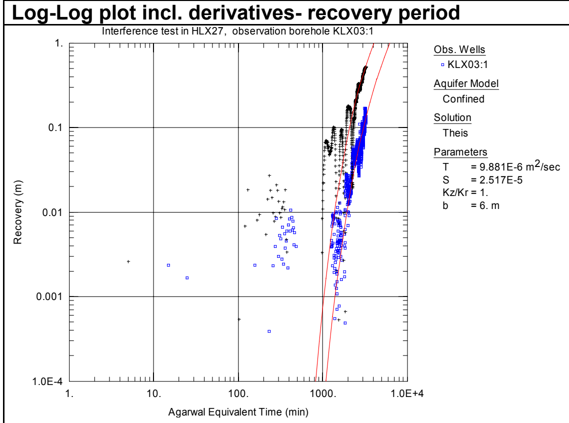


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	114.1		
p_p(kPa)	111.1	p_F (kPa)	112.3
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.2	Derivative fact.	0.2
r (m)	983	r (m)	983
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	Transition	Flow regime:	Transition
dt_1 (min)		dt_1 (min)	
dt_2 (min)		dt_2 (min)	
T (m^2/s)	($3.7 \cdot 10^{-4}$)	T (m^2/s)	($9.9 \cdot 10^{-6}$)
S (-)	($1.3 \cdot 10^{-4}$)	S (-)	($2.5 \cdot 10^{-5}$)
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.			
dt_1 (min)		C (m^3/Pa)	
dt_2 (min)		C_D (-)	
T_T (m^2/s)	($3.7 \cdot 10^{-4}$)	ξ (-)	
S (-)	($1.3 \cdot 10^{-4}$)		
K_s (m/s)			
S_s (1/m)			

Comments:

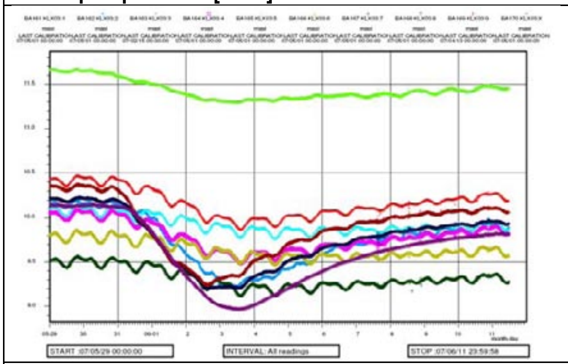
During both the flow period a transition to possible pseudo-radial flow occurred.

Transient evaluation was based on variable flow rate. The results from both the flow and recovery period are considered as very uncertain. The parameter values from the flow period are selected as the most representative.

Test Summary Sheet– Observation borehole KLX03:2, pumping borehole HLX27 (2007)

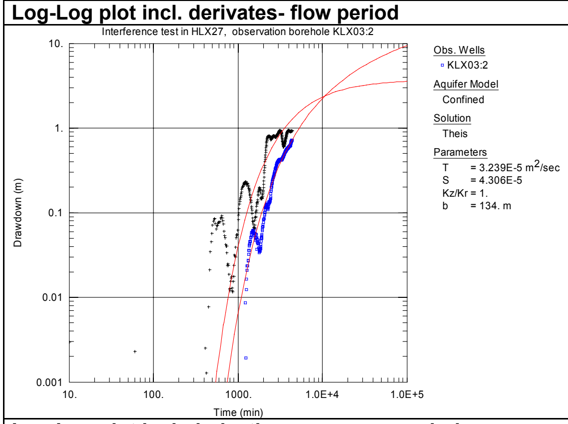
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX03:2	Test start:	2007-05-30 11:17:00
Test section (m):	830.5-964.5	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot pressure [masl]

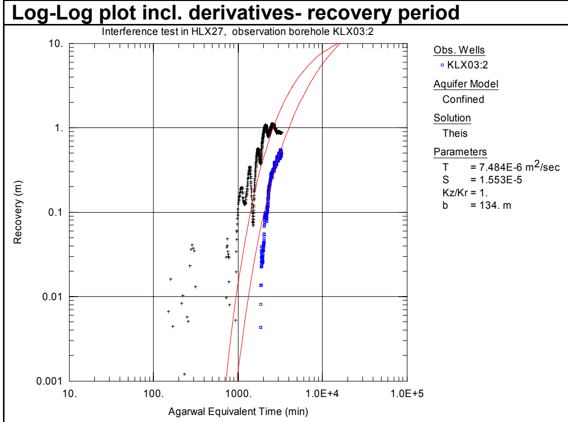


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	99.2		
p_p(kPa)	92.2	p_F (kPa)	97.0
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.2	Derivative fact.	0.2
r (m)	922	r (m)	922
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	Transition	Flow regime:	Transition
dt_1 (min)		dt_1 (min)	
dt_2 (min)		dt_2 (min)	
T (m^2/s)	$3.2 \cdot 10^{-5}$	T (m^2/s)	$7.5 \cdot 10^{-6}$
S (-)	$4.3 \cdot 10^{-5}$	S (-)	$1.6 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.

dt_1 (min)		C (m^3/Pa)	
dt_2 (min)		C_D (-)	
T_T (m^2/s)	$3.2 \cdot 10^{-5}$	ξ (-)	
S (-)	$4.3 \cdot 10^{-5}$		
K_s (m/s)			
S_s (1/m)			

Comments:

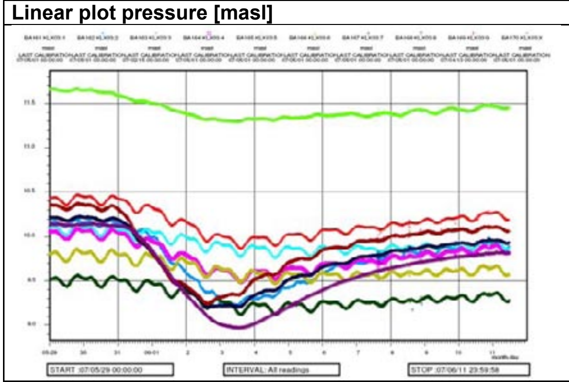
During both the flow period a transition to possible pseudo-radial flow occurred.

Transient evaluation was based on variable flow rate. The results from the recovery period are considered as uncertain. The parameter values from the flow period are selected as the most representative.

Test Summary Sheet –Observation borehole KLX03:3, pumping borehole HLX27 (2007)

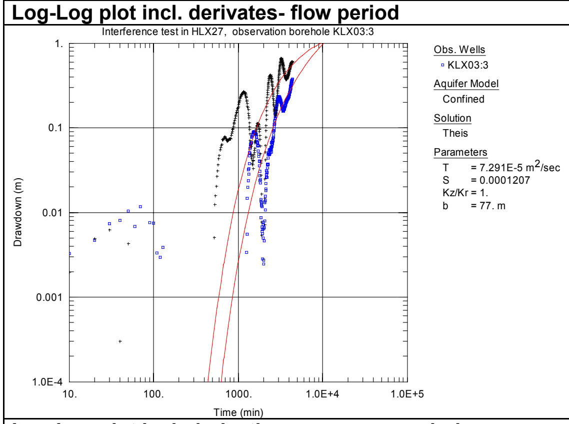
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX03:3	Test start:	2007-05-30 11:17:00
Test section (m):	752.5-829.5	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot pressure [masl]

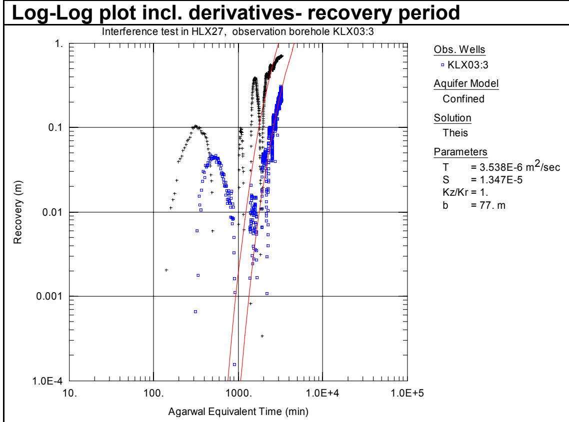


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	101.6		
p_p(kPa)	97.9	p_F (kPa)	100.0
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.3	Derivative fact.	0.3
r (m)	834	r (m)	834
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	Transition	Flow regime:	Transition
dt_1 (min)		dt_1 (min)	
dt_2 (min)		dt_2 (min)	
T (m^2/s)	$7.3 \cdot 10^{-5}$	T (m^2/s)	$3.5 \cdot 10^{-6}$
S (-)	$1.2 \cdot 10^{-4}$	S (-)	$1.3 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.

dt_1 (min)		C (m^3/Pa)	
dt_2 (min)		C_D (-)	
T_T (m^2/s)	$7.3 \cdot 10^{-5}$	ξ (-)	
S (-)	$1.2 \cdot 10^{-4}$		
K_s (m/s)			
S_s (1/m)			

Comments:

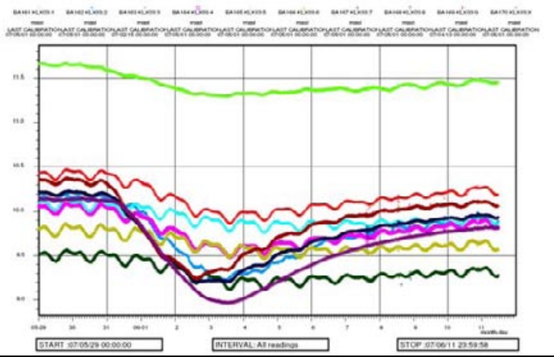
During both the flow period a transition to possible pseudo-radial flow occurred.

Transient evaluation was based on variable flow rate. The results from the recovery period are considered as uncertain. The parameter values from the flow period are selected as the most representative.

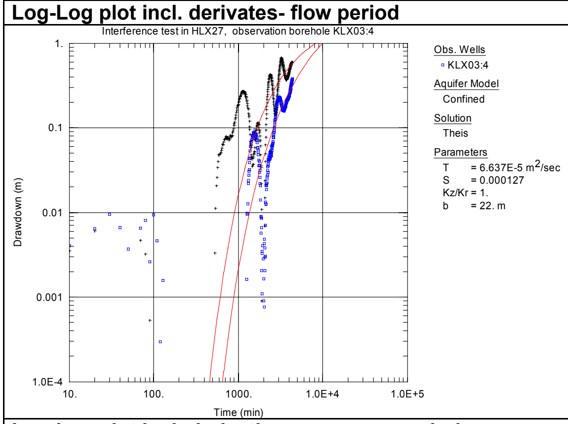
Test Summary Sheet –Observation borehole KLX03:4, pumping borehole HLX27 (2007)

Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX03:4	Test start:	2007-05-30 11:17:00
Test section (m):	729.5-751.5	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

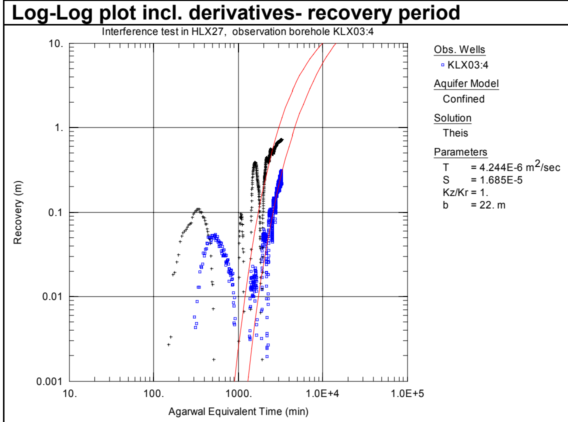
Linear plot pressure [masl]



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	97.9		
p_p(kPa)	94.1	p_F (kPa)	96.2
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.3	Derivative fact.	0.3
r (m)	796	r (m)	796
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	Transition	Flow regime:	Transition
dt_1 (min)		dt_1 (min)	
dt_2 (min)		dt_2 (min)	
T (m^2/s)	$6.6 \cdot 10^{-5}$	T (m^2/s)	$4.2 \cdot 10^{-6}$
S (-)	$1.3 \cdot 10^{-4}$	S (-)	$1.7 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Selected representative parameters.

dt_1 (min)		C (m^3/Pa)	
dt_2 (min)		C_D (-)	
T_T (m^2/s)	$6.6 \cdot 10^{-5}$	ξ (-)	
S (-)	$1.3 \cdot 10^{-4}$		
K_s (m/s)			
S_s (1/m)			

Comments:

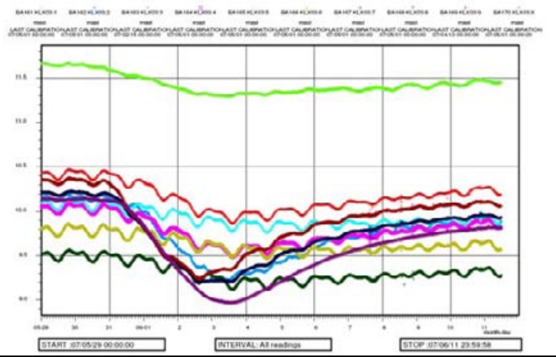
During both the flow period a transition to possible pseudo-radial flow occurred.

Transient evaluation was based on variable flow rate. The results from the recovery period are considered as uncertain. The parameter values from the flow period are selected as the most representative.

Test Summary Sheet –Observation borehole KLX03:8, pumping borehole HLX27 (2007)

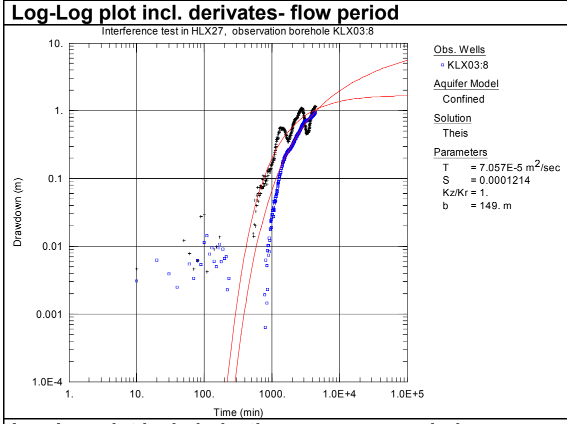
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX03:8	Test start:	2007-05-30 11:17:00
Test section (m):	199.5-348.5	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot pressure [masl]

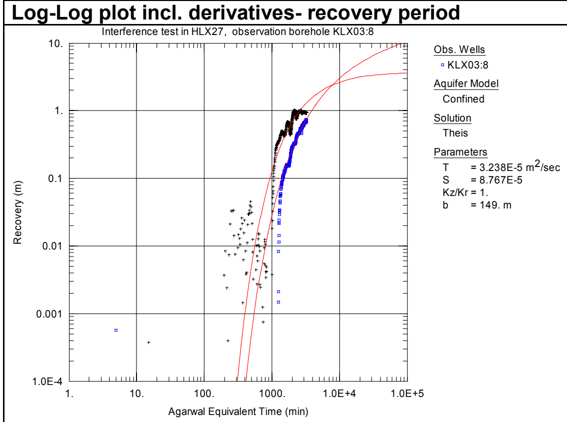


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	99.9		
p_p(kPa)	90.6	p_F (kPa)	97.4
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	552	r (m)	552
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	Transition	Flow regime:	Transition
dt_1 (min)		dt_1 (min)	
dt_2 (min)		dt_2 (min)	
T (m^2/s)	$7.1 \cdot 10^{-5}$	T (m^2/s)	$3.2 \cdot 10^{-5}$
S (-)	$1.2 \cdot 10^{-4}$	S (-)	$8.8 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.

dt_1 (min)		C (m^3/Pa)	
dt_2 (min)		C_D (-)	
T_T (m^2/s)	$7.1 \cdot 10^{-5}$	ξ (-)	
S (-)	$1.2 \cdot 10^{-4}$		
K_s (m/s)			
S_s (1/m)			

Comments:

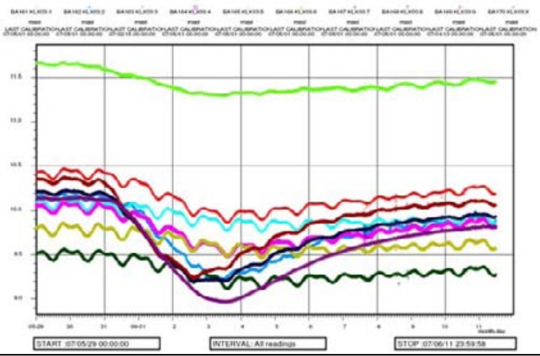
During both the flow period a transition to possible pseudo-radial flow occurred.

Transient evaluation was based on variable flow rate. The parameter values from the flow period are selected as the most representative.

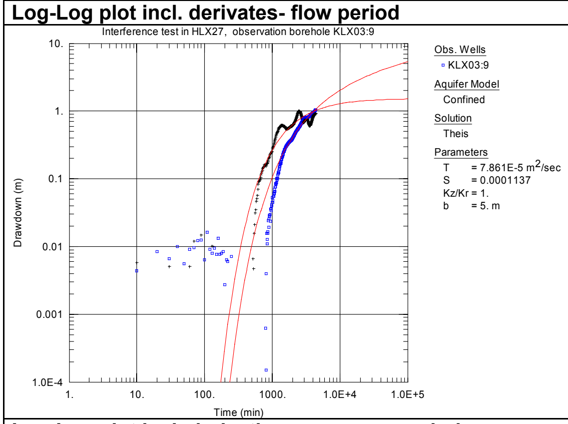
Test Summary Sheet –Observation borehole KLX03:9, pumping borehole HLX27 (2007)

Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX03:9	Test start:	2007-05-30 11:17:00
Test section (m):	193.5-198.5	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

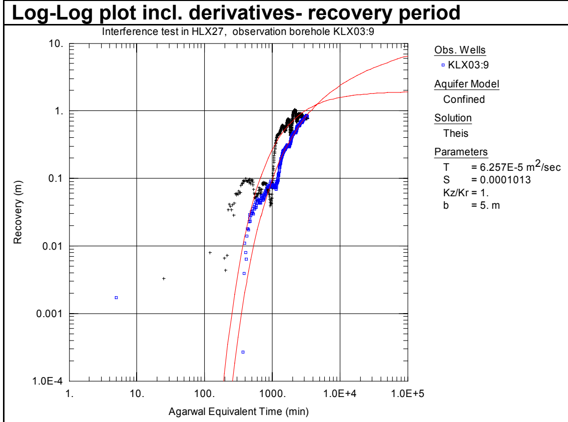
Linear plot pressure [masl]



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	101.1		
p_p(kPa)	90.9	p_F (kPa)	98.7
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(^{o}C)			
Derivative fact.	0.2	Derivative fact.	0.2
r (m)	544	r (m)	544
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	Transition	Flow regime:	Transition
dt_1 (min)		dt_1 (min)	
dt_2 (min)		dt_2 (min)	
T (m^2/s)	$7.9 \cdot 10^{-5}$	T (m^2/s)	$6.3 \cdot 10^{-5}$
S (-)	$1.1 \cdot 10^{-4}$	S (-)	$1.0 \cdot 10^{-4}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Selected representative parameters.

dt_1 (min)		C (m^3/Pa)	
dt_2 (min)		C_D (-)	
T_T (m^2/s)	$7.9 \cdot 10^{-5}$	ξ (-)	
S (-)	$1.1 \cdot 10^{-4}$		
K_s (m/s)			
S_s (1/m)			

Comments:

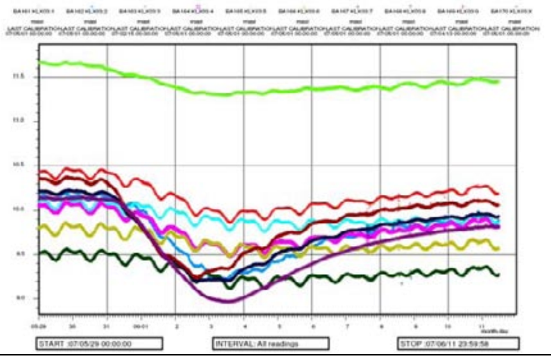
During both the flow period a transition to possible pseudo-radial flow occurred.

Transient evaluation was based on variable flow rate. Consistent results were obtained from the flow and recovery period. The parameter values from the flow period are selected as the most representative.

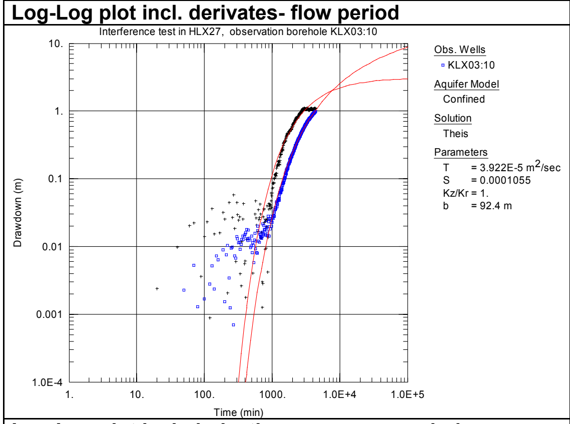
Test Summary Sheet– Observation borehole KLX03:10, pumping borehole HLX27 (2007)

Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX03:10	Test start:	2007-05-30 11:17:00
Test section (m):	100.1-192.5	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

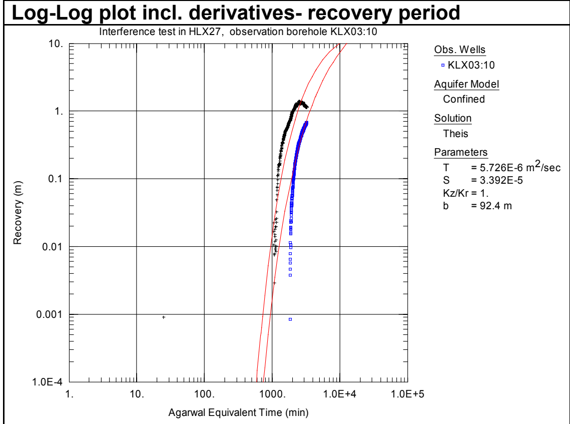
Linear plot pressure [masl]



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	99.4		
p_p(kPa)	89.8	p_F (kPa)	96.2
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	546	r (m)	546
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	Transition	Flow regime:	Transition
dt_1 (min)		dt_1 (min)	
dt_2 (min)		dt_2 (min)	
T (m^2/s)	$3.9 \cdot 10^{-5}$	T (m^2/s)	$5.7 \cdot 10^{-6}$
S (-)	$1.1 \cdot 10^{-4}$	S (-)	$3.4 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Selected representative parameters.

dt_1 (min)		C (m^3/Pa)	
dt_2 (min)		C_D (-)	
T_T (m^2/s)	$3.9 \cdot 10^{-5}$	ξ (-)	
S (-)	$1.1 \cdot 10^{-4}$		
K_s (m/s)			
S_s (1/m)			

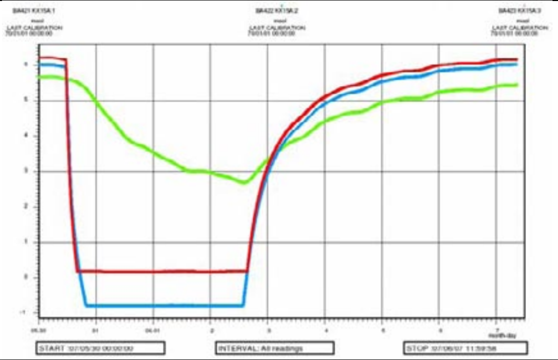
Comments:

During both the flow period a transition to possible pseudo-radial flow occurred.

Transient evaluation was based on variable flow rate. The results from the recovery period are considered as uncertain. The parameter values from the flow period are selected as the most representative.

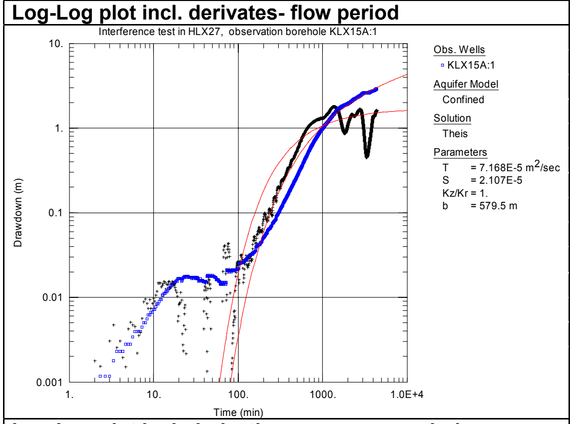
Test Summary Sheet –Observation borehole HLX15A:1, pumping borehole HLX27 (2007)			
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX15A:1	Test start:	2007-05-30 11:17:00
Test section (m):	421.0-1000.4	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot pressure [masl]

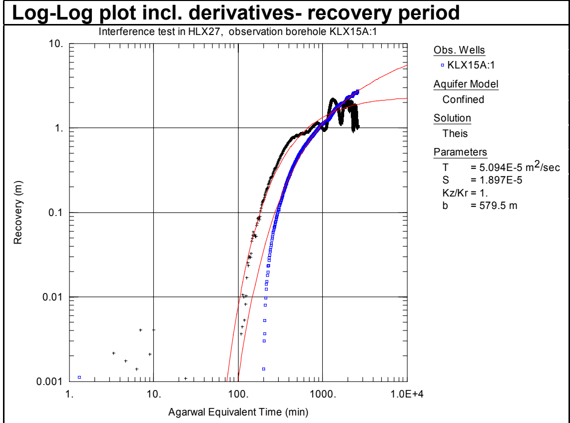


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	55.0		
p_p(kPa)	26.5	p_F (kPa)	53.5
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	611	r (m)	611
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	(PRF)	Flow regime:	(PRF)
dt_1 (min)	1000	dt_1 (min)	2000
dt_2 (min)	4000	dt_2 (min)	3000
T (m^2/s)	$7.2 \cdot 10^{-5}$	T (m^2/s)	$5.1 \cdot 10^{-5}$
S (-)	$2.1 \cdot 10^{-5}$	S (-)	$1.9 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.			
dt_1 (min)	1000	C (m^3/Pa)	
dt_2 (min)	4000	C_D (-)	
T_T (m^2/s)	$7.2 \cdot 10^{-5}$	ξ (-)	
S (-)	$2.1 \cdot 10^{-5}$		
K_s (m/s)			
S_s (1/m)			

Comments:

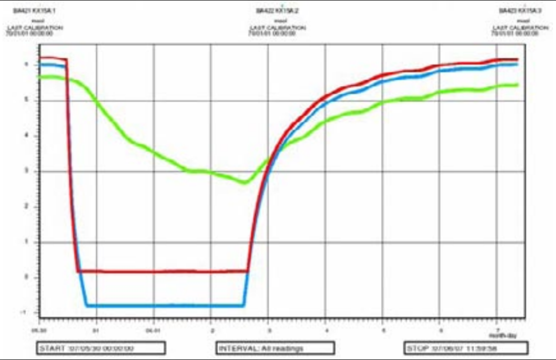
During both the flow period a transition to possible pseudo-radial flow occurred.

Transient evaluation was based on variable flow rate. Consistent results were obtained from the flow and recovery period. The parameter values from the flow period are selected as the most representative.

Test Summary Sheet –Observation borehole KLX15A:2, pumping borehole HLX27 (2007)

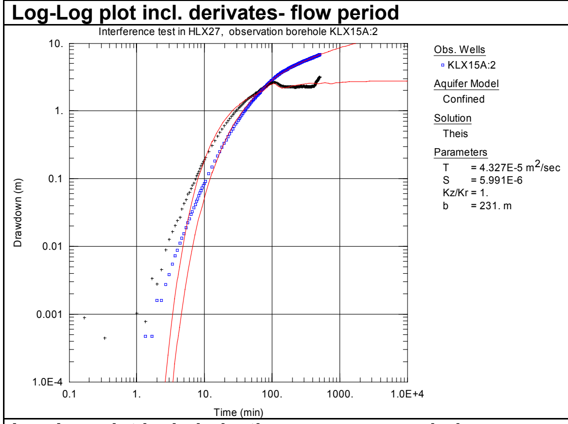
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX15A:2	Test start:	2007-05-30 11:17:00
Test section (m):	189.0-420.0	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot pressure [masl]

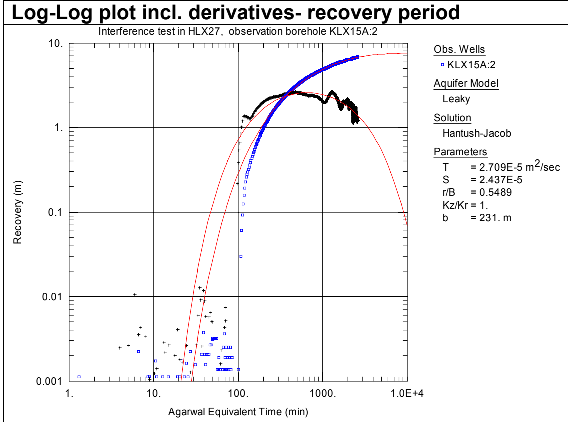


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	54.6		
p_p(kPa)	-7.8	p_F (kPa)	59.0
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(^{o}C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	219	r (m)	219
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	PRF	Flow regime:	PRF->PSF
dt_1 (min)	100	dt_1 (min)	
dt_2 (min)	500	dt_2 (min)	
T (m^2/s)	$4.3 \cdot 10^{-5}$	T (m^2/s)	$2.7 \cdot 10^{-5}$
S (-)	$6.0 \cdot 10^{-6}$	S (-)	$2.4 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.

dt_1 (min)	100	C (m^3/Pa)	
dt_2 (min)	500	C_D (-)	
T_T (m^2/s)	$4.3 \cdot 10^{-5}$	ξ (-)	
S (-)	$6.0 \cdot 10^{-6}$		
K_s (m/s)			
S_s (1/m)			

Comments:

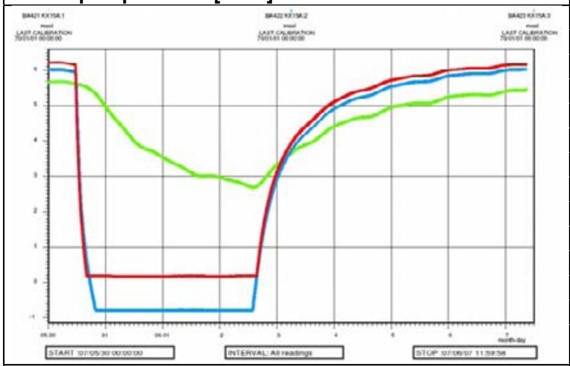
During the flow period a transition to pseudo-radial flow occurred. During the recovery period pseudo-radial flow transitioning to pseudo-spherical (leaky) flow occurred.

Transient evaluation was based on variable flow rate. The parameter values from the flow period are selected as the most representative.

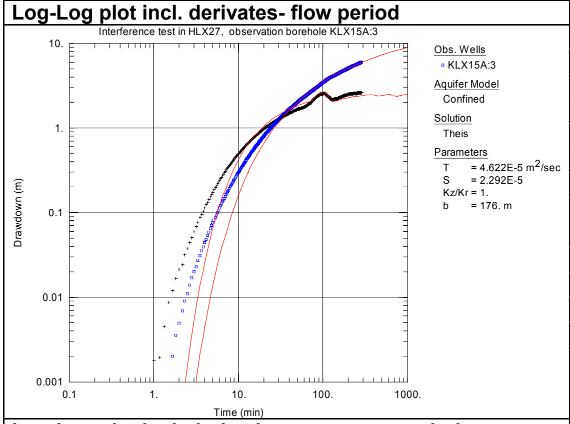
Test Summary Sheet –Observation borehole KLX15A:3, pumping borehole HLX27 (2007)

Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX15A:3	Test start:	2007-05-30 11:17:00
Test section (m):	11.7-188.0	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

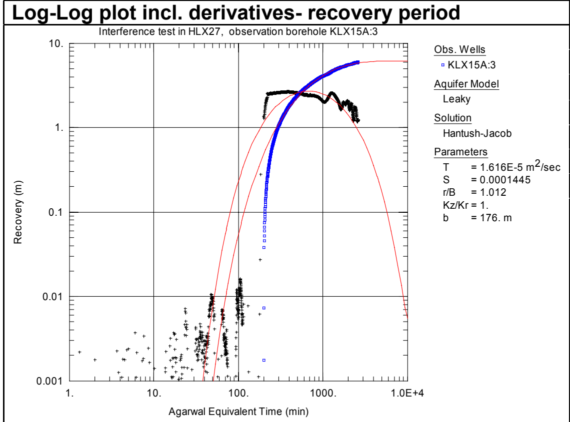
Linear plot pressure [masl]



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	60.4		
p_p(kPa)	1.8	p_F (kPa)	60.6
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	96	r (m)	96
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	PRF	Flow regime:	PRF->PSF
dt_1 (min)	150	dt_1 (min)	200
dt_2 (min)	300	dt_2 (min)	1000
T (m^2/s)	$4.6 \cdot 10^{-5}$	T (m^2/s)	$1.6 \cdot 10^{-5}$
S (-)	$2.3 \cdot 10^{-5}$	S (-)	$1.4 \cdot 10^{-4}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Selected representative parameters.			
dt_1 (min)	150	C (m^3/Pa)	
dt_2 (min)	300	C_D (-)	
T_T (m^2/s)	$4.6 \cdot 10^{-5}$	ξ (-)	
S (-)	$2.3 \cdot 10^{-5}$		
K_s (m/s)			
S_s (1/m)			

Comments:

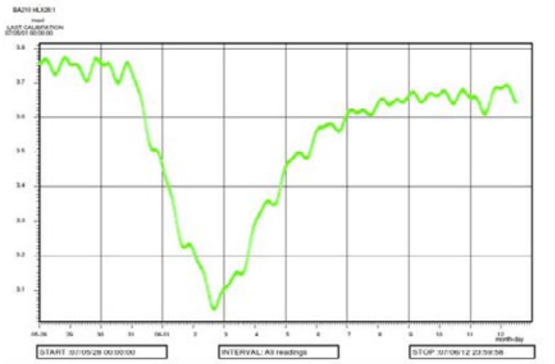
During the flow period a transition to pseudo-radial flow occurred. During the recovery period pseudo-radial flow transitioning to pseudo-spherical (leaky) flow occurred.

Transient evaluation was based on variable flow rate. The parameter values from the flow period are selected as the most representative.

Test Summary Sheet –Observation borehole HLX26:1, pumping borehole HLX27 (2007)

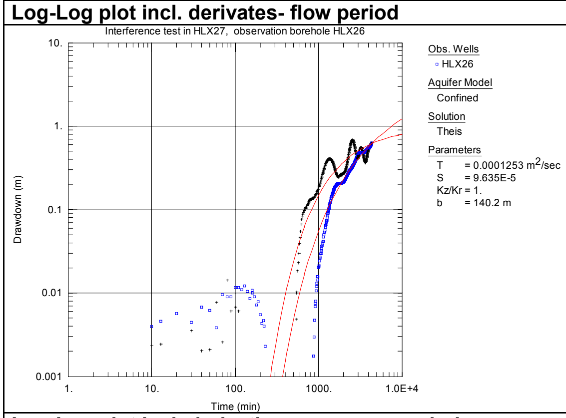
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	HLX26:1	Test start:	2007-05-30 11:17:00
Test section (m):	11.0-151.2	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.137	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot pressure [masl]

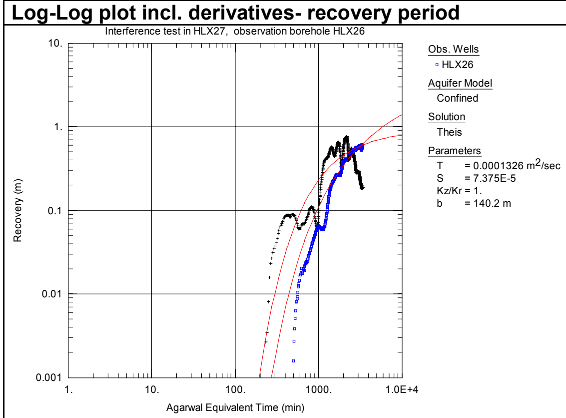


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	36.4		
p_p(kPa)	30.3	p_F (kPa)	35.8
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.2	Derivative fact.	0.2
r (m)	772	r (m)	772
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	PRF	Flow regime:	PRF
dt_1 (min)	2000	dt_1 (min)	1500
dt_2 (min)	4000	dt_2 (min)	3000
T (m^2/s)	$1.3 \cdot 10^{-4}$	T (m^2/s)	$1.3 \cdot 10^{-4}$
S (-)	$9.6 \cdot 10^{-5}$	S (-)	$7.4 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.			
dt_1 (min)	2000	C (m^3/Pa)	
dt_2 (min)	4000	C_D (-)	
T_T (m^2/s)	$1.3 \cdot 10^{-4}$	ξ (-)	
S (-)	$9.6 \cdot 10^{-5}$		
K_s (m/s)			
S_s (1/m)			

Comments:

During both the flow and recovery period a transition to a short period of pseudo-radial flow occurred by the end. The responses during the flow and recovery period are similar. Transient evaluation was based on variable flow rate.

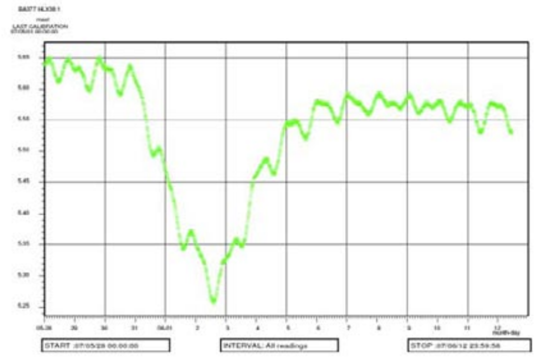
The agreement in evaluated parameter values between the flow and recovery period is very good. The parameter values from the flow period are selected as the most representative.

Test Summary Sheet – Observation borehole HLX38 (pumping borehole HLX27 (2007))

Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1

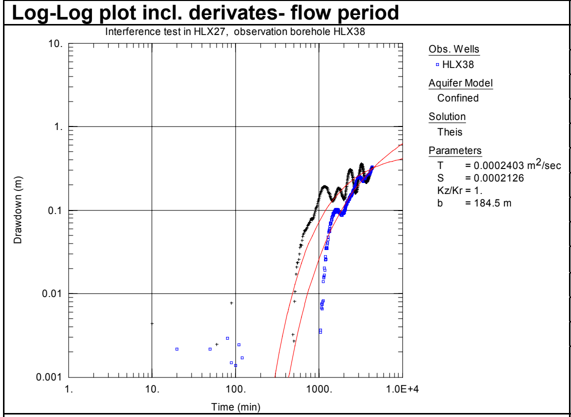
Borehole ID:	HLX38	Test start:	2007-05-30 11:17:00
Test section (m):	15.0-199.5	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.139	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot pressure [masl]

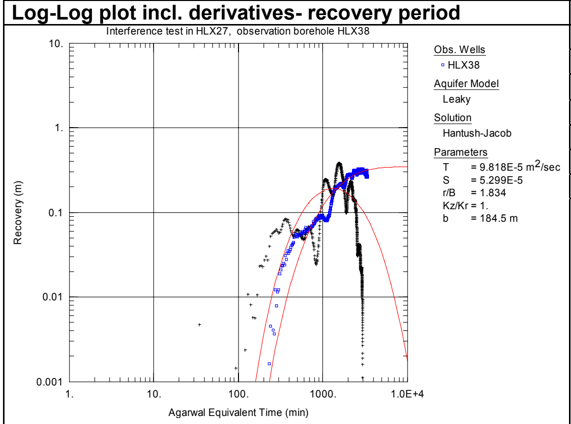


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	54.9		
p_p(kPa)	51.7	p_F (kPa)	54.2
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.3	Derivative fact.	0.3
r (m)	734	r (m)	734
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	(PRF)	Flow regime:	PRF->PSF
dt_1 (min)		dt_1 (min)	1000
dt_2 (min)		dt_2 (min)	2000
T (m^2/s)	$2.4 \cdot 10^{-4}$	T (m^2/s)	$9.8 \cdot 10^{-5}$
S (-)	$2.1 \cdot 10^{-4}$	S (-)	$5.3 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.			
dt_1 (min)	1000	C (m^3/Pa)	
dt_2 (min)	2000	C_D (-)	
T_T (m^2/s)	$9.8 \cdot 10^{-5}$	ξ (-)	
S (-)	$5.3 \cdot 10^{-5}$		
K_s (m/s)			
S_s (1/m)			

Comments:

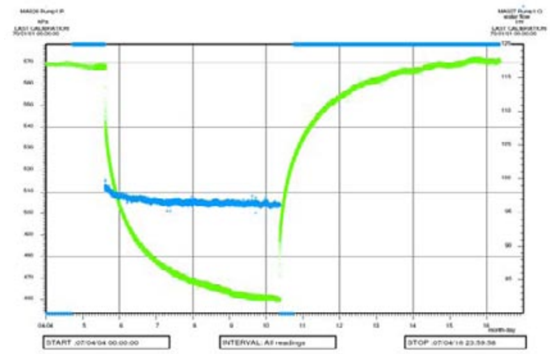
During the flow period a transition to possible pseudo-radial flow occurred. During the recovery period a short period of pseudo-radial flow transitioning to pseudo-spherical (leaky) flow occurred.

Transient evaluation was based on variable flow rate. The parameter values from the recovery period are selected as the most representative.

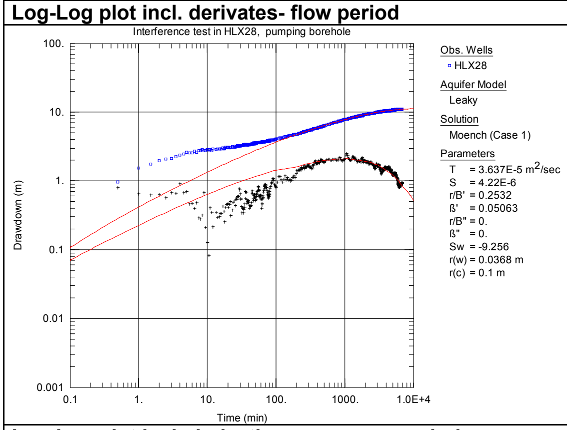
Test Summary Sheet – Pumping borehole HLX28

Project:	PLU	Test type:	1B
Area:	Oskarshamn	Test no:	1
Borehole ID:	HLX28	Test start:	2007-04-05 14:52:00
Test section (m):	6.0-154.2	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.068	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

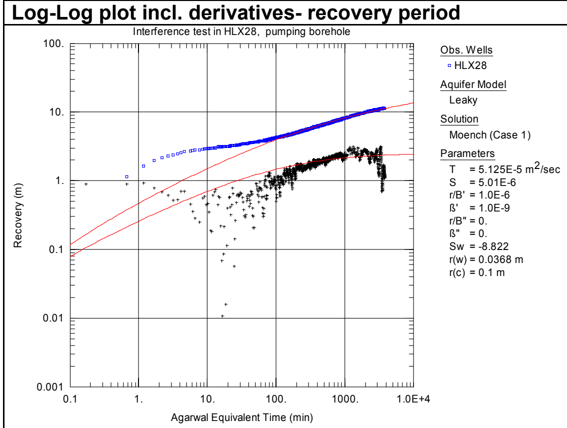
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	568.2		
p_p(kPa)	459.4	p_F (kPa)	571.3
Q_p (m³/s)	$1.60 \cdot 10^{-3}$		
t_p (min)	6839	t_F (min)	8616
S^* (-)	$4.2 \cdot 10^{-6}$	S^* (-)	$5.0 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.2	Derivative fact.	0.1
r (m)		r (m)	
Results		**Results**	
Q/s (m²/s)	$1.4 \cdot 10^{-4}$		
T_M (m²/s)	$2.0 \cdot 10^{-4}$		
Flow regime:	PLF-> PRF->PSF	Flow regime:	PLF->PRF ->(PSF)
dt_1 (min)	300	dt_1 (min)	400
dt_2 (min)	1500	dt_2 (min)	3000
T (m²/s)	$3.6 \cdot 10^{-5}$	T (m²/s)	$5.1 \cdot 10^{-5}$
S (-)		S (-)	
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m³/Pa)	$3.2 \cdot 10^{-6}$	C (m³/Pa)	$3.2 \cdot 10^{-6}$
C_D (-)		C_D (-)	
ξ (-)	-9.3	ξ (-)	-8.8
T_{GRF}(m²/s)		T_{GRF}(m²/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Selected representative parameters.

dt_1 (min)	300	C (m³/Pa)	$3.2 \cdot 10^{-6}$
dt_2 (min)	1500	C_D (-)	
T_T (m²/s)	$3.6 \cdot 10^{-5}$	ξ (-)	-9.3
S* (-)	$4.2 \cdot 10^{-6}$		
K_s (m/s)			
S_s (1/m)			

Comments:

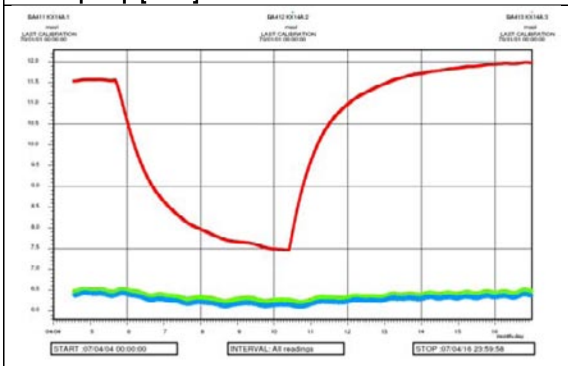
The flow rate was relatively constant during the flow period. During both the flow and recovery period, initial fracture responses (PLF) are followed by a transition to a short period of nearly pseudo-radial flow. By the end of the flow period a PSF is shown whereas this flow regime is only weakly developed during the recovery period.

Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively. The parameter values estimated from the flow period are selected as the most representative for the test section.

Test Summary Sheet – Observation borehole KLX14A:3 (pumping borehole HLX28)

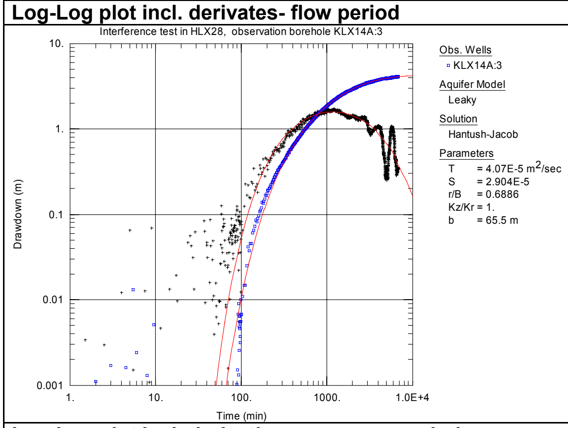
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX14A:3	Test start:	2007-04-05 14:52:00
Test section (m):	6.5-72.0	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot p [masl]

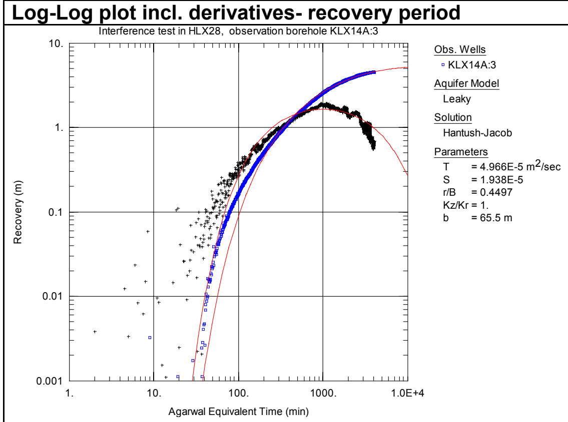


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	113.2		
p_p(kPa)	73.2	p_F (kPa)	117.4
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.05	Derivative fact.	0.05
r (m)	372	r (m)	372
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	PRF->PSF	Flow regime:	PRF->PSF
dt_1 (min)	80	dt_1 (min)	80
dt_2 (min)	1500	dt_2 (min)	1500
T (m^2/s)	$4.1 \cdot 10^{-5}$	T (m^2/s)	$5.0 \cdot 10^{-5}$
S (-)	$2.9 \cdot 10^{-5}$	S (-)	$1.9 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.			
dt_1 (min)	80	C (m^3/Pa)	
dt_2 (min)	1500	C_D (-)	
T_T (m^2/s)	$4.1 \cdot 10^{-5}$	ξ (-)	
S* (-)	$2.9 \cdot 10^{-5}$		
K_s (m/s)			
S_s (1/m)			

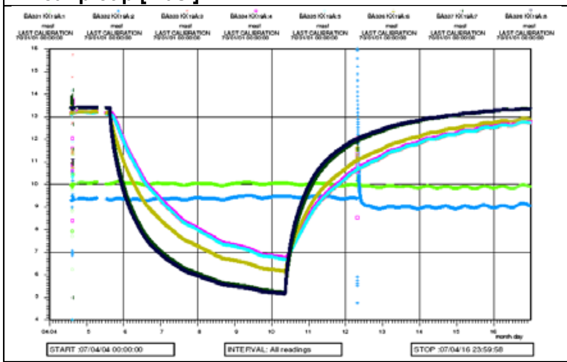
Comments:

Consistent responses were obtained during the flow and recovery period. After a short period of nearly pseudo-radial flow a transition to pseudo-spherical (leaky) flow occurred by the end.

Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively. The parameter values estimated from the flow period are selected as the most representative for the test section.

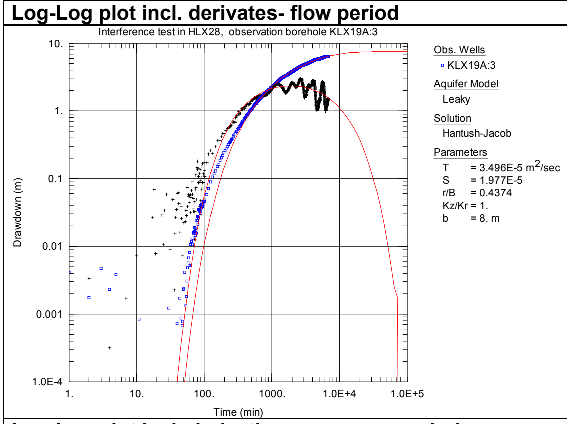
Test Summary Sheet – Observation borehole KLX19A:3 (pumping borehole HLX28)			
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX19A:3	Test start:	2007-04-05 14:52:00
Test section (m):	509.0-517.0	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot p [masl]

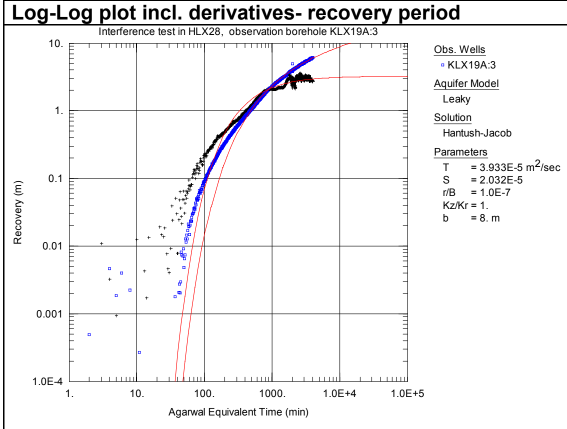


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	128.5		
p_p(kPa)	65.5	p_F (kPa)	124.7
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	425	r (m)	425
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	PRF->PSF	Flow regime:	PRF
dt_1 (min)	1000	dt_1 (min)	2000
dt_2 (min)	4000	dt_2 (min)	4000
T (m^2/s)	$3.5 \cdot 10^{-5}$	T (m^2/s)	$3.9 \cdot 10^{-5}$
S (-)	$2.0 \cdot 10^{-5}$	S (-)	$2.0 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.			
dt_1 (min)	1000	C (m^3/Pa)	
dt_2 (min)	4000	C_D (-)	
T_T (m^2/s)	$3.5 \cdot 10^{-5}$	ξ (-)	
S (-)	$2.0 \cdot 10^{-5}$		
K_s (m/s)			
S_s (1/m)			

Comments:

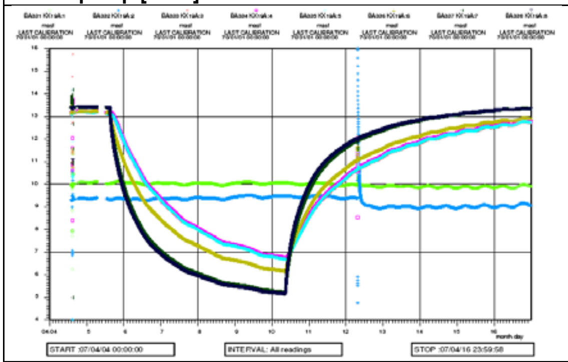
Distinct responses were obtained during the flow and recovery period. The flow period is dominated by nearly pseudo-radial flow transitioning to pseudo-spherical (leaky) flow. During the recovery period a transition to pseudo-radial flow occurred.

Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively. The parameter values estimated from the flow period are selected as the most representative for the test section.

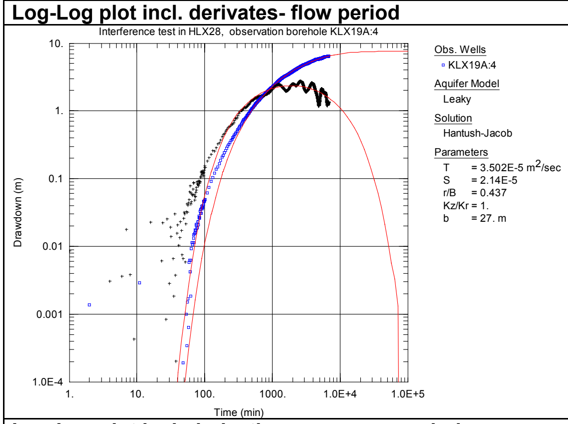
Test Summary Sheet – Observation borehole KLX19A:4 (pumping borehole HLX28)

Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX19A:4	Test start:	2007-04-05 14:52:00
Test section (m):	481.0-508.0	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

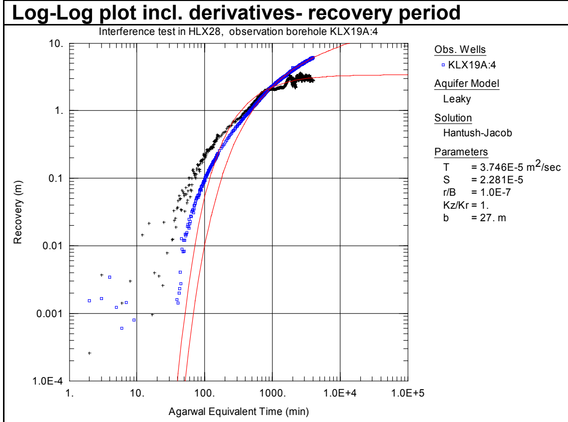
Linear plot p [masl]



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	129.1		
p_p(kPa)	66.1	p_F (kPa)	125.3
Q_p (m³/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	408	r (m)	408
Results		**Results**	
Q/s (m²/s)			
T_M (m²/s)			
Flow regime:	PRF->PSF	Flow regime:	PRF
dt_1 (min)	1000	dt_1 (min)	2000
dt_2 (min)	4000	dt_2 (min)	4000
T (m²/s)	$3.5 \cdot 10^{-5}$	T (m²/s)	$3.7 \cdot 10^{-5}$
S (-)	$2.1 \cdot 10^{-5}$	S (-)	$2.3 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m³/Pa)		C (m³/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m²/s)		T_{GRF}(m²/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Selected representative parameters.

dt_1 (min)	1000	C (m³/Pa)	
dt_2 (min)	4000	C_D (-)	
T_T (m²/s)	$3.5 \cdot 10^{-5}$	ξ (-)	
S (-)	$2.1 \cdot 10^{-5}$		
K_s (m/s)			
S_s (1/m)			

Comments:

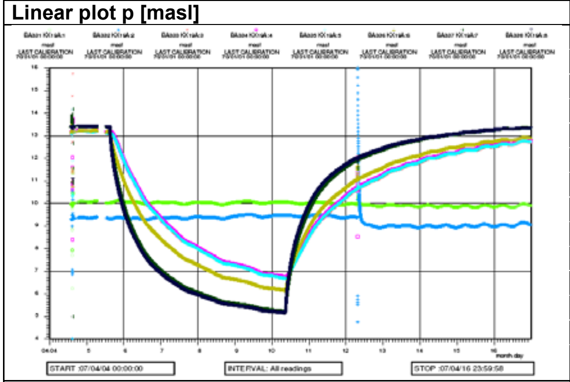
Distinct responses were obtained during the flow and recovery period. The flow period is dominated by nearly pseudo-radial flow transitioning to pseudo-spherical (leaky) flow. During the recovery period a transition to pseudo-radial flow occurred.

Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively. The parameter values estimated from the flow period are selected as the most representative for the test section.

Test Summary Sheet – Observation borehole KLX19A:5 (pumping borehole HLX28)

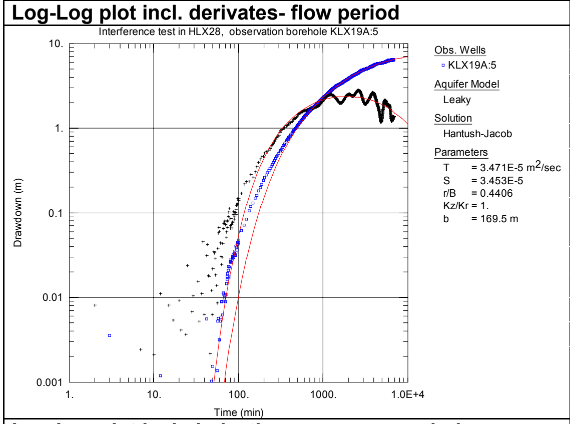
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX19A:5	Test start:	2007-04-05 14:52:00
Test section (m):	311.0-480.5	Responsible for test execution:	SKB field crew
Section diameter, 2·r_w (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot p [masl]

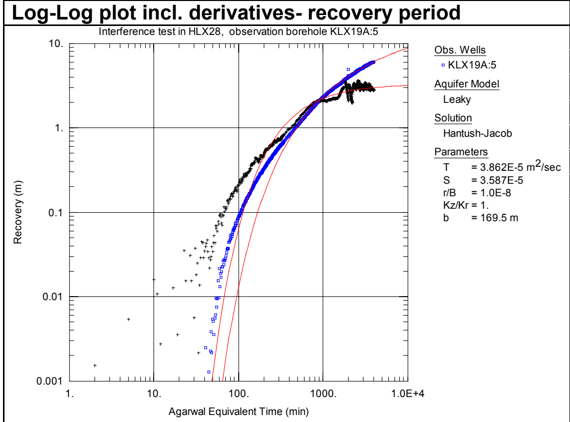


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	128.7		
p_p(kPa)	65.5	p_F (kPa)	125.1
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	321	r (m)	321
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	PRF->PSF	Flow regime:	PRF
dt_1 (min)	1000	dt_1 (min)	2000
dt_2 (min)	4000	dt_2 (min)	4000
T (m^2/s)	$3.5\cdot10^{-5}$	T (m^2/s)	$3.4\cdot10^{-5}$
S (-)	$3.5\cdot10^{-5}$	S (-)	$3.6\cdot10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.

dt_1 (min)	1000	C (m^3/Pa)	
dt_2 (min)	4000	C_D (-)	
T_T (m^2/s)	$3.5\cdot10^{-5}$	ξ (-)	
S (-)	$3.5\cdot10^{-5}$		
K_s (m/s)			
S_s (1/m)			

Comments:

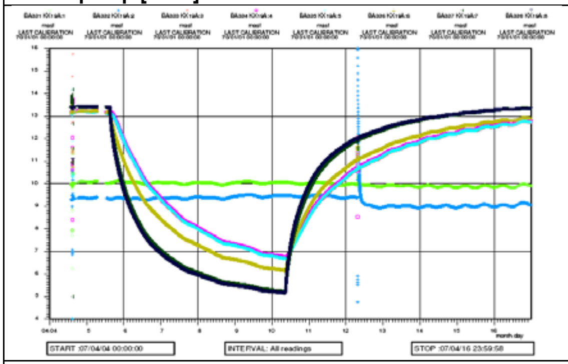
Distinct responses were obtained during the flow and recovery period. The flow period is dominated by nearly pseudo-radial flow transitioning to pseudo-spherical (leaky) flow. During the recovery period a transition to pseudo-radial flow occurred.

Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively. The parameter values estimated from the flow period are selected as the most representative for the test section.

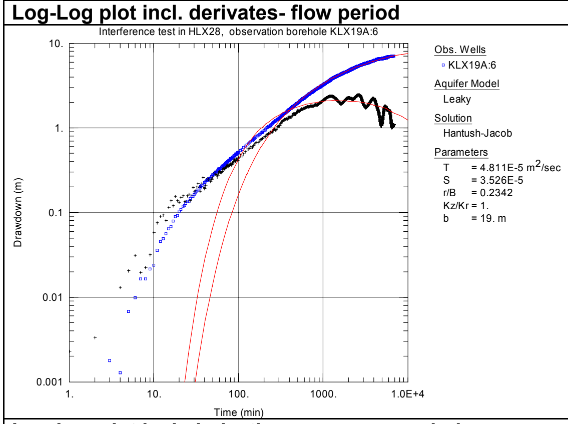
Test Summary Sheet – Observation borehole KLX19A:6 (pumping borehole HLX28)

Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX19A:6	Test start:	2007-04-05 14:52:00
Test section (m):	291.0-310.0	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

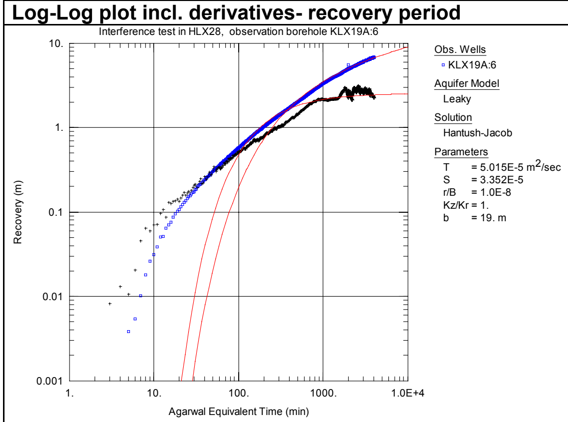
Linear plot p [masl]



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	129.2		
p_p(kPa)	60.1	p_F (kPa)	126.6
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	246	r (m)	246
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	PRF->PSF	Flow regime:	PRF
dt_1 (min)	1000	dt_1 (min)	1000
dt_2 (min)	4000	dt_2 (min)	4000
T (m^2/s)	$4.8 \cdot 10^{-5}$	T (m^2/s)	$5.0 \cdot 10^{-5}$
S (-)	$3.5 \cdot 10^{-5}$	S (-)	$3.4 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Selected representative parameters.

dt_1 (min)	1000	C (m^3/Pa)	
dt_2 (min)	4000	C_D (-)	
T_T (m^2/s)	$4.8 \cdot 10^{-5}$	ξ (-)	
S (-)	$3.5 \cdot 10^{-5}$		
K_s (m/s)			
S_s (1/m)			

Comments:

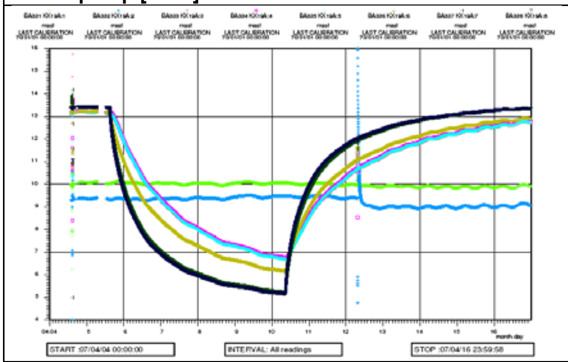
Distinct responses were obtained during the flow and recovery period. The flow period is dominated by nearly pseudo-radial flow transitioning to pseudo-spherical (leaky) flow. During the recovery period a transition to pseudo-radial flow occurred.

Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively. The parameter values estimated from the flow period are selected as the most representative for the test section.

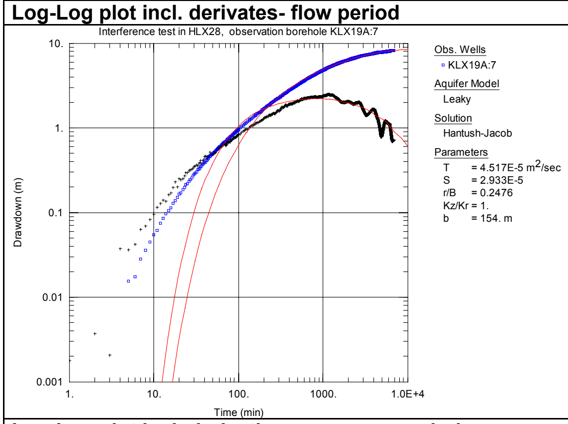
Test Summary Sheet – Observation borehole KLX19A:7 (pumping borehole HLX28)

Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX19A:7	Test start:	2007-04-05 14:52:00
Test section (m):	136.0-290.0	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

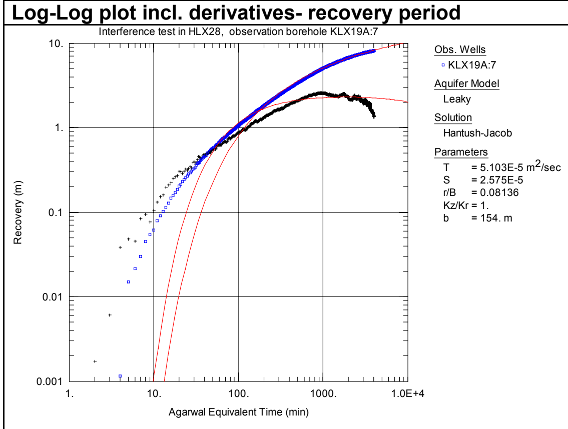
Linear plot p [masl]



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	131.3		
p_p(kPa)	51.2	p_F (kPa)	130.8
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(^{o}C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	193	r (m)	193
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	PRF->PSF	Flow regime:	PRF->(PSF)
dt_1 (min)	500	dt_1 (min)	500
dt_2 (min)	2000	dt_2 (min)	2000
T (m^2/s)	$4.5 \cdot 10^{-5}$	T (m^2/s)	$5.1 \cdot 10^{-5}$
S (-)	$2.9 \cdot 10^{-5}$	S (-)	$2.6 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Selected representative parameters.

dt_1 (min)	500	C (m^3/Pa)	
dt_2 (min)	2000	C_D (-)	
T_T (m^2/s)	$4.5 \cdot 10^{-5}$	ξ (-)	
S (-)	$2.9 \cdot 10^{-5}$		
K_s (m/s)			
S_s (1/m)			

Comments:

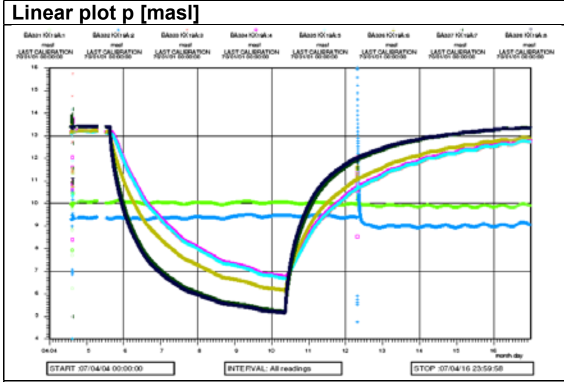
Distinct responses were obtained during the flow and recovery period. The flow period is dominated by nearly pseudo-radial flow transitioning to pseudo-spherical (leaky) flow. During the recovery period pseudo-radial flow transitioning to slightly leaky flow occurred.

Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively. The parameter values estimated from the flow period are selected as the most representative for the test section.

Test Summary Sheet – Observation borehole KLX19A:8 (pumping borehole HLX28)

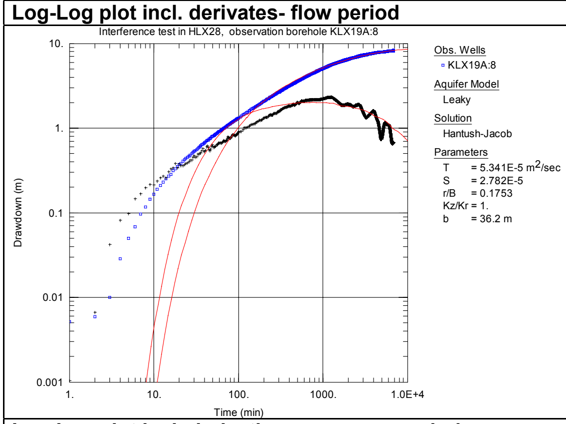
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX19A:8	Test start:	2007-04-05 14:52:00
Test section (m):	98.8-135.0	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot p [masl]

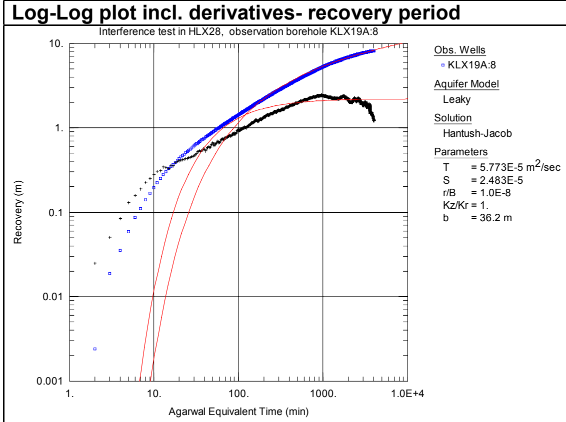


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	131.5		
p_p(kPa)	50.8	p_F (kPa)	130.8
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	172	r (m)	172
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	PRF->PSF	Flow regime:	PRF->(PSF)
dt_1 (min)	500	dt_1 (min)	600
dt_2 (min)	1500	dt_2 (min)	3000
T (m^2/s)	$5.3 \cdot 10^{-5}$	T (m^2/s)	$5.8 \cdot 10^{-5}$
S (-)	$2.8 \cdot 10^{-5}$	S (-)	$2.5 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.			
dt_1 (min)	500	C (m^3/Pa)	
dt_2 (min)	1500	C_D (-)	
T_T (m^2/s)	$5.3 \cdot 10^{-5}$	ξ (-)	
S (-)	$2.8 \cdot 10^{-5}$		
K_s (m/s)			
S_s (1/m)			

Comments:

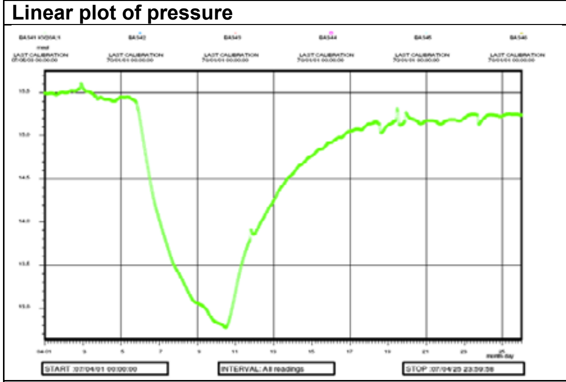
Distinct responses were obtained during the flow and recovery period. The flow period is dominated by nearly pseudo-radial flow transitioning to pseudo-spherical (leaky) flow. During the recovery period pseudo-radial flow transitioning to slightly leaky flow occurred.

Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively. The parameter values estimated from the flow period are selected as the most representative for the test section.

Test Summary Sheet – Observation borehole KLX20A (pumping borehole HLX28)

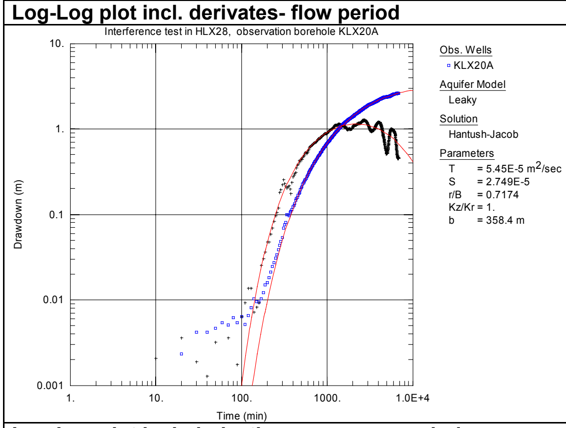
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	KLX20A	Test start:	2007-04-05 14:52:00
Test section (m):	100.90-457.92 (open borehole)	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot of pressure

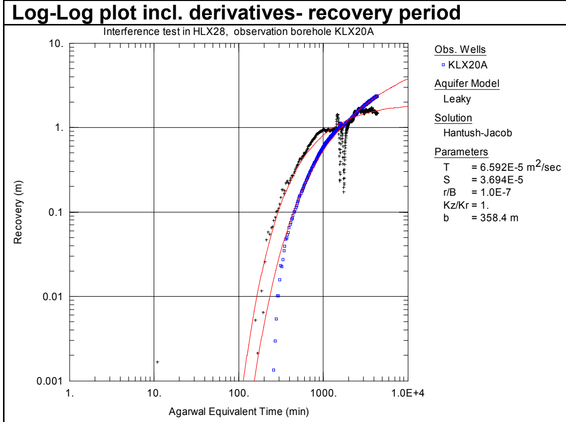


Flow period		Recovery period	
Indata		**Indata**	
h_0 (masl)			
h_i (masl)	15.42		
h_p (masl)	12.80	h_F (masl)	15.15
Q_p (m^3/s)			
t_p (min)	6839	t_F (min)	11671
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w (°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	612	r (m)	612
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	**(PRF)→PSF**	Flow regime:	**PRF**
dt_1 (min)	1000	dt_1 (min)	2500
dt_2 (min)	3000	dt_2 (min)	4000
T (m^2/s)	$5.4 \cdot 10^{-5}$	T (m^2/s)	$6.6 \cdot 10^{-5}$
S (-)	$2.7 \cdot 10^{-5}$	S (-)	$3.7 \cdot 10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF} (m^2/s)		T_{GRF} (m^2/s)	
S_{GRF} (-)		S_{GRF} (-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.

dt_1 (min)	1000	C (m^3/Pa)	
dt_2 (min)	3000	C_D (-)	
T_T (m^2/s)	$5.4 \cdot 10^{-5}$	ξ (-)	
S (-)	$2.7 \cdot 10^{-5}$		
K_s (m/s)			
S_s (1/m)			

Comments:

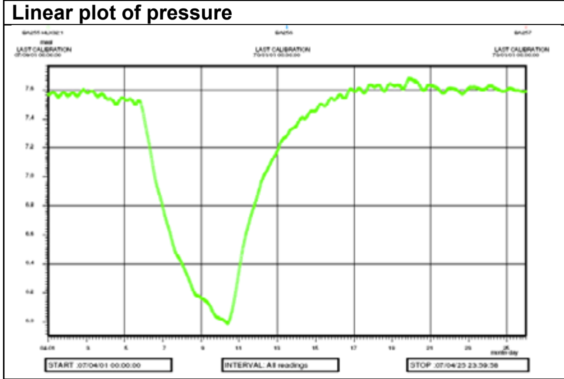
A distinct response is observed in this section from pumping in HLX28. During the flow period a short period of approximate pseudo-radial flow occurred transitioning to pseudo-spherical (leaky) flow. During the recovery period a pseudo-radial flow dominated by the end.

Consistent results of evaluated hydraulic parameter values are obtained from the flow and recovery period respectively. The parameter values estimated from the flow period are selected as the most representative for the test.

Test Summary Sheet – Observation borehole HLX32:1 (pumping borehole HLX28)

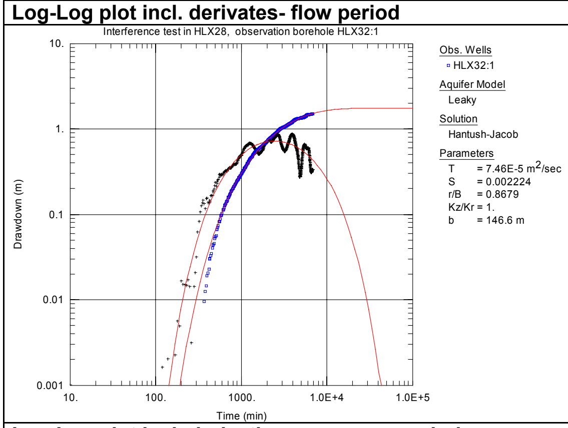
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	HLX32:1	Test start:	2007-04-05 14:52:00
Test section (m):	16.0-162.6	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.140	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot of pressure

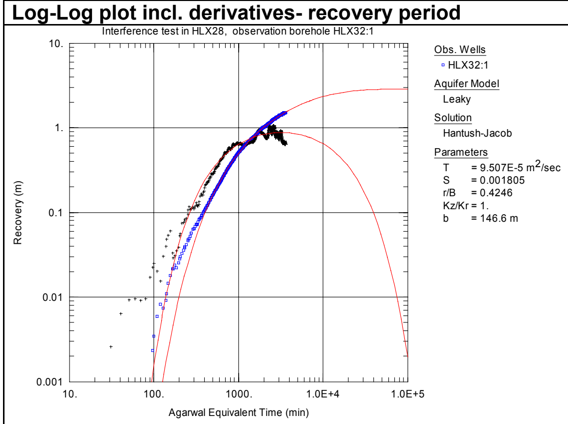


Flow period		**Recovery period**	
Indata		**Indata**	
h_0 (masl)	7.50		
h_i (masl)	7.50		
h_p (masl)	5.99	h_F (masl)	7.50
Q_p (m^3/s)			
t_p (min)	6839	t_F (min)	7491
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	93	r (m)	93
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	(PRF)→PSF	Flow regime:	(PRF)→PSF
dt_1 (min)	2000	dt_1 (min)	2000
dt_2 (min)	4000	dt_2 (min)	4000
T (m^2/s)	$7.5 \cdot 10^{-5}$	T (m^2/s)	$9.5 \cdot 10^{-5}$
S (-)	$2.2 \cdot 10^{-3}$	S (-)	$1.8 \cdot 10^{-3}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.

dt_1 (min)	2000	C (m^3/Pa)	
dt_2 (min)	4000	C_D (-)	
T_T (m^2/s)	$7.5 \cdot 10^{-5}$	ξ (-)	
S (-)	$2.2 \cdot 10^{-3}$		
K_s (m/s)			
S_s (1/m)			

Comments:

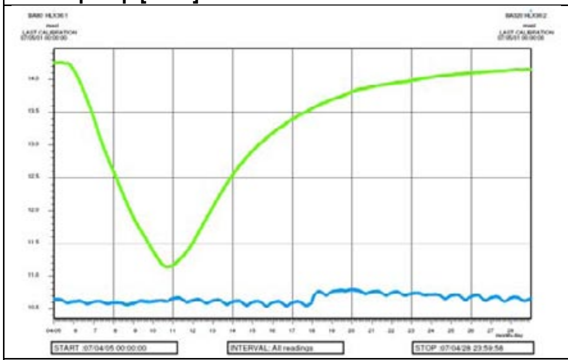
A distinct response is observed in this section from pumping in HLX28. During both the flow and recovery period a short period of approximate pseudo-radial flow occurred transitioning to pseudo-spherical (leaky) flow.

Consistent results of evaluated hydraulic parameter values are obtained from the flow and recovery period respectively. The parameter values estimated from the flow period are selected as the most representative for the test.

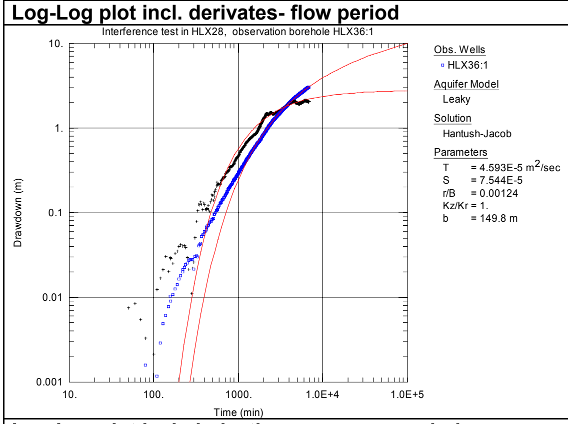
Test Summary Sheet – Observation borehole HLX36:1 (pumping borehole HLX28)

Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	HLX36:1	Test start:	2007-04-05 14:52:00
Test section (m):	50.0-199.8	Responsible for test execution:	SKB field crew
Section diameter, $2\cdot r_w$ (m):	0.140	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

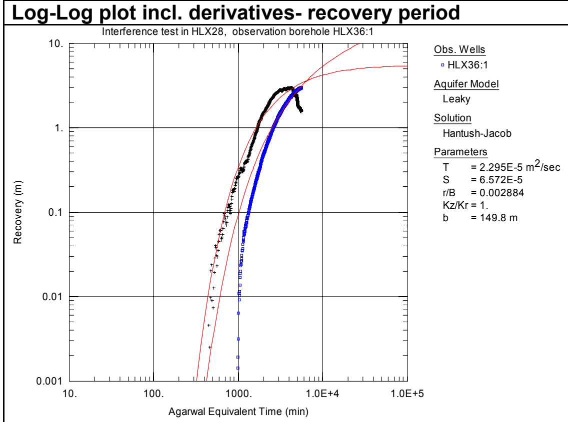
Linear plot p [masl]



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	139.7		
p_p(kPa)	110.0	p_F (kPa)	139.1
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(^oC)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	485	r (m)	485
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	PRF	Flow regime:	PRF->(PSF)
dt_1 (min)	4000	dt_1 (min)	3000
dt_2 (min)	7000	dt_2 (min)	5000
T (m^2/s)	$4.6\cdot10^{-5}$	T (m^2/s)	$2.3\cdot10^{-5}$
S (-)	$7.5\cdot10^{-5}$	S (-)	$6.6\cdot10^{-5}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Selected representative parameters.			
dt_1 (min)	4000	C (m^3/Pa)	
dt_2 (min)	7000	C_D (-)	
T_T (m^2/s)	$4.6\cdot10^{-5}$	ξ (-)	
S (-)	$7.5\cdot10^{-5}$		
K_s (m/s)			
S_s (1/m)			

Comments:

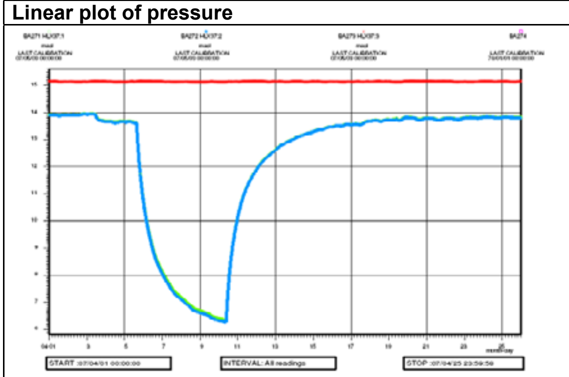
Distinct responses were obtained during the flow and recovery period. The flow period is dominated by pseudo-radial flow. During the recovery period pseudo-radial flow transitioning to slightly leaky flow occurred.

Consistent results of evaluated parameter values are obtained from the flow and recovery period respectively. The parameter values estimated from the flow period are selected as the most representative.

Test Summary Sheet – Observation borehole HLX37:1 (pumping borehole HLX28)

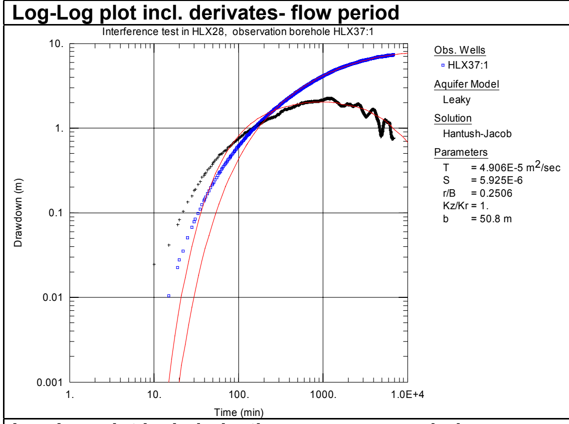
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	HLX37:1	Test start:	2007-04-05 14:52:00
Test section (m):	149.0-199.8	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.139	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot of pressure

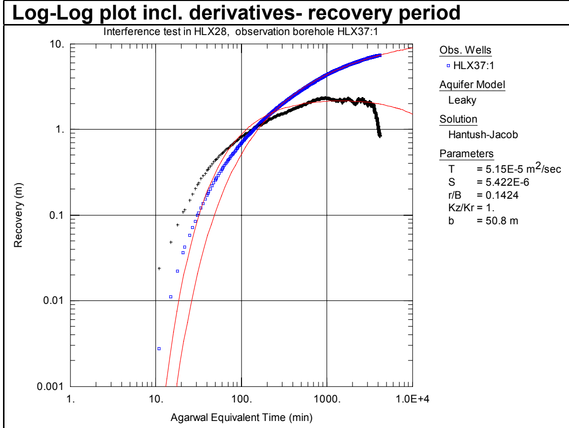


Flow period		Recovery period	
Indata		**Indata**	
h_0 (masl)			
h_i (masl)	13.65		
h_p (masl)	6.34	h_F (masl)	13.65
Q_p (m^3/s)			
t_p (min)	6839	t_F (min)	10591
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	486	r (m)	486
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	(PRF)→PSF	Flow regime:	(PRF)→PSF
dt_1 (min)	500	dt_1 (min)	600
dt_2 (min)	2000	dt_2 (min)	3000
T (m^2/s)	$4.9 \cdot 10^{-5}$	T (m^2/s)	$5.2 \cdot 10^{-5}$
S (-)	$5.9 \cdot 10^{-6}$	S (-)	$5.4 \cdot 10^{-6}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.

dt_1 (min)	500	C (m^3/Pa)	
dt_2 (min)	2000	C_D (-)	
T_T (m^2/s)	$4.9 \cdot 10^{-5}$	ξ (-)	
S (-)	$5.9 \cdot 10^{-6}$		
K_s (m/s)			
S_s (1/m)			

Comments:

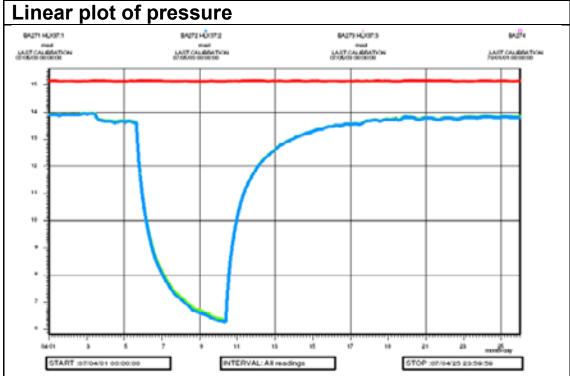
A distinct response is observed in this section from pumping in HLX28. During both the flow and recovery period a short period of approximate pseudo-radial flow occurred transitioning to pseudo-spherical (leaky) flow.

Consistent results of evaluated hydraulic parameter values are obtained from the flow and recovery period respectively. The parameter values estimated from the flow period are selected as the most representative for the test.

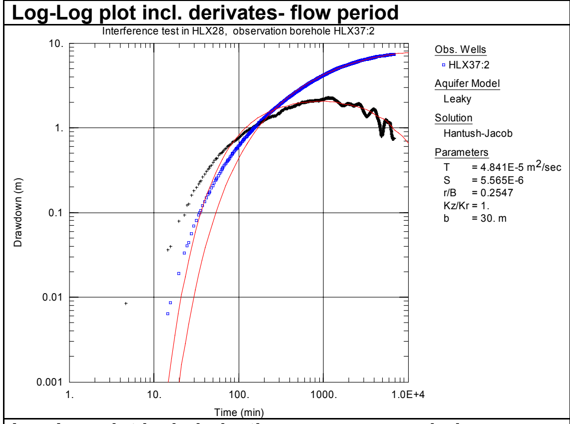
Test Summary Sheet – Observation borehole HLX37:2 (pumping borehole HLX28)

Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	HLX37:2	Test start:	2007-04-05 14:52:00
Test section (m):	118.0-148.0	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.139	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

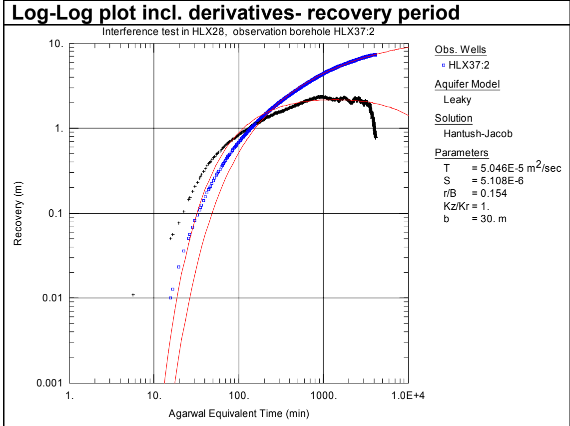
Linear plot of pressure



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		**Recovery period**	
Indata		**Indata**	
h_0 (masl)			
h_i (masl)	13.63		
h_p (masl)	6.26	h_F (masl)	13.63
Q_p (m^3/s)			
t_p (min)	6839	t_F (min)	10566
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	498	r (m)	498
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	(PRF)→PSF	Flow regime:	(PRF)→PSF
dt_1 (min)	500	dt_1 (min)	600
dt_2 (min)	2000	dt_2 (min)	3000
T (m^2/s)	$4.8 \cdot 10^{-5}$	T (m^2/s)	$5.0 \cdot 10^{-5}$
S (-)	$5.6 \cdot 10^{-6}$	S (-)	$5.1 \cdot 10^{-6}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Selected representative parameters.

dt_1 (min)	500	C (m^3/Pa)	
dt_2 (min)	2000	C_D (-)	
T_T (m^2/s)	$4.8 \cdot 10^{-5}$	ξ (-)	
S (-)	$5.6 \cdot 10^{-6}$		
K_s (m/s)			
S_s (1/m)			

Comments:

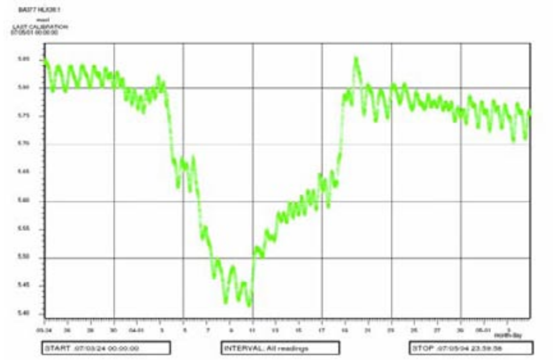
A distinct response is observed in this section from pumping in HLX28. During both the flow and recovery period a short period of approximate pseudo-radial flow occurred transitioning to pseudo-spherical (leaky) flow.

Consistent results of evaluated hydraulic parameter values are obtained from the flow and recovery period respectively. The parameter values estimated from the flow period are selected as the most representative for the test.

Test Summary Sheet – Observation borehole HLX38 (pumping borehole HLX28)

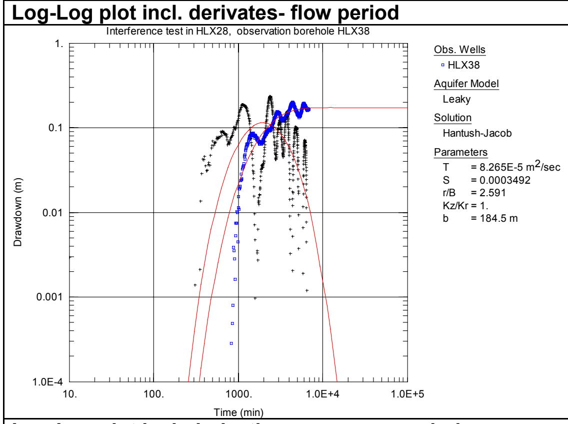
Project:	PLU	Test type:	2
Area:	Oskarshamn	Test no:	1
Borehole ID:	HLX38	Test start:	2007-04-05 14:52:00
Test section (m):	15.0-199.5	Responsible for test execution:	SKB field crew
Section diameter, $2 \cdot r_w$ (m):	0.139	Responsible for test evaluation:	GEOSIGMA AB Jan-Erik Ludvigson

Linear plot p [masl]

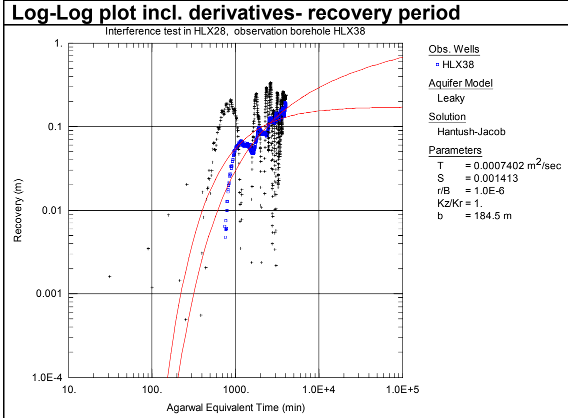


Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	55.1		
p_p(kPa)	53.5	p_F (kPa)	55.2
Q_p (m^3/s)			
t_p (min)		t_F (min)	
S^* (-)		S^* (-)	
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.2	Derivative fact.	0.2
r (m)	381	r (m)	381
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	PSF	Flow regime:	Transition
dt_1 (min)		dt_1 (min)	
dt_2 (min)		dt_2 (min)	
T (m^2/s)	$8.3 \cdot 10^{-5}$	T (m^2/s)	$7.4 \cdot 10^{-4}$
S (-)	$3.5 \cdot 10^{-4}$	S (-)	$1.4 \cdot 10^{-3}$
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)		C (m^3/Pa)	
C_D (-)		C_D (-)	
ξ (-)		ξ (-)	
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.			
dt_1 (min)		C (m^3/Pa)	
dt_2 (min)		C_D (-)	
T_T (m^2/s)	$8.3 \cdot 10^{-5}$	ξ (-)	
S (-)	$3.5 \cdot 10^{-4}$		
K_s (m/s)			
S_s (1/m)			

Comments:

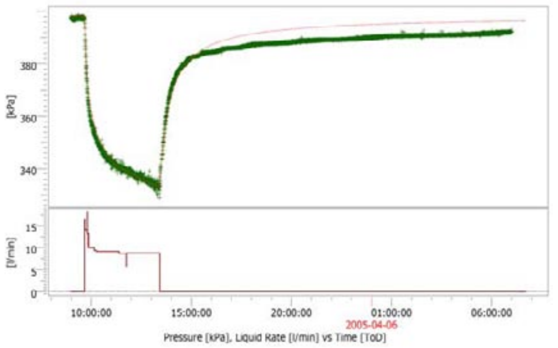
A small but consistent response was obtained during both the flow and recovery period in this observation section. During the flow period a transition to pseudo-spherical (leaky) flow occurred. During the recovery period a transition to possible pseudo-radial flow occurred. However, the response during the latter period is considered as uncertain due to natural pressure fluctuations.

The parameter values estimated from the flow period are selected as representative. The transient evaluation of the recovery period is considered as very uncertain.

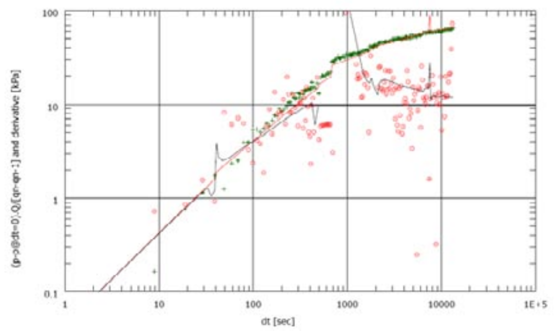
Test Summary Sheet – Pumping borehole HLX32

Project:	PLU	Test type:	1B
Area:	Oskarshamn	Test no:	1
Borehole ID:	HLX32	Test start:	2005-04-05 10:40:00
Test section (m):	12.3-162.6	Responsible for test execution:	SKB field crew
Section diameter, $2\cdot r_w$ (m):	0.140	Responsible for test evaluation:	SKB Mansueto Morosini

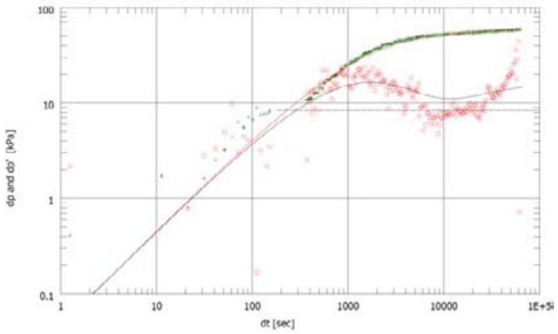
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (masl)			
p_i (masl)	40.6		
p_p(masl)	34.2	p_F (masl)	
Q_p (m^3/s)	$1.5\cdot10^{-4}$		
t_p (min)	225	t_F (min)	
S^* (-)	$1.5\cdot10^{-4}$	S^* (-)	$1.5\cdot10^{-4}$
EC_w (mS/m)			
Te_w(°C)			
Derivative fact.	0.1	Derivative fact.	0.1
r (m)	0.07	r (m)	0.07
Results		**Results**	
Q/s (m^2/s)			
T_M (m^2/s)			
Flow regime:	WBS-> IARF	Flow regime:	WBS->IARF->no flow boundary
dt_1 (min)		dt_1 (min)	
dt_2 (min)		dt_2 (min)	
T (m^2/s)	$1.13\cdot10^{-5}$	T (m^2/s)	$1.33\cdot10^{-5}$
S (-)		S (-)	
K_s (m/s)		K_s (m/s)	
S_s (1/m)		S_s (1/m)	
C (m^3/Pa)	$2.65\cdot10^{-6}$	C (m^3/Pa)	$3.06\cdot10^{-6}$
C_D (-)		C_D (-)	
ξ (-)	-4.3	ξ (-)	-4.0
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Selected representative parameters.

dt_1 (min)		C (m^3/Pa)	$3.07\cdot10^{-6}$
dt_2 (min)		C_D (-)	
T_T (m^2/s)	$1.33\cdot10^{-5}$	ξ (-)	-4.3
S* (-)			
K_s (m/s)			
S_s (1/m)			

Comments:

Consitent flow regimes and transmissivities were obtained for drawdown and recovery phase. WBS and IARF but recovery also show a no flow boundary further away.

Appendix 2

Response diagrams

Nomenclature in AQTESOLV:

T = transmissivity (m^2/s)
S = storativity (-)
K_Z/K_r = ratio of hydraulic conductivities in the vertical and radial direction (set to 1)
S_w = skin factor
r(w) = borehole radius (m)
r(c) = effective casing radius (m)
b = aquifer thickness
r/B=leakage factor (-)

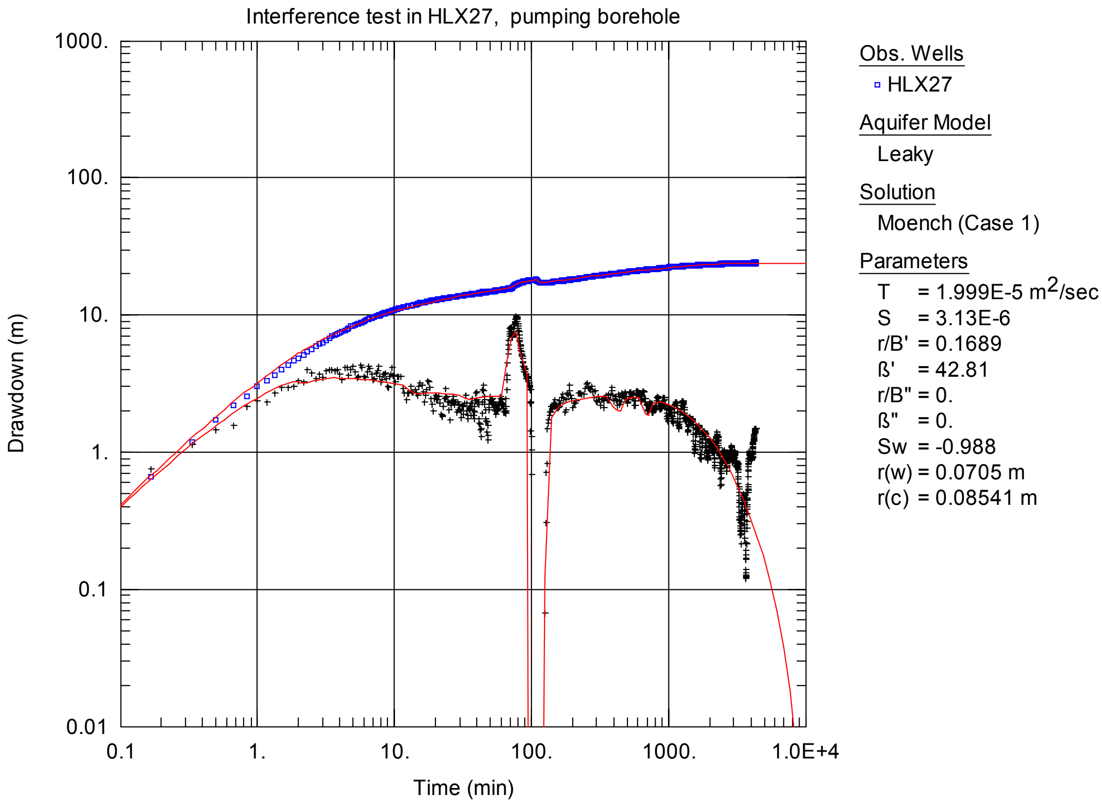


Figure 1. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with corresponding simulated curves (red) in the pumping borehole HLX27 (2007).*

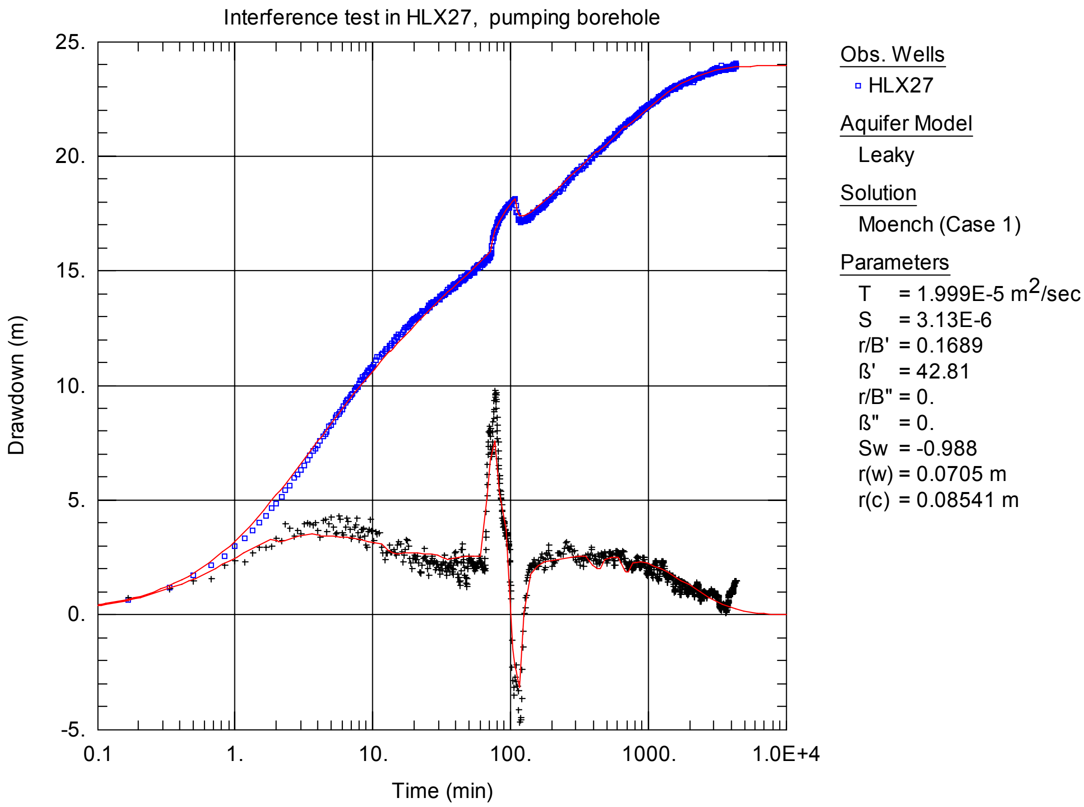


Figure 2. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with corresponding simulated curves (red) in the pumping borehole HLX27 (2007).*

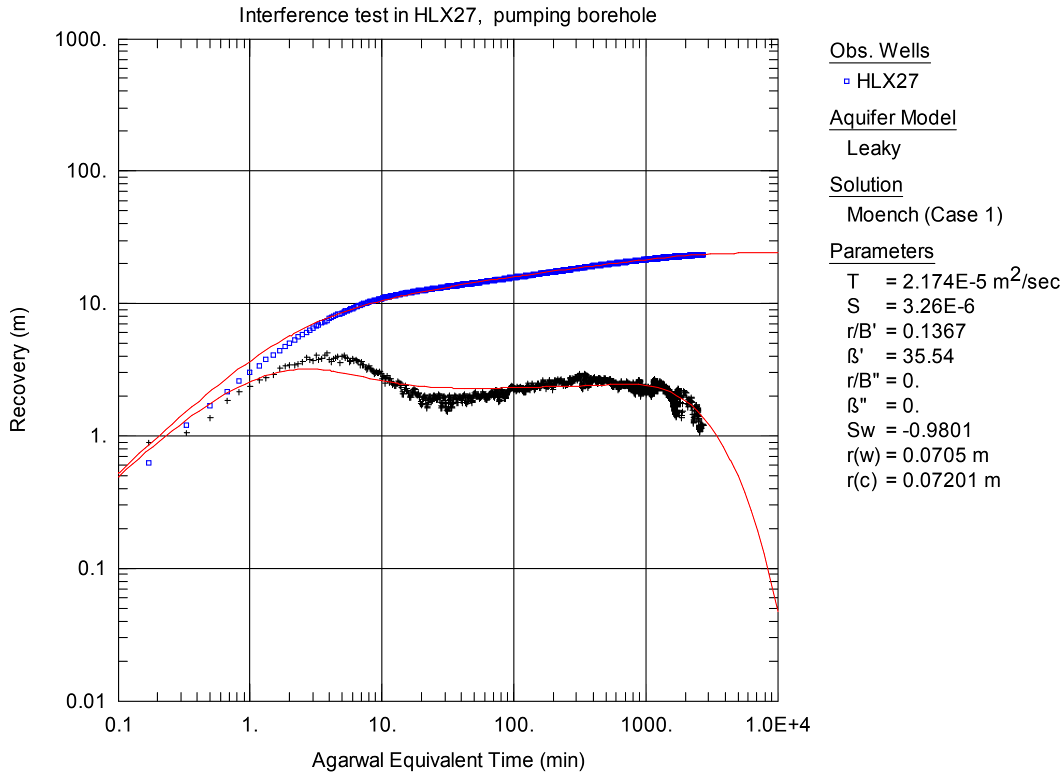


Figure 3. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) together with corresponding simulated curves (red) in the pumping borehole HLX27 (2007).*

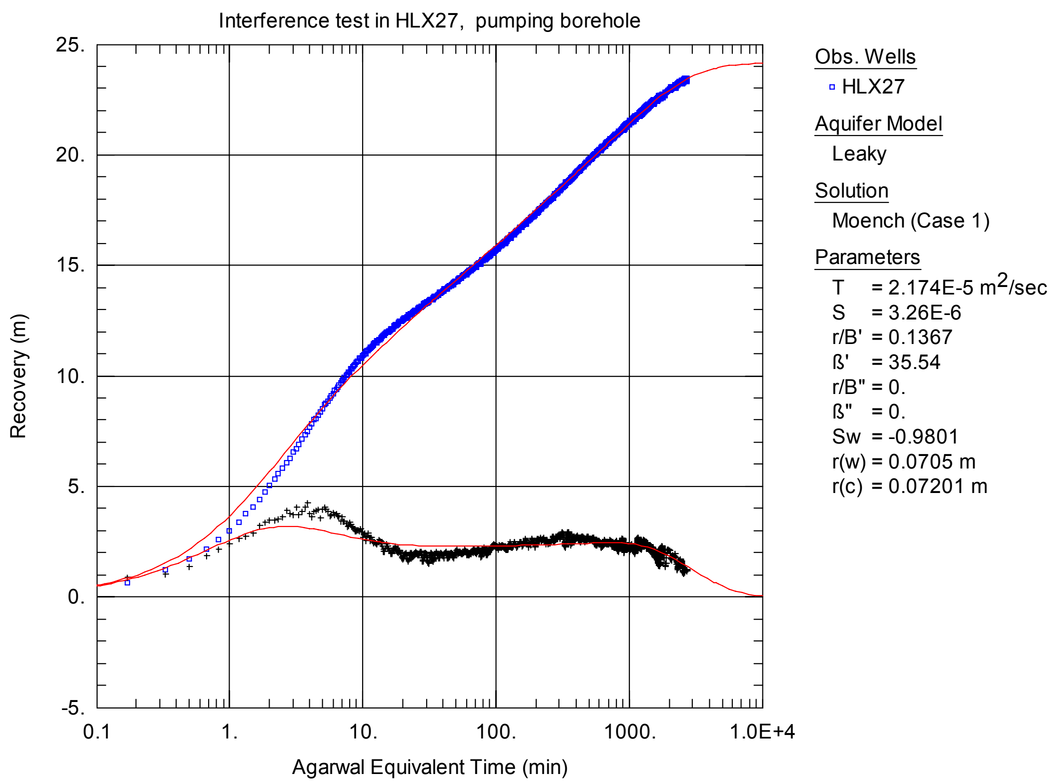


Figure 4. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) together with corresponding simulated curves (red) in the pumping borehole HLX27 (2007).*

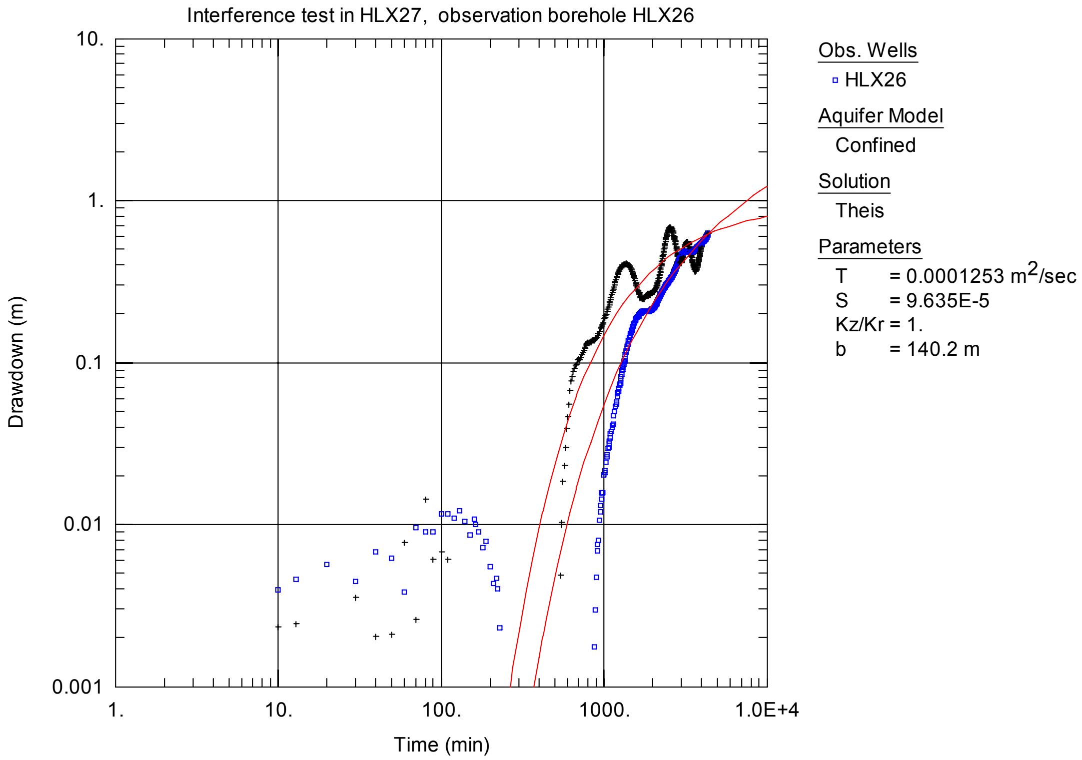


Figure 5. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX26 during pumping in borehole HLX27 (2007).*

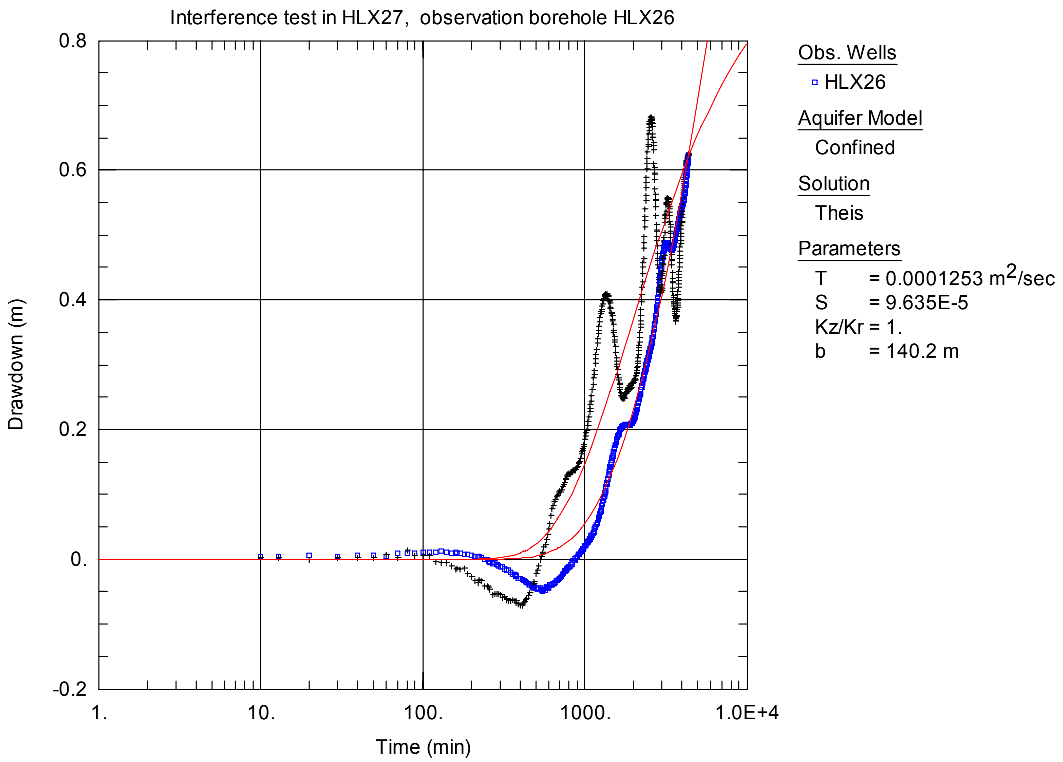


Figure 6. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX26 during pumping in borehole HLX27 (2007).*

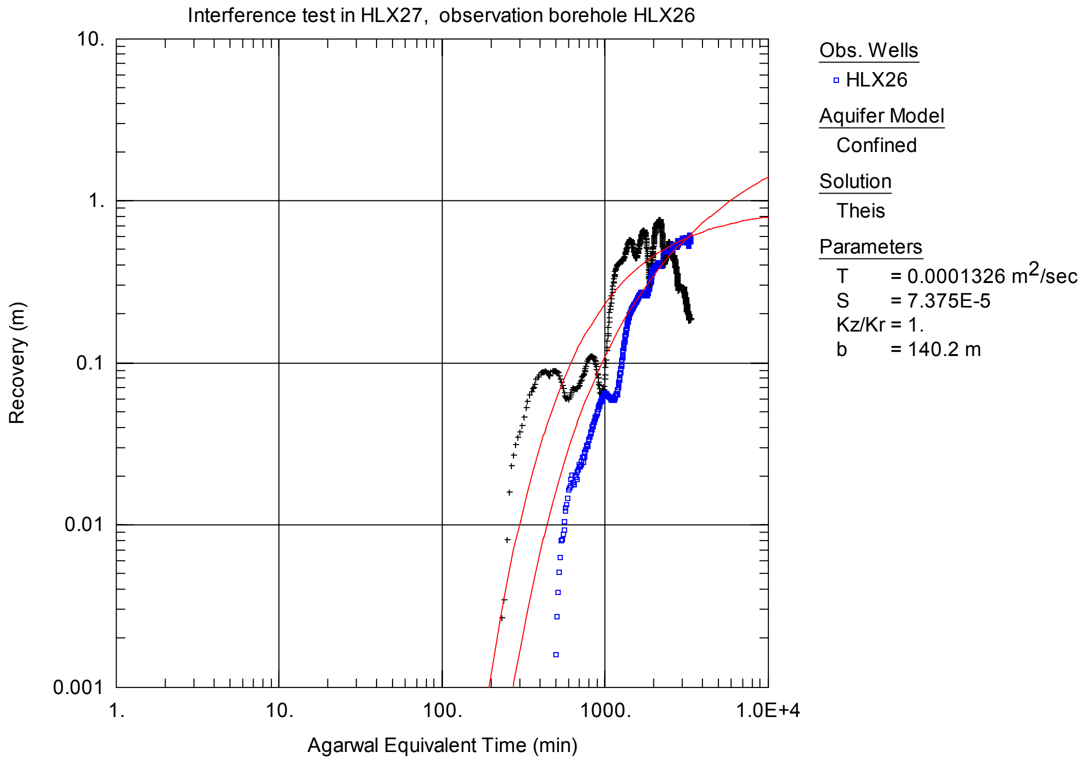


Figure 7. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX26 during pumping in borehole HLX27 (2007).*

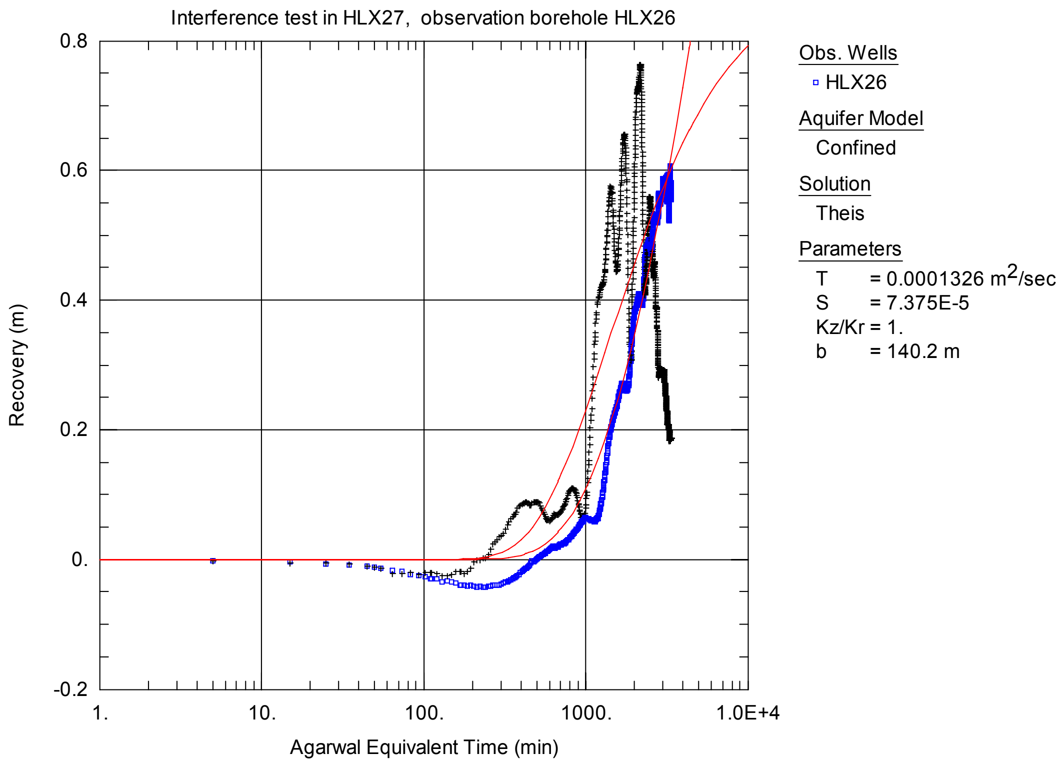


Figure 8. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX26 during pumping in borehole HLX27 (2007).*

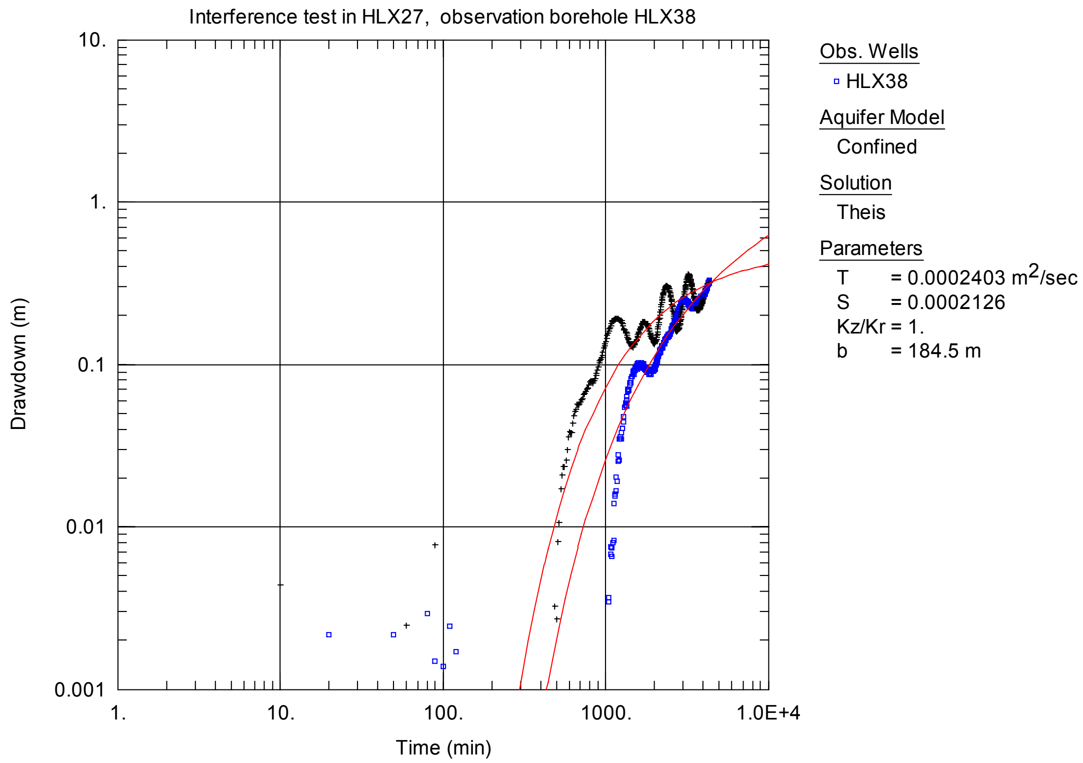


Figure 9. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX38 during pumping in borehole HLX27 (2007).*

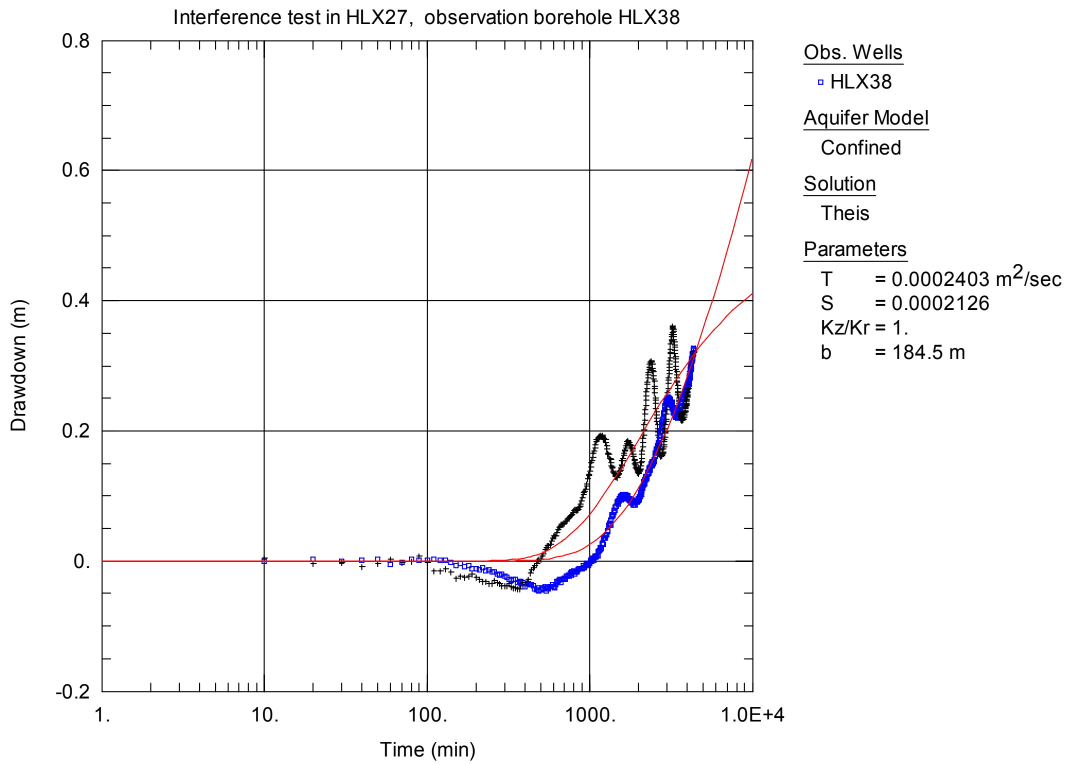


Figure 10. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX38 during pumping in borehole HLX27 (2007).*

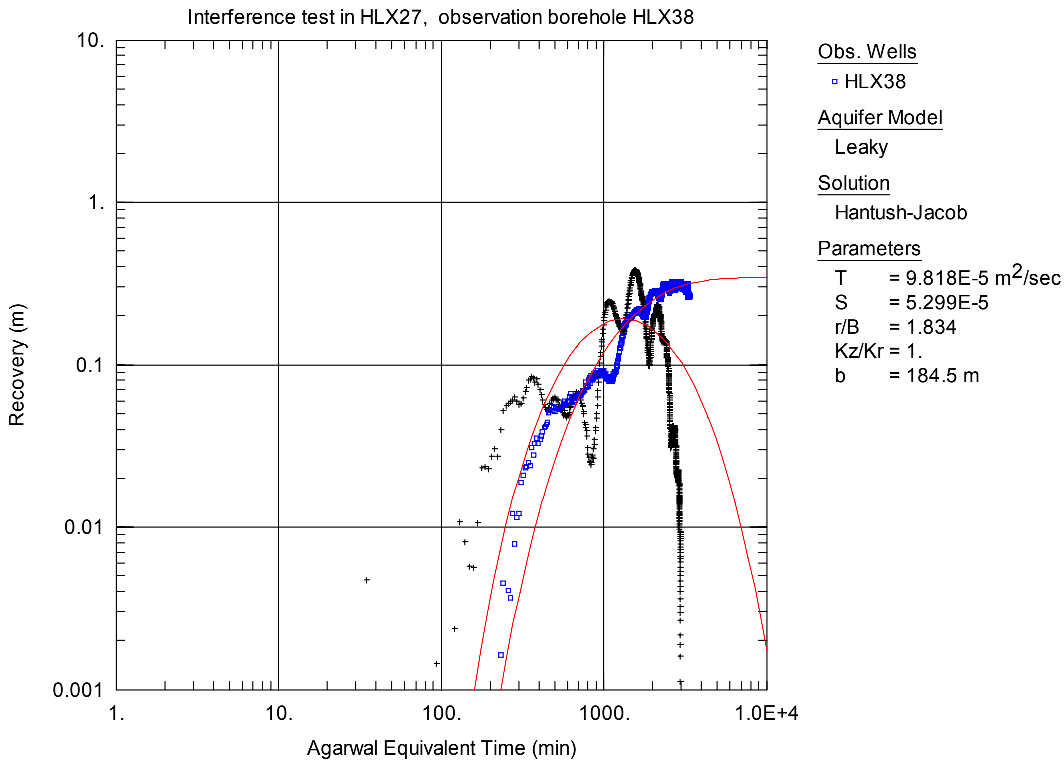


Figure 11. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX38 during pumping in borehole HLX27 (2007).*

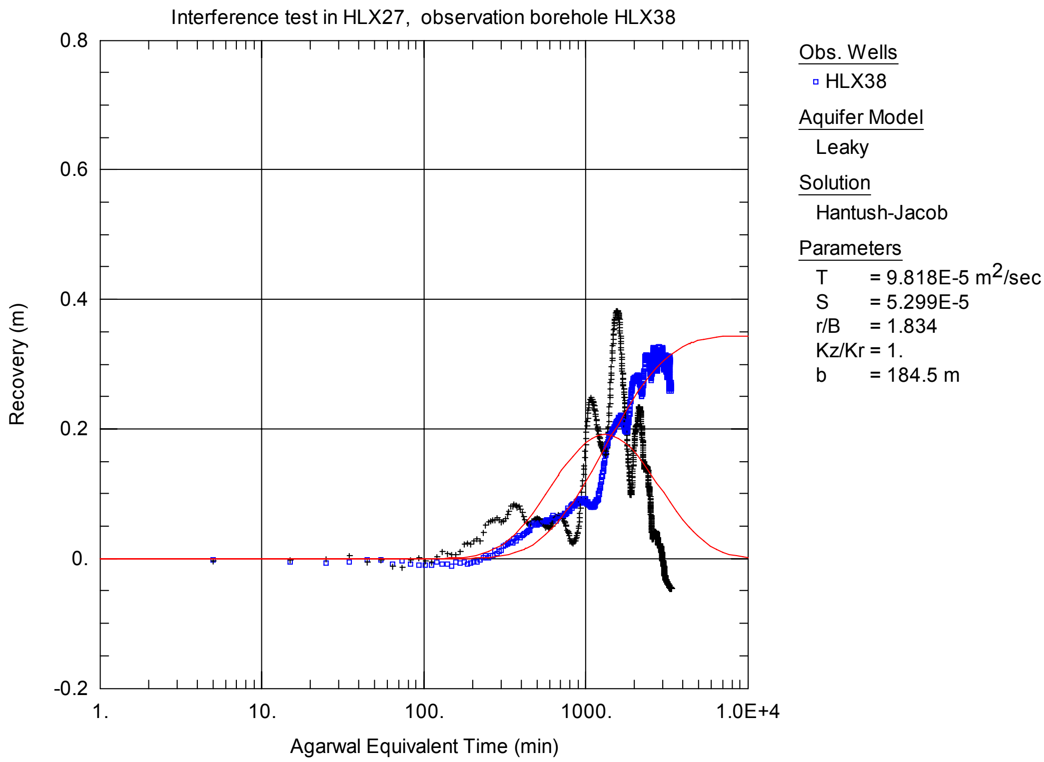


Figure 12. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX38 during pumping in borehole HLX27 (2007).*

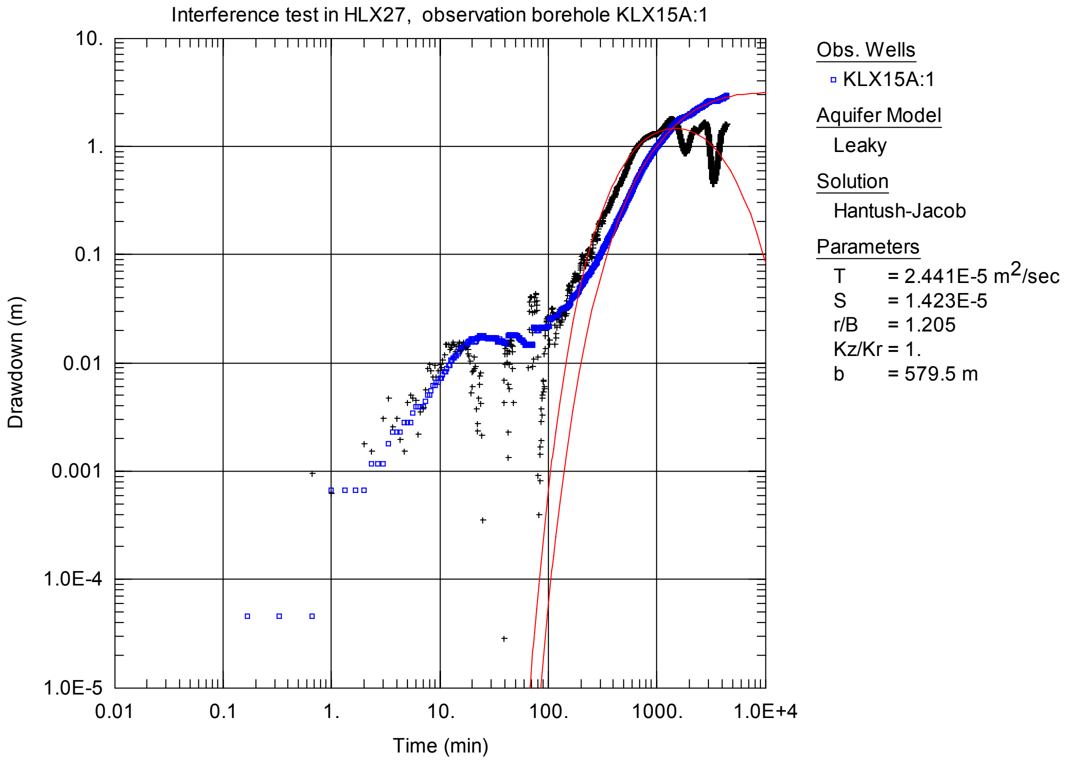


Figure 13. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX15A:1 during pumping in borehole HLX27 (2007).*

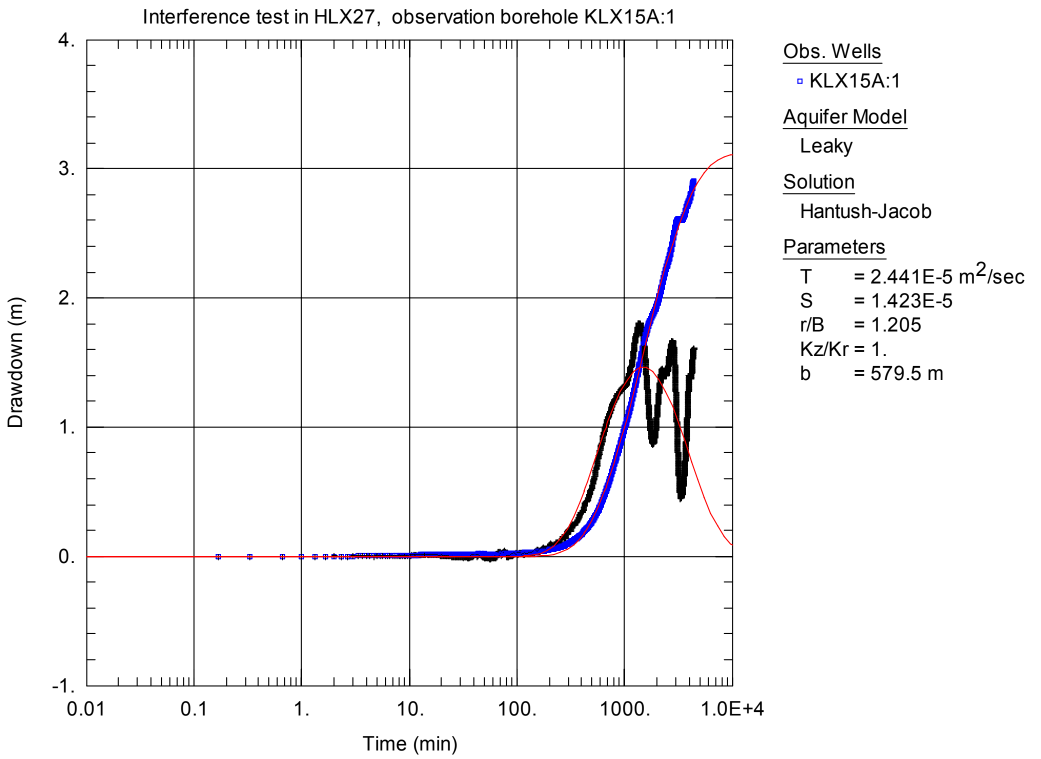


Figure 14. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX15A:1 during pumping in borehole HLX27 (2007).*

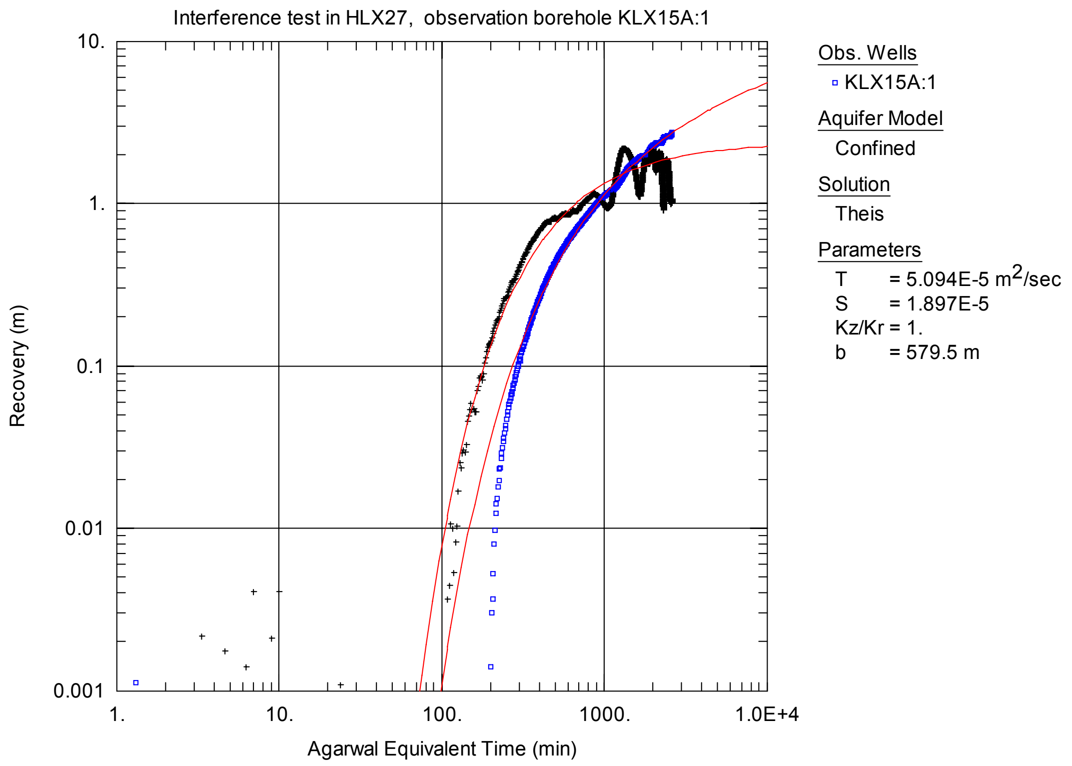


Figure 15. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX15A:1 during pumping in borehole HLX27 (2007).*

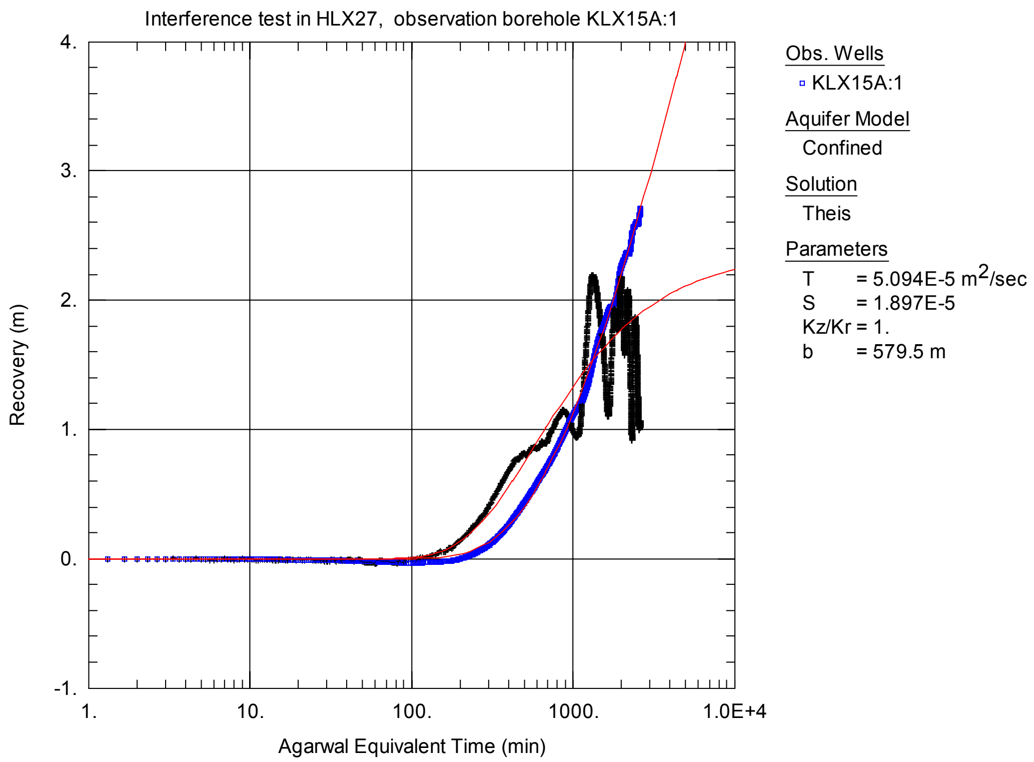


Figure 16. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX15A:1 during pumping in borehole HLX27 (2007).*

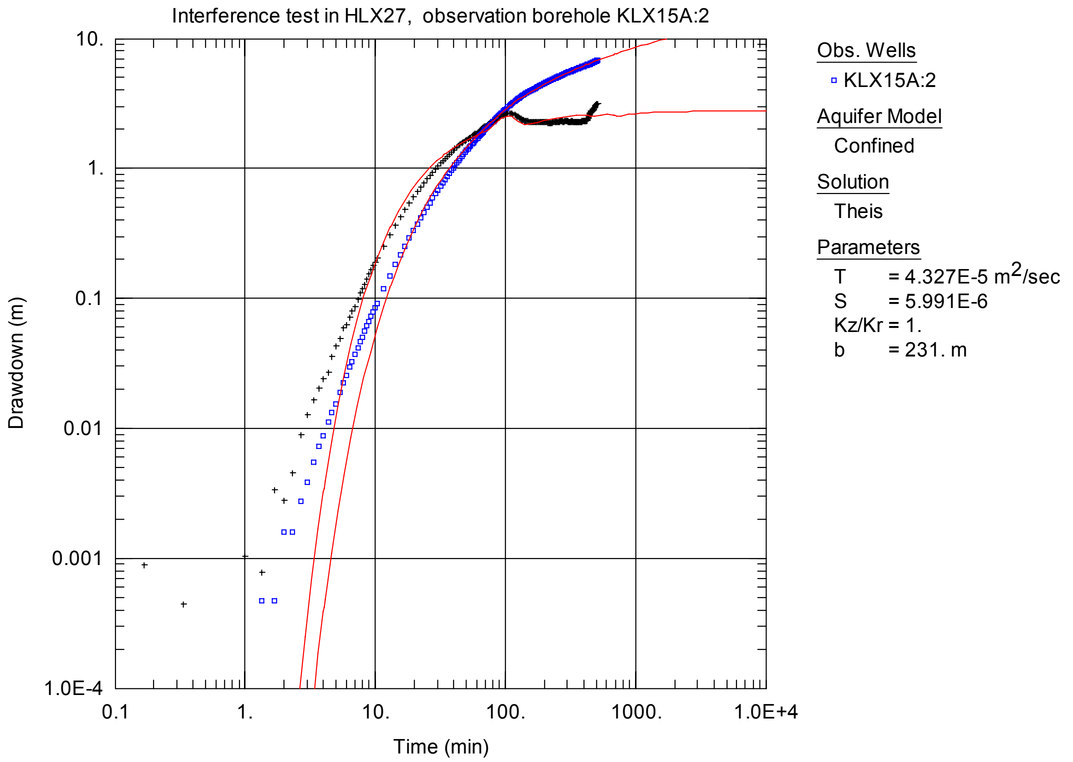


Figure 17. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX15A:2 during pumping in borehole HLX27 (2007).*

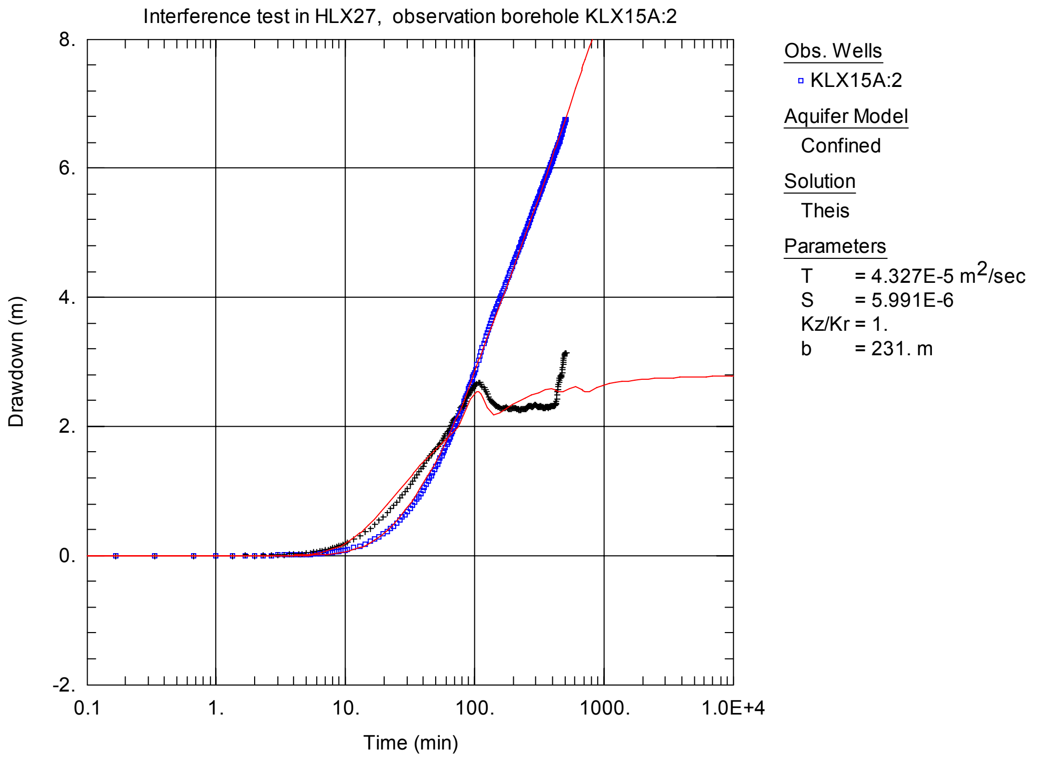


Figure 18. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX15A:2 during pumping in borehole HLX27 (2007).*

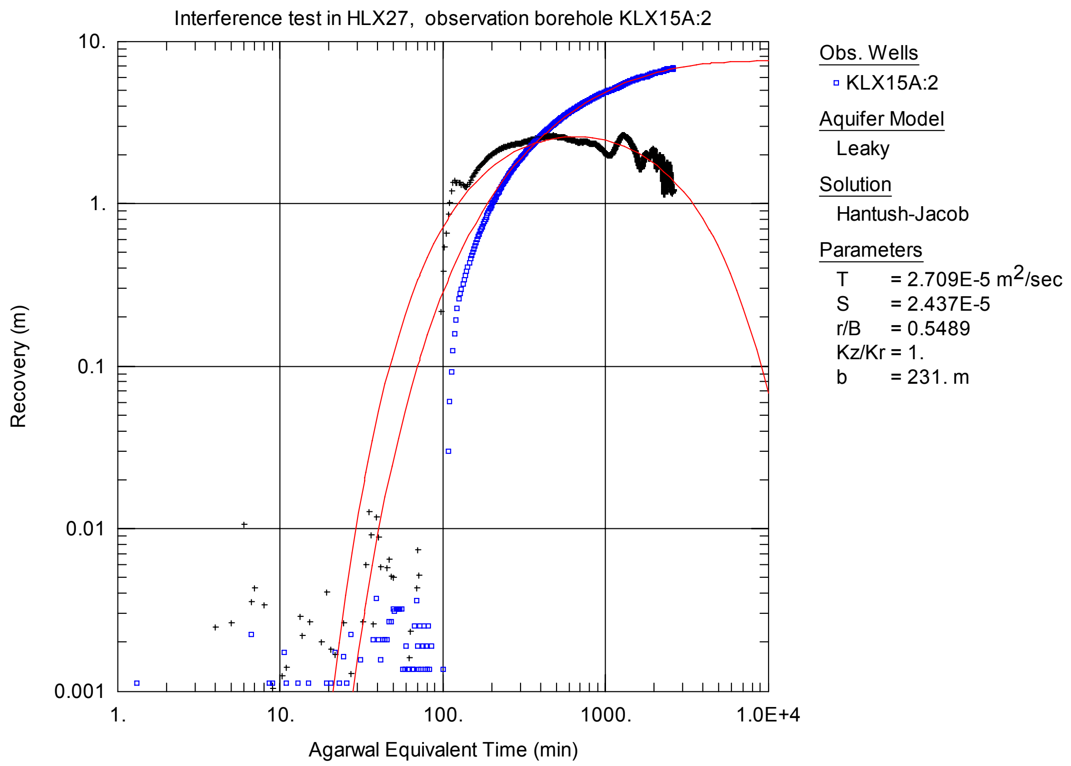


Figure 19. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX15A:2 during pumping in borehole HLX27 (2007).*

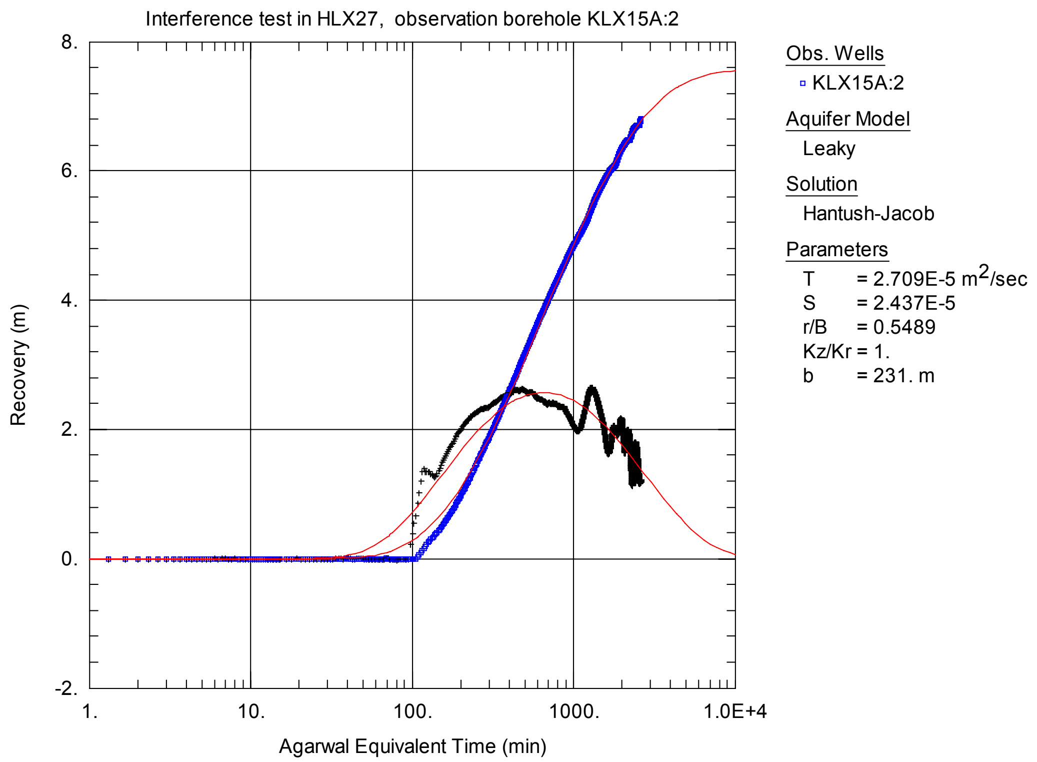


Figure 20. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX15A:2 during pumping in borehole HLX27 (2007).*

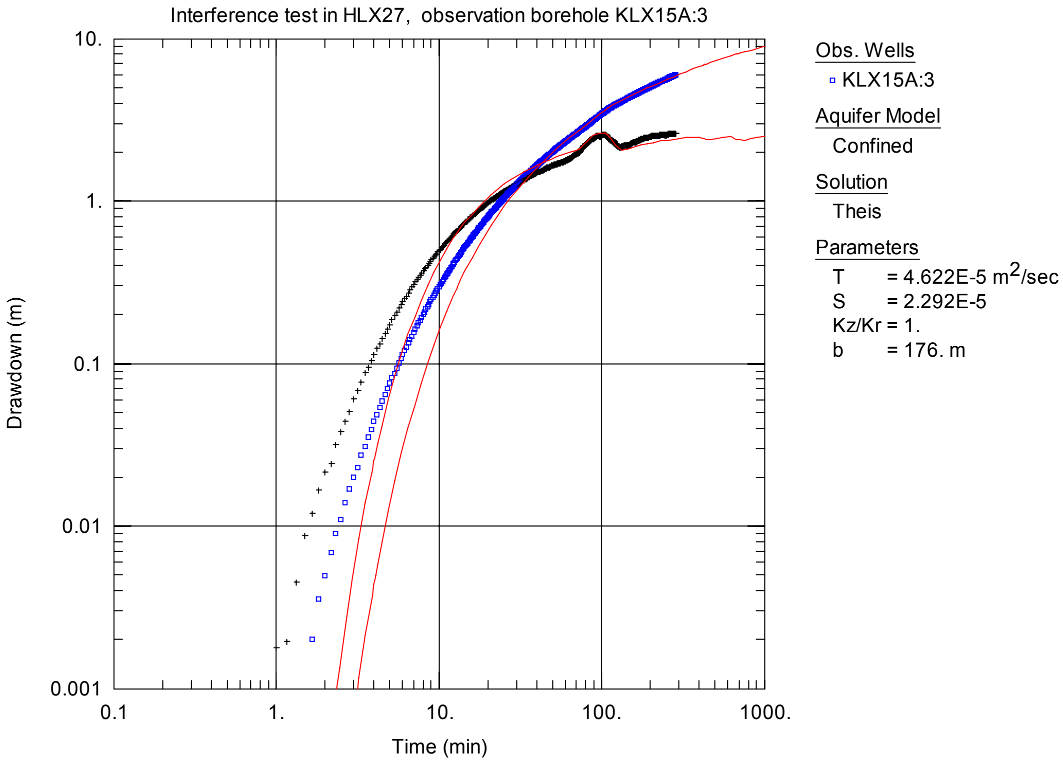


***Figure 21.** Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX15A:3 during pumping in borehole HLX27 (2007).*

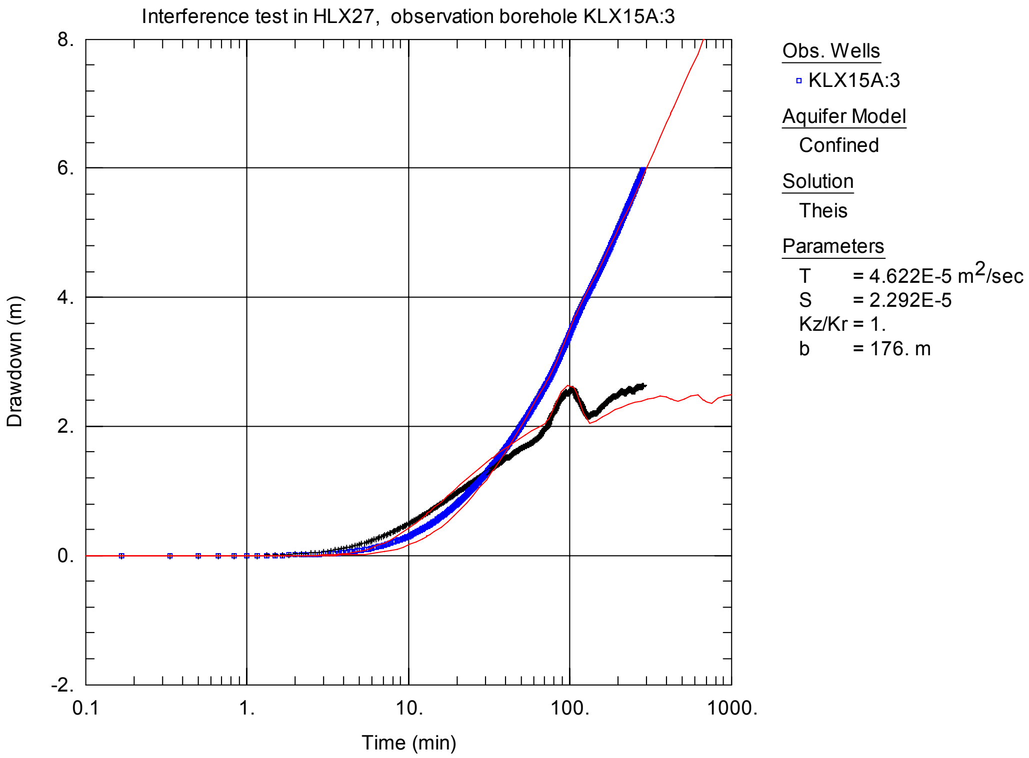


***Figure 22.** Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX15A:3 during pumping in borehole HLX27 (2007).*

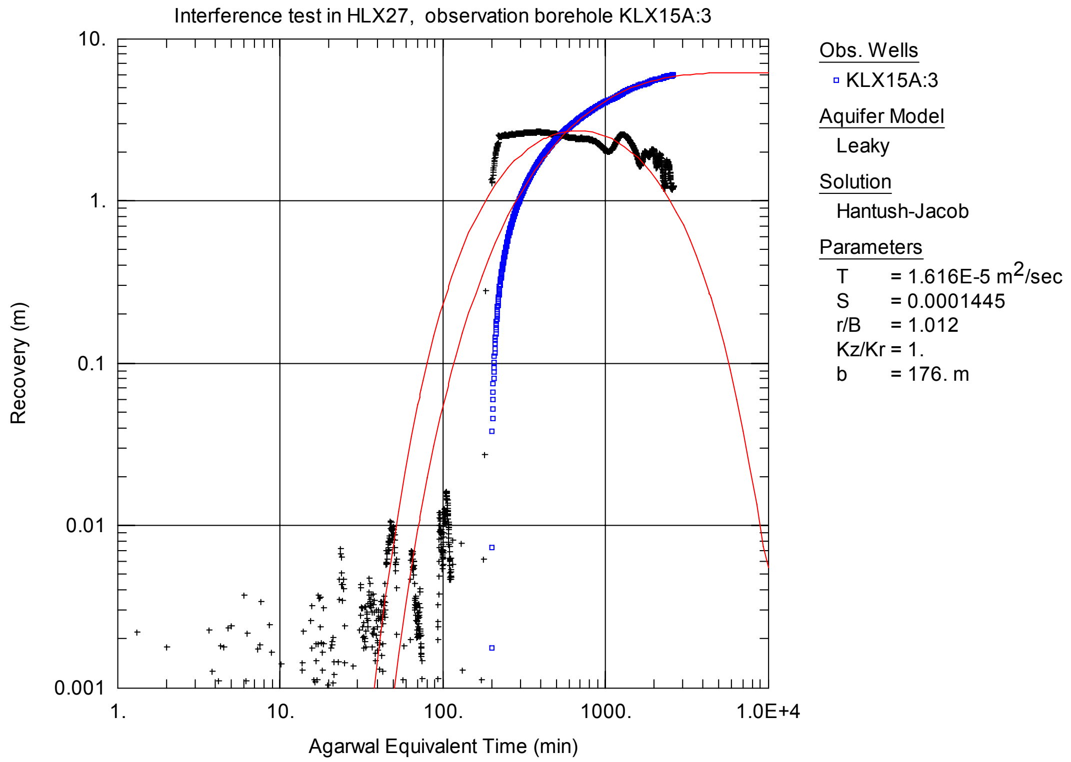


Figure 23. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX15A:3 during pumping in borehole HLX27 (2007).*

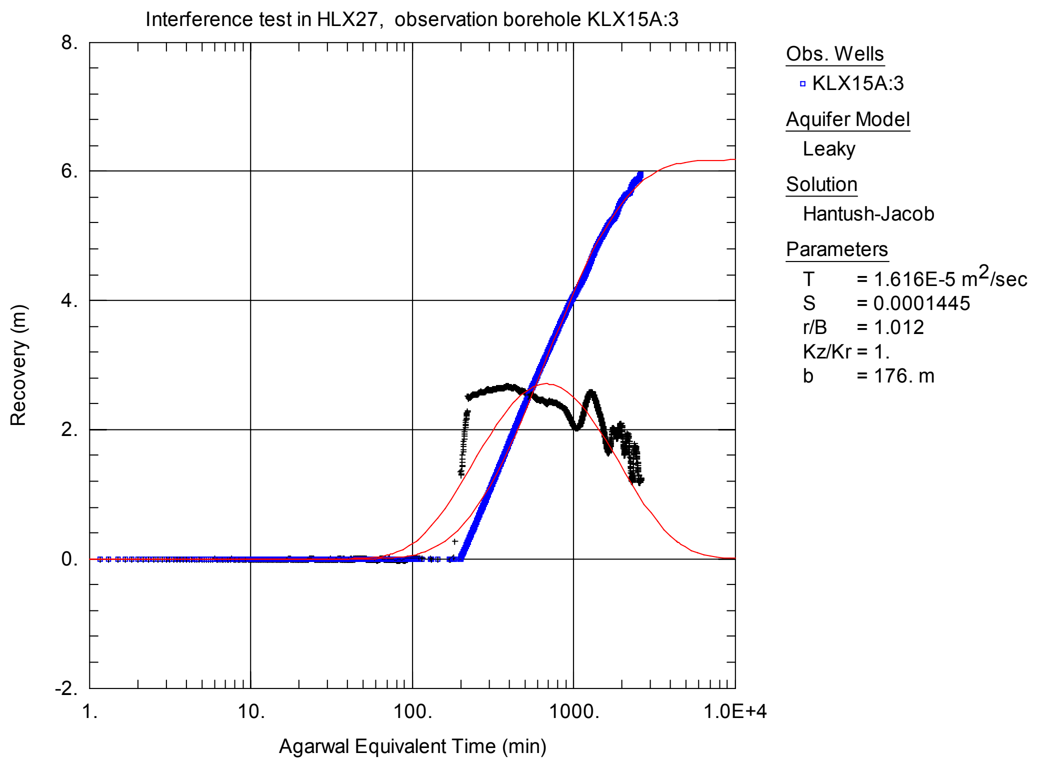


Figure 24. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX15A:3 during pumping in borehole HLX27 (2007).*

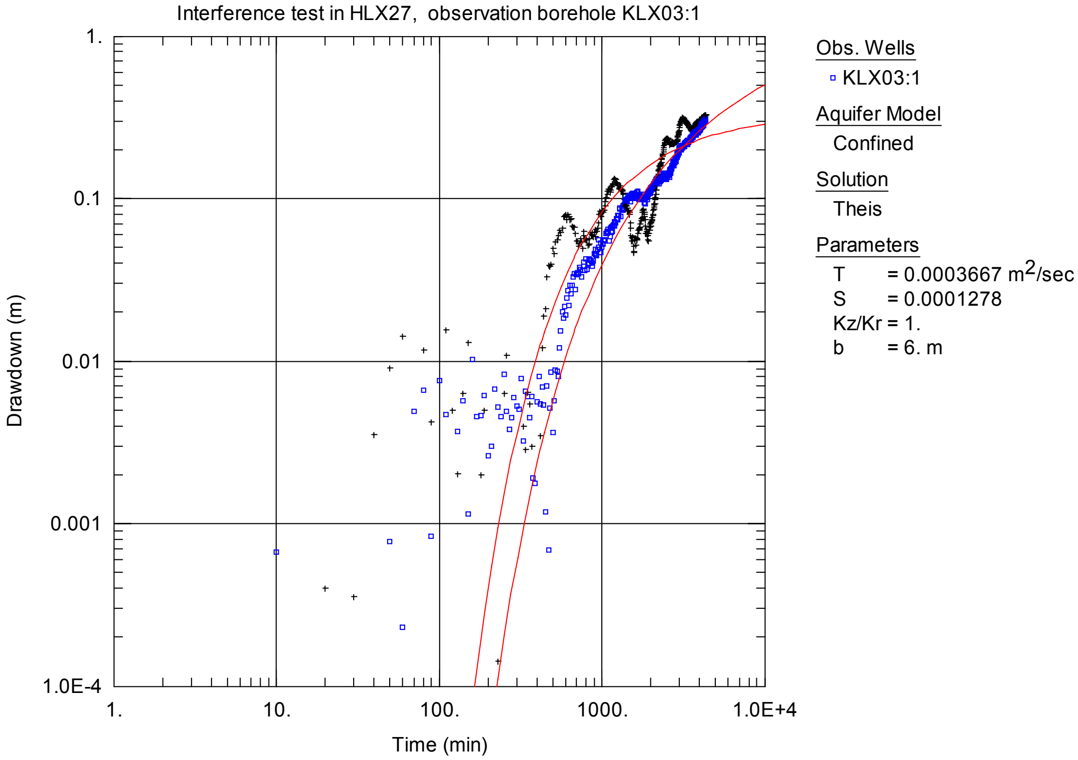


Figure 25. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:1 during pumping in borehole HLX27 (2007).*

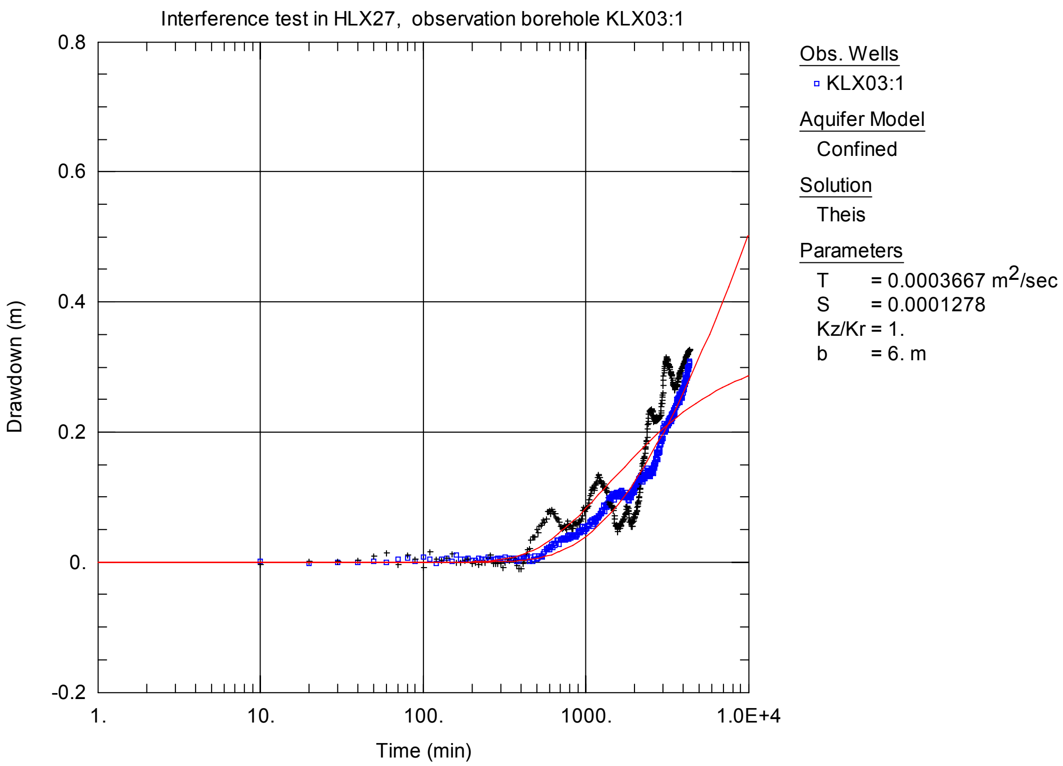


Figure 26. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:1 during pumping in borehole HLX27 (2007).*

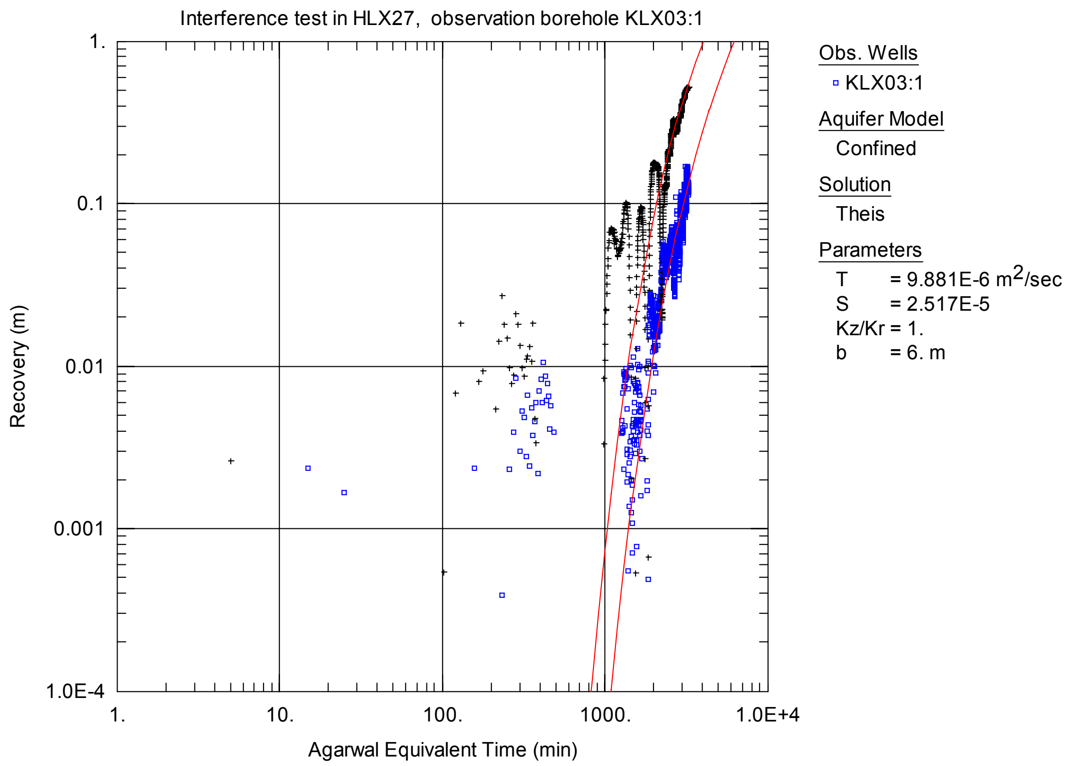


Figure 27. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:1 during pumping in borehole HLX27 (2007).*

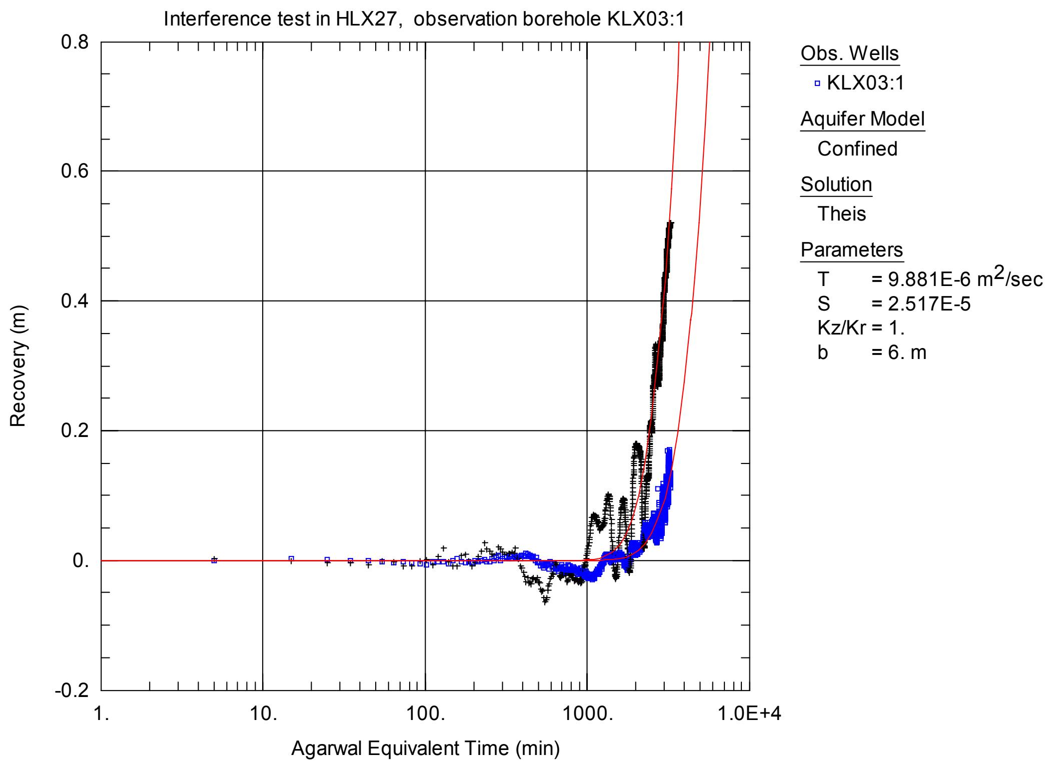


Figure 28. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:1 during pumping in borehole HLX27 (2007).*

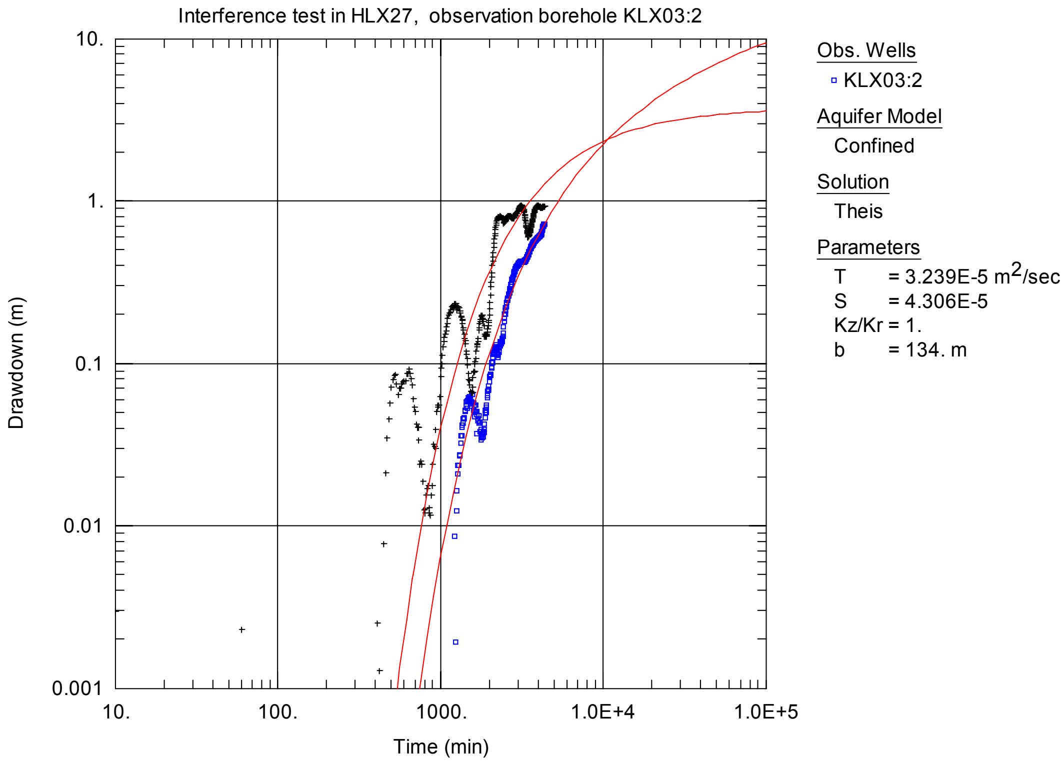


Figure 29. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:2 during pumping in borehole HLX27 (2007).*

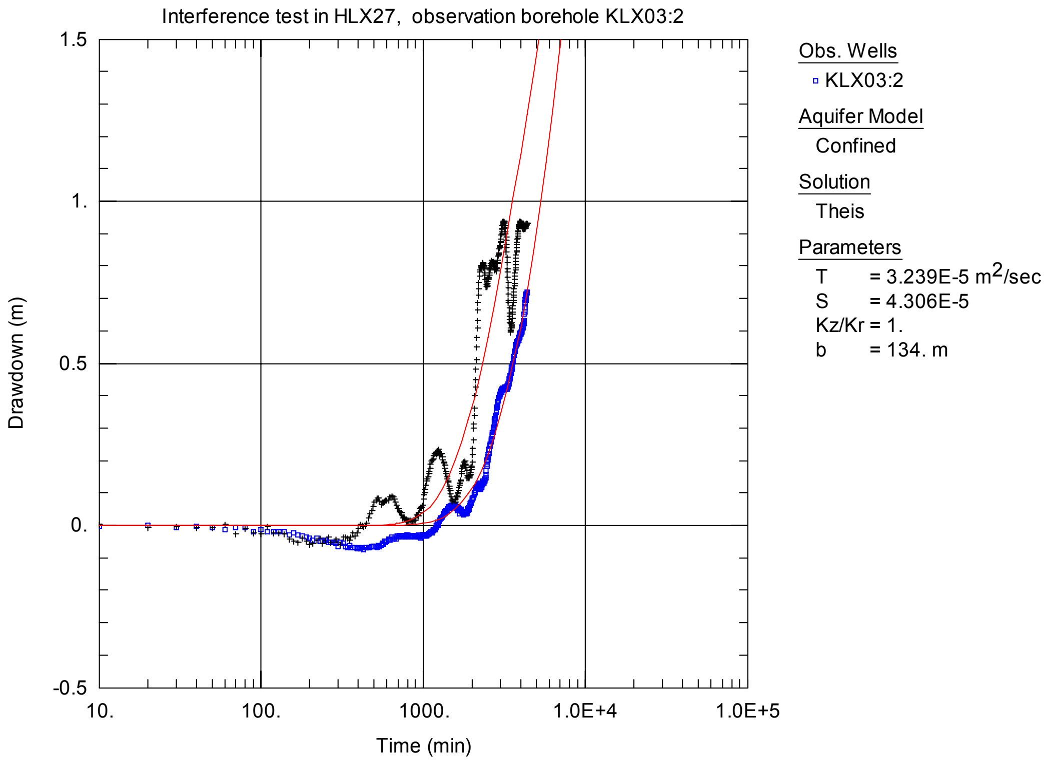


Figure 30. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:2 during pumping in borehole HLX27 (2007).*

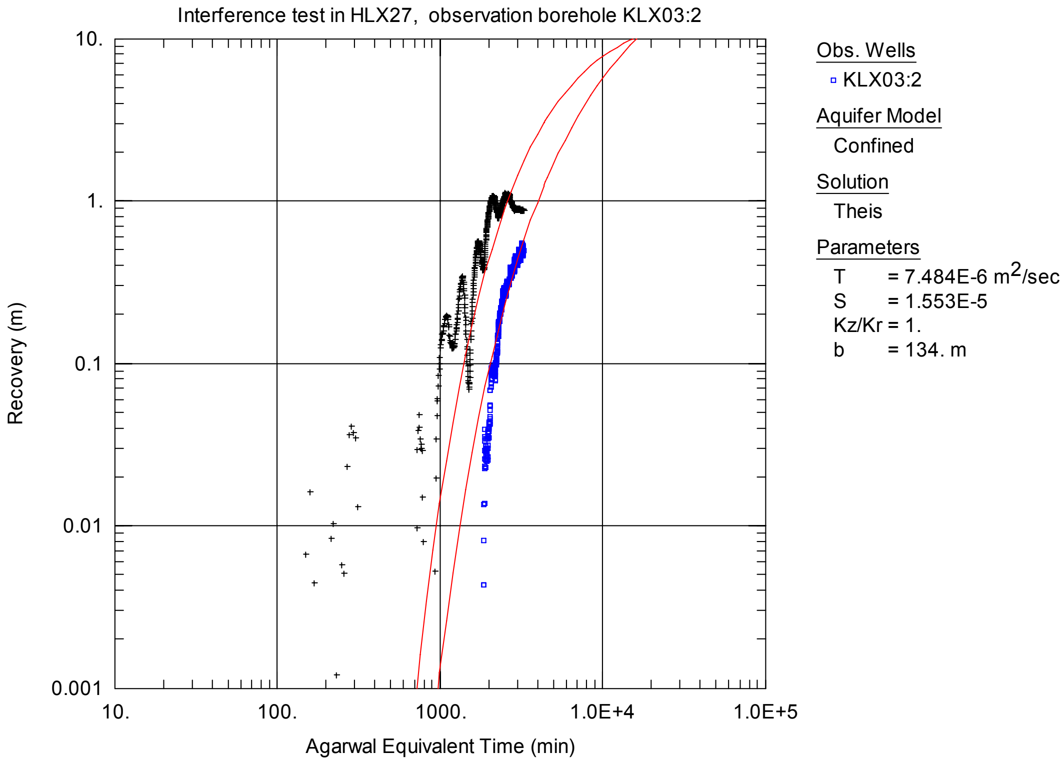


Figure 31. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:2 during pumping in borehole HLX27 (2007).*

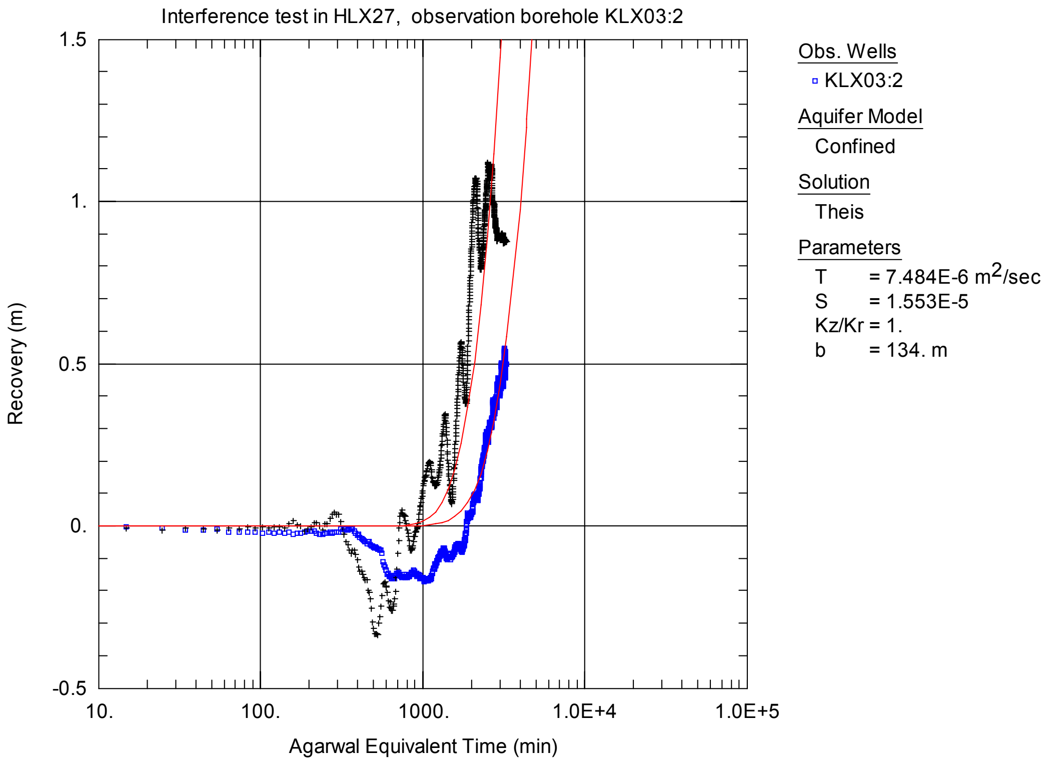


Figure 32. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:2 during pumping in borehole HLX27 (2007).*

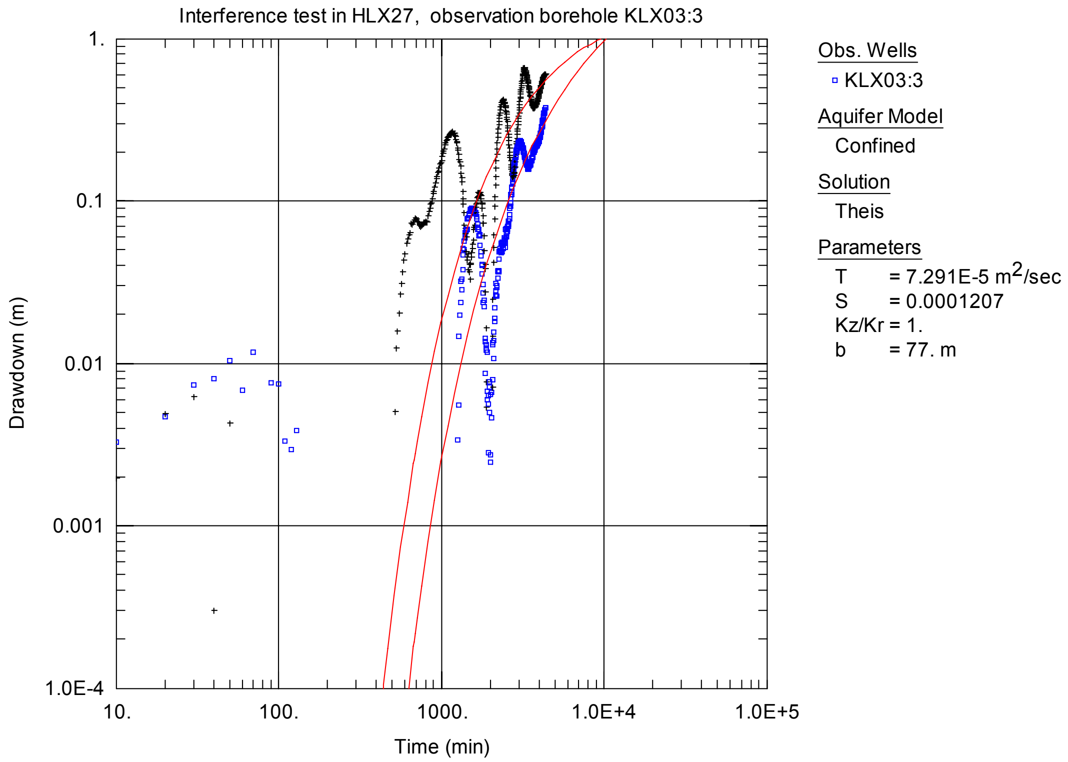


***Figure 33.** Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:3 during pumping in borehole HLX27 (2007).*

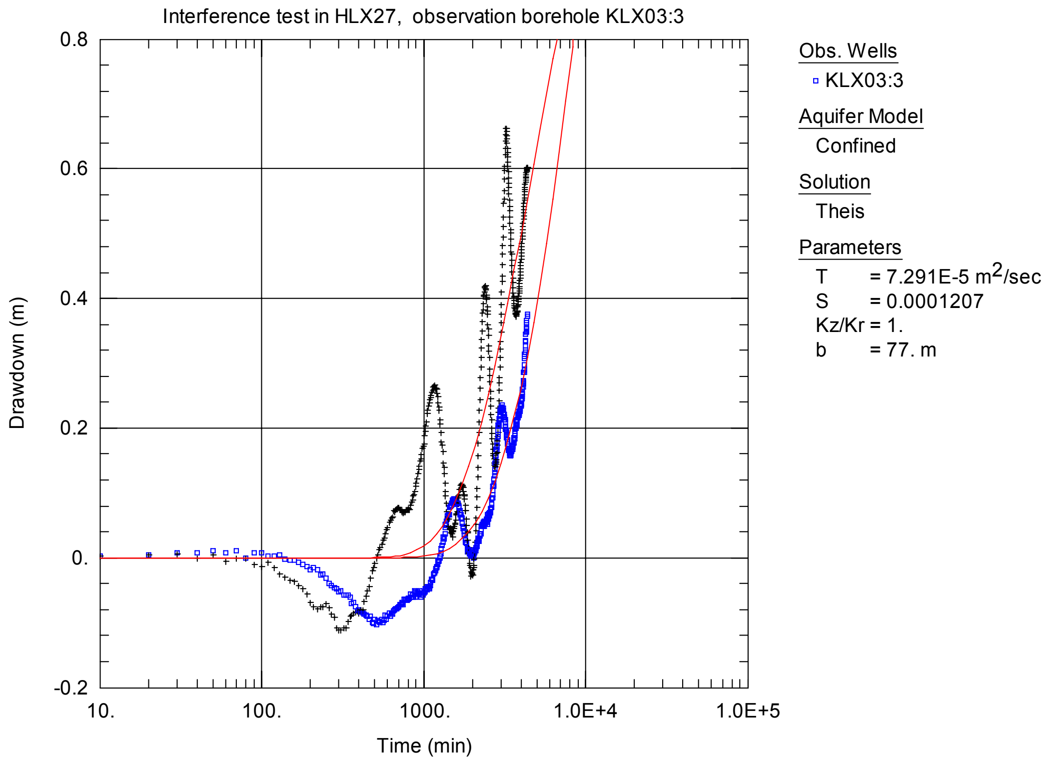


***Figure 34.** Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:3 during pumping in borehole HLX27 (2007).*

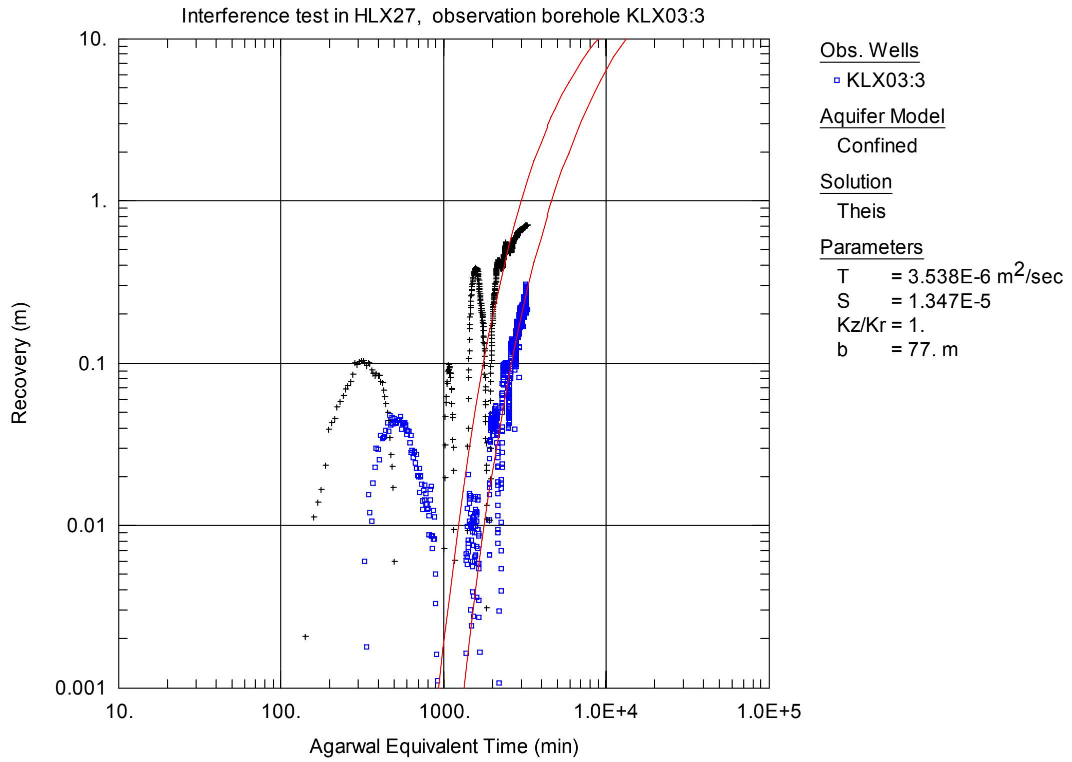


Figure 35. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:3 during pumping in borehole HLX27 (2007).*

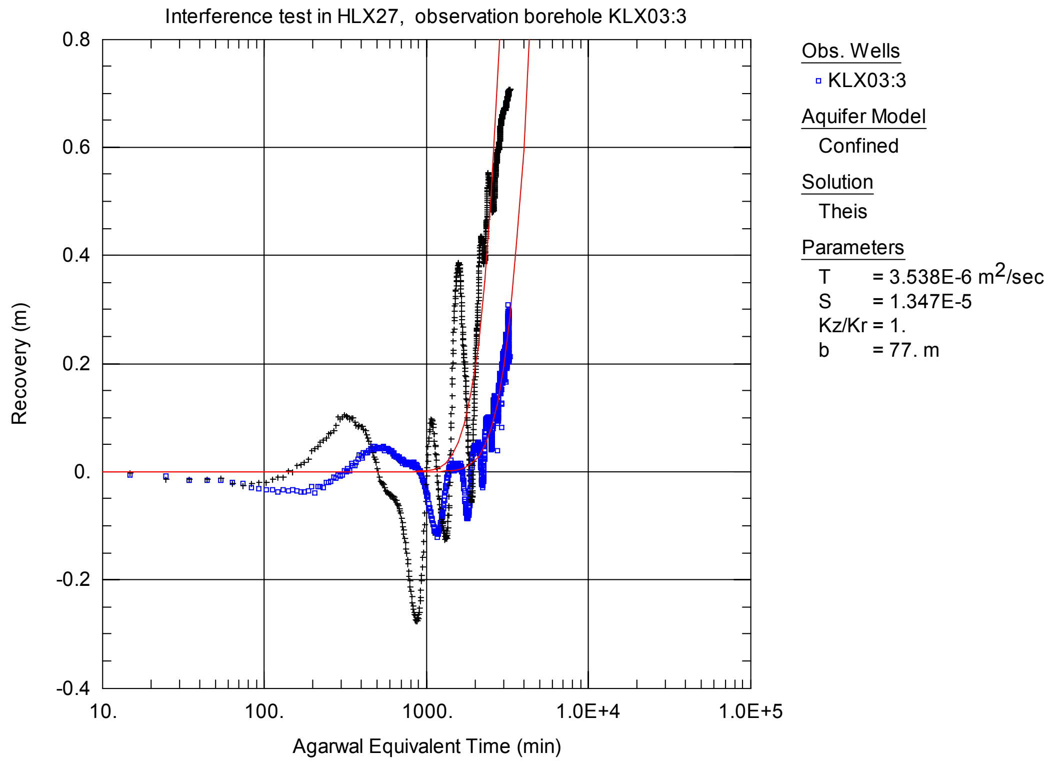


Figure 36. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:3 during pumping in borehole HLX27 (2007).*

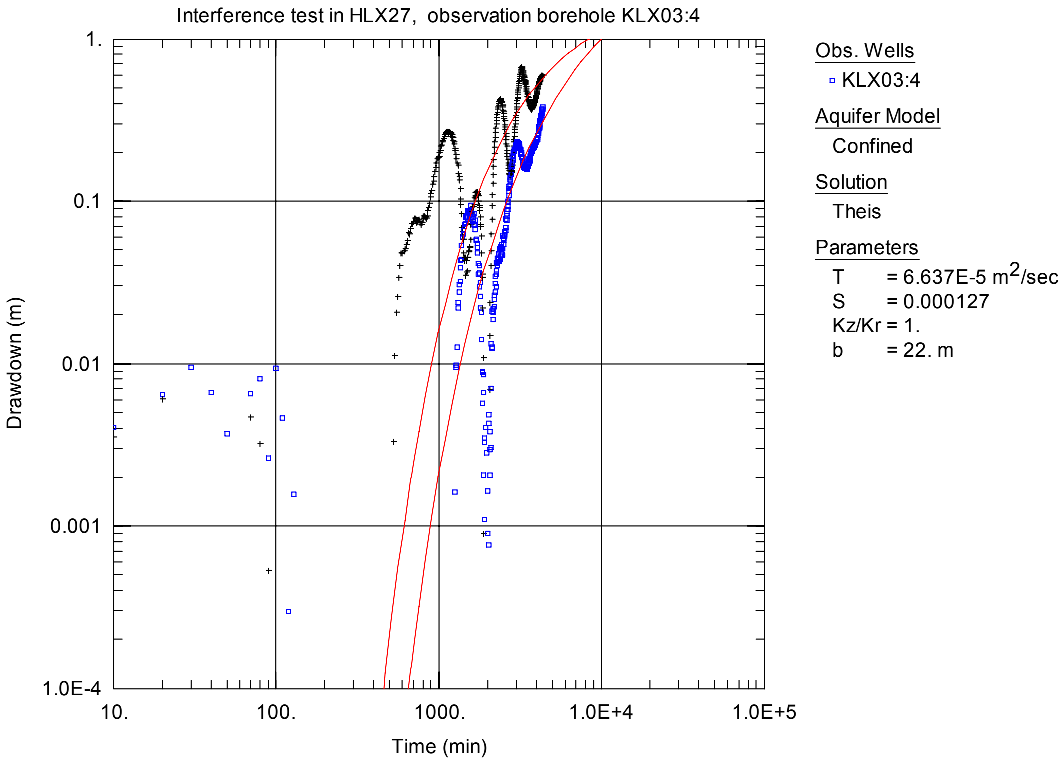


Figure 37. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:4 during pumping in borehole HLX27 (2007).*

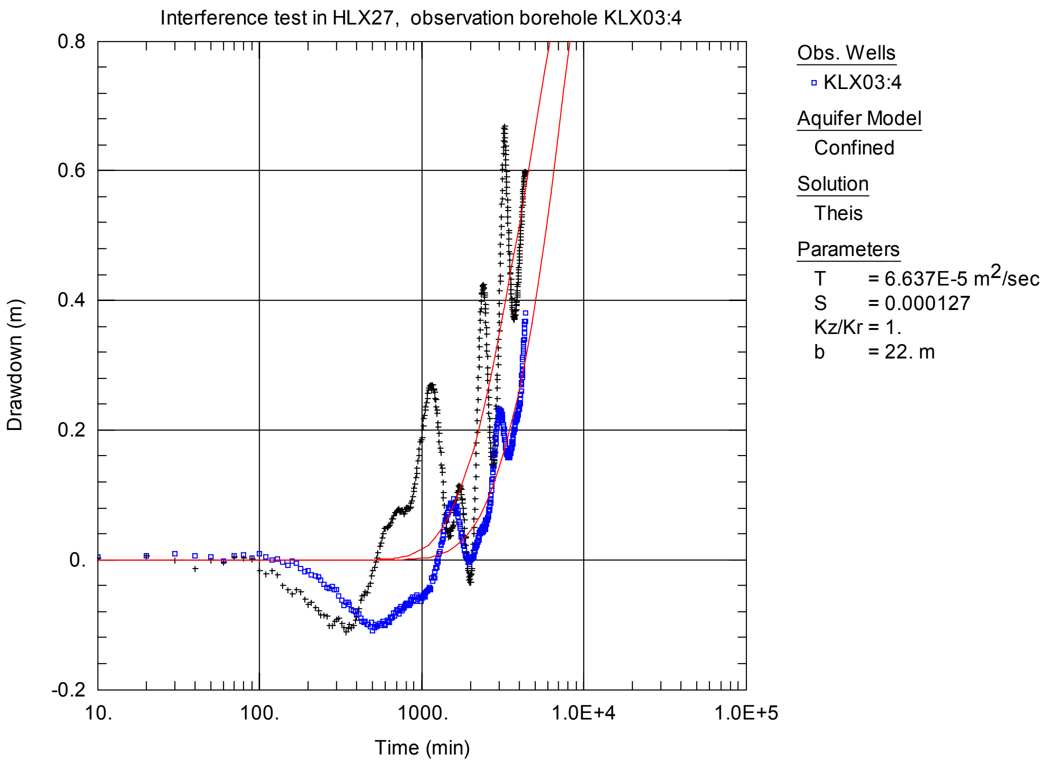


Figure 38. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:4 during pumping in borehole HLX27 (2007).*

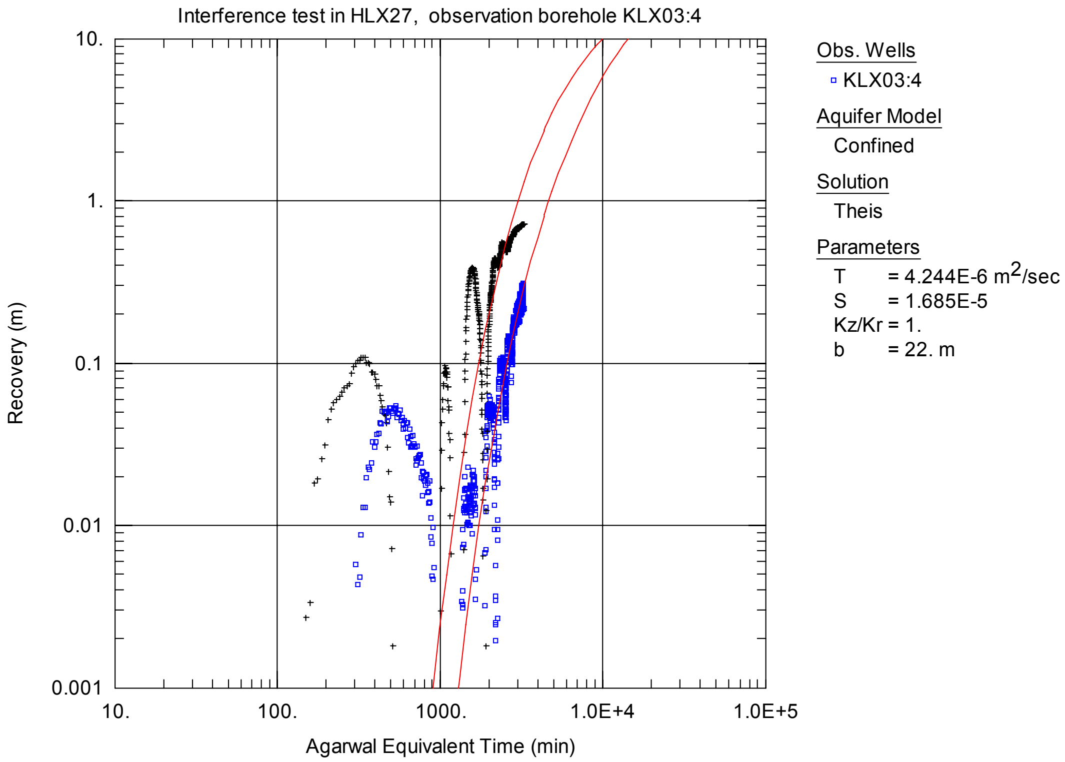


Figure 39. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:4 during pumping in borehole HLX27 (2007).*

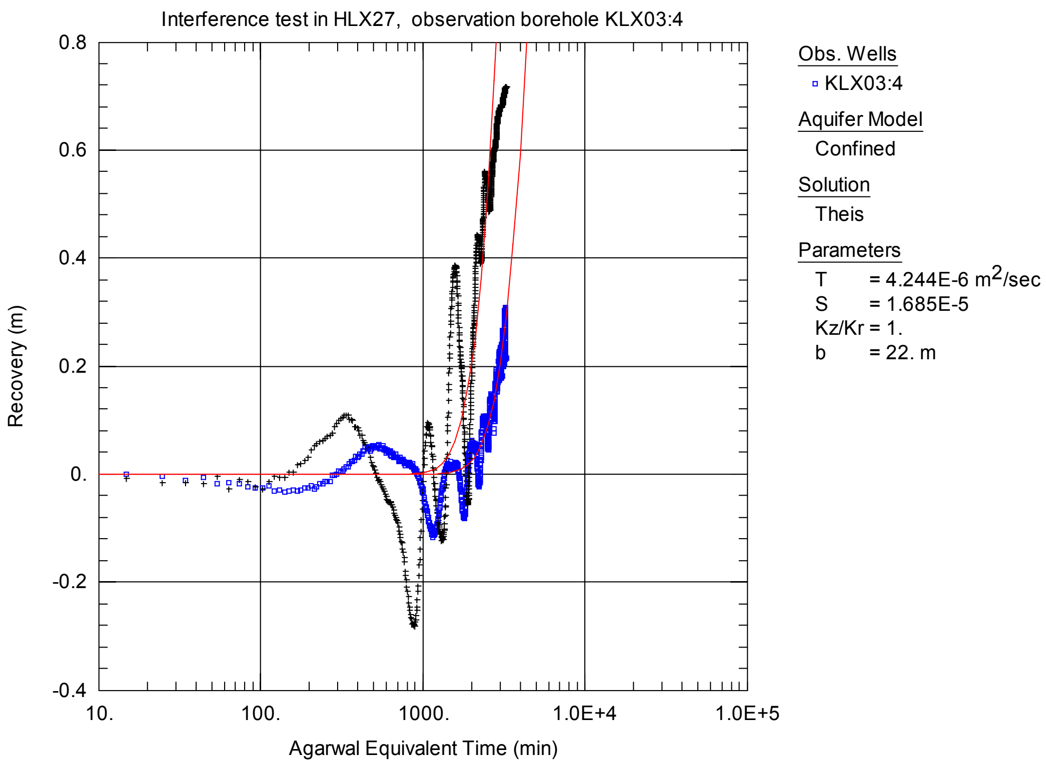


Figure 40. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:4 during pumping in borehole HLX27 (2007).*

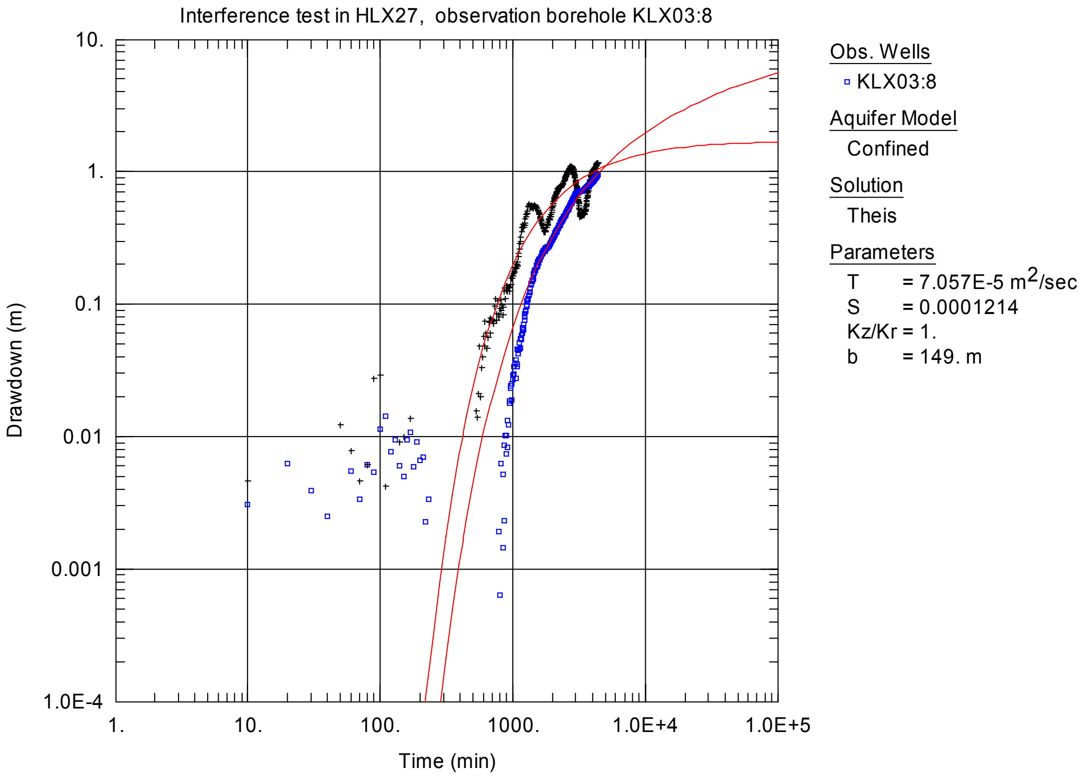


***Figure 41.**. Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:8 during pumping in borehole HLX27 (2007).*

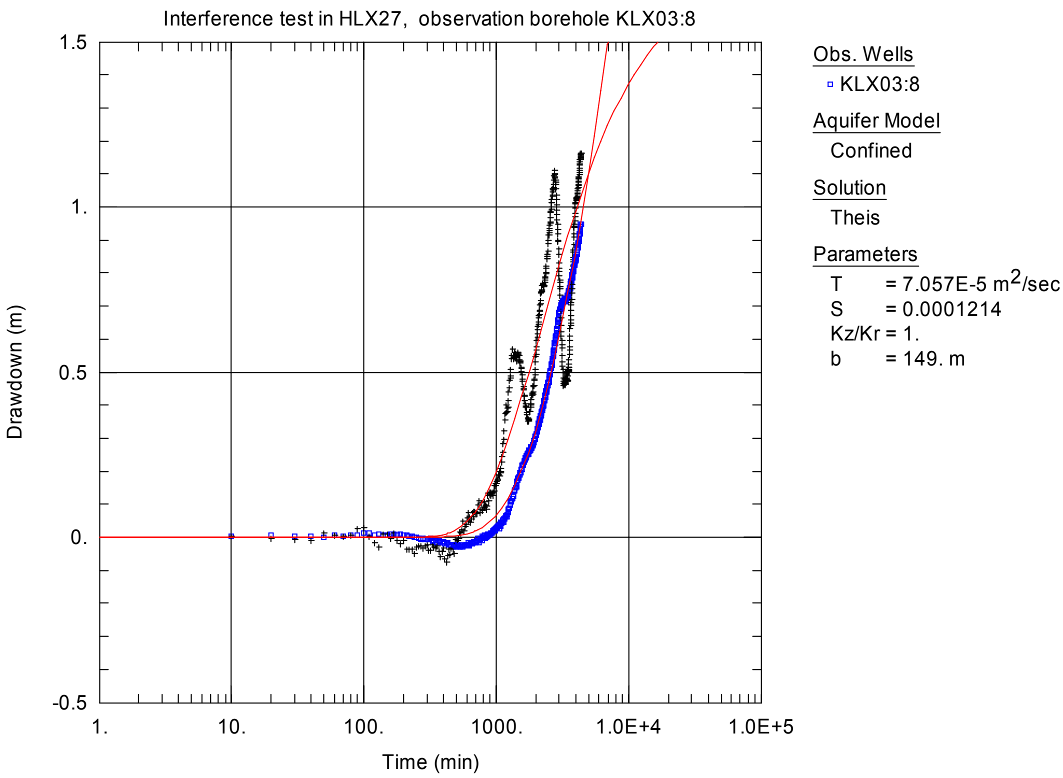


***Figure 42.** Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:8 during pumping in borehole HLX27 (2007).*

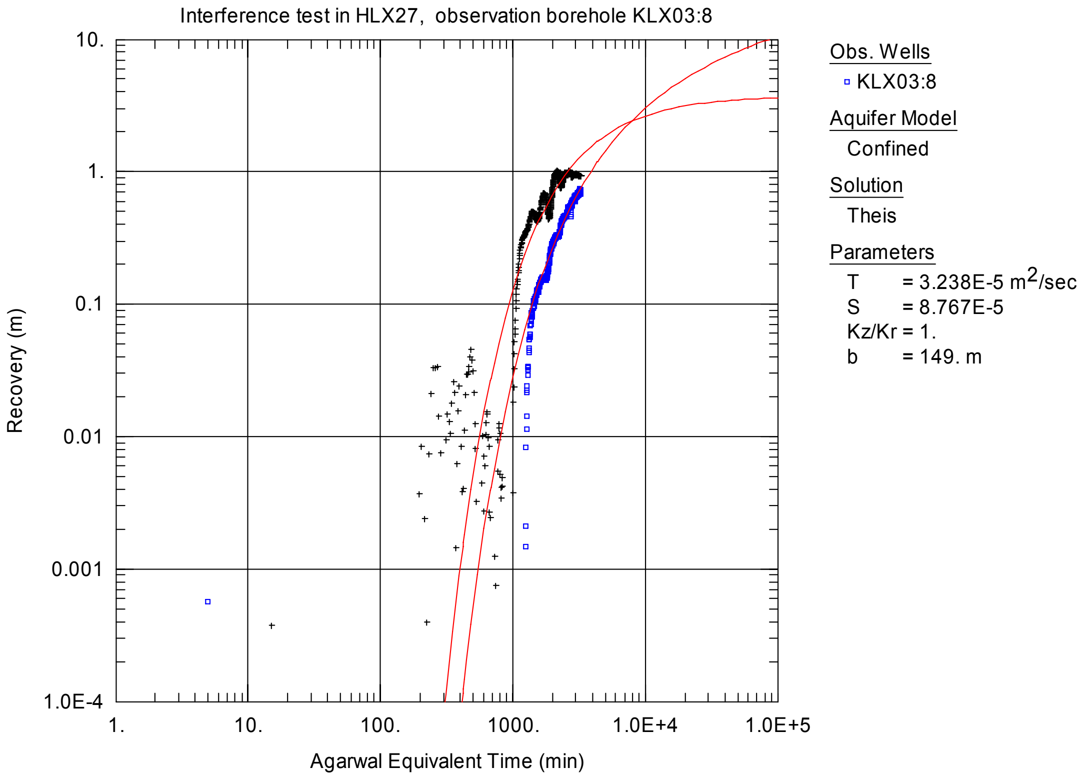


***Figure 43.** Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:8 during pumping in borehole HLX27 (2007).*

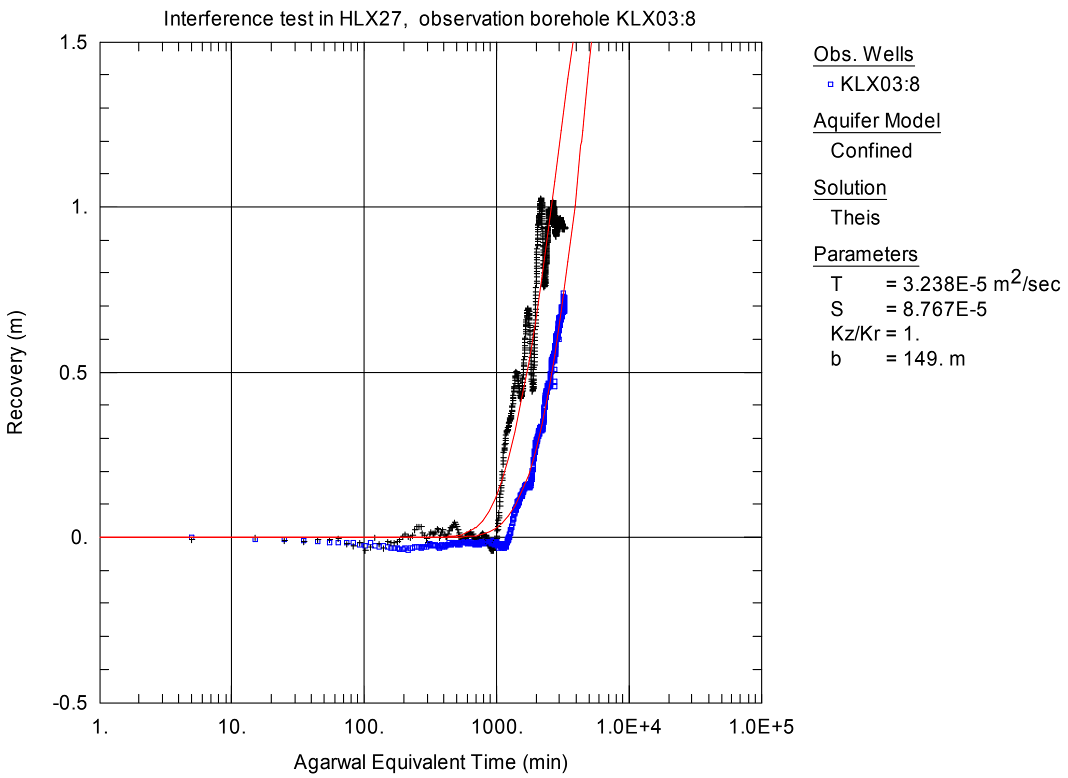


***Figure 44.** Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:8 during pumping in borehole HLX27 (2007).*

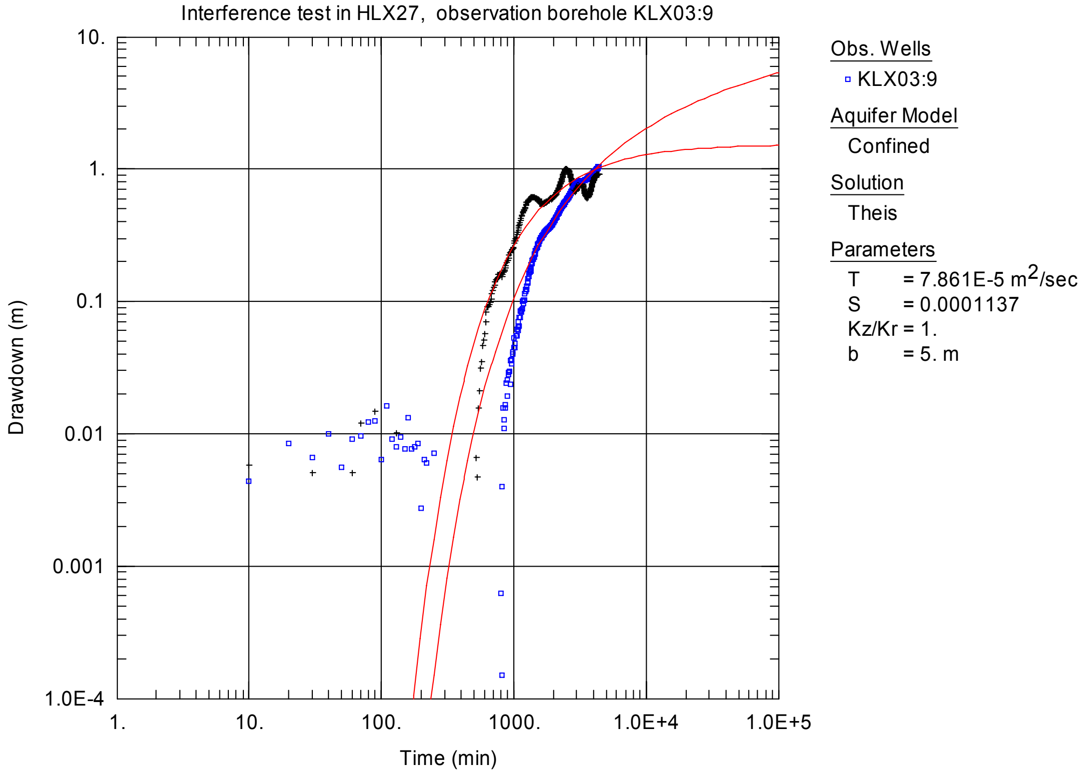


***Figure 45.** Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:9 during pumping in borehole HLX27 (2007).*

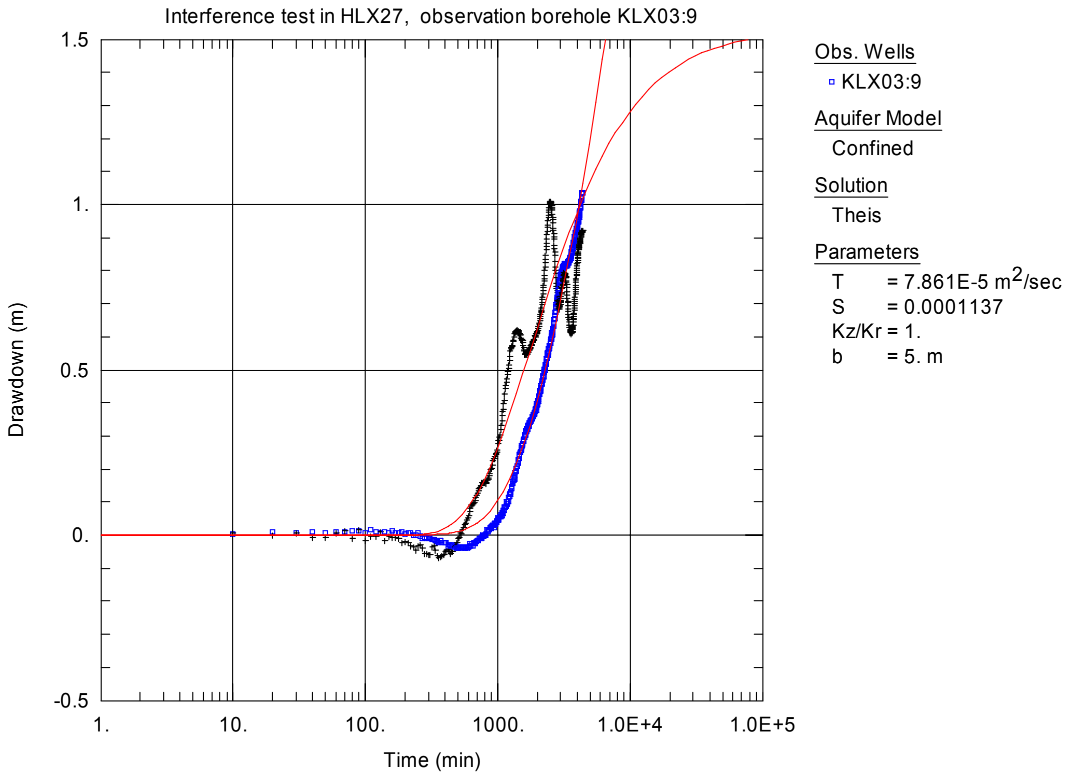


***Figure 46.** Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:9 during pumping in borehole HLX27 (2007).*

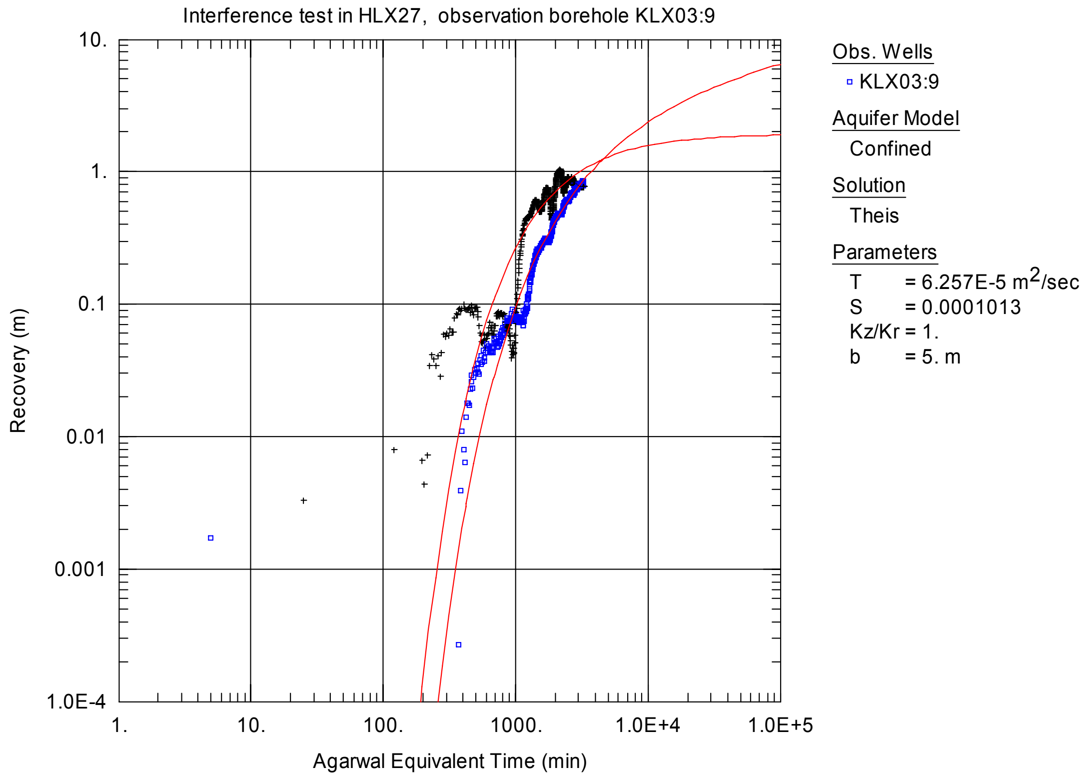


Figure 47. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:9 during pumping in borehole HLX27 (2007).*

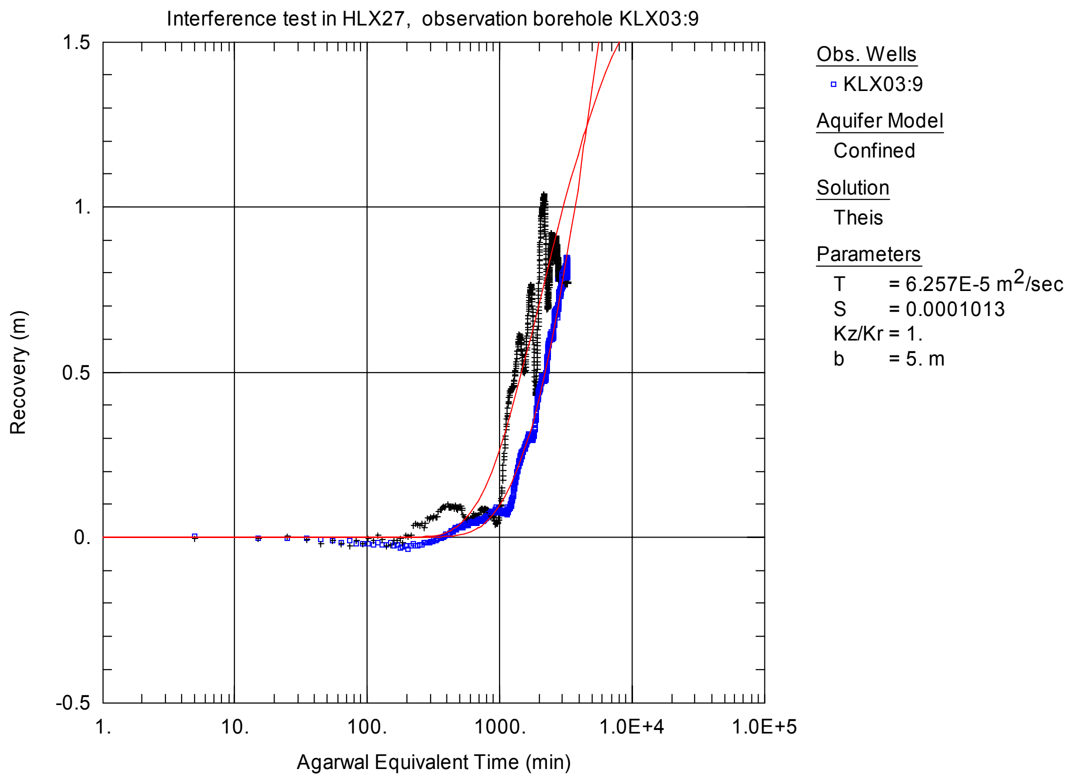


Figure 48. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:9 during pumping in borehole HLX27 (2007).*

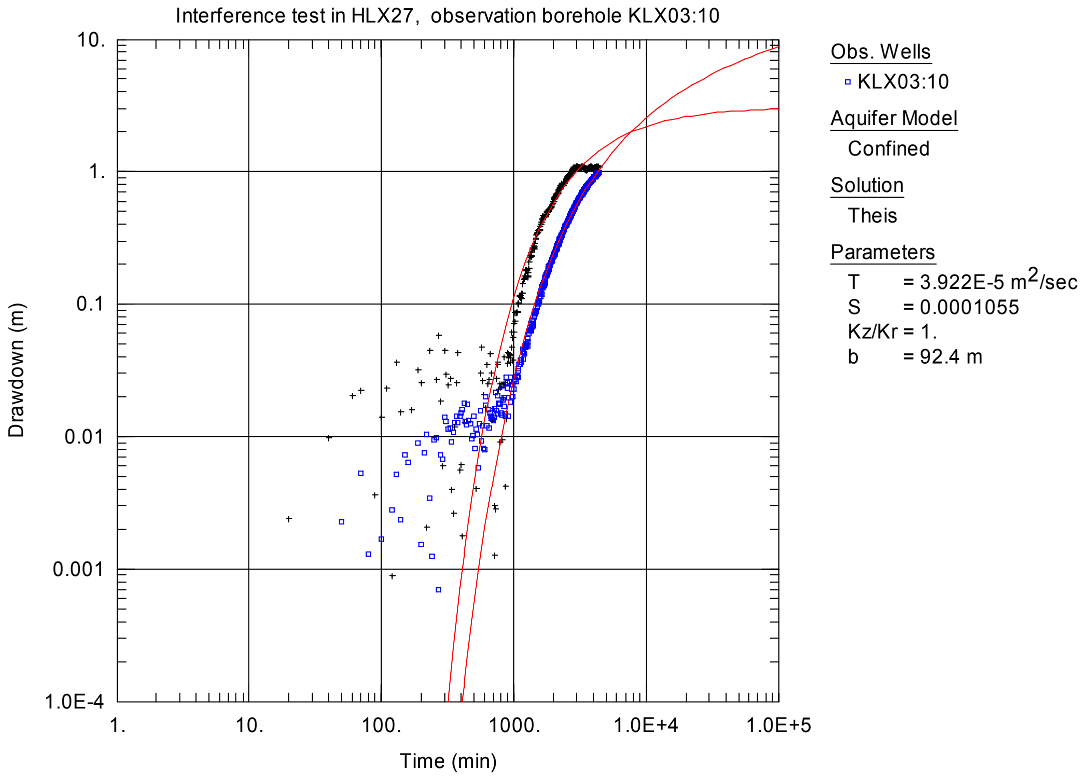


***Figure 49** Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:10 during pumping in borehole HLX27 (2007).*

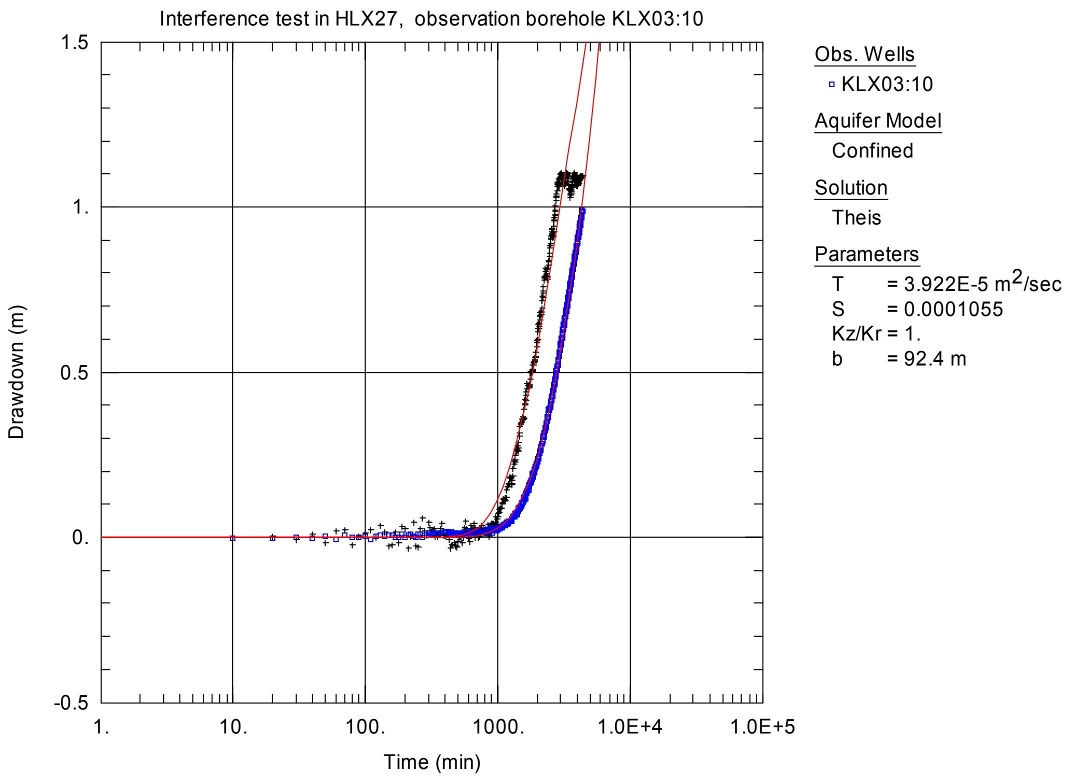


***Figure 50.** Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX03:10 during pumping in borehole HLX27 (2007).*

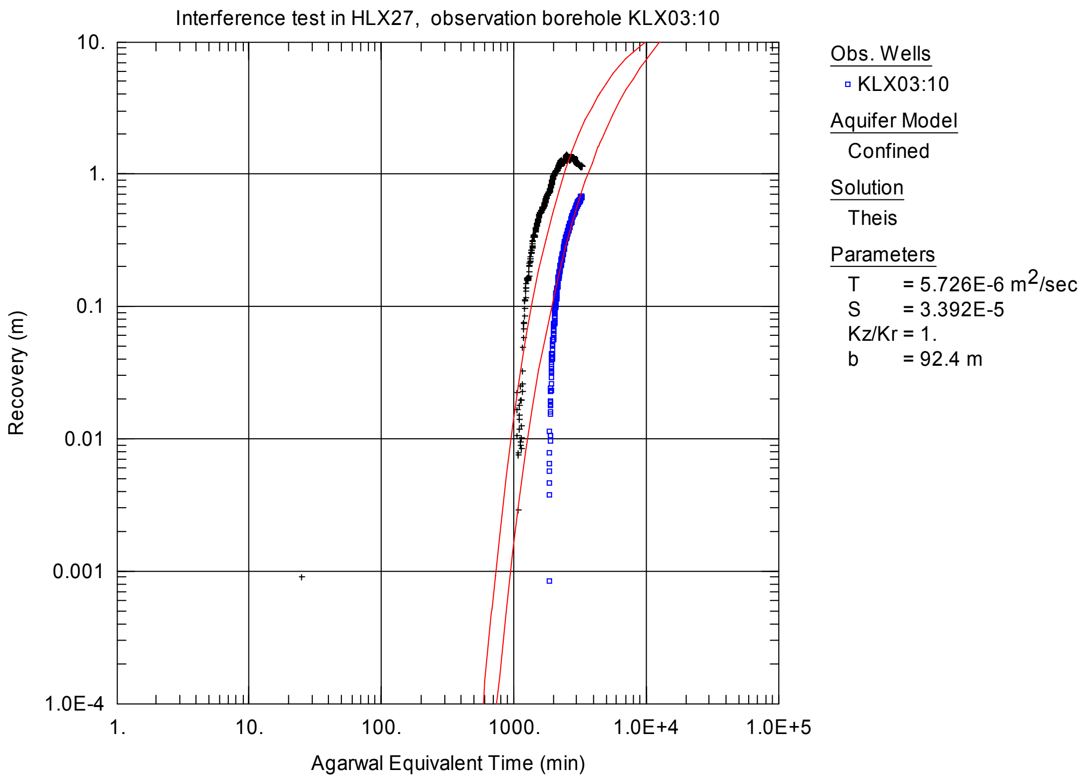


Figure 51. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:10 during pumping in borehole HLX27 (2007).*

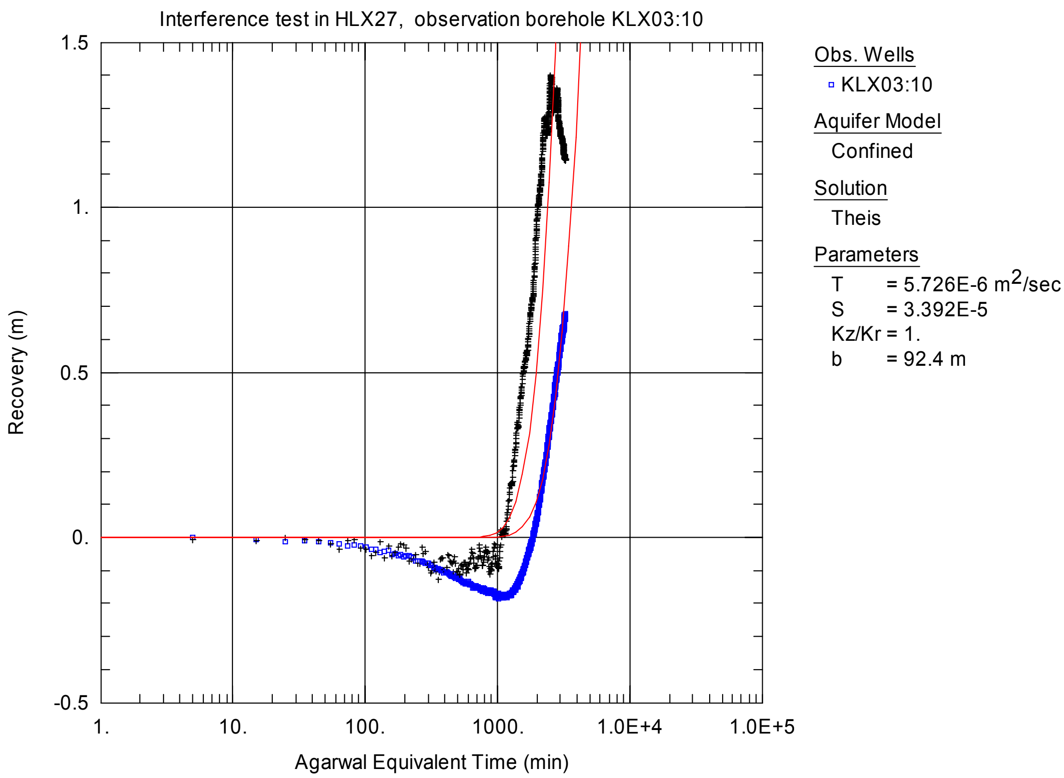


Figure 52. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX03:10 during pumping in borehole HLX27 (2007).*

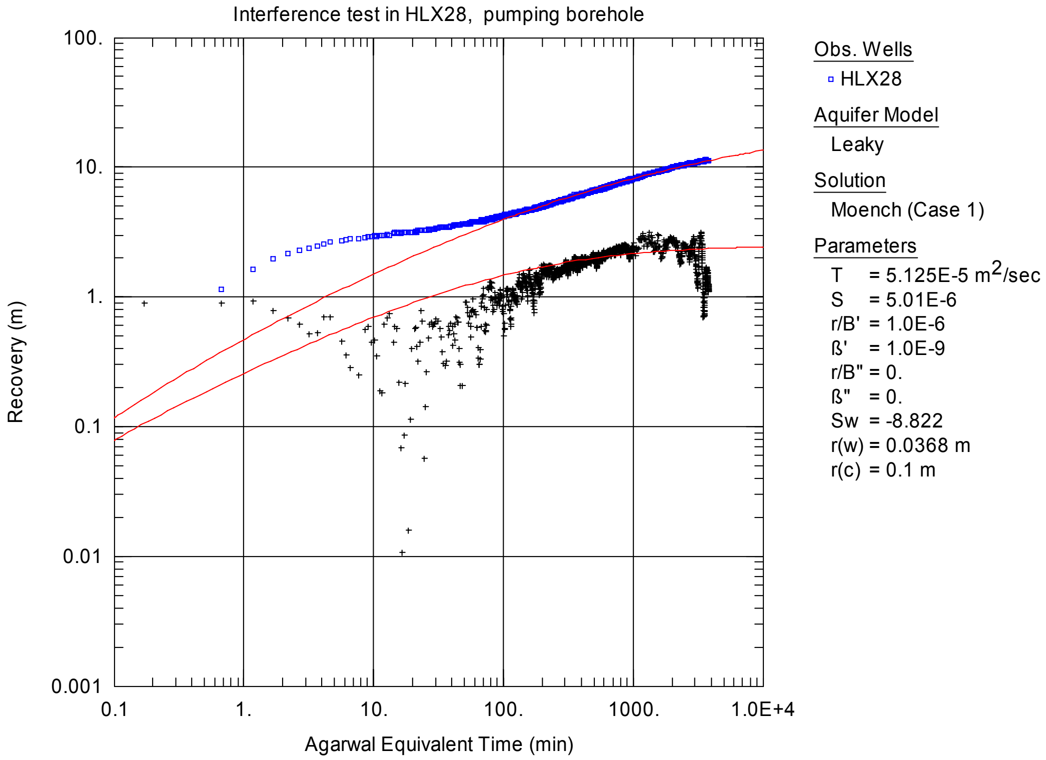


Figure 53. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) together with corresponding simulated curves (red) in the pumping borehole KLX14A. The evaluation is based on the late response.*

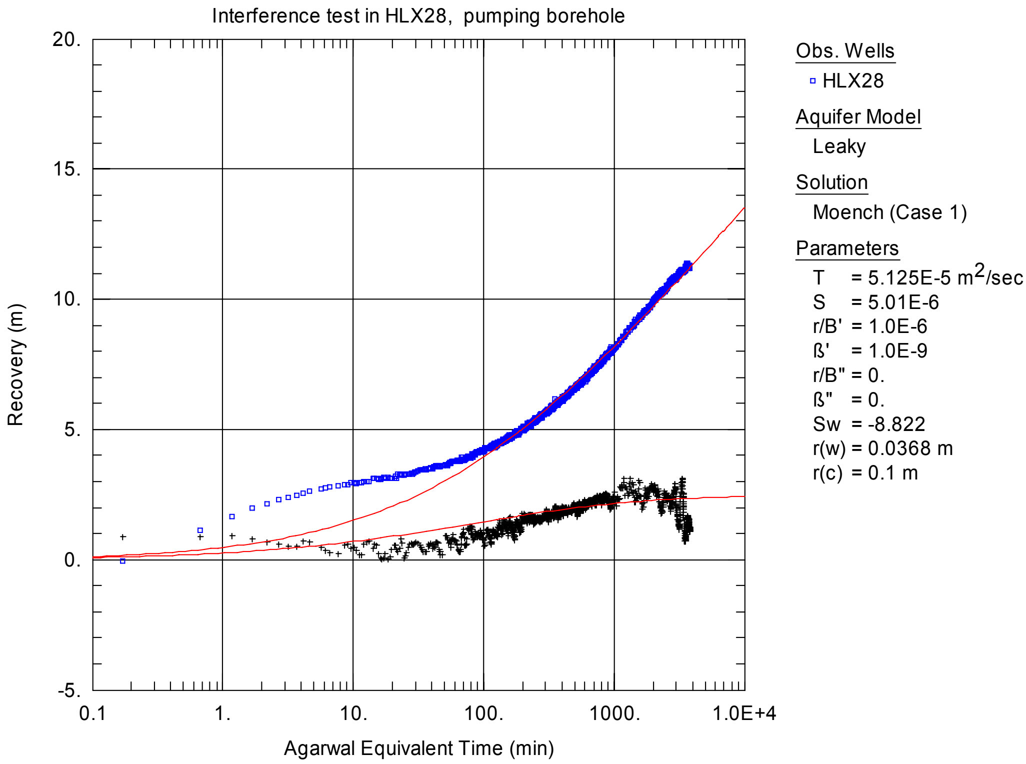


Figure 54. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) together with corresponding simulated curves (red) in the pumping borehole HLX28. The evaluation is based on the late response.*

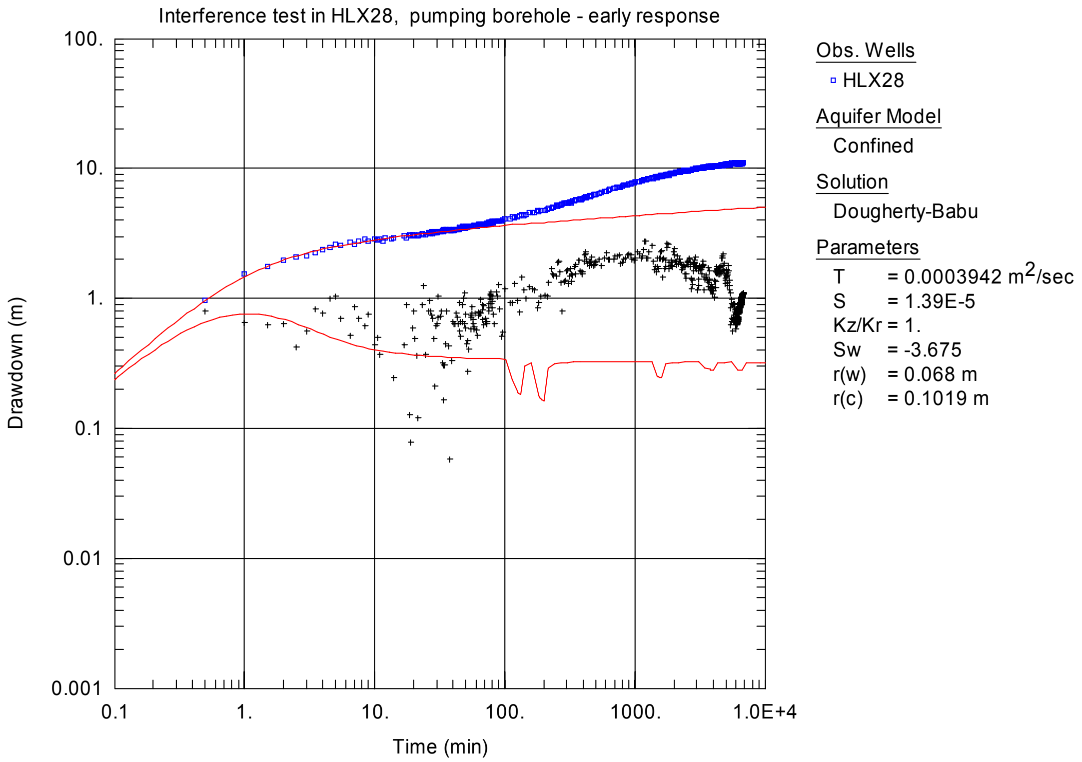


Figure 55. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with corresponding simulated curves (red) in the pumping borehole HLX28. The evaluation is based on the early response.*

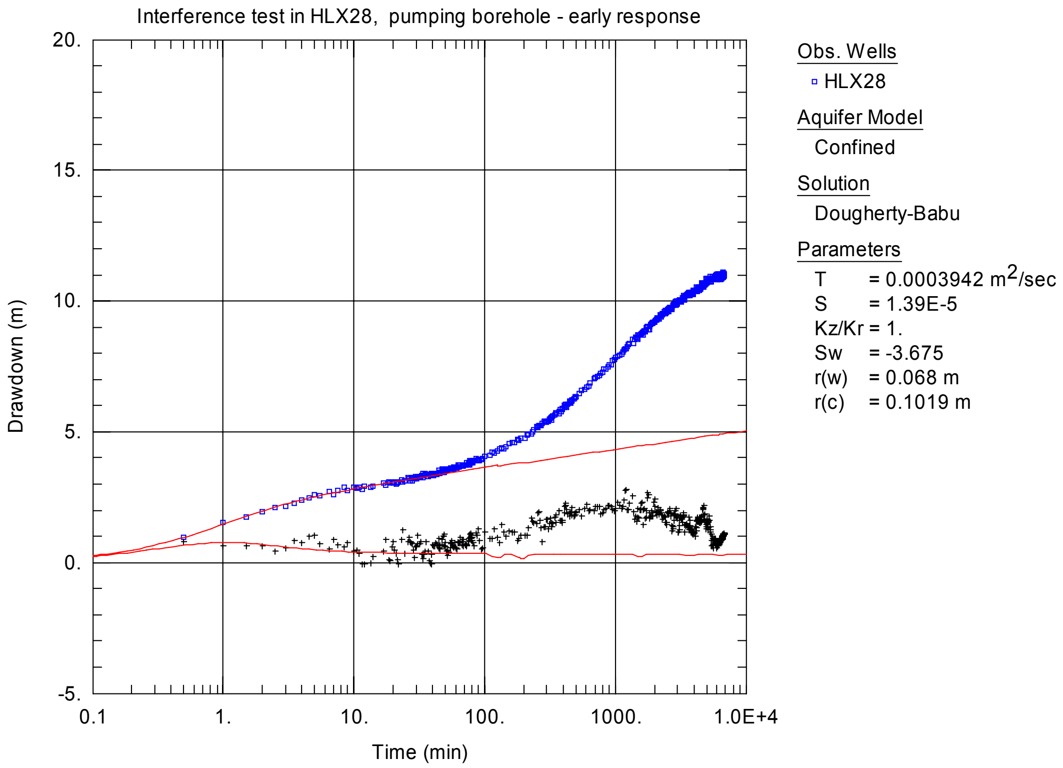


Figure 56. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with corresponding simulated curves (red) in the pumping borehole HLX28. The evaluation is based on the early response.*

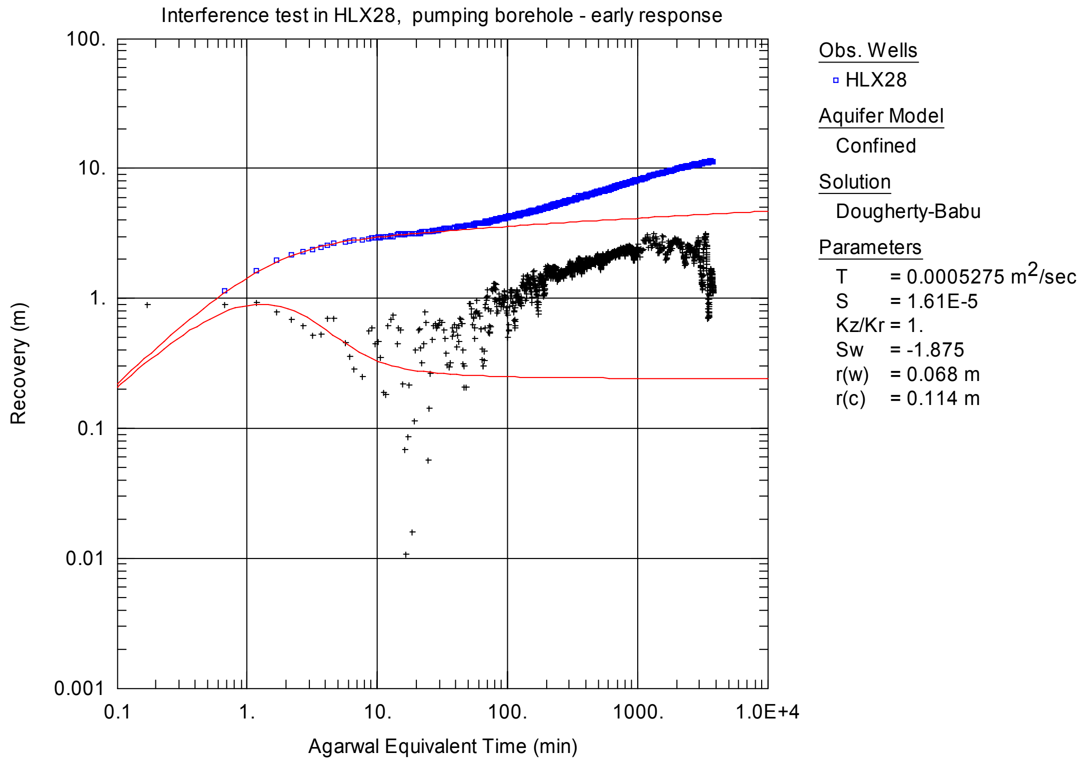


Figure 57. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) together with corresponding simulated curves (red) in the pumping borehole KLX14A. The evaluation is based on the early response.*

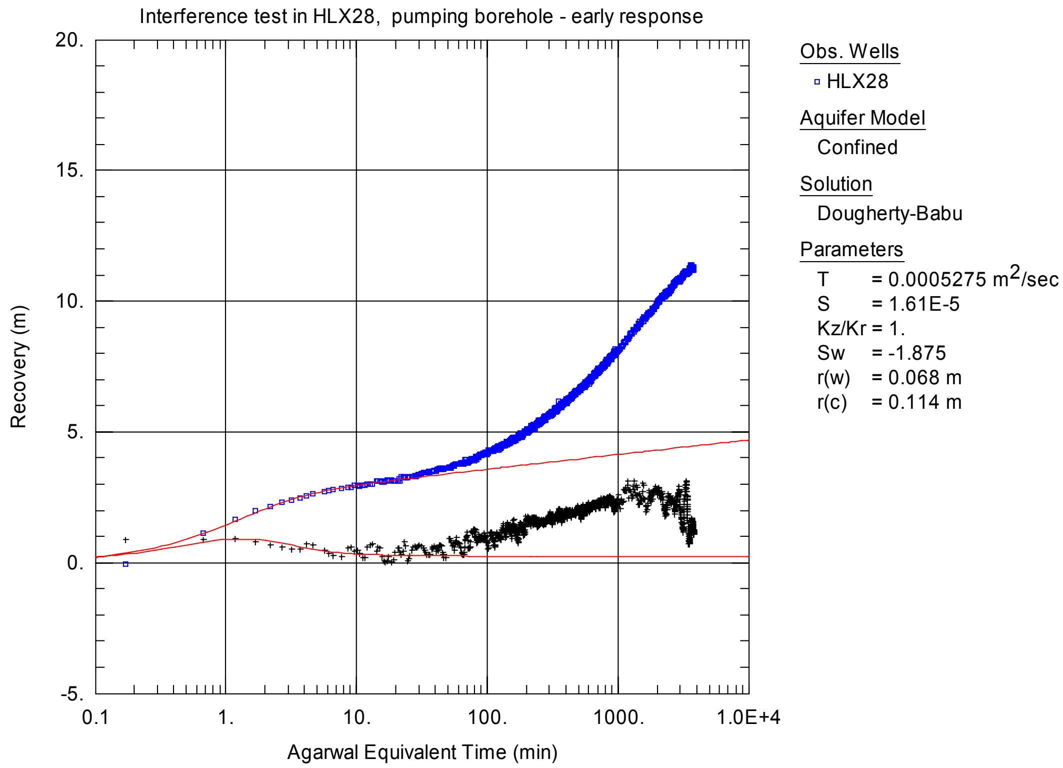


Figure 58. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) together with corresponding simulated curves (red) in the pumping borehole HLX28. The evaluation is based on the early response.*

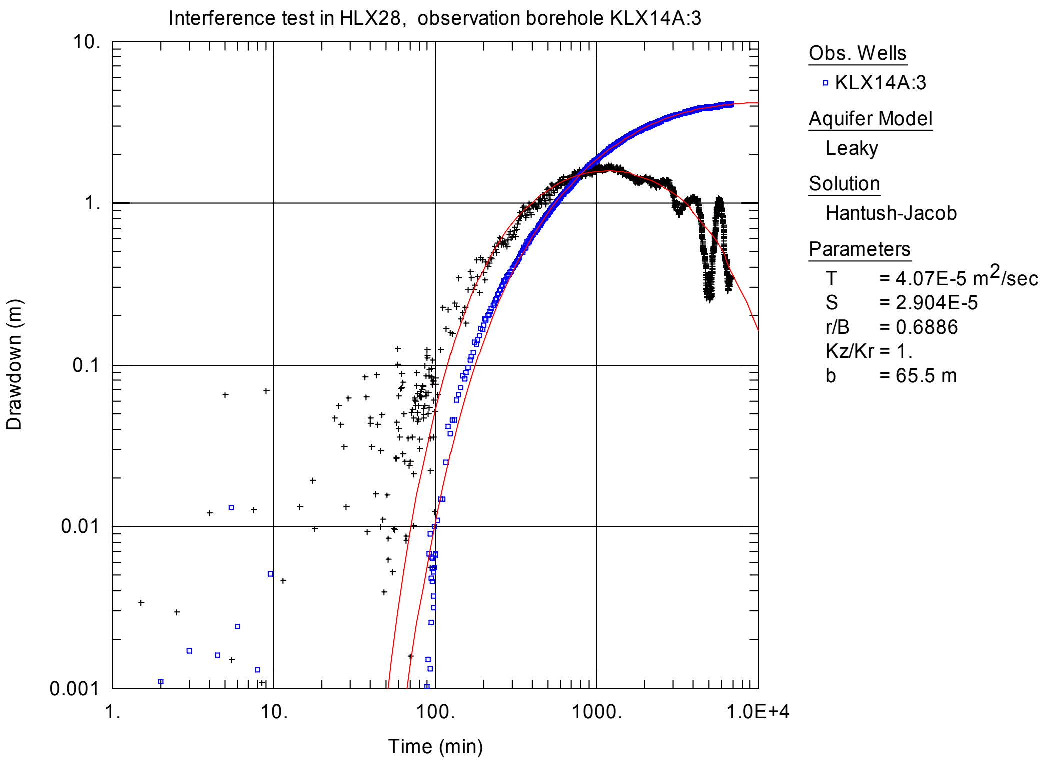


***Figure 59.** Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX14A:3 during pumping in borehole HLX28.*

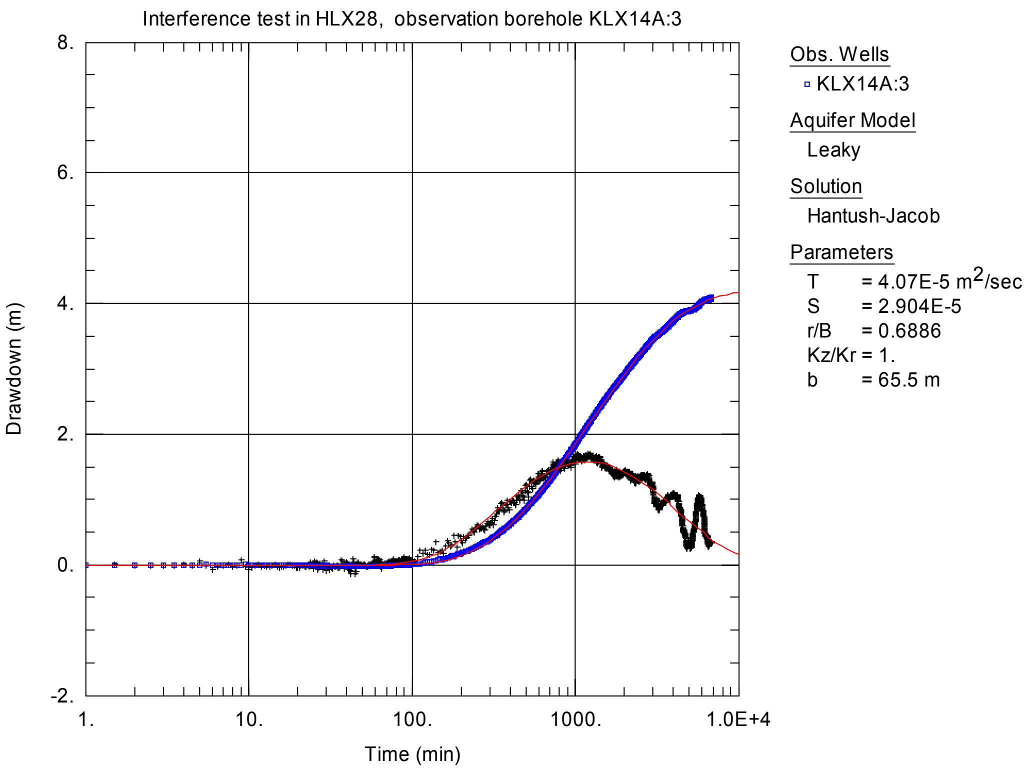


***Figure 60.** Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX14A:3 during pumping in borehole HLX28.*

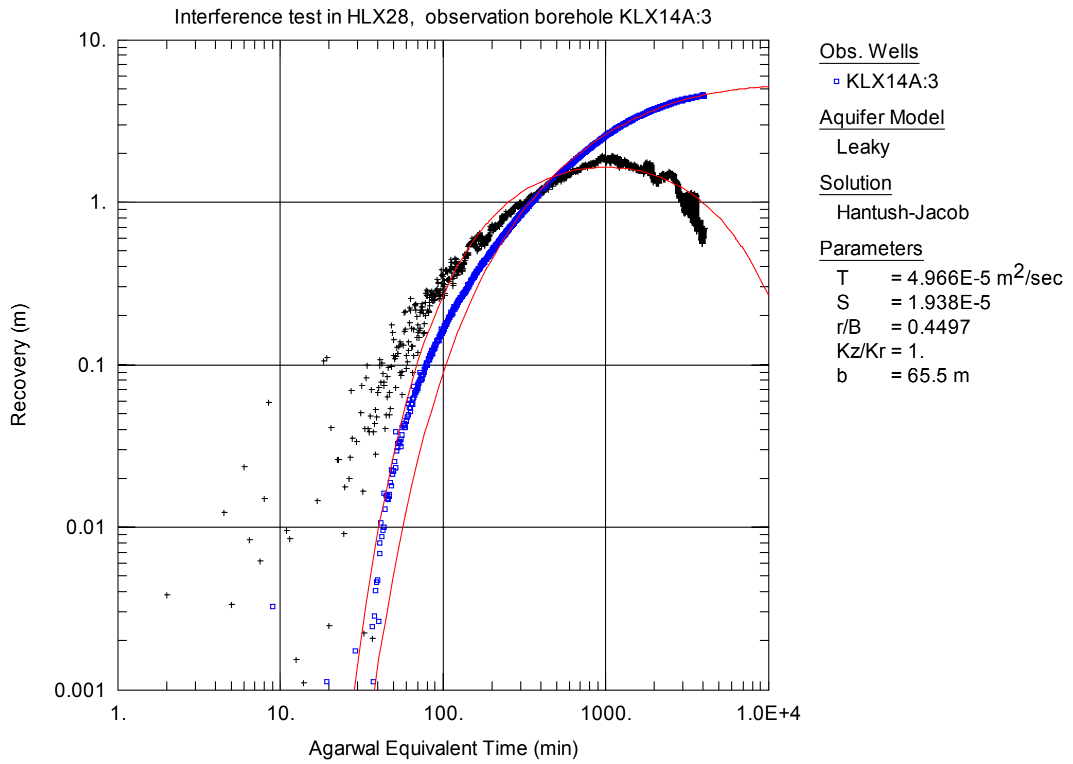


Figure 61. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX14A:3 during pumping in borehole HLX28.*

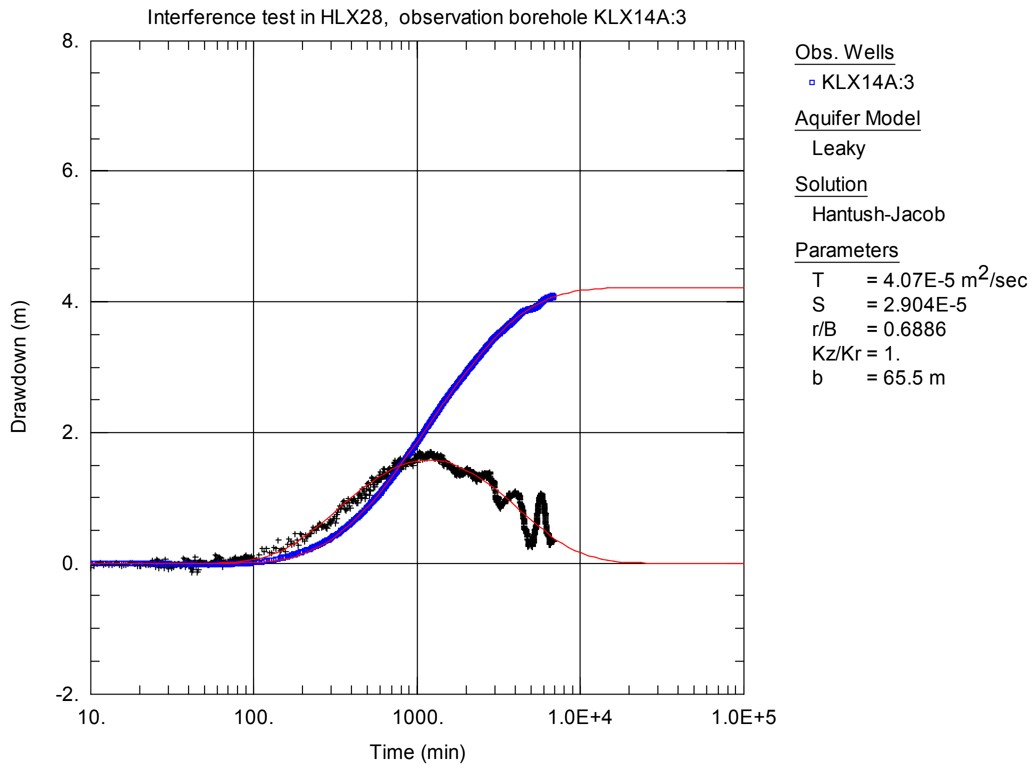


Figure 62. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX14A:3 during pumping in borehole HLX28.*

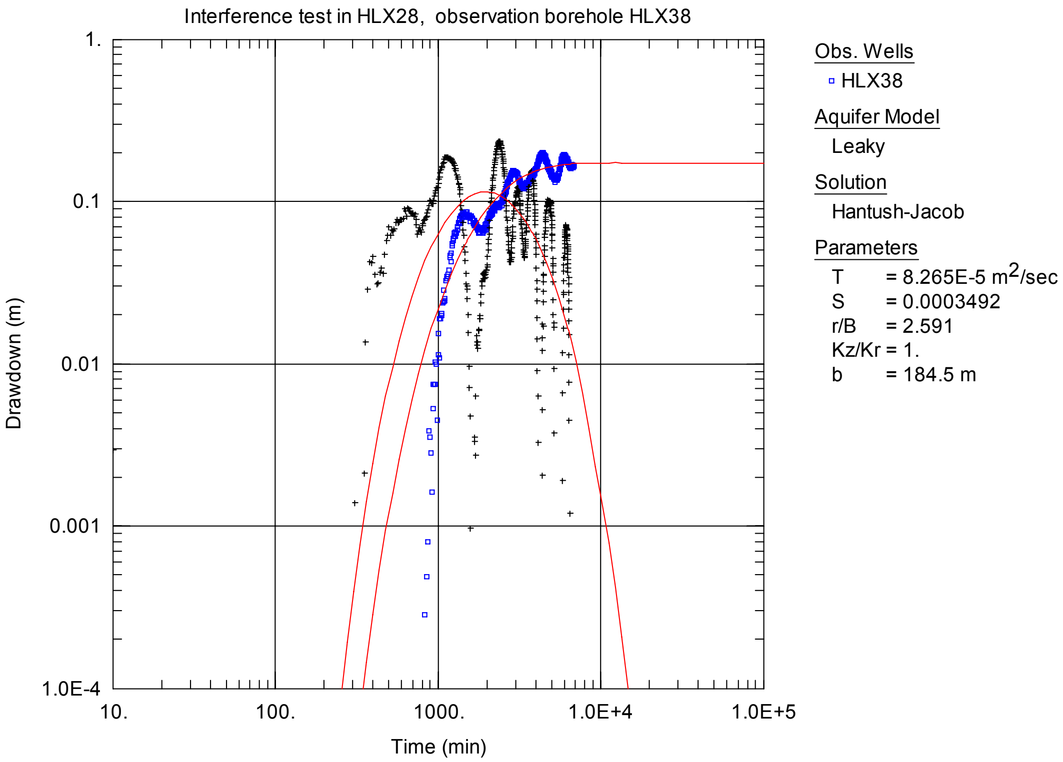


Figure 63. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX38 during pumping in borehole HLX28.*

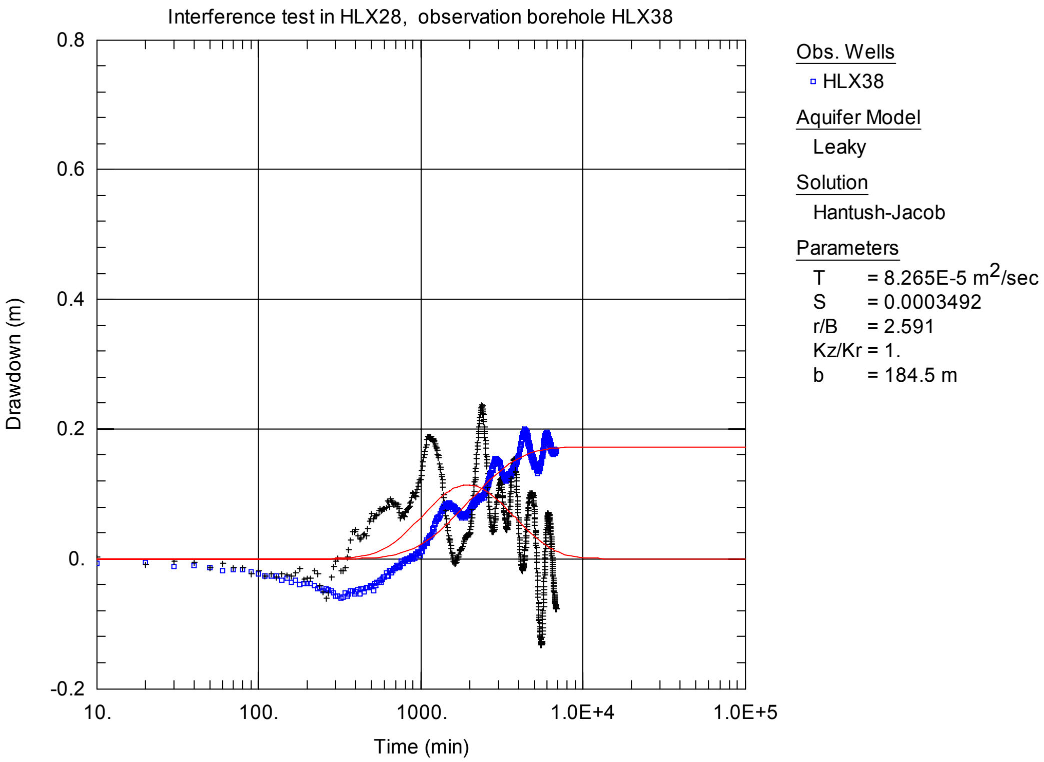


Figure 64. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX38 during pumping in borehole HLX28*

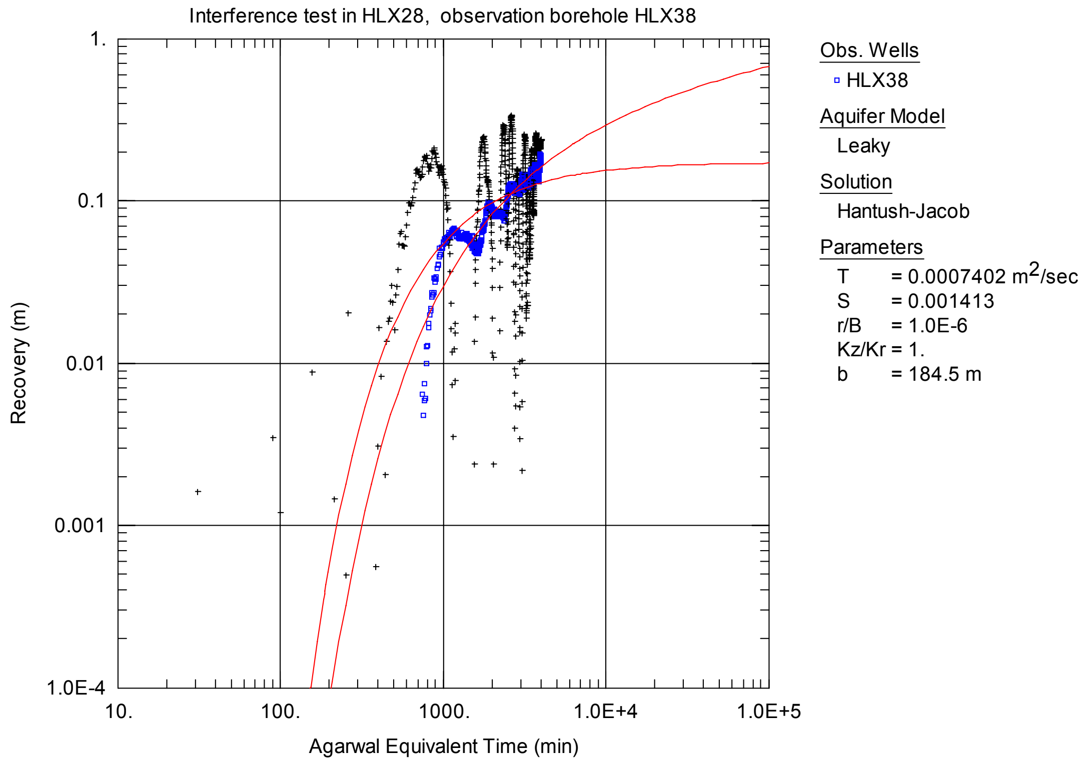


Figure 65. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX38 during pumping in borehole HLX28.*

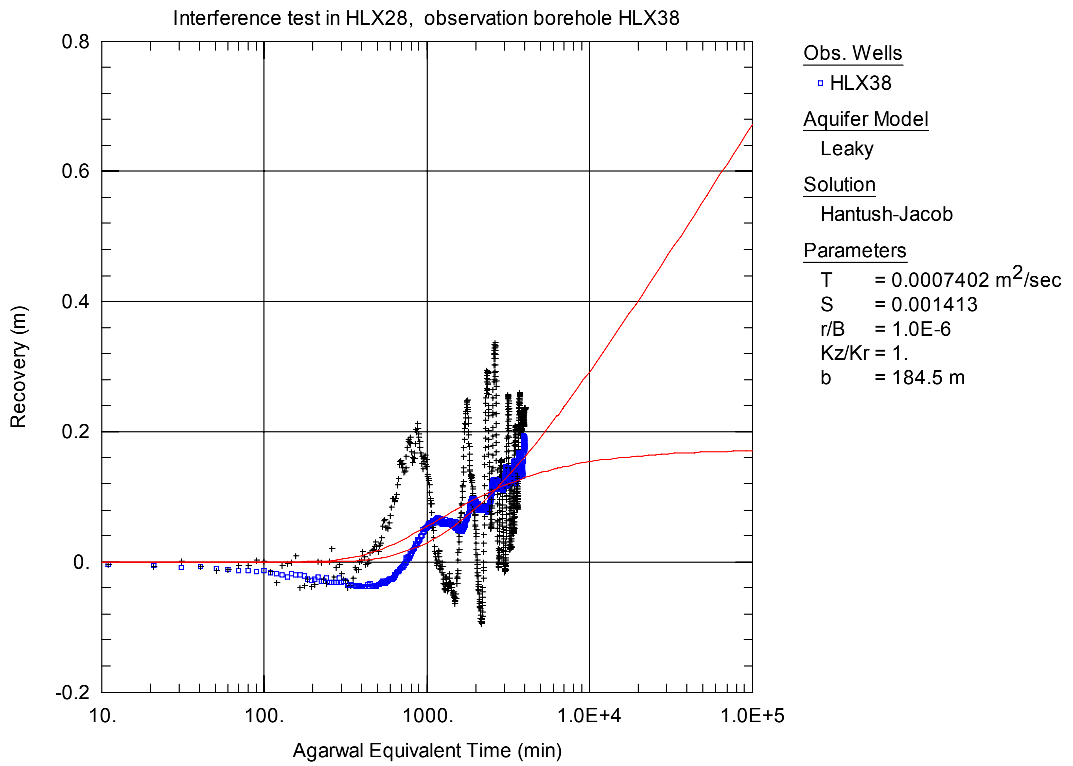


Figure 66. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX38 during pumping in borehole HLX28.*

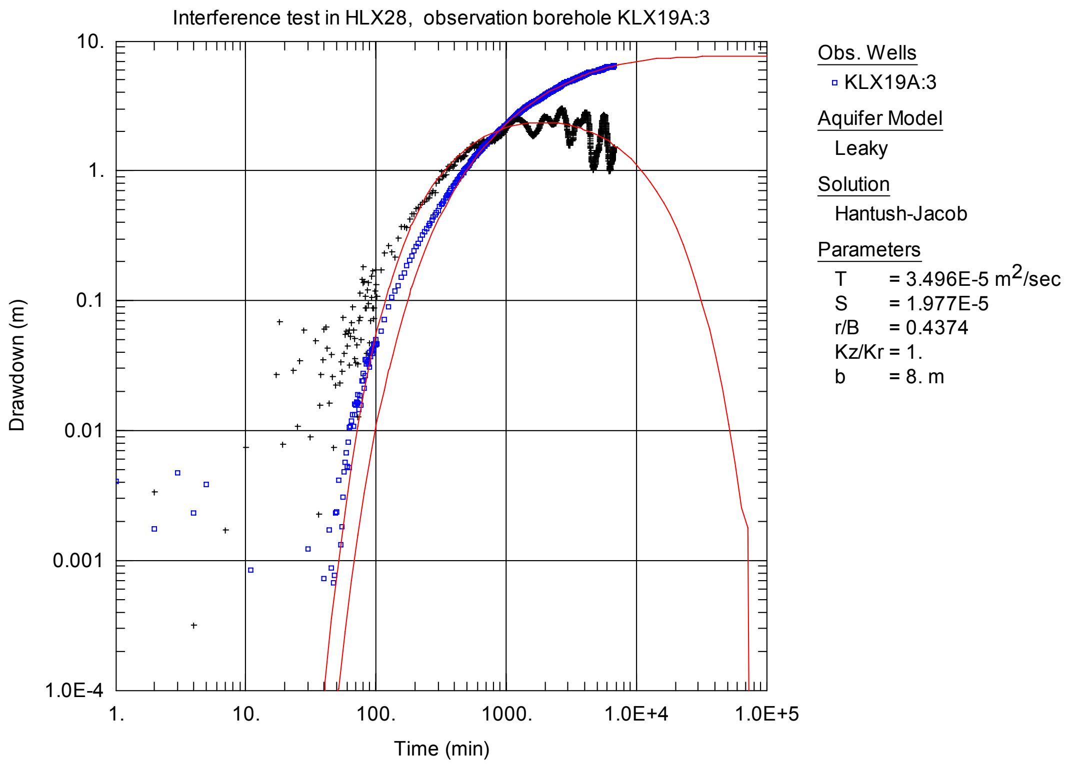


Figure 67. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:3 during pumping in borehole HLX28.*

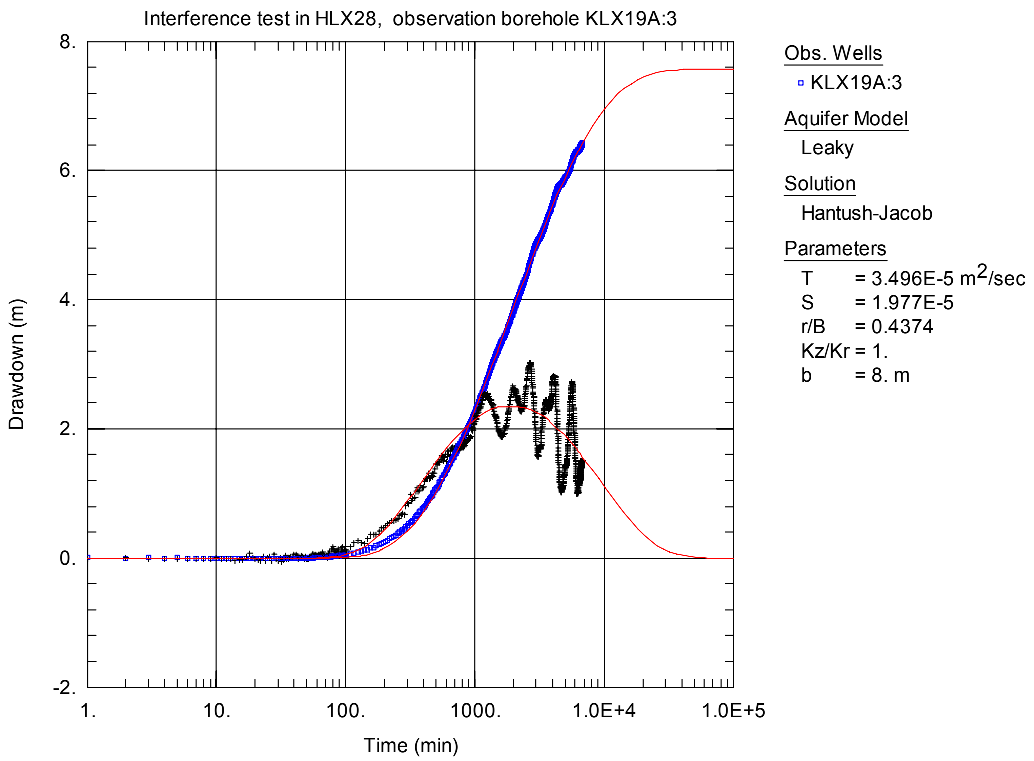


Figure 68. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:3 during pumping in borehole HLX28*

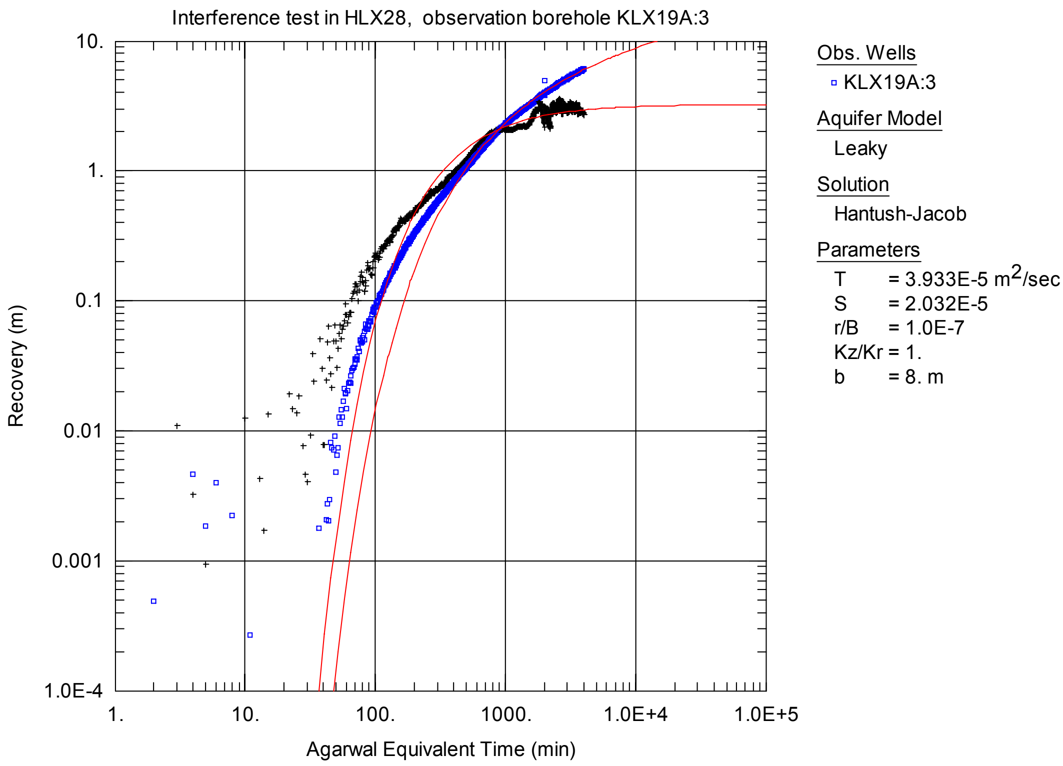


Figure 69. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:3 during pumping in borehole HLX28.*

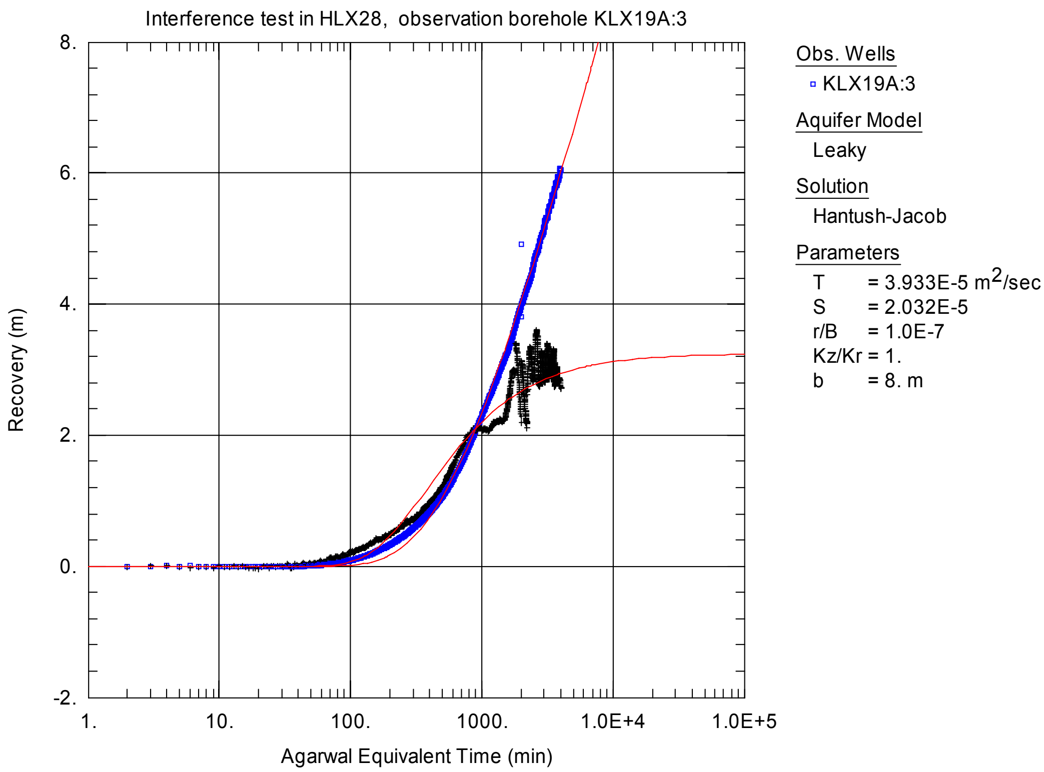


Figure 70. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:3 during pumping in borehole HLX28.*

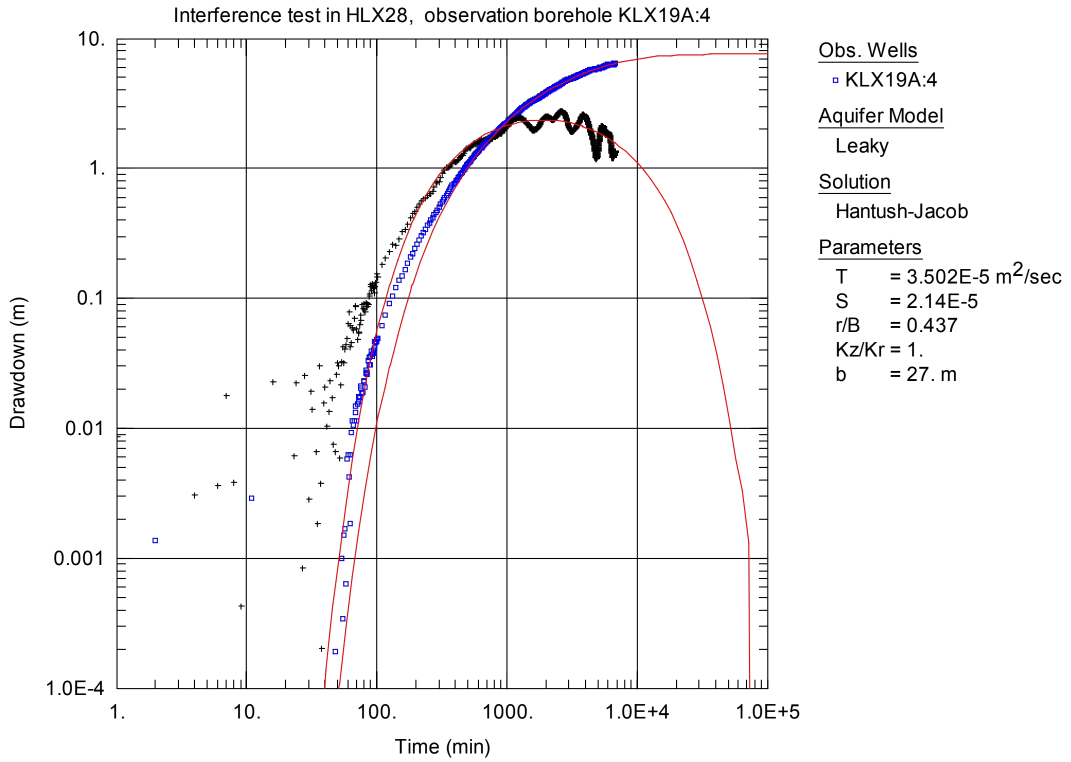


Figure 71. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:4 during pumping in borehole HLX28.*

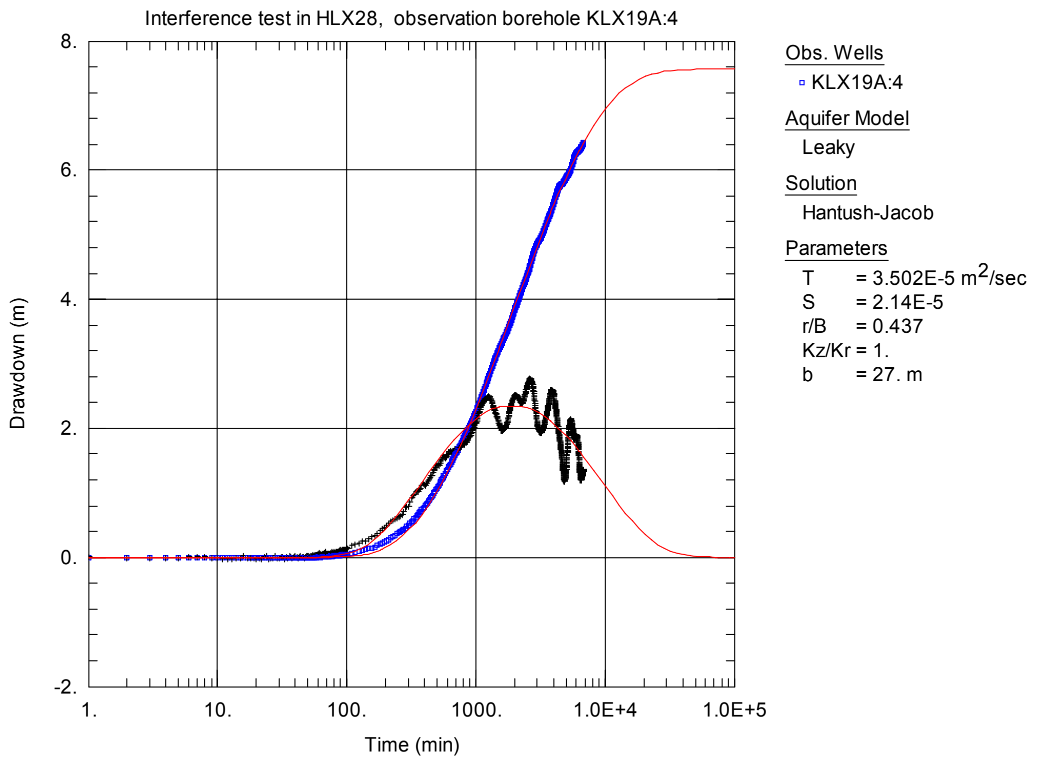


Figure 72. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:4 during pumping in borehole HLX28*

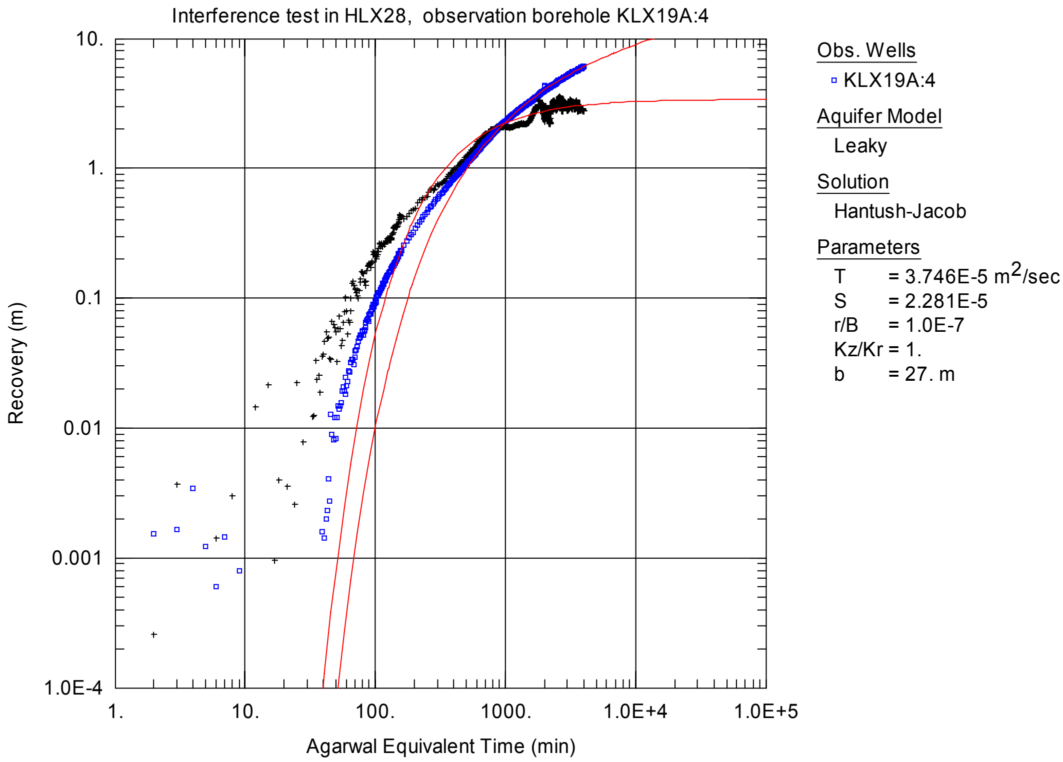


Figure 73. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:4 during pumping in borehole HLX28.*

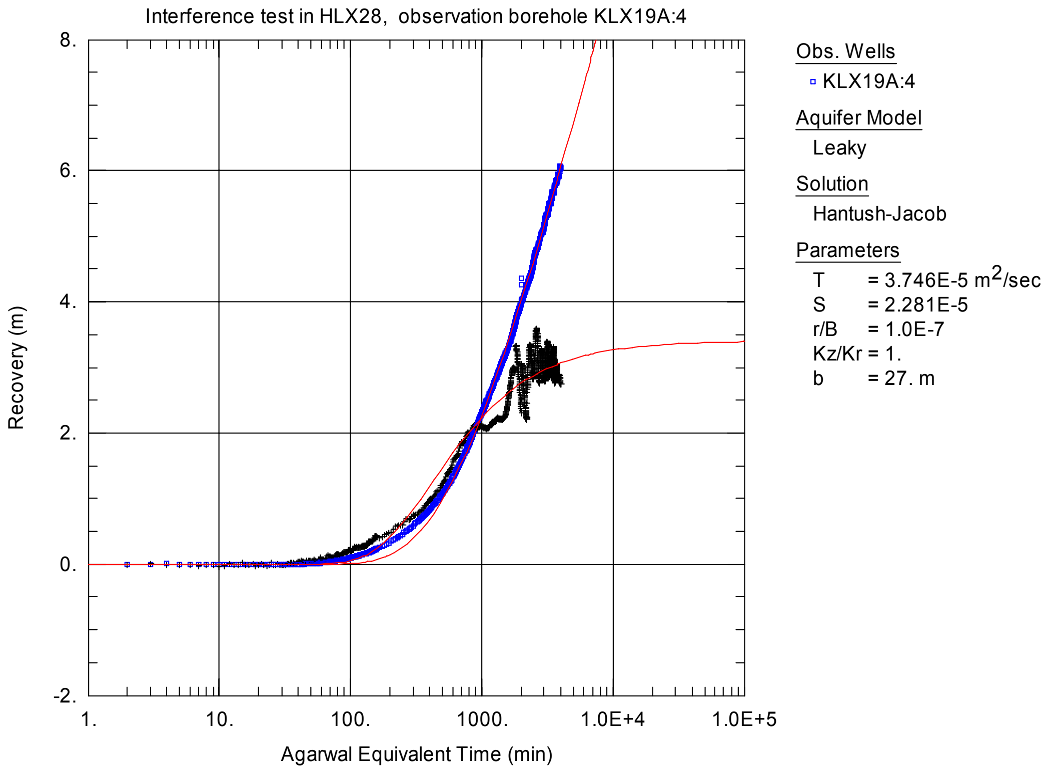


Figure 74. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:4 during pumping in borehole HLX28.*

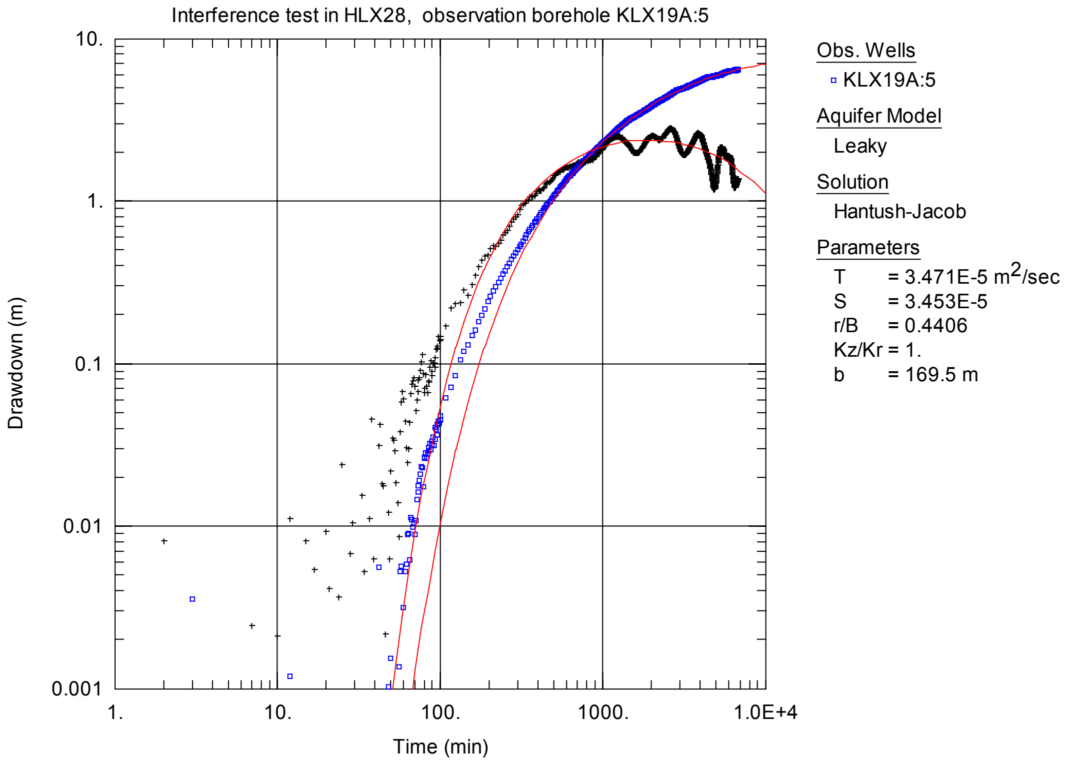


Figure 75. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:5 during pumping in borehole HLX28.*

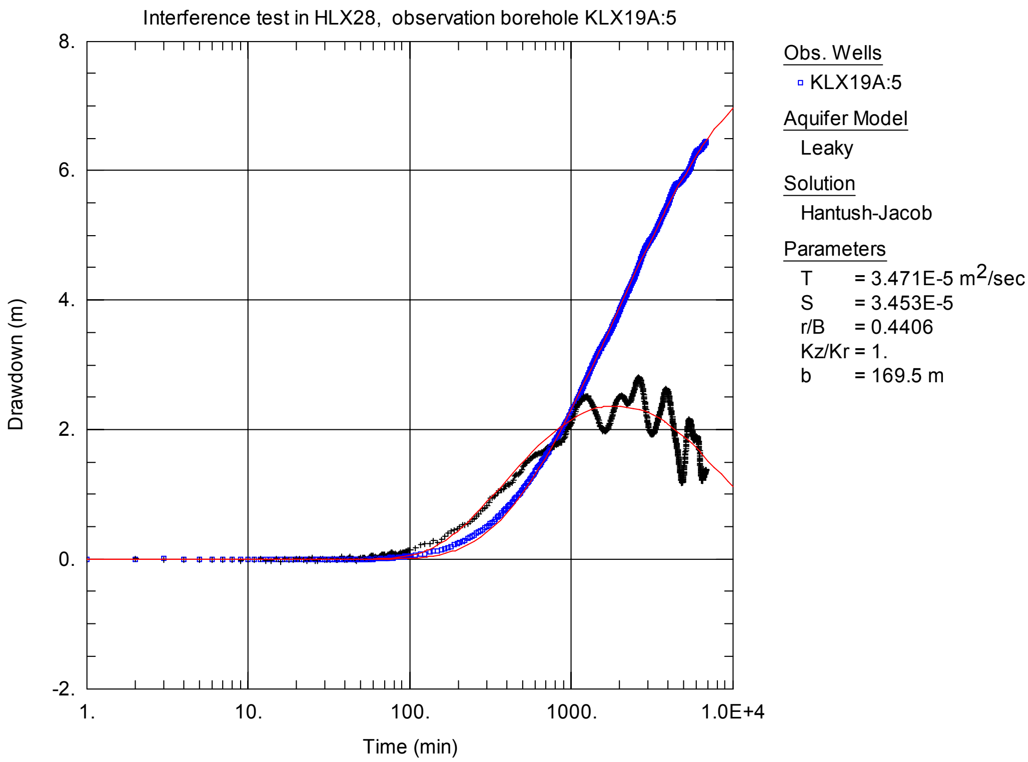


Figure 76. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:5 during pumping in borehole HLX28*

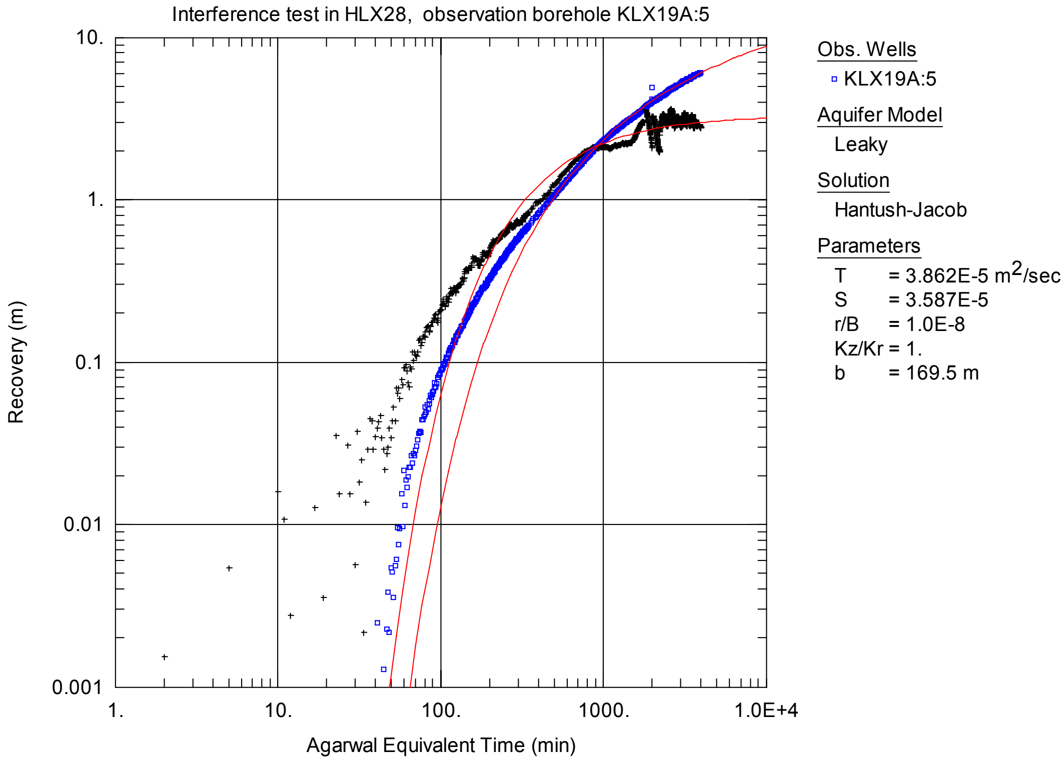


Figure 77. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:5 during pumping in borehole HLX28.*

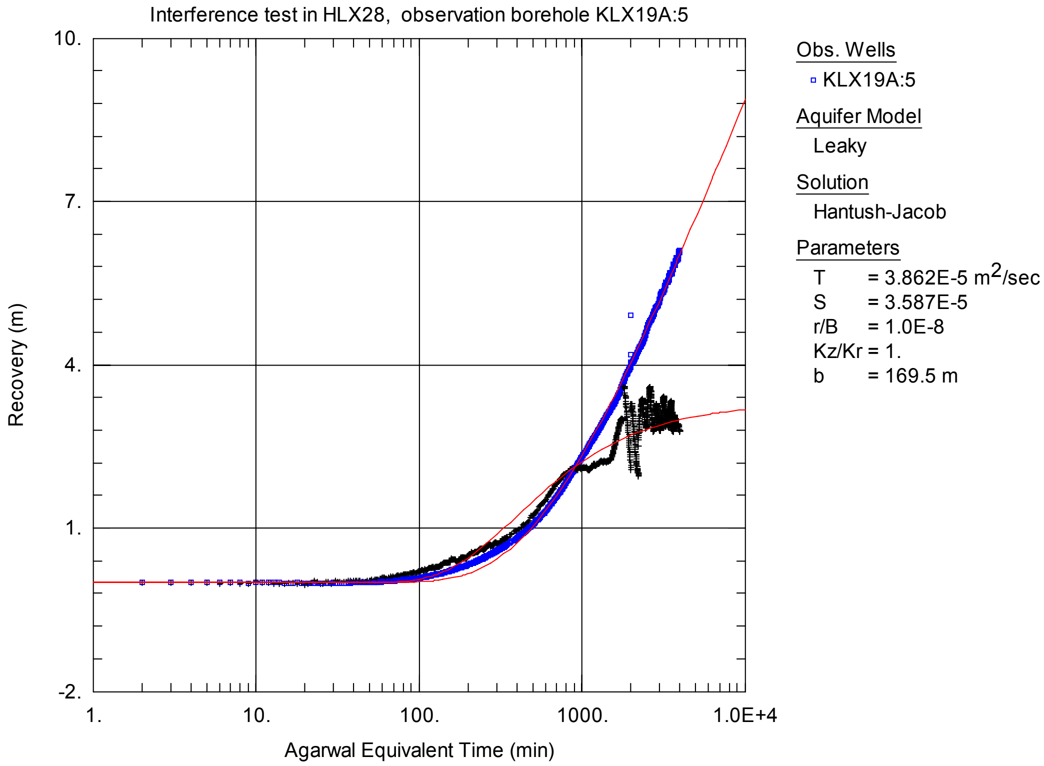


Figure 78. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:5 during pumping in borehole HLX28.*

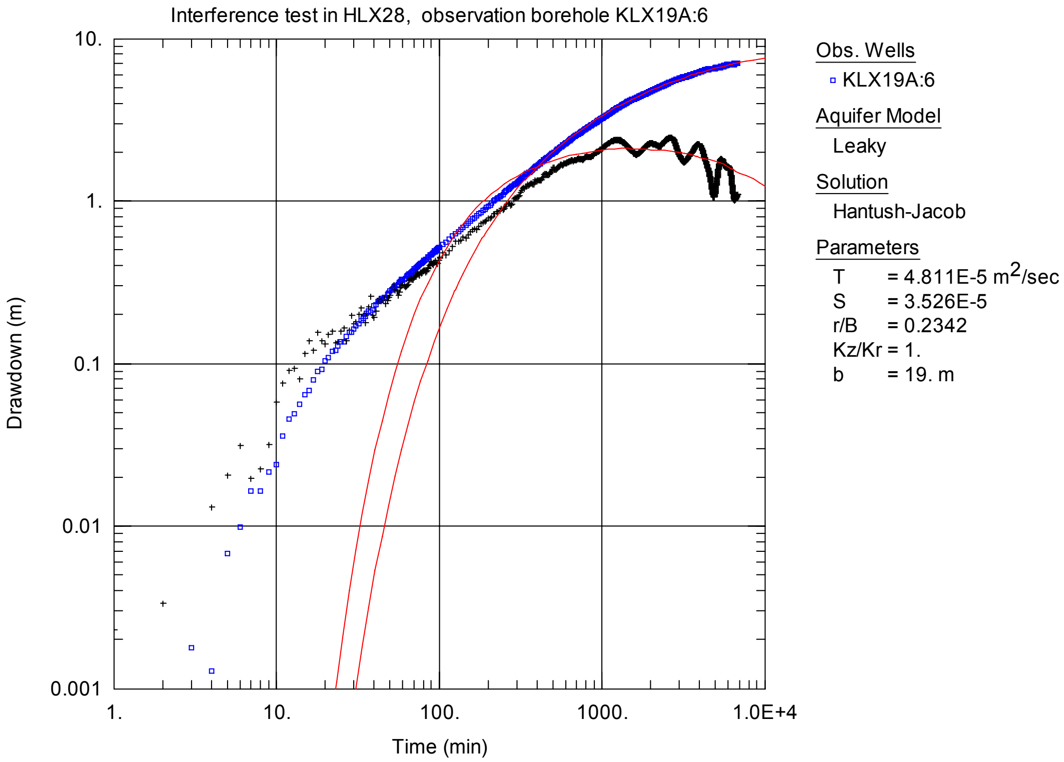


Figure 79. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:6 during pumping in borehole HLX28. The evaluation is based on the late response.*

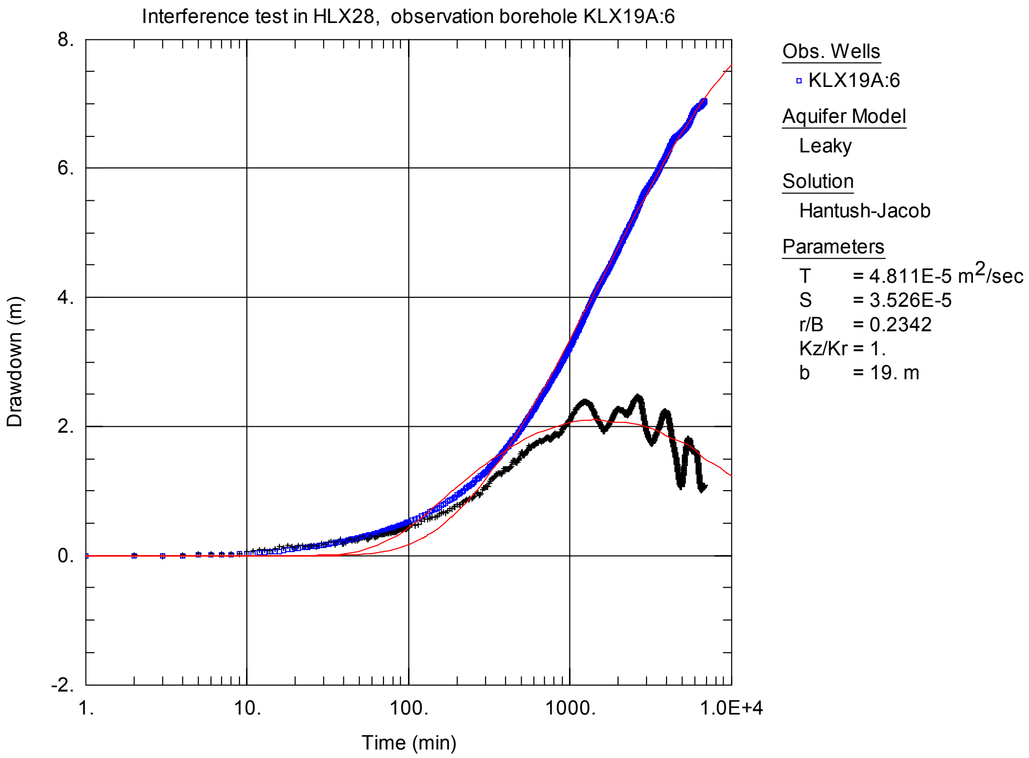


Figure 80. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:6 during pumping in borehole HLX28. The evaluation is based on the late response.*

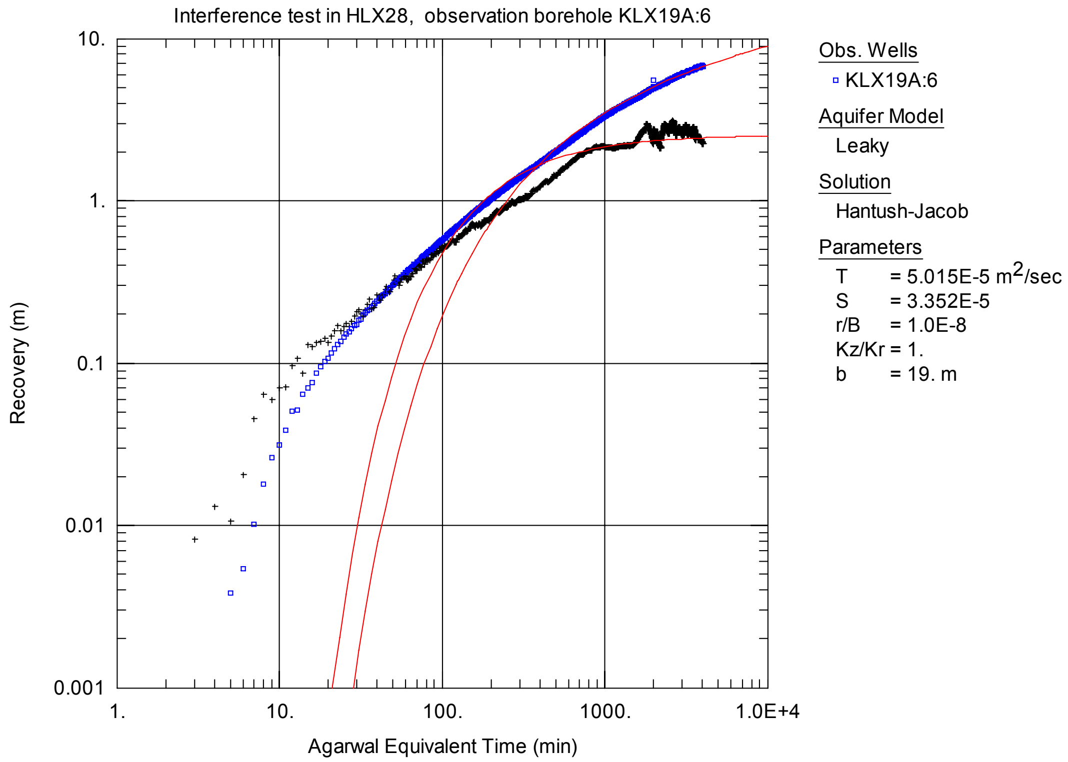


Figure 81. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:6 during pumping in borehole HLX28. The evaluation is based on the late response.*

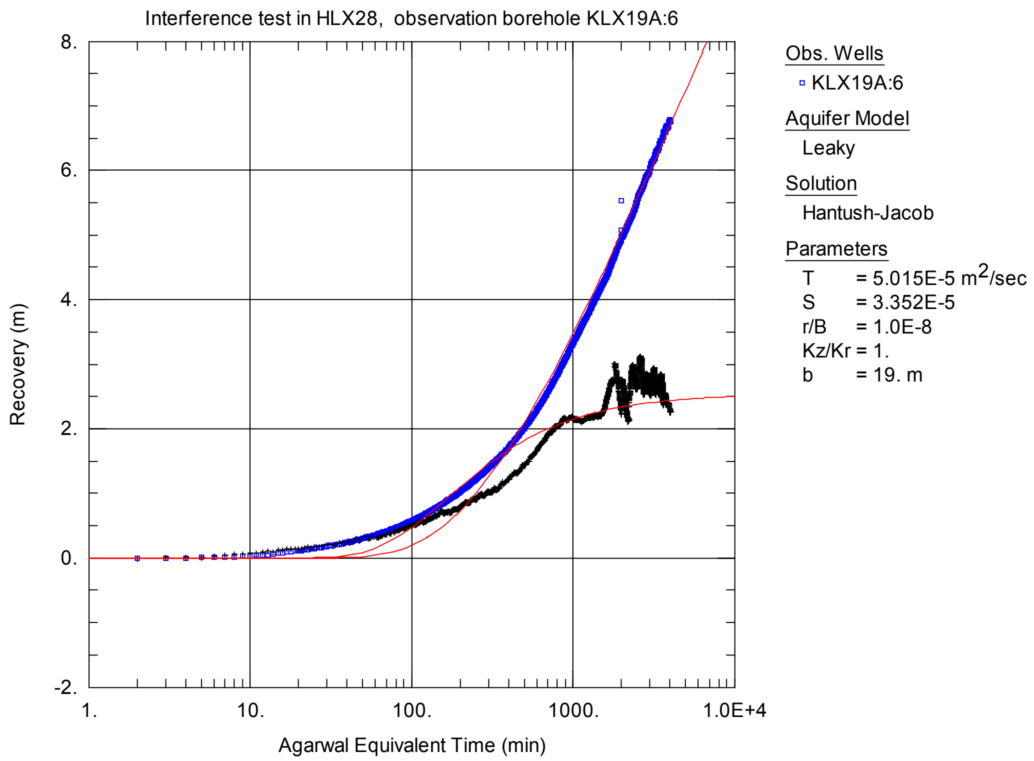


Figure 82. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:6 during pumping in borehole HLX28. The evaluation is based on the late response.*

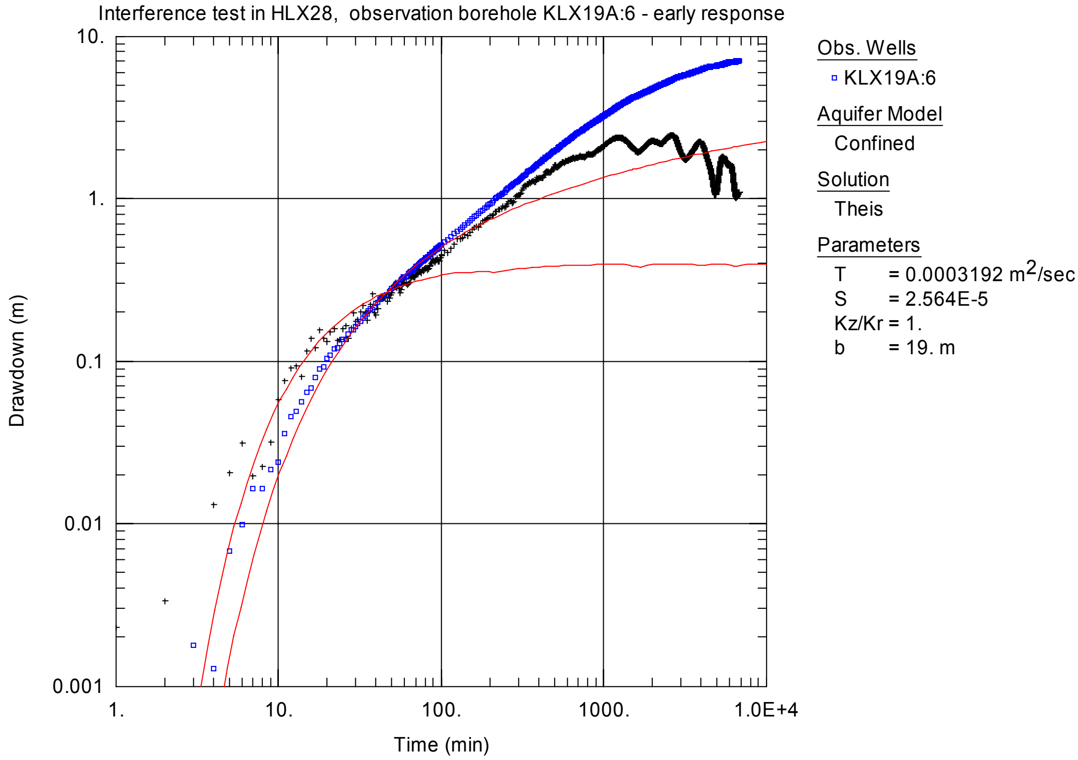


Figure 83. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:6 during pumping in borehole HLX28. The evaluation is based on the early response.*

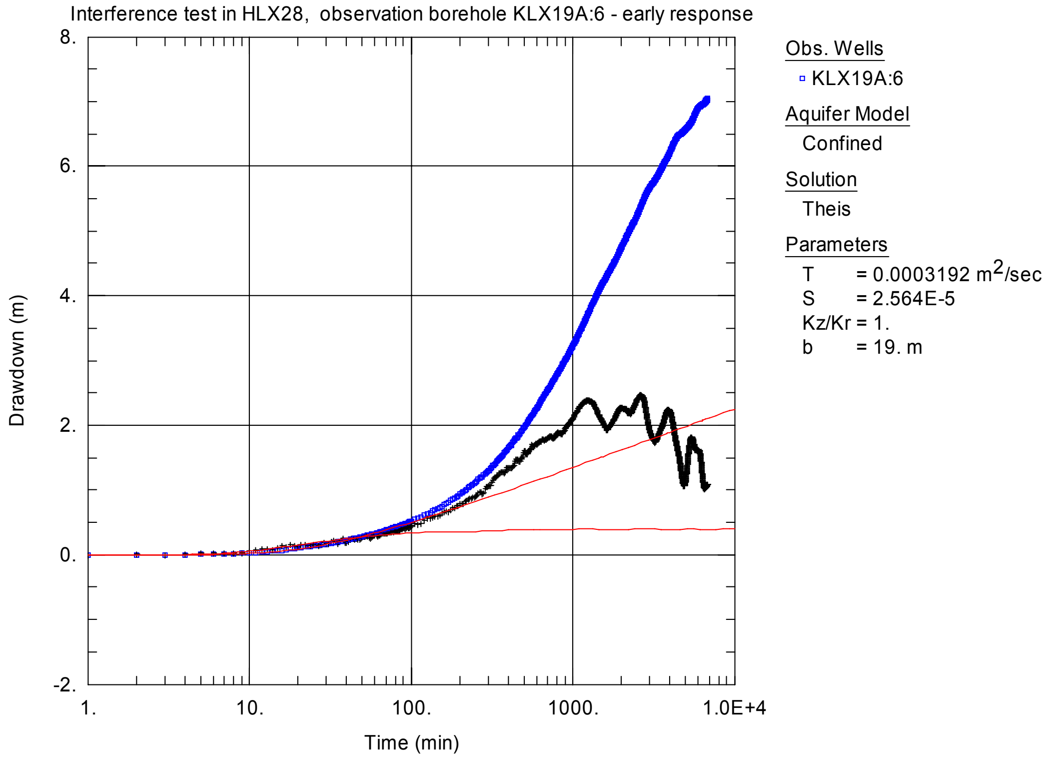


Figure 84. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:6 during pumping in borehole HLX28. The evaluation is based on the early response.*

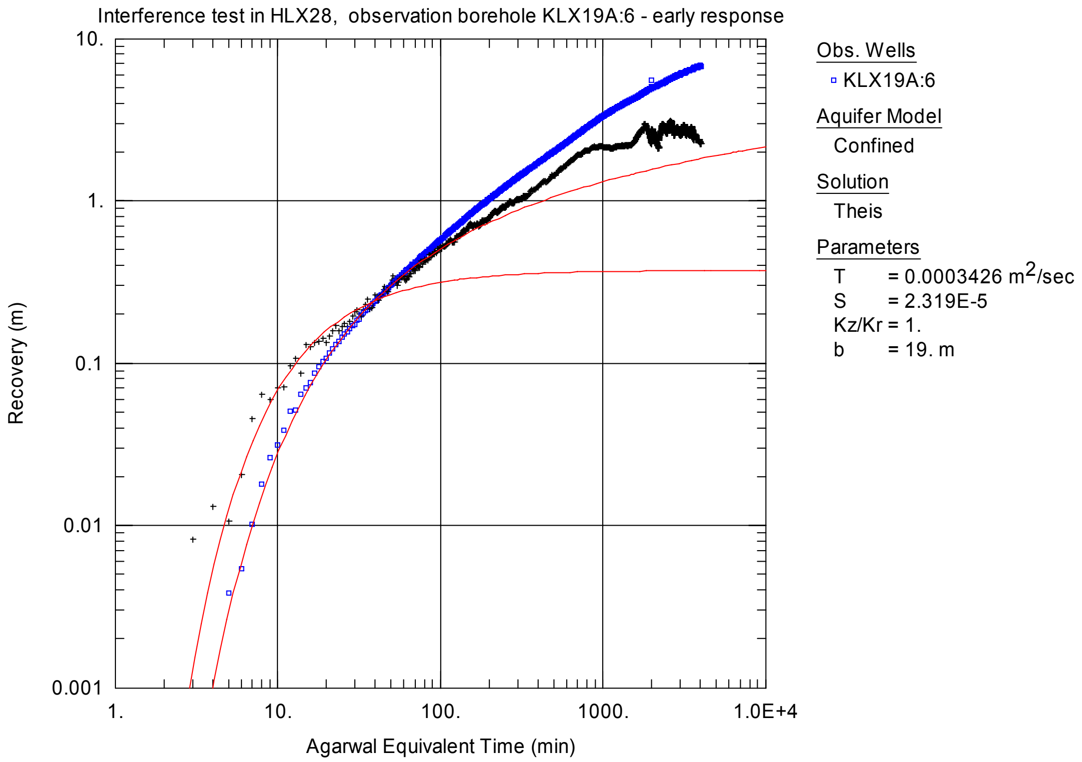


Figure 85. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:6 during pumping in borehole HLX28. The evaluation is based on the early response.*

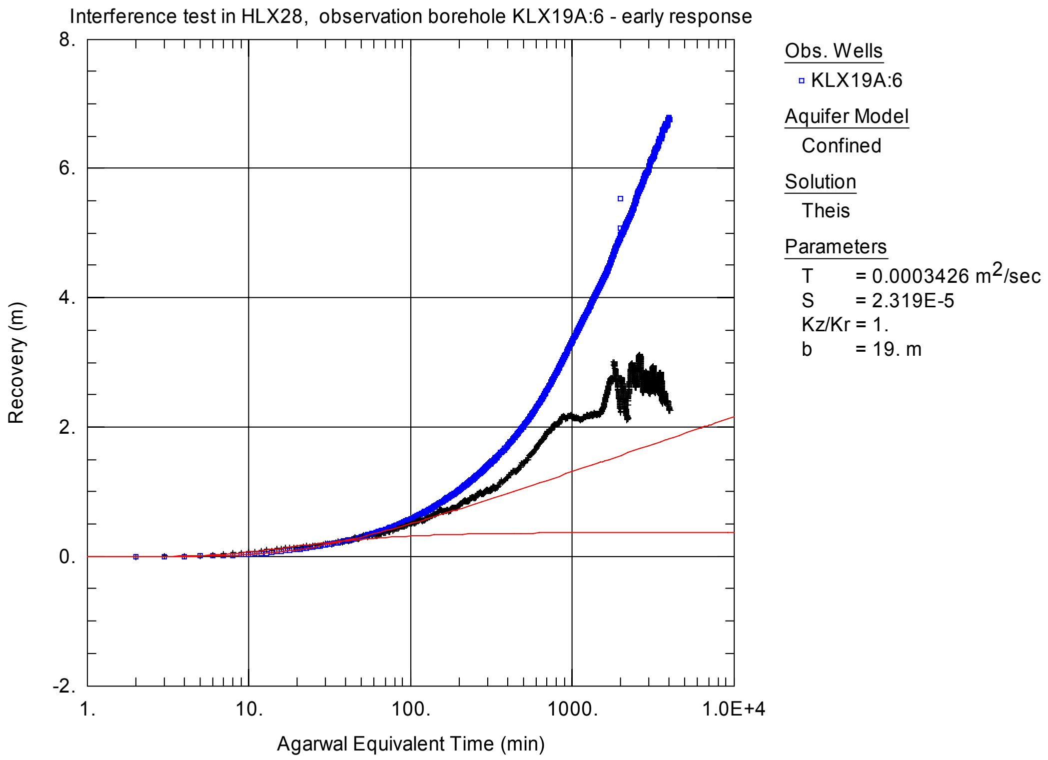


Figure 86. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:6 during pumping in borehole HLX28. The evaluation is based on the early response.*

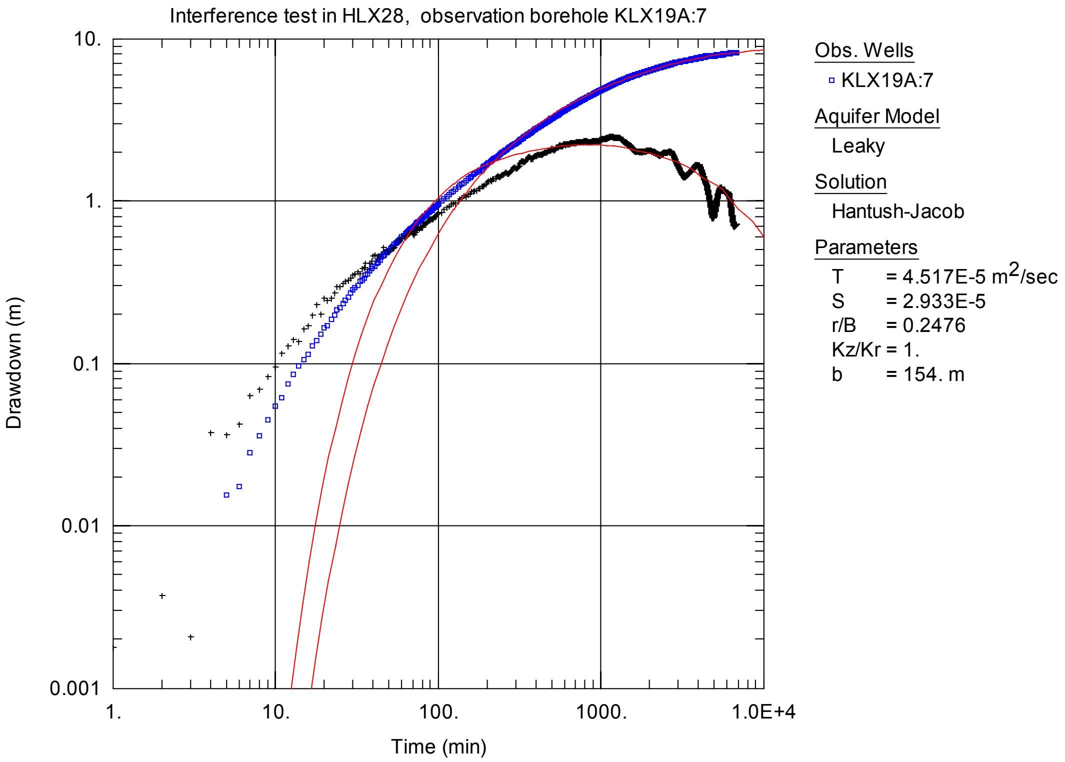


***Figure 87.** Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:7 during pumping in borehole HLX28. The evaluation is based on the late response.*

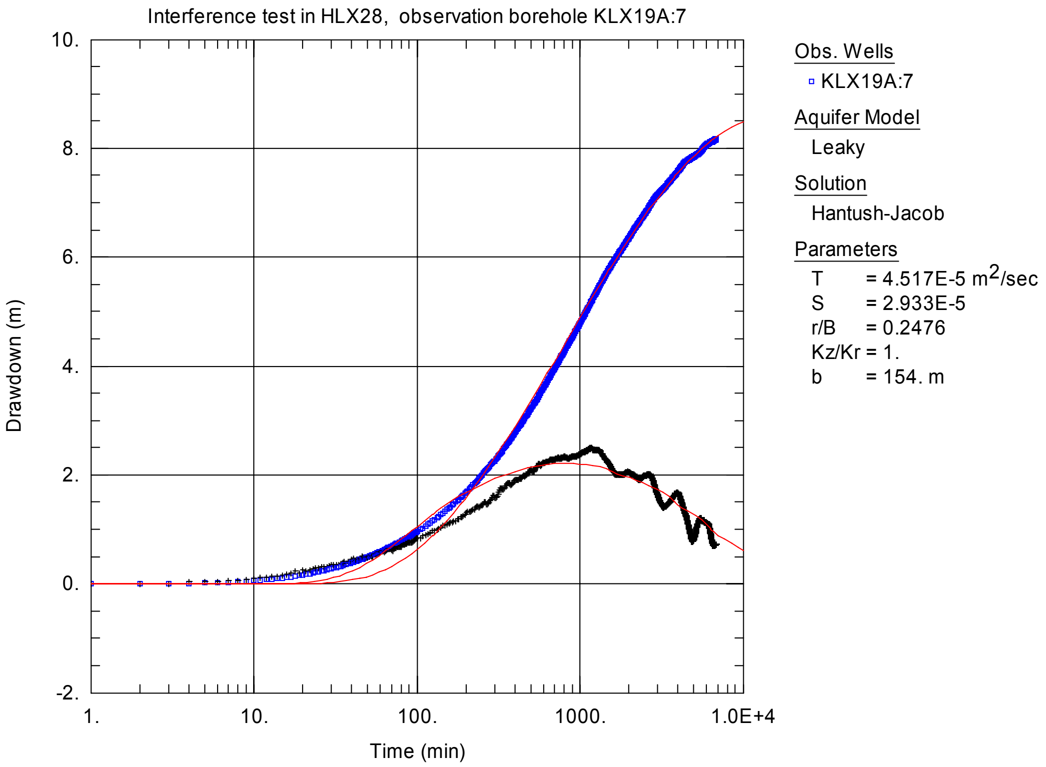


***Figure 88.** Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:7 during pumping in borehole HLX28. The evaluation is based on the late response.*

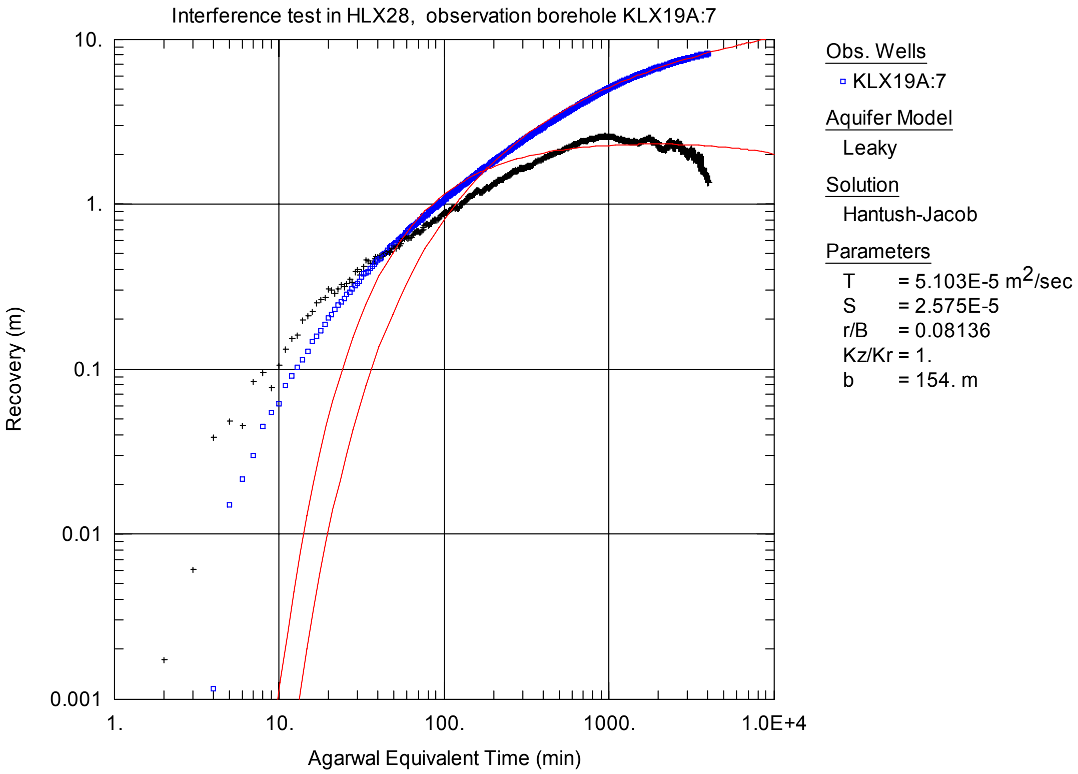


Figure 89. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:7 during pumping in borehole HLX28. The evaluation is based on the late response.*

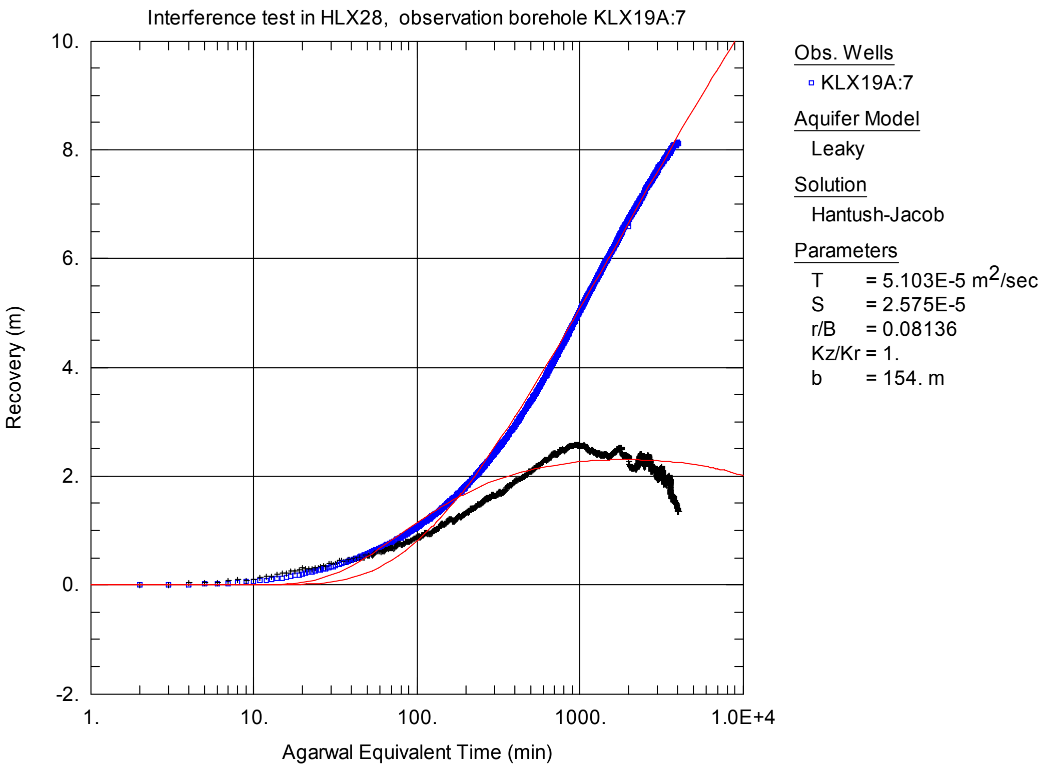


Figure 90. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:7 during pumping in borehole HLX28. The evaluation is based on the late response.*

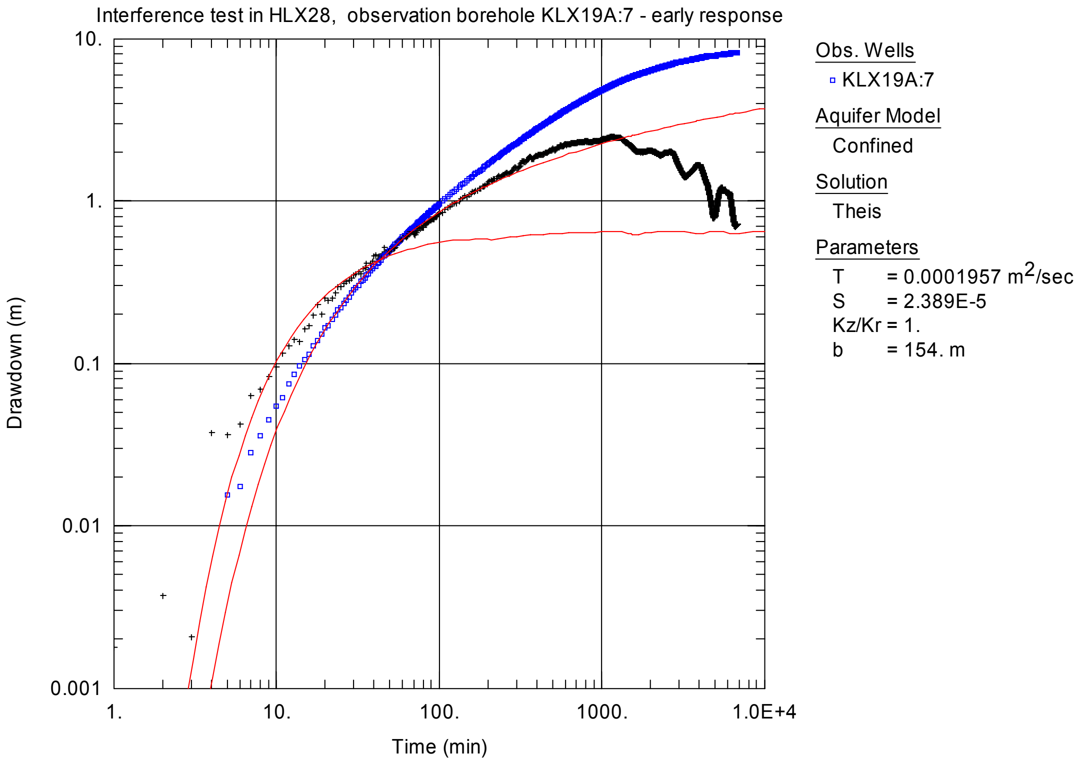


Figure 91. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:7 during pumping in borehole HLX28. The evaluation is based on the early response.*

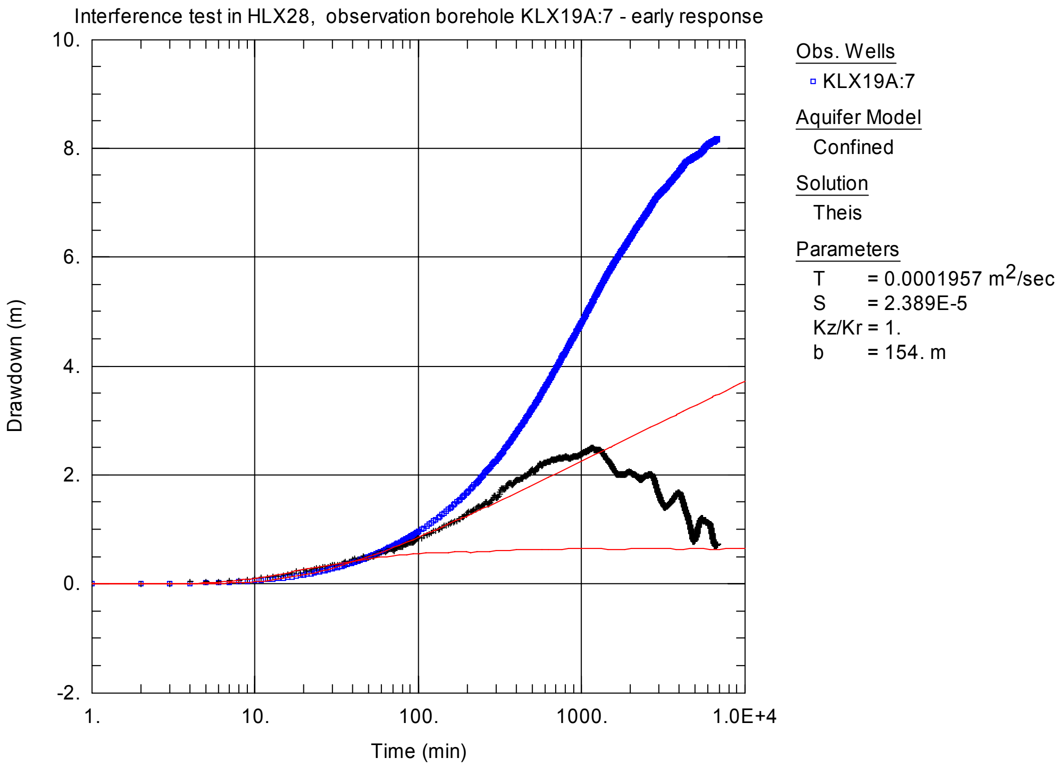


Figure 92. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:7 during pumping in borehole HLX28. The evaluation is based on the early response.*

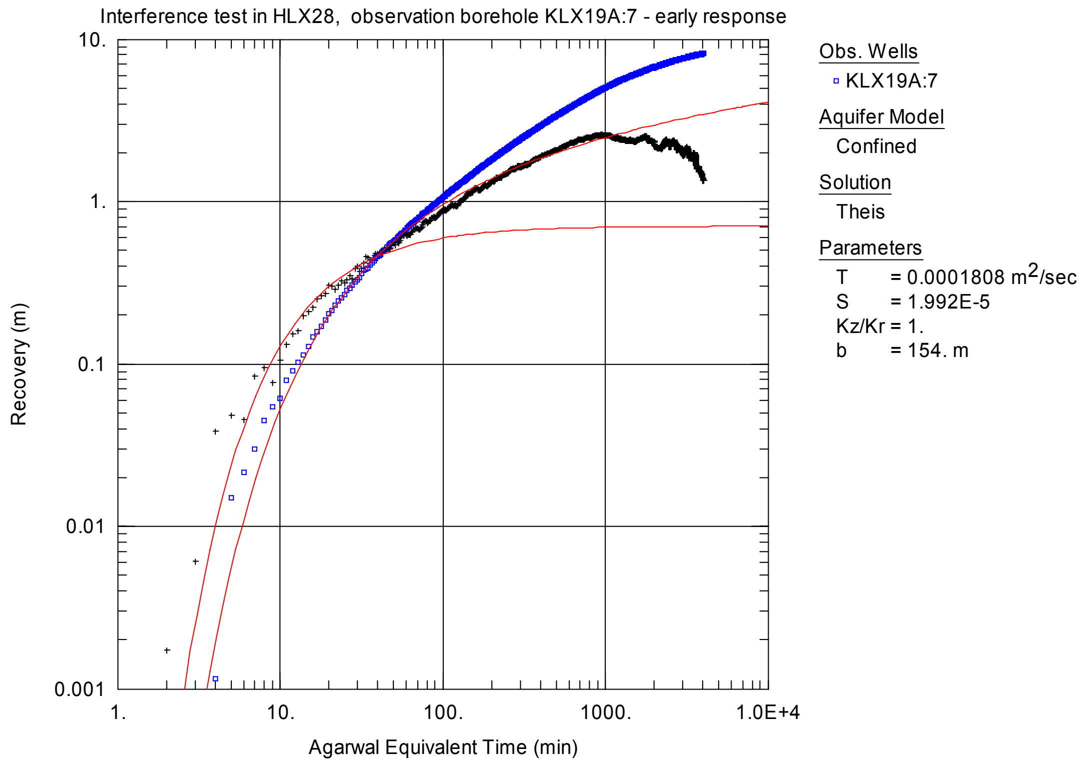


Figure 93. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:7 during pumping in borehole HLX28. The evaluation is based on the early response.*

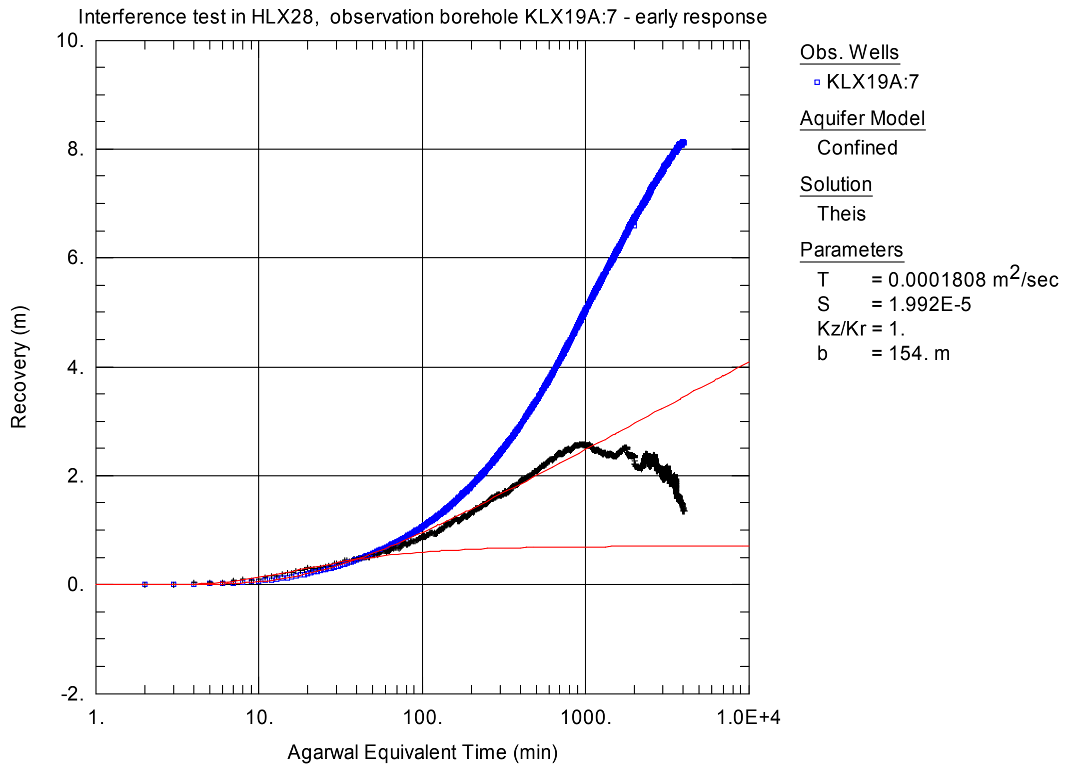


Figure 94. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:7 during pumping in borehole HLX28. The evaluation is based on the early response.*

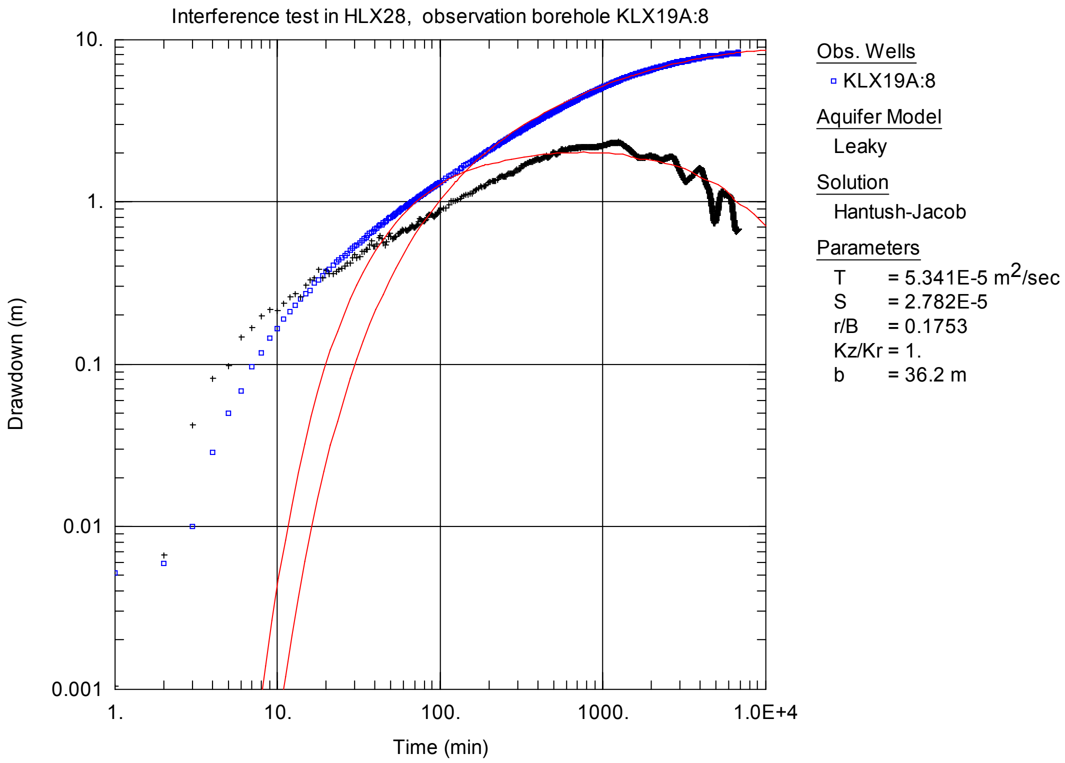


***Figure 95.** Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:8 during pumping in borehole HLX28. The evaluation is based on the late response.*

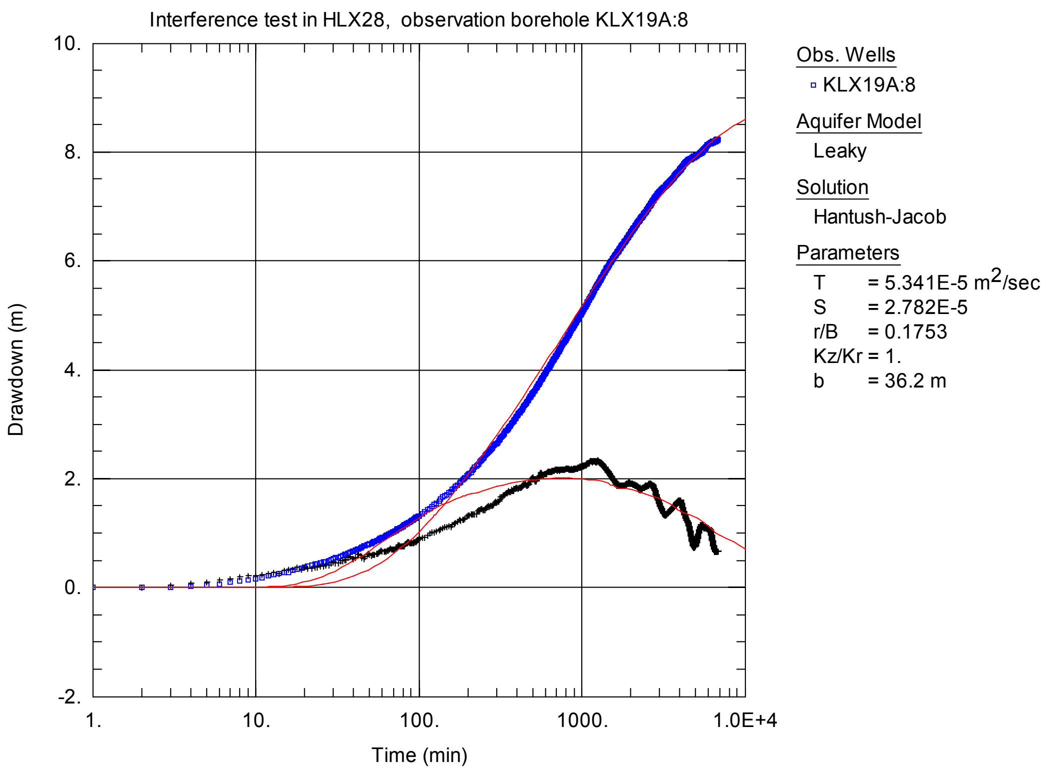


***Figure 96.** Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:8 during pumping in borehole HLX28. The evaluation is based on the late response.*

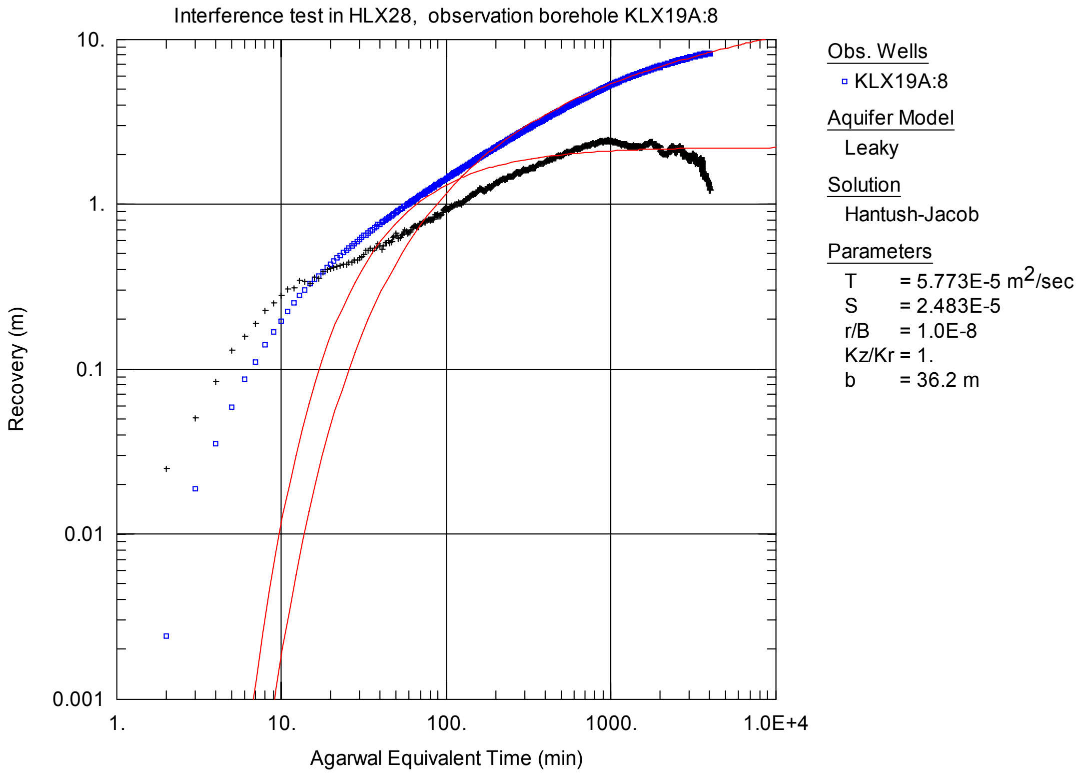


Figure 97. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:8 during pumping in borehole HLX28. The evaluation is based on the late response.*

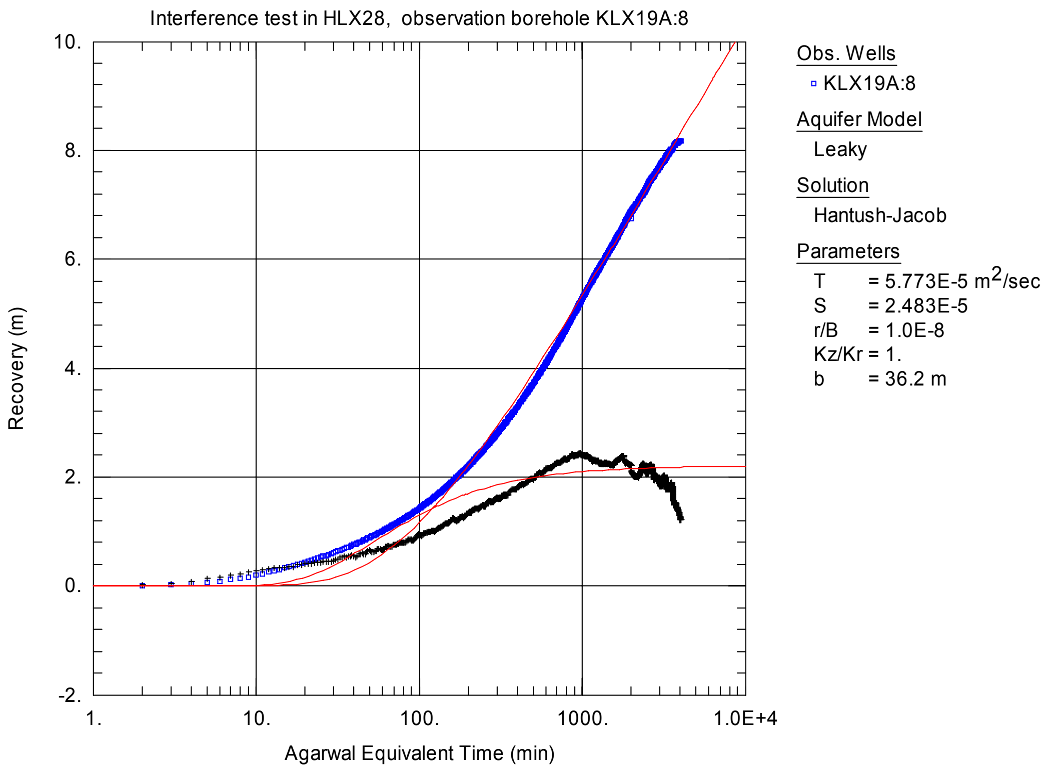


Figure 98. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:8 during pumping in borehole HLX28. The evaluation is based on the late response.*

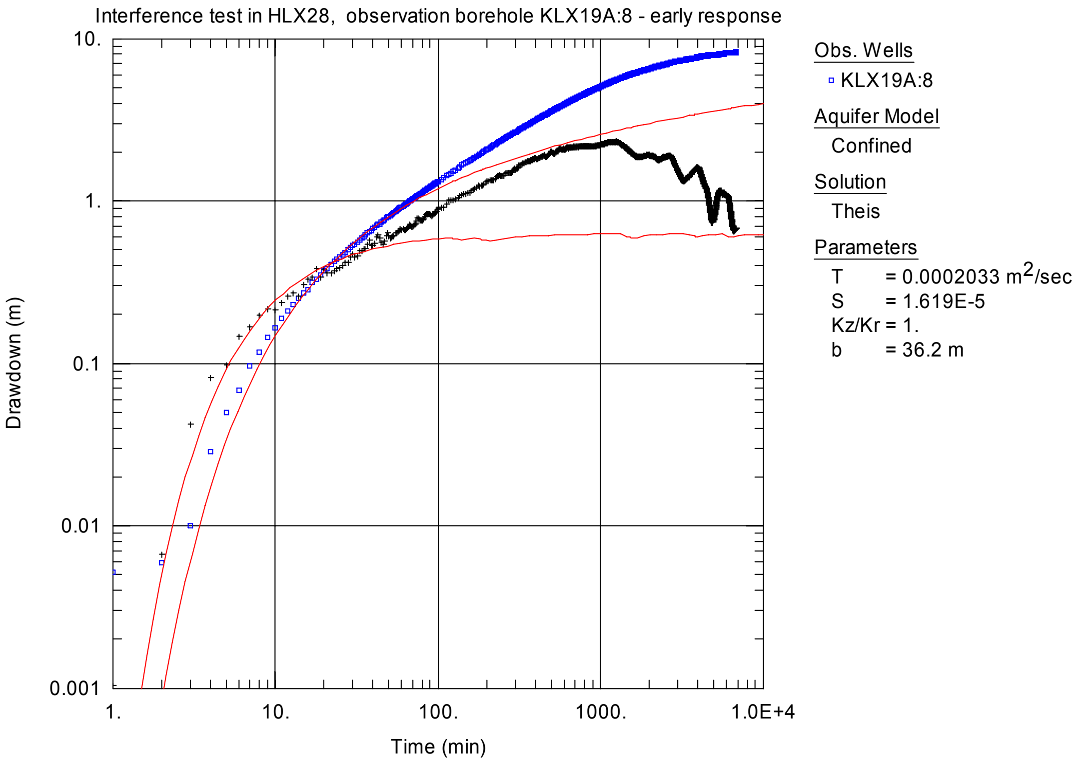


Figure 99. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:8 during pumping in borehole HLX28. The evaluation is based on the early response.*

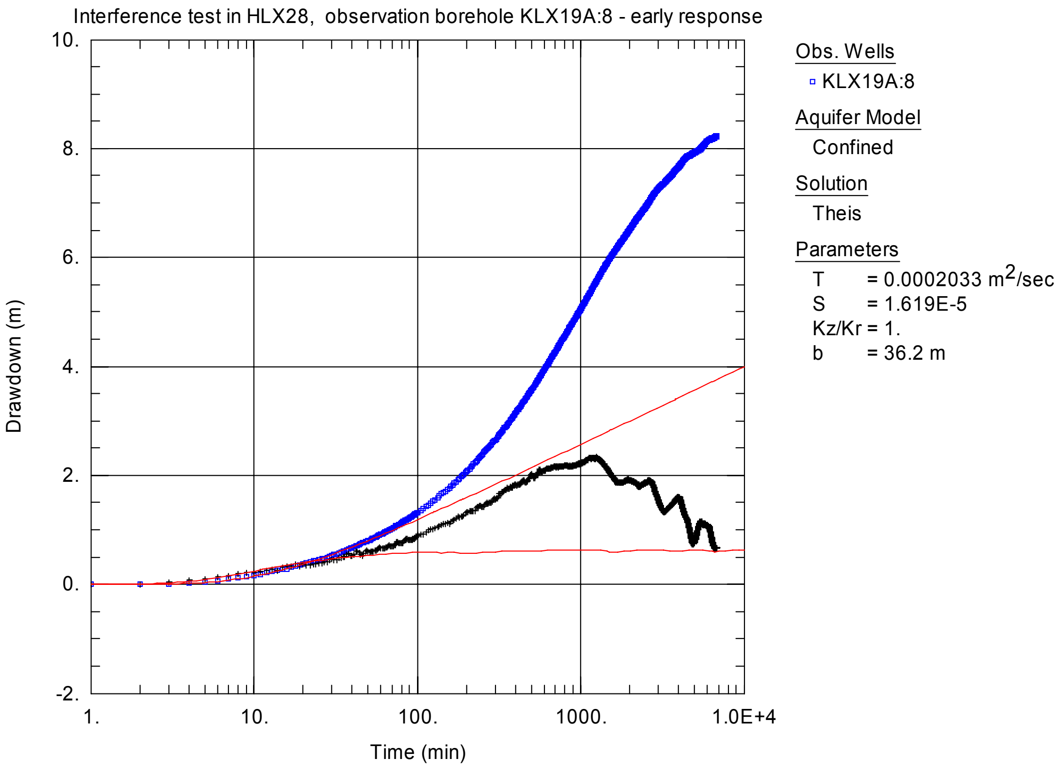


Figure 100. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole KLX19A:8 during pumping in borehole HLX28. The evaluation is based on the early response.*

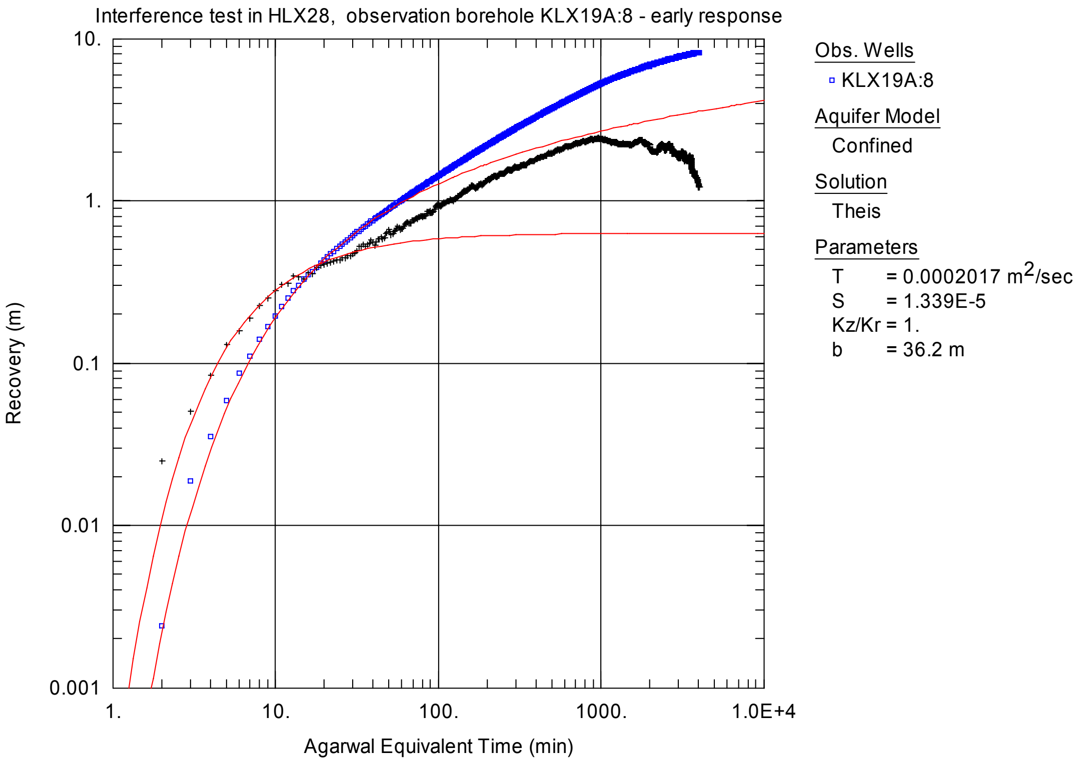


Figure 101. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:8 during pumping in borehole HLX28. The evaluation is based on the early response.*

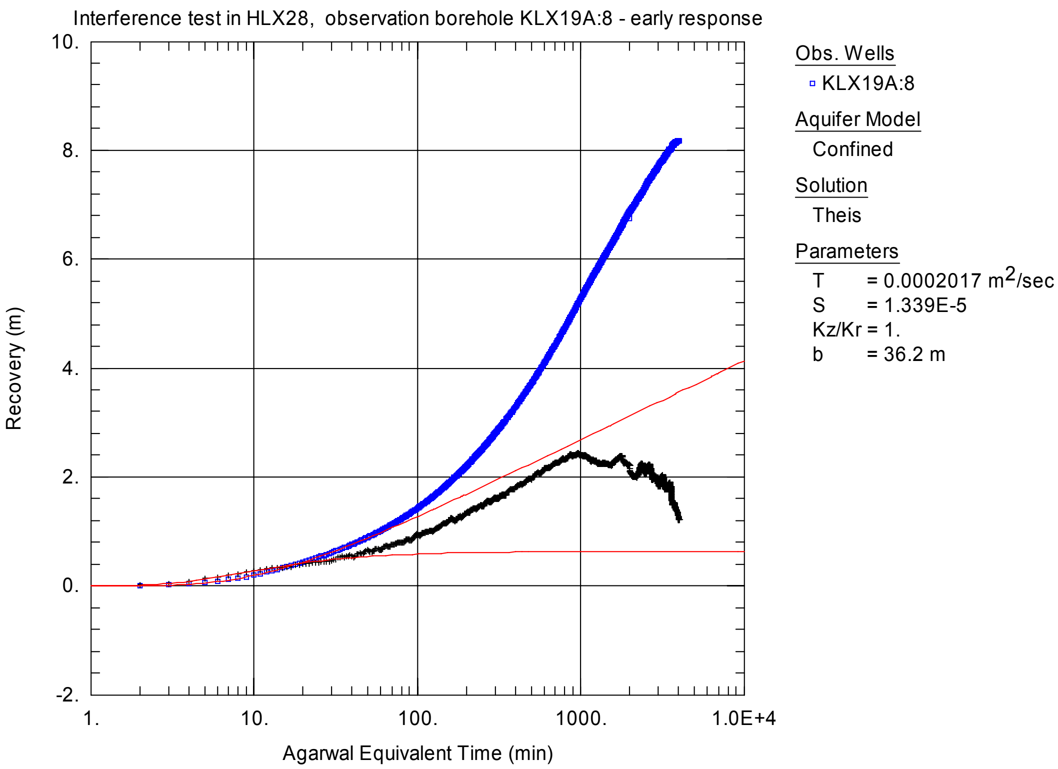


Figure 102. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole KLX19A:8 during pumping in borehole HLX28. The evaluation is based on the early response.*

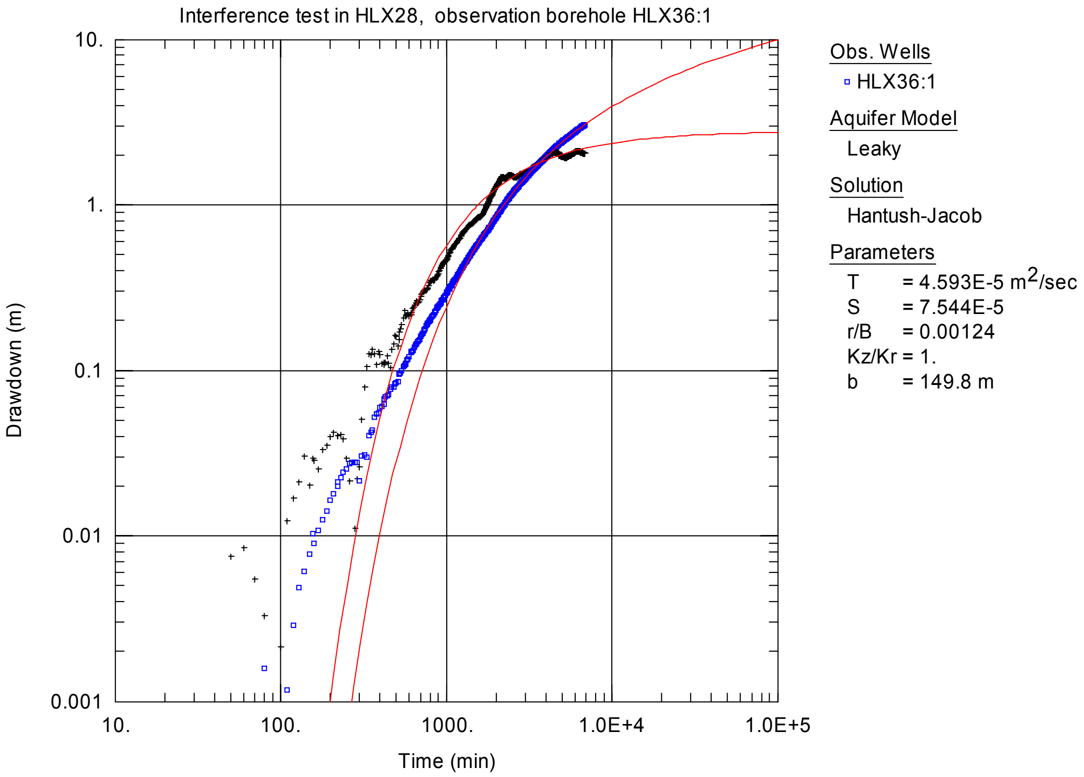


Figure 103. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

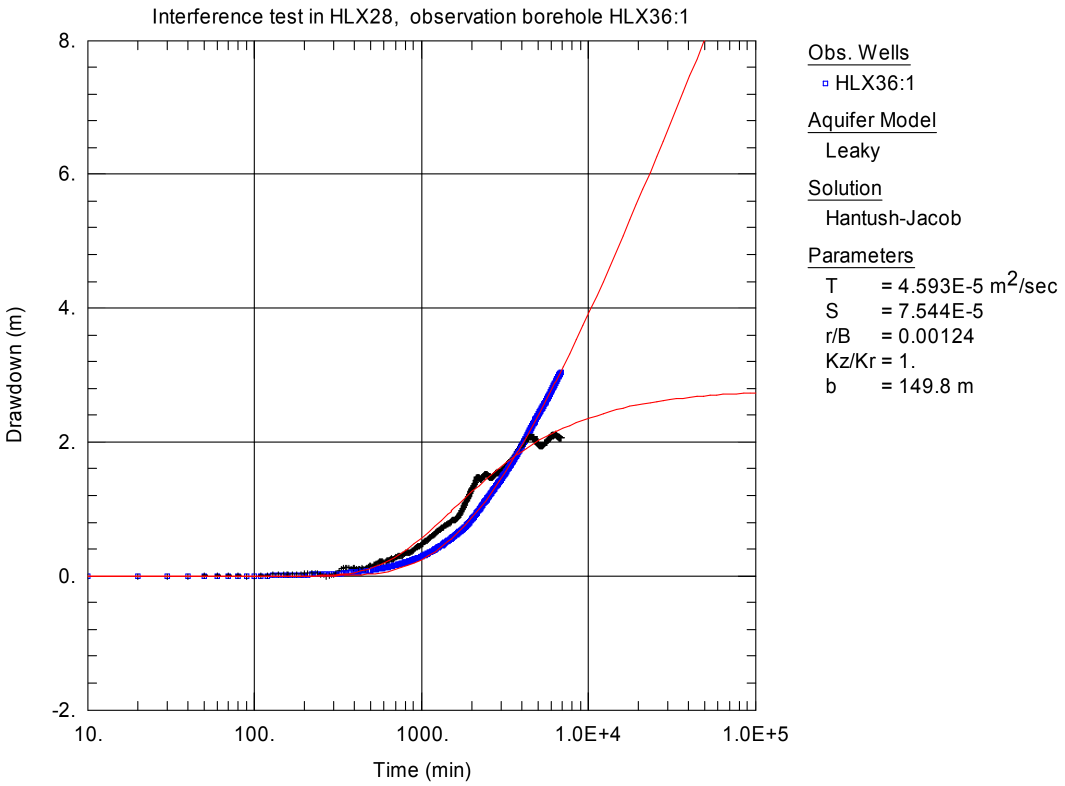


Figure 104. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

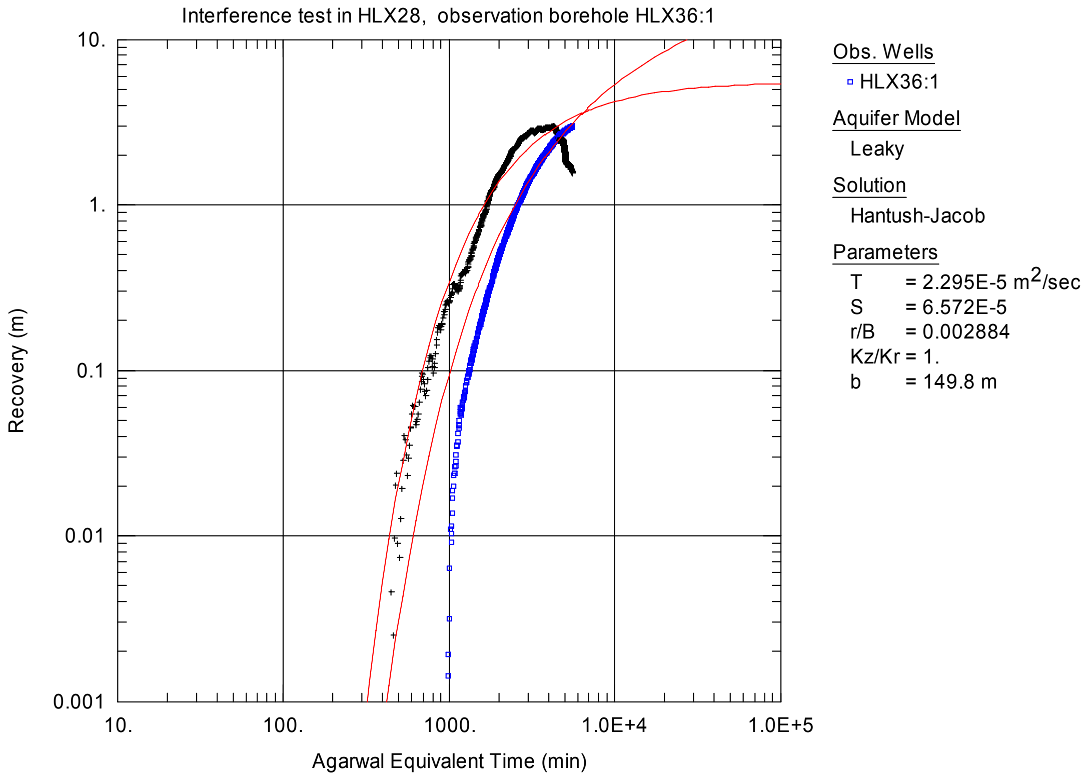


Figure 105. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

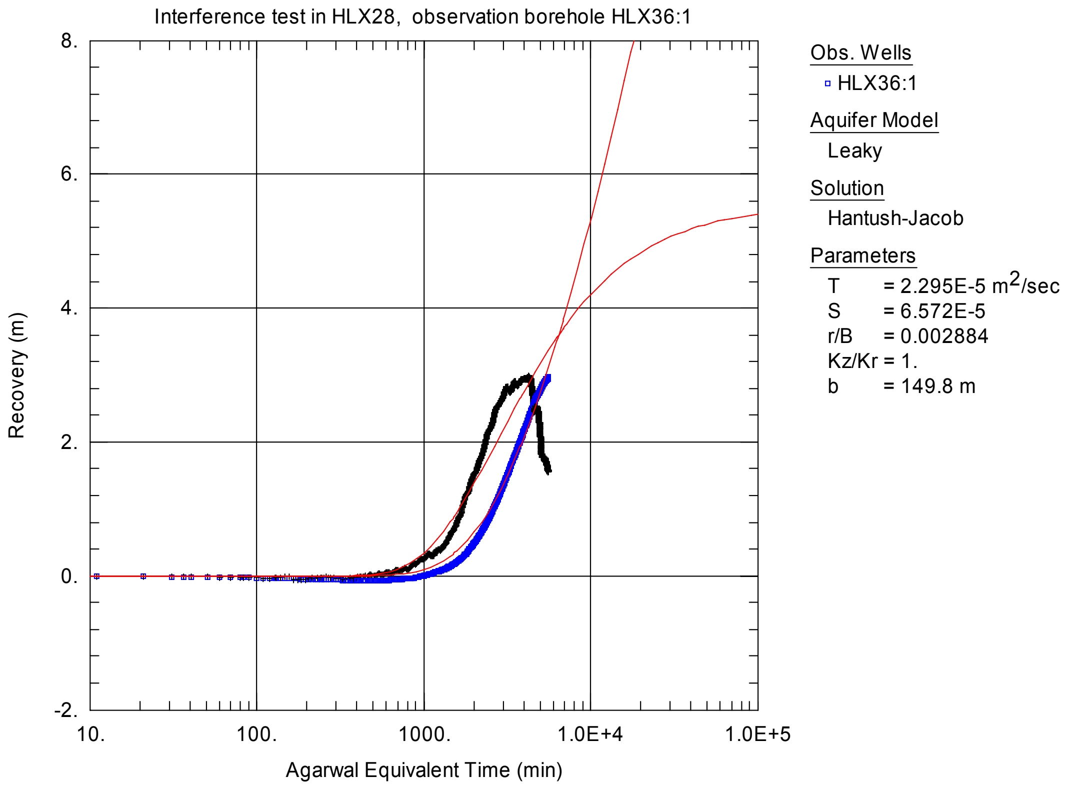


Figure 106. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

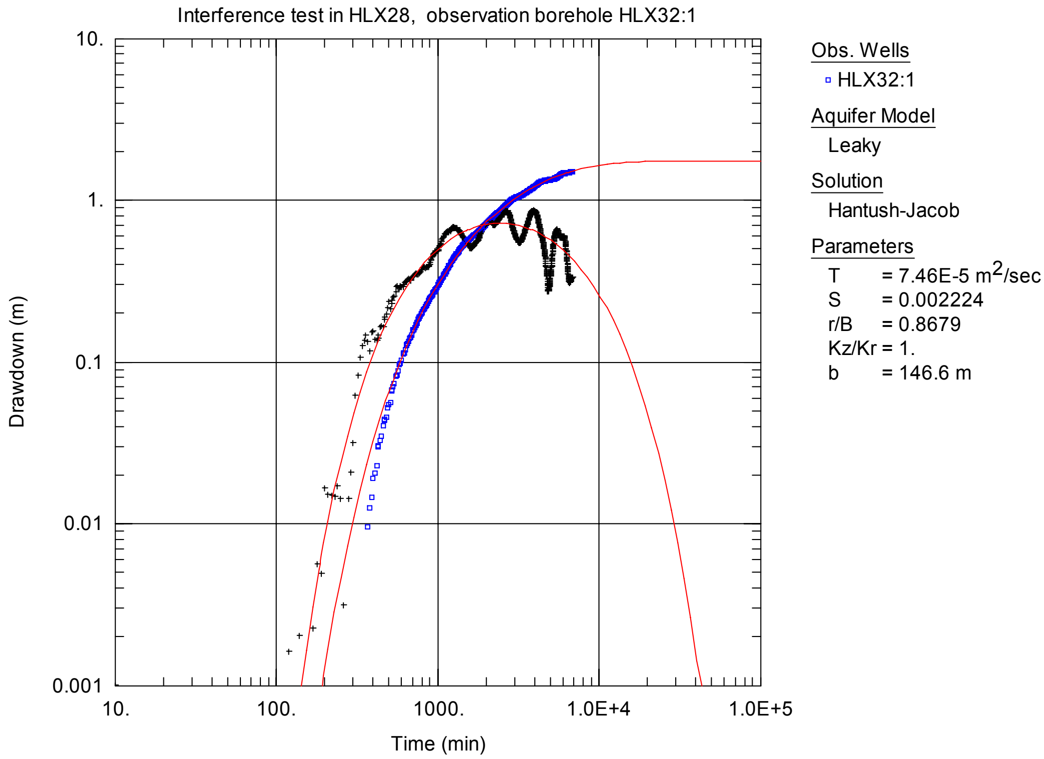


Figure 107. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

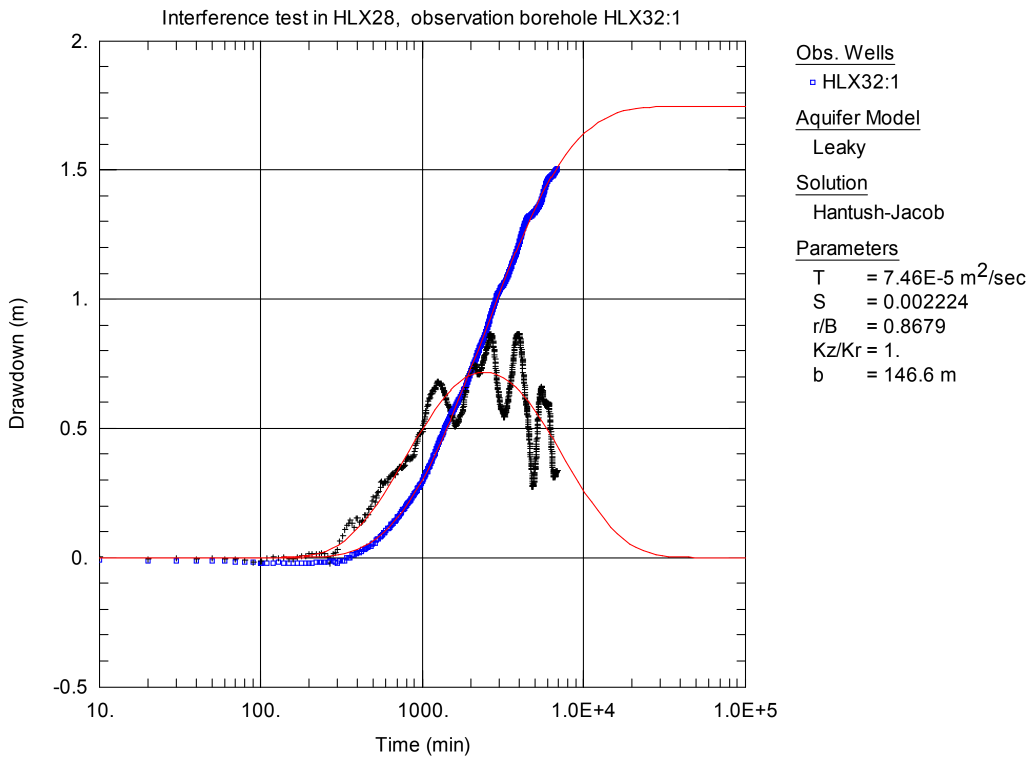


Figure 108. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

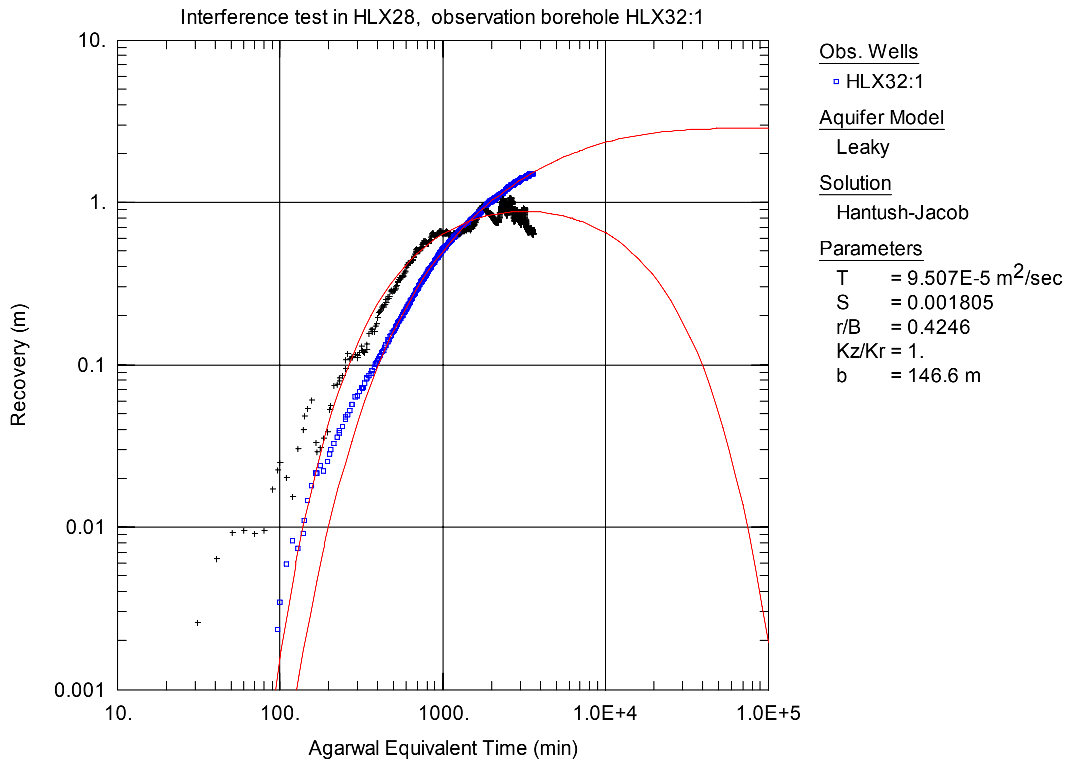


Figure 109. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

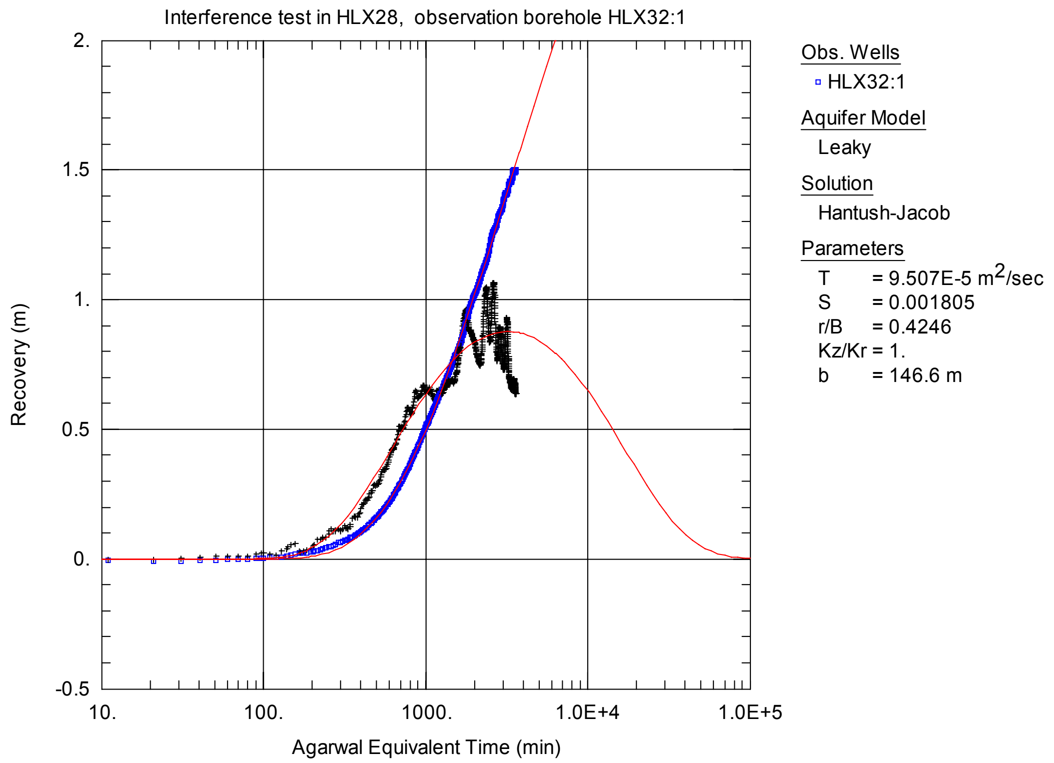


Figure 110. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

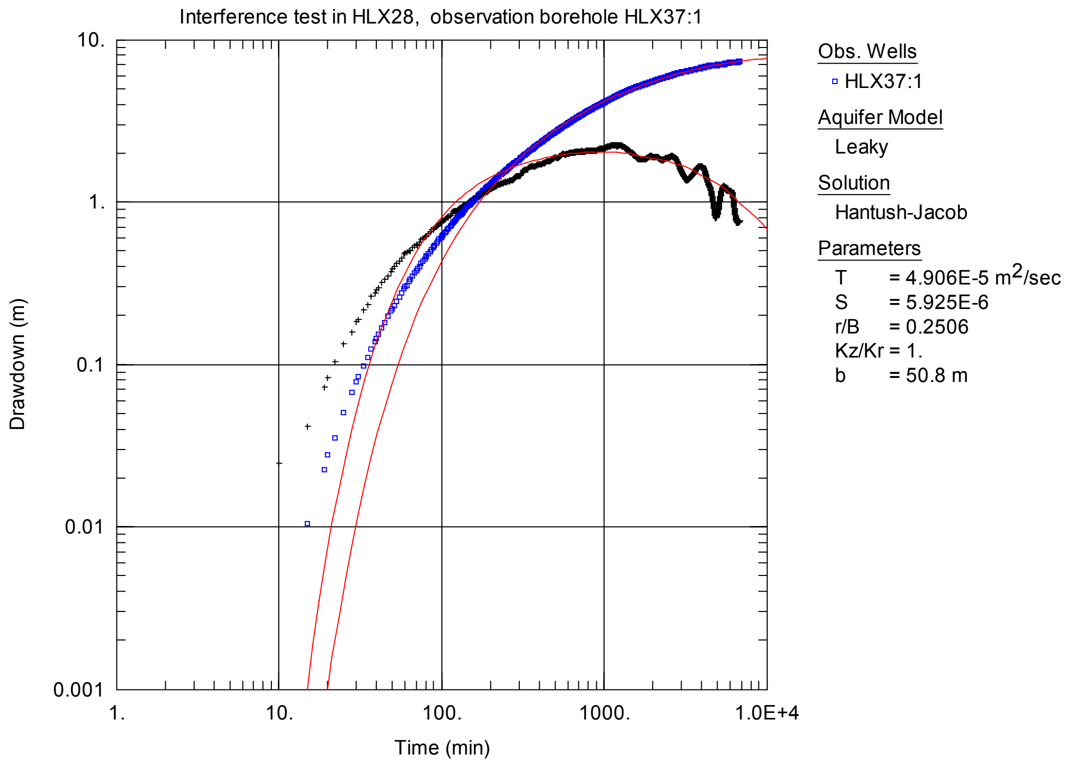


Figure 111. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

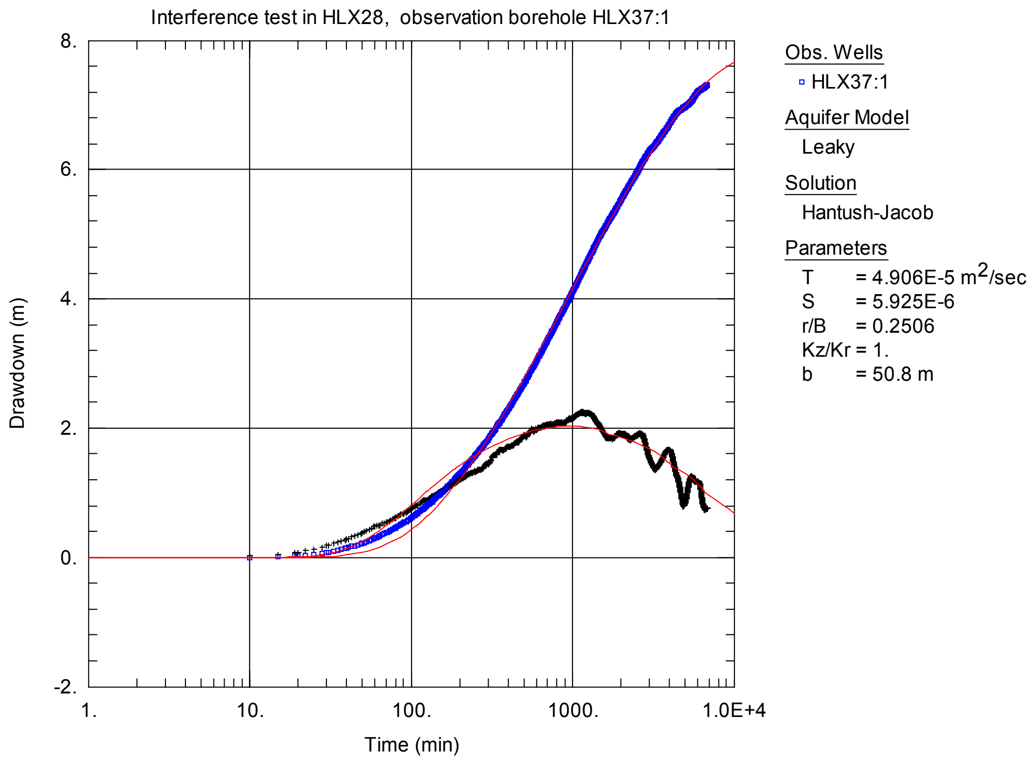


Figure 112. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

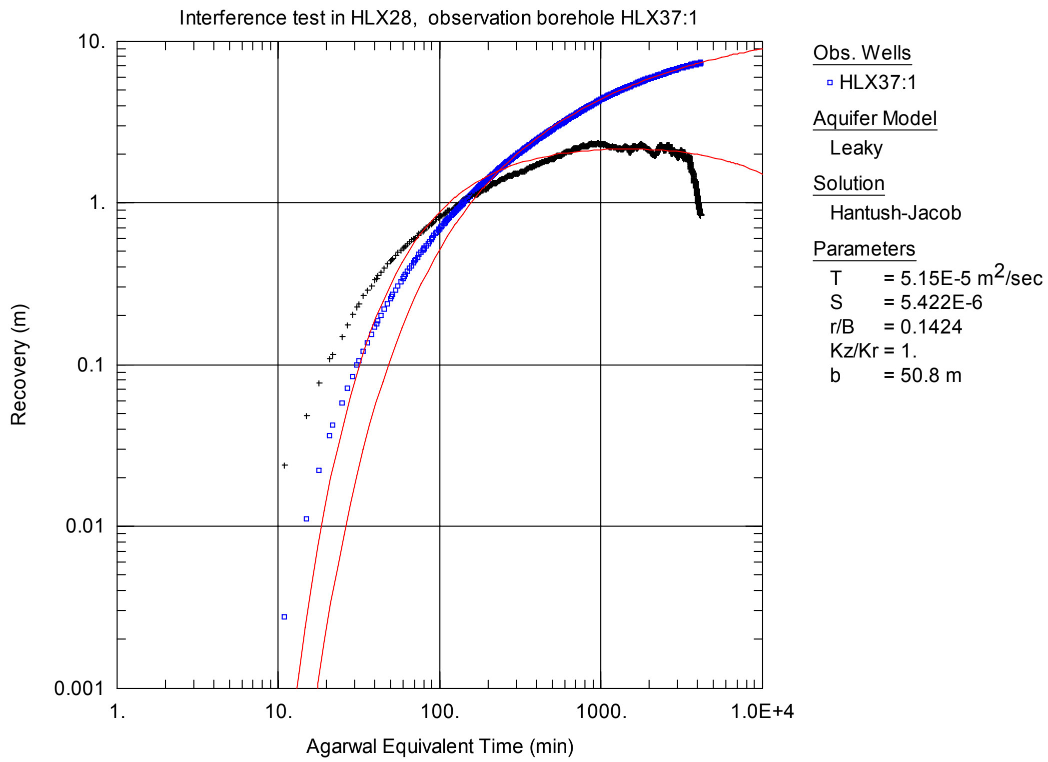


Figure 113. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

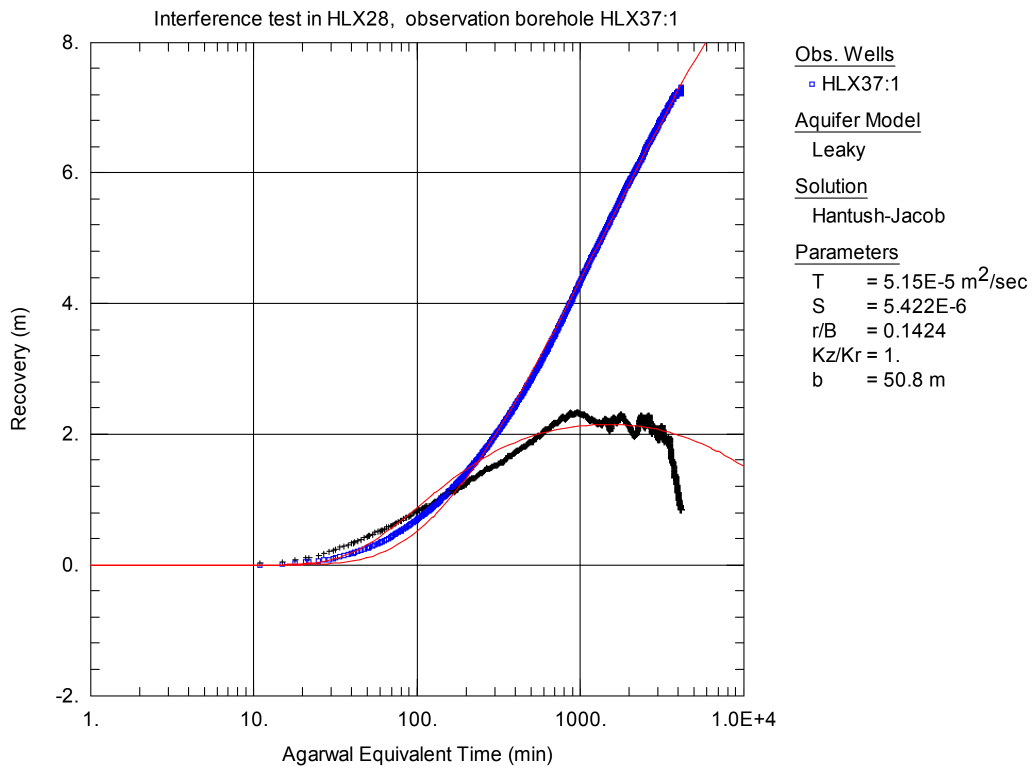


Figure 114. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

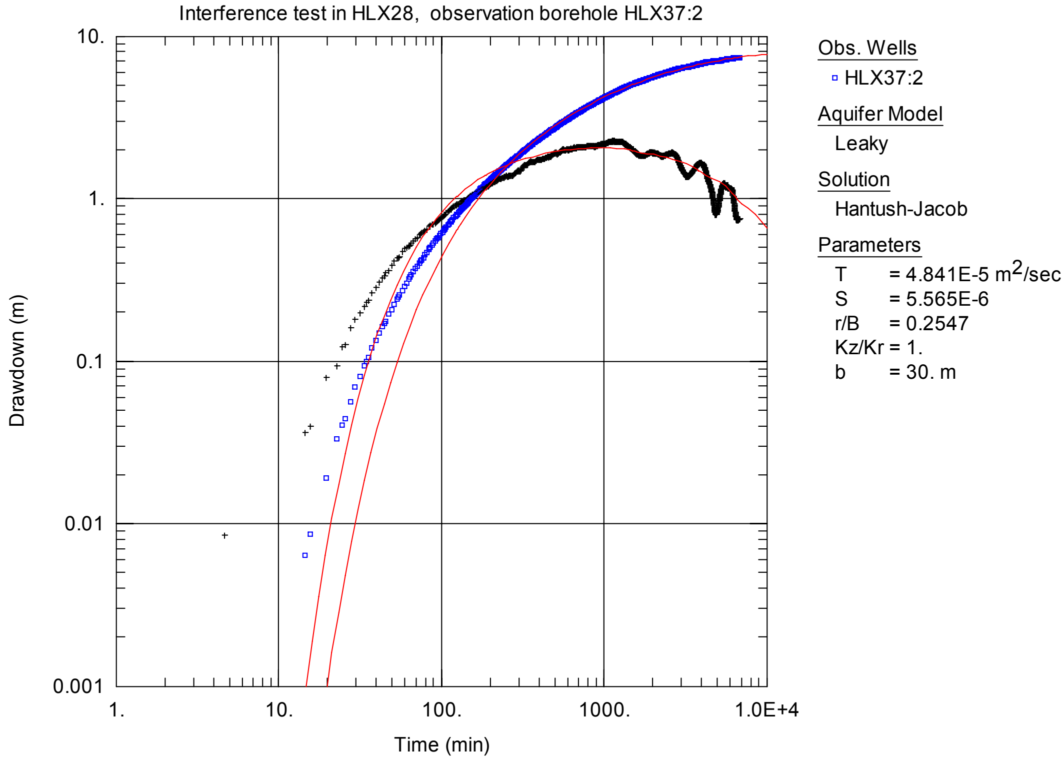


Figure 115. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

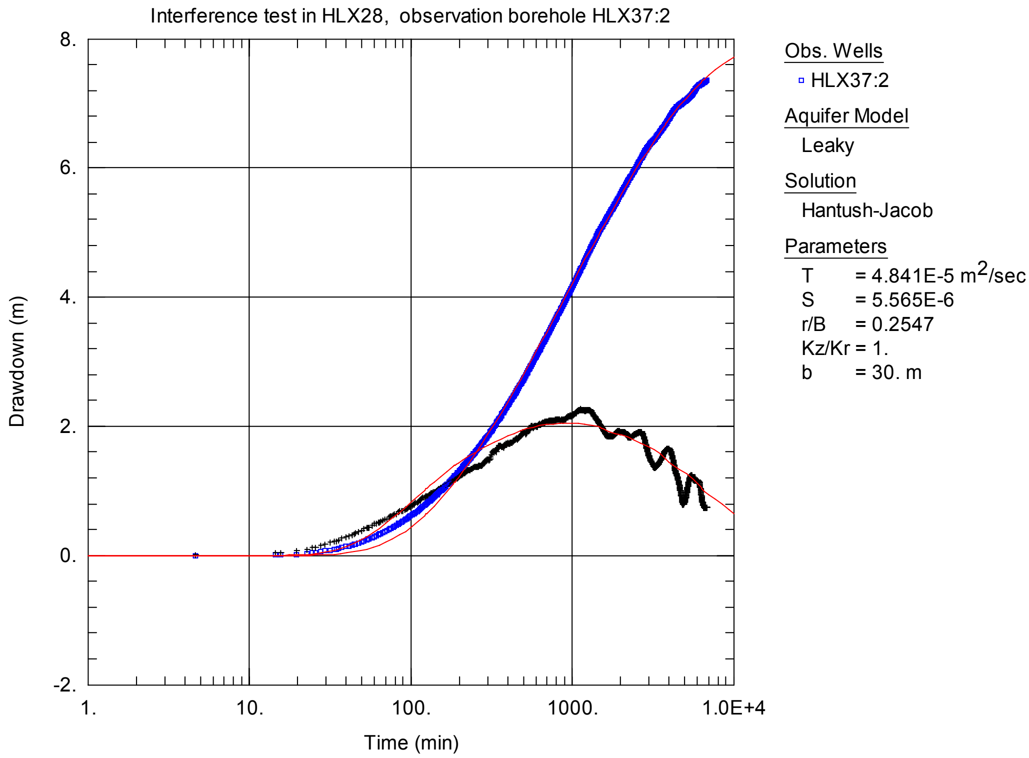


Figure 116. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

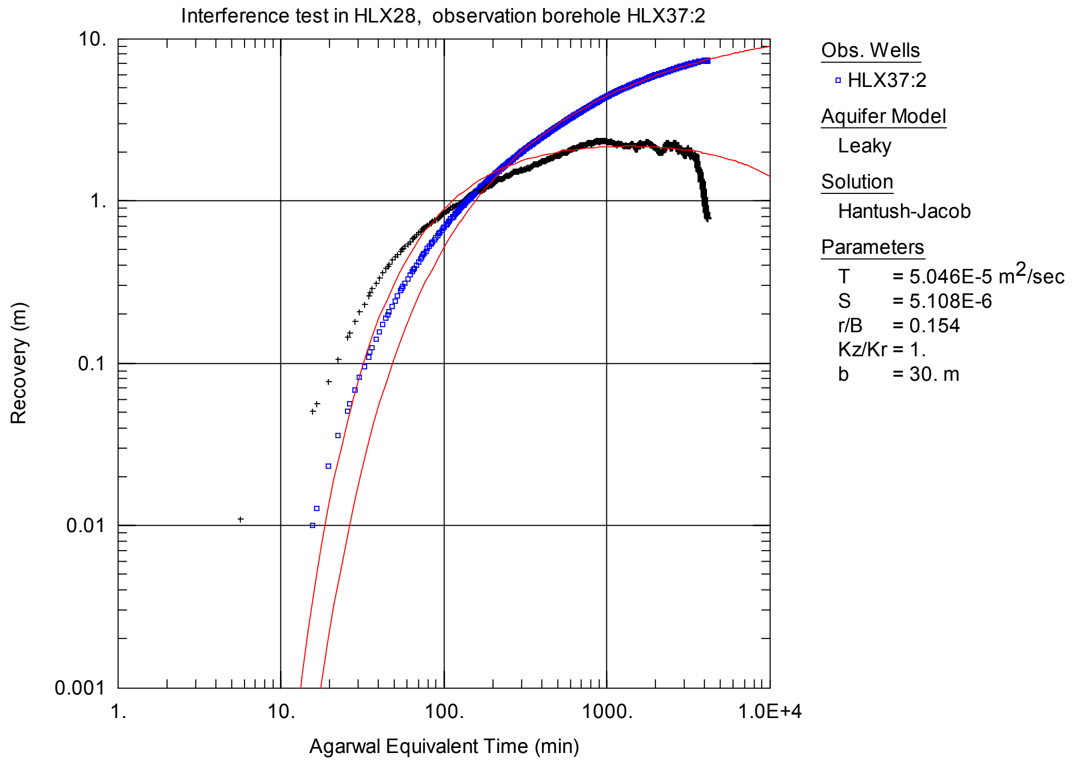


Figure 117. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

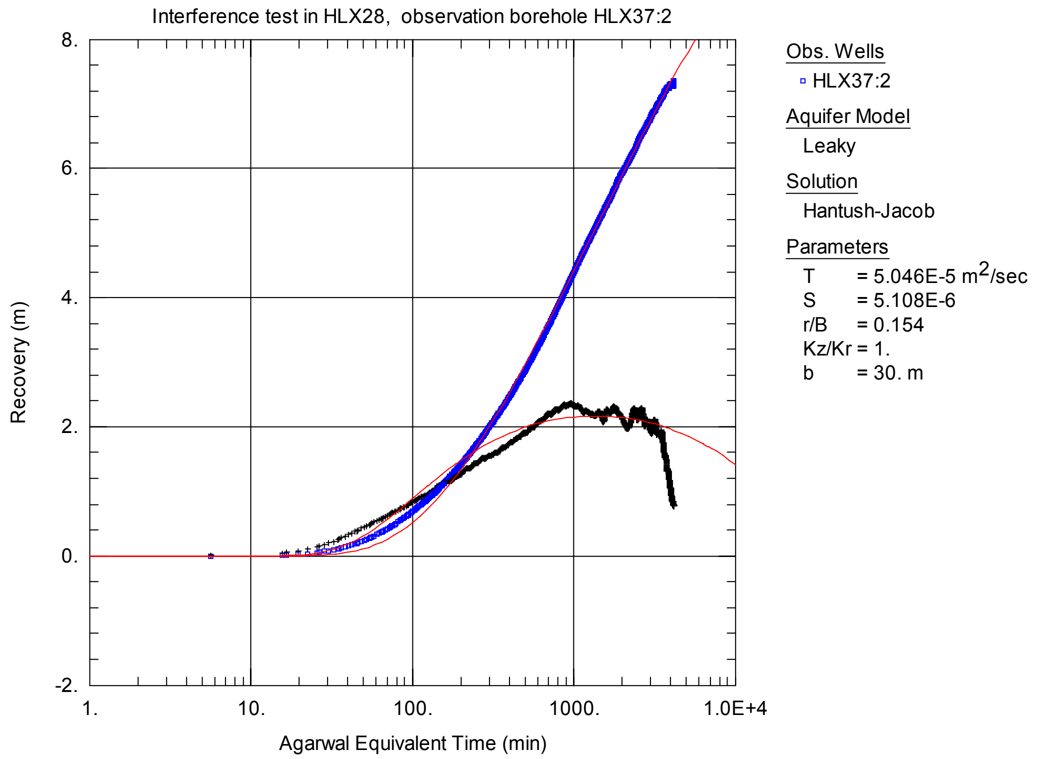


Figure 118. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

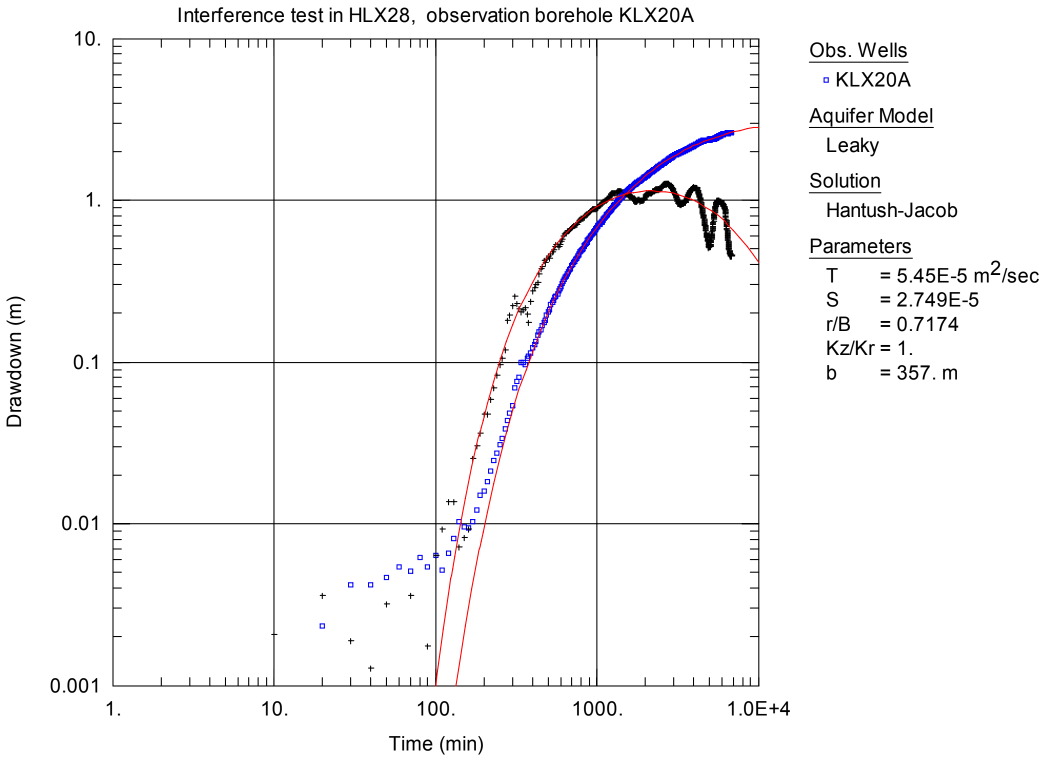


Figure 119. *Log-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

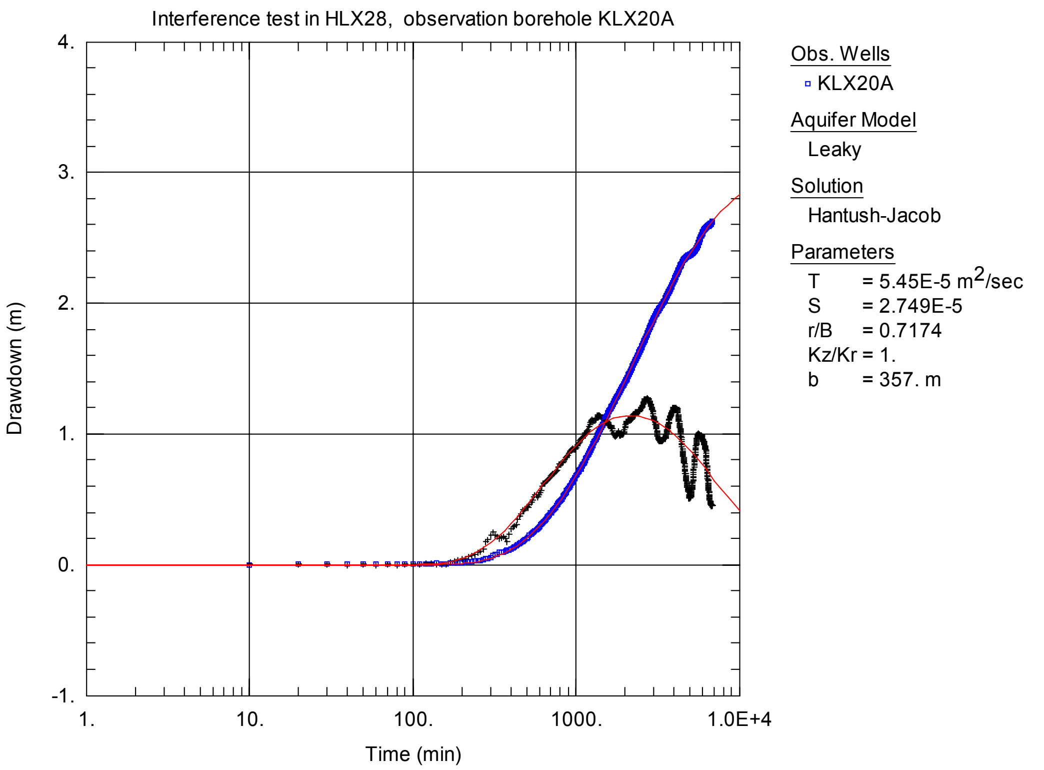


Figure 120. *Lin-log plot of drawdown (blue □) and drawdown derivative (black +) versus time together with simulated curves (red) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

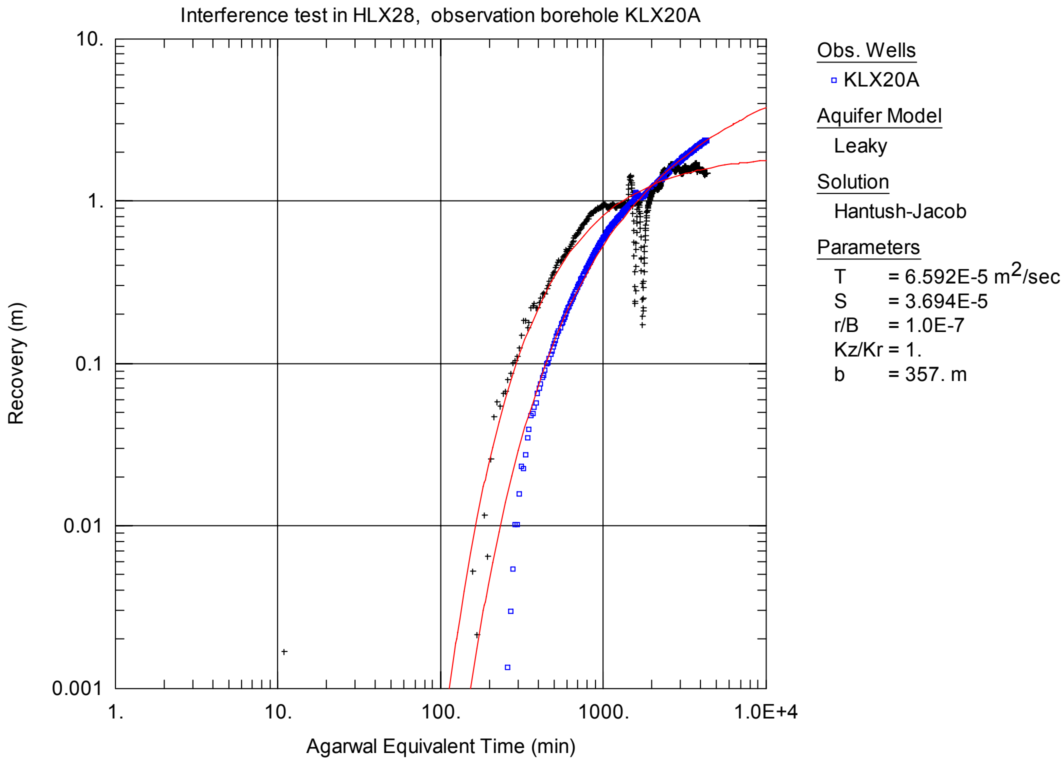


Figure 121. *Log-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX36:1 during pumping in borehole HLX28.*

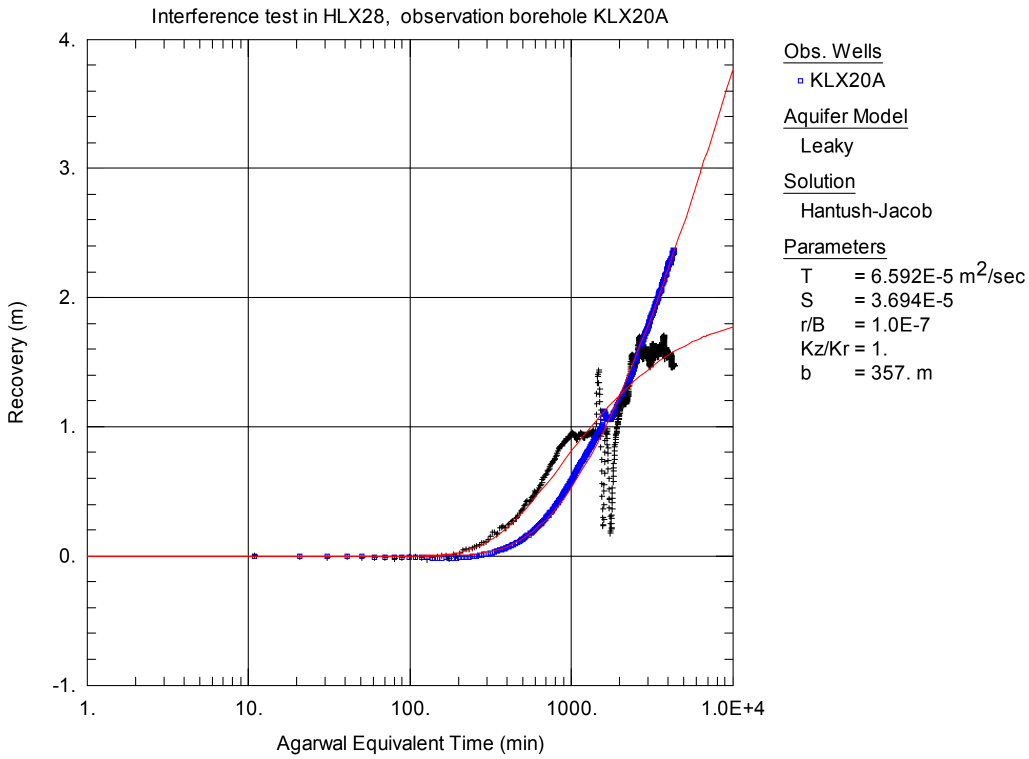
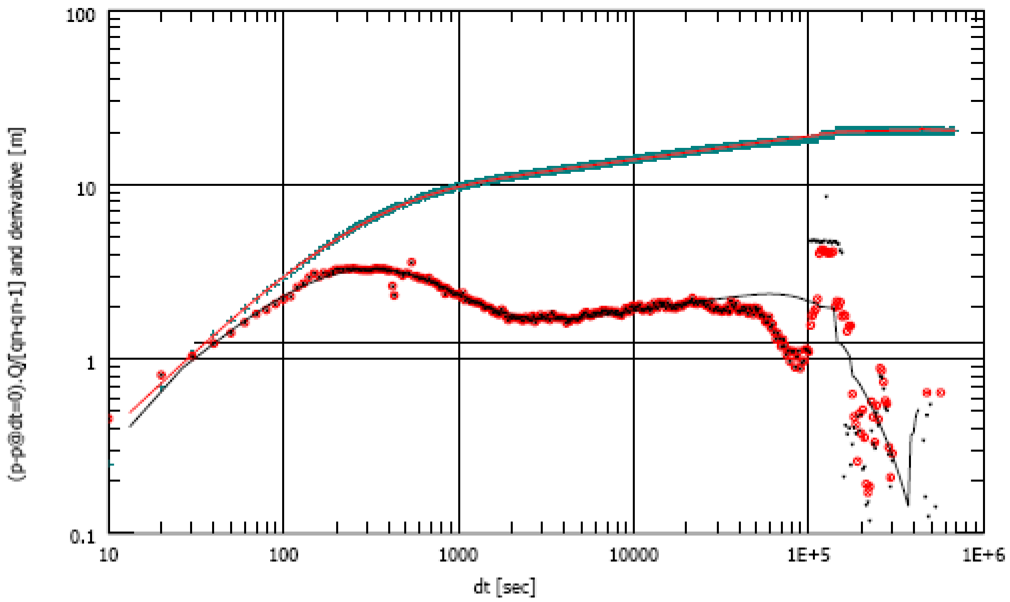


Figure 122. *Lin-log plot of pressure recovery (blue □) and -derivative (black +) versus equivalent time (dte) in the observation borehole HLX36:1 during pumping in borehole HLX28.*



HLX27 pumpbrunn.mio production #1
Rate 80.8 l/min
Rate change 80.8 l/min
P@dt=0 6.77392 m
Pi 6.7735 m
Smoothing 0.1

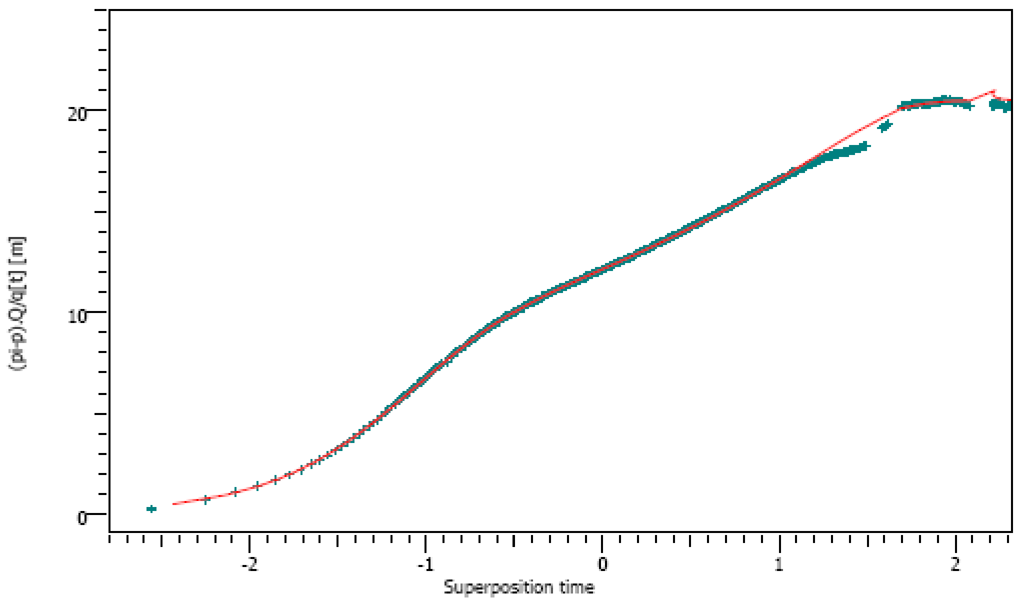
Selected Model
Model Option Standard Model
Well Vertical
Reservoir Radial composite
Boundary Circle, Constant P.

Main Model Parameters
TMatch 0.016 1/sec
PMatch 0.403 1/m
C 3.45E-6 m3/Pa
Total Skin -2.01
T 8.69E-5 m2/s
K 5.48E-7 m/s
Pi 6.7735 m

Model Parameters
Well & Wellbore parameters (HLX27 pumping well)
C 3.45E-6 m3/Pa
Skin -2.01
Reservoir & Boundary parameters
Pi 6.7735 m
T 8.69E-5 m2/s
K 5.48E-7 m/s
Ri 38.8 m
M 2.26
D 5.87
Re - Constant P. 221 m

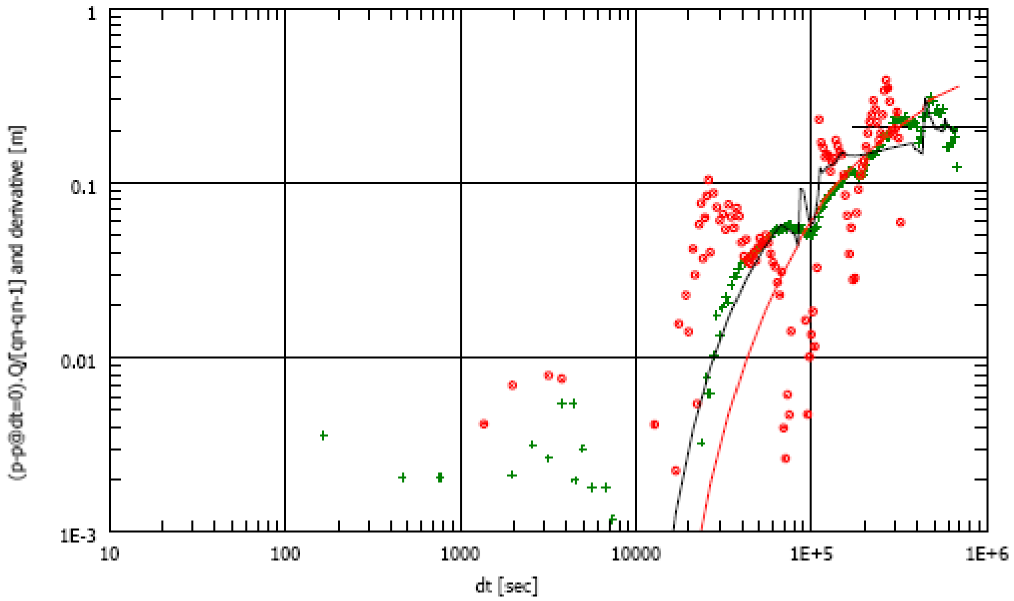
Derived & Secondary Parameters
Delta P (Total Skin) -4.98077 m
Delta P Ratio (Total Skin) -0.242582 Fraction

Figure 123. *Log-log plot of drawdown pjhase in the pumping borehole HLX27 (2004) together with evaluated parameters.*



HLX27 pumpbrunn.mio production #1		Model Parameters	
Rate	80.8 l/min	Well & Wellbore parameters (HLX27 pumping well)	
Rate change	80.8 l/min	C	3.45E-6 m3/Pa
P@dt=0	6.77392 m	Skin	-2.01
Pi	6.7735 m	Reservoir & Boundary parameters	
Smoothing	0.1	Pi	6.7735 m
		T	8.69E-5 m2/s
Selected Model		K	5.48E-7 m/s
Model Option	Standard Model	Ri	38.8 m
Well	Vertical	M	2.26
Reservoir	Radial composite	D	5.87
Boundary	Circle, Constant P.	Re - Constant P.	221 m
Main Model Parameters		Derived & Secondary Parameters	
TMatch	0.016 1/sec	Delta P (Total Skin)	-4.98077 m
PMatch	0.403 1/m	Delta P Ratio (Total Skin)	-0.242582 Fraction
C	3.45E-6 m3/Pa		
Total Skin	-2.01		
T	8.69E-5 m2/s		
K	5.48E-7 m/s		
Pi	6.7735 m		

Figure 124. *Semi-log plot of pressure versus time in the pumping borehole HLX27 (2004) together with evaluated parameters.*



HLX26 obs to HLX27pumping production #1

Rate	80.8 l/min
Rate change	80.8 l/min
P@dt=0	3.85186 m
Pi	3.84 m
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Line source
Reservoir	Homogeneous
Boundary	Infinite

Main Model Parameters

TMatch	2.89E-6 1/sec
PMatch	2.37 1/m
S	2.92E-4
T	4.99E-4 m2/s
K	3.25E-6 m/s
Pi	3.84 m
Well distance	769 m

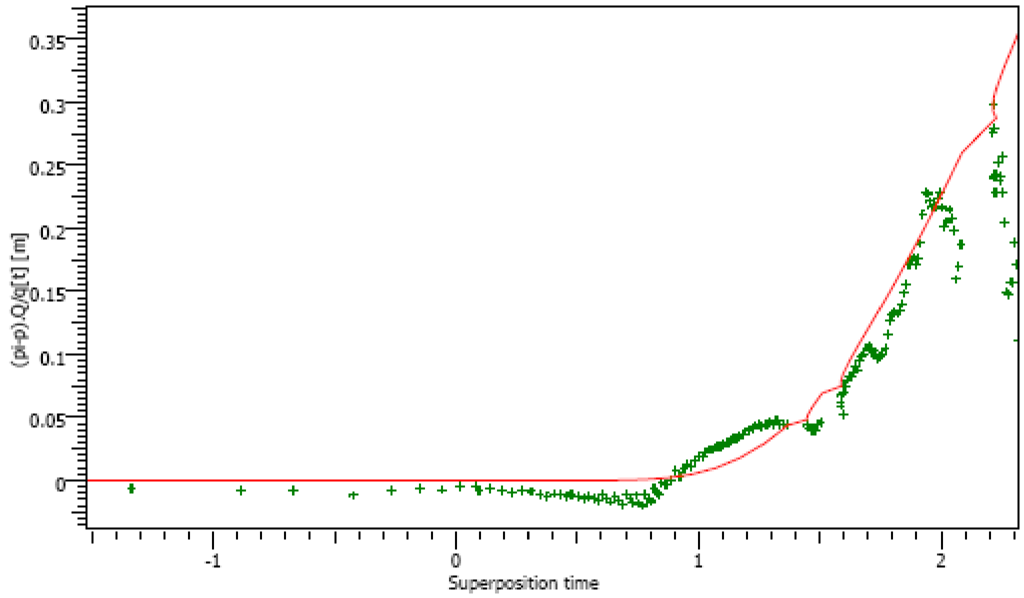
Model Parameters
Reservoir & Boundary parameters

Pi	3.84 m
T	4.99E-4 m2/s
K	3.25E-6 m/s
S	2.92E-4

Derived & Secondary Parameters

Rinv	1920 m
Test. Vol.	80.9844 MMm3

Figure 125. *Log-log plot ofdrawdwon phase of pressure data and derivative versus time in the observation borehole HLX26:1 during pumping in borehole HLX27 (2004), together with evaluated data.*



HLX26 obs to HLX27pumping production #1	
Rate	80.8 l/min
Rate change	80.8 l/min
P@dt=0	3.85186 m
Pi	3.84 m
Smoothing	0.1

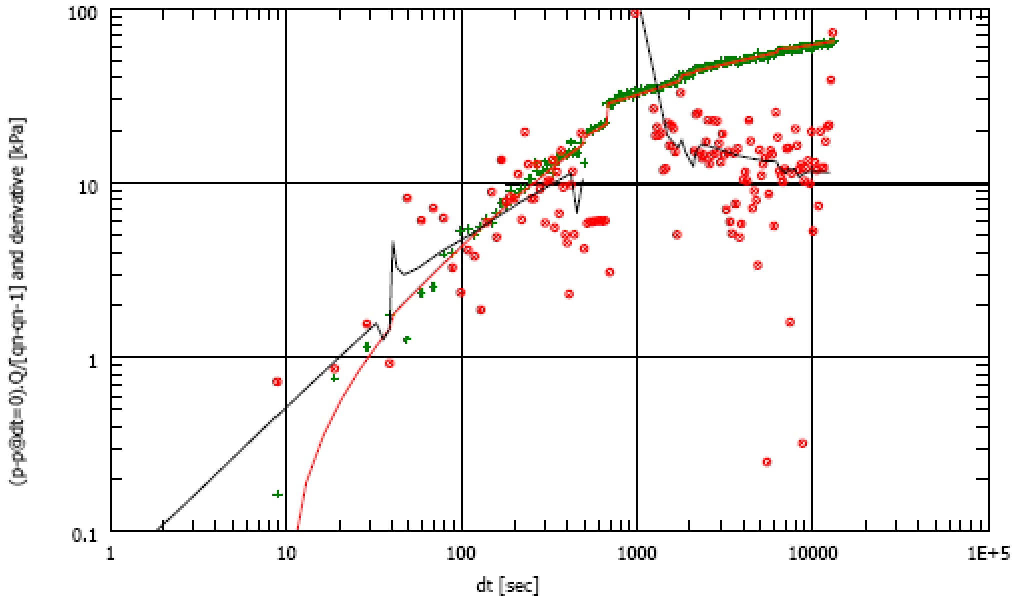
Selected Model	
Model Option	Standard Model
Well	Line source
Reservoir	Homogeneous
Boundary	Infinite

Main Model Parameters	
TMatch	2.89E-6 1/sec
PMatch	2.37 1/m
S	2.92E-4
T	4.99E-4 m2/s
K	3.25E-6 m/s
Pi	3.84 m
Well distance	769 m

Model Parameters	
Reservoir & Boundary parameters	
Pi	3.84 m
T	4.99E-4 m2/s
K	3.25E-6 m/s
S	2.92E-4

Derived & Secondary Parameters	
Rinv	1920 m
Test. Vol.	80.9844 MMm3

Figure 126. *Semi- log plot of pressure data versus time in the observation borehole HLX26:1 during pumping in borehole HLX27 (2004), together with evaluated data.*



HLX32 pumpning 050404.mio production #1	
Rate	8.73263 l/min
Rate change	8.73263 l/min
P@dt=0	397.506 kPa
Pi	398.419 kPa
Smoothing	0.1

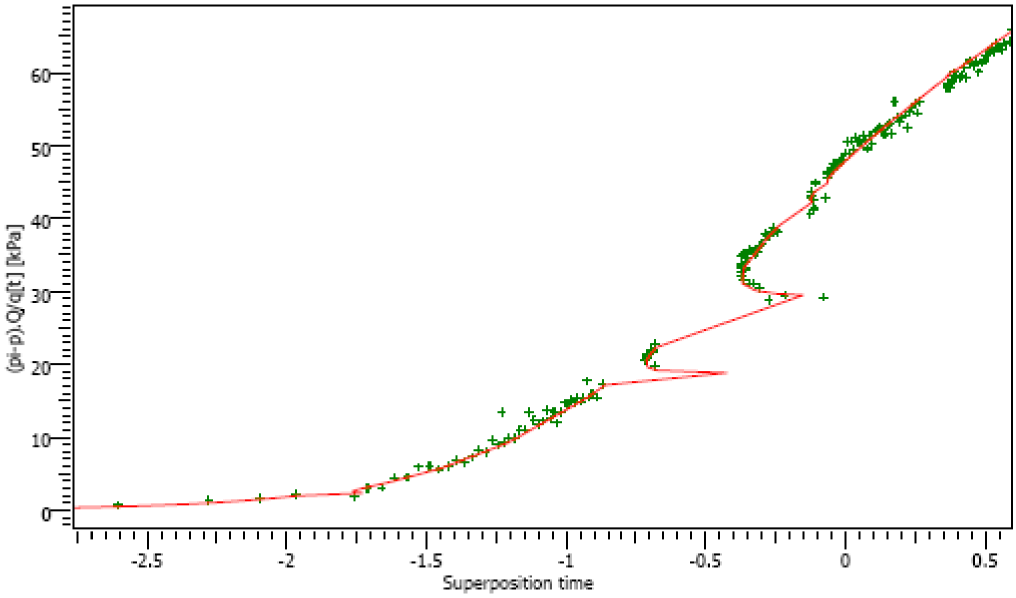
Derived & Secondary Parameters	
Rinv	179 m
Test. Vol.	1.56567 MMm3
Delta P (Total Skin)	-84.418 kPa
Delta P Ratio (Total Skin)	-1.28191 Fraction

Selected Model	
Model Option	Standard Model
Well	Vertical
Reservoir	Homogeneous
Boundary	Infinite

Main Model Parameters	
TMatch	0.00279 1/sec
PMatch	0.0508 1/kPa
C	2.65E-6 m3/Pa
Total Skin	-4.29
T	1.13E-5 m2/s
K	7.3E-8 m/s
Pi	398.419 kPa

Model Parameters	
Well & Wellbore parameters (HLX32 pumped borehole)	
C	2.65E-6 m3/Pa
Skin	-4.29
Reservoir & Boundary parameters	
Pi	398.419 kPa
T	1.13E-5 m2/s
K	7.3E-8 m/s

Figure 127. *Log-log plot of drawdown phase in the pumping borehole HLX32 together with evaluated parameters.*



HLX32 pumpning 050404.mio production #1
Rate 8.73263 l/min
Rate change 8.73263 l/min
P@dt=0 397.506 kPa
Pi 398.419 kPa
Smoothing 0.1

Selected Model
Model Option Standard Model
Well Vertical
Reservoir Homogeneous
Boundary Infinite

Main Model Parameters
TMatch 0.00279 1/sec
PMatch 0.0508 1/kPa
C 2.65E-6 m3/Pa
Total Skin -4.29
T 1.13E-5 m2/s
K 7.3E-8 m/s
Pi 398.419 kPa

Model Parameters
Well & Wellbore parameters (HLX32 pumped borehole)
C 2.65E-6 m3/Pa
Skin -4.29
Reservoir & Boundary parameters
Pi 398.419 kPa
T 1.13E-5 m2/s
K 7.3E-8 m/s

Derived & Secondary Parameters
Rinv 179 m
Test. Vol. 1.56567 MMm3
Delta P (Total Skin) -84.418 kPa
Delta P Ratio (Total Skin) -1.28191 Fraction

Figure 128. *Semi-log plot of drawdown phase with pressure versus time in the pumping borehole HLX32 together with evaluated parameters.*

Appendix 3

Response matrix

Explanations for the response indices can be found in Section 5, L = low, M = medium, H = high, E = excellent, 0 = no response and
blank = not evaluated.

	Pumping Hole	HLX27 (2007)			HLX28			HLX27 (2004)			HLX32		
	Section (m.b.TOC)	6.0 - 165.0			6.0 - 154.2			6.0-165.0			12.3-162.6		
	Flow rate (l/min)	91			96.2			85			9		
	Drawdown (kPa)	231.6			108.9			195.8			62.9		
Observation borehole	Response indices	1	2	2 new	1	2	2 new	1	2	2 new	1	2	2 new
	Section (m)												
KLX15A:1	721.0-1000.0	H	L	M									
KLX15A:2	189.0-420.0	H	L	M									
KLX15A:3	188.0-11.7	H	L	M									
HLX26:1	11.0-151.2	M	L	L				L	L	L	0	0	0
HLX38	15.0-199.5	M	L	L	L	L	L						
KLX03A:1	965.5-971.5	H	L	L									
KLX03A:2	830.5-964.5	M	L	L									
KLX03A:3	752.5-829.5	M	L	L									
KLX03A:4	729.5-751.5	M	L	L									
KLX03A:5	652.5-728.5	0	0	0									
KLX03A:6	465.5-651.5	0	0	0									
KLX03A:7	349.5-464.5	0	0	0									
KLX03A:8	199.5-348.5	M	L	L									
KLX03A:9	193.5-198.5	M	L	L									
KLX03A:10	100.1-194.5	M	L	L									
KLX05A:1	721.0-1000.0	0	0	0									
KLX05A:2	634.0-720.0	0	0	0									
KLX05A:3	625.0-633.0	0	0	0									
KLX05A:4	501.0-624.0	0	0	0									
KLX05A:5	361.0-500.0	0	0	0									
KLX05A:6	256.0-360.0	0	0	0									
KLX05A:7	241.0-255.0	0	0	0									
KLX05A:8	220.0-240.0	0	0	0									
KLX05A:9	128.0-219.0	0	0	0									
KLX05A:10	15.0-127.0	0	0	0									
KLX19A:1	661.0-800.07	0	0	0	0	0	0						
KLX19A:2	518.0-660.0	0	0	0	0	0	0						
KLX19A:3	509.0-517.0	0	0	0	H	L	M						
KLX19A:4	481.5-508.0	0	0	0	H	L	M						
KLX19A:5	311.0-480.5	0	0	0	H	L	M						
KLX19A:6	291.0-310.0	0	0	0	H	L	M						
KLX19A:7	136.0-290.0	0	0	0	H	L	M						
KLX19A:8	6.3-135.0	0	0	0	H	L	M						
KLX14A:1	120.0-176.3				0	0	0						
KLX14A:2	73.0-119.0				0	0	0						
KLX14A:3	6.5-72.0				H	L	M						
KLX20A	6.0-457.92												
HLX36:1	50.0-199.8				M	L	M						
HLX36:2	6.03-49.0				0	0	0						
HLX32:1	12.3-132.6				L	L	L						
HLX37:1	149.0-199.8				E	L	M						
HLX37:2	118.0-148.0				E	L	M						
HLX37:3	12.03-117.0				0	0	0						
HLX15	12.04-151.90							0	0	0			
HLX28	6.0-154.2							0	0	0	0	0	0
HLX27	6.0-165.0										0	0	0
HLX42:1	30.0-152.6	0	0	0									
HLX42:2	9.1-29.0	0	0	0									
KLX20A	6.0-457.92				H	L	M						

Salinity of water from HLX27 and Laxemarån

Water pumped from HLX27 was discharged into the nearby Laxemarån. For the purpose of environmental control the electrical conductivity was monitored of

- water pumped from HLX27 which was discharged into the Laxemarån and,
- water in Laxemarån where the pumped water was discharged into. This was done immediately upstream of the discharge point, 100 m downstream and 1,200 m downstream at gauging station PSM000364

During the pumping the HLX27 water increased its salinity from about 200 to 350 mS/m while the salinity of the stream increased from about 25 to 60 mS/m, see Figure A4-1.

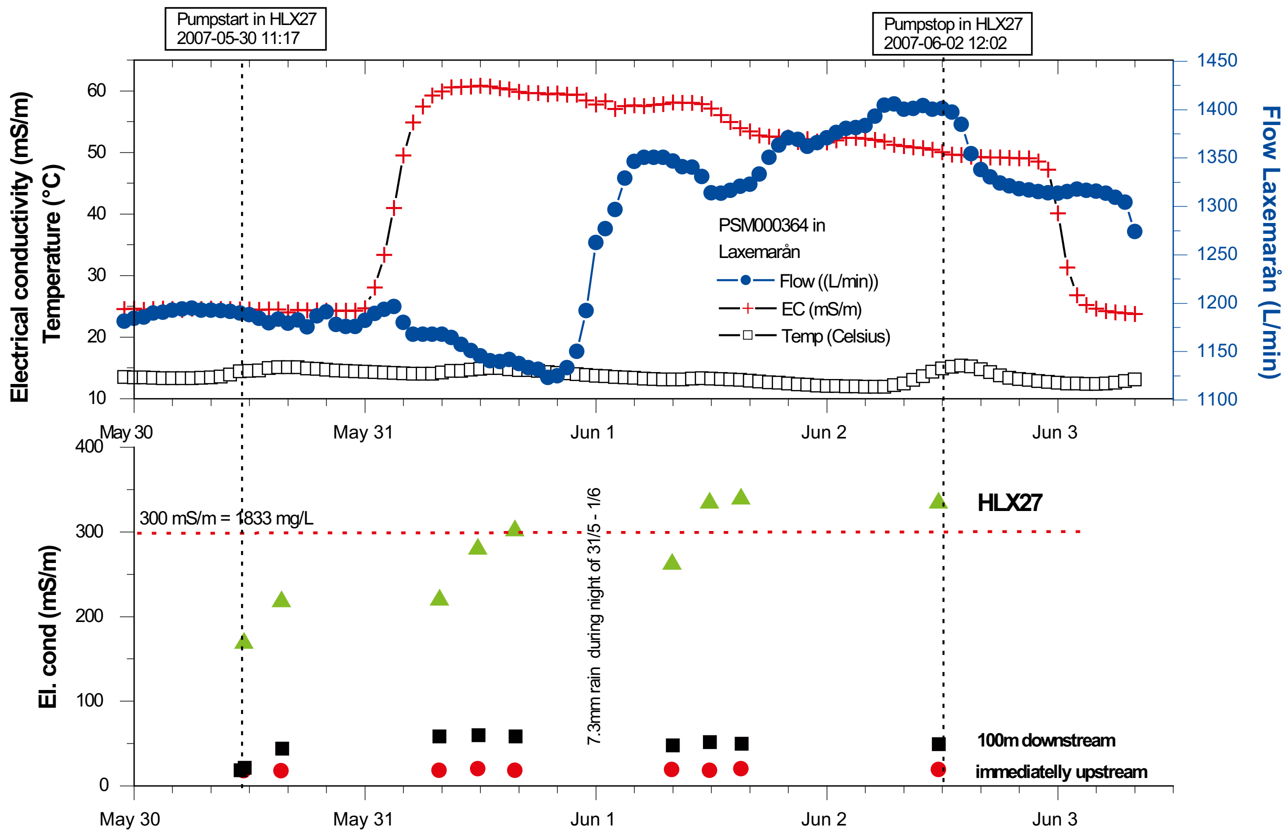
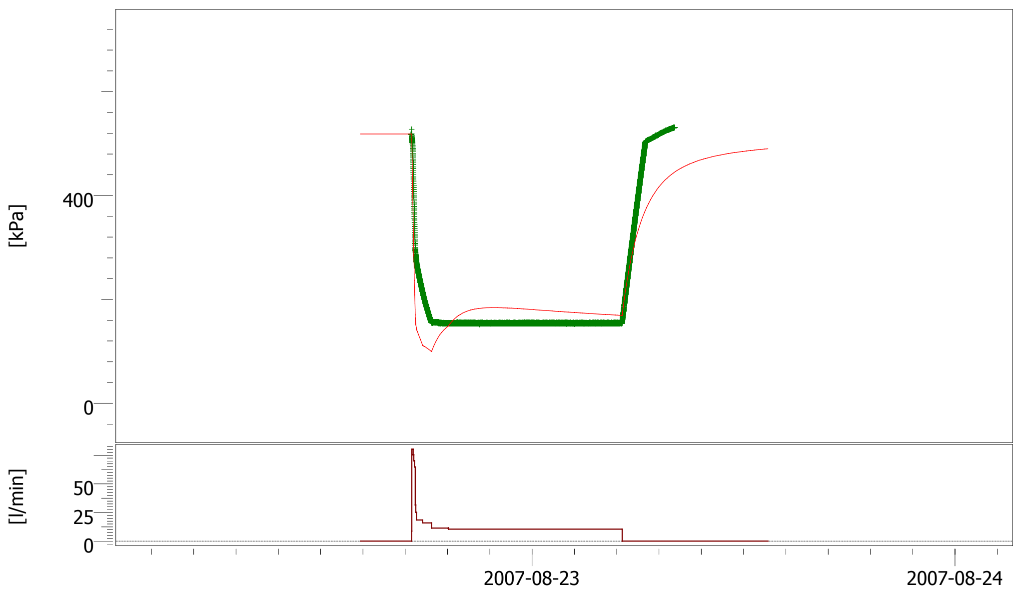


Figure A4-1. Measured electrical conductivity of pumped water from HLX27 and of the stream where the water was discharged.

Test summary sheet and test diagrams for KLX27A

History plot	Dd1
Company Svensk Kärnbränslehantering AB Well KLX27A grovdel	Field Laxemar Test Name / # KLX27A grovdel



Pressure [kPa], Liquid Rate [l/min] vs Time [ToD]

KLX27Agrovdel production #1

Rate	10.5 l/min
Rate change	10.5 l/min
P@dt=0	527.512 kPa
Pi	518.5 kPa
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Homogeneous
Boundary	Infinite

Main Model Parameters

TMatch	0.00173 [sec]-1
PMatch	0.0216 [kPa]-1
C	2.19E-6 m3/Pa
Total Skin	0
T	5.95E-6 m2/s
K	1.06E-7 m/s
Pi	518.5 kPa

Model Parameters

Well & Wellbore parameters (KLX27A grovdel)

C	2.19E-6 m3/Pa
Skin	0

Reservoir & Boundary parameters

Pi	518.5 kPa
T	5.95E-6 m2/s
K	1.06E-7 m/s

Derived & Secondary Parameters

Rinv	182 m
Test. Vol.	0.582903 MMm3
Delta P (Total Skin)	0 kPa
Delta P Ratio (Total Skin)	0 Fraction

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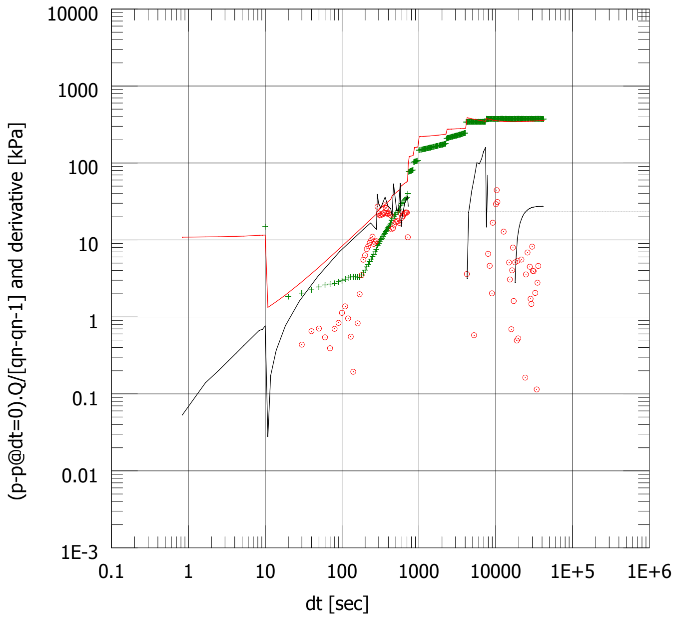
Log-Log plot	Dd1
Company Svensk Kärnbränslehantering AB Well KLX27A grovdel	Field Laxemar Test Name / # KLX27A grovdel



KLX27Agrovdel production #1
Rate 10.5 l/min
Rate change 10.5 l/min
P@dt=0 527.512 kPa
Pi 518.5 kPa
Smoothing 0.1

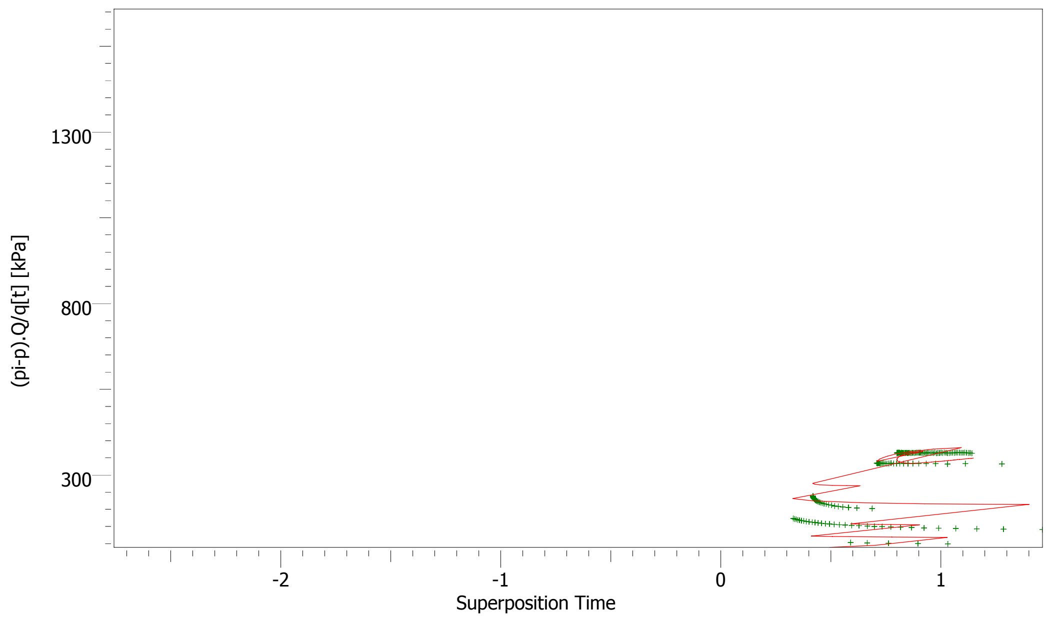
Selected Model
Model Option Standard Model
Well Vertical
Reservoir Homogeneous
Boundary Infinite

Main Model Parameters
TMatch 0.00173 [sec]-1
PMatch 0.0216 [kPa]-1
C 2.19E-6 m3/Pa
Total Skin 0
T 5.95E-6 m2/s
K 1.06E-7 m/s
Pi 518.5 kPa

Model Parameters
Well & Wellbore parameters (KLX27A grovdel)
C 2.19E-6 m3/Pa
Skin 0
Reservoir & Boundary parameters
Pi 518.5 kPa
T 5.95E-6 m2/s
K 1.06E-7 m/s

Derived & Secondary Parameters
Rinv 182 m
Test. Vol. 0.582903 MMm3
Delta P (Total Skin) 0 kPa
Delta P Ratio (Total Skin) 0 Fraction

Semi-Log plot	Dd1
Company Svensk Kärnbränslehantering AB Well KLX27A grovdel	Field Laxemar Test Name / # KLX27A grovdel



KLX27Agrovdel production #1

Rate	10.5 l/min
Rate change	10.5 l/min
P@dt=0	527.512 kPa
Pi	518.5 kPa
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Homogeneous
Boundary	Infinite

Main Model Parameters

TMatch	0.00173 [sec]-1
PMatch	0.0216 [kPa]-1
C	2.19E-6 m3/Pa
Total Skin	0
T	5.95E-6 m2/s
K	1.06E-7 m/s
Pi	518.5 kPa

Model Parameters

Well & Wellbore parameters (KLX27A grovdel)

C	2.19E-6 m3/Pa
Skin	0

Reservoir & Boundary parameters

Pi	518.5 kPa
T	5.95E-6 m2/s
K	1.06E-7 m/s

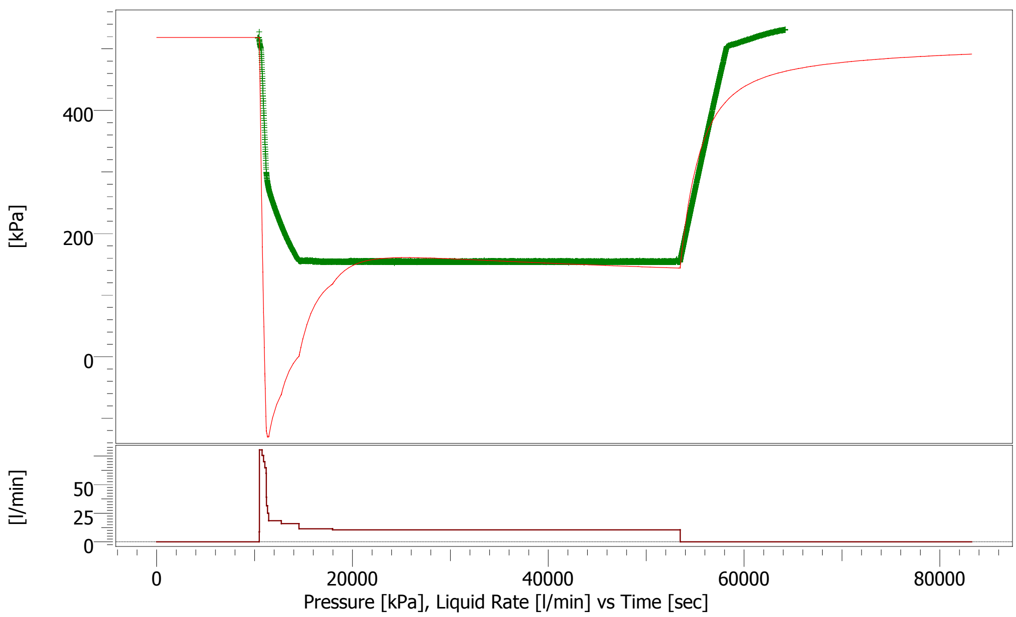
Derived & Secondary Parameters

Rinv	182 m
Test. Vol.	0.582903 MMm3
Delta P (Total Skin)	0 kPa
Delta P Ratio (Total Skin)	0 Fraction

Main Results	Dd1
Company Svensk Kärnbränslehantering AB Well KLX27A grovdel	Field Laxemar Test Name / # KLX27A grovdel

Test date / time	2007-08-22 18:10
Formation interval	9.2 - 75.6m b toc
Perforated interval	open hole
Gauge type / #	
Gauge depth	65 m b ToC
Field crew	P. Hagman, SKB and J. Henriksson, NEA
Analysis	Mansueto Morosini, SKB
TEST TYPE	Standard
Porosity Phi (%)	10
Well Radius rw	0.08 m
Pay Zone h	56.05 m
Water Salt (ppm)	10000
Form. compr.	4.35113E-10 Pa-1
Reservoir T	15 °C
Reservoir P	750 kPa
Fluid type	Water
Volume Factor B	1 B/STB
Viscosity	1E-3 Pa.sec
Total Compr. ct	4.35113E-10 Pa-1
Selected Model	
Model Option	Standard Model
Well	Vertical
Reservoir	Homogeneous
Boundary	Infinite
Main Model Parameters	
TMatch	0.00173 [sec]-1
PMatch	0.0216 [kPa]-1
C	2.19E-6 m3/Pa
Total Skin	0
T	5.95E-6 m2/s
K	1.06E-7 m/s
Pi	518.5 kPa
Model Parameters	
Well & Wellbore parameters (KLX27A grovdel)	
C	2.19E-6 m3/Pa
Skin	0
Reservoir & Boundary parameters	
Pi	518.5 kPa
T	5.95E-6 m2/s
K	1.06E-7 m/s
Derived & Secondary Parameters	
Rinv	182 m
Test. Vol.	0.582903 MMm3
Delta P (Total Skin)	0 kPa
Delta P Ratio (Total Skin)	0 Fraction

	History plot	Bu1
SKB	Company Svensk Kärnbränslehantering AB Well KLX27A grovdel	Field Laxemar Test Name / # KLX27A grovdel



KLX27Agrovdel build-up #1
Rate 0 l/min
Rate change 10.5 l/min
P@dt=0 154.488 kPa
Pi 518.5 kPa
Smoothing 0.1

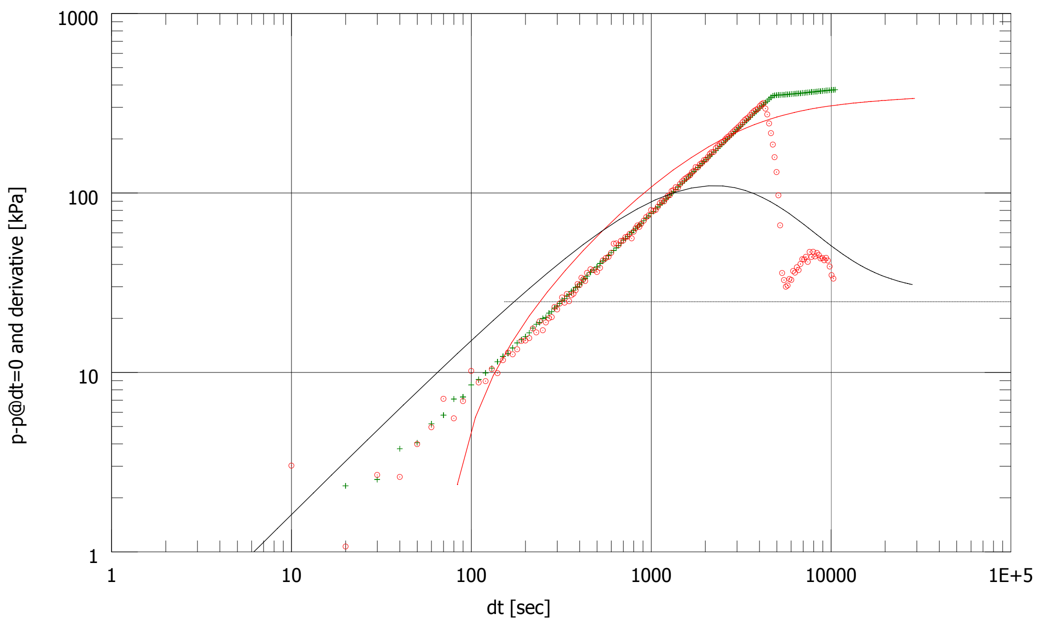
Selected Model
Model Option Standard Model
Well Vertical
Reservoir Homogeneous
Boundary Infinite

Main Model Parameters
TMatch 0.00328 [sec]-1
PMatch 0.0202 [kPa]-1
C 1.08E-6 m3/Pa
Total Skin 0
T 5.55E-6 m2/s
K 9.91E-8 m/s
Pi 518.5 kPa

Model Parameters
Well & Wellbore parameters (KLX27A grovdel)
C 1.08E-6 m3/Pa
Skin 0
Reservoir & Boundary parameters
Pi 518.5 kPa
T 5.55E-6 m2/s
K 9.91E-8 m/s

Derived & Secondary Parameters
Rinv 88.1 m
Test. Vol. 0.136645 MMm3
Delta P (Total Skin) 0 kPa
Delta P Ratio (Total Skin) 0 Fraction

Log-Log plot	Bu1
Company Svensk Kärnbränslehantering AB Well KLX27A grovdel	Field Laxemar Test Name / # KLX27A grovdel



KLX27Agrovdel build-up #1

Rate	0 l/min
Rate change	10.5 l/min
P@dt=0	154.488 kPa
Pi	518.5 kPa
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Homogeneous
Boundary	Infinite

Main Model Parameters

TMatch	0.00328 [sec]-1
PMatch	0.0202 [kPa]-1
C	1.08E-6 m3/Pa
Total Skin	0
T	5.55E-6 m2/s
K	9.91E-8 m/s
Pi	518.5 kPa

Model Parameters

Well & Wellbore parameters (KLX27A grovdel)

C	1.08E-6 m3/Pa
Skin	0

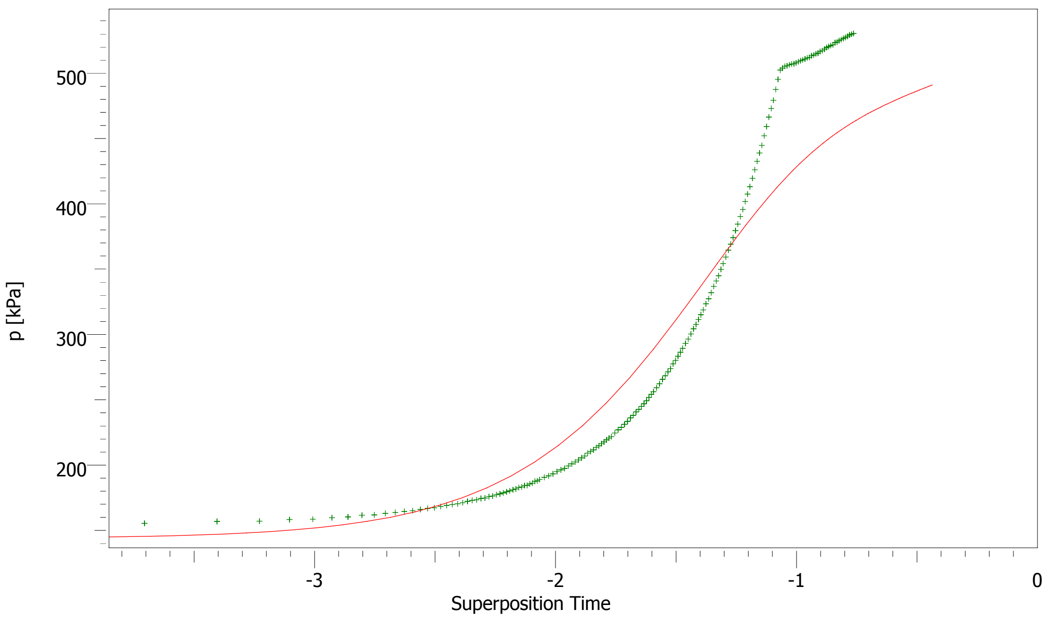
Reservoir & Boundary parameters

Pi	518.5 kPa
T	5.55E-6 m2/s
K	9.91E-8 m/s

Derived & Secondary Parameters

Rinv	88.1 m
Test. Vol.	0.136645 MMm3
Delta P (Total Skin)	0 kPa
Delta P Ratio (Total Skin)	0 Fraction

	Semi-Log plot	Bu1
SKB	Company Svensk Kärnbränslehantering AB Well KLX27A grovdel	Field Laxemar Test Name / # KLX27A grovdel



KLX27Agrovdel build-up #1

Rate	0 l/min
Rate change	10.5 l/min
P@dt=0	154.488 kPa
Pi	518.5 kPa
Smoothing	0.1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Homogeneous
Boundary	Infinite

Main Model Parameters

TMatch	0.00328 [sec]-1
PMatch	0.0202 [kPa]-1
C	1.08E-6 m3/Pa
Total Skin	0
T	5.55E-6 m2/s
K	9.91E-8 m/s
Pi	518.5 kPa

Model Parameters

Well & Wellbore parameters (KLX27A grovdel)

C	1.08E-6 m3/Pa
Skin	0

Reservoir & Boundary parameters

Pi	518.5 kPa
T	5.55E-6 m2/s
K	9.91E-8 m/s

Derived & Secondary Parameters

Rinv	88.1 m
Test. Vol.	0.136645 MMm3
Delta P (Total Skin)	0 kPa
Delta P Ratio (Total Skin)	0 Fraction

Main Results	Bu1
Company Svensk Kärnbränslehantering AB Well KLX27A grovdel	Field Laxemar Test Name / # KLX27A grovdel

Test date / time	2007-08-22 18:10
Formation interval	9.2 - 75.6m b toc
Perforated interval	open hole
Gauge type / #	
Gauge depth	65 m b ToC
Field crew	P. Hagman, SKB and J. Henriksson, NEA
Analysis	Mansueto Morosini, SKB
TEST TYPE	Standard
Porosity Phi (%)	10
Well Radius rw	0.08 m
Pay Zone h	56.05 m
Water Salt (ppm)	10000
Form. compr.	4.35113E-10 Pa-1
Reservoir T	15 °C
Reservoir P	750 kPa
Fluid type	Water
Volume Factor B	1 B/STB
Viscosity	1E-3 Pa.sec
Total Compr. ct	4.35113E-10 Pa-1

Selected Model

Model Option	Standard Model
Well	Vertical
Reservoir	Homogeneous
Boundary	Infinite

Main Model Parameters

TMatch	0.00328 [sec]-1
PMatch	0.0202 [kPa]-1
C	1.08E-6 m3/Pa
Total Skin	0
T	5.55E-6 m2/s
K	9.91E-8 m/s
Pi	518.5 kPa

Model Parameters

Well & Wellbore parameters (KLX27A grovdel)

C	1.08E-6 m3/Pa
Skin	0

Reservoir & Boundary parameters

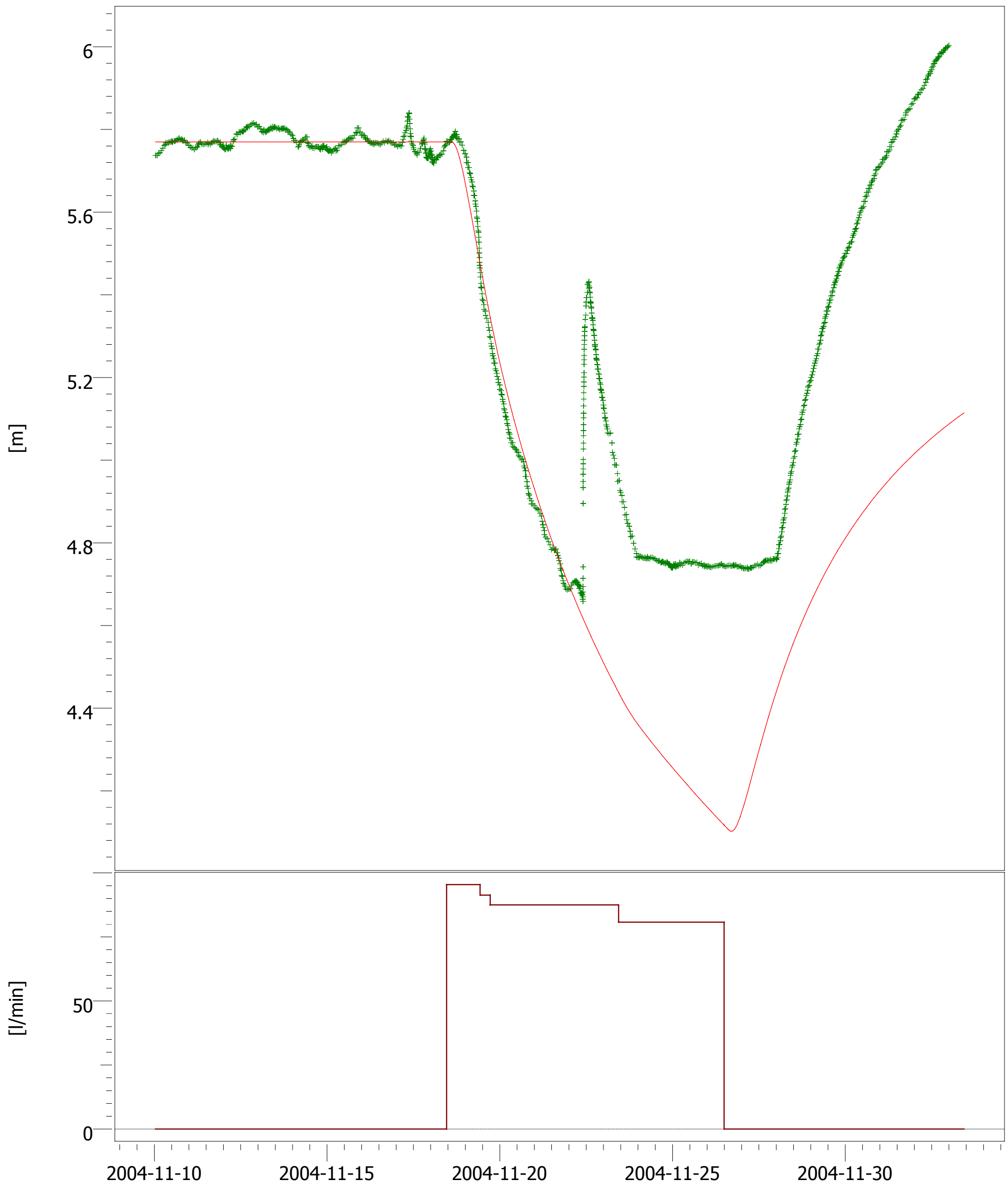
Pi	518.5 kPa
T	5.55E-6 m2/s
K	9.91E-8 m/s

Derived & Secondary Parameters

Rinv	88.1 m
Test. Vol.	0.136645 MMm3
Delta P (Total Skin)	0 kPa
Delta P Ratio (Total Skin)	0 Fraction

Test diagrams for HLX15 observation hole during HLX27 pumping in November 2004

History plot	Dd1
Company Svensk Kärnbränslehantering AB Well HLX15 Observation well	Field Laxemar Test Name / # HLX27pumpwell



Pressure [m], Liquid Rate [l/min] vs Time [ToD]

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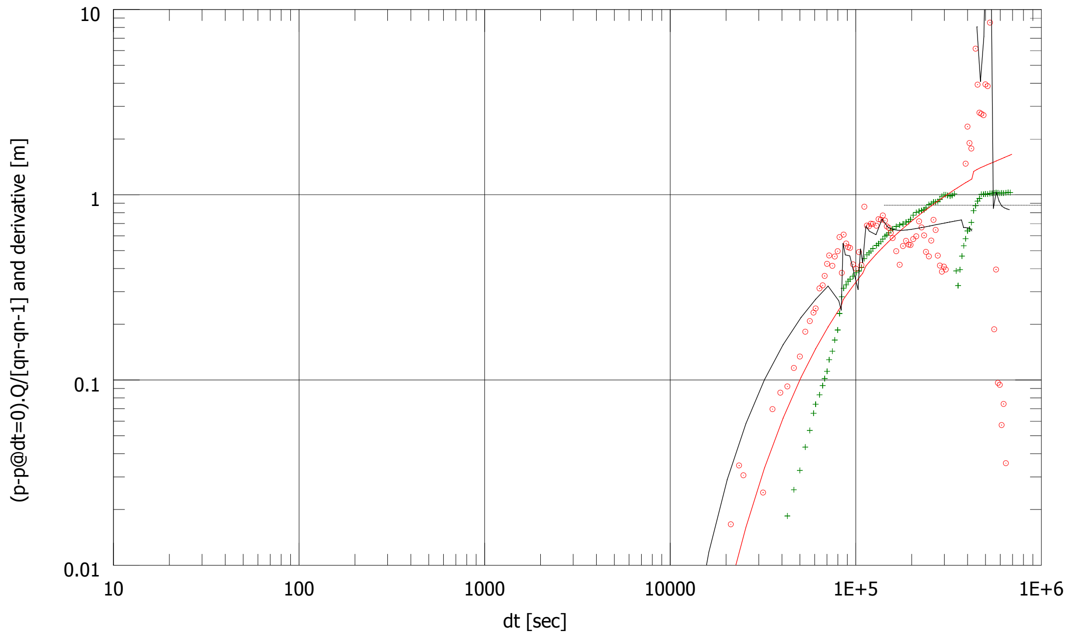
Log-Log plot		Dd1	
Company	Svensk Kärnbränslehantering AB	Field	Laxemar
Well	HLX15 Observation well	Test Name / #	HLX27pumpwell



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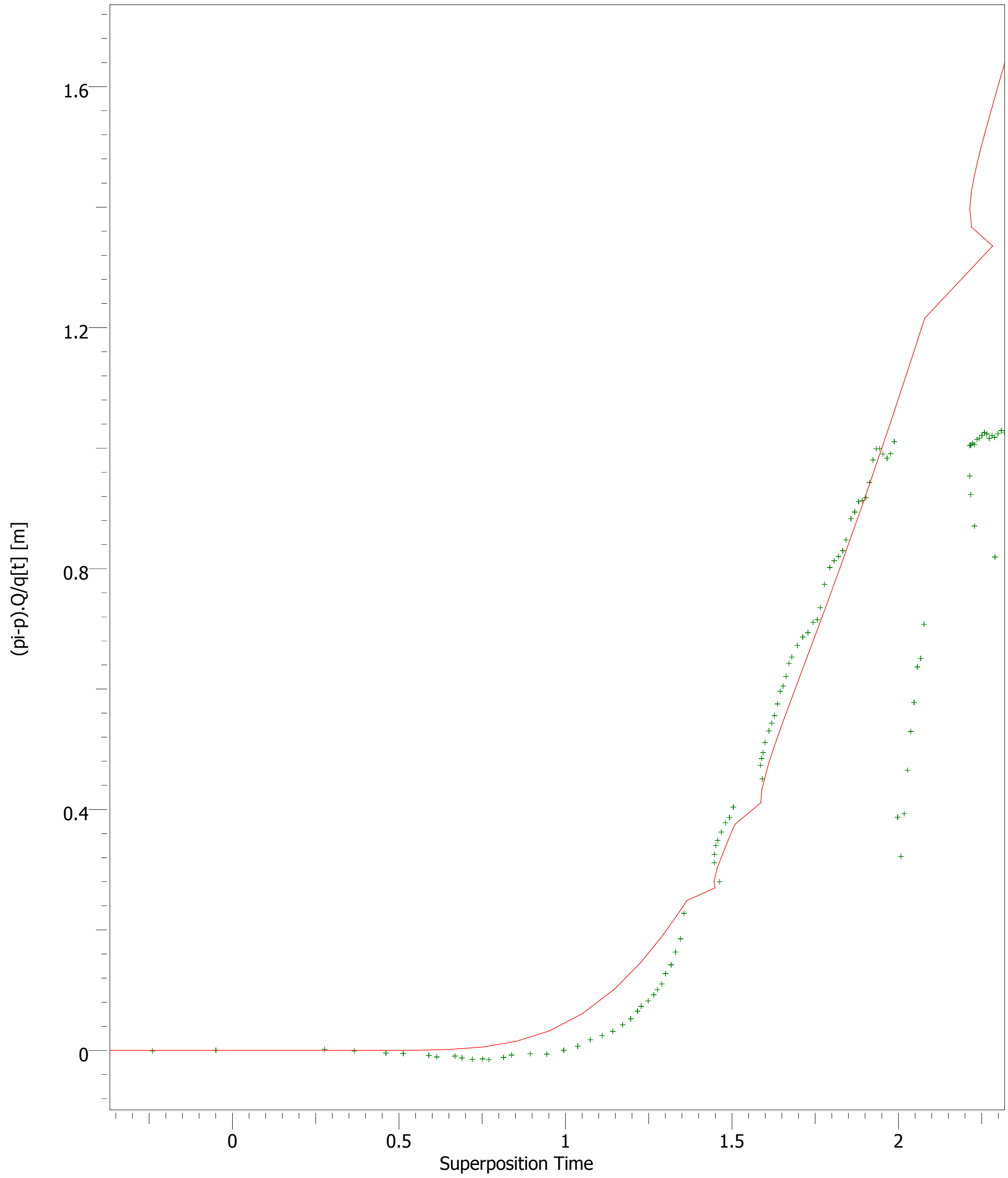
Semi-Log plot	Dd1
Company Svensk Kärnbränslehantering AB Well HLX15 Observation well	Field Laxemar Test Name / # HLX27pumpwell



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SKB	Main Results	Dd1
	Company Svensk Kärnbränslehantering AB Well HLX15 Observation well	Field Laxemar Test Name / # HLX27pumpwell

Test date / time	2004-11-18
Formation interval	12,04 - 151,90m
Perforated interval	open hole
Gauge type / #	
Gauge depth	
Field crew	SKB
Analysis	M. Morosini, SKB
TEST TYPE	Interference
Well distance	824 m
Well Radius rw	0.07 m
Pay Zone h	140 m
Water Salt (ppm)	10000
Form. compr.	4.35113E-10 Pa-1
Reservoir T	100 °C
Reservoir P	3515.35 m
Fluid type	Water
Volume Factor B	1 B/STB
Viscosity	1E-3 Pa.sec
Total Compr. ct	4.35113E-10 Pa-1
Selected Model	
Model Option	Standard Model
Well	Line source
Reservoir	Homogeneous
Boundary	Infinite
Main Model Parameters	
TMatch	3.52E-6 [sec]-1
PMatch	0.569 [m]-1
S	5.1E-5
T	1.22E-4 m2/s
K	8.69E-7 m/s
Pi	5.77 m
Well distance	824 m
Model Parameters	
Reservoir & Boundary parameters	
Pi	5.77 m
T	1.22E-4 m2/s
K	8.69E-7 m/s
S	5.1E-5
Derived & Secondary Parameters	
Rinv	2280 m
Test. Vol.	194.775 MMm3

Precipitation, air temperature and head in HLX15 observation hole during HLX27 pumping in November 2004