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Calle Hjerne
Johanna Ragvald
Erik Palmfjord

SVENSK KÄRNBRÄNSLEHANTERING AB

SWEDISH NUCLEAR FUEL
AND WASTE MANAGEMENT CO

Box 250, SE-101 24 Stockholm
Phone +46 8 459 84 00
skb.se

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Calle Hjerne, Johanna Ragvald, Erik Palmfjord
Geosigma AB

Keywords: Hydrogeology, Hydraulic interference tests, K03009F01, K08028F01, Äspö Hard Rock Laboratory.

Abstract

Hydraulic interference tests in boreholes K08028F01 and K03009F01 at Äspö Hard Rock laboratory were carried out by SKB AB in October 2014. The tests were designed, planned and evaluated by Geosigma AB. This report accounts for the execution, analysis and results of the hydraulic interference tests.

The interference tests included nine tests with pumping in four different sections in borehole K08028F01 and pumping of five sections in borehole K03009F01. In total there were nine sections in K08028F01 and ten in K03009F01 used for observation of pressure and responses to the pumpings. The packer configuration and interference tests were designed based on results of the preceding PFL flow logging in the boreholes together with supporting information from the respective drilling. The tests were in most cases performed by using a constant flow rate regulated and measured with the specially designed equipment HWIC. Transient evaluation of hydraulic parameters and calculation of response indices of the responding observation sections during the interference tests was made. The hydraulic diffusivity T/S of the responding observation sections was estimated from the transient evaluation.

In general good hydraulic responses were noted in sections located in the same borehole as the pumping section. When pumping in K03009F01 there were generally small responses in K08028F01. However, very few responses could be detected in K03009F01 when pumping in K08028F01. Reciprocity in response pattern could however, not be ruled out since the transmissivity is higher in the rock sampled by K03009F01 compared to that sampled by K08028F01. Consequently low responses were to be expected in K03009F01 for the given circumstances existing during the tests.

Transient evaluation of the pumped sections resulted in most cases in a much higher transmissivity than obtained from evaluations assuming steady state conditions, this attributed due to high skin prevailing during the tests.

The KBS-3H design has been developed jointly by SKB and Posiva since 2002. This report has been prepared within the project phase "KBS-3H – System Design 2011–2016".

Sammanfattning

Hydrauliska interferenstester i borrhål K08028F01 och K03009F01 vid Äspö laboratoriet utfördes av SKB AB i oktober 2014. Testerna designades, planerades och utvärderas av Geosigma AB. Denna rapport redovisar utförande, analys och resultat av de hydrauliska interferenstesterna.

Interferenstesterna omfattade nio pumptest i fyra sektioner i borrhål K08028F01 och fem sektioner i borrhål K03009F01. Totalt fanns det nio observationssektioner i K08028F01 och tio i K03009F01. Manschettkonfigurationen och interferenstesterna utformades utifrån tidigare resultat från differensflödesloggning i borrhålen tillsammans med stödjade information från borrningen. Testerna utfördes i del flesta fall med ett konstant flöde som reglerades och mättes med den specialutformade utrustningen HWIC. Transienta utvärderingar av hydrauliska parametrar och beräkning av responsindex för observationssektionerna har genomförts. Hydraulisk diffusivitet, T/S, av responderade sektioner beräknades från de transienta utvärderingarna.

Generellt noterades goda responser i sektioner belägna i samma borrhål som pumpsektionen. Vid pumpning i K03009F01 var det generellt låga responser i K08028F01. Det var dock mycket få responser i K03009F01 när pumpning utfördes i K08028F01. Ömsesidiga responser i borrhålen kan dock inte uteslutas eftersom transmissiviteten är högre i K03009F01 än i K08028F01, så låga responser var förväntade i K03009F01 under de förutsättningar som funnits under testerna.

Transienta utvärderingar av pumpsektionerna resulterade i de flesta fall i en betydligt högre transmissivitet än motsvarande stationära utvärderingar för att testerna utförts under förhållanden med högt skin.

Contents

1 Introduction

A new test site has been established at the Äspö Hard Rock Laboratory at the −400 m level within the project KBS-3H Project System Design, sub project KBS-3H Sub-System Demonstration. The project DETUM-1, sub project Large Fractures focuses on investigations in tunnels and boreholes to develop methodology to identify and quantify the extent of geological structures in the rock mass. As a part of these projects, measurements were conducted between the Posiva/SKB KBS-3H borehole in the tunnel TAS08 (K08028F01) and the DETUM borehole in tunnel TAS03 (K03009F01), see Figure 1-1 and Table 1-1. Specifically, cross-hole hydraulic interference tests between the aforementioned boreholes were performed at c. −400 m elevation in the Äspö Hard Rock Laboratory in co-operation between two projects. The current report accounts for the design, planning, execution and interpretation of these tests.

The KBS-3H design has been developed jointly by SKB and Posiva since 2002. This report has been prepared within the project phase "KBS-3H – System Design 2011–2016".

Table 1-1. Basic data for boreholes K08028F01 and K03009F01. The horizontal coordinate system is ÄSPÖ96 and elevation coordination system is RHB70.

Borehole	K08028F01	K03009F01
Diameter [mm]	75.8	75.8
Length [m]	94.39	100.92
Inclination (°)	+2.18	−0.37
Bearing (°)	320.366	330.9995
Coordinates for starting point		
Northing (m)	7450.637	7415.816
Easting (m)	2386.037	2368.412
Elevation (m.a.s.l.)	−396.612	−399.226

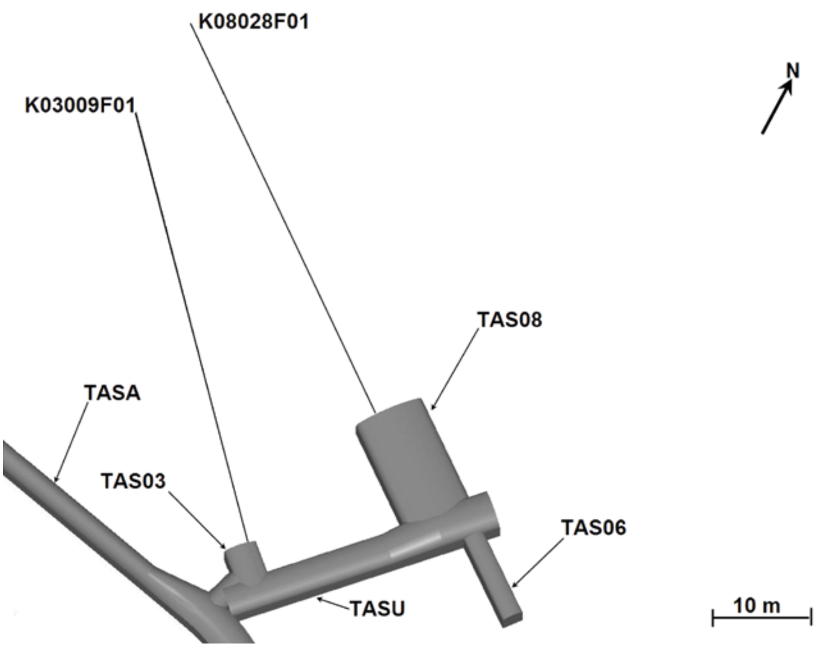

Figure 1-1. Location of boreholes K08028F01 (in tunnel TAS08) and K03009F01 (in tunnel TAS03) at approximately −400 m level at Äspö Hard Rock Laboratory.

2 Objectives

The primary objective of this work was to perform interference test and evaluate hydraulic connectivity and parameters which may be used for interpretation of position, geometry, extent and hydrogeological properties for water bearing structures in the rock mass penetrated by the boreholes that have a Euclidian separation varying between c. 20 and 40 m. The results of the tests and analysis is expected to provide information for verification of prognoses made and form the basis for further modelling and planning of investigation programmes in the rock mass.

3 Execution of the hydraulic interference tests

3.1 Preparations prior to the tests

Prior to the interference tests, the boreholes (K08028F01 and K03009F01) were equipped with multi-packer assemblies made up of hydraulically controlled packers with separate pressure gauges for each section. The installations had the following objectives:

- to facilitate controlled reciprocal interference tests (i.e. possibility to use sections in both boreholes as pumping sections) between boreholes K030009F01 and K08028F01 with simultaneous observation of pressure responses in both boreholes,
- to obtain representative pressure profiles in the sampled rock mass.

The planned test section limits and type of section are shown in Figure 3-1. This is also the configuration that was believed to be in place during the tests. However, during the deinstallation the packer system after the tests, it was noticed that one 2 m rod to few had been used in K03009F01:5 causing this section to be 2 m shorter and the packers inside further into K03009F01 be 2 m closer to the tunnel. Fortunately, this mistake turned out to have only a minor impact on the tests since the major flow anomalies ended up in the expected sections anyway. The planned as well as actually used section limits are presented in Table 3-1.

Figure 3-1 shows the boreholes projected onto a horizontal plane in the local coordinate system ÄSPÖ96. However, since the boreholes are close to horizontal and are collared at approximately the same depth, the figure is a fairly good approximation of the true distances between the borehole sections. All sections are equipped with an individual hose connected to an individual pressure gauge in the tunnel. All pressure gauges are connected to the HMS (Hydro Monitoring System). Sections marked with Q are also equipped with a hose with an inner diameter of 6 mm. The purpose of the latter hose is to enable pumping of an individual section but still being able to observe the pressure in the section. All clocks used for registration of flow and pressure were prior to the tests synchronized to the clock in HMS.

Table 3-1. Planned and actually used section limits. Deviations from the planned section limits are indicated in red.

		Planned section limits		Actual section limits	
Borehole	Secno	Secup [m]	Seclow [m]	Secup [m]	Seclow [m]
K03009F01	1	89	100.92	87	100.92
K03009F01	2	61	88	59	86
K03009F01	3	41	60	39	58
K03009F01	4	27.5	40	25.5	38
K03009F01	5	21.5	26.5	21.5	24.5
K03009F01	6	18.5	20.5	18.5	20.5
K03009F01	7	14.5	17.5	14.5	17.5
K03009F01	8	9	13.5	9	13.5
K03009F01	9	4	8	4	8
K03009F01	10	1.5	3	1.5	3
K08028F01	1	84	94.39	84	94.39
K08028F01	2	61	83	61	83
K08028F01	3	40	60	40	60
K08028F01	4	37	39	37	39
K08028F01	5	33	36	33	36
K08028F01	6	30	32	30	32
K08028F01	7	19	29	19	29
K08028F01	8	10	18	10	18
K08028F01	9	2	9	2	9

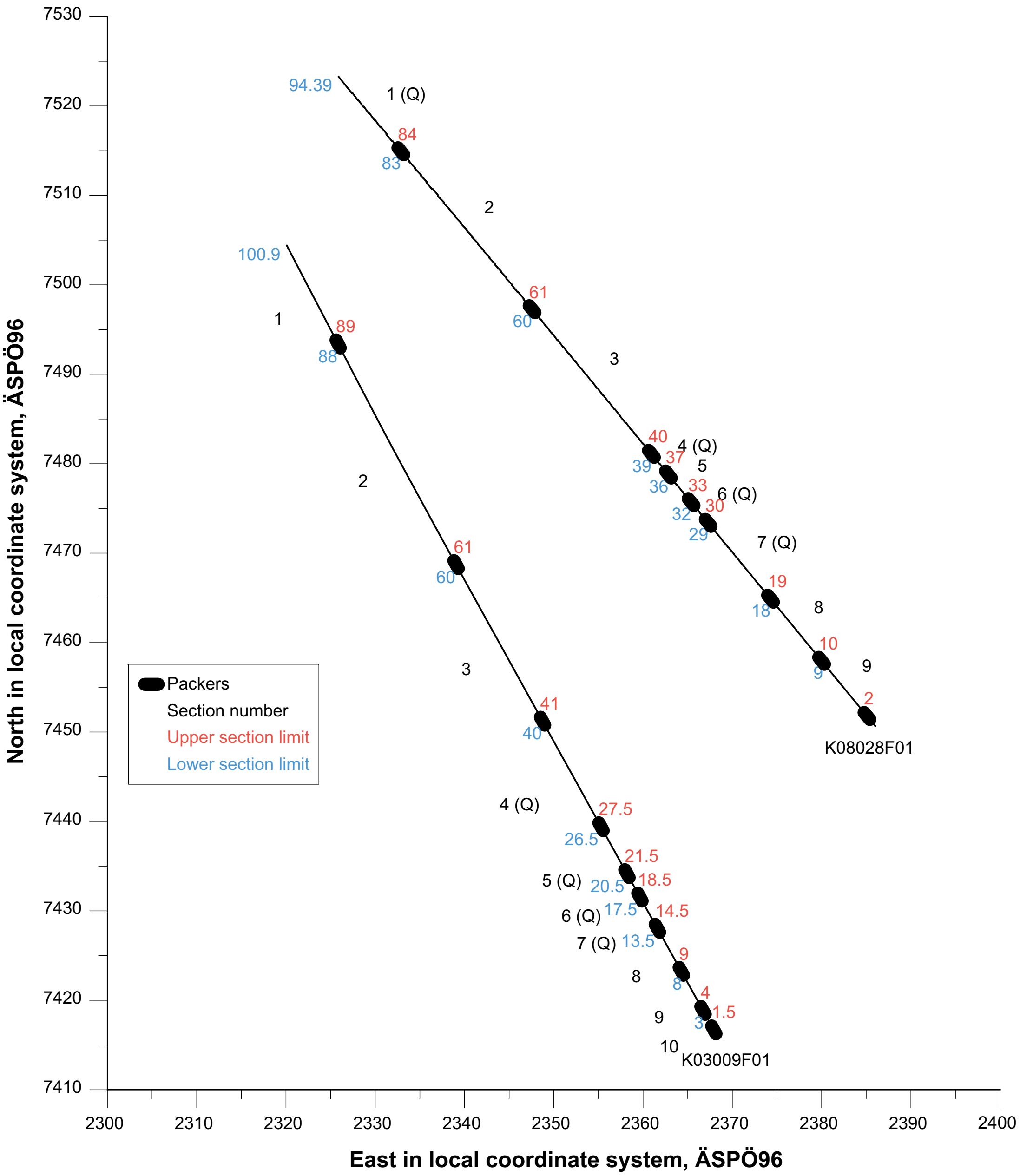

Figure 3-1. Overview of planned installations in K08028F01 and K03009F01 used during the interference tests. The figure show the boreholes projected in a horizontal plane in the local coordinate system ÄSPÖ96. Sections marked with Q were equipped with an extra hose used for flowing of water.

The design and configuration of the installations were primarily based on the flow logging reported by Komulainen and Pöllänen (2016), but also on previously observed pressure responses in K03009F01 during drilling of K08028F01 as well as basic geological information.

The instrumentation of the boreholes was finalized September 18 for K03009F01 and September 26 for K08028F01. Short capacity tests were carried out in both boreholes September 26.

3.2 Test performance

Nine hydraulic interference tests were performed with pumping in boreholes K08028F01 and K03009F01 during the period October 6 through October 27. The term *pumping* is in this report used for flow from a borehole section to the tunnel but without the use of an actual pump. If nothing else is stated in this chapter, the test performance is in accordance with recommendations in the internal unpublished SKB document SKB MD 330.003. At the start of the tests, the multipacker installations with pressure gauges had been in place for almost ten days so that section pressure had time to adjust to the ambient pressure in the rock mass. The tests are listed in chronological order in Table 3-2 below.

The first seven tests (no 1–7) were carried out with a constant flow rate controlled by the SKB equipment HWIC (High pressure Water Injection Controller) which is specially designed for hydraulic tests performed in tunnels. HWIC includes a Programmable Logic Controller (PLC) which enables maintaining a steady pressure or flow rate during the tests. A constant flow rate was used to facilitate the transient evaluation of observation sections. The range of flow rate possible to measure with HWIC is c. 1 mL/min to more than 30 L/min. HWIC also includes a logger for registration of flow and pressure data. The target flow rate was for these tests decided prior to the tests such that it was projected that the pressure in the pumping section would be in the range of 200–500 kPa during the pumping period. The ambient pressures in the pumping sections were typically in the range of 3100–3400 kPa. The estimation of the target flow rate was based on the previously performed Posiva flow logging and short capacity tests carried out in in conjunction with the installation of packers in the boreholes.

The HWIC was not used for the two last two tests (no 8 and 9). The reason for this was that a very low flow rate was expected from these two sections, such that it was deemed beneficial to maximize the drawdown during the pumping period in order to enable detection of pressure interference in the other borehole sections. These tests were carried out as constant head test by opening a hydraulic tube connected to the test section and the flow rate was read manually by measuring a certain volume of water over time.

The pumping period was for most tests approximately 24 hours with a recovery period of 24 hours. However, for the two tests with the highest flow rate it was considered beforehand that a pumping period of c. 6 hours would be sufficient to detect any pressure responses.

Water sampling for chemical analyses was carried out during the pumping periods. The results of the water sampling and analysis are not included in this report. No water sampling was carried out in K03009F01:1 due to a large section (water volume) and a very low flow rate.

Table 3-2. Basic data of the interference tests and pumping sections.

Test no	Borehole	Sec no	Secup [m]	Seclow [m]	Pumping period		Start water sampling	Final flow rate Q_p [l/min]
					Start	Stop		
1	K08028F01	6	30	32	okt-06 14:38:30	okt-07 13:38:00	okt-07 08:52:00	0.40
2	K08028F01	4	37	39	okt-08 13:33:06	okt-09 13:29:22	okt-09 09:16:00	0.30
3	K03009F01	6	18.5	20.5	okt-10 08:00:38	okt-10 13:59:58	okt-10 09:08:00	4.00
4	K03009F01	4	25.5	38	okt-13 09:26:15	okt-13 15:25:58	okt-13 13:28:00	1.60
5	K03009F01	7	14.5	17.5	okt-14 09:25:07	okt-15 08:54:58	okt-14 13:22:00	0.60
6	K03009F01	5	21.5	24.5	okt-16 08:45:07	okt-17 08:38:06	okt-16 12:47:00	0.70
7	K08028F01	1	84	94.39	okt-20 09:23:06	okt-21 09:02:02	okt-20 11:02:00	0.030
8	K03009F01	1	87	100.92	okt-22 09:05:00	okt-23 08:37:00	–	0.048
9	K08028F01	7	19	29	okt-24 08:55:00	okt-27 10:38:00	okt-27 08:00:00	0.051

Section pressure was registered in HMS during the tests. Pressure responses and flow rate during the tests are presented graphically in Appendix 1.

At the start of the pumping period there is a large pressure decrease in the pumping section. Since the packers are elastic and all packers in a borehole are connected hydraulically through the common expansion hose, this probably caused a minor initial decrease in packer pressure (for all packers in the pumping borehole) during the tests. The pressure decrease caused the packers to decrease slightly in size, thus possibly causing a pressure decrease in the actual sections. This phenomenon is further on in this report referred to as *packer compliance*. Figure 3-2 shows an example of packer compliance affecting the initial section pressure for a given test.

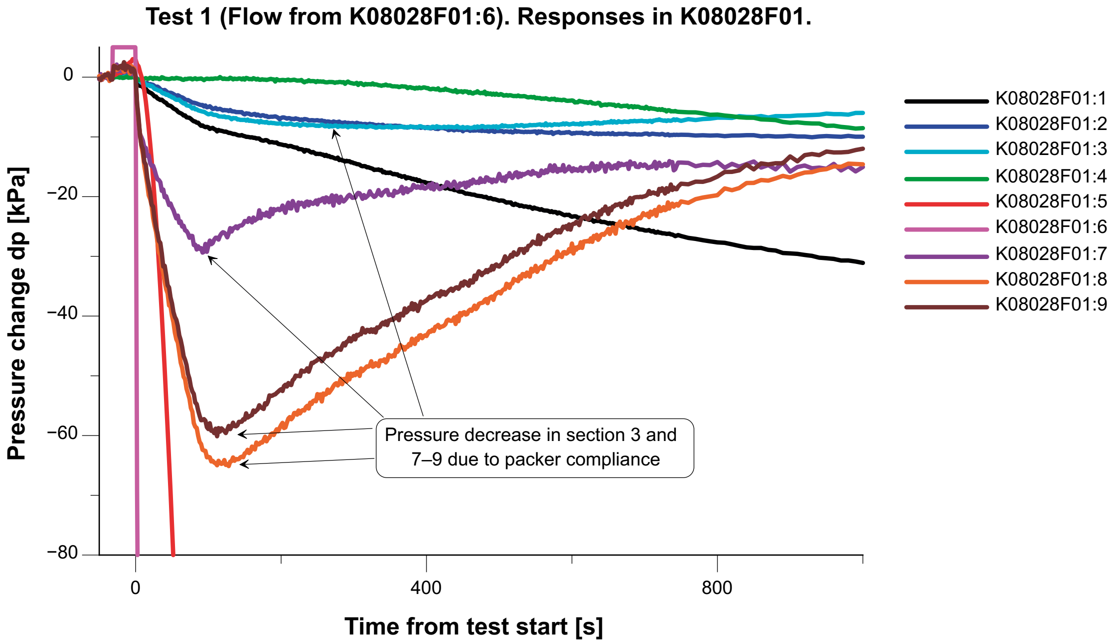

Figure 3-2. *Example of packer compliance affecting the initial pressure in section 3 and 7–9 in K08028F01 at pumping start in section 6 in the same borehole.*

4 Test evaluation methodology

4.1 General

Standard methods for constant flow rate interference tests in an equivalent porous medium were used for transient evaluation of the responses in the observation borehole sections. The responses in the pumping sections were evaluated according to theories for single-hole tests, taking effects of wellbore storage and skin into account. If nothing else is stated in this chapter, the evaluation methods are in accordance with recommendations in the internal unpublished SKB documents SKB MD 320.004 and SKB MD 330.003.

The hydraulic head (and drawdown) data collected in the observation borehole sections are influenced by natural fluctuations of the hydraulic head such as tidal effects, sea water level fluctuations, changes in air pressure and long term trends. These background variations of hydraulic head may sometimes make it difficult to deduce whether the observation sections are affected by the pumping or not. Tidal effects are often in the range of 1–3 kPa (see e.g. Appendix 1). However, since the pumping and recovery times for the present tests are rather short, the effect of sea water level fluctuations, changes in air pressure and other long term trends are considered to be rather limited in these tests, at least of lesser importance than tidal effects.

4.2 Response analysis

In the diagnostic analysis, data from all observation borehole sections included in the interference tests were studied in linear pressure versus time diagrams to identify potential responding sections. For sections with a clear pressure response (i.e. evident response due to pumping), response indices 1 and 2_new were calculated according to Equation 4-1 and Equation 4-2.

The pumping flow rate (Qp), was used in combination with the response time (dtL), spherical (Euclidian) distance (rs) and maximum drawdown (sp) to calculate the response indices. The response time, dtL, is defined as the time lag after start of pumping until a drawdown response of 0.1 m is observed in the actual observation section. The spherical distance is calculated as the straight line distance between the application point of the pumping section and that of the observation sections. The application point of each section is selected based on the positions of the dominant hydraulic features in each borehole section. If no hydraulic features are detected in a section prior to the analysis, the midpoint of the given section is selected as the point of application.

Index 1 and Index 2_new represent the speed of propagation and strength of the responses, respectively, which in turn are assumed to characterize the hydraulic connection between the pumping and the observation sections. Classification of Index 1 and Index 2_new used for presenting results in this report is presented in Table 4-1 below.

Index 1 [m^2/s]**:**

Normalised spherical distance (r_s) with respect to the response time dt_L (s = 0.1 m).

$$Index\,1 = \frac{r_s^2}{dt_L} \qquad \text{Equation 4-1}$$

Index 2_new [s/m^2]**:**

Normalised maximum drawdown (s_p) with respect to the pumping rate by the end of the flow period (Q_p), also considering the distance (r_s) assuming r_0= 1 m (fictive borehole radius).

$$Index\,2\_new = \frac{s_p}{Q_p} \cdot \ln\left(\frac{r_s}{r_0}\right) \qquad \text{Equation 4-2}$$

Table 4-1. Classification of response indices.

	Standard limits (SKB MD 330.003)	Limits used in this report	Classification	Colour code
Index 1 [m²/s]	Index 1 > 100 m²/s	Index 1 > 100 m²/s	Excellent (E)	Red
	10 < Index 1 ≤ 100 m²/s	10 < Index 1 ≤ 100 m²/s	High (H)	Yellow
	1 < Index 1 ≤ 10 m²/s	1 < Index 1 ≤ 10 m²/s	Medium (M)	Green
	Index 1 ≤ 1 m²/s	Index 1 ≤ 1 m²/s	Low (L)	Blue
	s_p < 0.1 m	s_p < 0.1 m	No response (N)	Grey
Index 2_new [s/m²]	Index 2_new > 5×10^5 s/m²	Index 2_new > 1×10^7 s/m²	Excellent (E)	Red
	5×10^4 < Index 2_new ≤ 5×10^5 s/m²	1×10^6 < Index 2_new ≤ 1×10^7 s/m²	High (H)	Yellow
	5×10^3 < Index 2_new ≤ 5×10^4 s/m²	1×10^5 < Index 2_new ≤ 1×10^6 s/m²	Medium (M)	Green
	Index 2_new ≤ 5×10^3 s/m²	Index 2_new ≤ 1×10^5 s/m²	Low (L)	Blue
	s_p < 0.1 m	s_p < 0.1 m	No response (N)	Grey

As seen in Table 4-1, higher limits than normally used by SKB for interference tests (according to internal unpublished SKB document SKB MD 330.003) were used for Index 2_new. The reason for this is that only rather low flow rates could be applied for the present interference tests, resulting in only very high values for Index 2_new for the responding sections, i.e. no or few responding sections would be classified as medium or low. If the standard limits had been used large differences in Index 2_new would not be clearly visible in the analysis.

4.3 Pumping sections – stationary evaluation

Interpretation of the transmissivity based on the assumption of steady-state conditions in the pumping sections was performed with Moye's formula in accordance with SKB MD 320.004 (Equation 4-3):

$$T_M = \frac{Q_p \cdot \rho_w \cdot g}{dp_p} \cdot C_M$$

$$C_M = \frac{1 + \ln\left(\dfrac{L_w}{2r_w}\right)}{2\pi} \qquad \text{Equation 4-3}$$

T_M = Transmissivity according to Moye´s formula (m²/s),

Q_p = flow rate at the end of the flow period (m³/s),

ρ_w = density of water (kg/m³),

g = acceleration due to gravity (m/s²),

C_M = geometrical shape factor (-),

$dp_p = p_p - p_i$ (Pa). Pressure drawdown at the end of the pumping period,

p_p = pressure in the pumping section just before pump stop,

p_i = pressure in the pumping section just before pump start,

r_w = borehole radius (m),

L_w = section length (m).

4.4 Pumping sections – transient evaluation

The transmissivity, T (m²/s), and skin factor, ξ (-), of the pumping boreholes were obtained from transient analysis based on a preceding diagnostic analysis of flow regimes using pressure derivatives.

Initially, a qualitative evaluation of acting flow regimes, e.g. wellbore storage (WBS), pseudo-linear flow regime (PLF), pseudo-radial flow regime (PRF), pseudo-spherical flow regime (PSF) and pseudo-stationary flow regime (PSS), respectively, was performed. In addition, indications of outer boundary conditions, such as no-flow boundary (NFB) and constant head boundary (CHB), during the tests were identified. The qualitative evaluation was mainly interpreted from the log-log plots of flow rate and pressure together with the corresponding derivatives. Figure 4-1 shows a schematic plot of flow regimes acting during a theoretical test. The progression of flow regimes reflect the conditions around the test section, as the early response is due to conditions close to the test section and flow regimes appearing later reflect the hydraulic conditions further away from the test section. It is however very rare that many different flow regimes occur sequentially during one and the same test as illustrated in Figure 4-1. However, intermediate flow regimes and transition phases are often identifiable as illustrated in Figure 4-2 where WBS dominates the early phase followed by a transition to an intermediate between PRF and PSF.

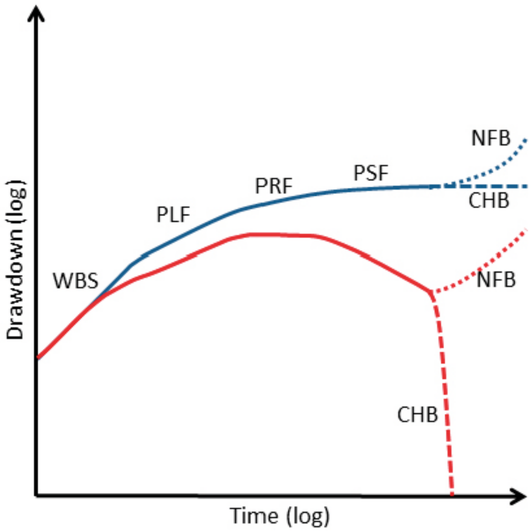

Figure 4-1. *Schematic plot of flow regimes during a constant flow rate test. The blue line represents the data and red line represents its derivative.*

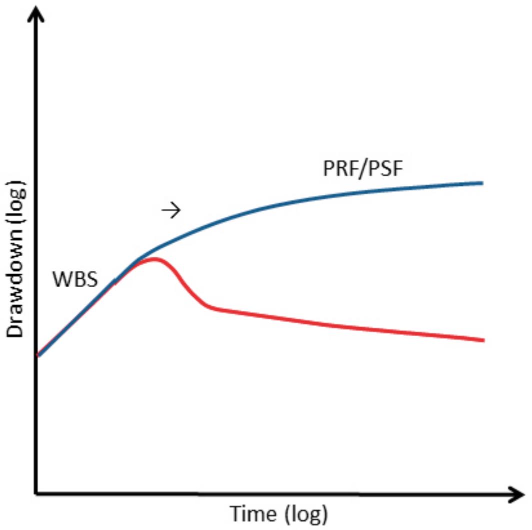

Figure 4-2. *Schematic plot of flow regimes during a constant flow rate test. The blue line represents the data and red line represents its derivative.*

The transient analysis was performed using the software AQTESOLV Pro v. 4.5 (HydroSOLVE, Inc., Reston, Virginia) that enables both manual and automatic type curve matching. The analysis was carried out as an iterative process of manual type curve matching and automatic non-linear regression. The estimation of the hydraulic parameters is normally based on the identified pseudo-radial flow regime and associated flow regimes during the tests, e.g. pseudo spherical (leaky) flow.

For transient analysis when a certain period with pseudo-radial flow could be identified, a model presented by Dougherty and Babu (1984) was used. In this model, a variety of transient solutions for flow in fractured porous media are available, accounting for e.g. wellbore storage and skin effects, double porosity etc. For tests characterized by pseudo-spherical (leaky) flow, a model by Moench (1985) was used for the transient evaluation.

Storatitivity and skin factor are strongly correlated using the effective borehole radius concept, why it is not possible to determine these independently. Instead, the storativity was assumed using an empirical relationship based on transmissivity presented in Rhén et al. (2006):

$S = 0.0007 \cdot T^{0.5}$

S = storativity (-) Equation 4-4

T = transmissivity (m^2s^{-1})

Firstly, the transmissivity and skin factor were obtained by type curve matching on the data curve using a fixed storativity value of 10^{-6}. From the transmissivity value obtained, the storativity was then assumed according to Equation 4-4 and the type curve matching was repeated. In most cases the change of storativity did not significantly alter the calculated transmissivity by the new type curve matching. Instead, the estimated skin factor, was altered correspondingly.

The pumping and recovery period were in general evaluated separately, so that two separate estimates of transient transmissivity (and skin factor) were available. Finally, one of the evaluations was selected as representative transient transmissivity, T_T. The selection of a representative transient transmissivity value is bound to be highly subjective since several aspects needs to be considered, e.g. data quality, type of flow regime and how well the selected model fits the data, see also discussion in Section 5.1.

4.5 Observation sections – transient evaluation

In the transient evaluation of observation sections responses, sections with clear responses were analysed with standard transient methods, mainly regarding transmissivity and storativity. In addition, the hydraulic diffusivity T/S of the observation sections was calculated from the evaluations. For sections where a period with pseudo-radial flow could be identified, the model presented by Theis (1935) was used to estimate T and S. For tests characterized by pseudo-spherical (leaky) flow, a model by Hantush and Jacob (1955) was used for the transient evaluation of the observation sections. Besides T and S, a leakage parameter (r/B) is used for curve fitting in this model. Figure 4-3 is a schematic plot showing PRF (solid lines) and PSF (dashed lines) in an observation section for a theoretical test.

The pumping and recovery periods were in general evaluated separately, so that two separate set of estimates of T and S were made available. Finally, one of the evaluations was selected as representative transient transmissivity, T_T. As for the pumping section, several aspects needs to be considered when selecting the representative transient transmissivity.

In order to present the result of the transient evaluation in a clear way, transmissivity (T), storativity (S) and hydraulic diffusivity (T/S) are classified according to the colour coding presented in Table 4-2. The intervals in Table 4-2 were selected specifically for the analysis made for this report, different classes (colours) would be represented in the results from another location or site.

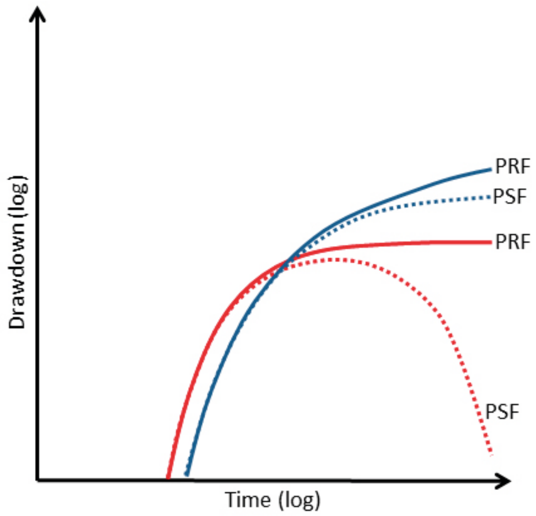

Figure 4-3. *Schematic plot of flow regimes in an observation section during a constant flow rate test. The blue lines represent the data and red lines represent its derivative while solid lines show PRF and dashed lines show a PSF.*

Table 4-2. Classification of transmissivity (T), storativity (S) and hydraulic diffusivity (T/S).

T [m²/s]		S [-]		T/S [m²/s]	
min	max	min	max	min	max
1.0E−06		1.0E−05		1.0E+01	
1.0E−07	1.0E−06	1.0E−06	1.0E−05	1.0E+00	1.0E+01
1.0E−08	1.0E−07	1.0E−07	1.0E−06	1.0E−01	1.0E+00
	1.0E−08		1.0E−07		1.0E−01

5 Results

5.1 Pumping sections

Hydraulic parameters were evaluated for the pumping sections according to the description in Sections 4.3 and 4.4. Transient evaluation could not be carried out for the two tests (no 8 and 9), cf. Table 3-1, performed as constant head tests, since only a few measurements of flow rate was available for the tests. Test no 7 (K08028F01:1 84–94.39 m) could not be evaluated with transient methods since the pressure unexpectedly increased for a major part of the pumping period and no clear flow regime could be identified for the recovery period. The cause of this increased pressure is not clear, but it could for example be associated with displacement of pockets of gas in the fractures which is not unlikely to have existed in the end of K08028F01 since it is directed upwards. It could also depend on displacement of fracture fillings (fault gouge) or flushing of drilling debris, but this is maybe more unlikely since the pressure increase exists during a substantial time period.

For all tests accounted for in this report, the estimated parameters from the pumping period were considered to be the most representative for the tests. The general reason for this is that the recovery in most cases was very fast so that the evaluations of the recovery period were very dependent on small pressure changes making the evaluation rather uncertain due to the possible superimposed effects, e.g. long term pressure trends and tidal effects. There are also some questions about why the recovery is so fast (> 100 m in 10 s). It could, for instance, be an effect of turbulence during the pumping period implicating that the pressure close to the borehole during pumping is relatively high. This is accounted for in the transient evaluation of the pumping period (as skin). But during the recovery period, the flow rate to the borehole (and thus any turbulence) drops to almost zero. In such a case, the effective drawdown controlling the recovery is lower than measured during the pumping period. But it is not possible based on data to determine how much lower it is. This possible effect also contributes to the uncertainty about the evaluated parameters for the recovery period.

Evaluated transmissivities and skin factors from the transient evaluations of both the pumping and recovery period are presented in Table 5-1. It is notable that the evaluation of the recovery period results in higher transmissivity values and very high estimates of skin factors (except for K08028F01:6). Evaluated hydraulic parameters considered to be the most representative are presented in Table 5-2. Evaluated transmissivities from the previously performed flow logging in K03009F01 and K08028F01 reported by Komulainen and Pöllänen (2016) are also included in the table for comparison. It is interesting to note that T_M and Sum T_{PFL} are rather similar but T_T is significantly higher for five of the six tests possible to evaluate with transient methods. The evaluation of these five tests also displays high skin factors.

Figure 5-1 shows an example of a transient evaluation for the pumping section K08028F01:30–32 m. This particular test display initial WBS and a transition to a clear PRF (after c 1000 s) with a high skin factor.

Table 5-1. Summary of transient evaluation of pumping sections.

				Pumping period			Recovery period		
Borehole	**Secno**	**Secup [m]**	**Seclow [m]**	**Flow regime**	**T [m²/s]**	**Skin [-]**	**Flow regime**	**T [m²/s]**	**Skin [-]**
K03009F01	4	25.5	38	WBS->PRF	1.3E−06	66	WBS->PRF	3.2E−06	176
K03009F01	5	21.5	24.5	WBS->PRF	2.9E−07	31	WBS->PRF	4.2E−06	591
K03009F01	6	18.5	20.5	WBS->PRF	1.9E−06	21	PRF	6.3E−06	90
K03009F01	7	14.5	17.5	WBS->PRF	2.7E−07	29	WBS->PRF	5.4E−06	770
K08028F01	1	84	94.39	WBS->?	a)	a)	WBS->	b)	b)
K08028F01	4	37	39	WBS->PRF	3.8E−08	5	WBS->PRF	8.8E−08	20
K08028F01	6	30	32	WBS->PRF	1.8E−07	26	PSF?	1.1E−08	0.8

a) Not possible to evaluate due to increasing pressure during the pumping period.

b) Not possible to achieve an unambiguous evaluation.

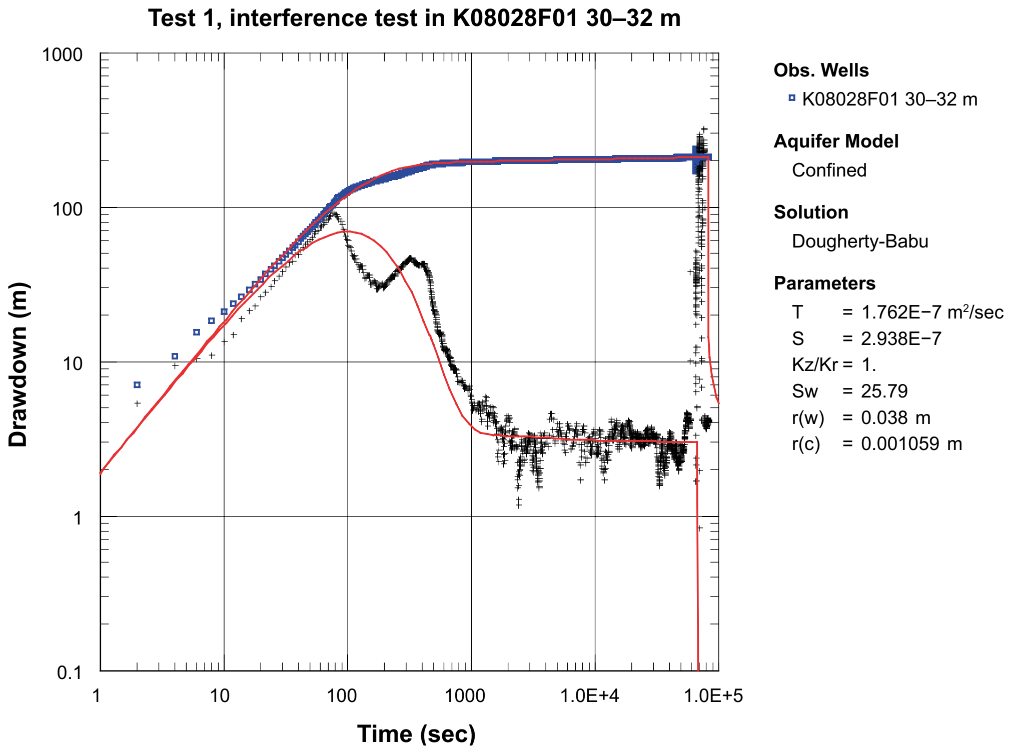

Figure 5-1. *Example of transient evaluation of a pumping section.*

Table 5-2. Summary of evaluated hydraulic parameters for the different borehole intervals.

Borehole	Secno	Secup [m]	Seclow [m]	T_M [m²/s]	T_T [m²/s]	Skin [-]	Sum T_{PFL} [m²/s]
K03009F01	1	87	100.92	2.4E−09	a)	a)	1.5E−09
K03009F01	2	59	86	c)	c)	c)	4.3E−11
K03009F01	3	39	58	c)	c)	c)	8.3E−10
K03009F01	4	25.5	38	1.1E−07	1.3E−06	67.6	7.1E−08
K03009F01	5	21.5	24.5	3.7E−08	2.9E−07	31.1	2.5E−08
K03009F01	6	18.5	20.5	2.7E−07	1.9E−06	21.3	3.9E−07
K03009F01	7	14.5	17.5	3.2E−08	2.7E−07	29.3	2.8E−08
K03009F01	8	9	13.5	c)	c)	c)	3.1E−09
K03009F01	9	4	8	c)	c)	c)	1.9E−09
K03009F01	10	1.5	3	c)	c)	c)	2.0E−07
K08028F01	1	84	94.39	1.7E−09	b)	b)	d)
K08028F01	2	61	83	c)	c)	c)	d)
K08028F01	3	40	60	c)	c)	c)	d)
K08028F01	4	37	39	1.2E−08	3.8E−08	5.0	2.3E−08
K08028F01	5	33	36	c)	c)	c)	d)
K08028F01	6	30	32	2.2E−08	1.8E−07	25.8	2.1E−08
K08028F01	7	19	29	2.6E−09	a)	a)	1.6E−09
K08028F01	8	10	18	c)	c)	c)	d)
K08028F01	9	2	9	c)	c)	c)	d)

a) Not possible to evaluate due to few flow rate measurements during a constant head test.
b) Not possible to evaluate due to increasing pressure during the test.
c) Section only used as an observation section.
d) Below measurement limit (see Komulainen and Pöllänen 2016).

5.2 Observations sections

Response analysis and transient evaluations for the observation sections were carried out according to procedures outlined in Sections 4.2 and 4.5.

The result of the response analysis is presented in Table 5-3 and Table 5-4 for pumping in K08208F01 and K03009F01, respectively. For several observation sections in the same borehole as the pumping section it was not possible to evaluate the pressure response time, dt_L, due to effects of packer compliance as described in Section 3.2. Hence, for these sections it was not possible to calculate Index 1. For some other observation sections, with a very small pressure response, it was not possible to estimate the pressure response time due to scattered pressure data, tidal effects and/or other disturbing long terms trends. Since the packer installations were in place for almost ten days before the first test, the pressure had in most sections adjusted to the ambient pressure in the rock. However, the pressure in section 2 of K08028F01 was still increasing during the tests whereby the response evaluation for this section had to be corrected according to the general trend.

The transient evaluations of observation section responses are presented in Table 5-5 and Table 5-6 for pumping in K08208F01 and K030009F01, respectively. For some weak responses it was not possible to do any transient evaluation without including rather large uncertainties. For some other observation sections it was not possible to do any transient evaluation since the responses do not fit any available analytical model. These evaluations are not included in Table 5-5 and Table 5-6 below. Relevant plots from the transient evaluations using AQTESOLV Pro v. 4.5 for the observation sections are shown in Appendix 3. An example is shown in Figure 5-2. The pressure response for this particular test and observation section is dominated by a PRF.

The response analysis and transient evaluations of the observation sections are presented in Figure 5-3 through Figure 5-11. Since it was impossible to calculate Index 1 for many sections, it is not included in the indicated figures. Figure 5-3 through Figure 5-11 are projections is the same way as in Figure 3-1, made in the local coordinate system ÄSPÖ96 with north directed up in the figures.

In addition to the evaluation of pressure responses in K08028F01 and K03009F01, the presence of pressure responses were controlled in other boreholes in the vicinity. This evaluation was only qualitative so that the pressure responses were classified according to Y = Yes, clear response; N = No response and finally P = probable, but uncertain response. The results of this evaluation are presented in Appendix 4. No responses in surrounding boreholes could be found when pumping in K08028F01 or K03009F01:1 (89–100.92) and hence these tests are not included in Appendix 4.

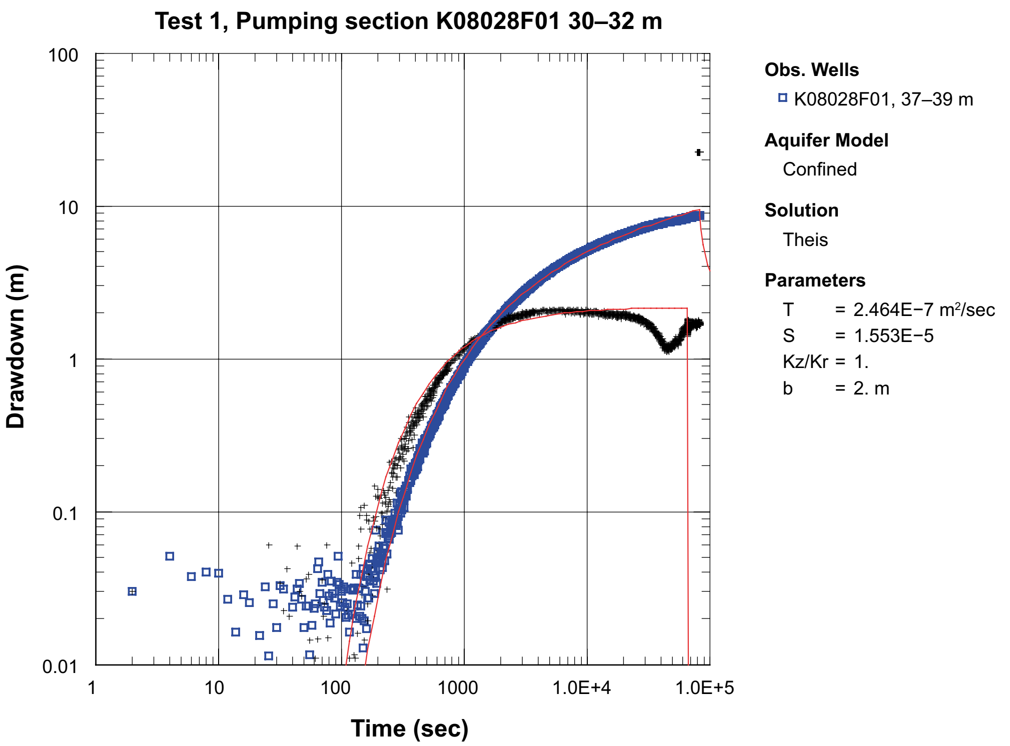

Figure 5-2. Example of transient evaluation of an observation section.

Table 5-3. Response indices calculated for interference tests with pumping in K08028F01, sections 1, 4, 6 and 7 (test no 1, 2, 7 and 9). The colour codings for Index 1 and Index 2_new are according to Table 4-1.

Pumping section		**Test no**		9		1		2		7	
		Borehole ID		K08028F01		K08028F01		K08028F01		K08028F01	
		Secno		7		6		4		1	
		Secup		19		30		37		84	
		Seclow		29		32		39		94.39	
Observation section											
Borehole ID	**Secno**	**Secup**	**Seclow**	**Index 1**	**Index 2_new**	**Index 1**	**Index 2_new**	**Index 1**	**Index 2_new**	**Index 1**	**Index 2_new**
K03009F01	1	87	100.92			2.9E–01	7.8E+05	b)	7.8E+04	3.8E–01	1.0E+07
K03009F01	2	59	86								
K03009F01	3	39	58								
K03009F01	4	25.5	38								
K03009F01	5	21.5	24.5								
K03009F01	6	18.5	20.5								
K03009F01	7	14.5	17.5								
K03009F01	8	9	13.5								
K03009F01	9	4	8								
K03009F01	10	1.5	3								
K08028F01	1	84	94.39			9.9E+02	4.3E+06	a)	4.5E+05	Pumping section	
K08028F01	2	61	83			a)	7.4E+05			a)	3.4E+07
K08028F01	3	40	60	a)	3.3E+06	a)	1.3E+06	a)	2.6E+06		
K08028F01	4	37	39	a)	1.3E+07	1.2E–01	2.4E+06	Pumping section			
K08028F01	5	33	36	a)	5.6E+06	a)	2.0E+07	a)	1.2E+06	3.6E+03	4.0E+07
K08028F01	6	30	32	a)	4.2E+06	Pumping section		a)	1.9E+06	1.3E+03	3.3E+06
K08028F01	7	19	29	Pumping section		a)	4.5E+06	a)	9.9E+06		
K08028F01	8	10	18	a)	7.3E+07	a)	3.4E+06	a)	6.4E+06		
K08028F01	9	2	9	a)	7.2E+06	a)	1.3E+06	a)	2.5E+06		

a) Not possible to evaluate due to initial pressure disturbances due to packer compliance.
b) Not reported due to very uncertain evaluation.

Table 5-4. Response indices calculated for interference tests with pumping in K03009F01, sections 1 and 4–7 (test no 3–6 and 8). The colour codings for Index 1 and Index 2_new are according to Table 4-1.

Pumping section		Test nr		5		3		6		4		8	
		Borehole ID		K03009F01		K03009F01		K03009F01		K03009F01		K03009F01	
		Secno		7		6		5		4		1	
		Secup		14.5		18.5		21.5		25.5		87	
		Seclow		17.5		20.5		24.5		38		100.92	
Observation section													
Borehole ID	**Secno**	**Secup**	**Seclow**	**Index 1**	**Index 2_new**	**Index 1**	**Index 2_new**	**Index 1**	**Index 2_new**	**Index 1**	**Index 2_new**	**Index 1**	**Index 2_new**
K03009F01	1	87	100.92									Pumping section	
K03009F01	2	59	86									a)	7.6E+06
K03009F01	3	39	58	4.5E+00	2.7E+05	a)	2.6E+05	1.1E+02	4.6E+05	1.6E+02	2.1E+07		
K03009F01	4	25.5	38	1.2E+00	2.2E+05	a)	1.9E+05	1.7E+01	2.8E+05	Pumping section			
K03009F01	5	21.5	24.5	a)	1.7E+05	a)	1.9E+05	Pumping section		8.7E+00	3.0E+05		
K03009F01	6	18.5	20.5	2.1E−01	9.7E+04	Pumping section		3.0E+00	1.9E+05	2.5E+00	1.9E+05		
K03009F01	7	14.5	17.5	Pumping section		a)	8.2E+04	a)	1.8E+05	4.6E+00	1.9E+05		
K03009F01	8	9	13.5	a)	1.7E+05	a)	1.3E+05	a)	2.3E+05	a)	2.1E+05		
K03009F01	9	4	8	a)	2.0E+05	a)	3.2E+05	3.7E+02	6.5E+07	2.1E+02	5.4E+05		
K03009F01	10	1.5	3										
K08028F01	1	84	94.39					b)	4.0E+04			2.4E−01	7.2E+06
K08028F01	2	61	83										
K08028F01	3	40	60					b)	3.5E+04			9.4E−02	6.5E+05
K08028F01	4	37	39	1.8E−01	1.2E+05	1.5E+00	8.9E+04	2.4E−01	1.3E+05	3.8E−01	7.4E+04		
K08028F01	5	33	36	1.6E−01	8.1E+04	1.0E+00	6.4E+04	1.8E−01	9.8E+04	3.1E−01	5.9E+04		
K08028F01	6	30	32	1.2E−01	8.0E+04	9.3E−01	6.6E+04	1.6E−01	9.6E+04	3.1E−01	5.9E+04		
K08028F01	7	19	29	8.7E−02	1.1E+05	2.7E+00	8.3E+04	b)	1.2E+05	4.9E−01	6.6E+04		
K08028F01	8	10	18	b)	1.1E+05	1.5E+00	7.8E+04	b)	9.1E+04	3.1E−01	5.8E+04		
K08028F01	9	2	9	9.3E−01	1.1E+05	2.1E+00	4.8E+04	4.0E−02	6.0E+04				

a) Not possible to evaluate due to initial pressure disturbances due to packer compliance.
b) Not reported due to very uncertain evaluation.

Table 5-5. Result from transient evaluation of observation section for interference tests with pumping in K08028F01, sections 1, 4, 6 and 7 (test no 1, 2, 7 and 9). The colour codings for T, S and T/S are according to Table 4-2.

Pumping section		Test nr		9			1			2			7		
		Borehole ID		K08028F01			K08028F01			K08028F01			K08028F01		
		Secno		7			6			4			1		
		Secup		19			30			37			84		
		Seclow		29			32			39			94.39		
		TT					1.8E−07			3.8E−08					
		TM		2.6E−09			2.2E−08			1.2E−08			1.7E−09		
Observation section															
Borehole ID	**Secno**	**Secup**	**Seclow**	**T**	**S**	**T/S**	**T**	**S**	**T/S**	**T**	**S**	**T/S**	**T**	**S**	**T/S**
K03009F01	1	87	100.92				6.5E−07	1.0E−05	6.3E−02	a)	a)	a)	3.5E−08	7.5E−07	6.6E−01
K03009F01	2	59	86												
K03009F01	3	39	58												
K03009F01	4	25.5	38												
K03009F01	5	21.5	24.5												
K03009F01	6	18.5	20.5												
K03009F01	7	14.5	17.5												
K03009F01	8	9	13.5												
K03009F01	9	4	8												
K03009F01	10	1.5	3												
K08028F01	1	84	94.39				5.4E−07	1.4E−08	3.8E+01	a)	a)	a)	Pumping section		
K08028F01	2	61	83				a)	a)	a)				a)	a)	a)
K08028F01	3	40	60	a)	a)	a)	3.3E−07	3.0E−05	1.1E−02	2.2E−07	1.3E−05	1.7E−02			
K08028F01	4	37	39	a)	a)	a)	2.5E−07	1.6E−05	1.6E−02	Pumping section					
K08028F01	5	33	36	a)	a)	a)	6.1E−09	1.8E−07	3.4E−02	2.8E−07	6.0E−05	4.6E−03	a)	a)	a)
K08028F01	6	30	32	a)	a)	a)	Pumping section			2.8E−07	1.5E−05	1.8E−02	a)	a)	a)
K08028F01	7	19	29	Pumping section			1.3E−07	3.3E−06	3.9E−02	5.4E−08	9.1E−07	6.0E−02			
K08028F01	8	10	18	a)	a)	a)	1.9E−07	4.0E−06	4.8E−02	8.8E−08	1.5E−06	6.0E−02			
K08028F01	9	2	9	a)	a)	a)	5.0E−07	7.0E−06	7.2E−02	1.6E−07	3.1E−06	5.1E−02			

a) Hydraulic response but not possible to evaluate T, S and T/S.

Table 5-6. Result from transient evaluation of observation section for interference tests with pumping in K03009F01, sections 1 and 4–7 (test no 3–6 and 8). The colour codings for T, S and T/S are according to Table 4-2.

Pumping section		Test nr		5			3			6			4			8		
		Borehole ID		K03009F01			K03009F01			K03009F01			K03009F01			K03009F01		
		Secno		7			6			5			4			1		
		Secup		14.5			18.5			21.5			25.5			87		
		Seclow		17.5			20.5			24.5			38			100.92		
		TT		2.7E−07			1.9E−06			2.9E−07			1.3E−06					
		TM		3.2E−08			2.7E−07			3.7E−08			1.1E−07			2.4E−09		
Observation section																		
Borehole ID	**Secno**	**Secup**	**Seclow**	**T**	**S**	**T/S**	**T**	**S**	**T/S**	**T**	**S**	**T/S**	**T**	**S**	**T/S**	**T**	**S**	**T/S**
K03009F01	1	87	100.92	6.8E−06	7.5E−05	9.1E−02										Pumping section		
K03009F01	2	59	86													a)	a)	a)
K03009F01	3	39	58	6.2E−06	3.5E−06	1.8E+00	5.9E−06	1.3E−06	4.6E+00	6.2E−06	2.0E−08	3.1E+02	2.6E−09	1.1E−09	2.4E+00			
K03009F01	4	25.5	38	6.2E−06	1.1E−05	5.7E−01	5.9E−06	5.7E−06	1.0E+00	6.1E−06	2.0E−07	3.1E+01	Pumping section					
K03009F01	5	21.5	24.5	6.4E−06	3.0E−05	2.1E−01	6.2E−06	8.9E−07	7.0E+00	Pumping section			4.1E−06	6.6E−07	6.3E+00			
K03009F01	6	18.5	20.5	6.7E−06	7.7E−05	8.7E−02	Pumping section			5.8E−06	4.1E−06	1.4E+00	5.3E−06	8.5E−06	6.3E−01			
K03009F01	7	14.5	17.5	Pumping section			6.2E−06	8.2E−05	7.5E−02	6.1E−06	1.8E−05	3.3E−01	5.3E−06	1.1E−05	4.6E−01			
K03009F01	8	9	13.5	7.4E−06	1.7E−06	4.5E+00	6.0E−06	3.4E−05	1.8E−01	6.4E−06	3.0E−06	2.1E+00	5.4E−06	7.0E−06	7.7E−01			
K03009F01	9	4	8	6.5E−06	1.3E−05	5.1E−01	6.2E−06	1.1E−07	5.7E+01	a)	a)	a)	4.2E−06	3.5E−08	1.2E+02			
K03009F01	10	1.5	3															
K08028F01	1	84	94.39							a)	a)	a)				a)	a)	a)
K08028F01	2	61	83															
K08028F01	3	40	60							a)	a)	a)				a)	a)	a)
K08028F01	4	37	39	4.7E−06	5.3E−05	9.0E−02	a)	a)	a)	4.6E−06	6.1E−05	7.5E−02	4.7E−06	5.5E−05	8.5E−02			
K08028F01	5	33	36	7.5E−07	5.5E−05	1.4E−02	a)	a)	a)	6.7E−06	8.9E−05	7.5E−02	6.6E−06	7.1E−05	9.4E−02			
K08028F01	6	30	32	6.8E−06	7.5E−05	9.1E−02	a)	a)	a)	5.8E−06	1.1E−04	5.3E−02	7.5E−06	7.2E−05	1.0E−01			
K08028F01	7	19	29	5.0E−06	8.0E−05	6.3E−02	a)	a)	a)	4.2E−06	1.1E−04	3.9E−02	5.6E−06	9.0E−05	6.3E−02			
K08028F01	8	10	18	a)	a)	a)	a)	a)	a)	a)	a)	a)	a)	a)	a)			
K08028F01	9	2	9	9.0E−06	5.4E−05	1.7E−01	a)	a)	a)	a)	a)	a)						

a) Hydraulic response but not possible to evaluate T, S and T/S.

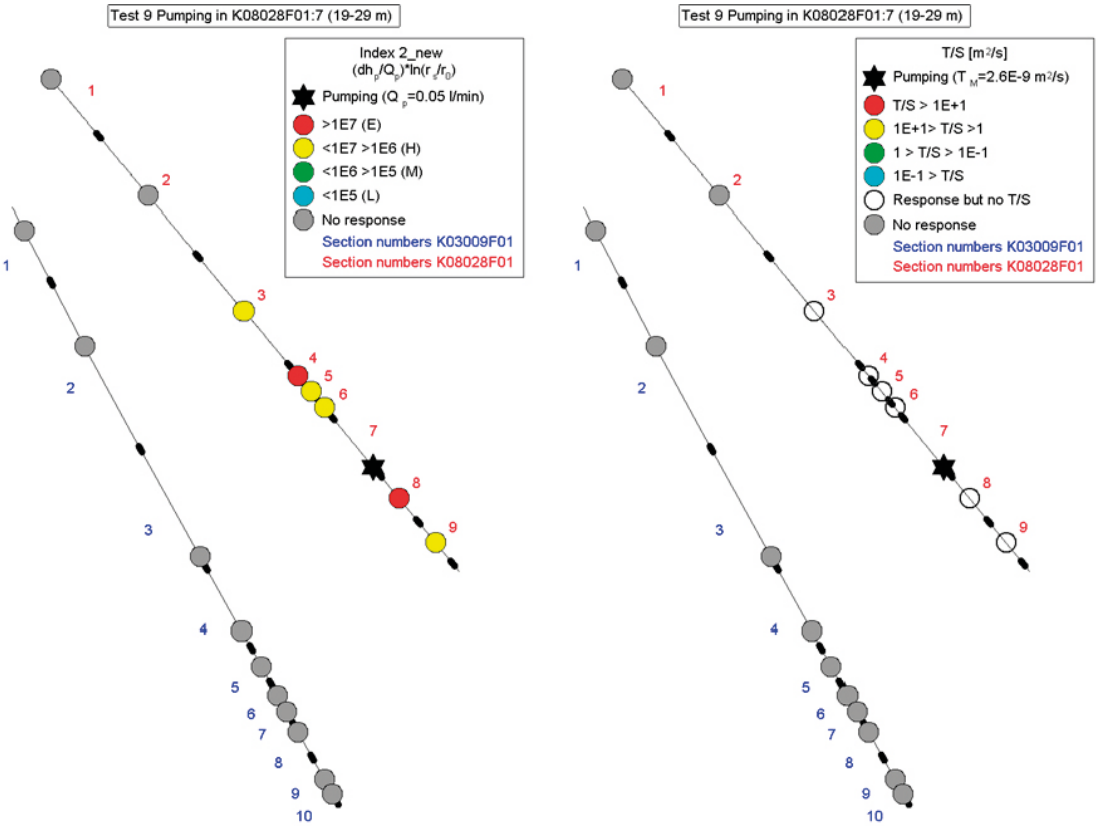

Figure 5-3. *Index 2_new and hydraulic diffusivity (T/S) for observation sections in interference test with pumping in K08028F01:7, 19–29 m (test no 9).*

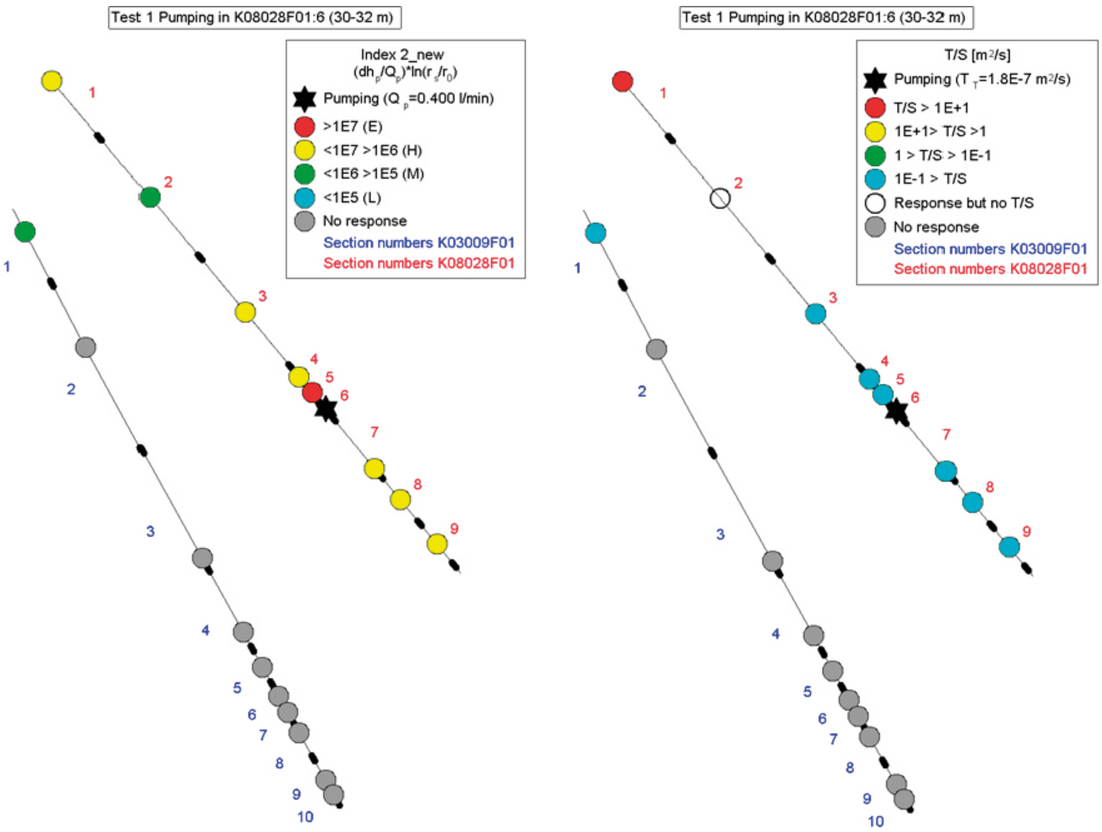

Figure 5-4. *Index 2_new and hydraulic diffusivity (T/S) for observation sections in interference test with pumping in K08028F01:6, 30–32 m (test no 1).*

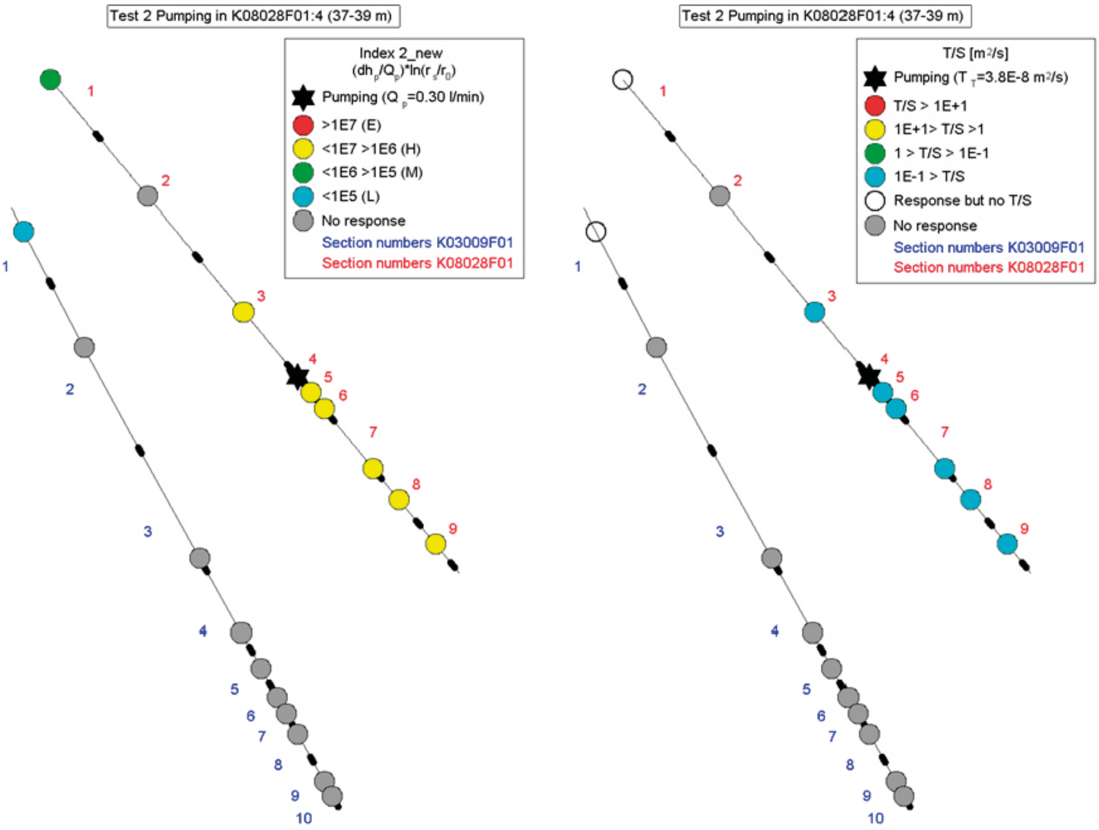

Figure 5-5. *Index 2_new and hydraulic diffusivity (T/S) for observation sections in interference test with pumping in K08028F01:4, 37–39 m (test no 2).*

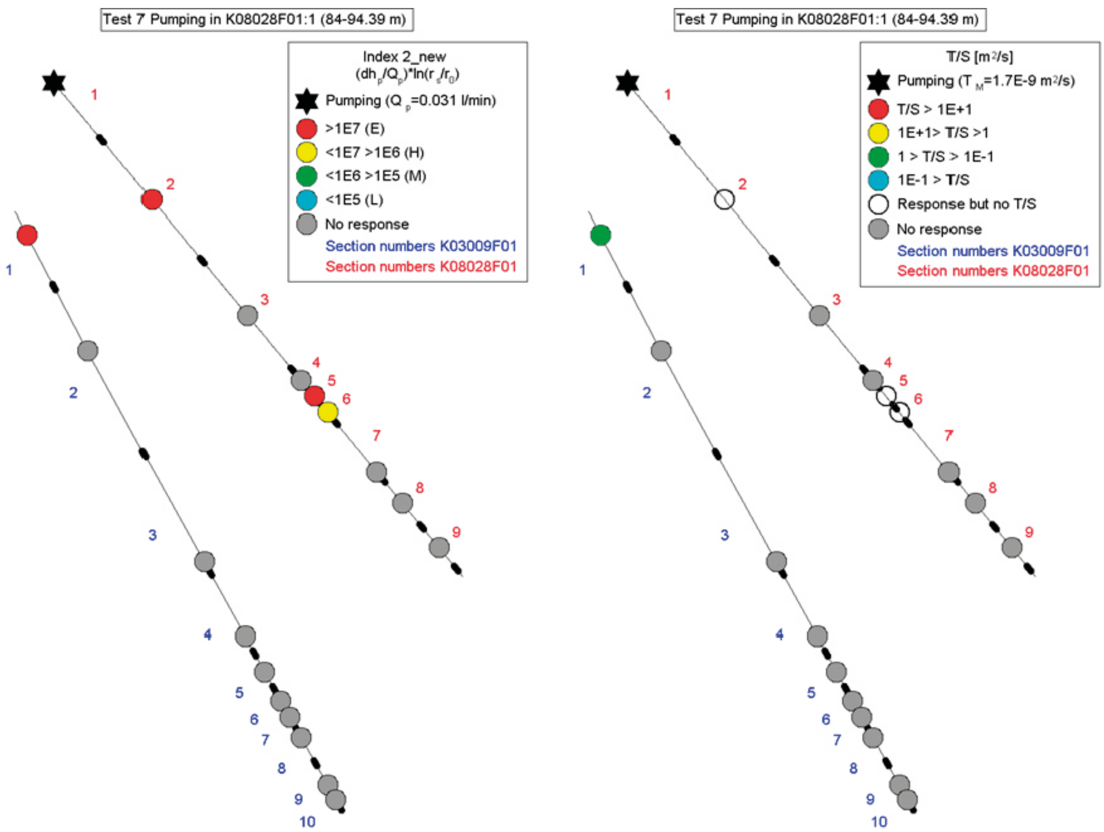

Figure 5-6. *Index 2_new and hydraulic diffusivity (T/S) for observation sections in interference test with pumping in K08028F01:7, 84–94.39 m (test no 7).*

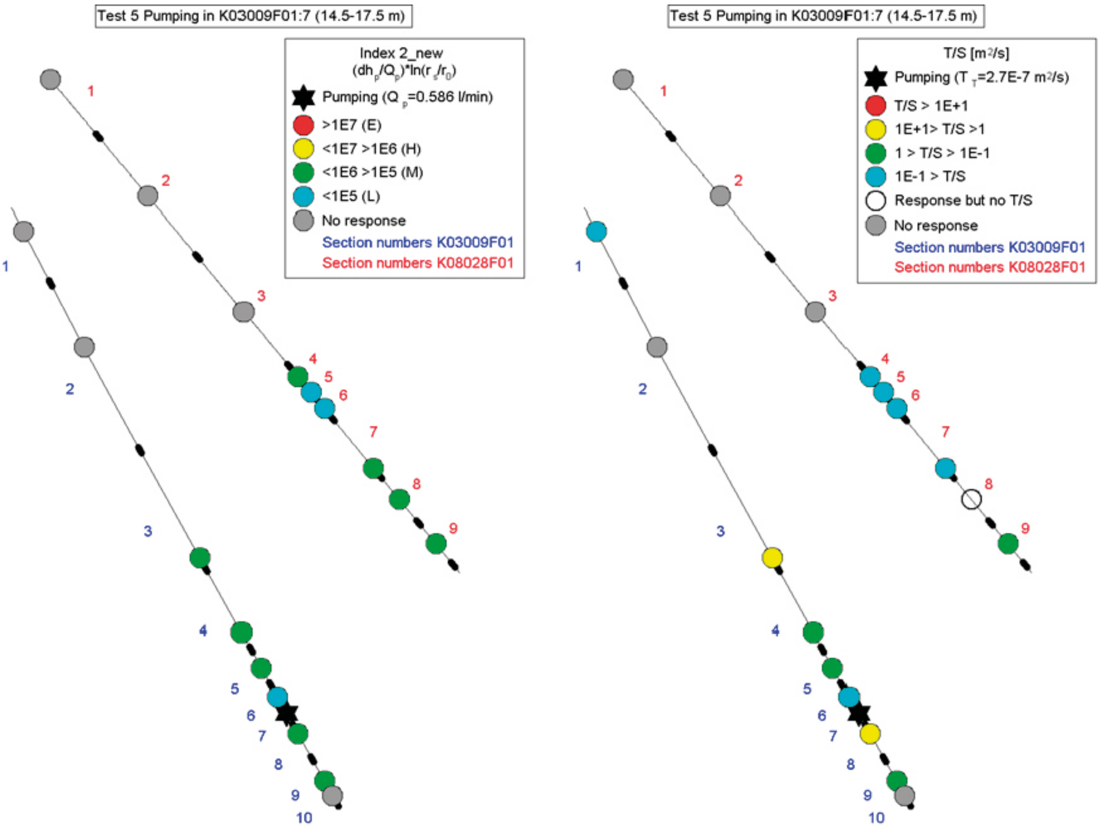

Figure 5-7. *Index 2_new and hydraulic diffusivity (T/S) for observation sections in interference test with pumping in K03009F01:7, 14.5–17.5 m (test no 5).*

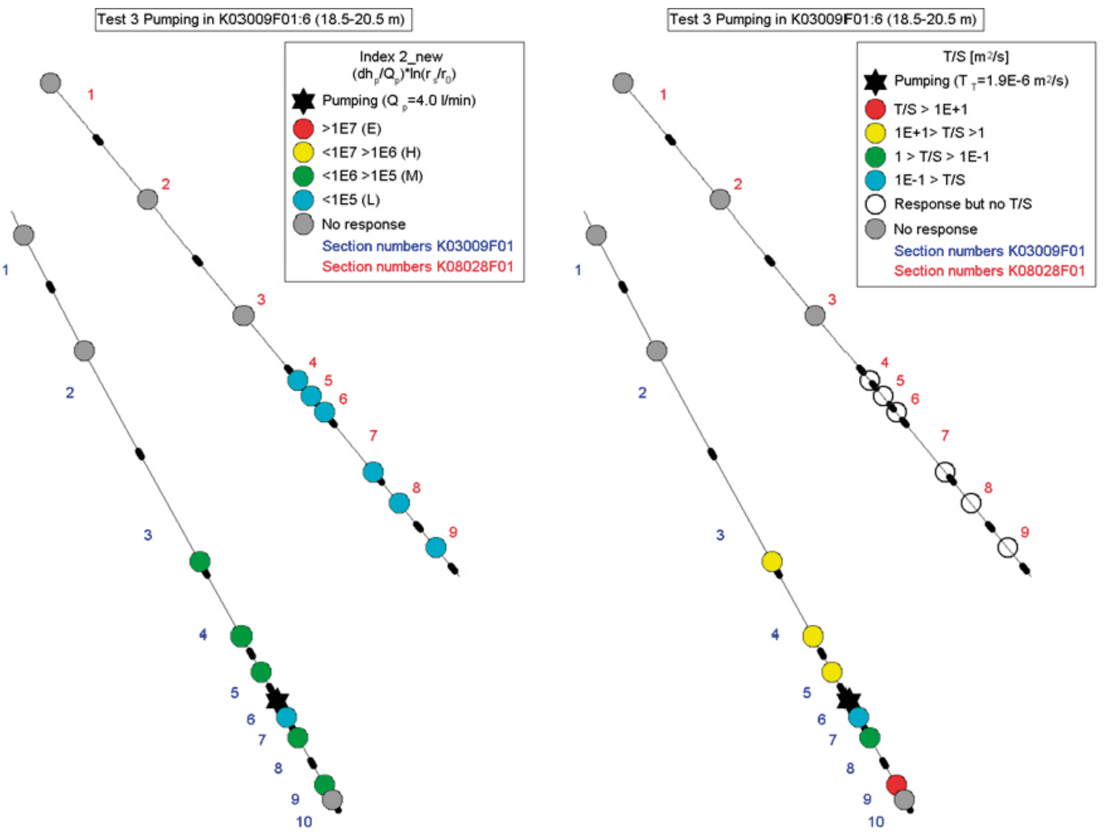

Figure 5-8. *Index 2_new and hydraulic diffusivity (T/S) for observation sections in interference test with pumping in K03009F01:6, 18.5–20.5 m (test no 3).*

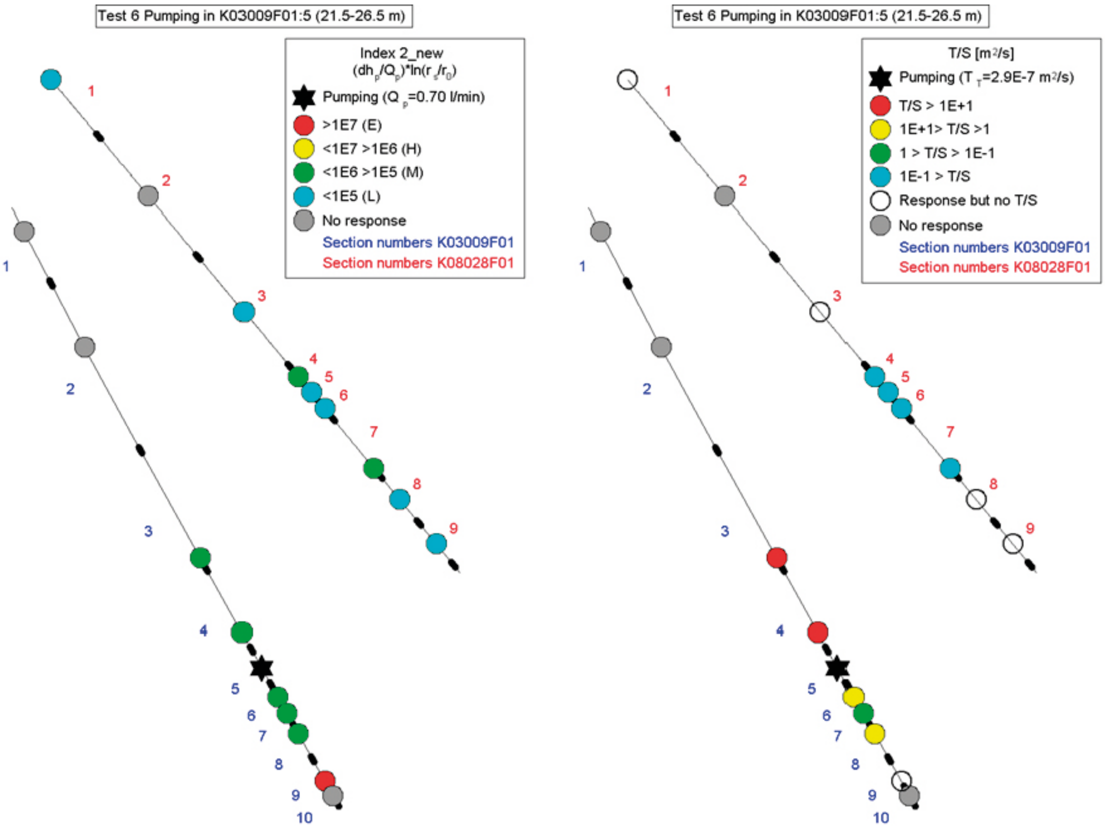

Figure 5-9. *Index 2_new and hydraulic diffusivity (T/S) for observation sections in interference test with pumping in K03009F01:5, 21.5–26.5 m (test no 6).*

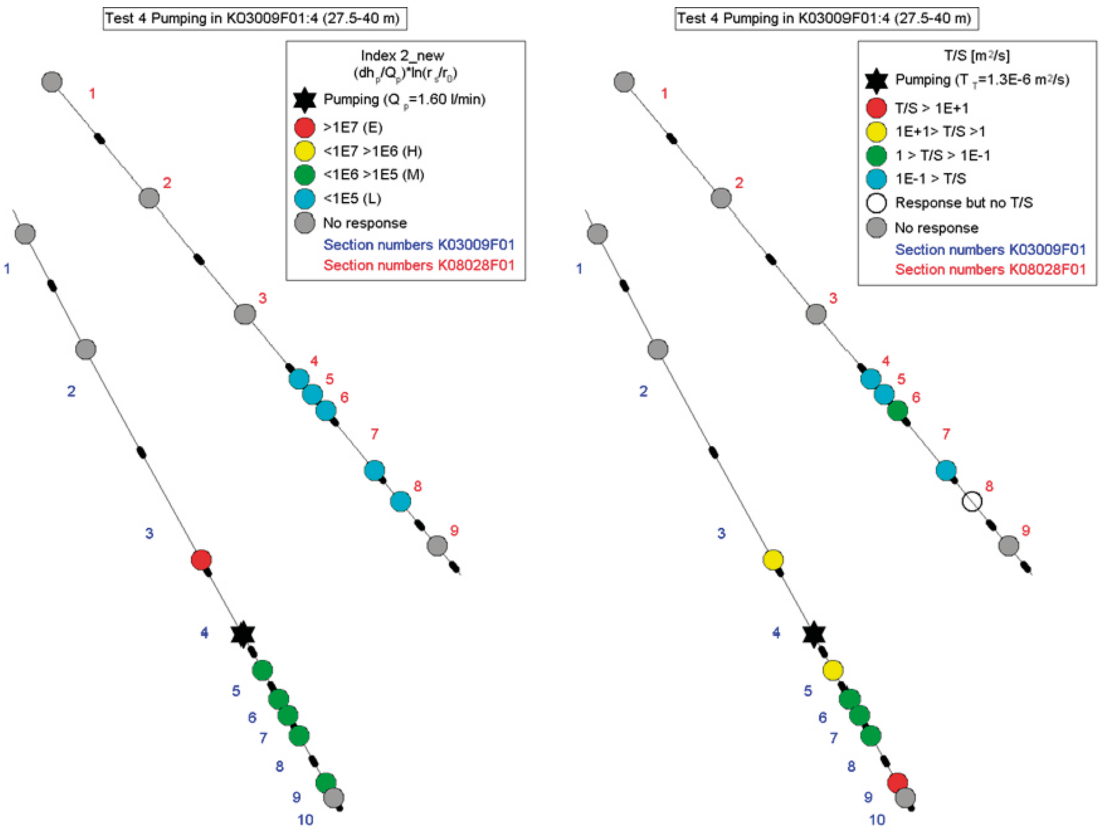

Figure 5-10. *Index 2_new and hydraulic diffusivity (T/S) for observation sections in interference test with pumping in K03009F01:4, 27.5–40 m (test no 4).*

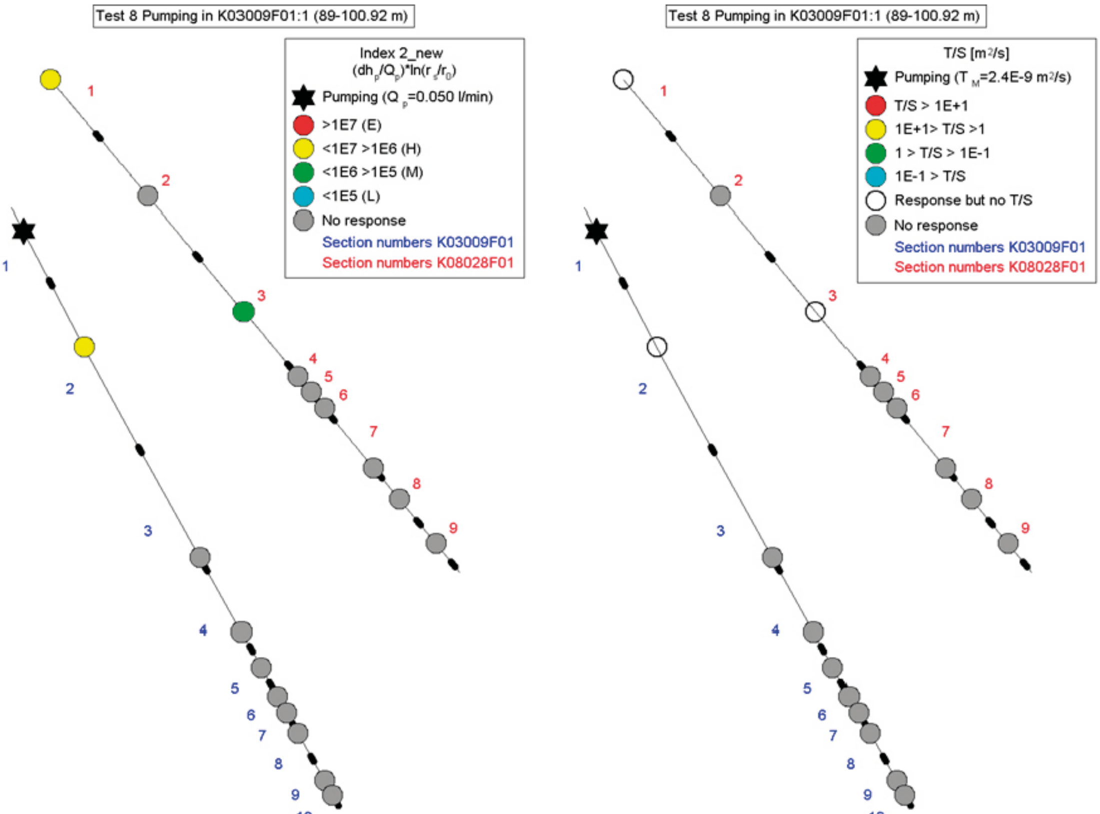

Figure 5-11. *Index 2_new and hydraulic diffusivity (T/S) for observation sections in interference test with pumping in K03009F01:1, 89–100.92 m (test no 8).*

6 Conclusion and discussions

The mutual hydraulic responses as observed between K03009F01 and K08028F01 during the nine interference tests are compiled in Figure 6-1 through Figure 6-3 in terms of T/S, Index2_new and Index1, respectively. The figures also include mapping of evaluated transmissivity for all sections. When several transmissivity estimates are available for a section (see Table 5-2), transient evaluations from the flowing phase of the pumping tests (T_T) were prioritized before T_M and finally Sum T_{PFL}. Responses in sections located in the same borehole as the pumping section are not included in Figure 6-1 through Figure 6-3, simply because they are so abundant that their inclusion would make the figures unclear. See Figures 5-1 through 5-9 for illustration of the intra hole responses.

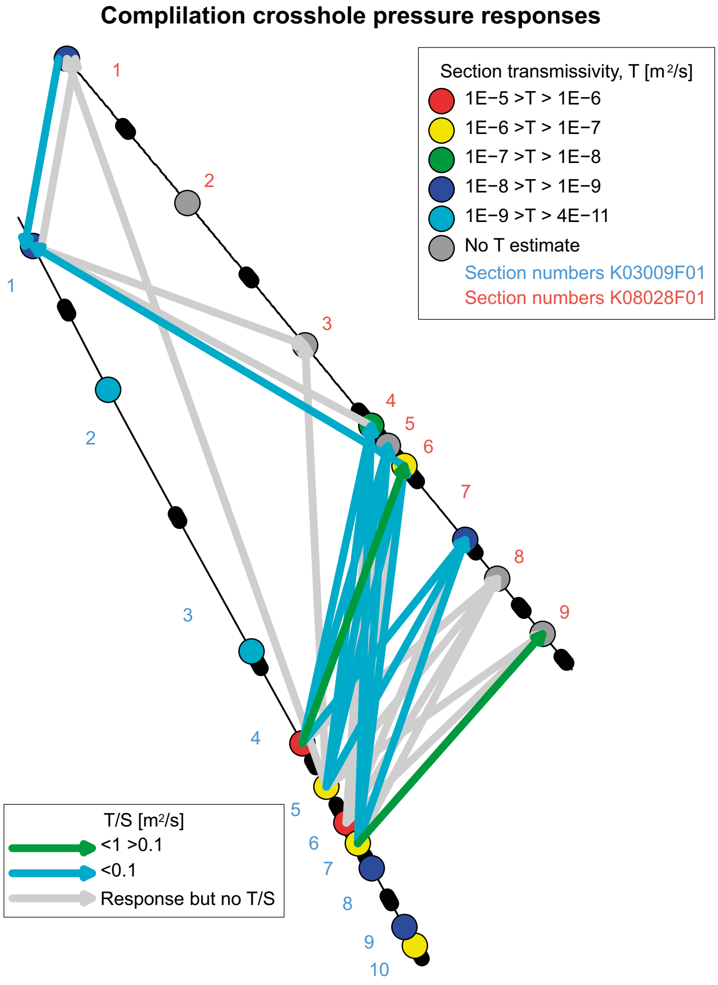

Figure 6-1. Compilation of hydraulic responses in between K08028F01 and K03009F01 together with indication a section transmissivity. Arrows indicate hydraulic responses regarding hydraulic diffusivity, T/S, during the interference tests pointing from the pumping section to the responding section.

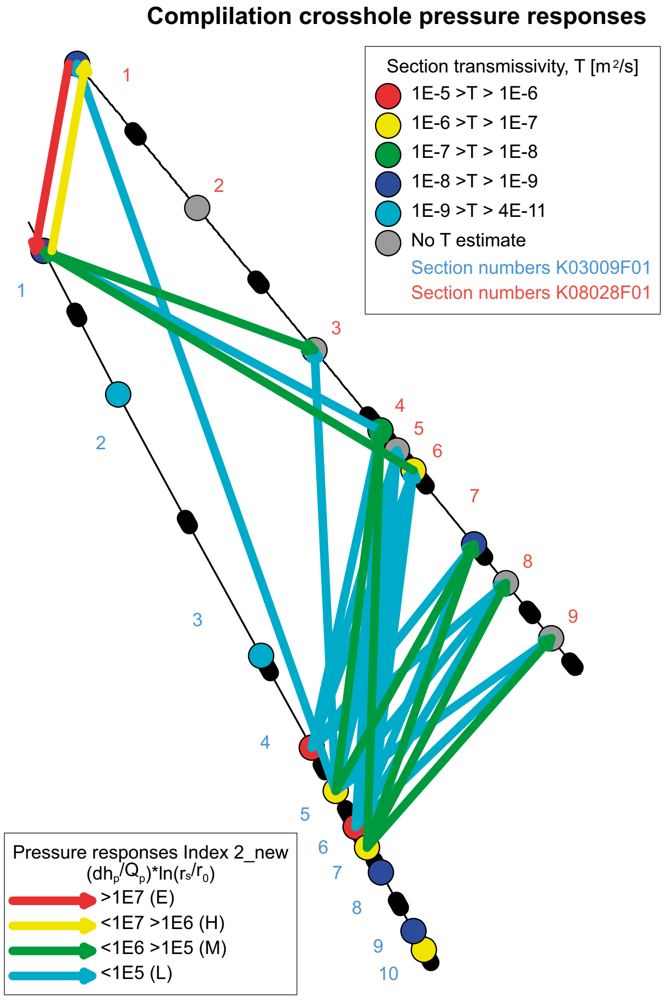

Figure 6-2. *Compilation of hydraulic responses in between K08028F01 and K03009F01 together with indication a section transmissivity. Arrows indicate hydraulic responses regarding Index 2_new during the interference tests pointing from the pumping section to the responding section.*

The hydraulic responses noted during the interference tests in K03009F01 and K08028F01 may be summarized with the following notes:

- Generally good responses in sections located in the same borehole as the pumping section.
- Low to medium responses in K08028F01 sections 4 through 8 (3 through 9 for some tests) when pumping in K03009F01 sections 4 through 7. But no responses in K03009F01 sections 2 through 10 when pumping in K08028F01 sections 4, 6 and 7, respectively.
- Low response in K08028F01 section 1 when pumping in K03009F01 section 5. But no reciprocal responses are observed.
- Low to medium responses in K03009F01 section 1 when pumping in K08028F01 sections 4 and 6, but no corresponding reciprocal responses are observed.
- High to excellent response between K03009F01 section 1 and K08028F01 section 1 considering Index2_new, but low repsonses when considering Index1.
- Low to medium response in K08028F01 section 3 when pumping in K03009F01 section 1. However, it is noted that K08208F01 section 3 is considered to be very low conductive.

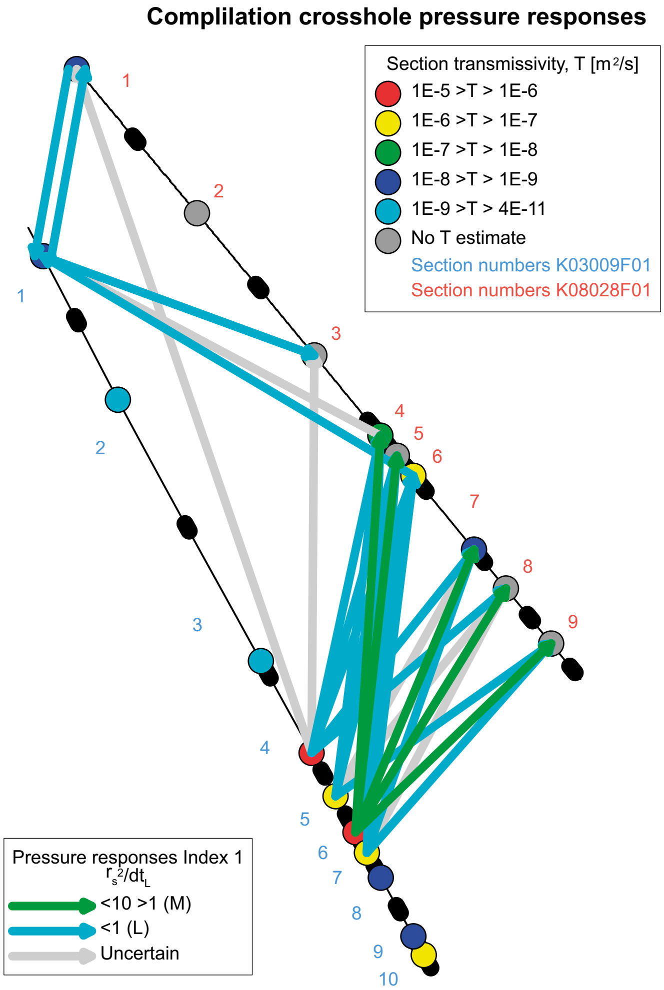

Figure 6-3. *Compilation of hydraulic responses in between K08028F01 and K03009F01 together with indication a section transmissivity. Arrows indicate hydraulic responses regarding Index 1 during the interference tests pointing from the pumping section to the responding section.*

The responses in K08028F01 when pumping in K03009F01 are generally in the range of 5 to 10 kPa (see Appendix 1). Considering the lower pumping flow rate in K08028F01 and general higher transmissivity in K03009F01, a lower pressure response is to be expected in K03009F01 when pumping in K08028F01 assuming fully developed reciprocity. Considering that disturbing factors such as tidal effects and measurement noise are in the range of 1 to 3 kPa, reciprocity between K08028F01 and K03009F01 cannot be ruled out, even though that the presented results do not show direct evidence of such reciprocity.

An important finding is that transient evaluation for a majority of the pumping sections results in a transmissivity close to a factor 10 higher than stationary evaluations (T_M from pumping tests and Sum T_{PFL} from flow logging). This discrepancy is probably due to the high skin factor found in the transient evaluations. Possible explanations for high skin factors may be significant turbulence and/or an elastic decompression of the fractures close to the boreholes when the tests are performed with a large pressure decrease, as in these cases. A similar discrepancy between transient evaluations and stationary evaluations for test with a large pressure decrease has also been observed by Hjerne et al. (2016) when hydraulic injection tests were compared with flow logging in short pilot holes for experimental deposition holes at the Posiva ONKALO facility. The conclusion is that it is especially important to include skin factor (i.e. use transient evaluation) when evaluating tests with a large pressure decrease.

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Hjerne C, Komulainen J, Aro S, Winberg A, 2016. Development of hydraulic test strategies in support of deposition hole acceptance. Results of hydraulic injection tests in ONKALO DT2 pilot holes for experimental deposition holes. Posiva 2016-06, Posiva Oy, Finland.

Komulainen J, Pöllänen J, 2016. KBS-3H ─ DETUM Large fractures. Difference flow logging in boreholes K03009F01 and K08028F01. SKB P-15-13, Svensk Kärnbränslehantering AB.

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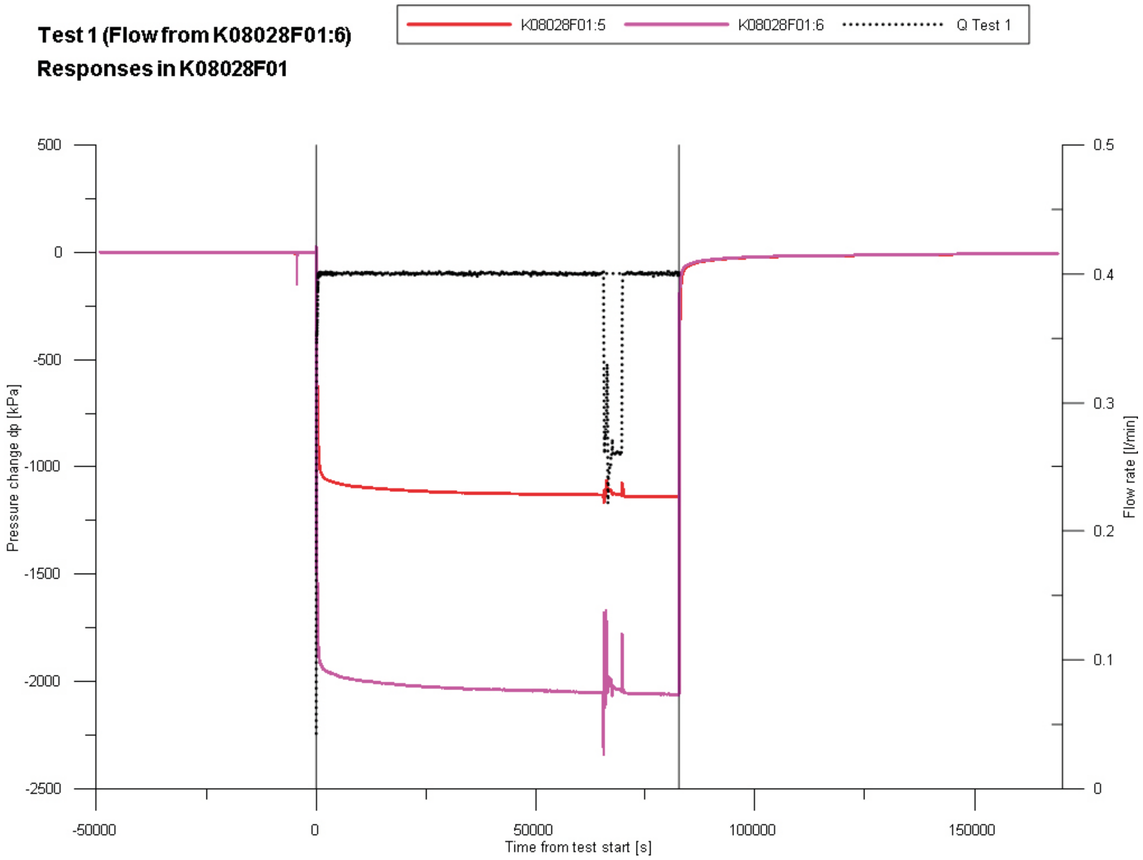
Theis C V, 1935. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage. Eos, Transactions American Geophysical Union 16, 519–524.

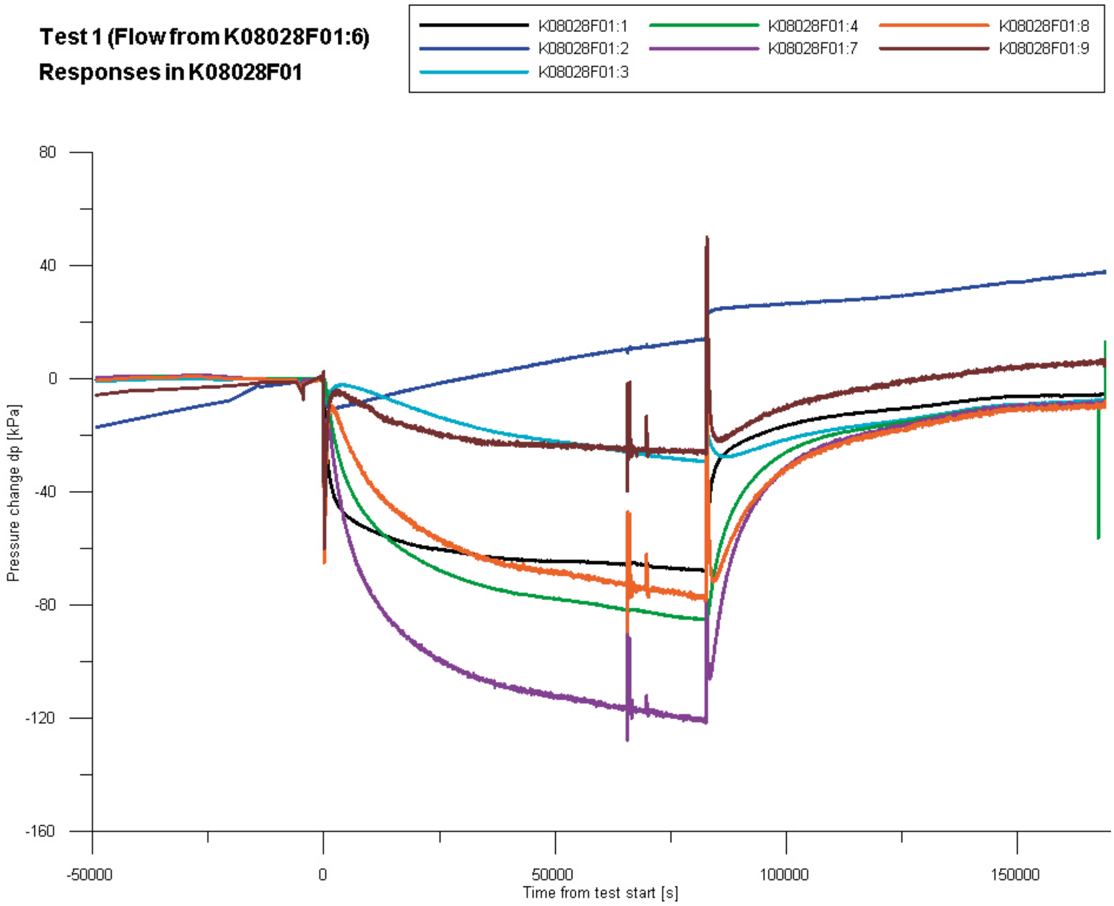
Overview of interference tests

The plots presented in this appendix show the pressure in all sections of K08028F01 and K03009F01 during the interference tests. The pressure is presented as pressure change, dp (kPa), during the tests, i.e. the pressure is 0 at the time of pumping start. Observe that the scale of y-axes differ between the plots.

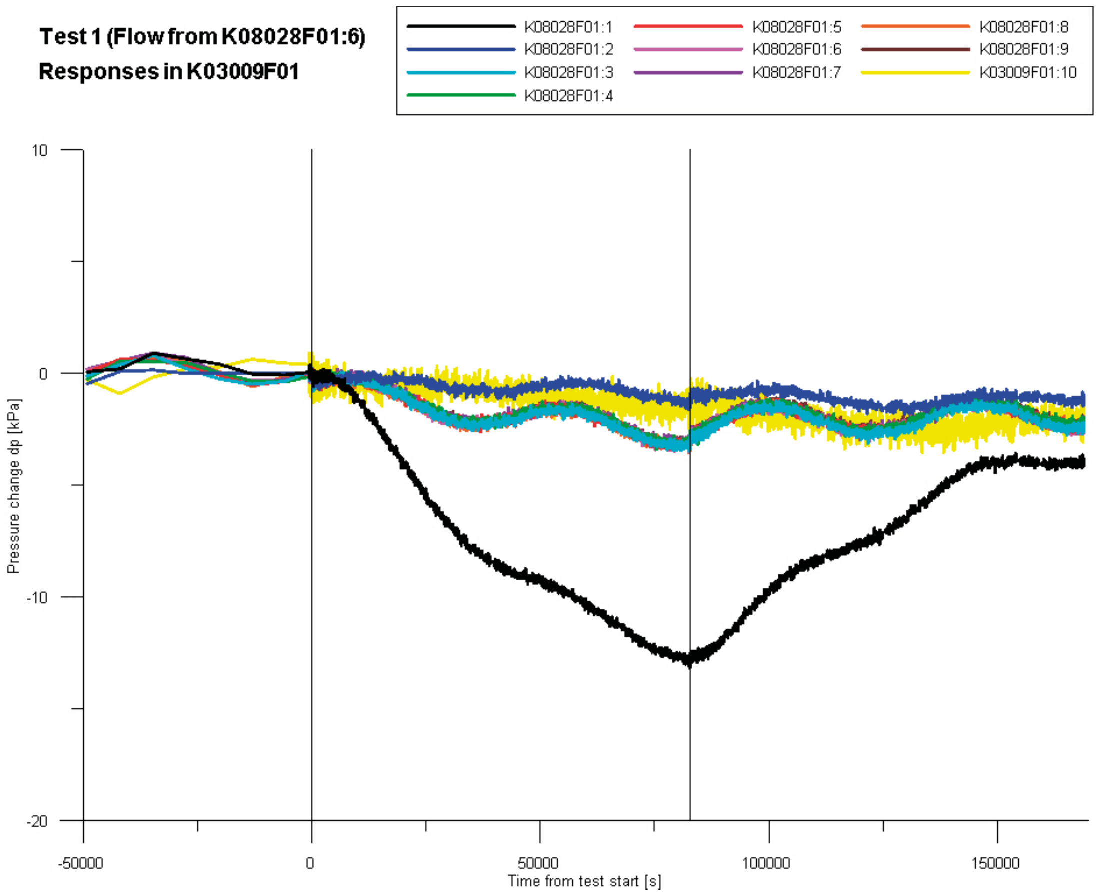
The flow rate of the pumping section as registered by HWIC is also presented. During the water sampling, some or all of the pumping water, was not passing HWIC, why the flow rate was seemingly lower during some periods. Note that is apparent lower flow rate is not representative for the true flow rate from the pumping section.

Test no 1. Interference test in K08028F01 30–32 m





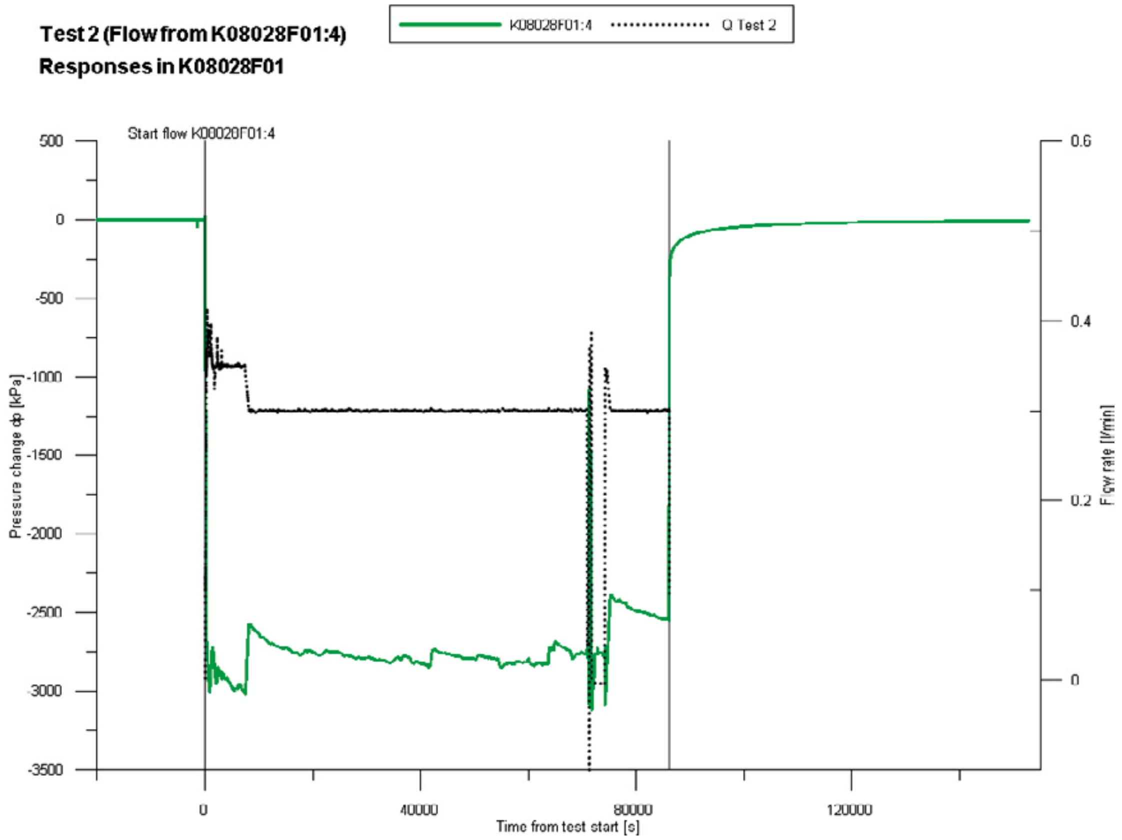
Test 1 (Flow from K08028F01:6)
Responses in K08028F01
K08028F01:1
K08028F01:2
K08028F01:3
K08028F01:4
K08028F01:7
K08028F01:8
K08028F01:9
80
40
0
-40
-80
-120
-160
Pressure change dp [kPa]
-50000
0
50000
100000
150000
Time from test start [s]



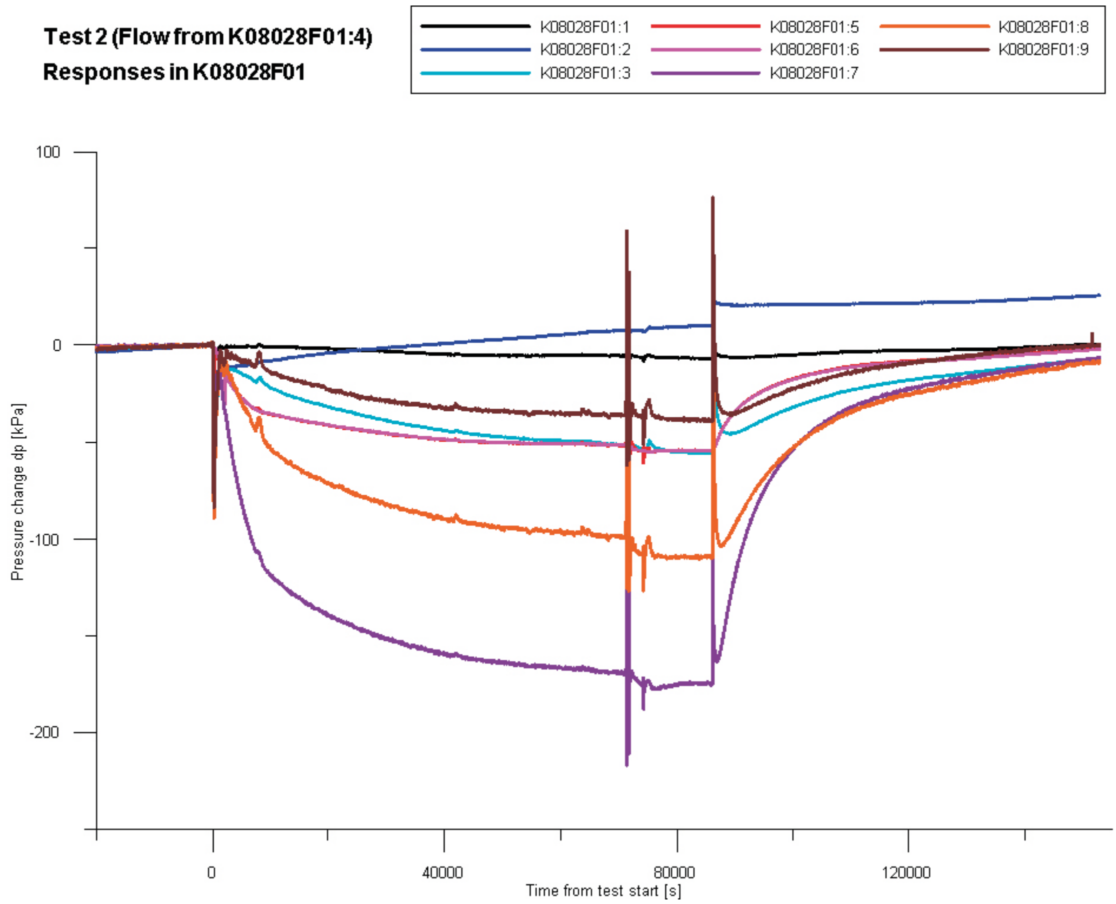
Test 1 (Flow from K08028F01:6)
Responses in K03009F01
K08028F01:1
K08028F01:2
K08028F01:3
K08028F01:4
K08028F01:5
K08028F01:6
K08028F01:7
K08028F01:8
K08028F01:9
K03009F01:10
10
0
-10
-20
Pressure change dp [kPa]
-50000
0
50000
100000
150000
Time from test start [s]

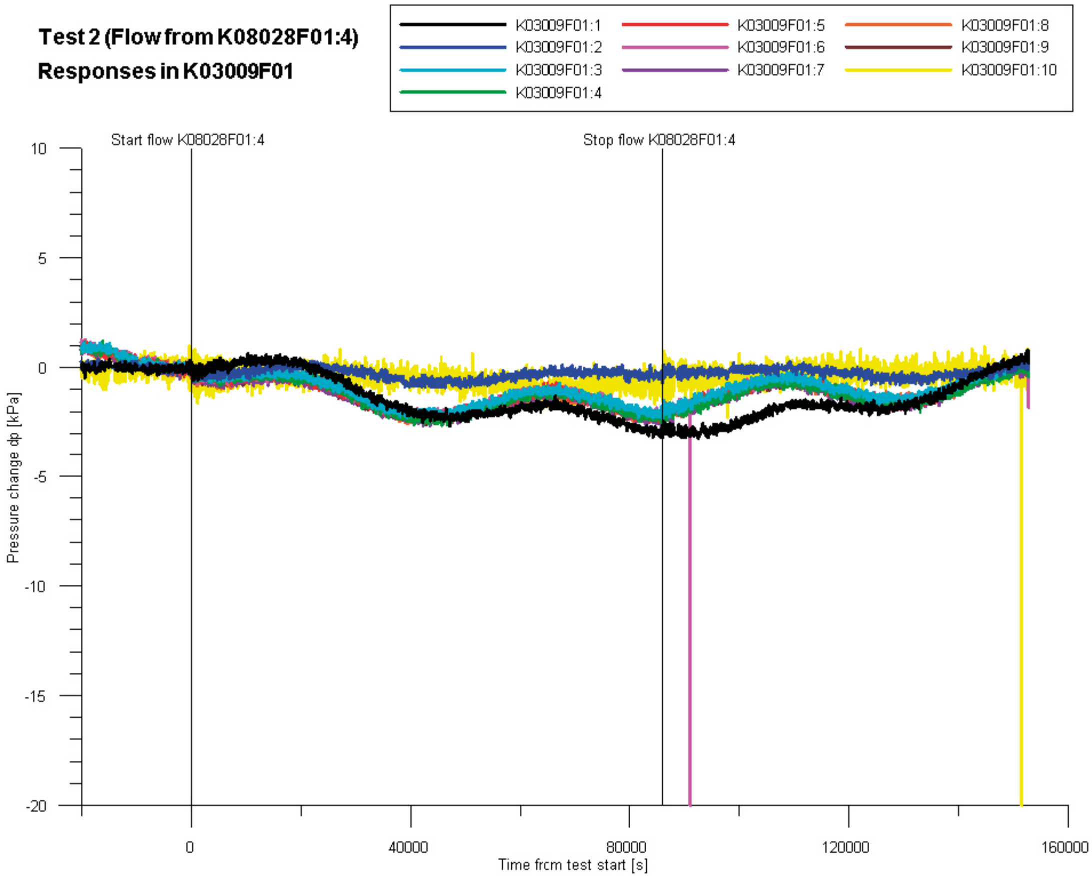
Test no 2. Interference test in K08028F01 37–39 m

Test 2 (Flow from K08028F01:4)
Responses in K08028F01

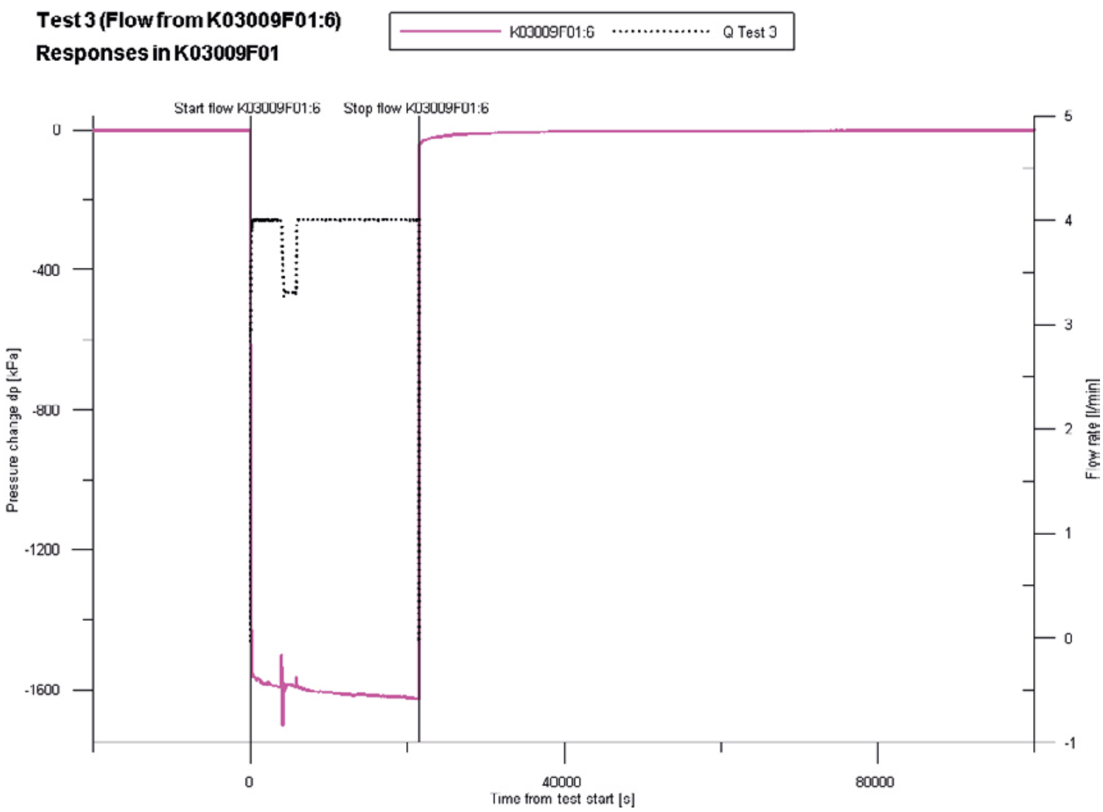


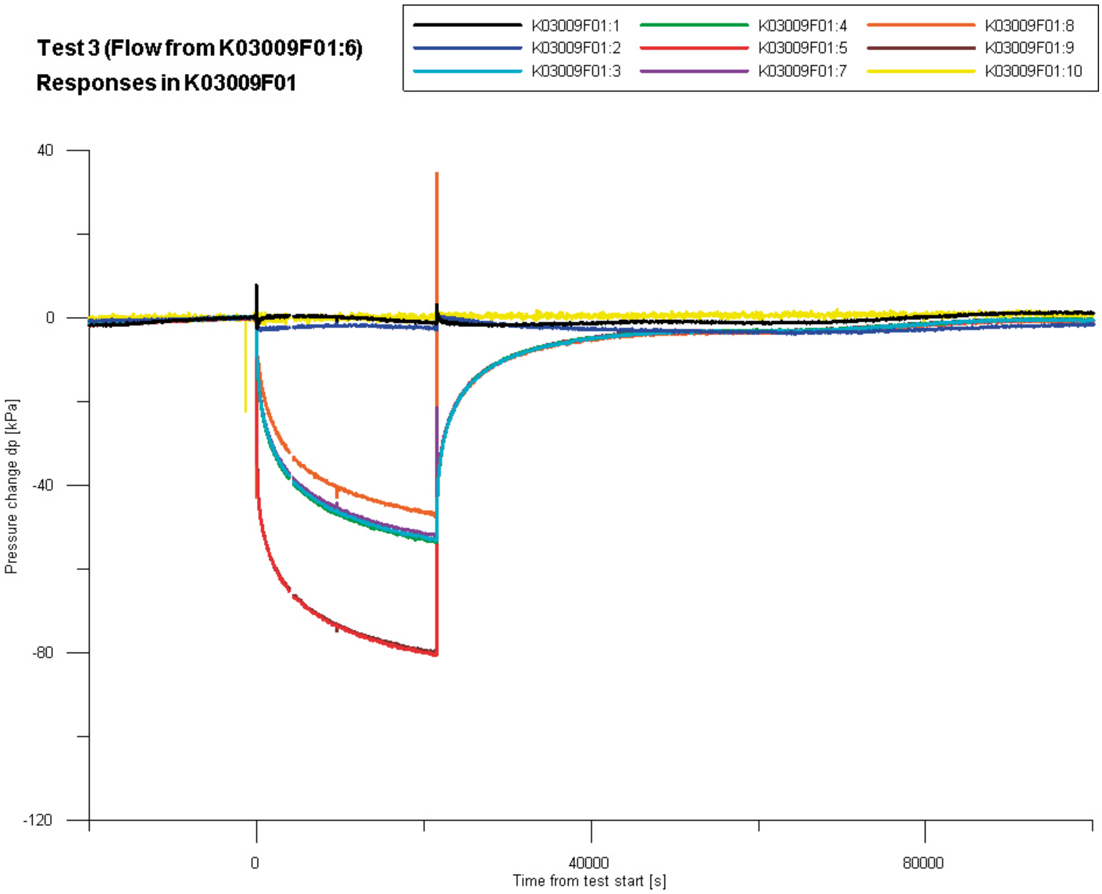
Test 2 (Flow from K08028F01:4)
Responses in K08028F01

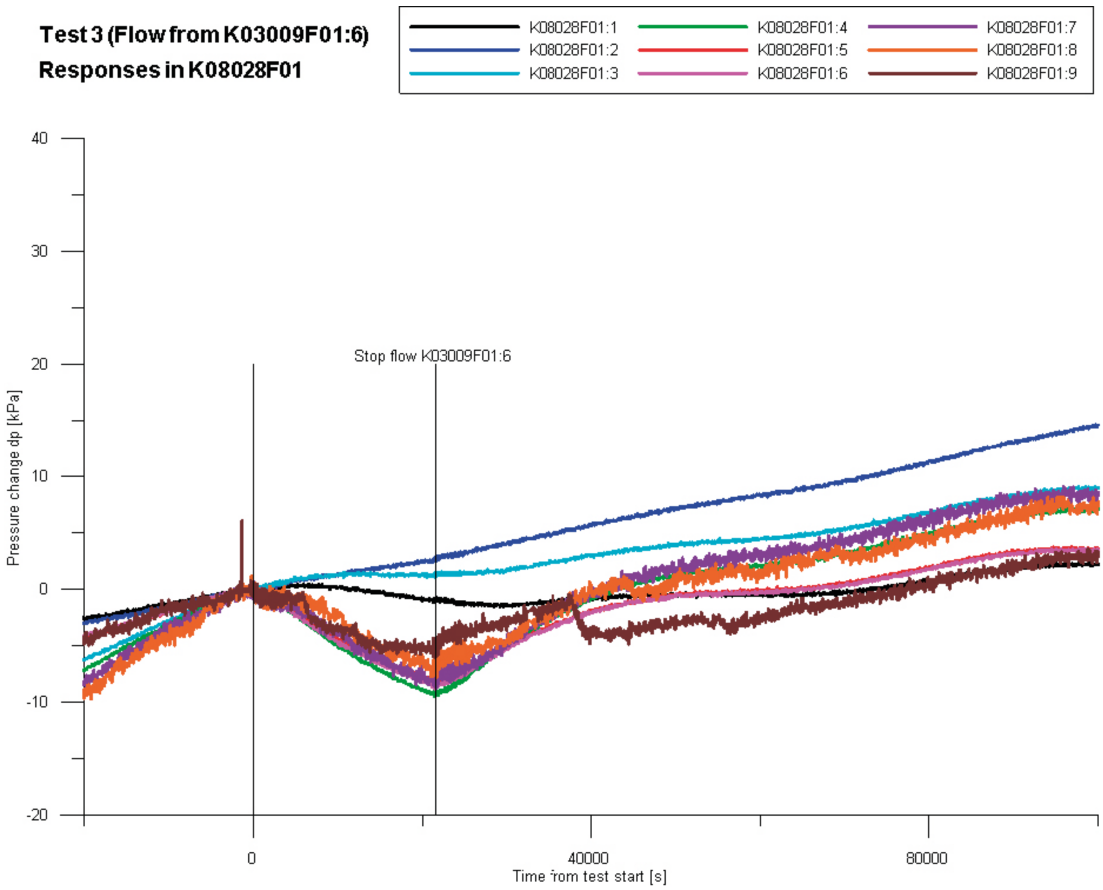




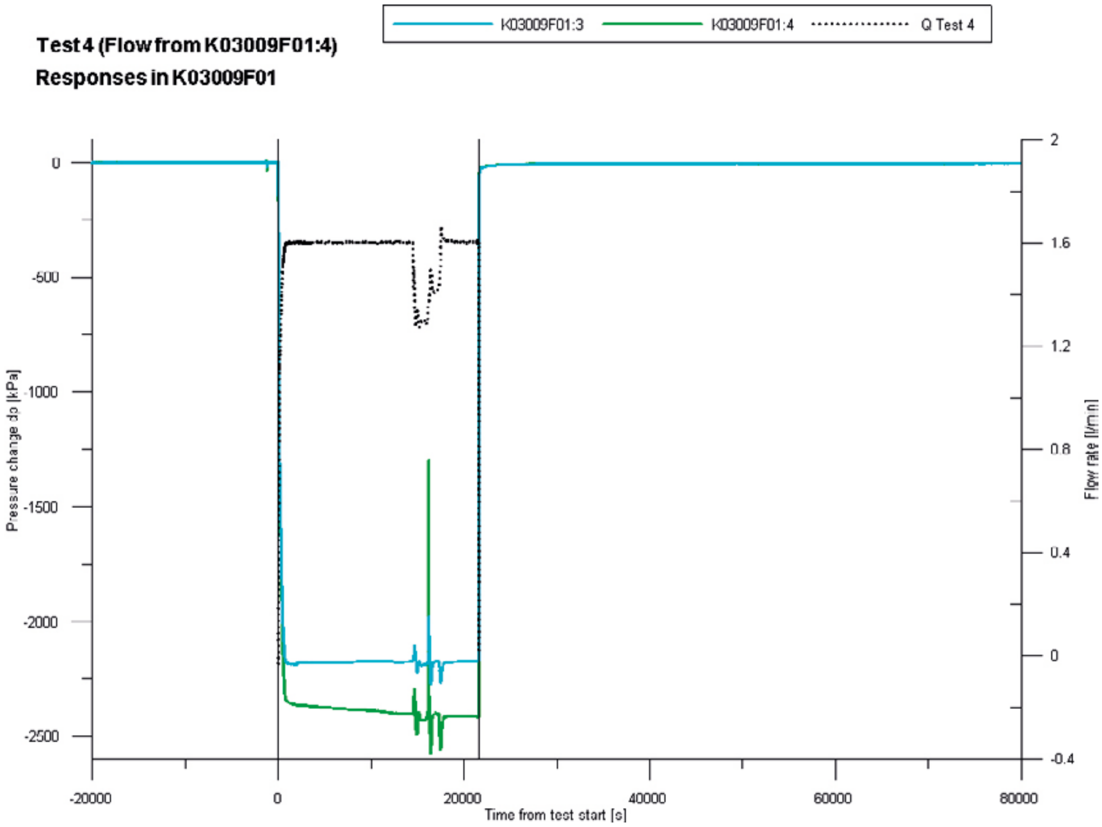
Test no 3. Interference test in K03009F01 18.5–20.5 m

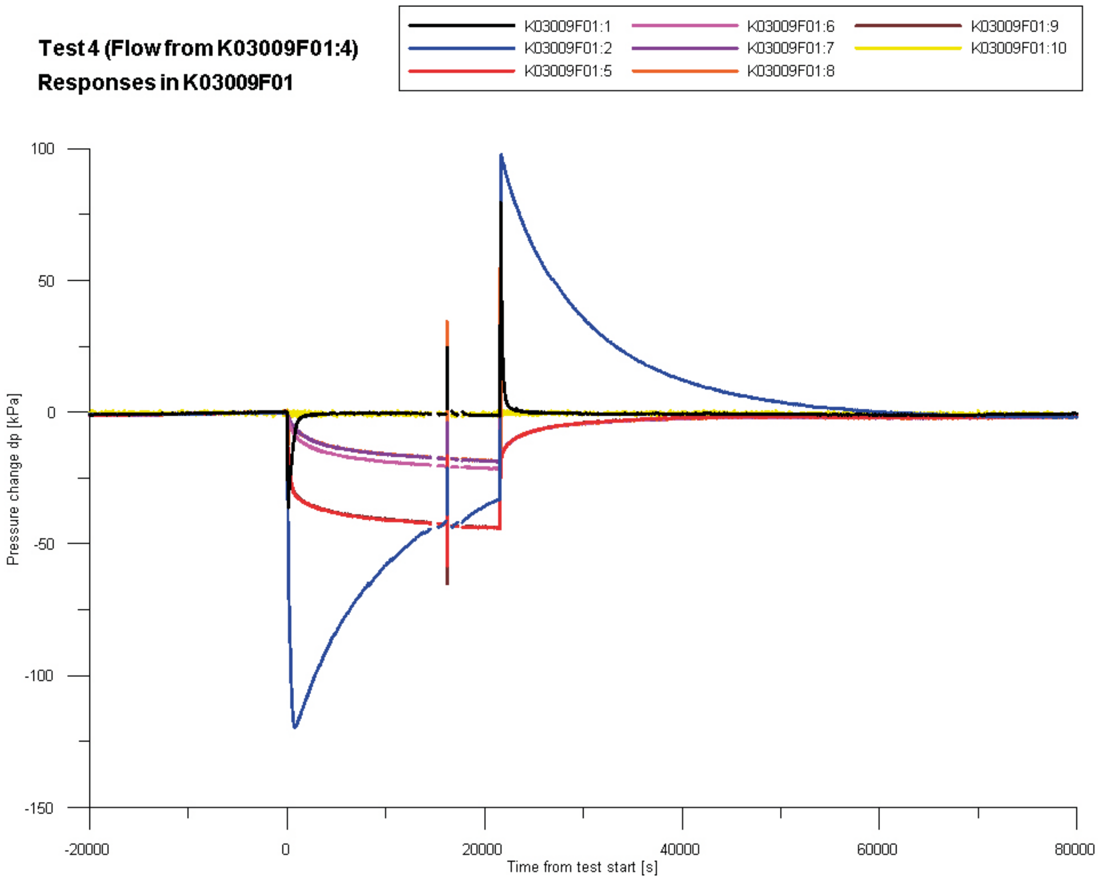


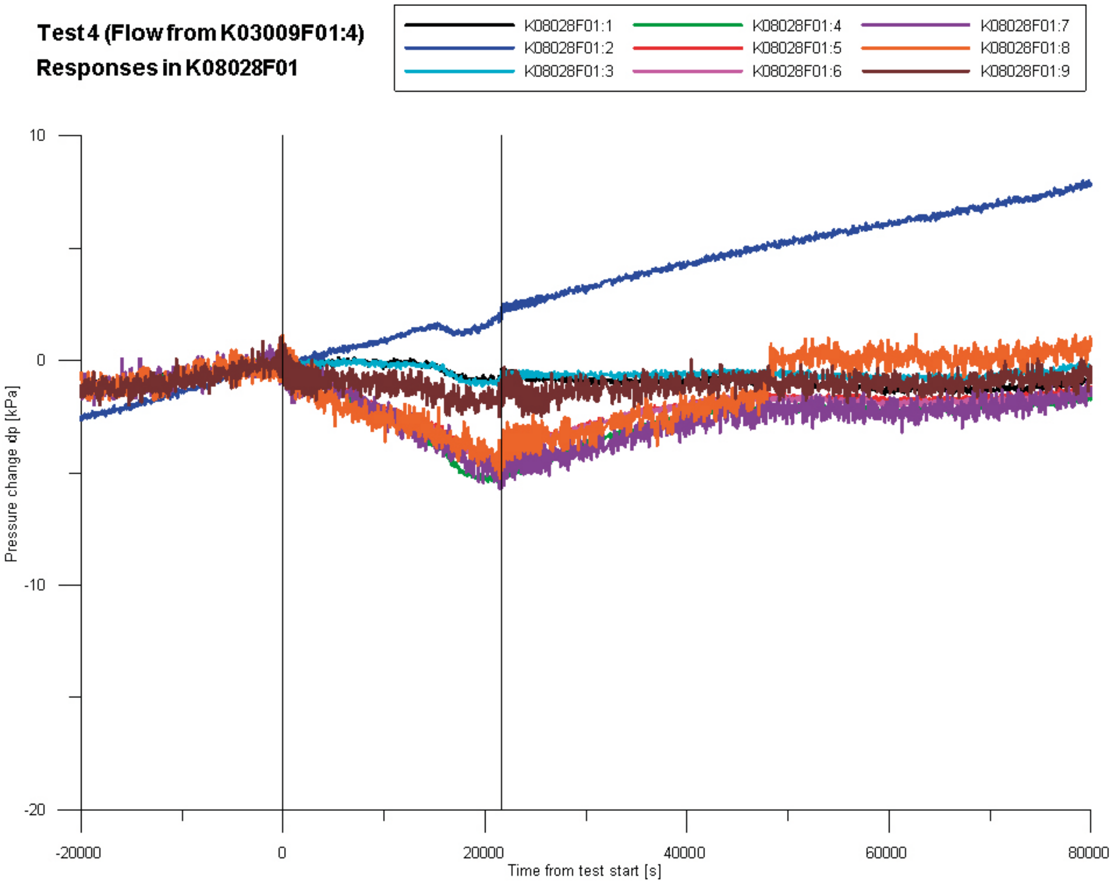

Test 3 (Flow from K03009F01:6)
Responses in K03009F01
K03009F01:1
K03009F01:2
K03009F01:3
K03009F01:4
K03009F01:5
K03009F01:7
K03009F01:8
K03009F01:9
K03009F01:10
40
0
-40
-80
-120
Pressure change dp [kPa]
0
40000
80000
Time from test start [s]


Test 3 (Flow from K03009F01:6)
Responses in K08028F01
K08028F01:1
K08028F01:2
K08028F01:3
K08028F01:4
K08028F01:5
K08028F01:6
K08028F01:7
K08028F01:8
K08028F01:9
Stop flow K03009F01:6
40
30
20
10
0
-10
-20
Pressure change dp [kPa]
0
40000
80000
Time from test start [s]

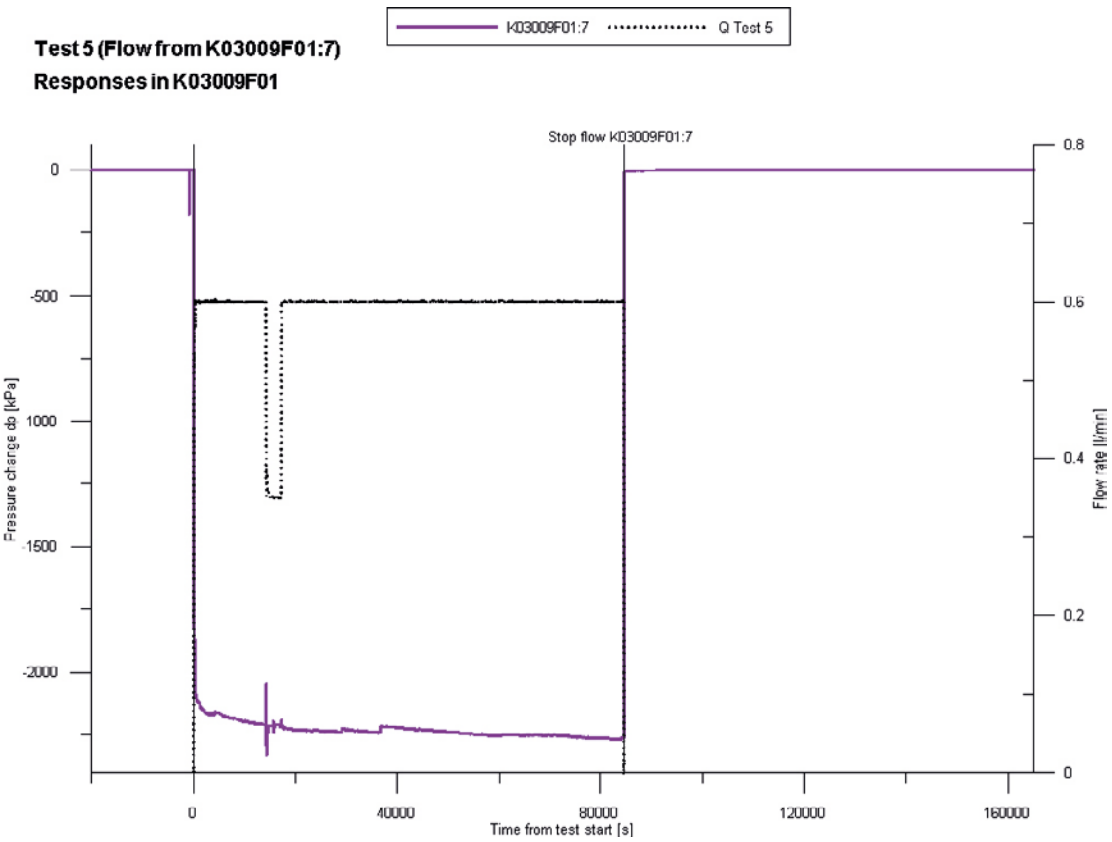
Test no 4. Interference test in K03009F01 25.5–38 m

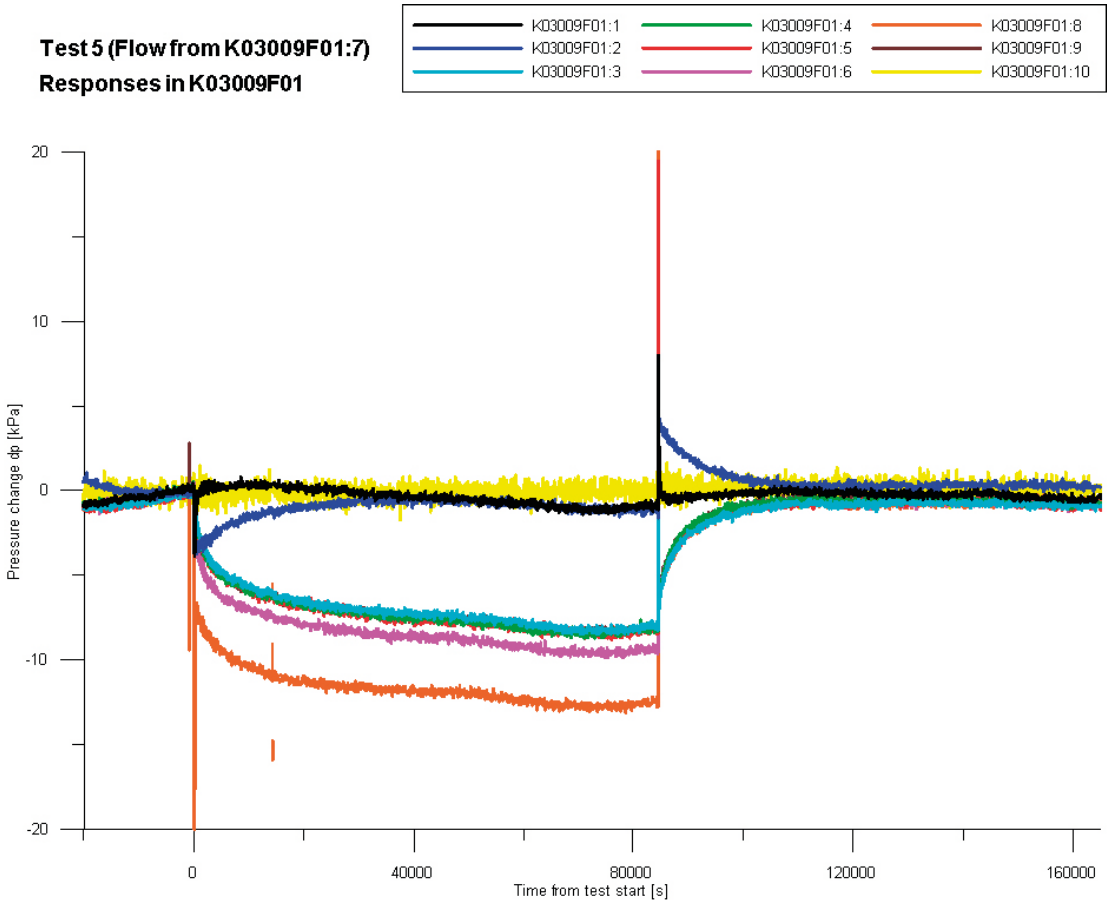




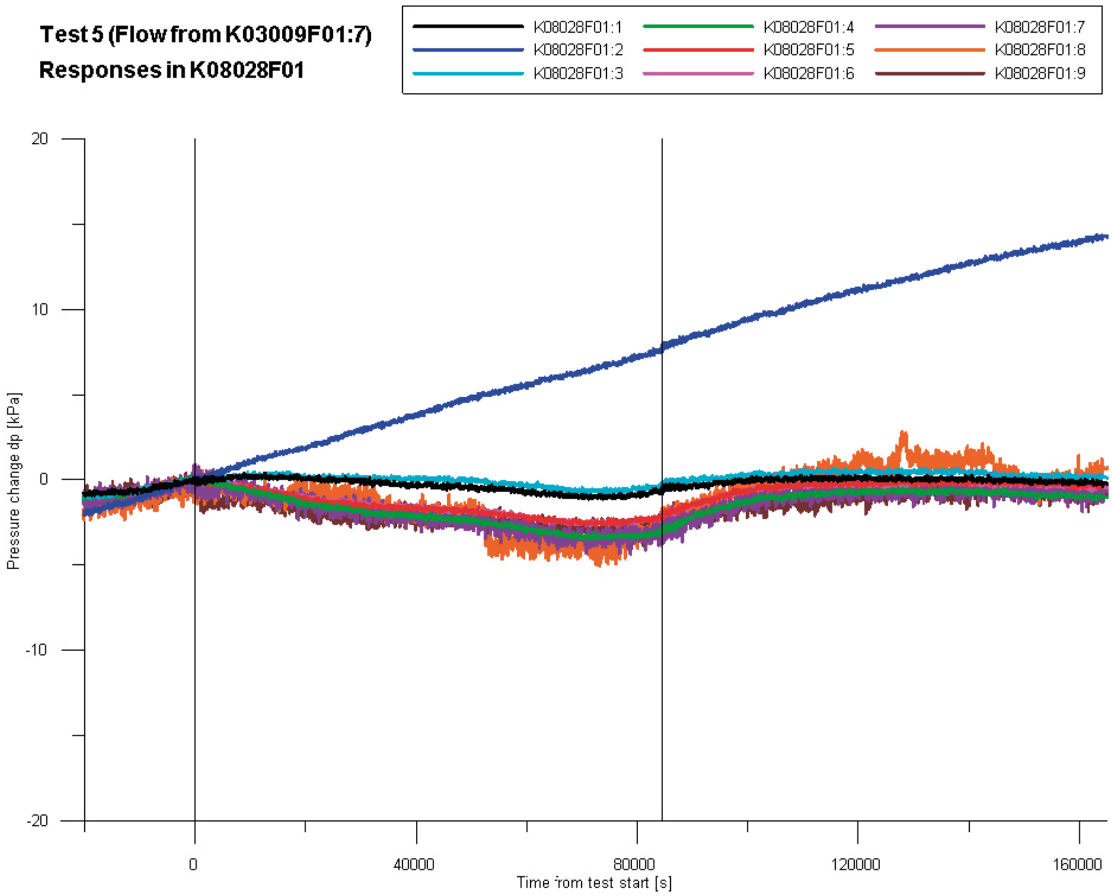


Test no 5. Interference test in K03009F01 14.5–17.5 m



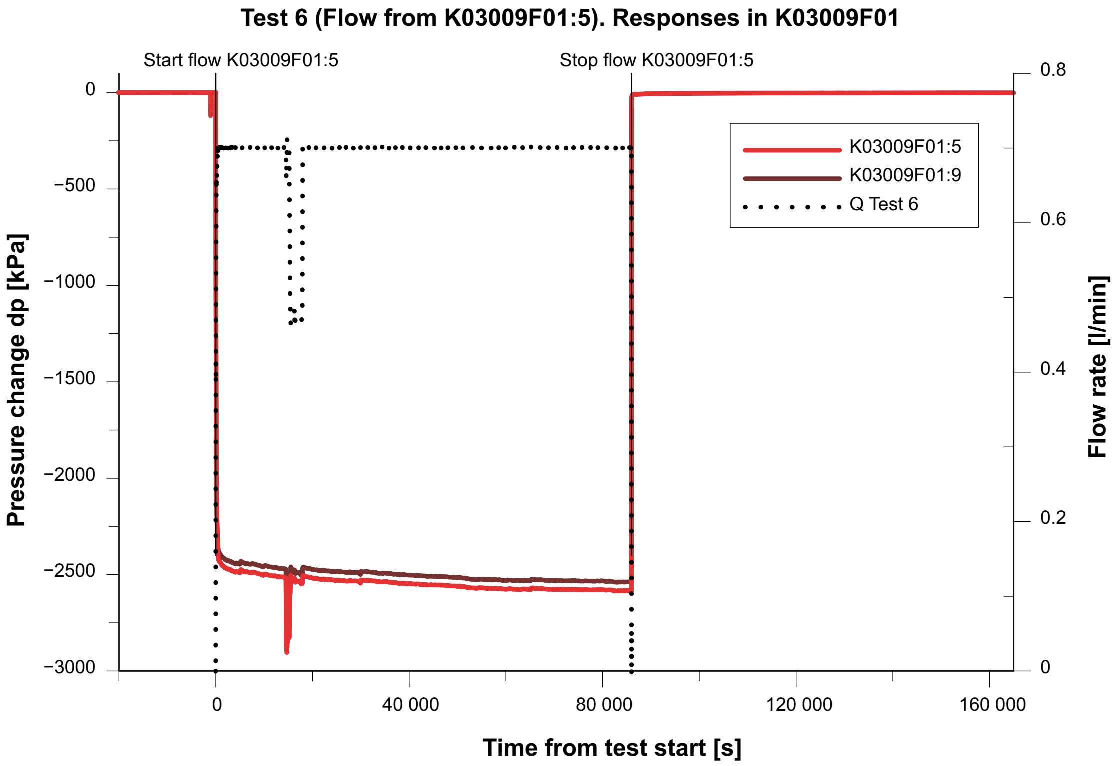


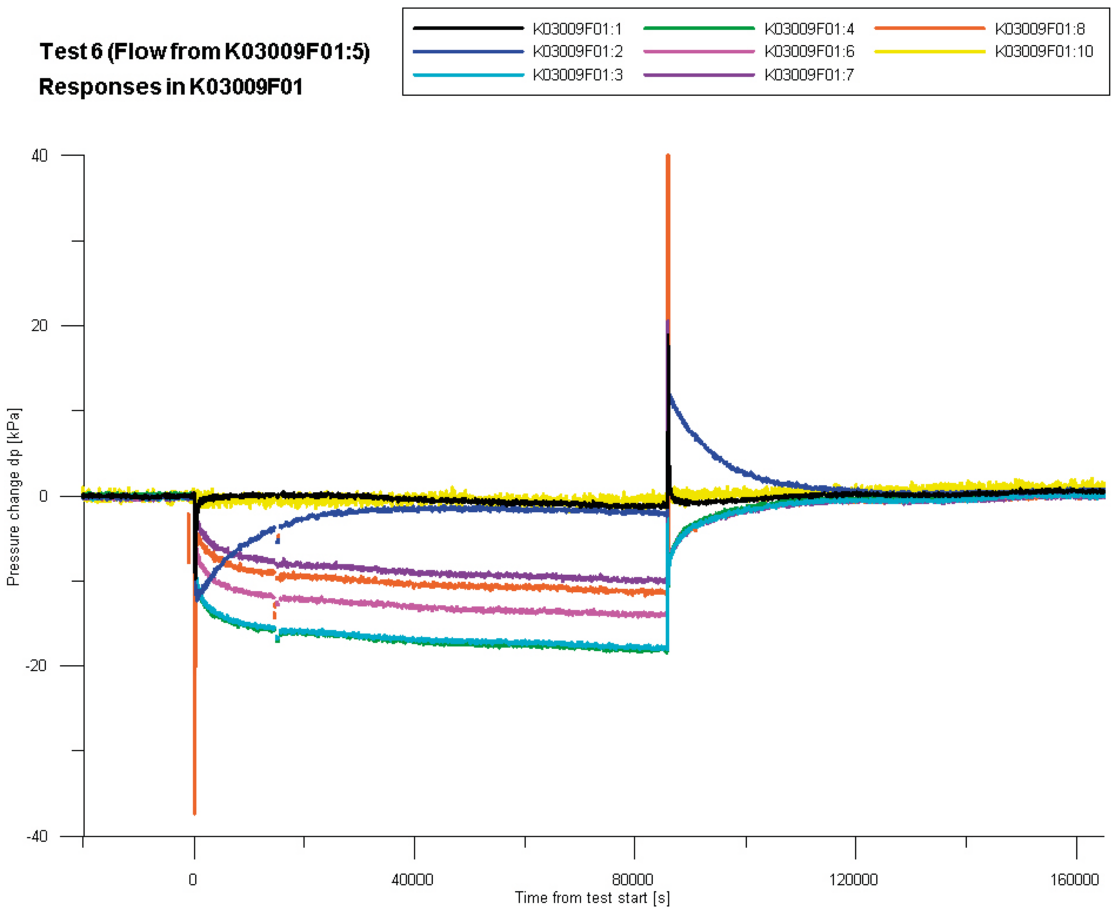
Test 5 (Flow from K03009F01:7)
Responses in K03009F01
K03009F01:1
K03009F01:2
K03009F01:3
K03009F01:4
K03009F01:5
K03009F01:6
K03009F01:8
K03009F01:9
K03009F01:10
20
10
0
-10
-20
Pressure change dp [kPa]
0
40000
80000
120000
160000
Time from test start [s]

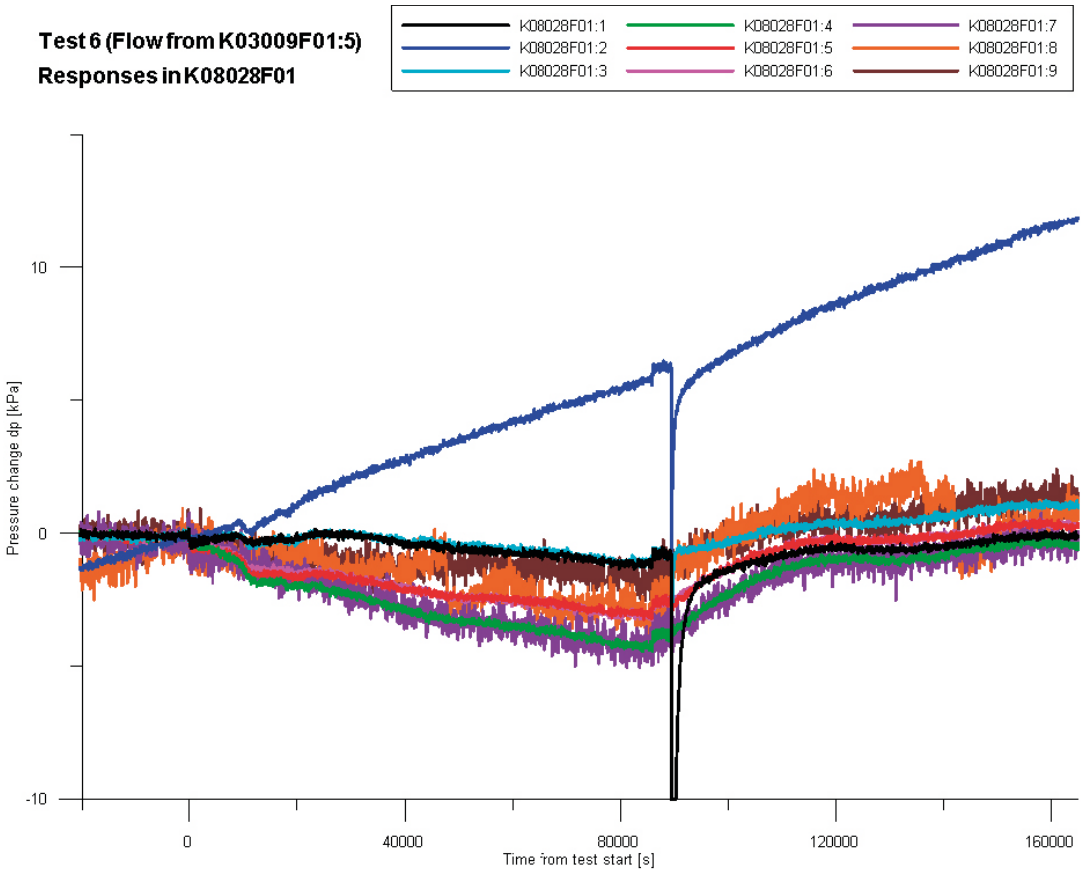


Test 5 (Flow from K03009F01:7)
Responses in K08028F01
K08028F01:1
K08028F01:2
K08028F01:3
K08028F01:4
K08028F01:5
K08028F01:6
K08028F01:7
K08028F01:8
K08028F01:9
20
10
0
-10
-20
Pressure change dp [kPa]
0
40000
80000
120000
160000
Time from test start [s]

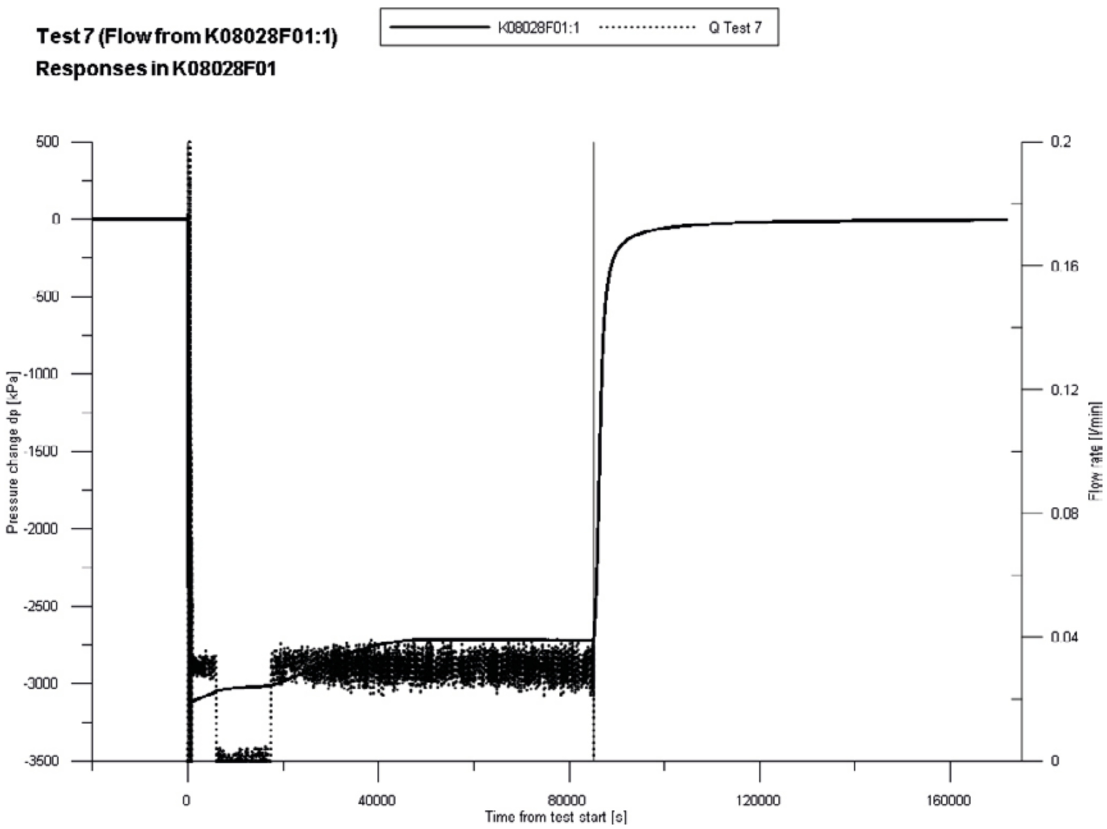
Test no 6. Interference test in K03009F01 21.5–24.5 m

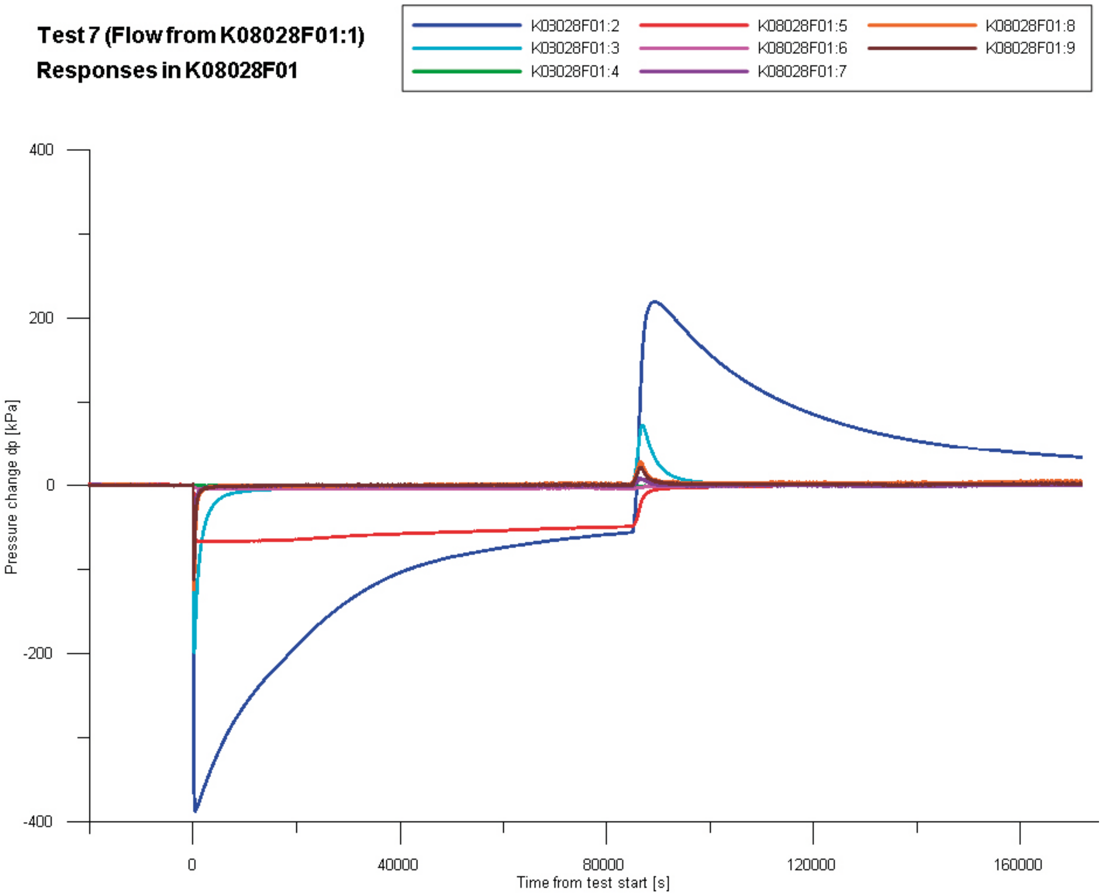


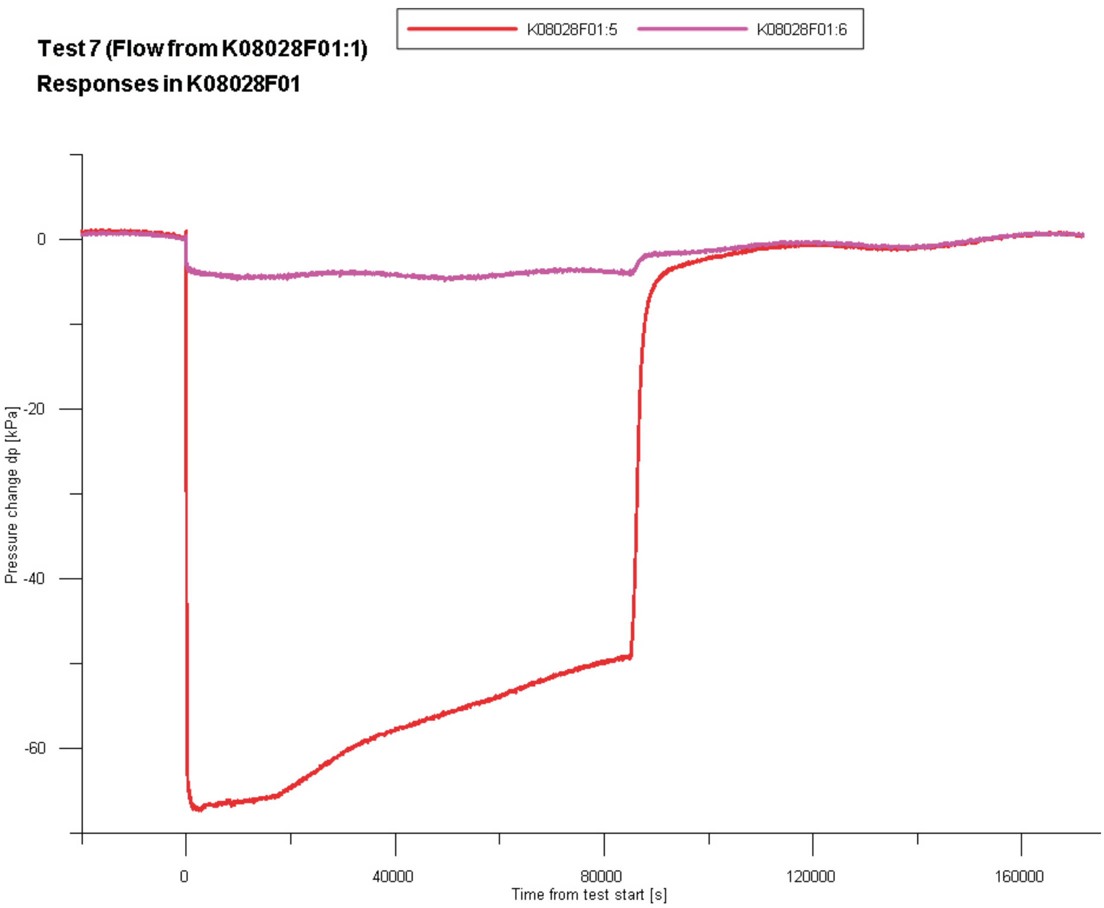


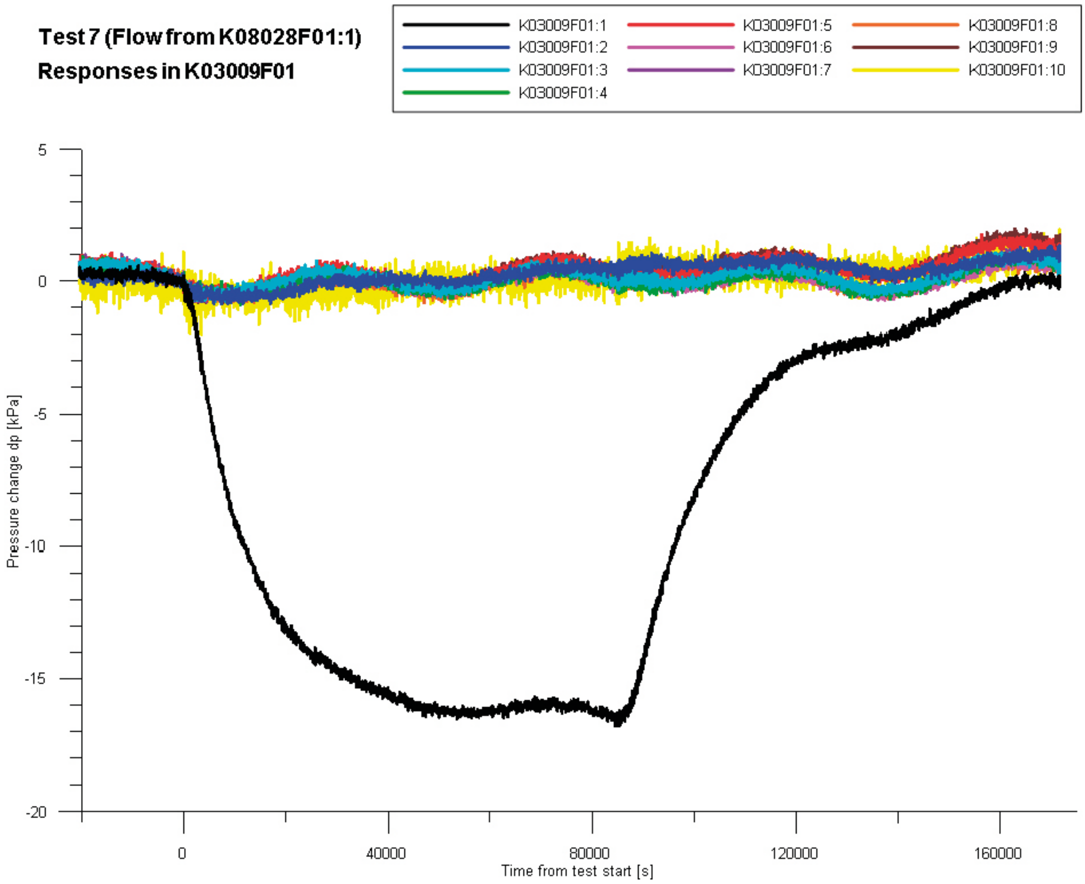


Test no 7. Interference test in K08028F01 84–94.39 m

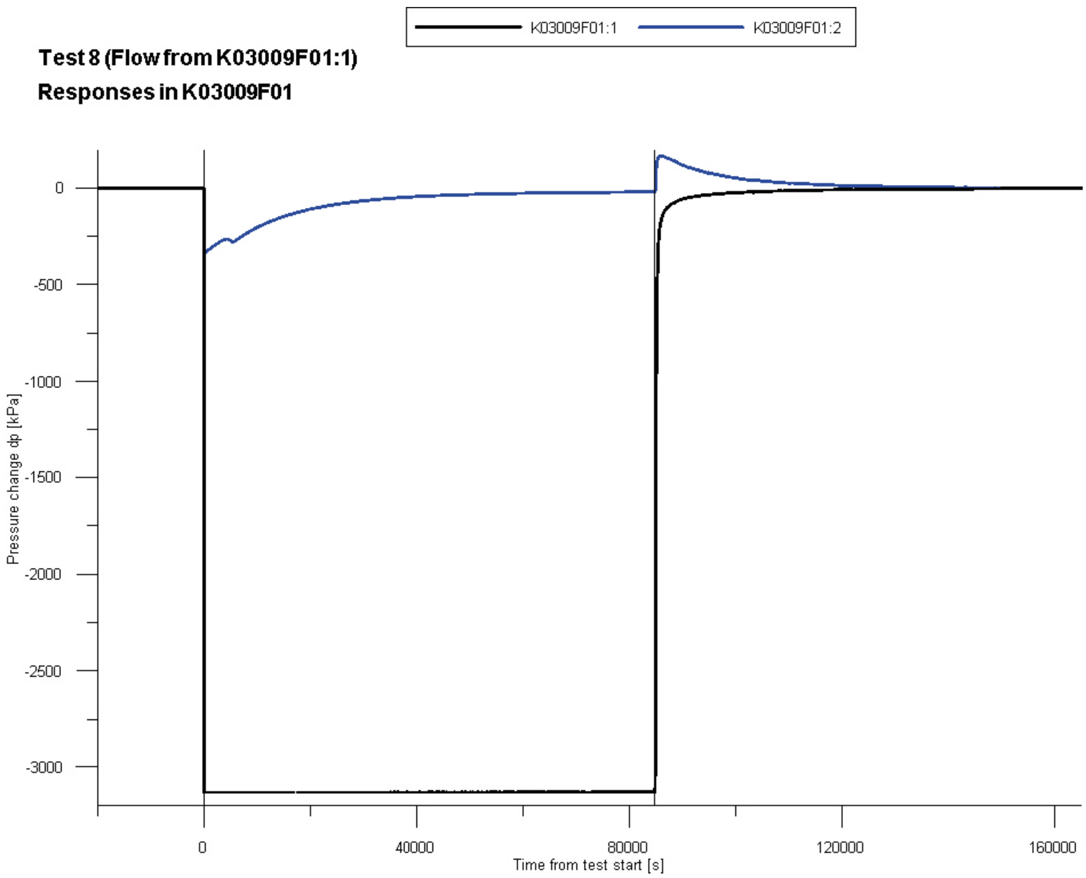


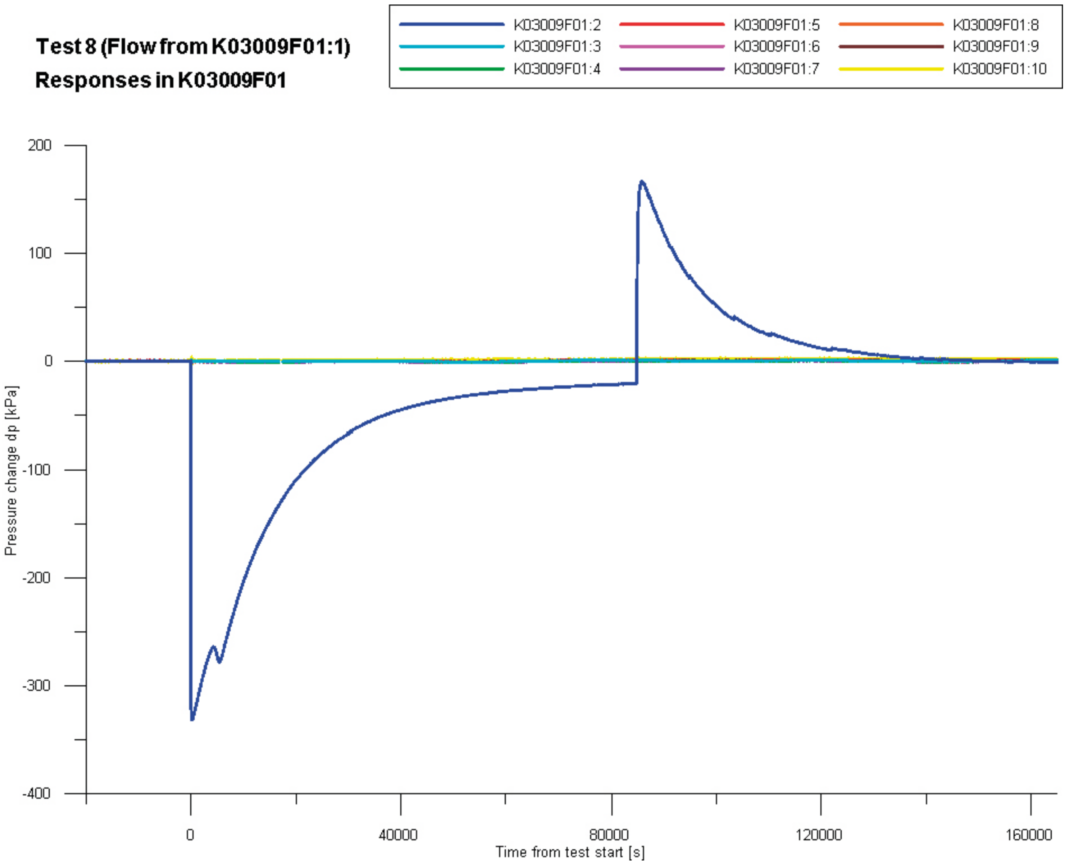

Test 7 (Flow from K08028F01:1)
Responses in K08028F01
K03028F01:2
K03028F01:3
K03028F01:4
K08028F01:5
K08028F01:6
K08028F01:7
K08028F01:8
K08028F01:9
400
200
0
-200
-400
Pressure change dp [kPa]
0
40000
80000
120000
160000
Time from test start [s]


Test 7 (Flow from K08028F01:1)
Responses in K08028F01
K08028F01:5
K08028F01:6
0
-20
-40
-60
Pressure change dp [kPa]
0
40000
80000
120000
160000
Time from test start [s]

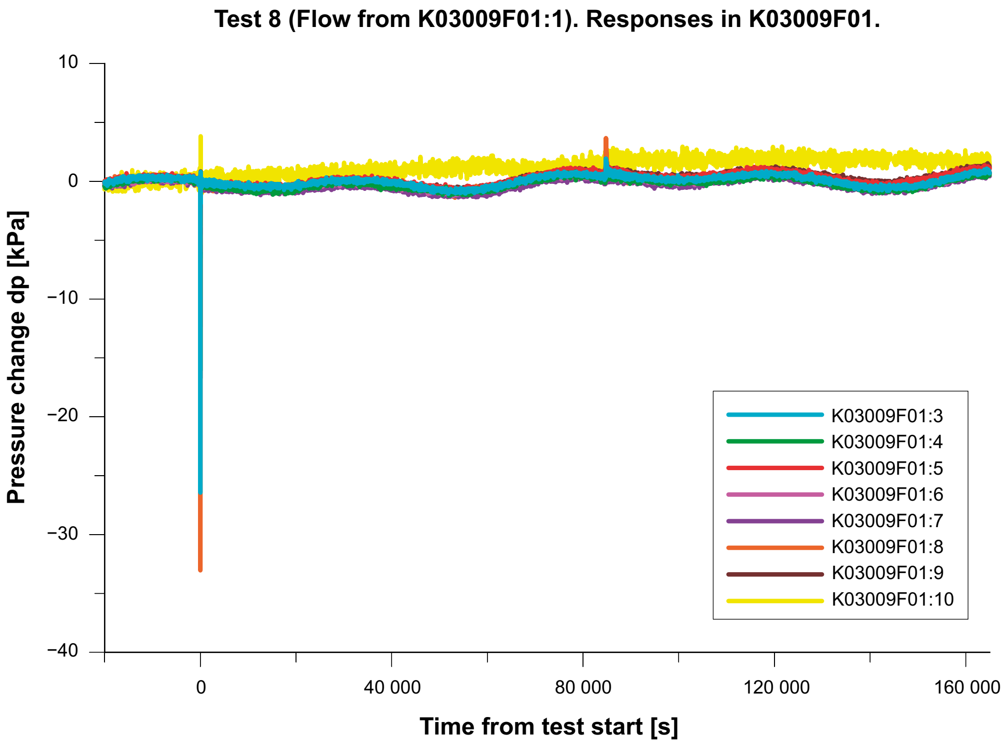


Test no 8. Interference test in K03009F01 87–100.92 m

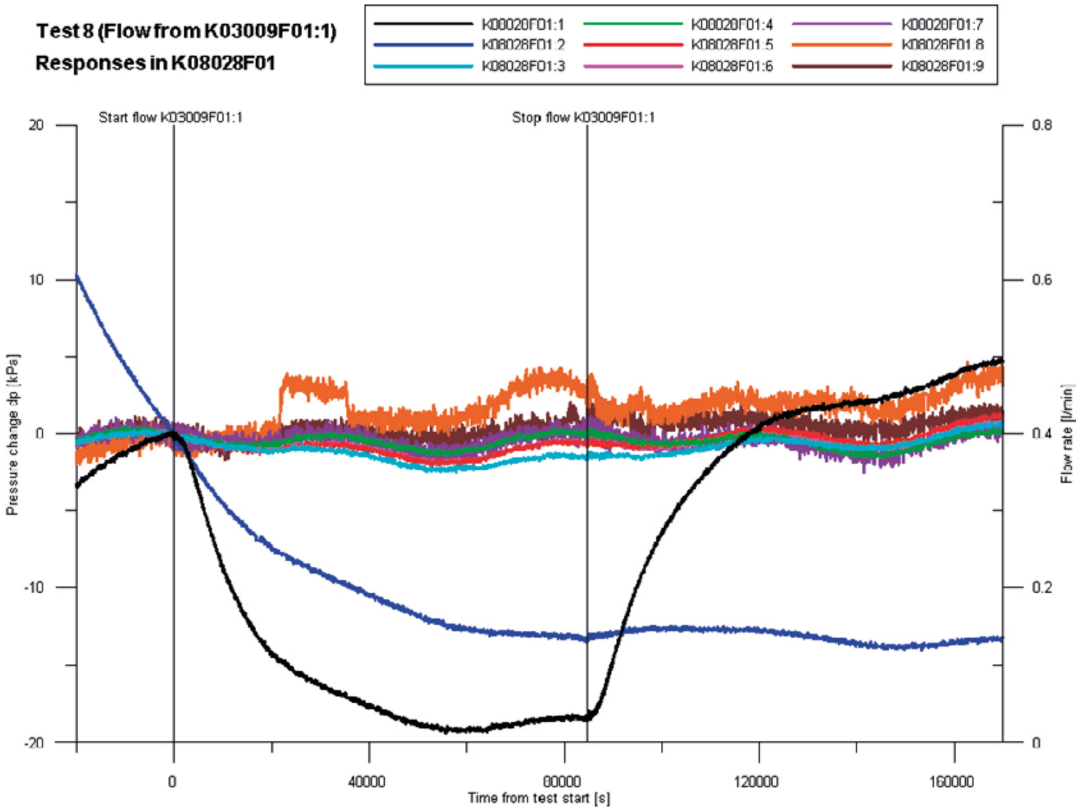




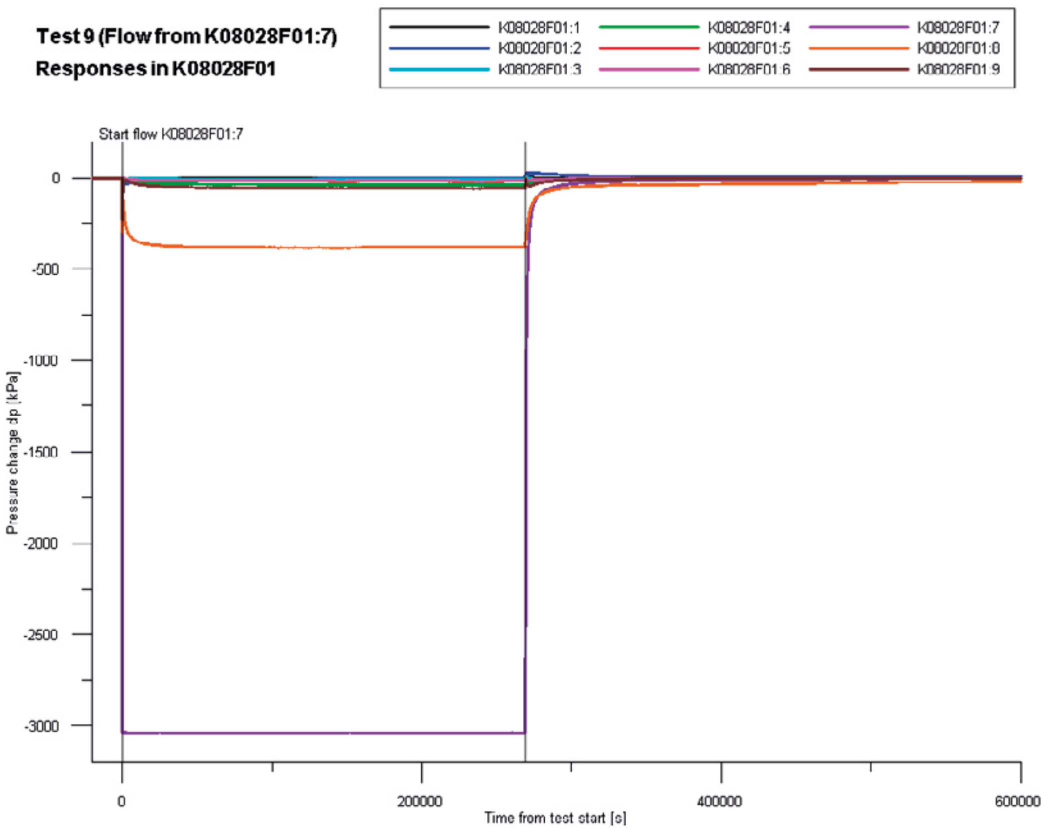
Test 8 (Flow from K03009F01:1)
Responses in K03009F01
K03009F01:2
K03009F01:3
K03009F01:4
K03009F01:5
K03009F01:6
K03009F01:7
K03009F01:8
K03009F01:9
K03009F01:10
200
100
0
-100
-200
-300
-400
Pressure change dp [kPa]
0
40000
80000
120000
160000
Time from test start [s]

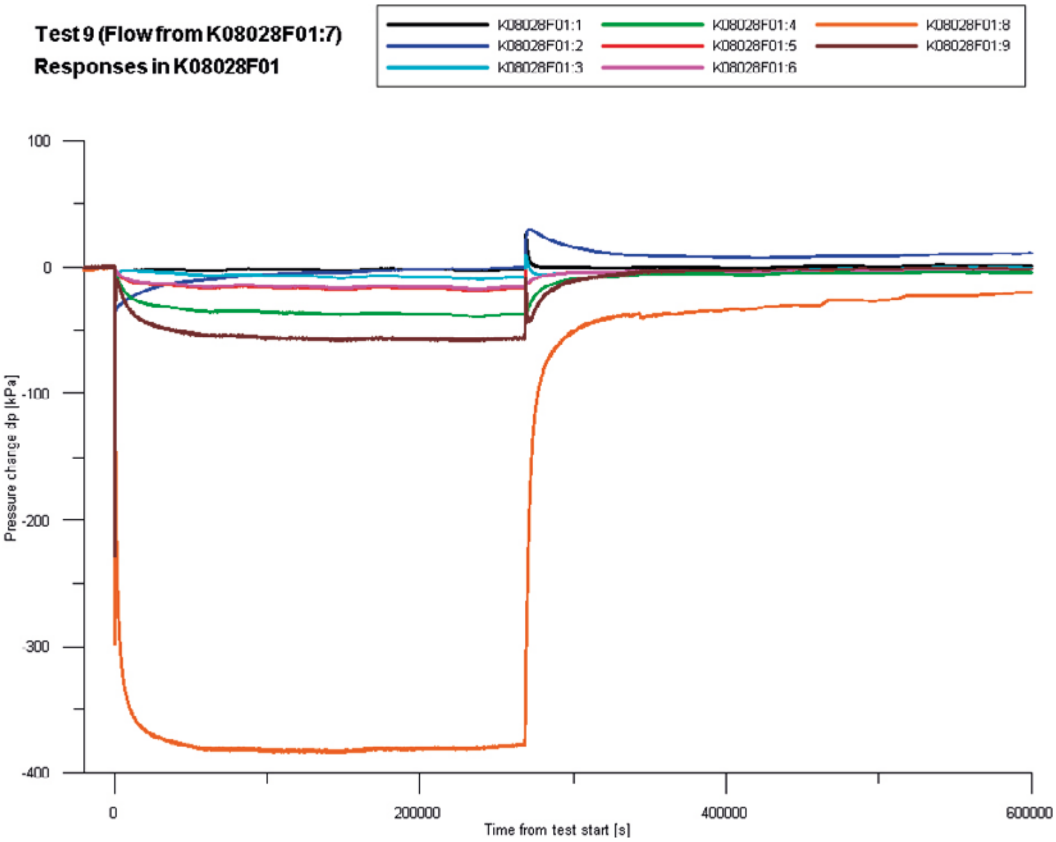


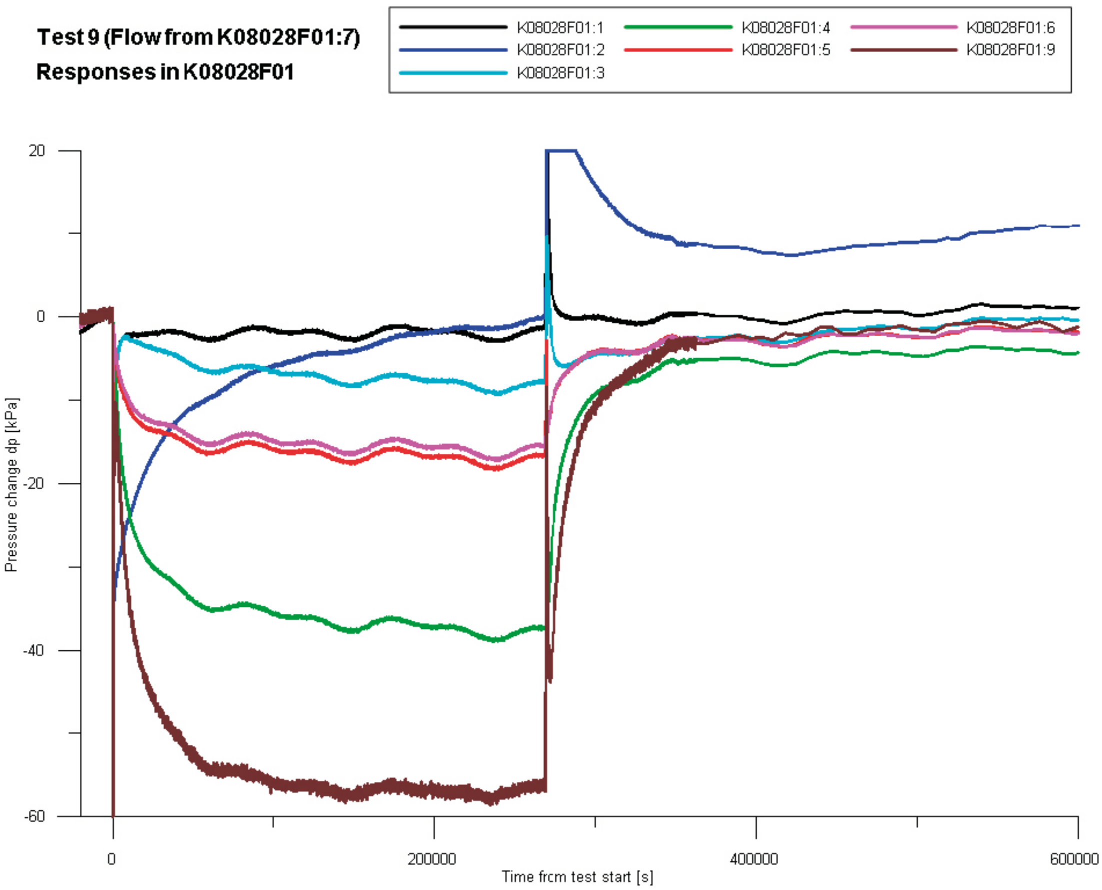
Test 8 (Flow from K03009F01:1). Responses in K03009F01.
10
0
−10
−20
−30
−40
Pressure change dp [kPa]
K03009F01:3
K03009F01:4
K03009F01:5
K03009F01:6
K03009F01:7
K03009F01:8
K03009F01:9
K03009F01:10
0
40 000
80 000
120 000
160 000
Time from test start [s]

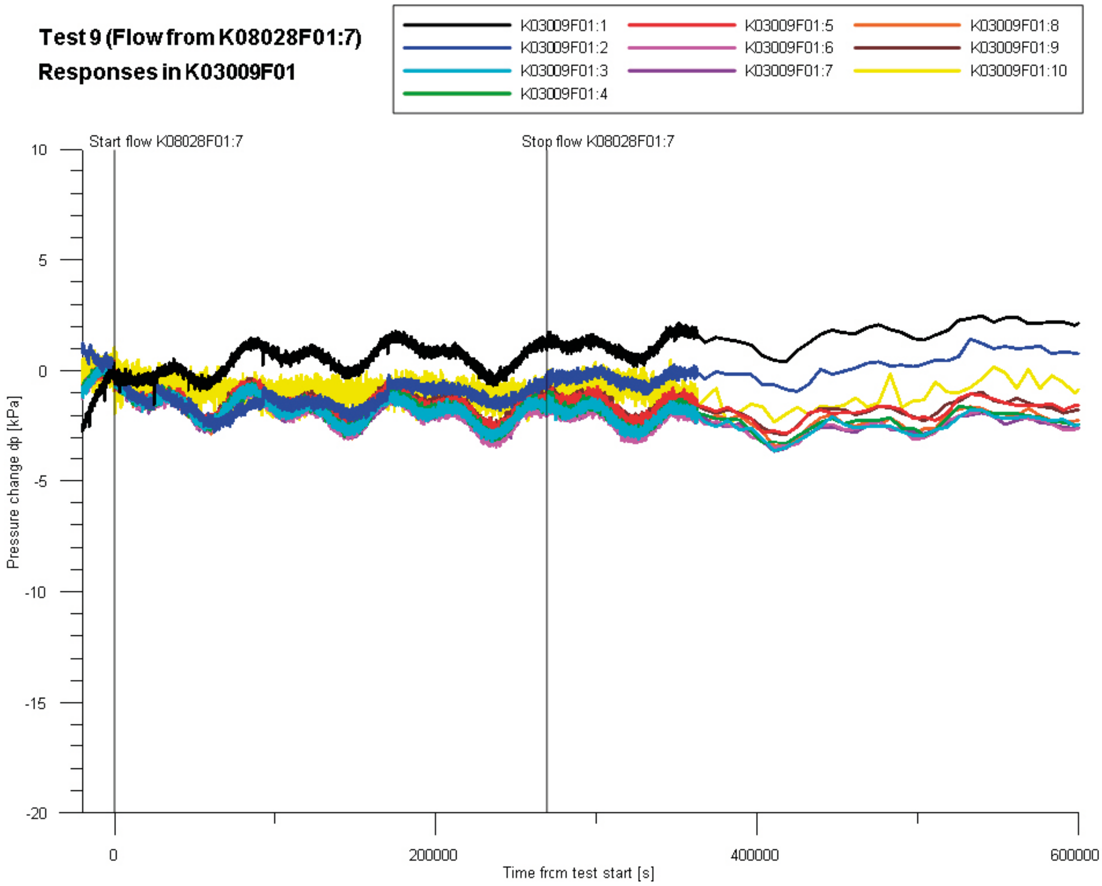


Test no 9. Interference test in K08028F01 19–29 m




Test 9 (Flow from K08028F01:7)
Responses in K08028F01
K08028F01:1
K08028F01:2
K08028F01:3
K08028F01:4
K08028F01:5
K08028F01:6
K08028F01:8
K08028F01:9
100
0
-100
-200
-300
-400
Pressure change dp [kPa]
0
200000
400000
600000
Time from test start [s]


Test 9 (Flow from K08028F01:7)
Responses in K08028F01
K08028F01:1
K08028F01:2
K08028F01:3
K08028F01:4
K08028F01:5
K08028F01:6
K08028F01:9
20
0
-20
-40
-60
Pressure change dp [kPa]
0
200000
400000
600000
Time from test start [s]

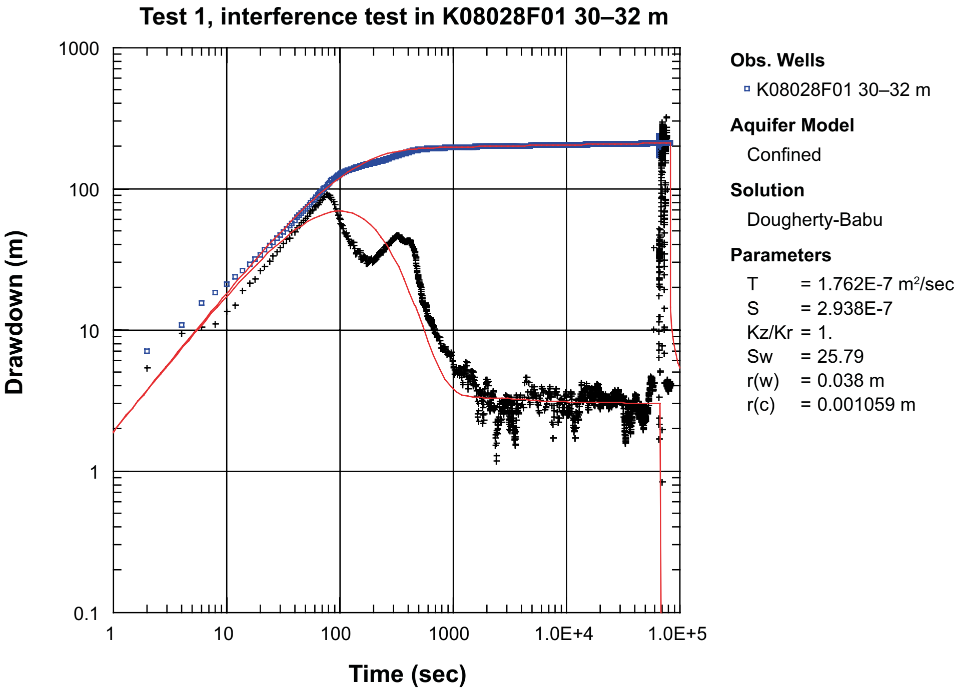


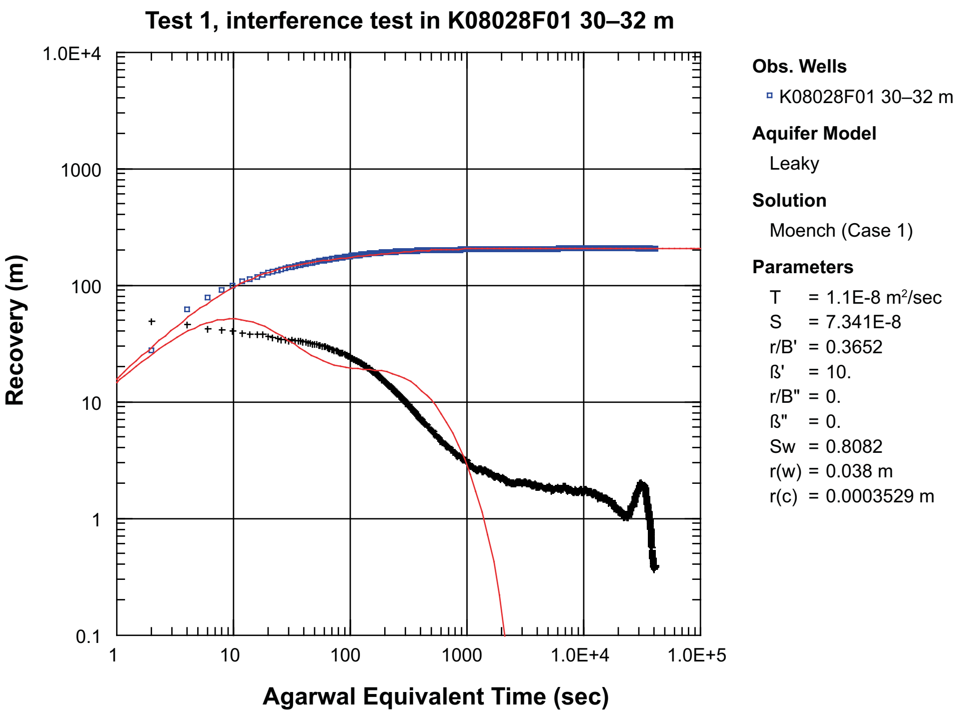
Test 9 (Flow from K08028F01:7)
Responses in K03009F01
K03009F01:1
K03009F01:2
K03009F01:3
K03009F01:4
K03009F01:5
K03009F01:6
K03009F01:7
K03009F01:8
K03009F01:9
K03009F01:10
Start flow K08028F01:7
Stop flow K08028F01:7
Pressure change dp [kPa]
Time frcm test start [s]
10
5
0
-5
-10
-15
-20
0
200000
400000
600000

Transient evaluation of pumping sections

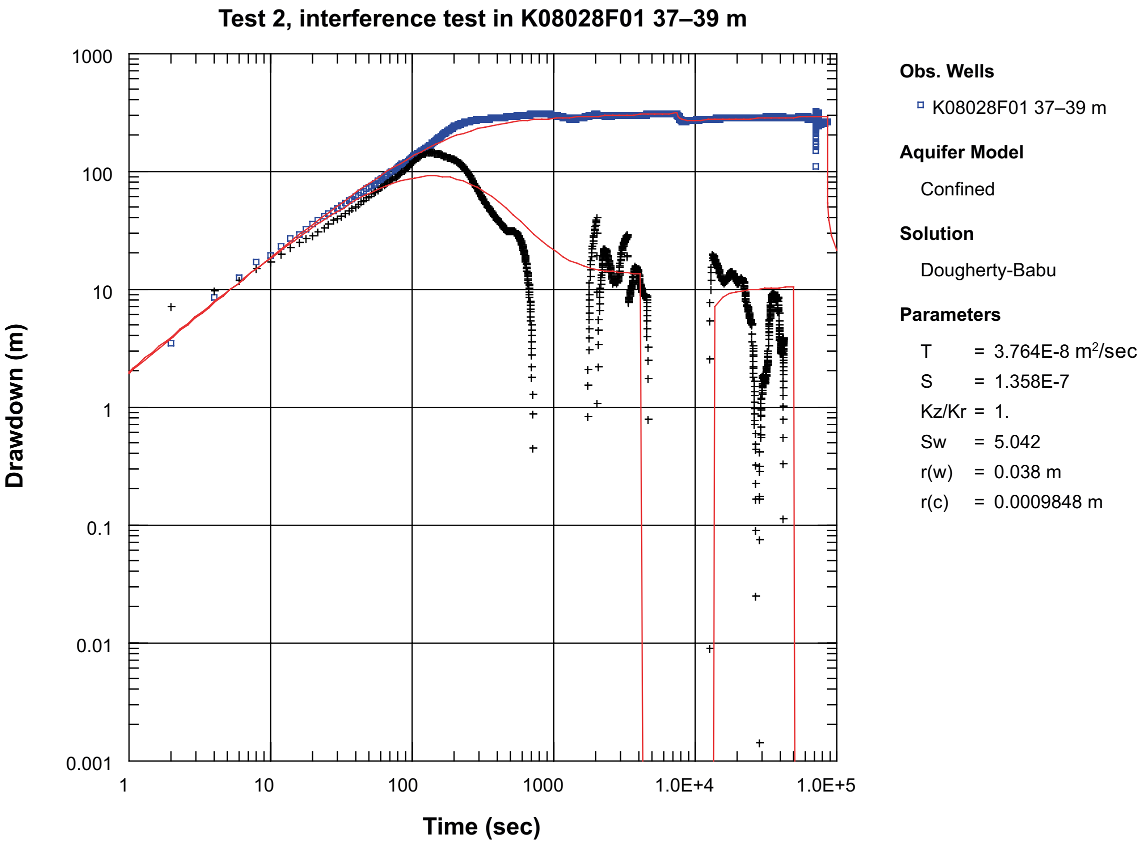
The plots presented in this appendix shows transient evaluations performed with AQTESOLV Pro v. 4.5. For interference tests no 1–7, one transient evaluation for the pumping period and one for the recovery period for the pumping section is presented below. However, for test no 7, no unambiguous transient evaluation was possible for the pumping or the recovery period.

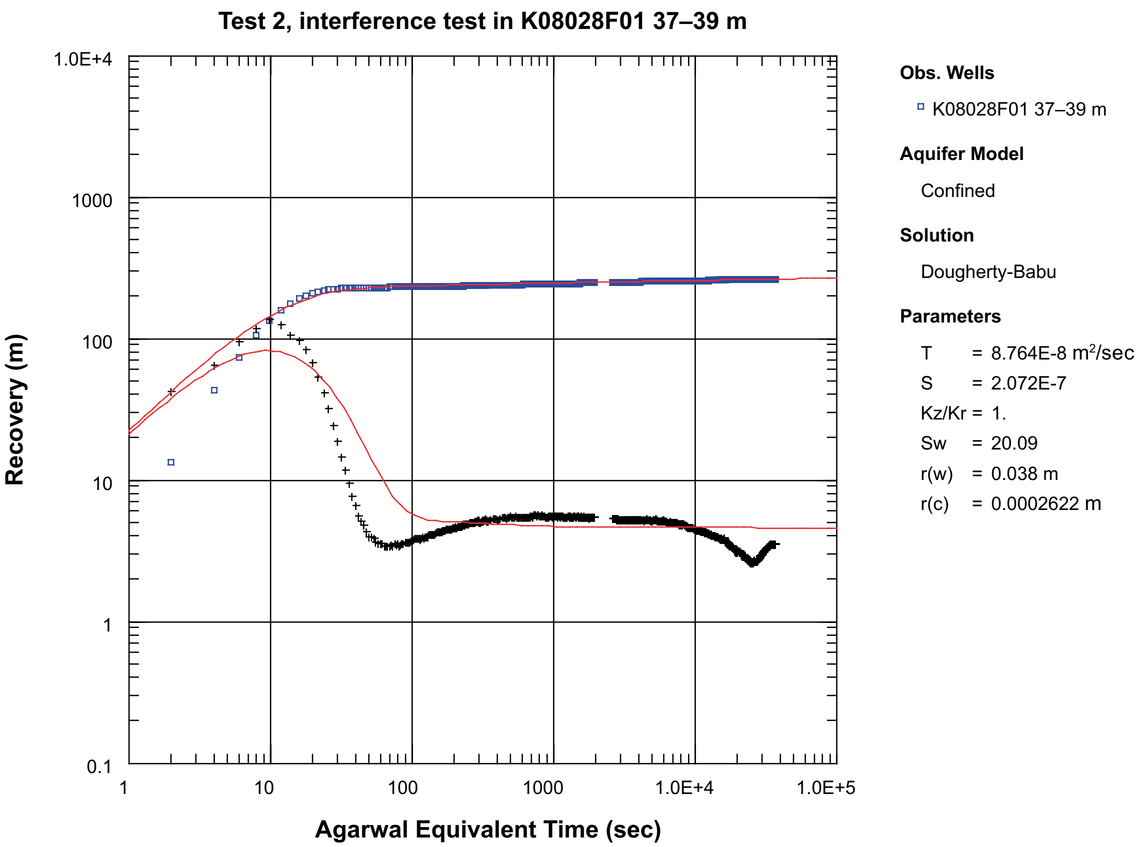
Test no 1. Interference test in K08028F01 30–32 m





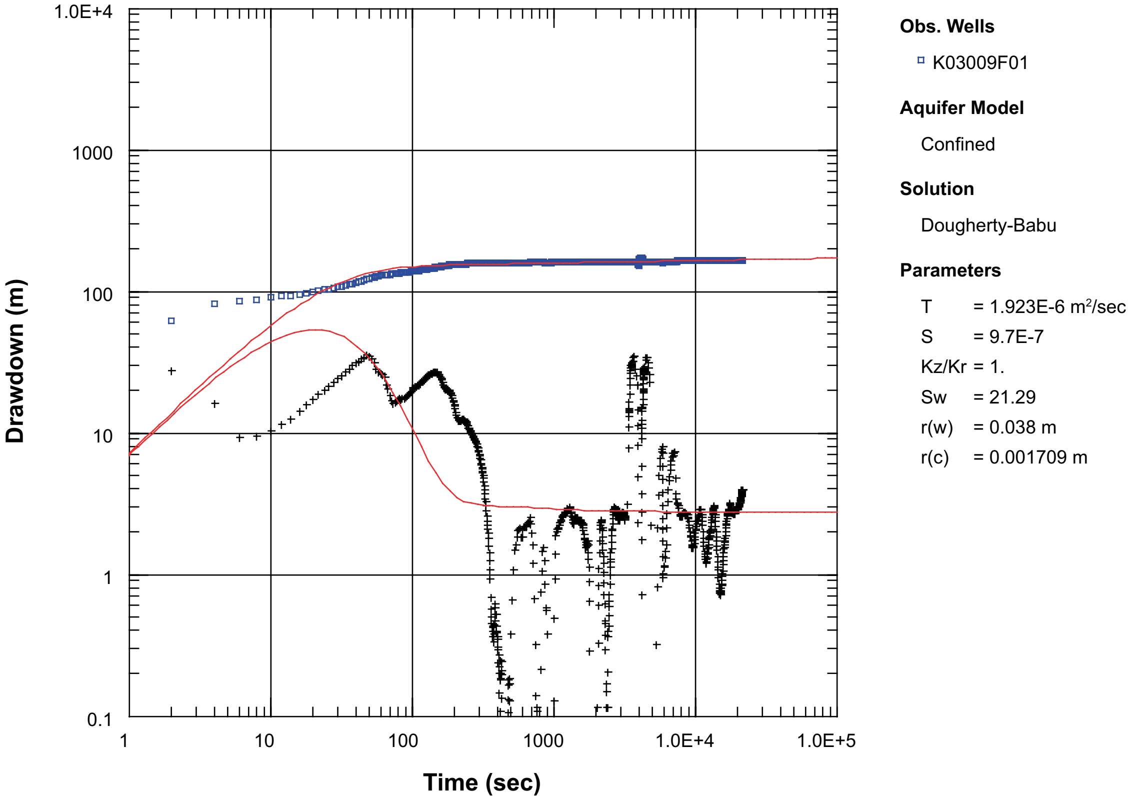
Test no 2. Interference test in K08028F01 37–39 m



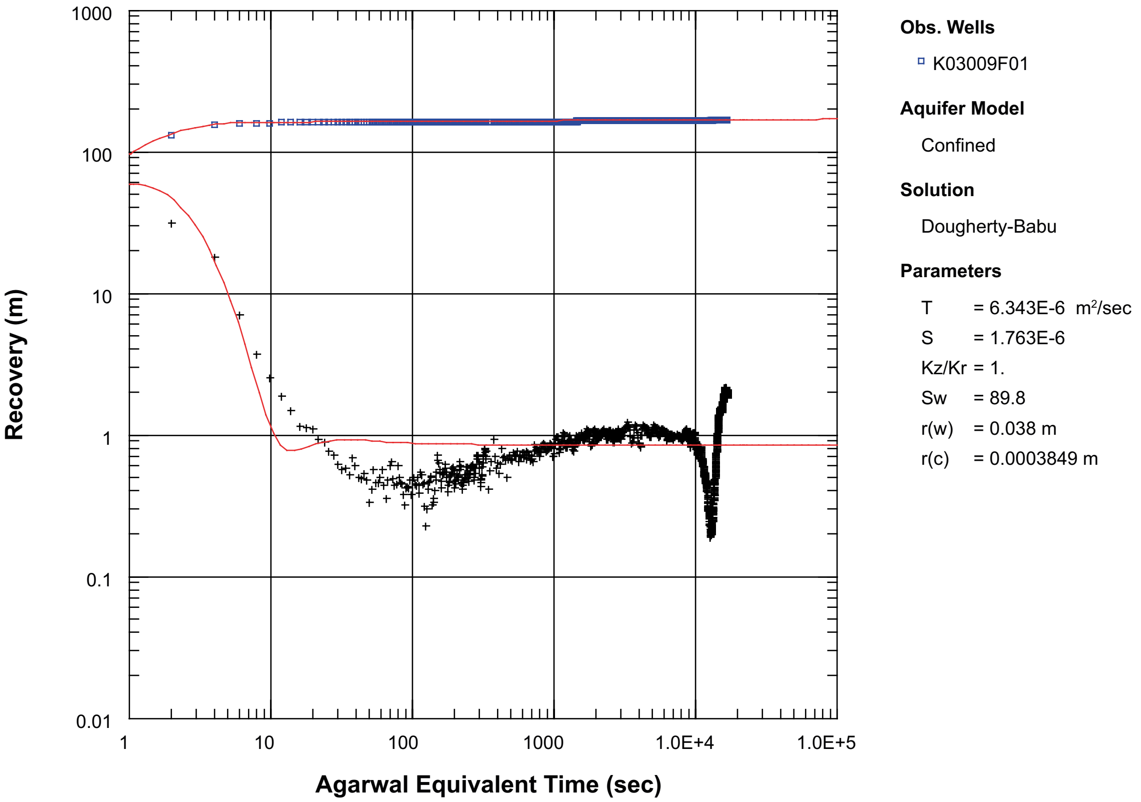


Test no 3. Interference test in K03009F01 18.5–20.5 m

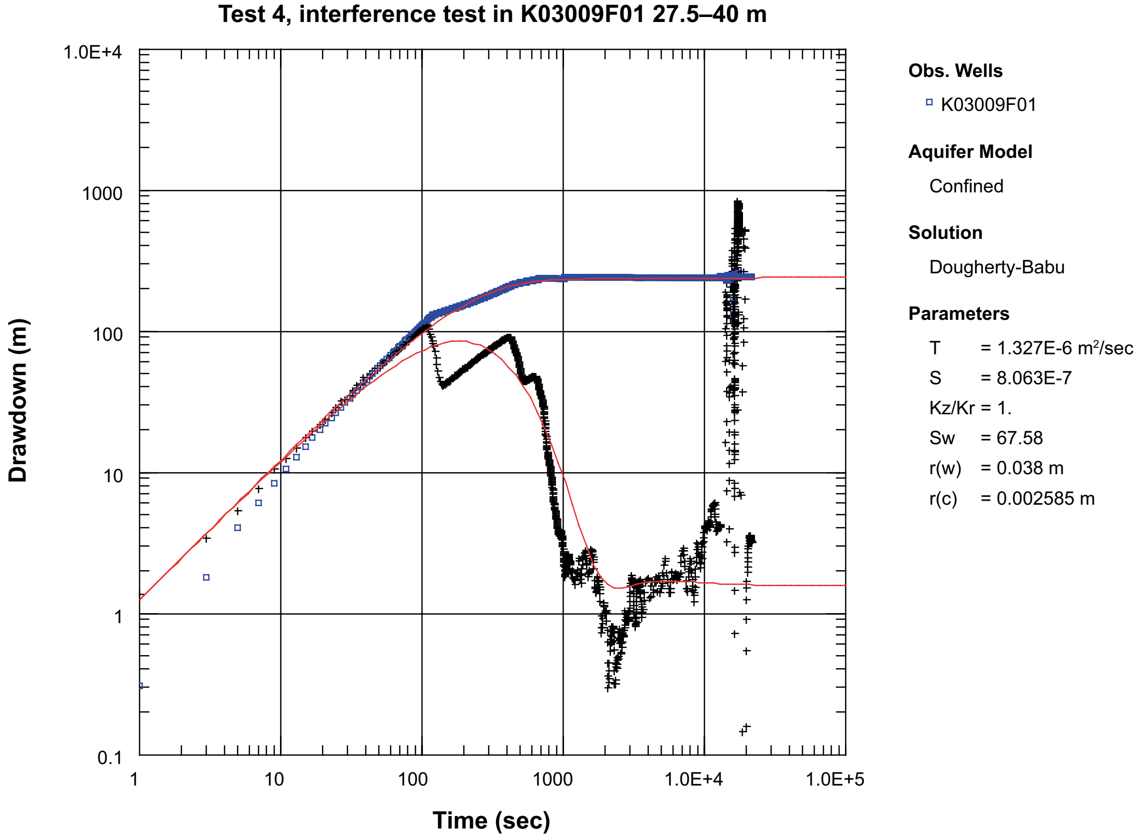
Test 3, interference test in K03009F01 18.5–20.5 m

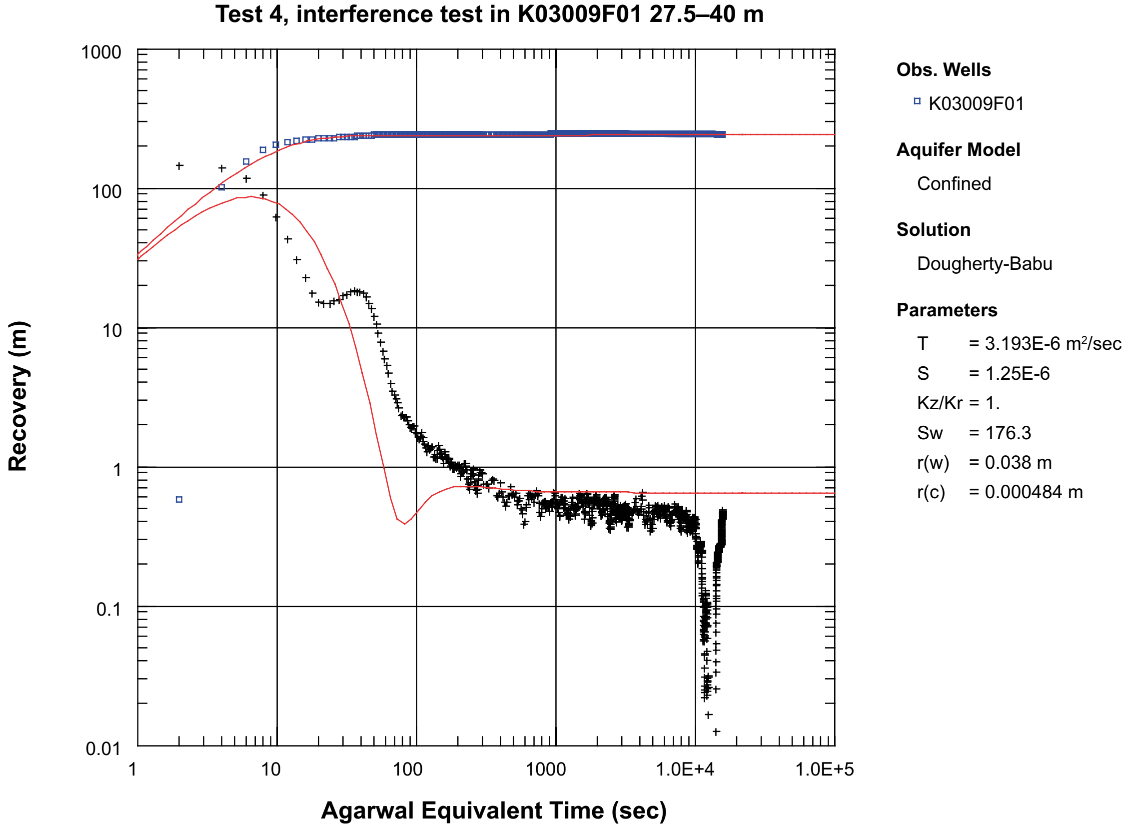


Test 3, interference test in K03009F01 18.5–20.5 m

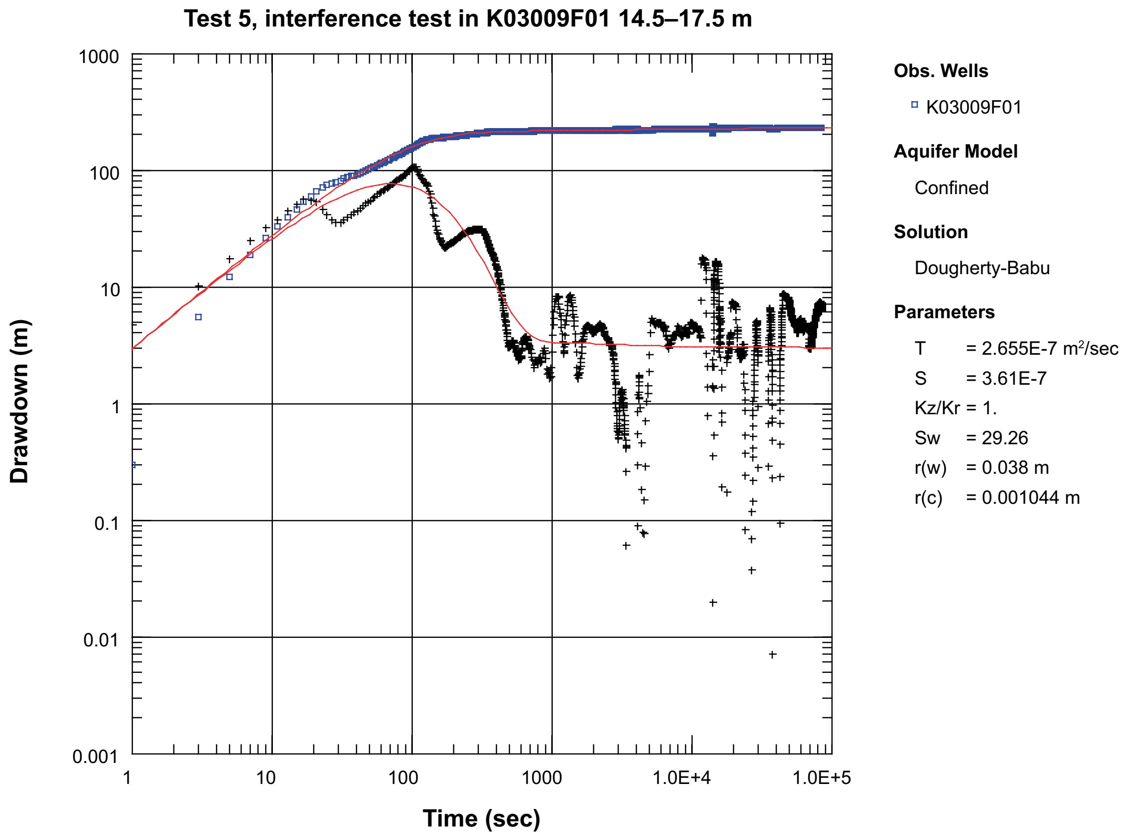


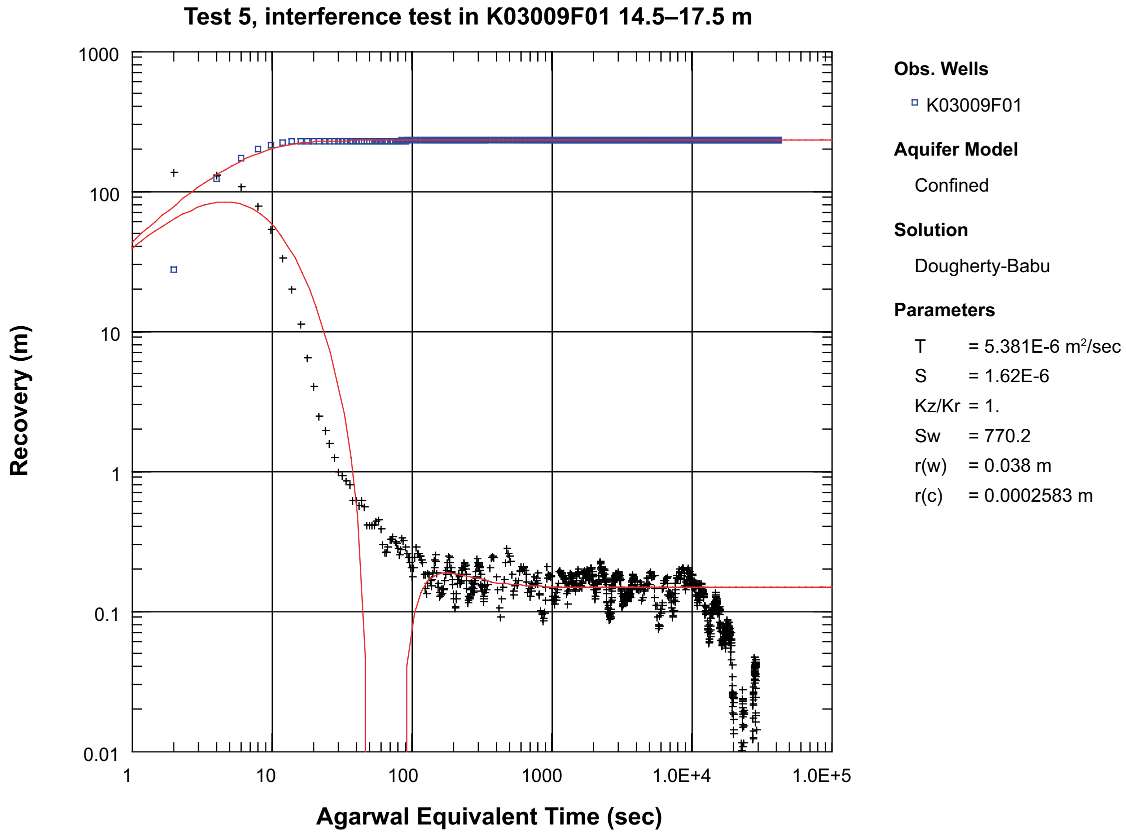
Test no 4. Interference test in K03009F01 25.5–38 m



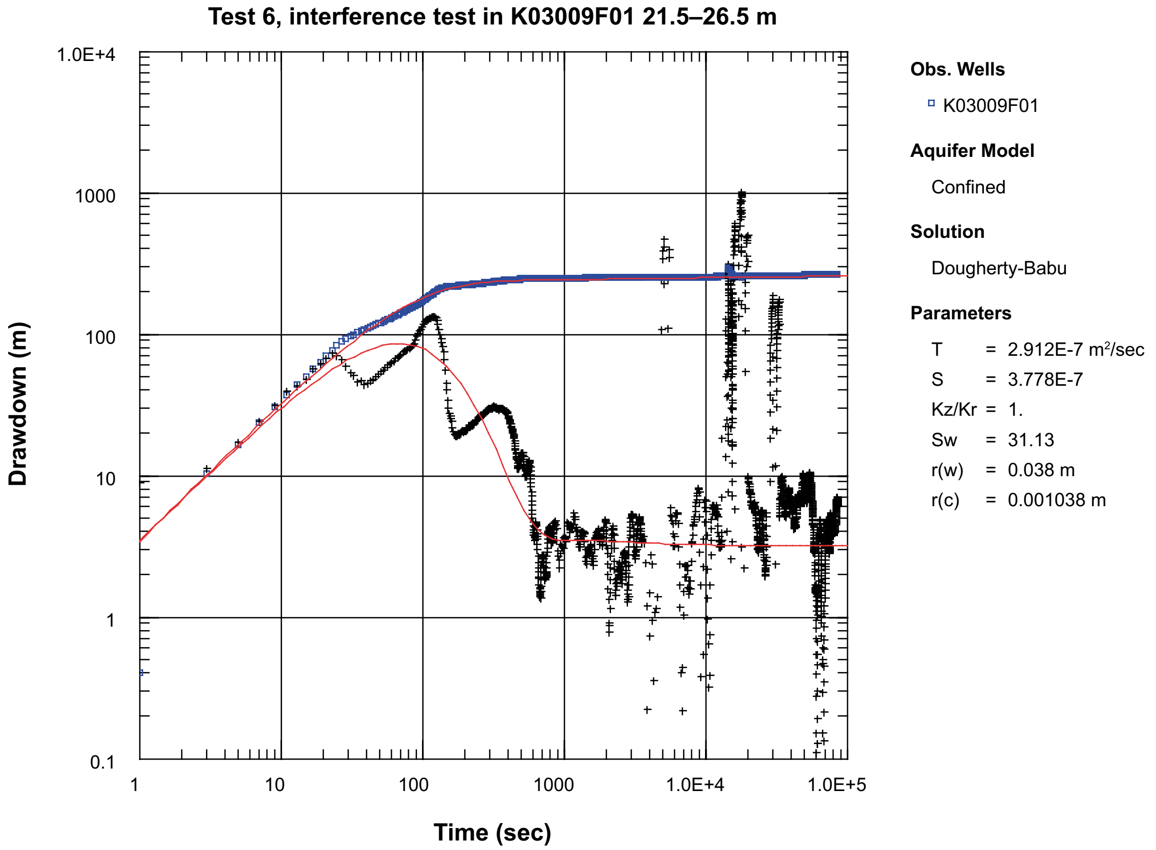


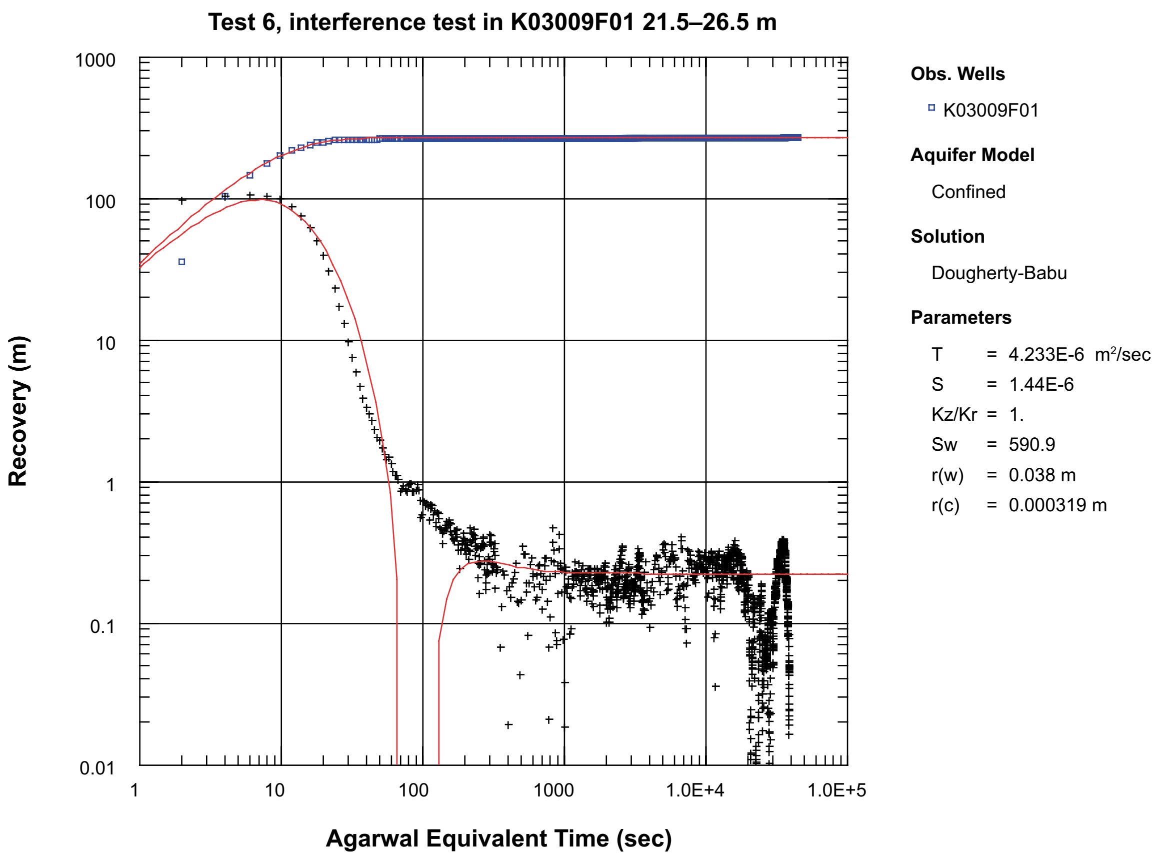
Test no 5. Interference test in K03009F01 14.5–17.5 m



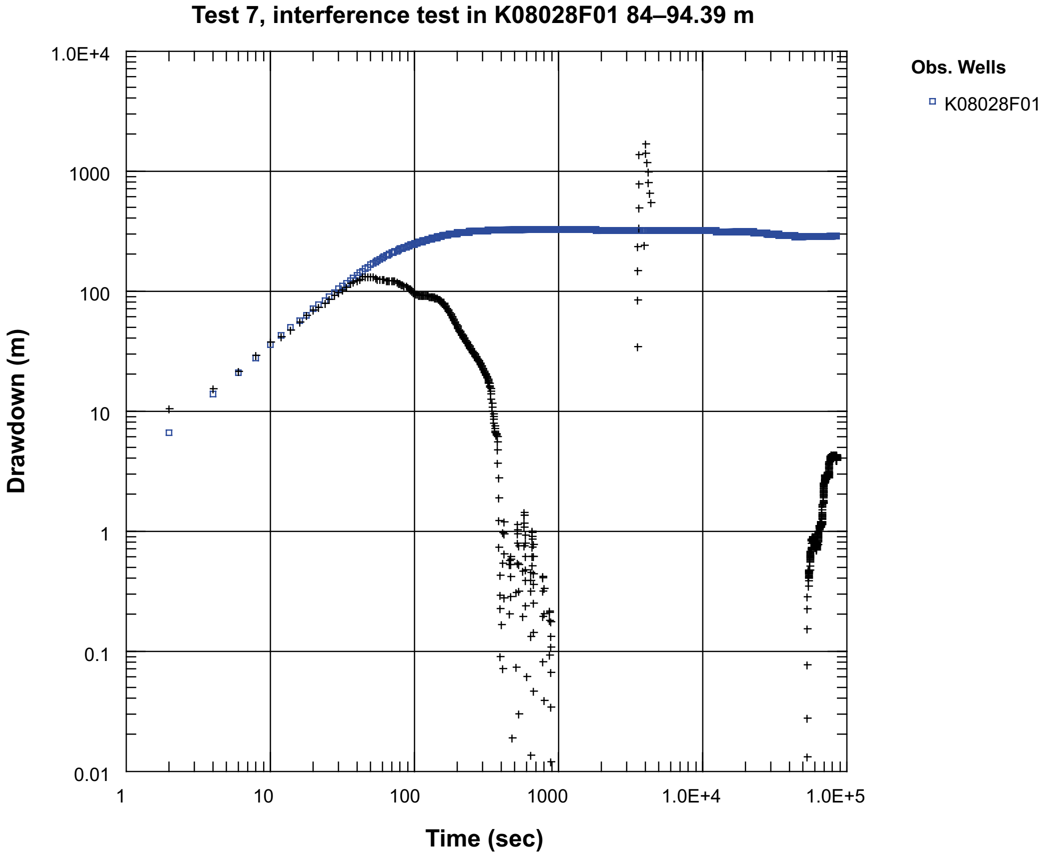


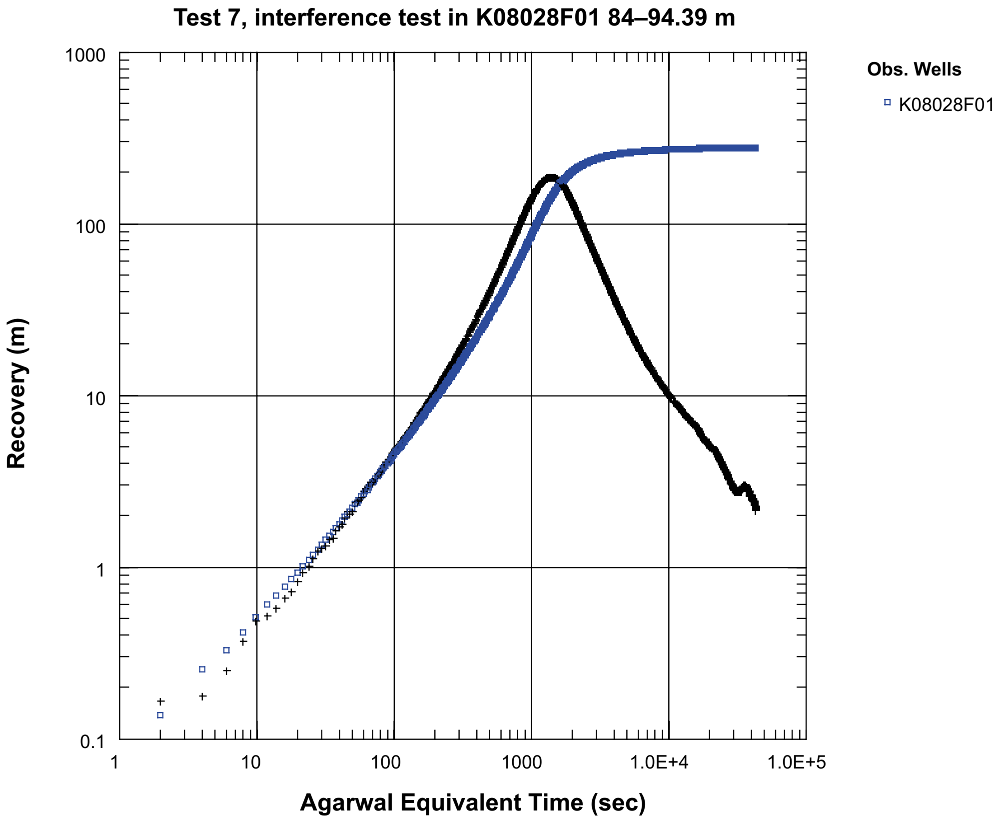
Test no 6. Interference test in K03009F01 21.5–24.5 m





Test no 7. Interference test in K08028F01 84–94.39 m

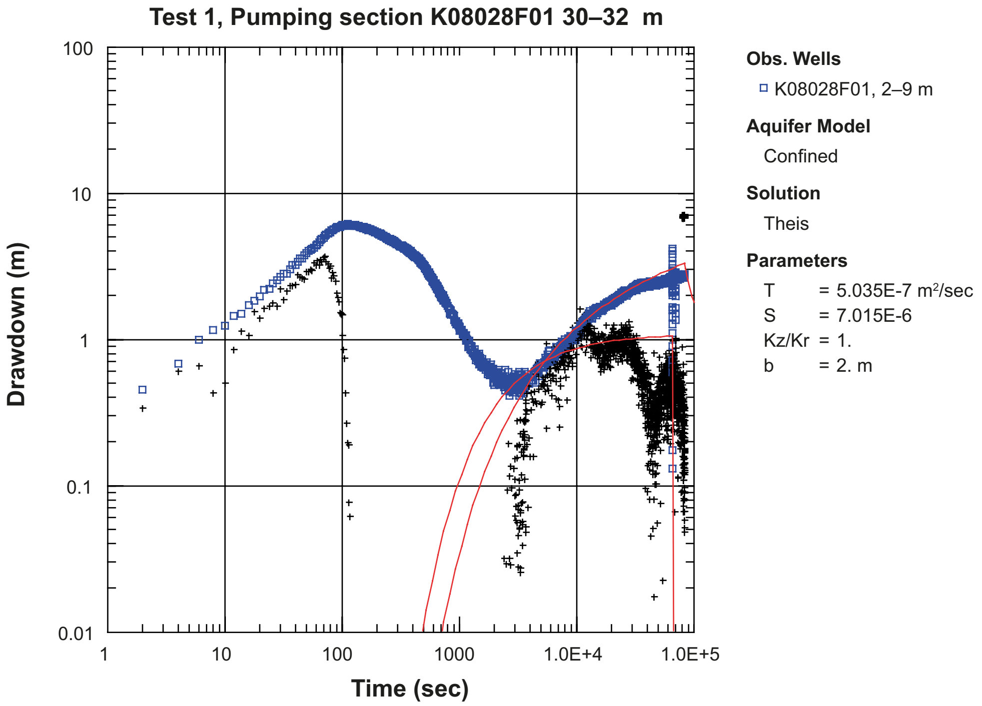


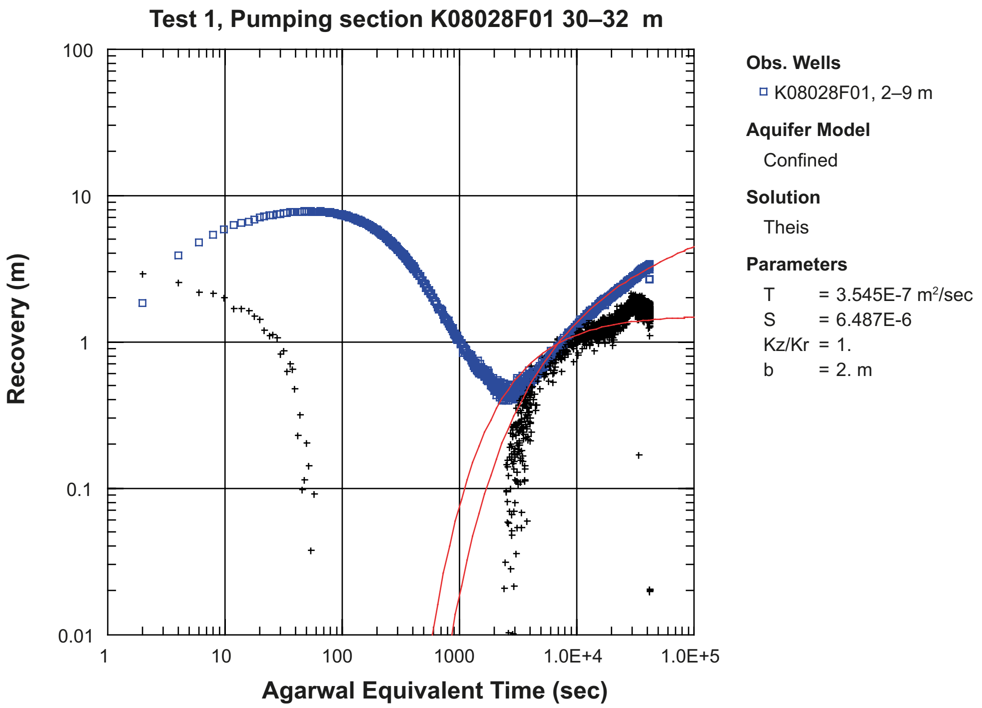


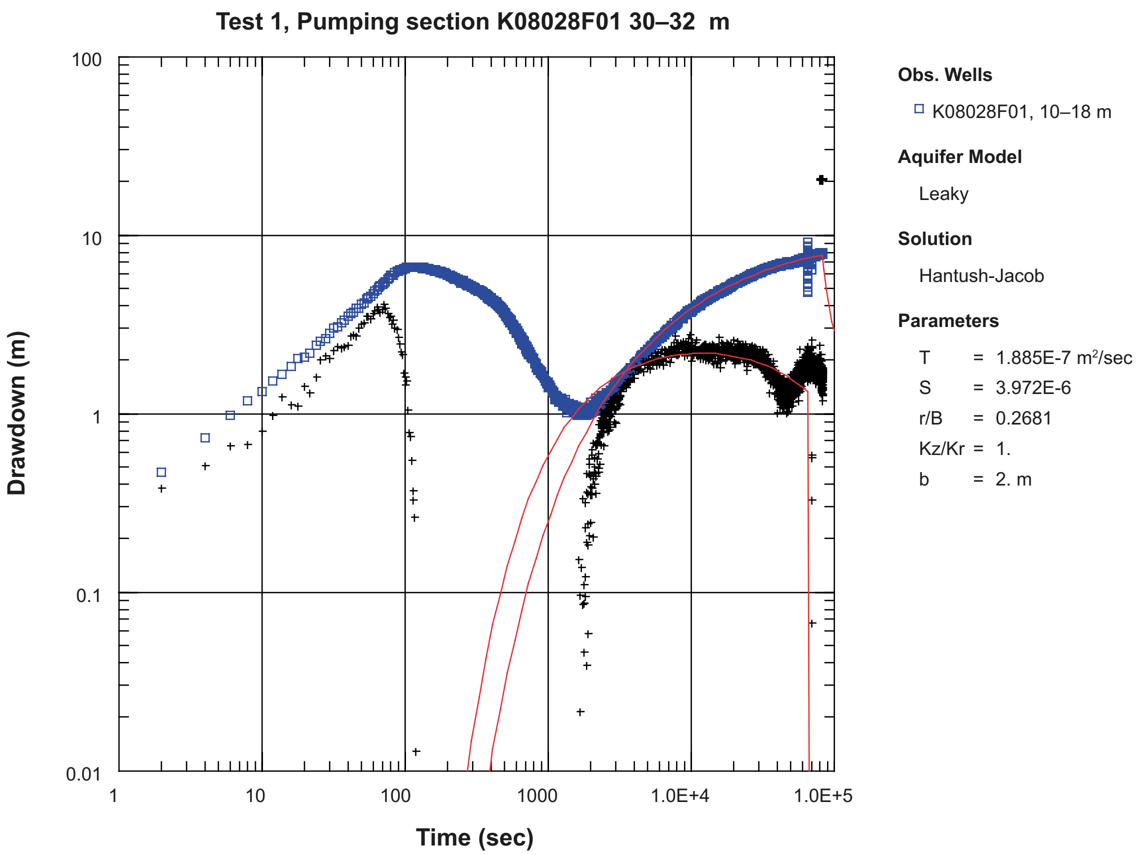
Transient evaluation of observations sections

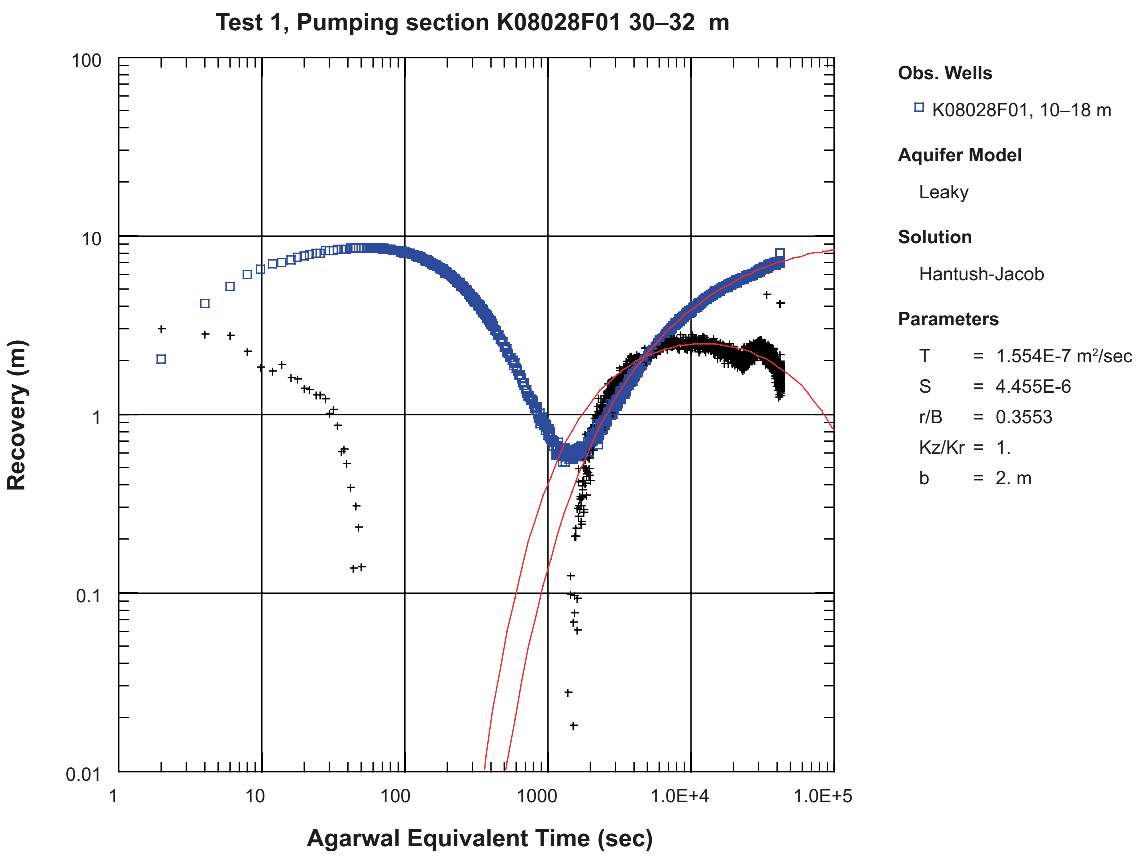
The plots presented in this appendix shows transient evaluations performed with AQTESOLV Pro v. 4.5 for the observation sections. For test no 8 (Pumping in K03009F01 89–100.92) no transient evaluations were possible. Some plots without any evaluation (i.e. fit with a model) are included below simply to illustrate that a transient evaluation is not possible even though that the response was quite clear.

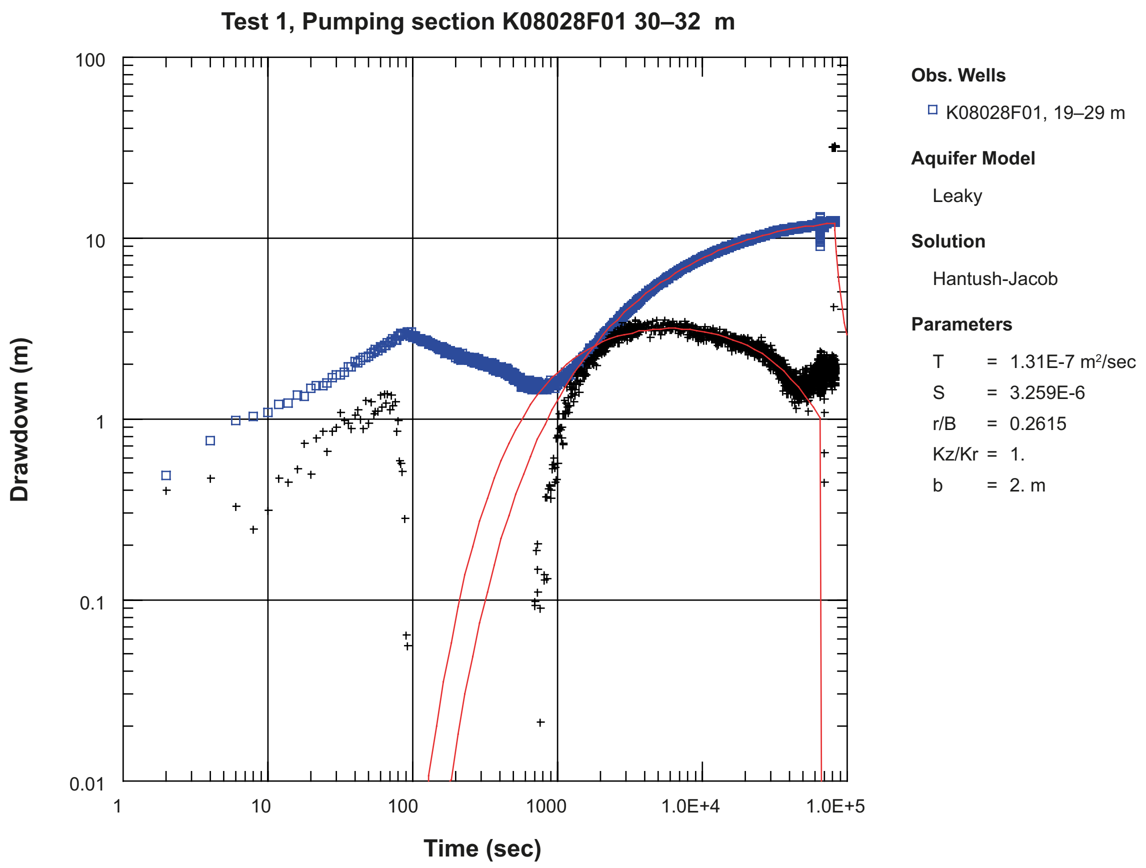
Test no 1. Interference test in K08028F01 30–32 m

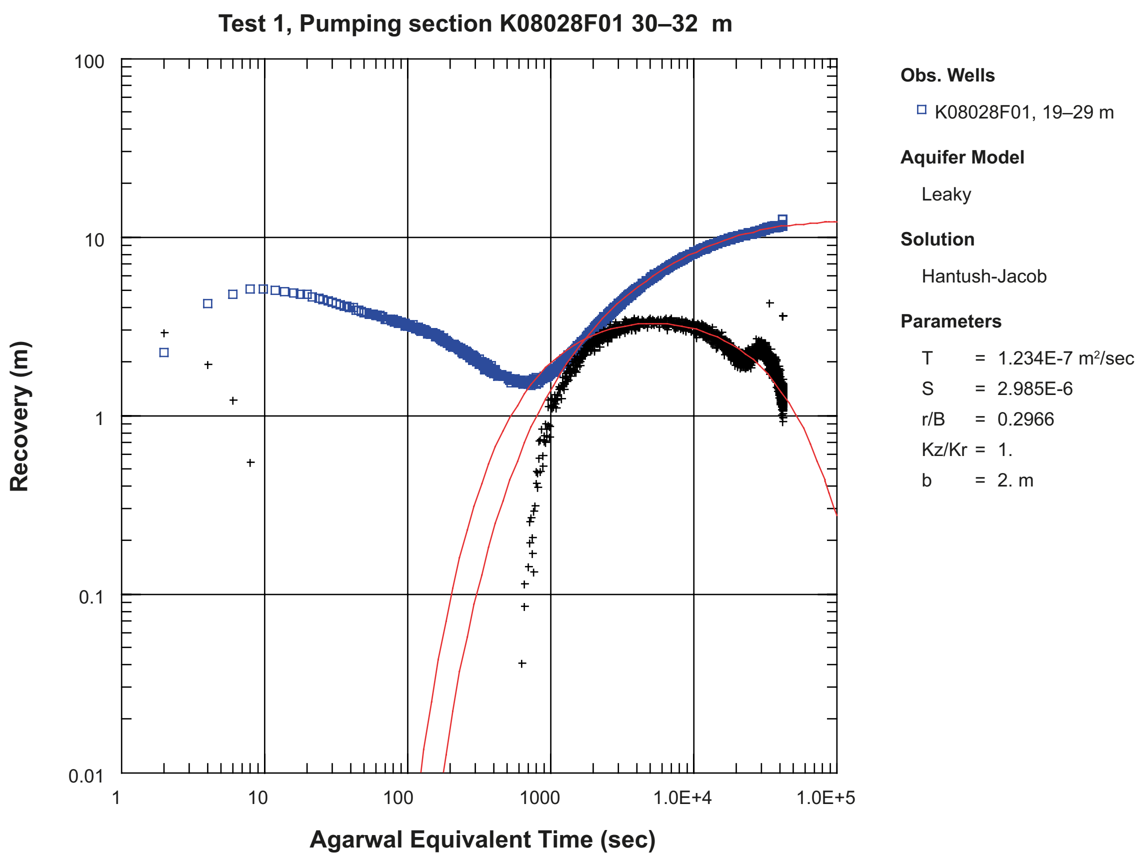


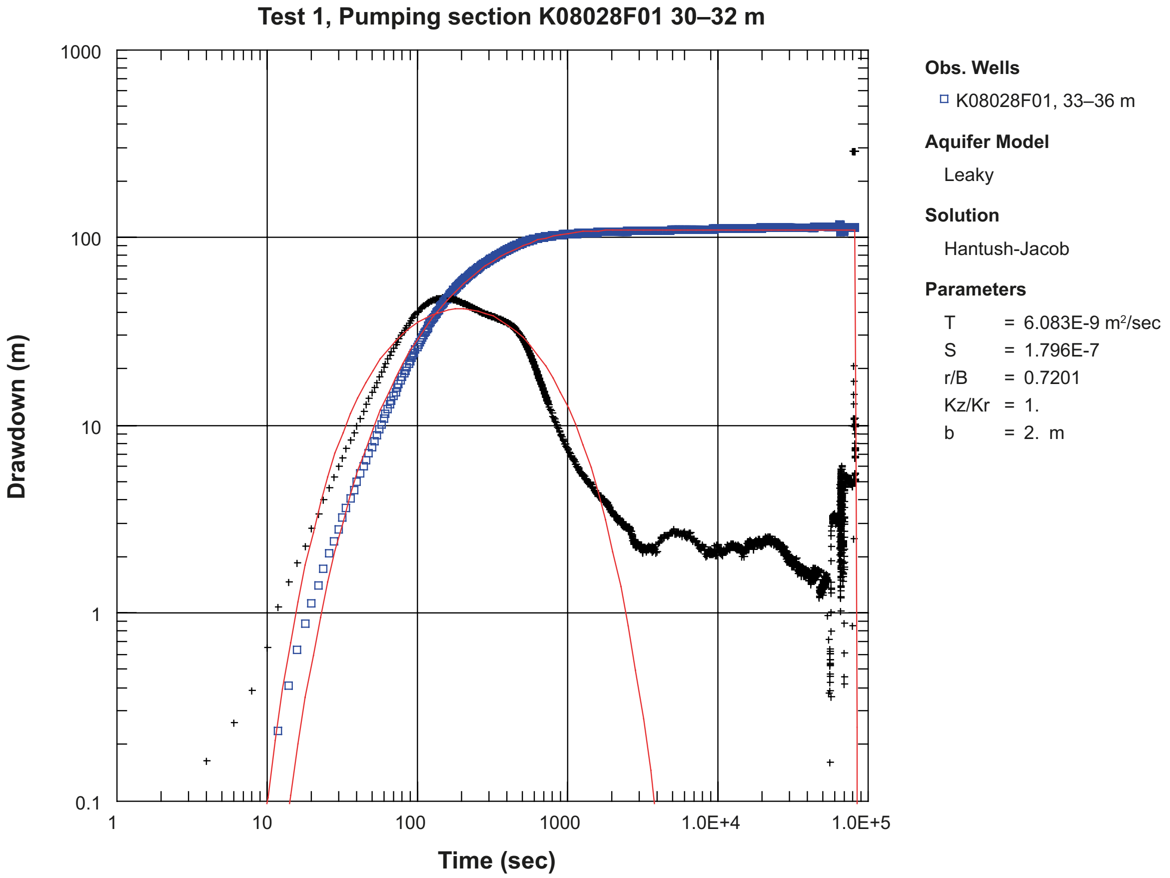


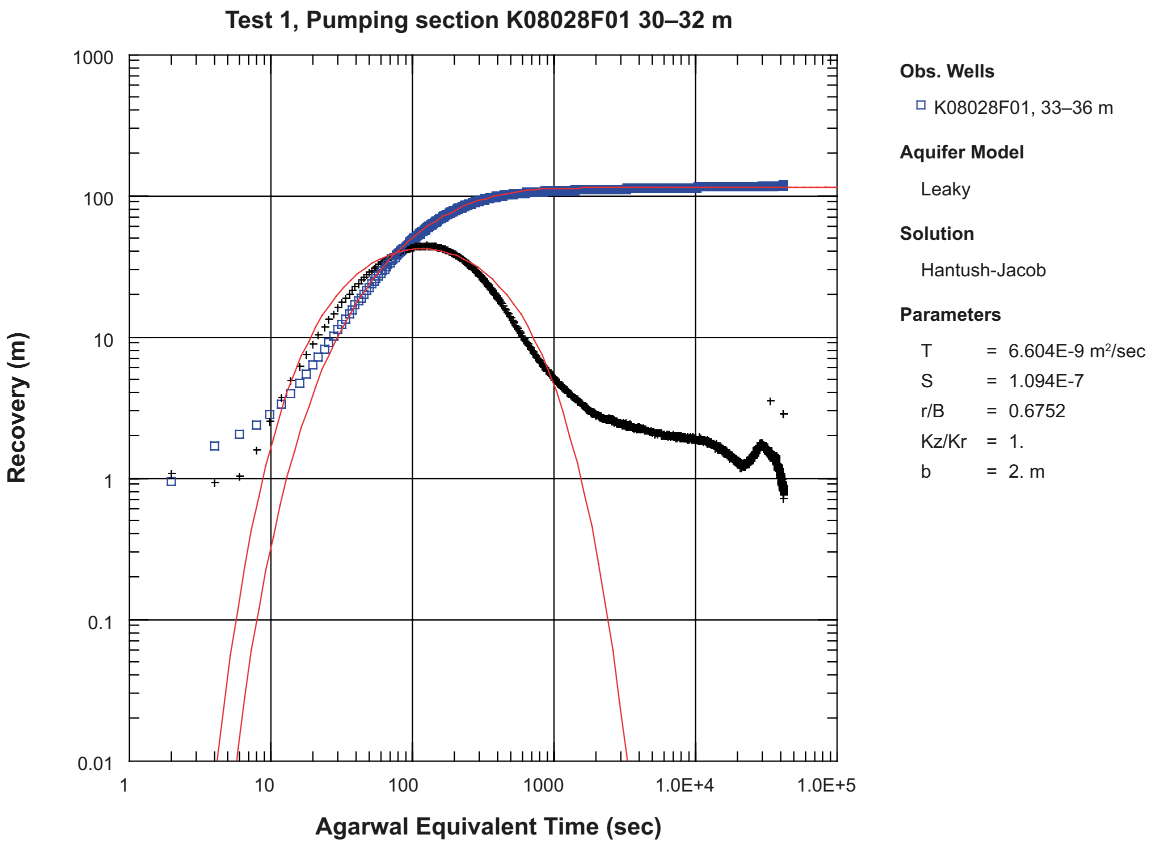

Test 1, Pumping section K08028F01 30–32 m
Drawdown (m)
Time (sec)
100
10
1
0.1
0.01
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01, 10–18 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 1.885E-7 m²/sec
S = 3.972E-6
r/B = 0.2681
Kz/Kr = 1.
b = 2. m

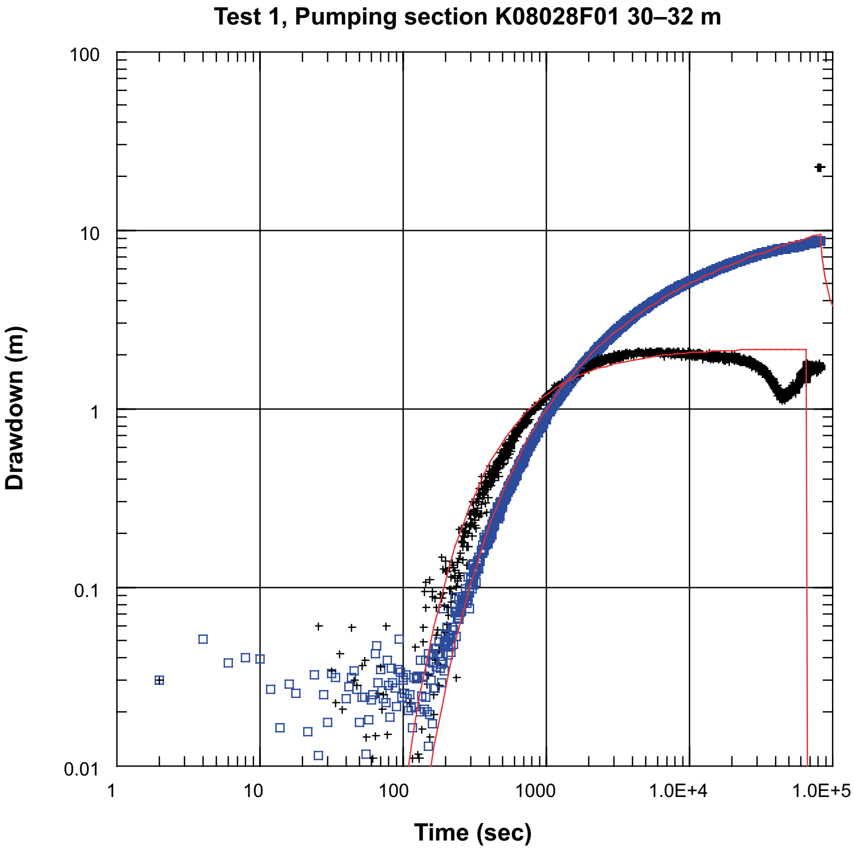

Test 1, Pumping section K08028F01 30–32 m
Recovery (m)
Agarwal Equivalent Time (sec)
100
10
1
0.1
0.01
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01, 10–18 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 1.554E-7 m²/sec
S = 4.455E-6
r/B = 0.3553
Kz/Kr = 1.
b = 2. m


Test 1, Pumping section K08028F01 30–32 m
100
10
1
0.1
0.01
Drawdown (m)
1
10
100
1000
1.0E+4
1.0E+5
Time (sec)
Obs. Wells
K08028F01, 19–29 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 1.31E-7 m²/sec
S = 3.259E-6
r/B = 0.2615
Kz/Kr = 1.
b = 2. m

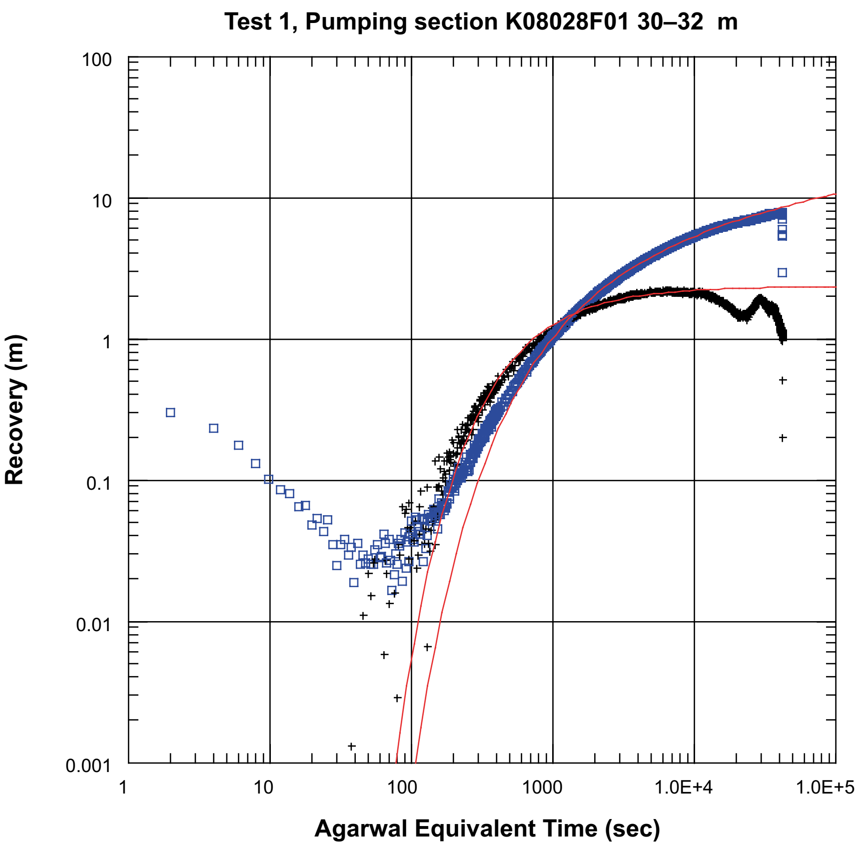

Test 1, Pumping section K08028F01 30–32 m
100
10
1
0.1
0.01
Recovery (m)
1
10
100
1000
1.0E+4
1.0E+5
Agarwal Equivalent Time (sec)
Obs. Wells
K08028F01, 19–29 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 1.234E-7 m²/sec
S = 2.985E-6
r/B = 0.2966
Kz/Kr = 1.
b = 2. m


Test 1, Pumping section K08028F01 30–32 m
Drawdown (m)
Time (sec)
1000
100
10
1
0.1
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01, 33–36 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 6.083E-9 m²/sec
S = 1.796E-7
r/B = 0.7201
Kz/Kr = 1.
b = 2. m

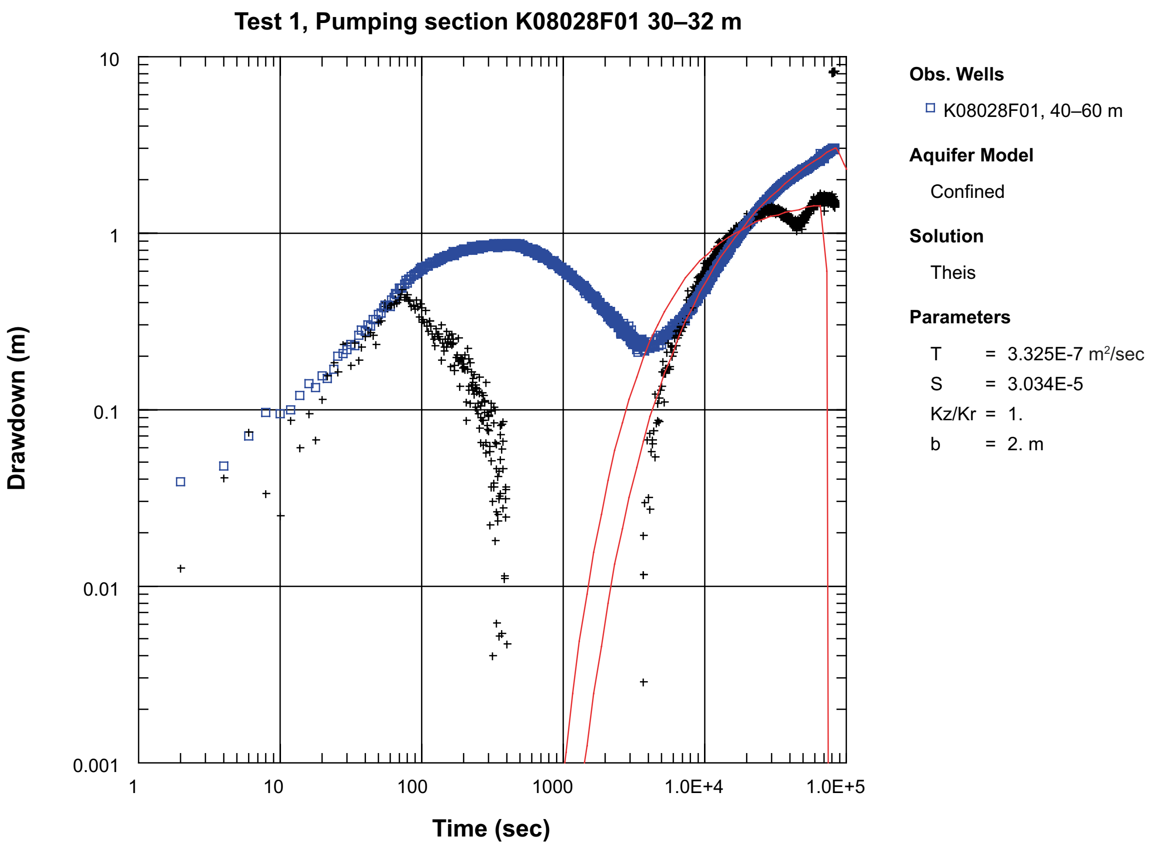

Test 1, Pumping section K08028F01 30–32 m
Recovery (m)
Agarwal Equivalent Time (sec)
1000
100
10
1
0.1
0.01
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01, 33–36 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 6.604E-9 m²/sec
S = 1.094E-7
r/B = 0.6752
Kz/Kr = 1.
b = 2. m

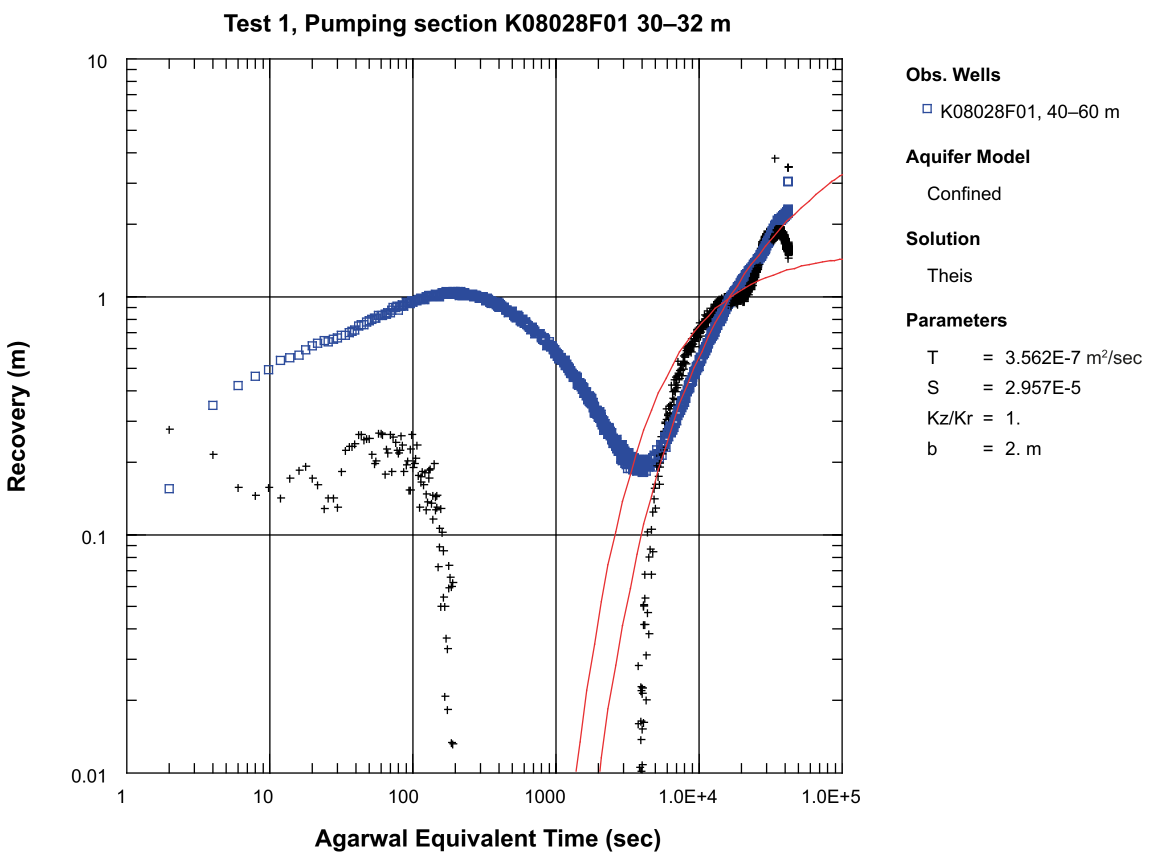

Test 1, Pumping section K08028F01 30–32 m
Drawdown (m)
Time (sec)
100
10
1
0.1
0.01
1
10
100
1000
1.0E+4
1.0E+5

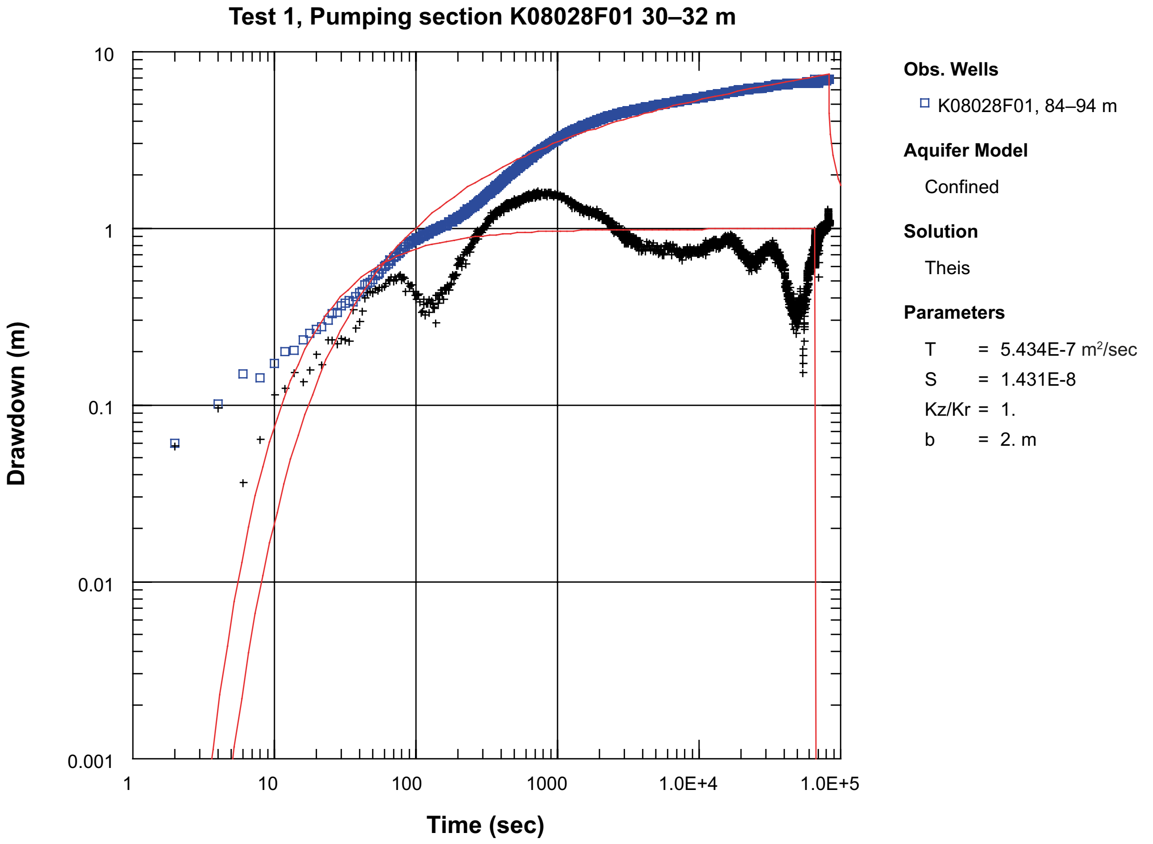
Obs. Wells
K08028F01, 37–39 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 2.464E-7 m²/sec
S = 1.553E-5
Kz/Kr = 1.
b = 2. m

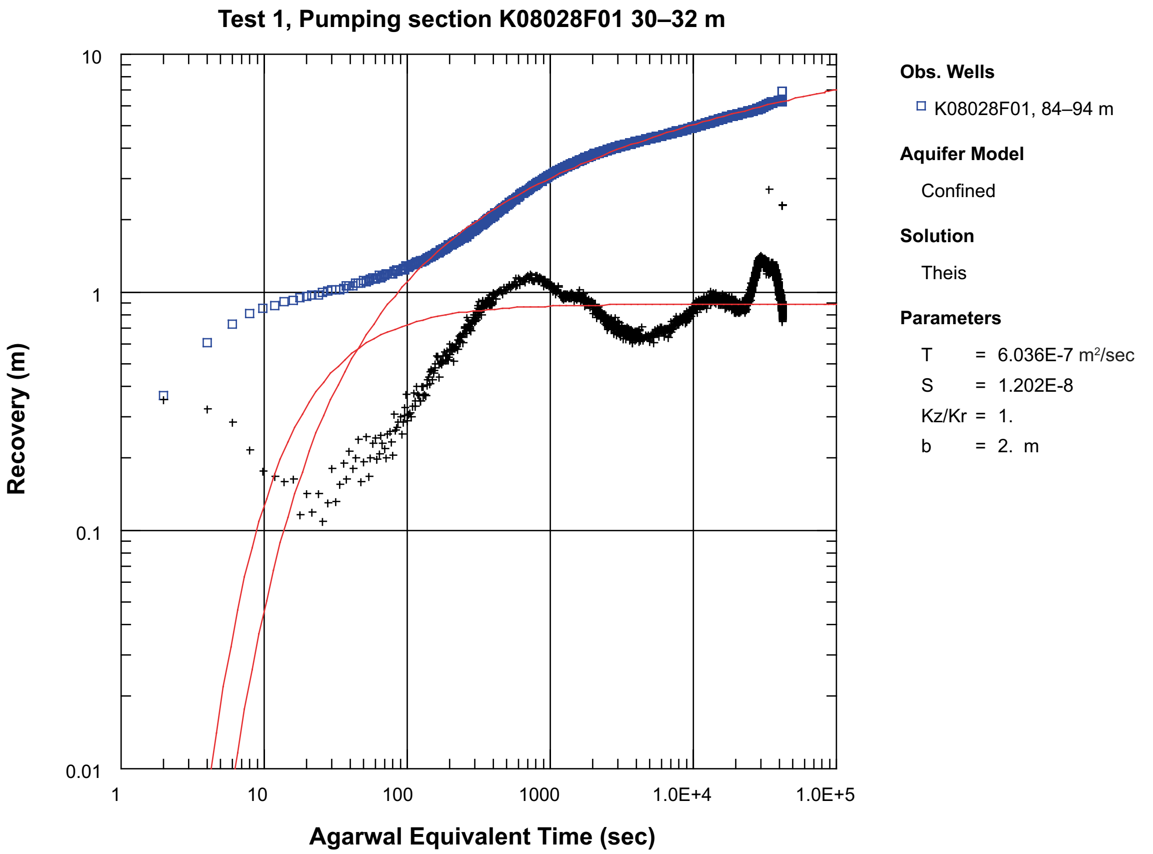

Test 1, Pumping section K08028F01 30–32 m
Recovery (m)
Agarwal Equivalent Time (sec)
100
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5

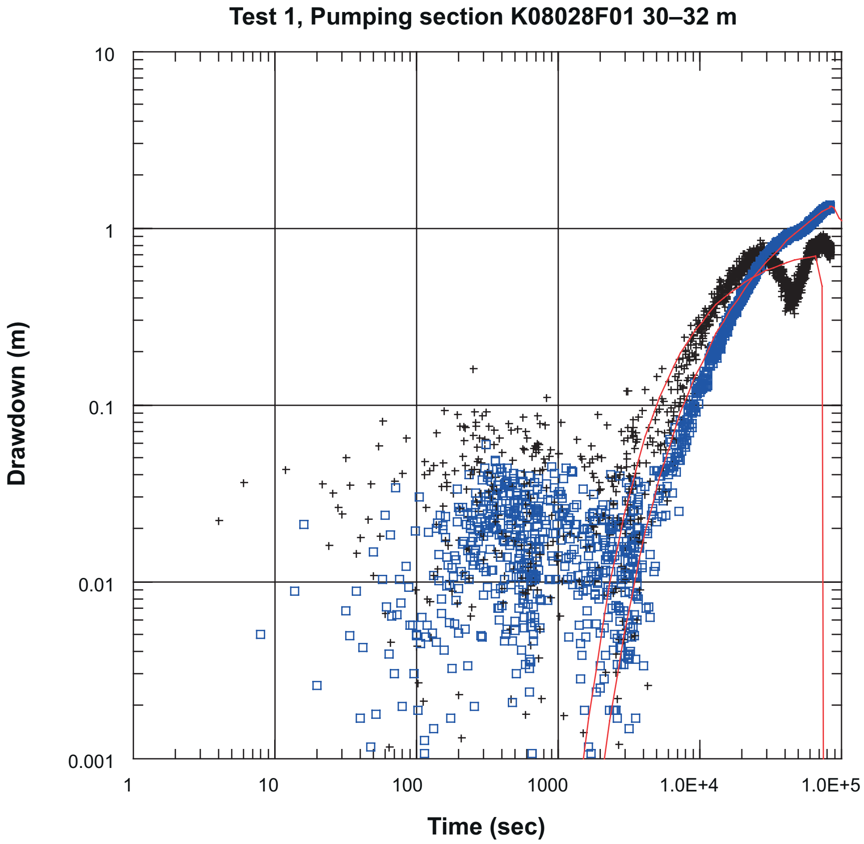
Obs. Wells
K08028F01, 37–39 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 2.282E-7 m²/sec
S = 1.493E-5
Kz/Kr = 1.
b = 2. m


Test 1, Pumping section K08028F01 30–32 m
Drawdown (m)
Time (sec)
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01, 40–60 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 3.325E-7 m²/sec
S = 3.034E-5
Kz/Kr = 1.
b = 2. m


Test 1, Pumping section K08028F01 30–32 m
Recovery (m)
Agarwal Equivalent Time (sec)
10
1
0.1
0.01
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01, 40–60 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 3.562E-7 m²/sec
S = 2.957E-5
Kz/Kr = 1.
b = 2. m


Test 1, Pumping section K08028F01 30–32 m
Drawdown (m)
Time (sec)
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01, 84–94 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.434E-7 m²/sec
S = 1.431E-8
Kz/Kr = 1.
b = 2. m


Test 1, Pumping section K08028F01 30–32 m
Recovery (m)
Agarwal Equivalent Time (sec)
10
1
0.1
0.01
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01, 84–94 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.036E-7 m²/sec
S = 1.202E-8
Kz/Kr = 1.
b = 2. m



Obs. Wells

K03009F01, 89–101 m

Aquifer Model

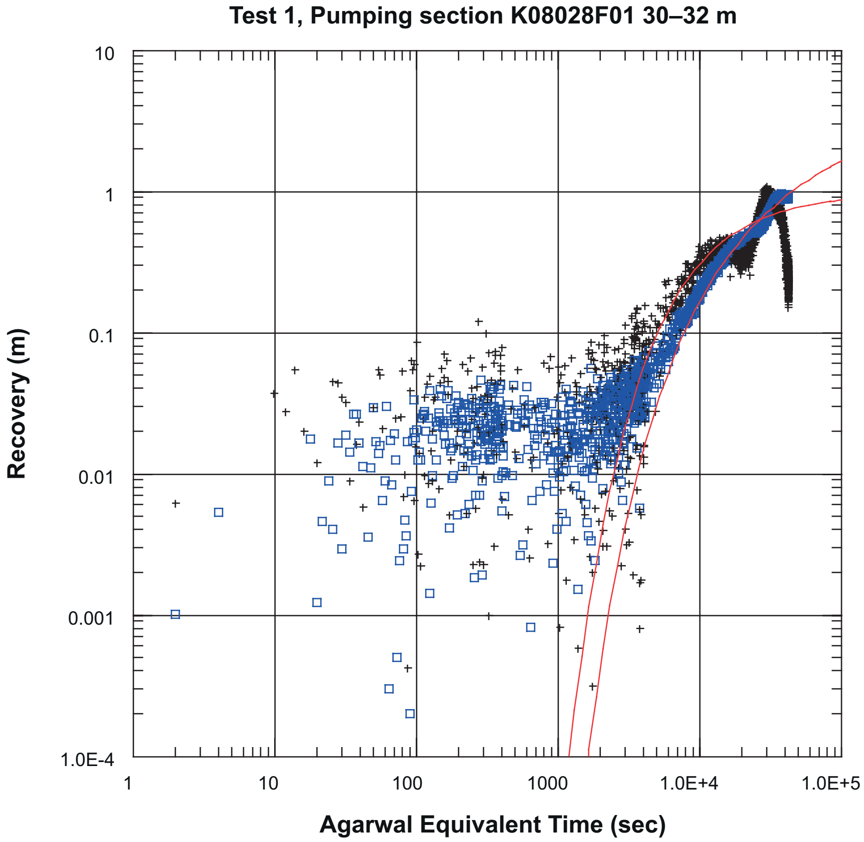
Confined

Solution

Theis

Parameters

T = 6.524E-7 m²/sec
S = 1.04E-5
Kz/Kr = 1.
b = 2. m



Obs. Wells

K03009F01, 89–101 m

Aquifer Model

Confined

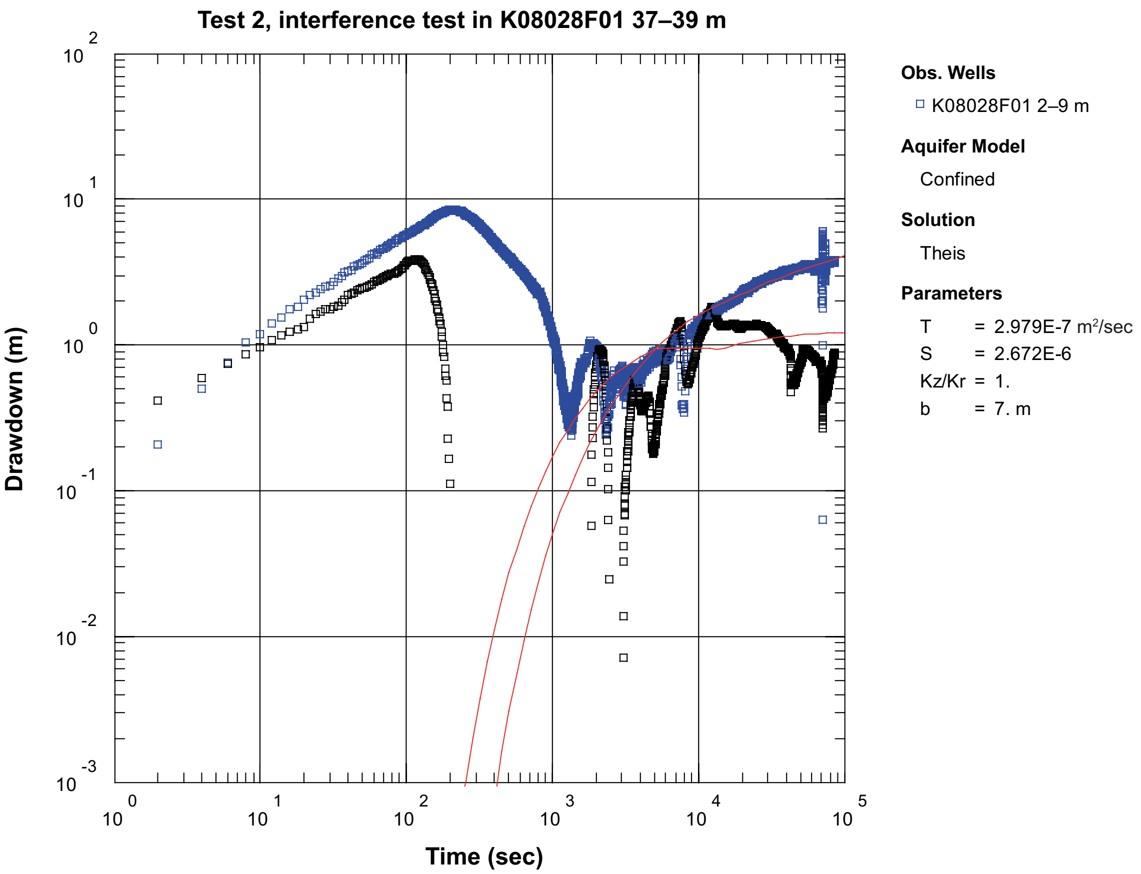
Solution

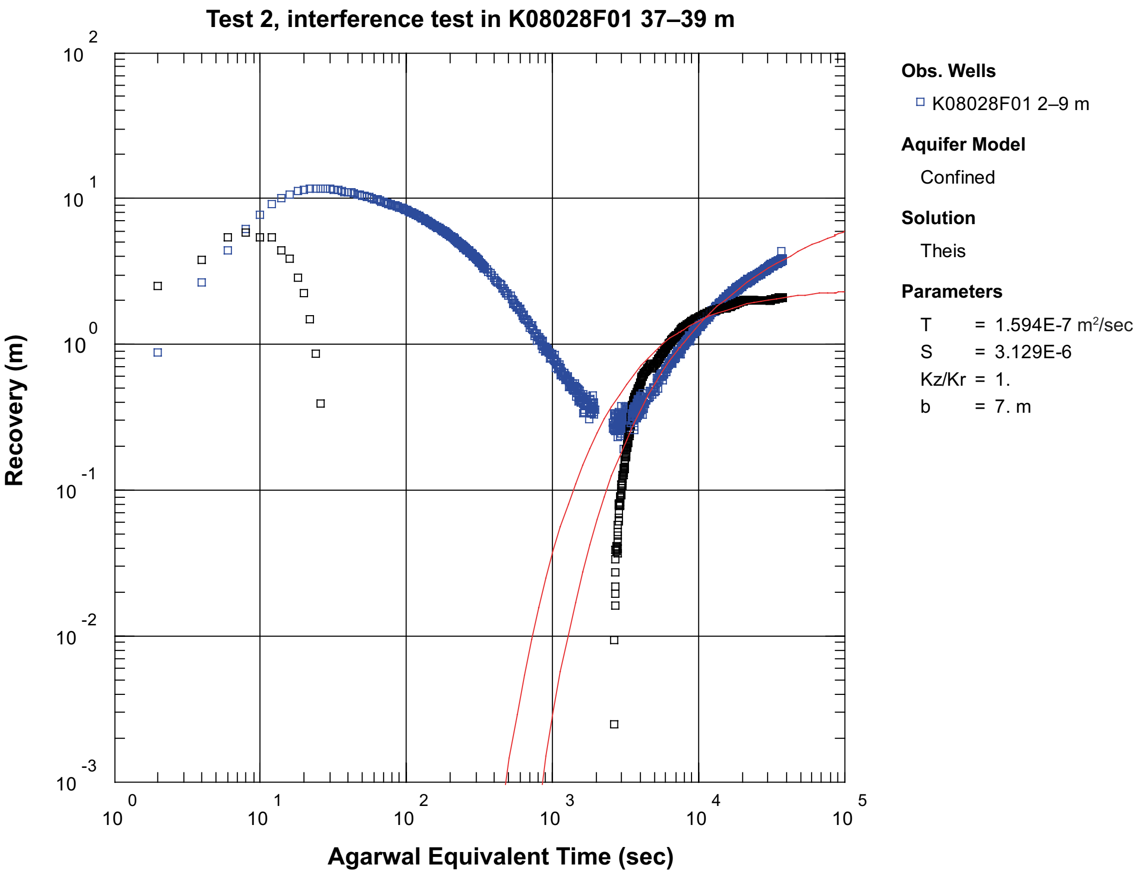
Theis

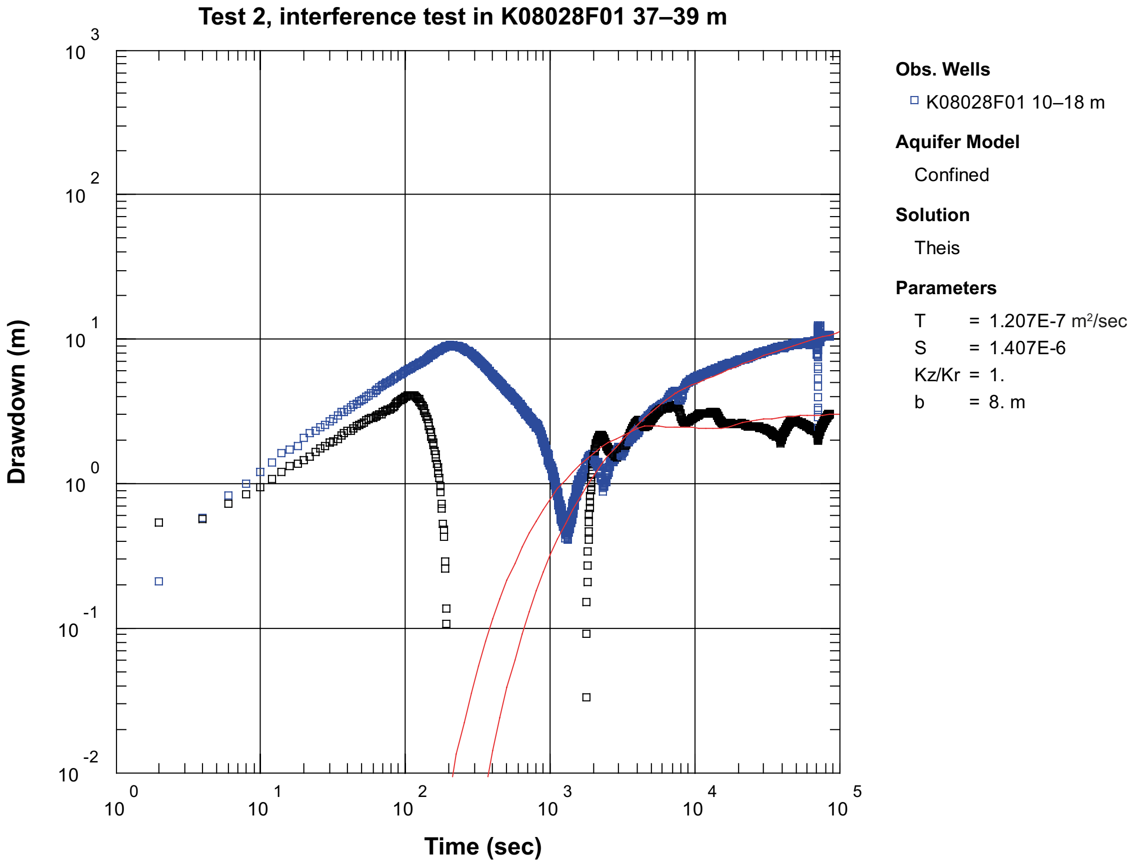
Parameters

T = 5.592E-7 m²/sec
S = 9.753E-6
Kz/Kr = 1.
b = 2. m

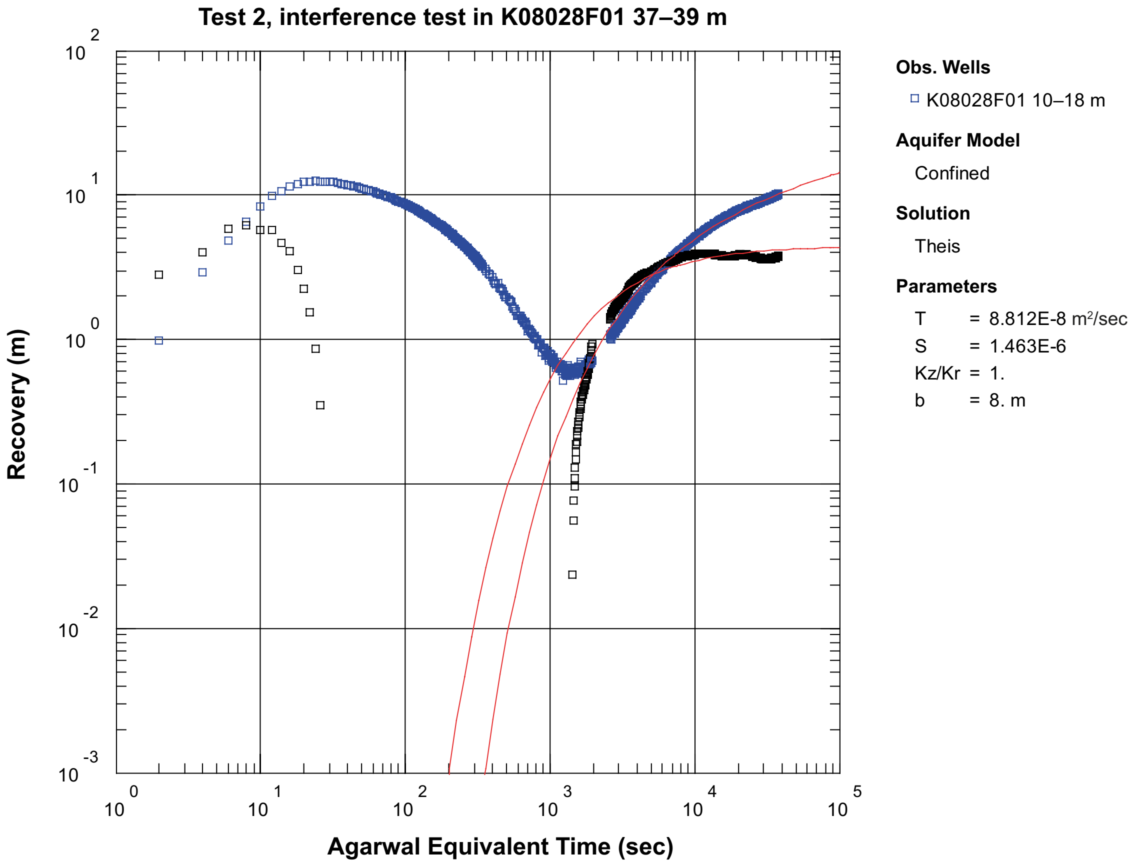
Test no 2. Interference test in K08028F01 37–39 m



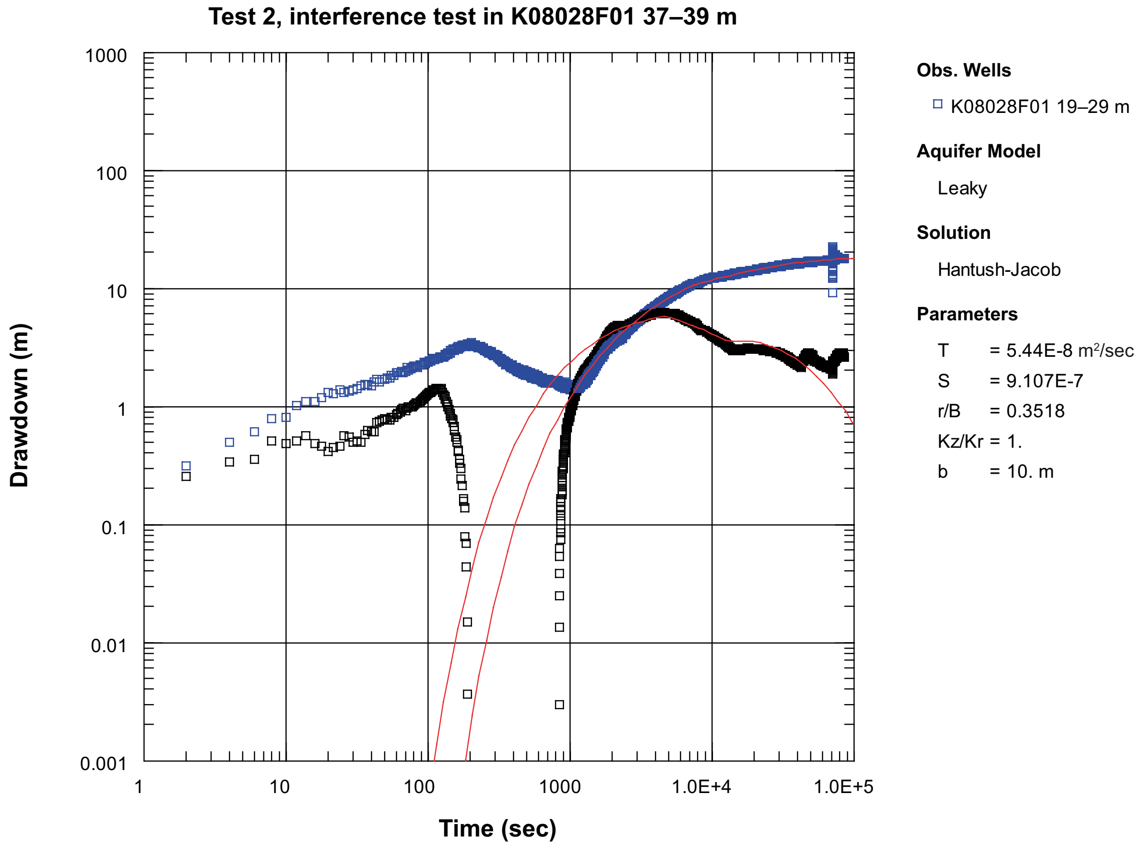




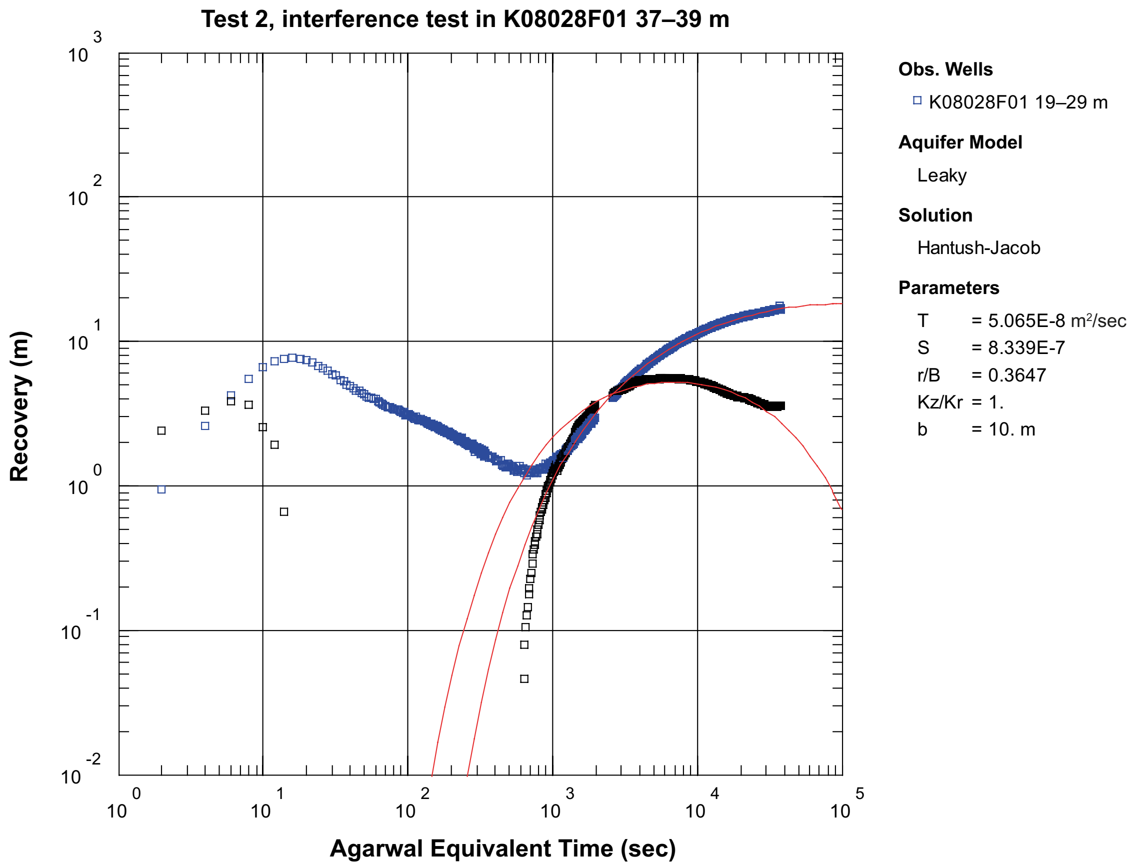
Test 2, interference test in K08028F01 37–39 m
Drawdown (m)
Time (sec)
Obs. Wells
K08028F01 10–18 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 1.207E-7 m²/sec
S = 1.407E-6
Kz/Kr = 1.
b = 8. m



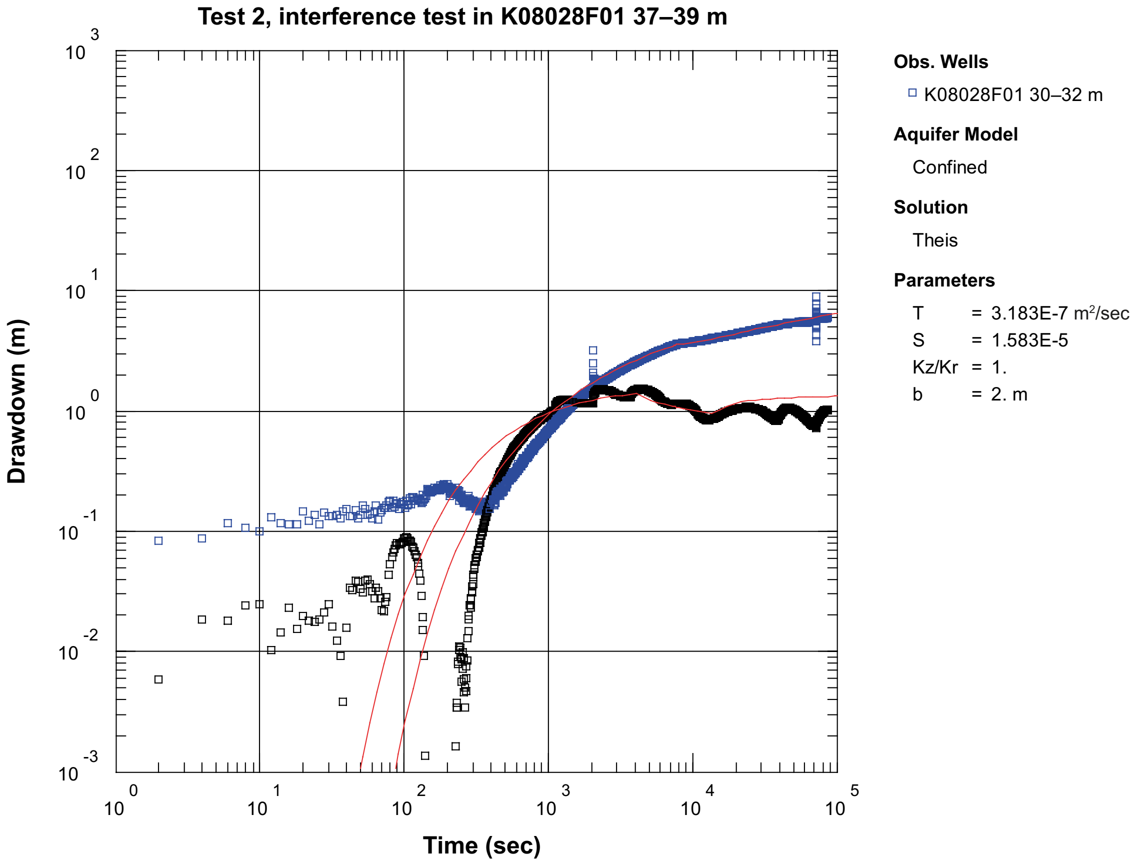
Test 2, interference test in K08028F01 37–39 m
Recovery (m)
Agarwal Equivalent Time (sec)
Obs. Wells
K08028F01 10–18 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 8.812E-8 m²/sec
S = 1.463E-6
Kz/Kr = 1.
b = 8. m



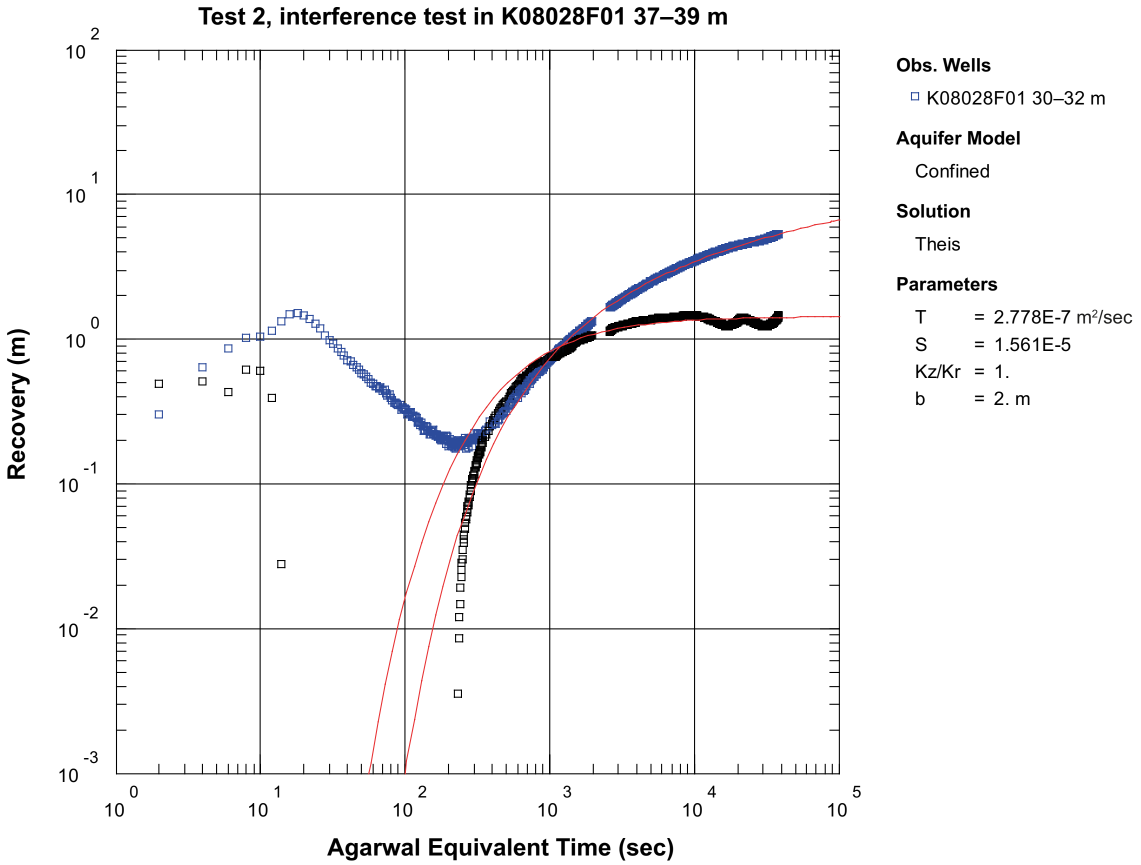
Test 2, interference test in K08028F01 37–39 m
Drawdown (m)
Time (sec)
1000
100
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01 19–29 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 5.44E-8 m²/sec
S = 9.107E-7
r/B = 0.3518
Kz/Kr = 1.
b = 10. m



Test 2, interference test in K08028F01 37–39 m
Recovery (m)
Agarwal Equivalent Time (sec)
10^3
10^2
10^1
10^0
10^-1
10^-2
10^0
10^1
10^2
10^3
10^4
10^5
Obs. Wells
K08028F01 19–29 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 5.065E-8 m²/sec
S = 8.339E-7
r/B = 0.3647
Kz/Kr = 1.
b = 10. m

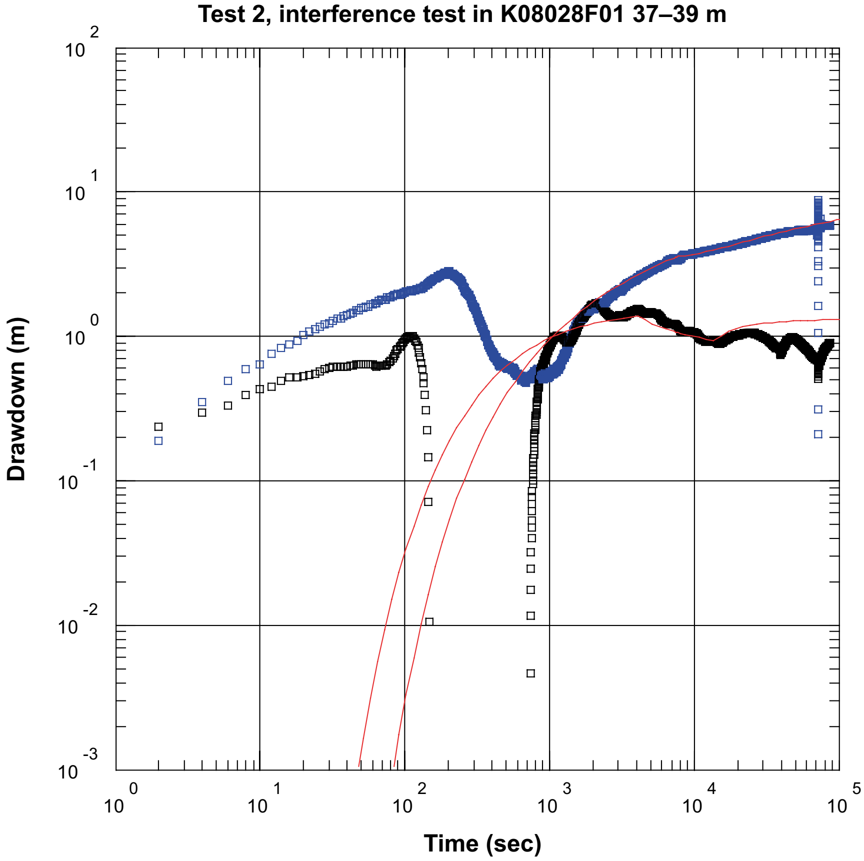


Test 2, interference test in K08028F01 37–39 m
Drawdown (m)
Time (sec)
Obs. Wells
K08028F01 30–32 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 3.183E-7 m²/sec
S = 1.583E-5
Kz/Kr = 1.
b = 2. m



Test 2, interference test in K08028F01 37–39 m
Recovery (m)
Agarwal Equivalent Time (sec)
Obs. Wells
K08028F01 30–32 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 2.778E-7 m²/sec
S = 1.561E-5
Kz/Kr = 1.
b = 2. m

Test 2, interference test in K08028F01 37–39 m



Obs. Wells

K08028F01 33–36 m

Aquifer Model

Confined

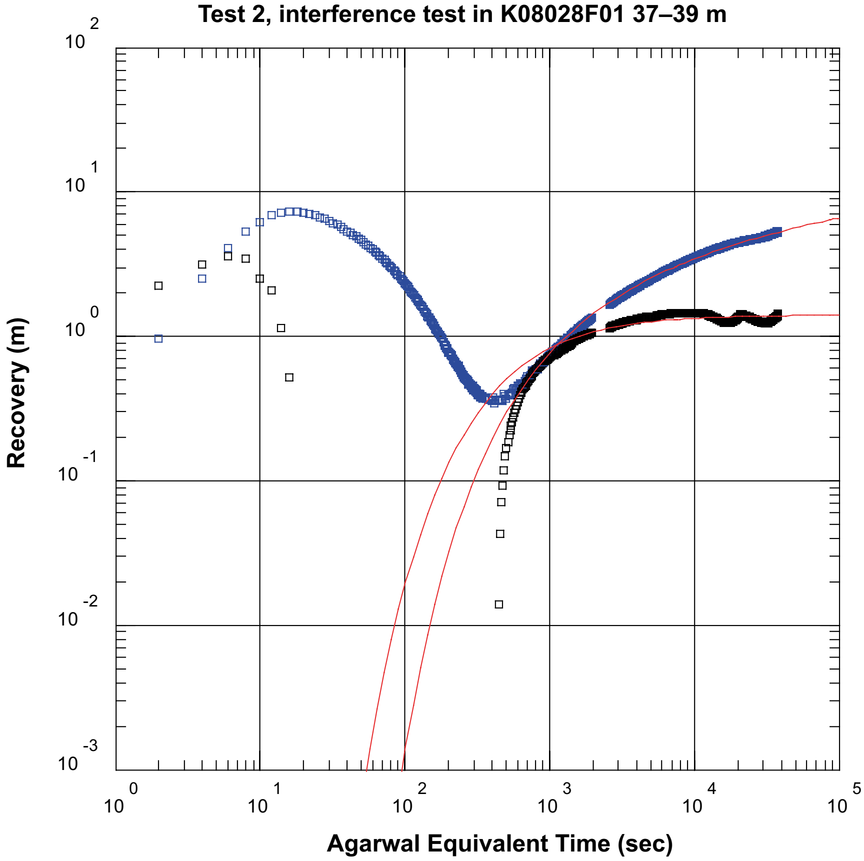
Solution

Theis

Parameters

T = 3.17E-7 m²/sec
S = 6.065E-5
Kz/Kr = 1.
b = 3. m

Test 2, interference test in K08028F01 37–39 m



Obs. Wells

K08028F01 33–36 m

Aquifer Model

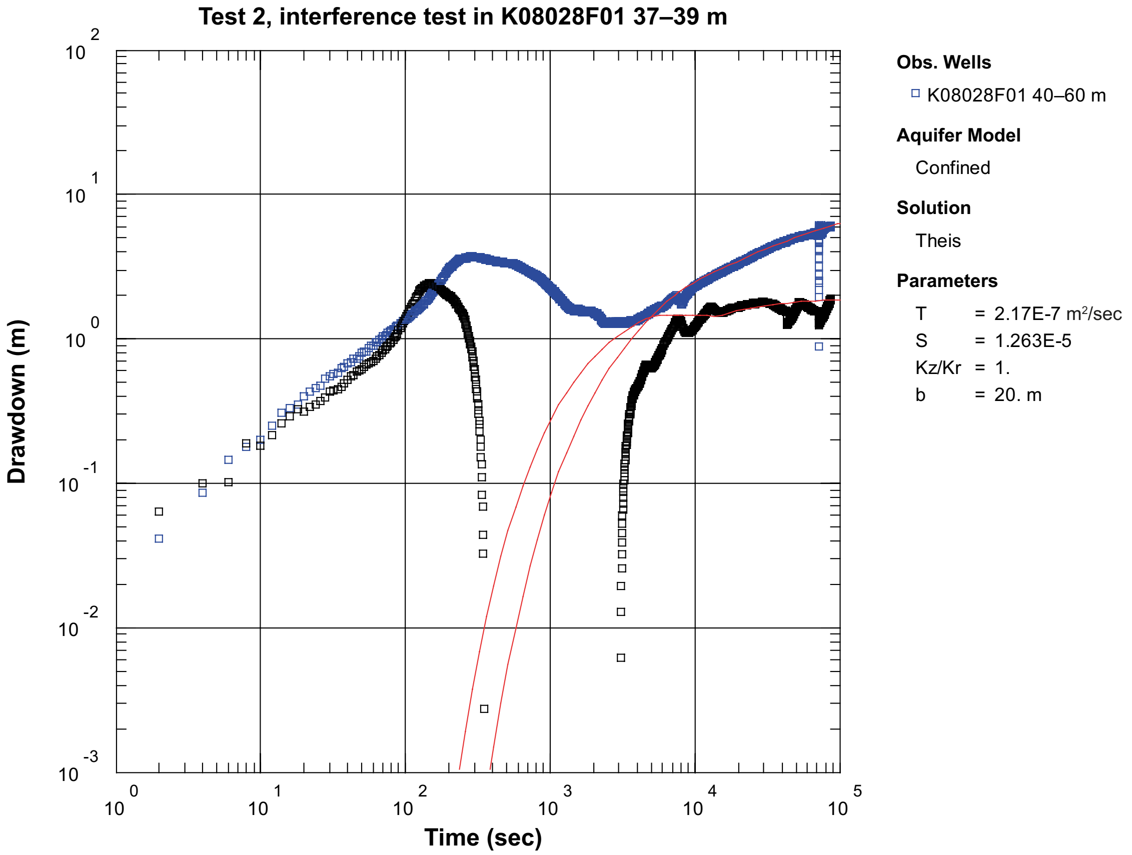
Confined

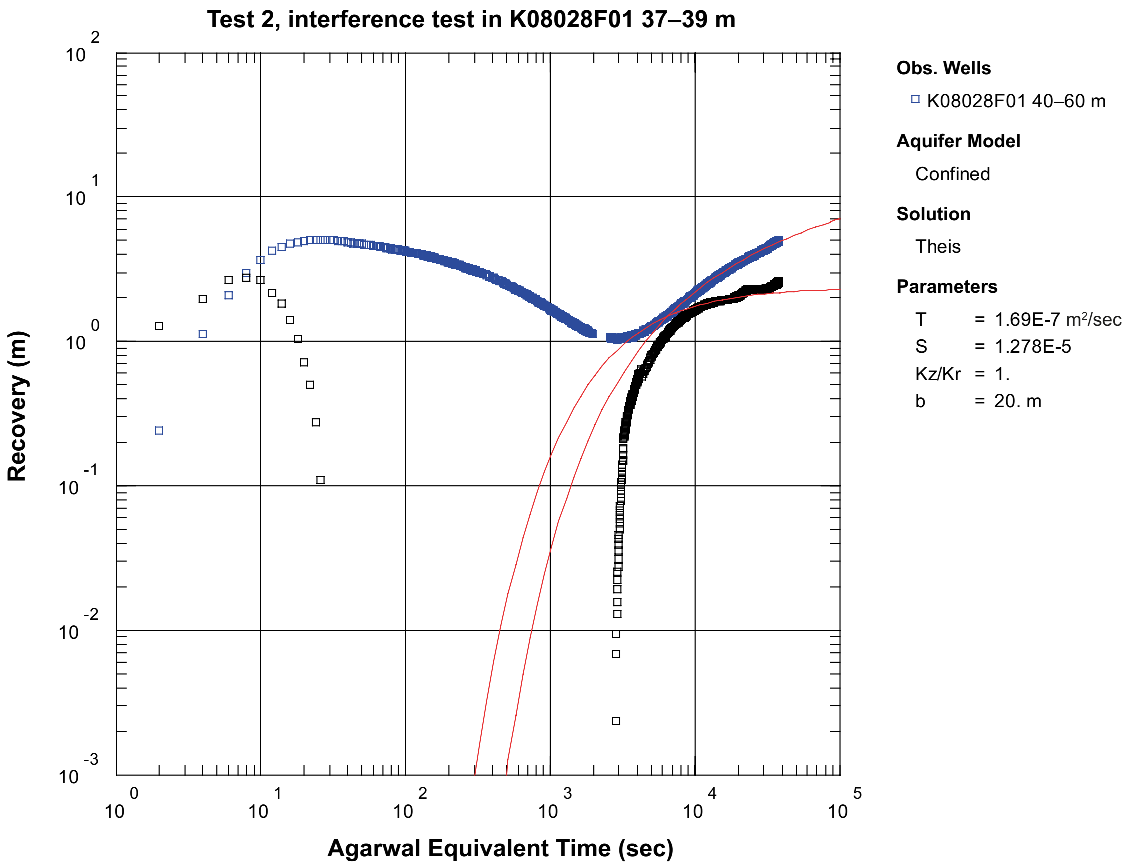
Solution

Theis

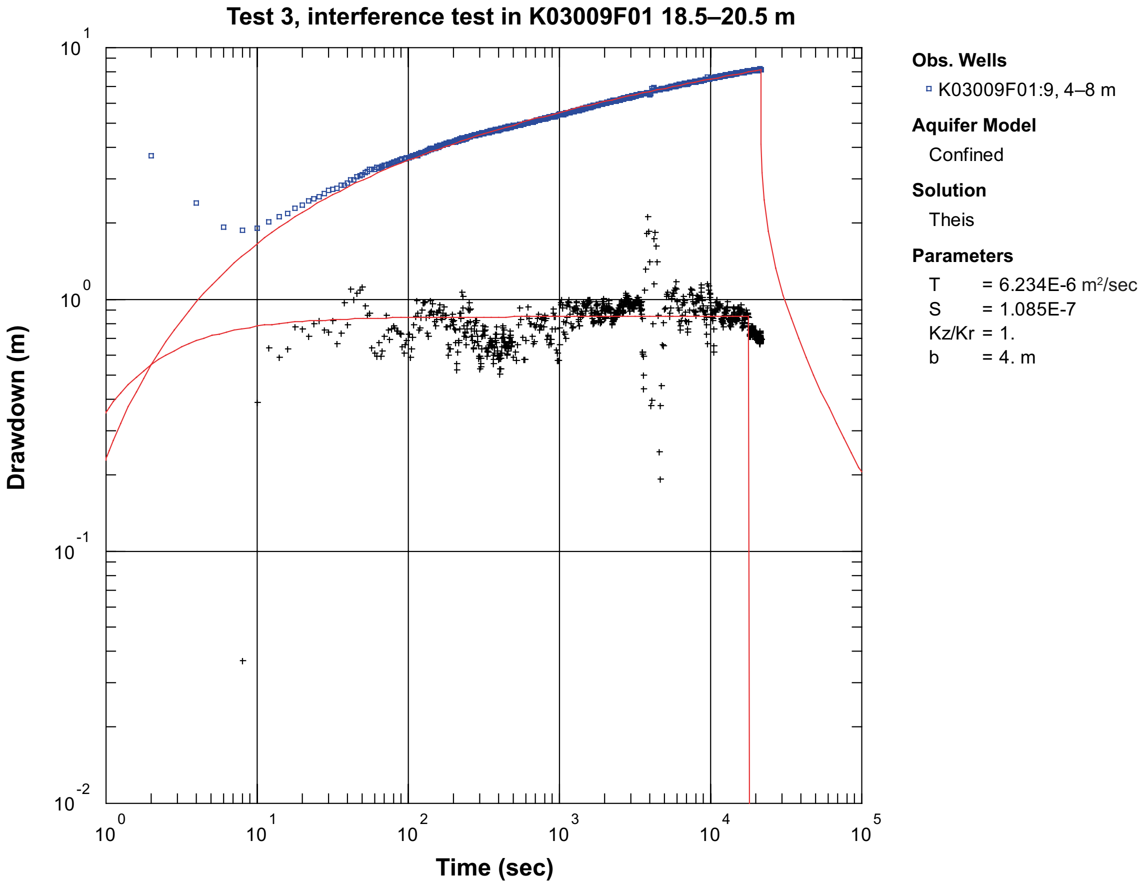
Parameters

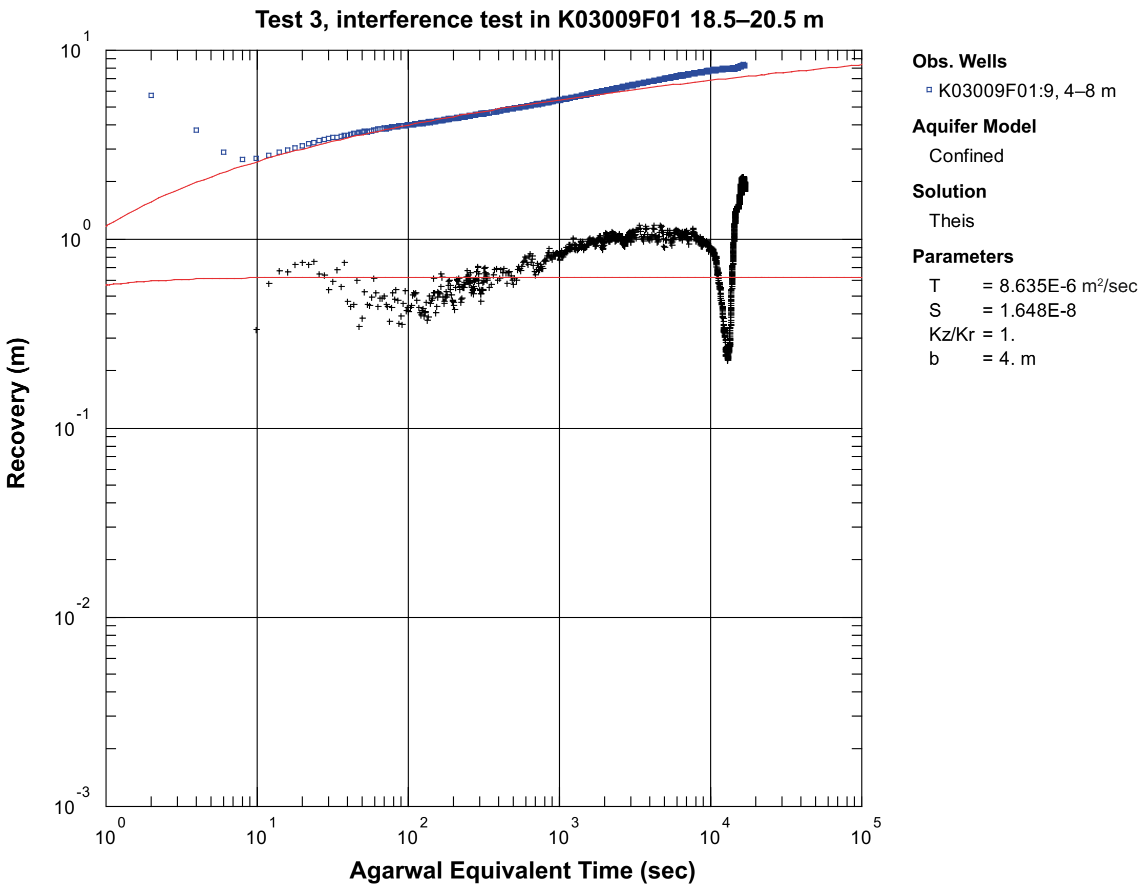
T = 2.775E-7 m²/sec
S = 6.037E-5
Kz/Kr = 1.
b = 3. m

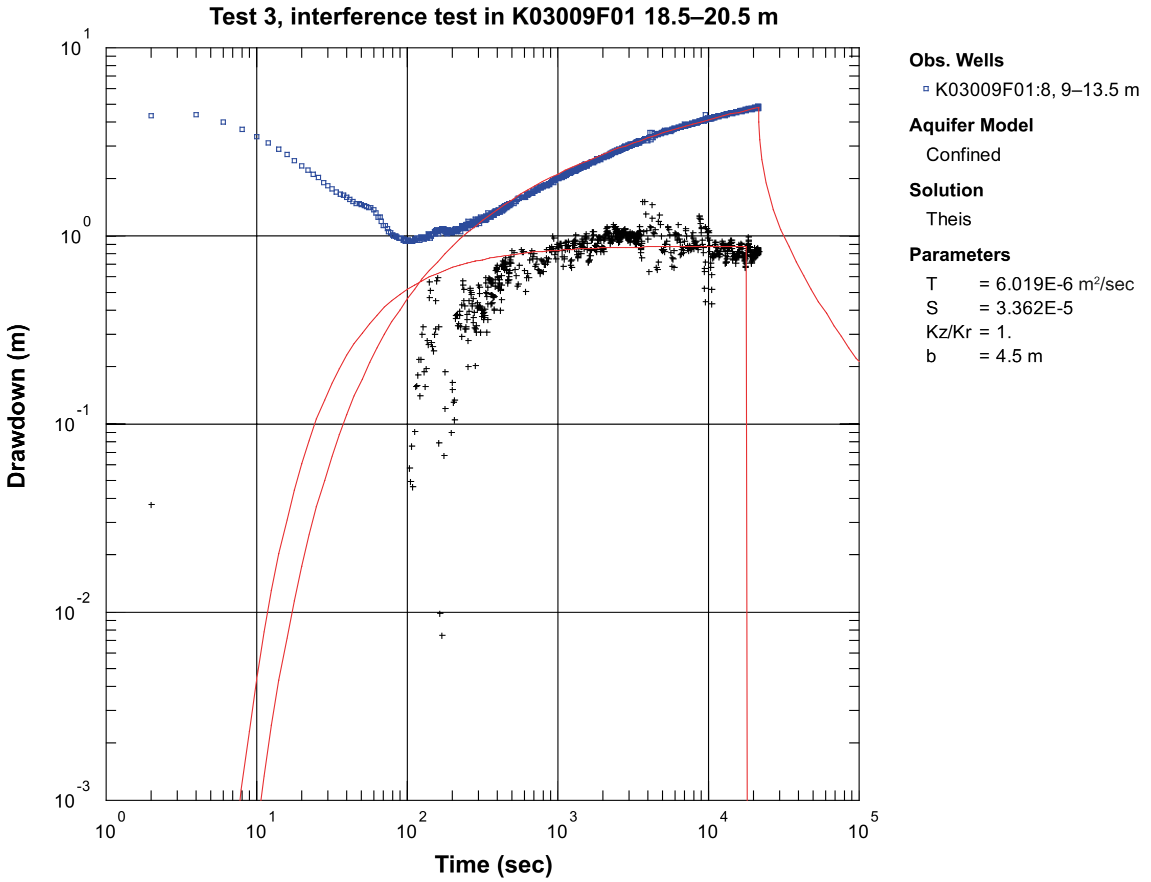

Test 2, interference test in K08028F01 37–39 m
Drawdown (m)
Time (sec)
Obs. Wells
K08028F01 40–60 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 2.17E-7 m²/sec
S = 1.263E-5
Kz/Kr = 1.
b = 20. m


Test 2, interference test in K08028F01 37–39 m
Recovery (m)
Agarwal Equivalent Time (sec)
Obs. Wells
K08028F01 40–60 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 1.69E-7 m²/sec
S = 1.278E-5
Kz/Kr = 1.
b = 20. m

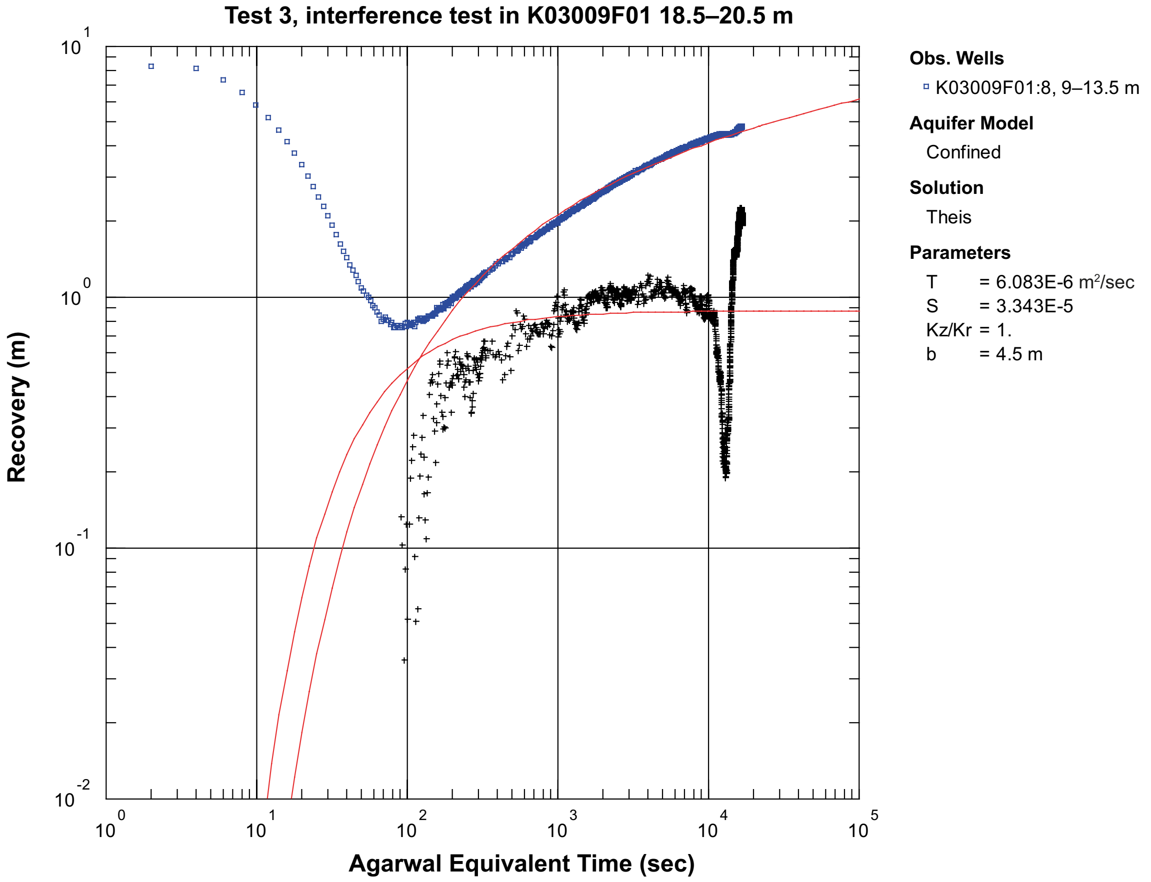
Test no 3. Interference test in K03009F01 18.5–20.5 m



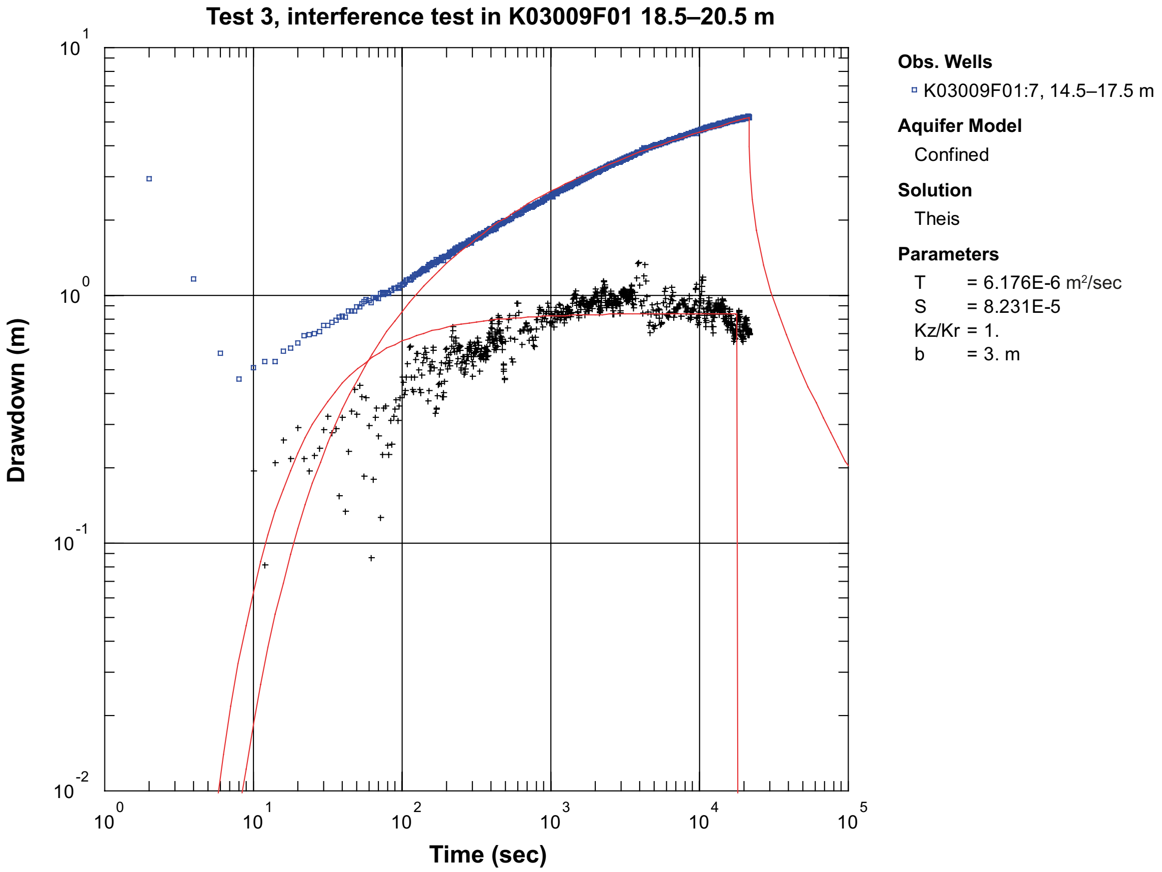


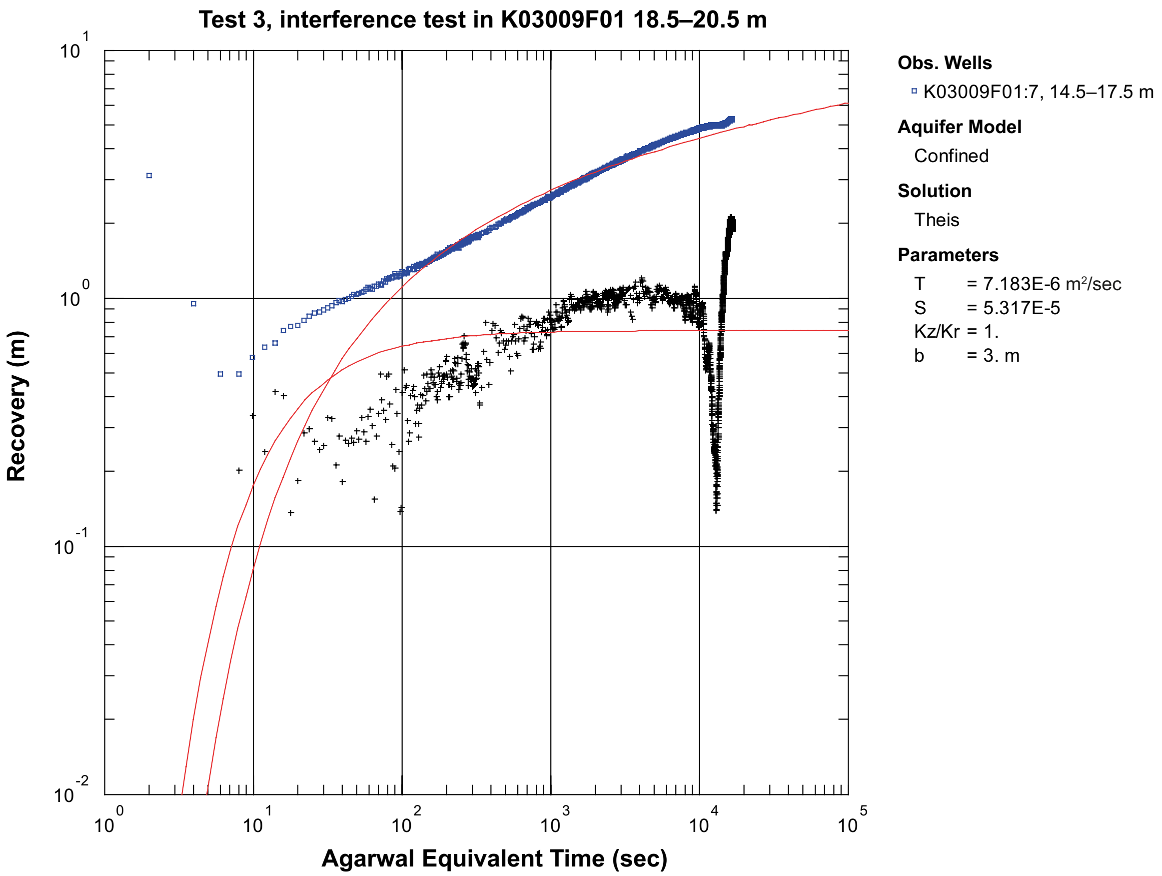


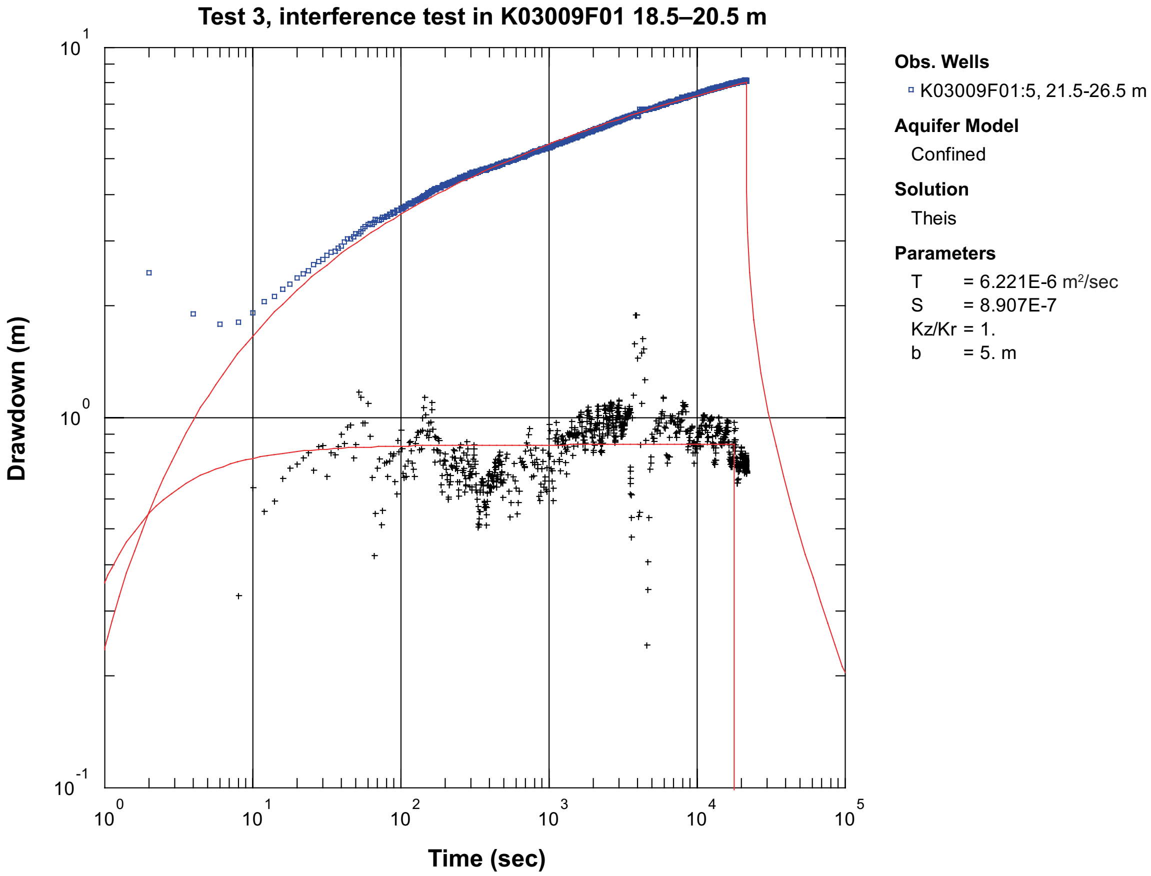
Test 3, interference test in K03009F01 18.5–20.5 m
Drawdown (m)
Time (sec)
Obs. Wells
K03009F01:8, 9–13.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.019E-6 m²/sec
S = 3.362E-5
Kz/Kr = 1.
b = 4.5 m

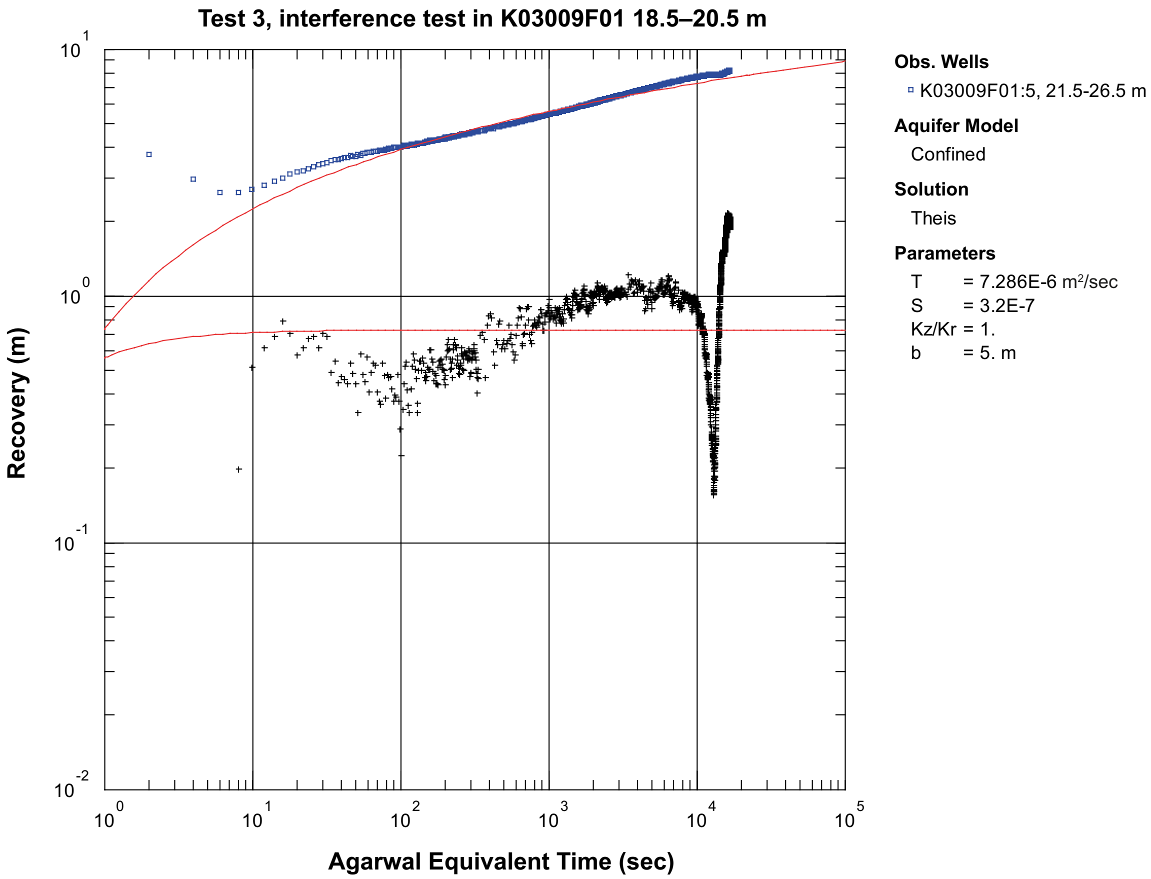


Test 3, interference test in K03009F01 18.5–20.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
Obs. Wells
K03009F01:8, 9–13.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.083E-6 m²/sec
S = 3.343E-5
Kz/Kr = 1.
b = 4.5 m

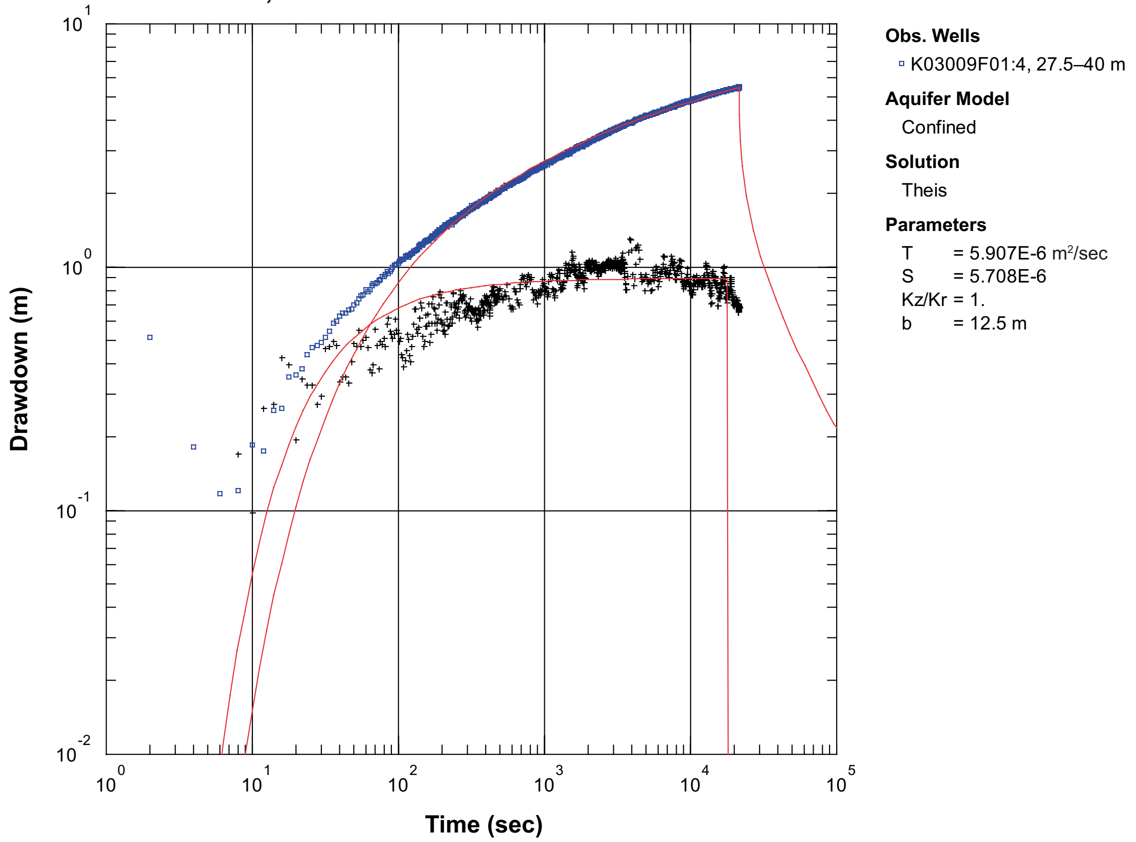

Test 3, interference test in K03009F01 18.5–20.5 m
Drawdown (m)
Time (sec)
Obs. Wells
K03009F01:7, 14.5–17.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.176E-6 m²/sec
S = 8.231E-5
Kz/Kr = 1.
b = 3. m


Test 3, interference test in K03009F01 18.5–20.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
Obs. Wells
K03009F01:7, 14.5–17.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 7.183E-6 m²/sec
S = 5.317E-5
Kz/Kr = 1.
b = 3. m

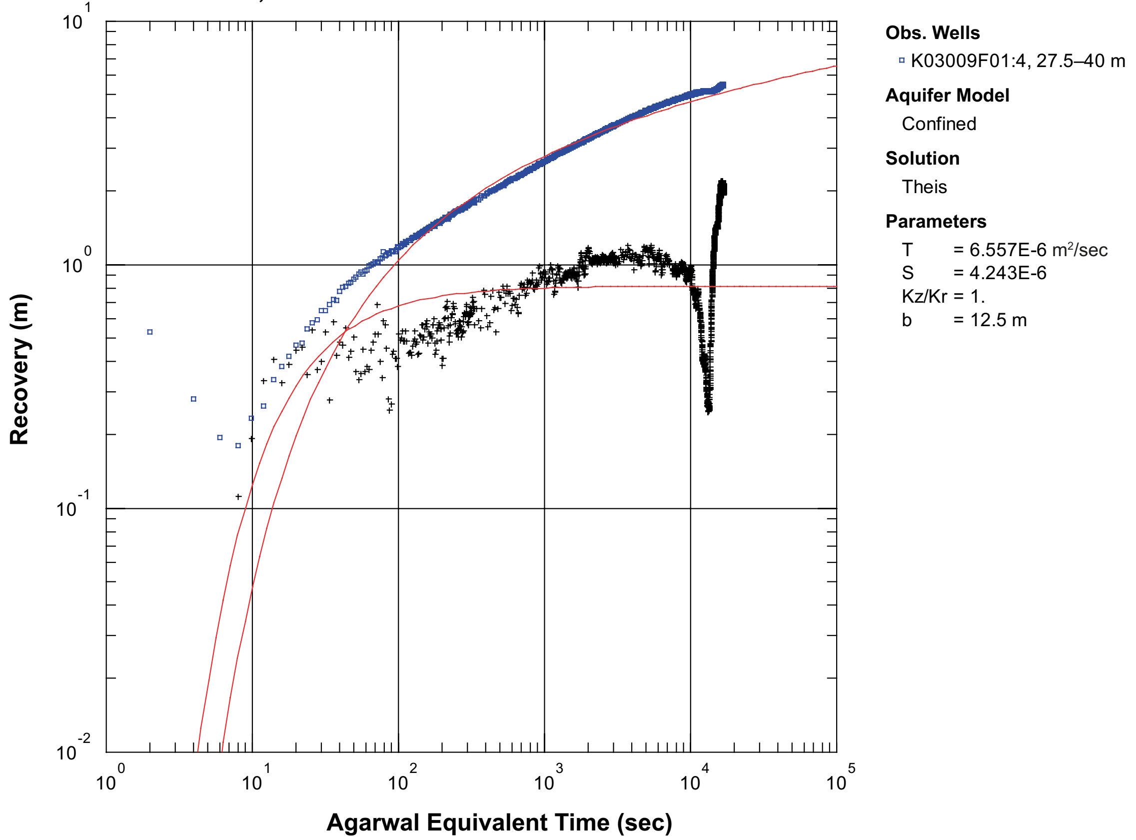

Test 3, interference test in K03009F01 18.5–20.5 m
Drawdown (m)
Time (sec)
Obs. Wells
K03009F01:5, 21.5-26.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.221E-6 m²/sec
S = 8.907E-7
Kz/Kr = 1.
b = 5. m

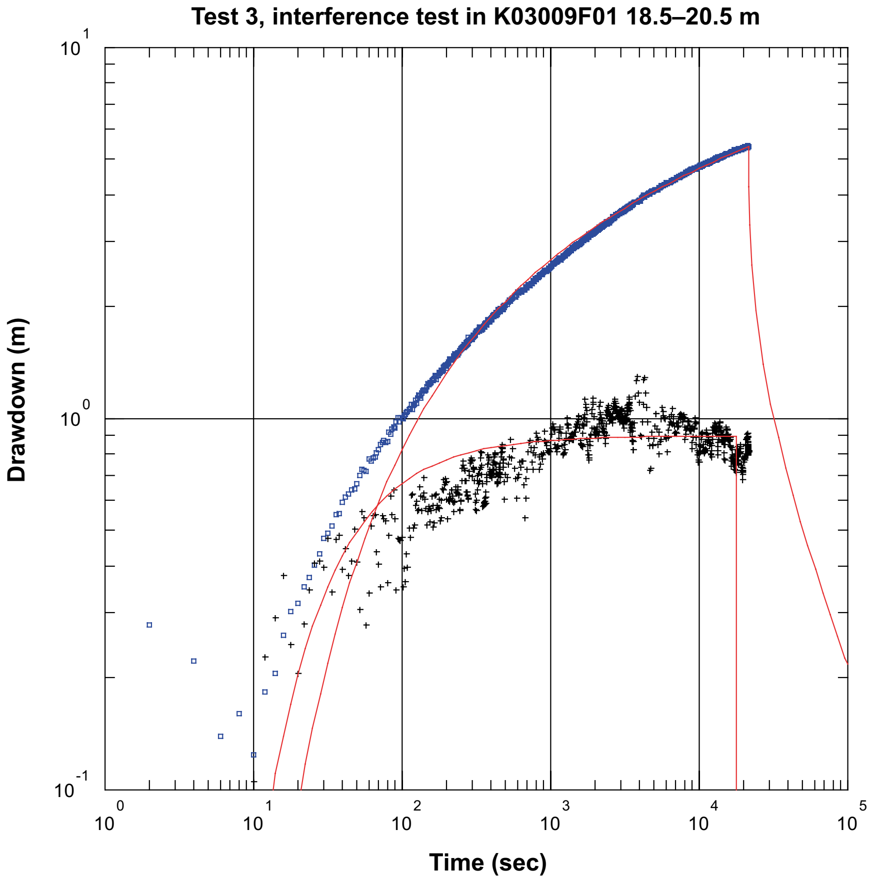

Test 3, interference test in K03009F01 18.5–20.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
Obs. Wells
K03009F01:5, 21.5-26.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 7.286E-6 m²/sec
S = 3.2E-7
Kz/Kr = 1.
b = 5. m

Test 3, interference test in K03009F01 18.5–20.5 m



Test 3, interference test in K03009F01 18.5–20.5 m





Obs. Wells

▫ K03009F01:3, 41–60 m

Aquifer Model

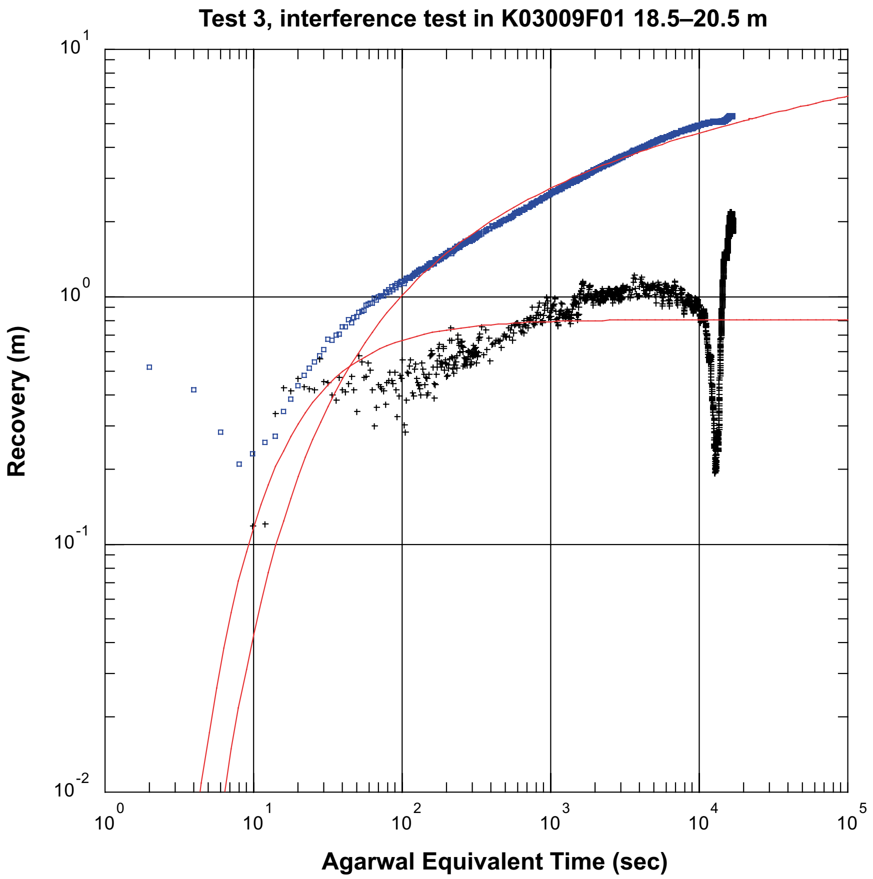
Confined

Solution

Theis

Parameters

T = 5.911E-6 m^2/sec
S = 1.297E-6
Kz/Kr = 1.
b = 19. m



Obs. Wells

▫ K03009F01:3, 41–60 m

Aquifer Model

Confined

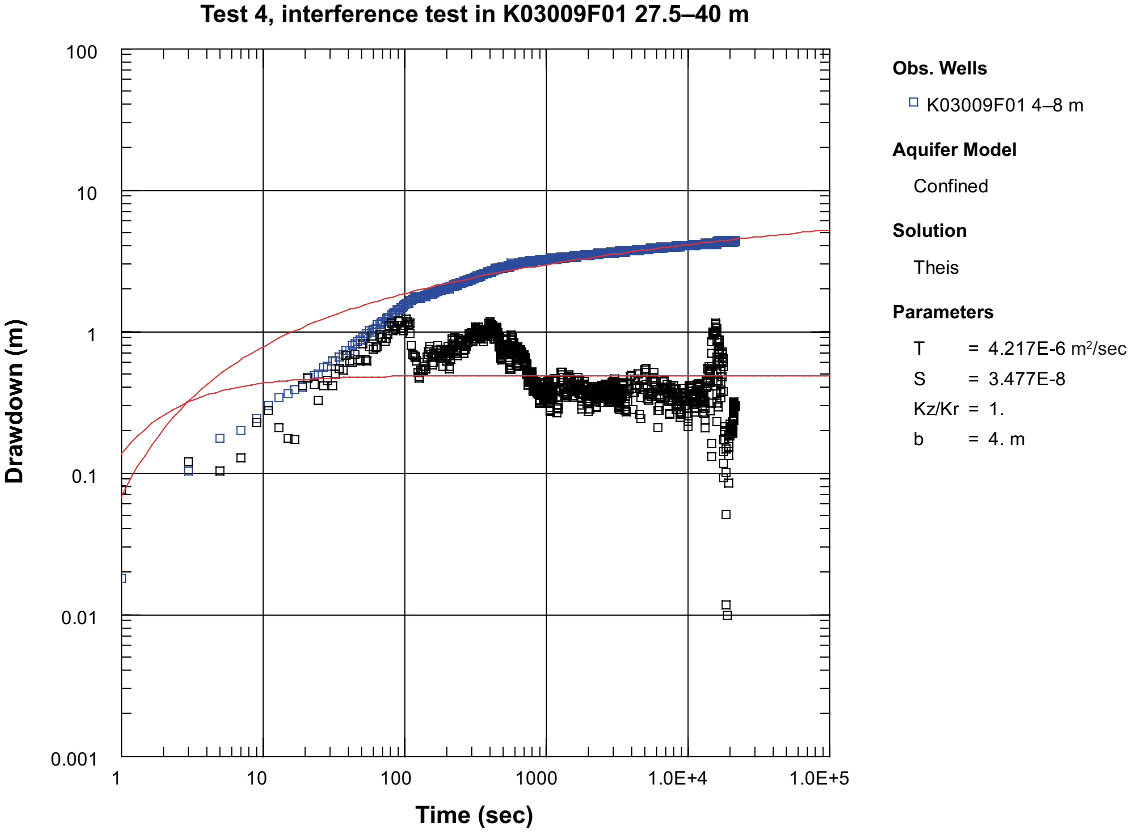
Solution

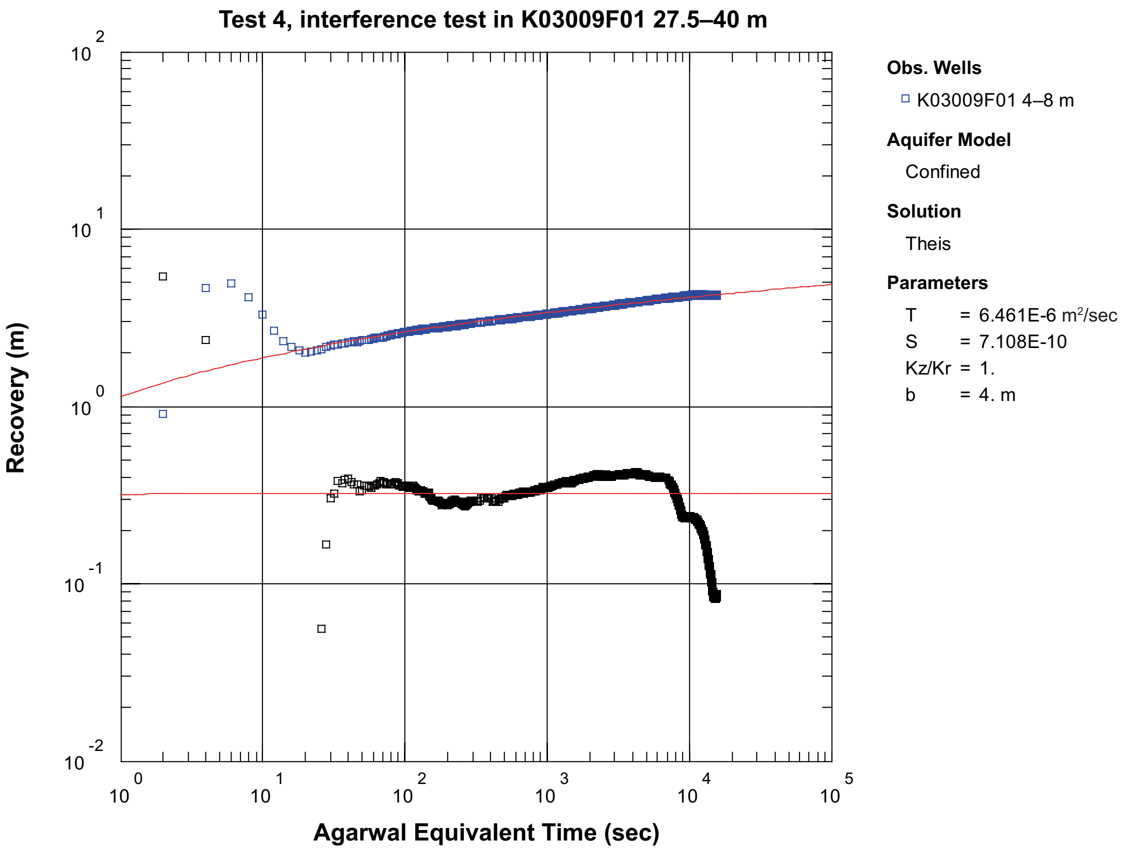
Theis

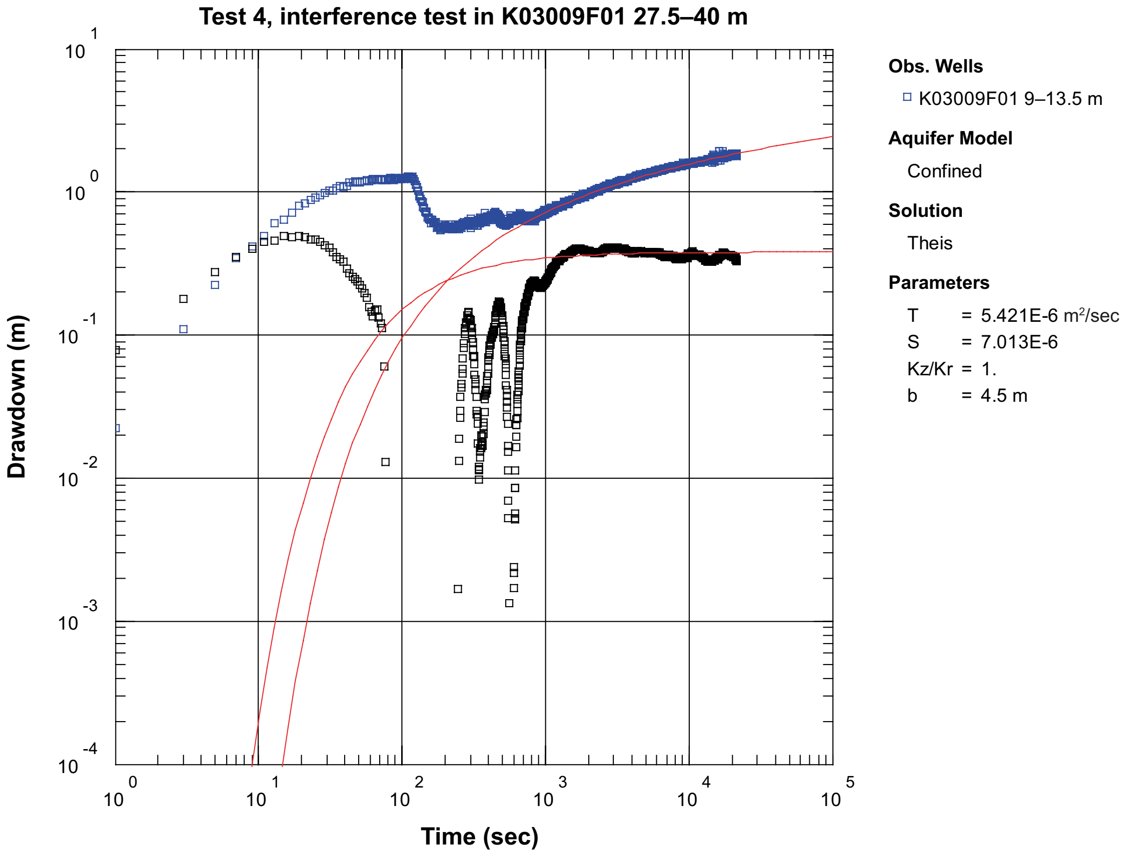
Parameters

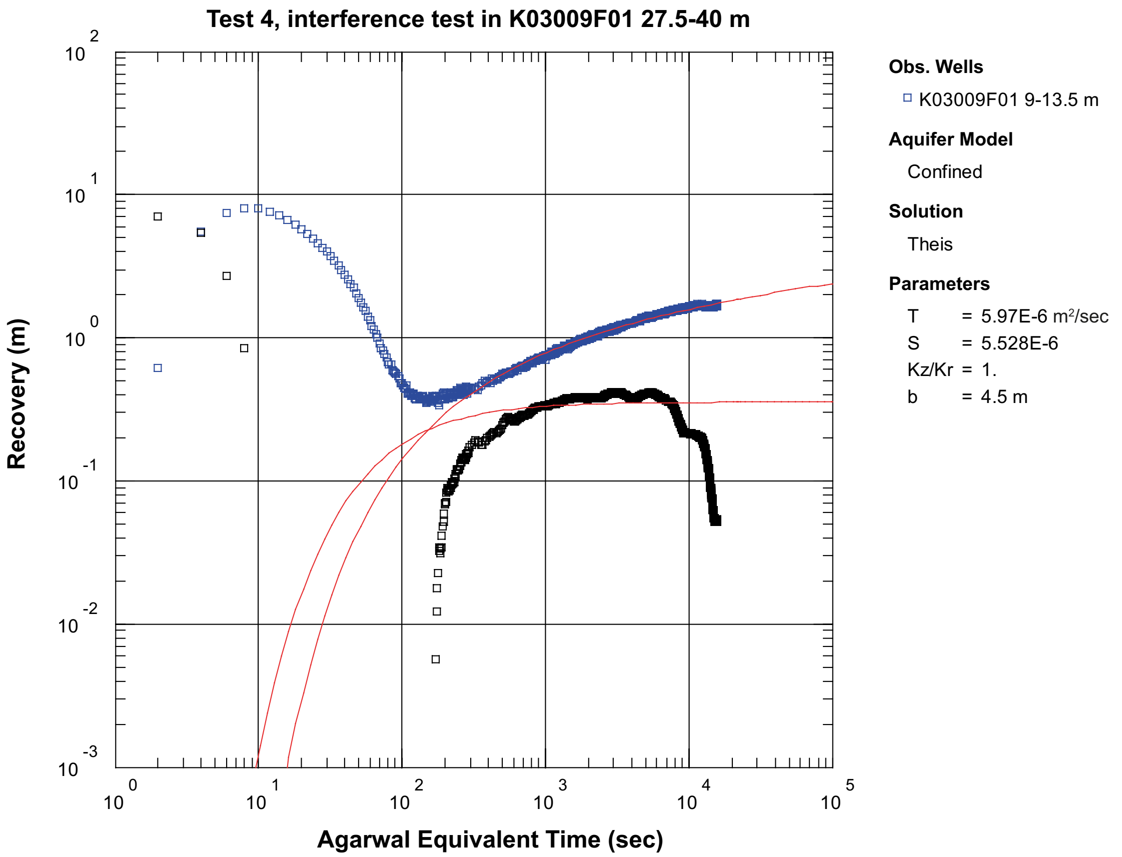
T = 6.622E-6 m^2/sec
S = 9.485E-7
Kz/Kr = 1.
b = 19. m

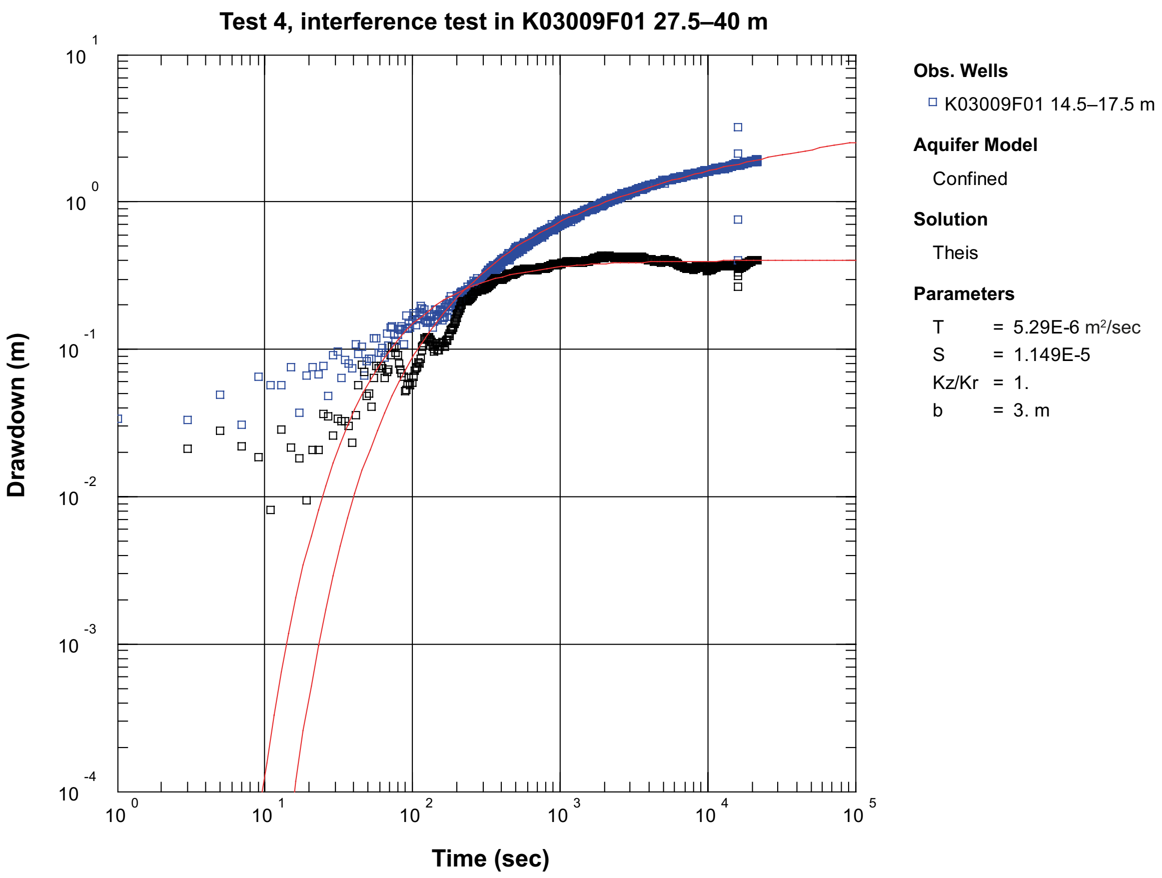
Test no 4. Interference test in K03009F01 25.5–38 m

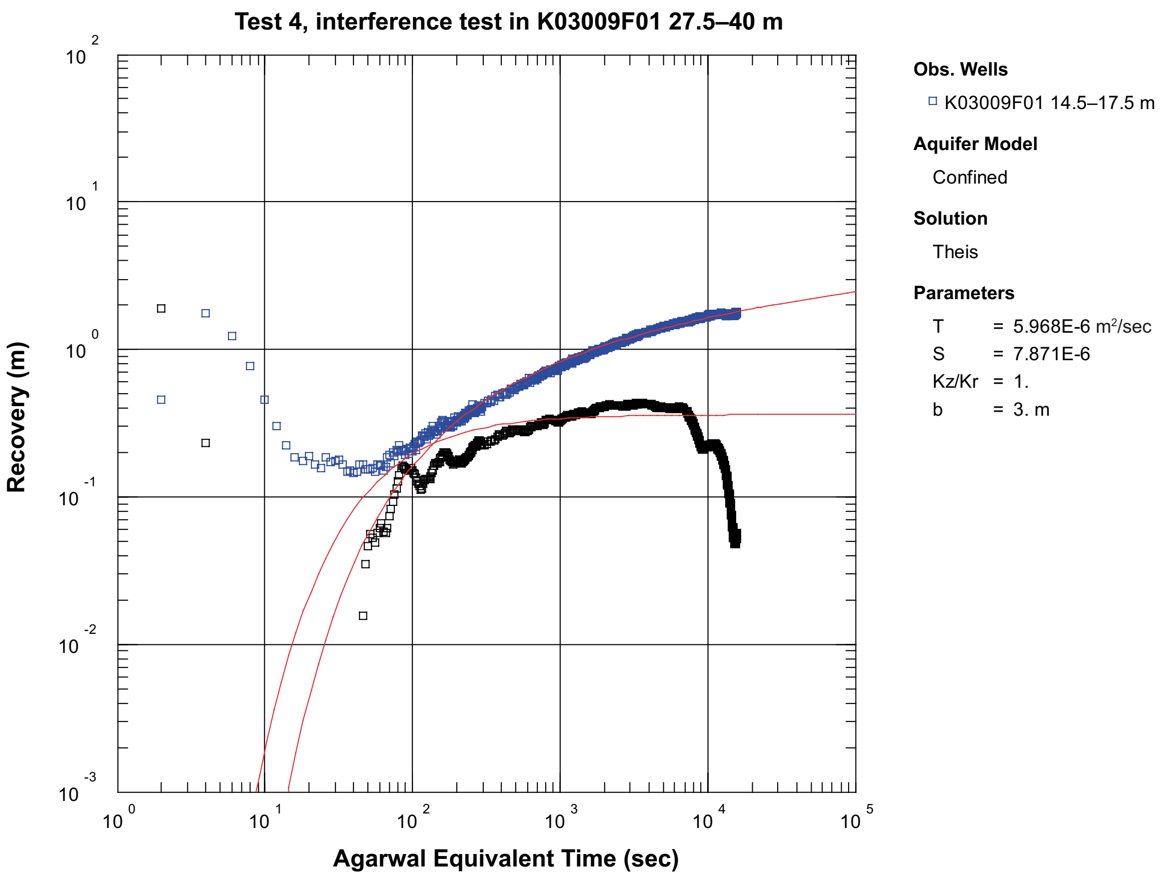


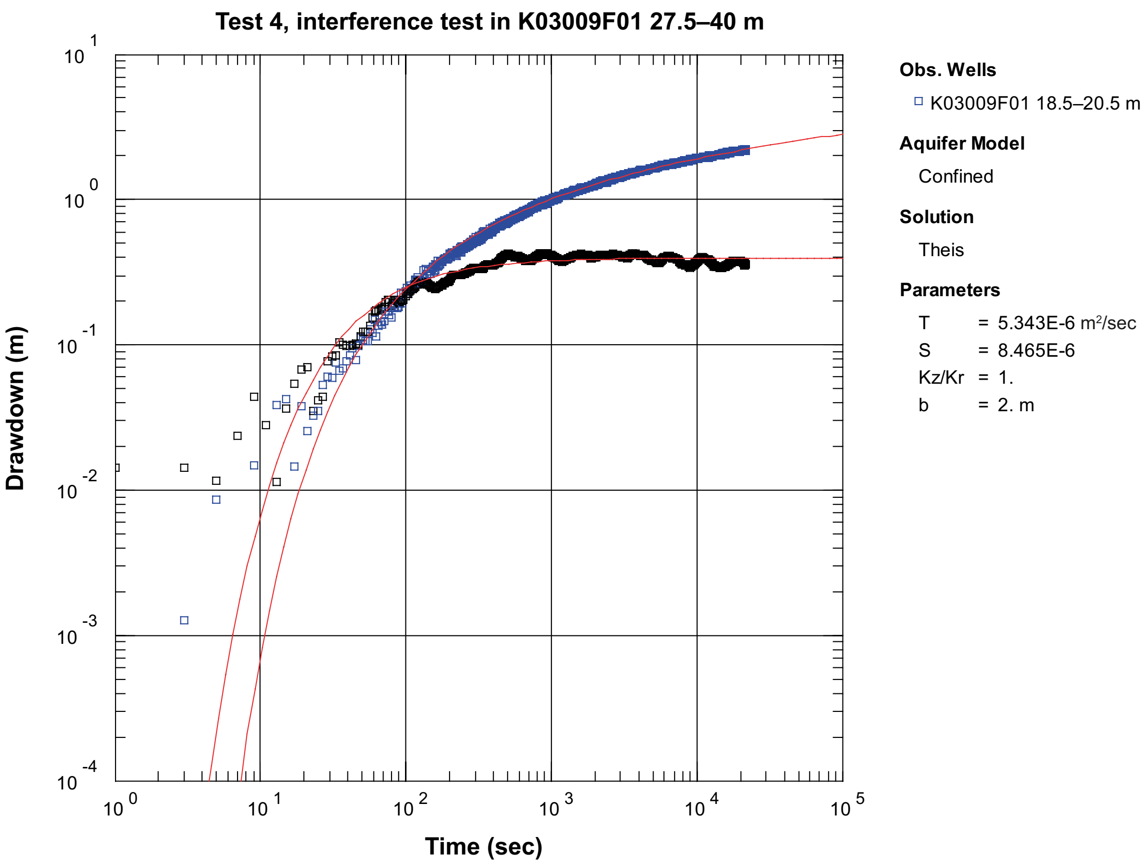



Test 4, interference test in K03009F01 27.5–40 m
Drawdown (m)
Time (sec)
Obs. Wells
K03009F01 9–13.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.421E-6 m²/sec
S = 7.013E-6
Kz/Kr = 1.
b = 4.5 m

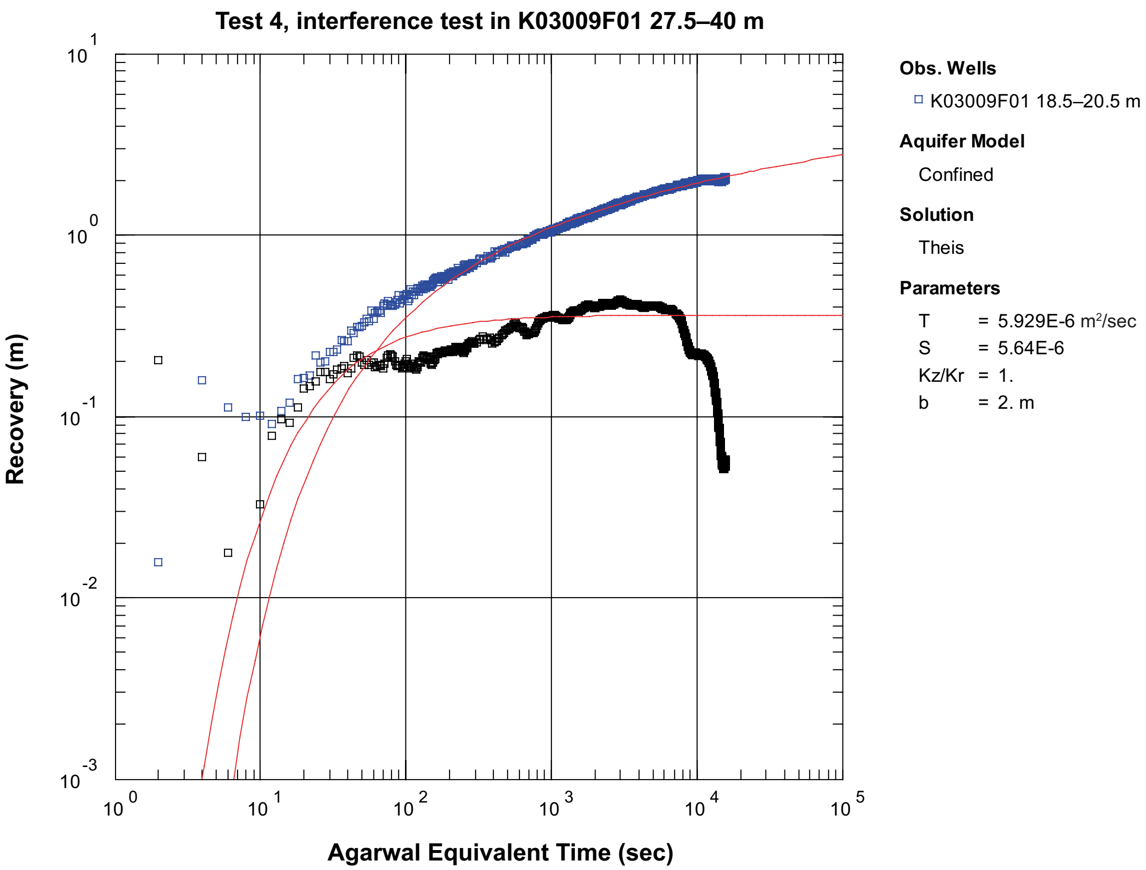

Test 4, interference test in K03009F01 27.5-40 m
Recovery (m)
Agarwal Equivalent Time (sec)
Obs. Wells
K03009F01 9-13.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.97E-6 m²/sec
S = 5.528E-6
Kz/Kr = 1.
b = 4.5 m


Test 4, interference test in K03009F01 27.5–40 m
Drawdown (m)
Time (sec)
Obs. Wells
K03009F01 14.5–17.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.29E-6 m²/sec
S = 1.149E-5
Kz/Kr = 1.
b = 3. m

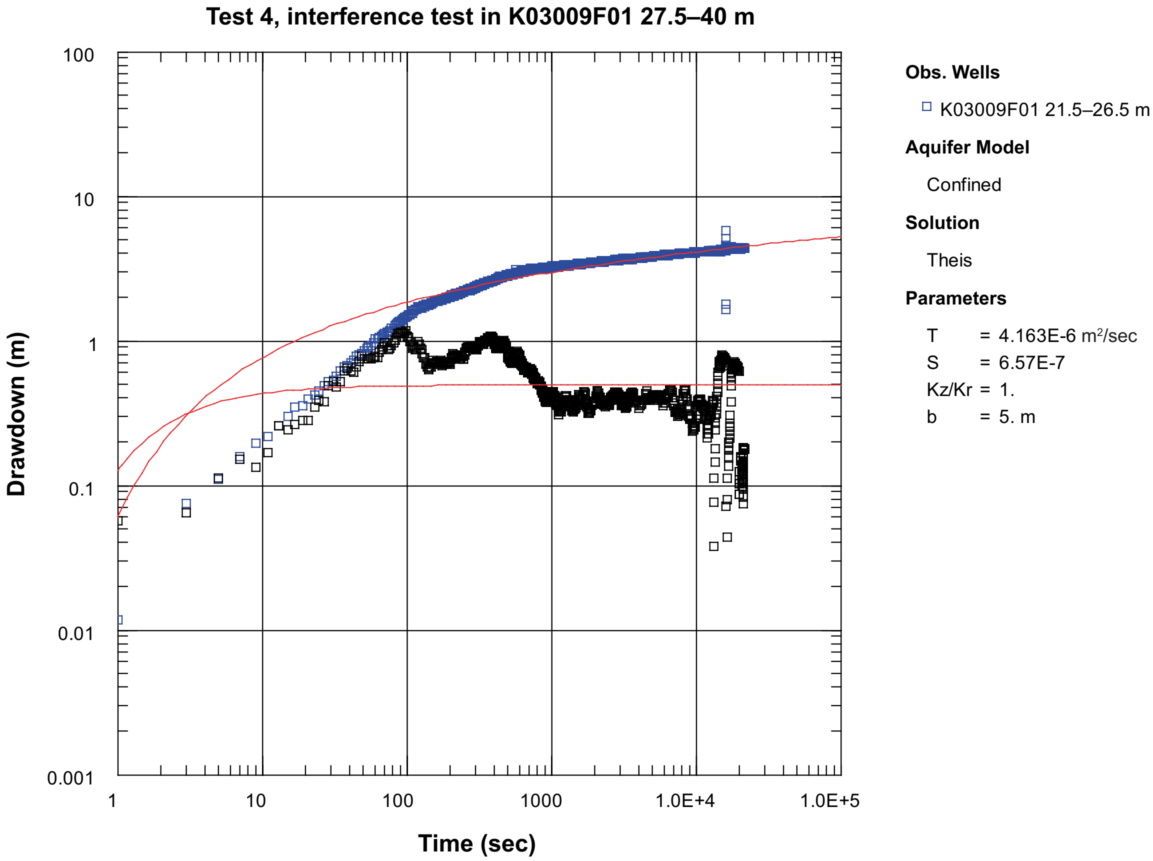

Test 4, interference test in K03009F01 27.5–40 m
Recovery (m)
Agarwal Equivalent Time (sec)
Obs. Wells
K03009F01 14.5–17.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.968E-6 m²/sec
S = 7.871E-6
Kz/Kr = 1.
b = 3. m

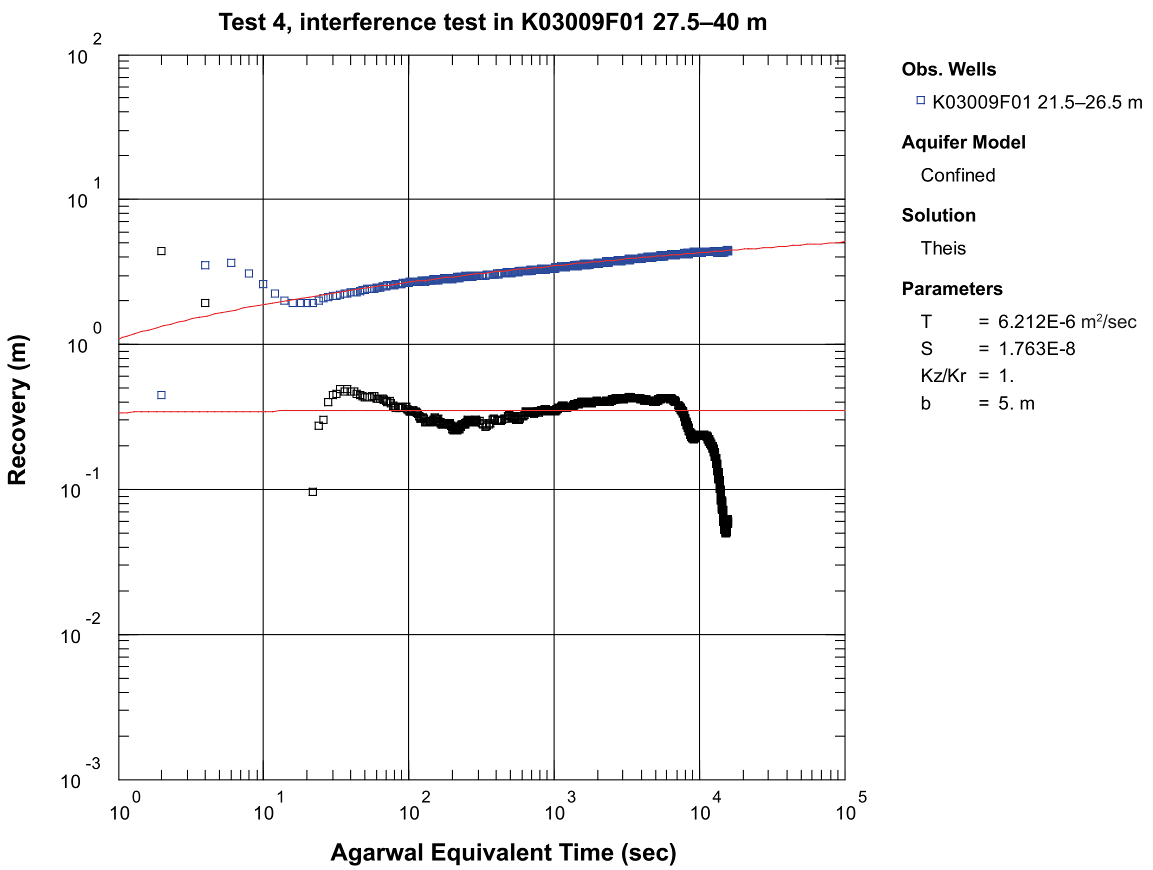


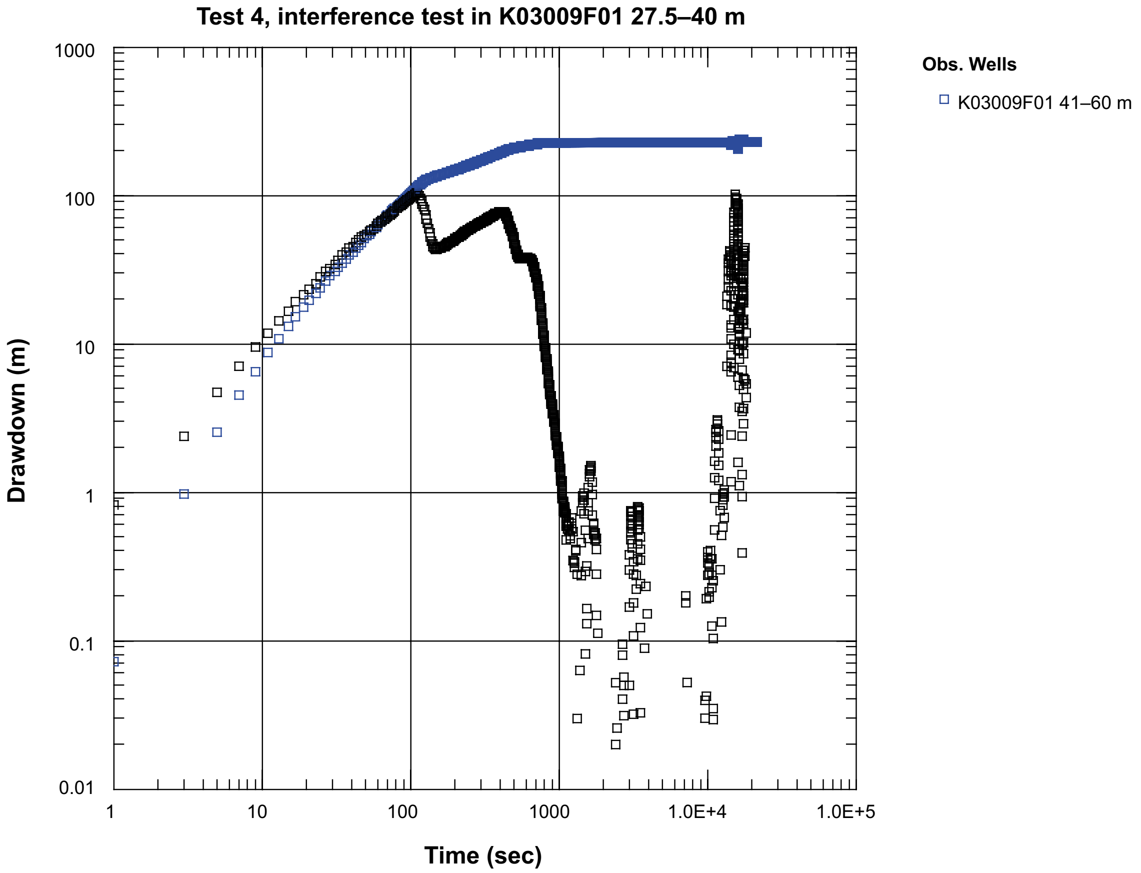
Test 4, interference test in K03009F01 27.5–40 m
Drawdown (m)
Time (sec)
Obs. Wells
K03009F01 18.5–20.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.343E-6 m²/sec
S = 8.465E-6
Kz/Kr = 1.
b = 2. m



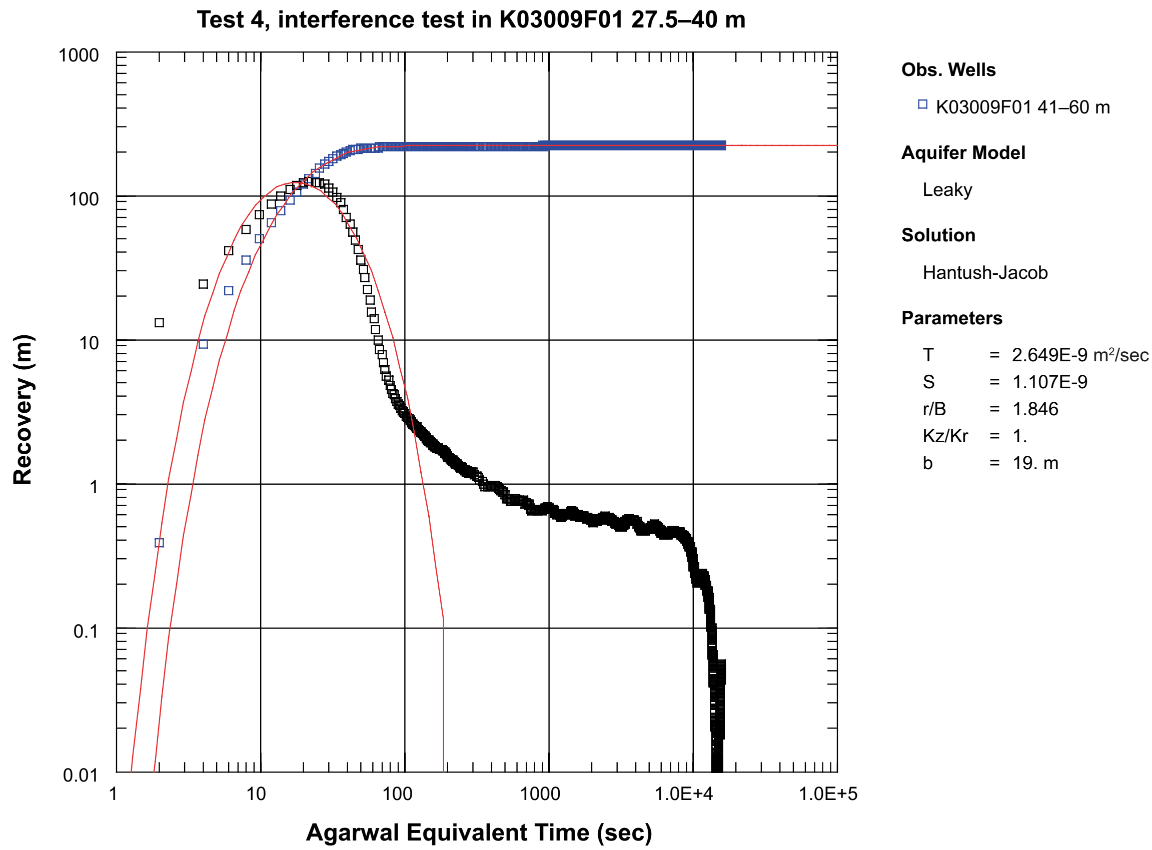
Test 4, interference test in K03009F01 27.5–40 m
Recovery (m)
Agarwal Equivalent Time (sec)
Obs. Wells
K03009F01 18.5–20.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.929E-6 m²/sec
S = 5.64E-6
Kz/Kr = 1.
b = 2. m


Test 4, interference test in K03009F01 27.5–40 m
100
10
1
0.1
0.01
0.001
Drawdown (m)
1
10
100
1000
1.0E+4
1.0E+5
Time (sec)
Obs. Wells
K03009F01 21.5–26.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 4.163E-6 m²/sec
S = 6.57E-7
Kz/Kr = 1.
b = 5. m

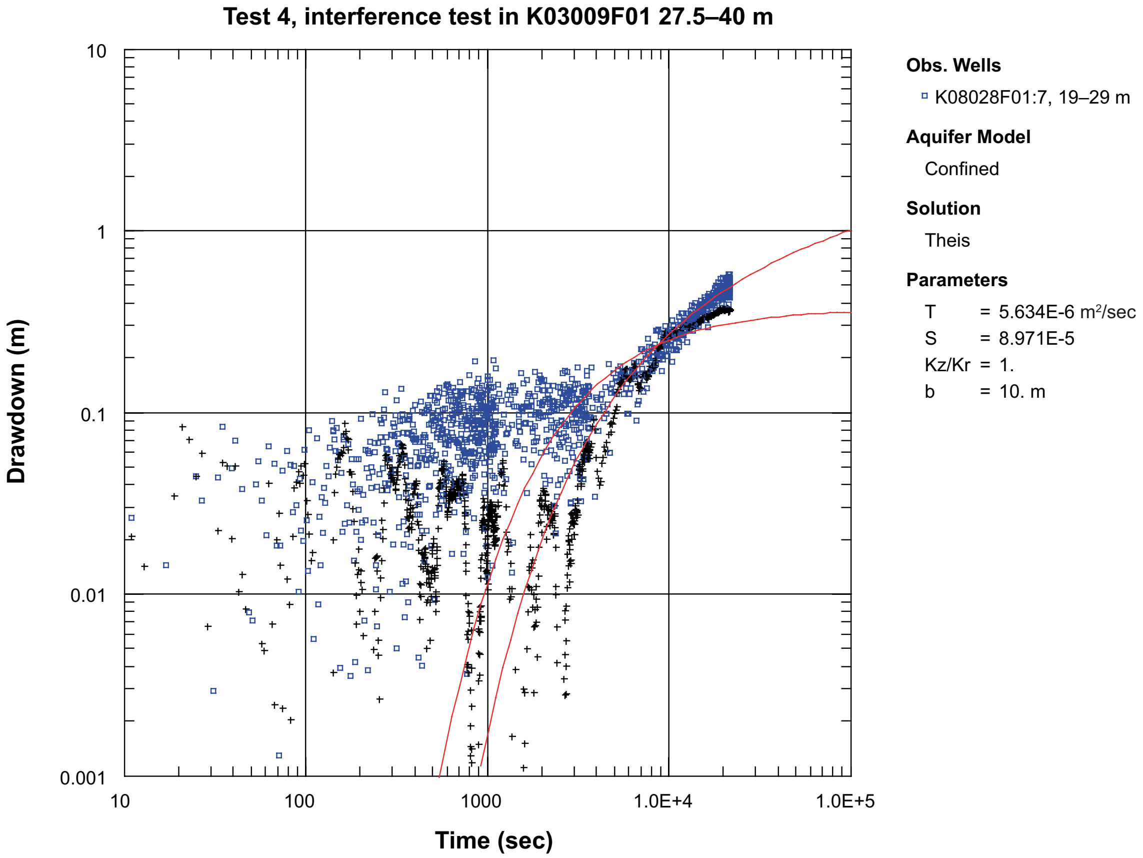

Test 4, interference test in K03009F01 27.5–40 m
10^2
10^1
10^0
10^-1
10^-2
10^-3
Recovery (m)
10^0
10^1
10^2
10^3
10^4
10^5
Agarwal Equivalent Time (sec)
Obs. Wells
K03009F01 21.5–26.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.212E-6 m²/sec
S = 1.763E-8
Kz/Kr = 1.
b = 5. m

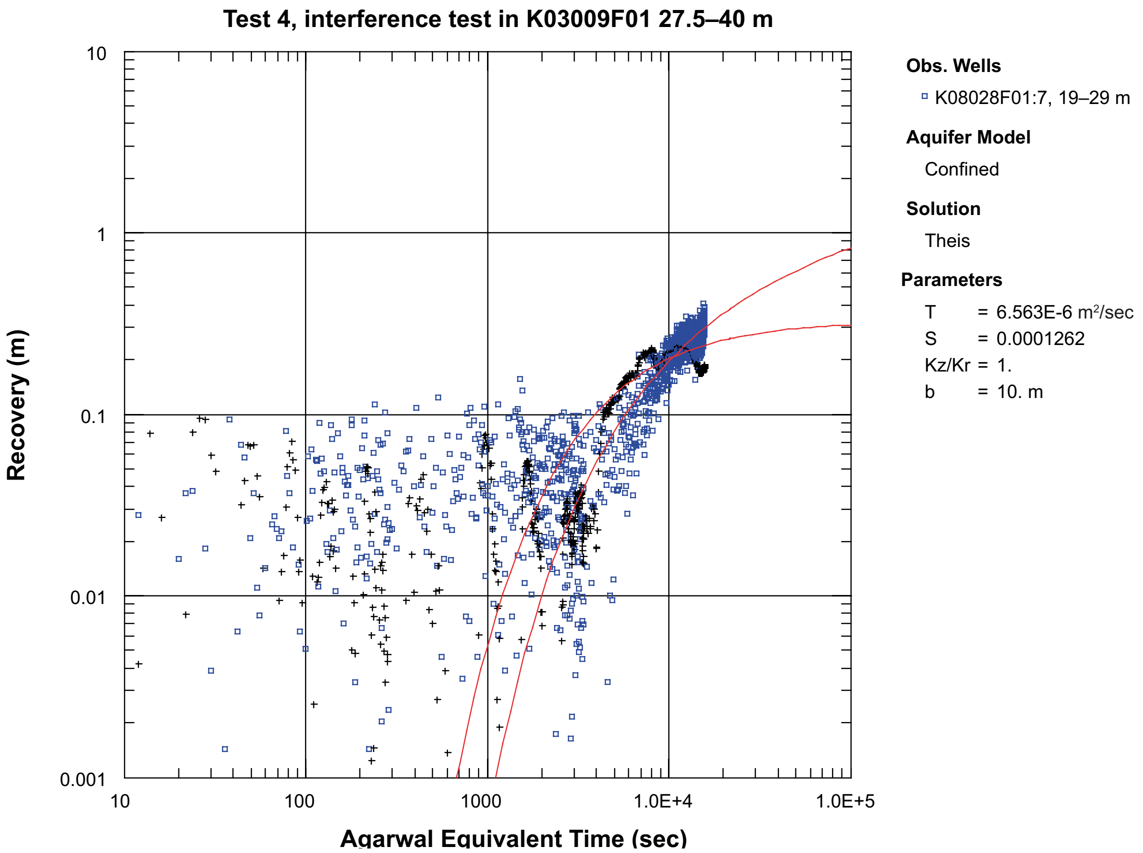


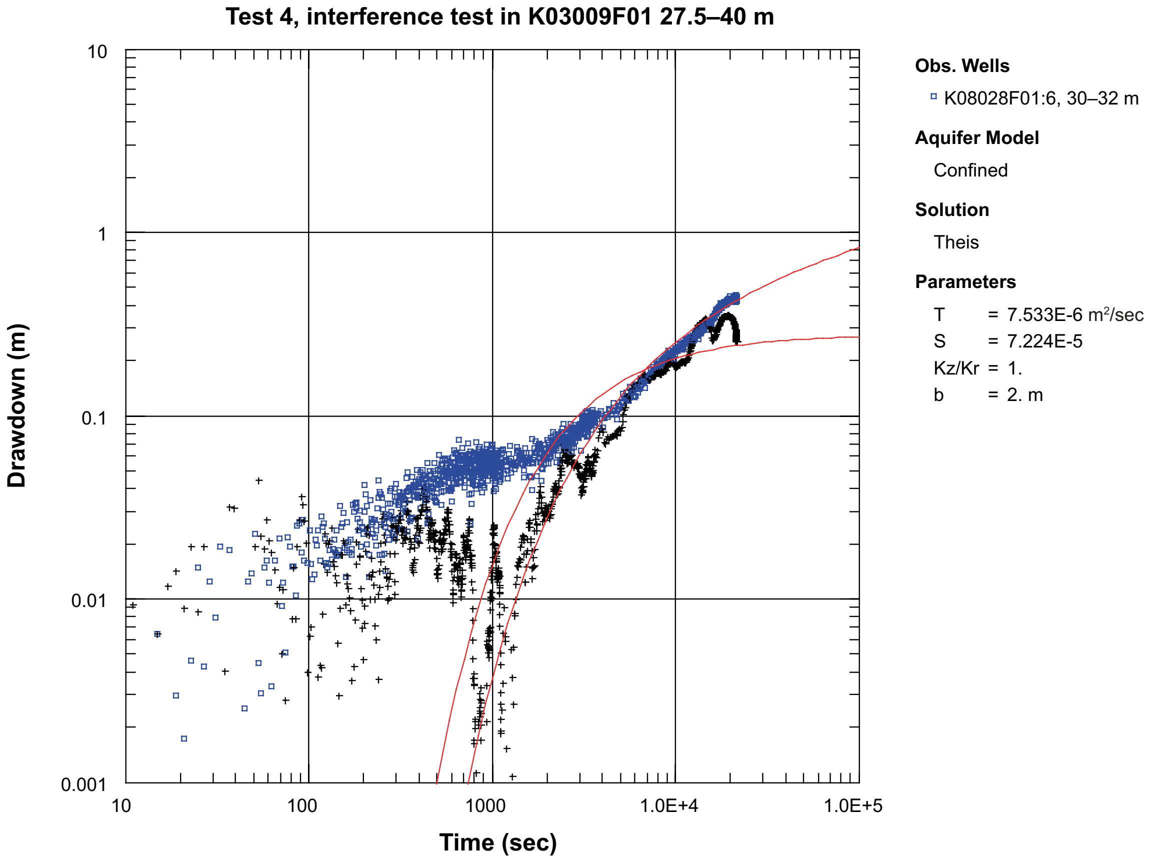
Test 4, interference test in K03009F01 27.5–40 m
Drawdown (m)
Time (sec)
1000
100
10
1
0.1
0.01
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01 41–60 m

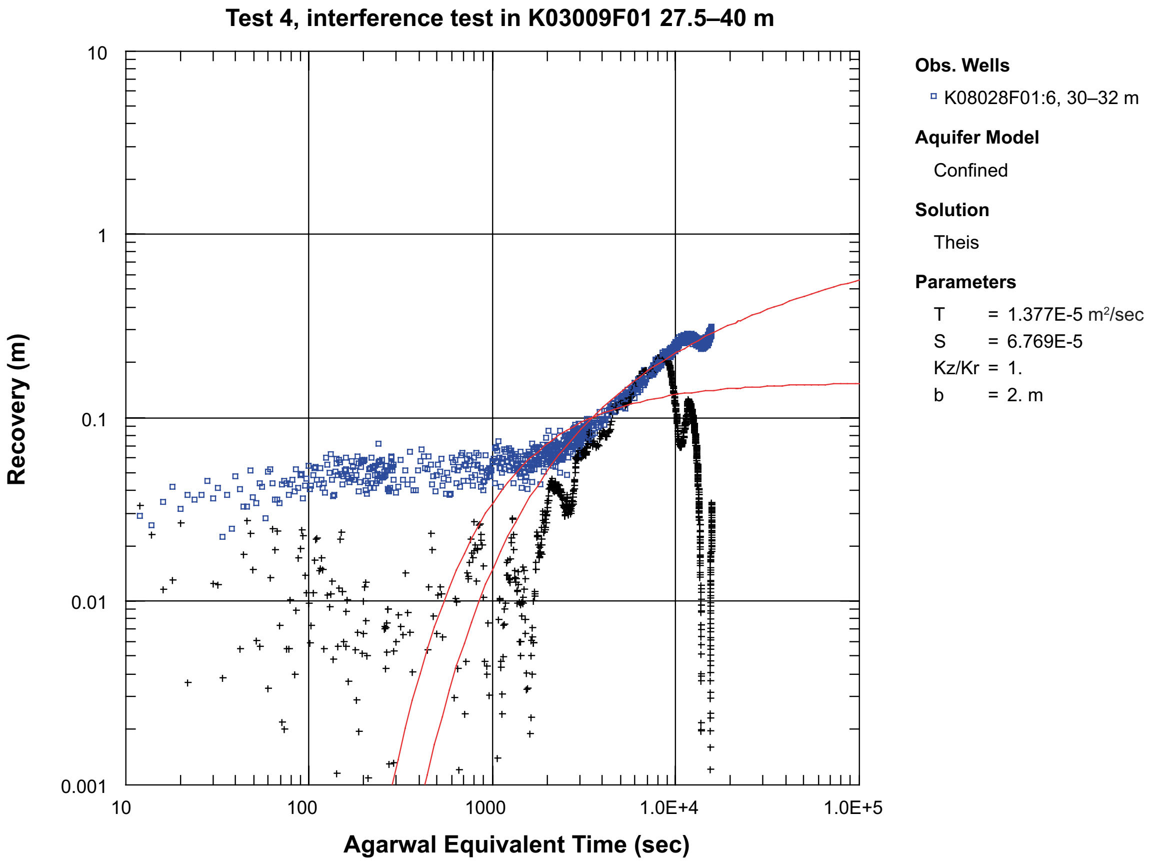


Test 4, interference test in K03009F01 27.5–40 m
Recovery (m)
Agarwal Equivalent Time (sec)
1000
100
10
1
0.1
0.01
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01 41–60 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 2.649E-9 m²/sec
S = 1.107E-9
r/B = 1.846
Kz/Kr = 1.
b = 19. m

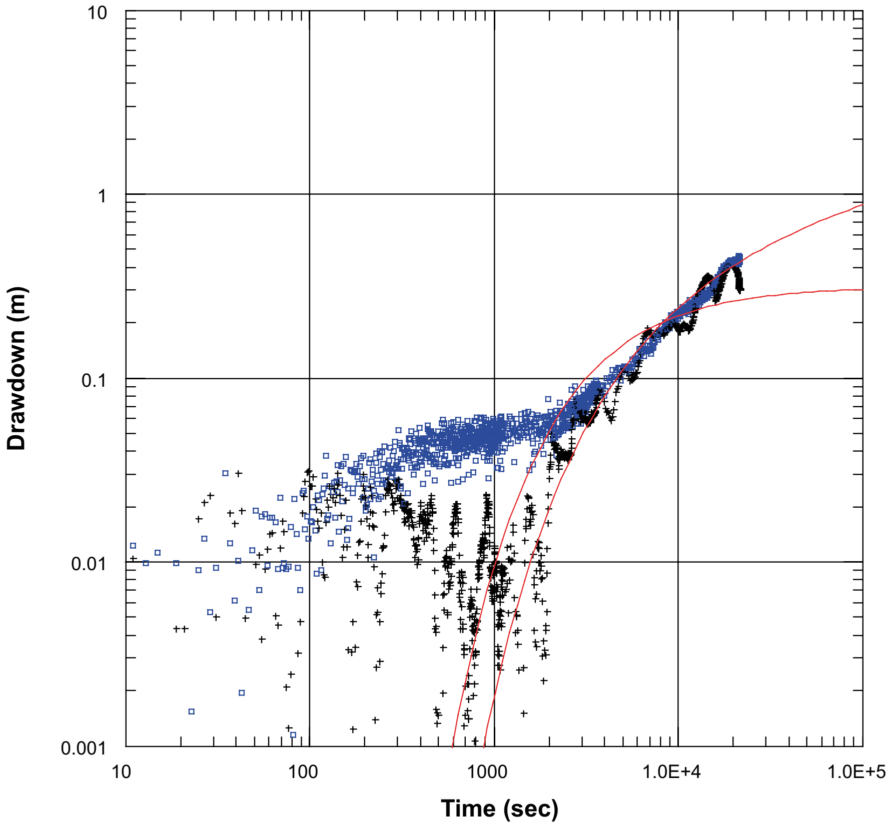

Test 4, interference test in K03009F01 27.5–40 m
Drawdown (m)
Time (sec)
10
1
0.1
0.01
0.001
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:7, 19–29 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.634E-6 m²/sec
S = 8.971E-5
Kz/Kr = 1.
b = 10. m


Test 4, interference test in K03009F01 27.5–40 m
Recovery (m)
Agarwal Equivalent Time (sec)
10
1
0.1
0.01
0.001
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:7, 19–29 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.563E-6 m²/sec
S = 0.0001262
Kz/Kr = 1.
b = 10. m


Test 4, interference test in K03009F01 27.5–40 m
Drawdown (m)
Time (sec)
10
1
0.1
0.01
0.001
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:6, 30–32 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 7.533E-6 m²/sec
S = 7.224E-5
Kz/Kr = 1.
b = 2. m


Test 4, interference test in K03009F01 27.5–40 m
Recovery (m)
Agarwal Equivalent Time (sec)
10
1
0.1
0.01
0.001
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:6, 30–32 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 1.377E-5 m²/sec
S = 6.769E-5
Kz/Kr = 1.
b = 2. m

Test 4, interference test in K03009F01 27.5–40 m



Obs. Wells

K08028F01:5, 33–36 m

Aquifer Model

Confined

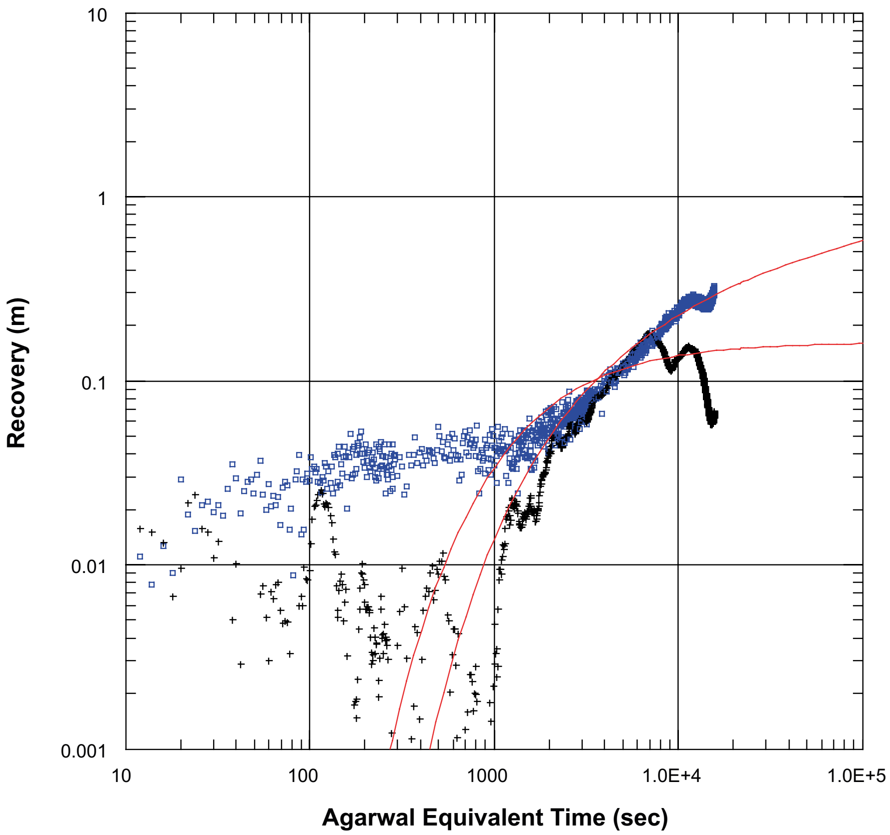
Solution

Theis

Parameters

T = 6.638E-6 m²/sec
S = 7.071E-5
Kz/Kr = 1.
b = 3. m

Test 4, interference test in K03009F01 27.5–40 m



Obs. Wells

K08028F01:5, 33–36 m

Aquifer Model

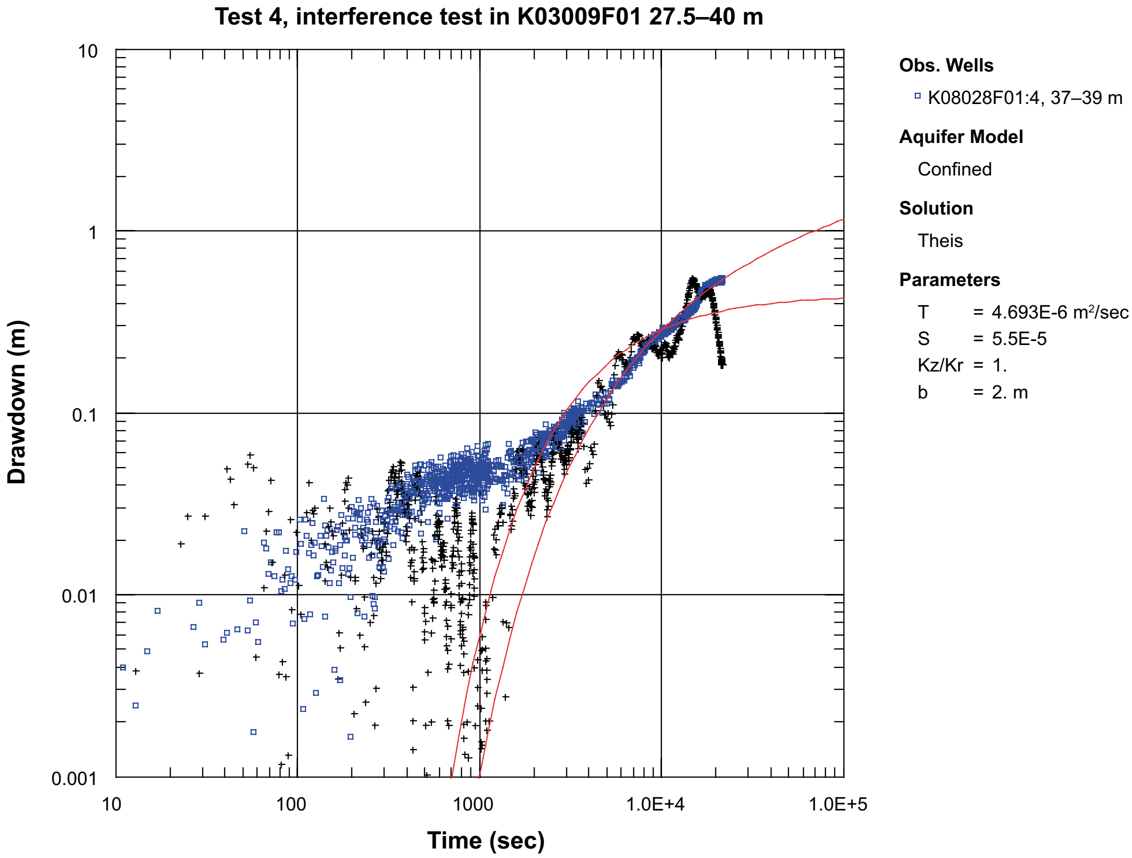
Confined

Solution

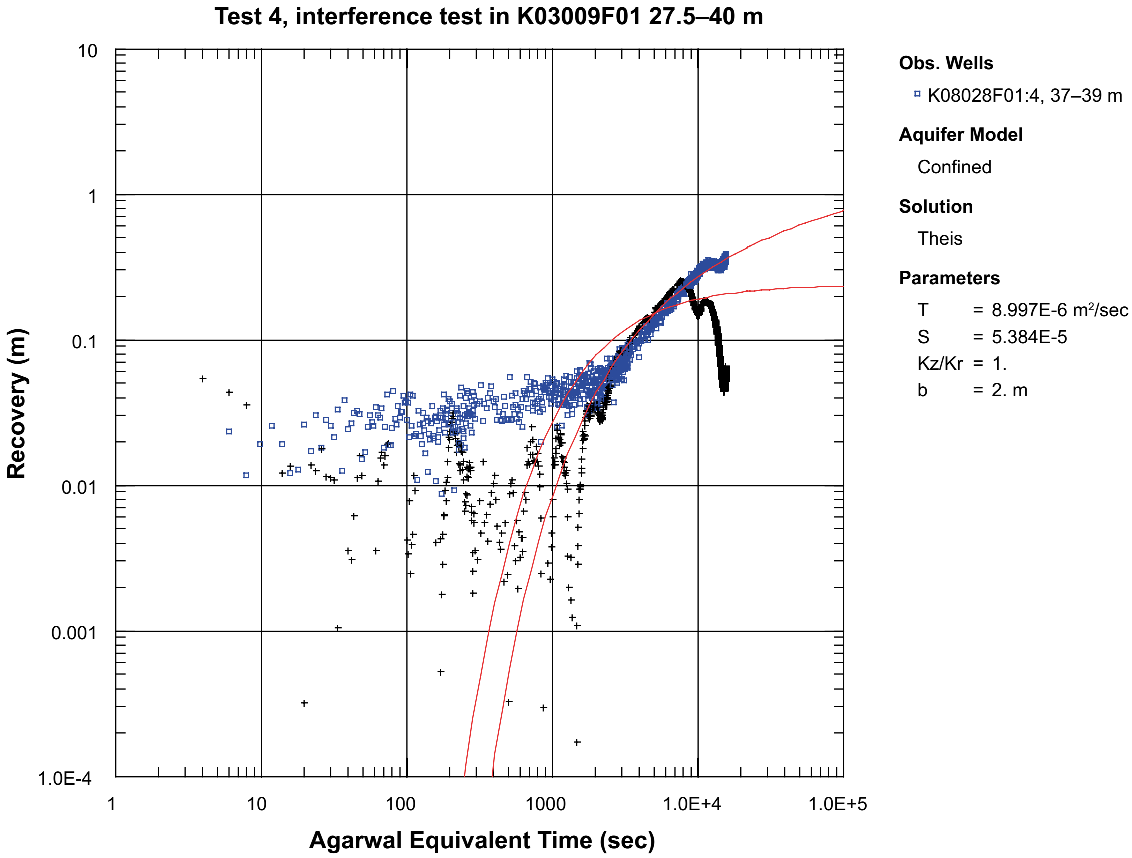
Theis

Parameters

T = 1.324E-5 m²/sec
S = 6.237E-5
Kz/Kr = 1.
b = 3. m

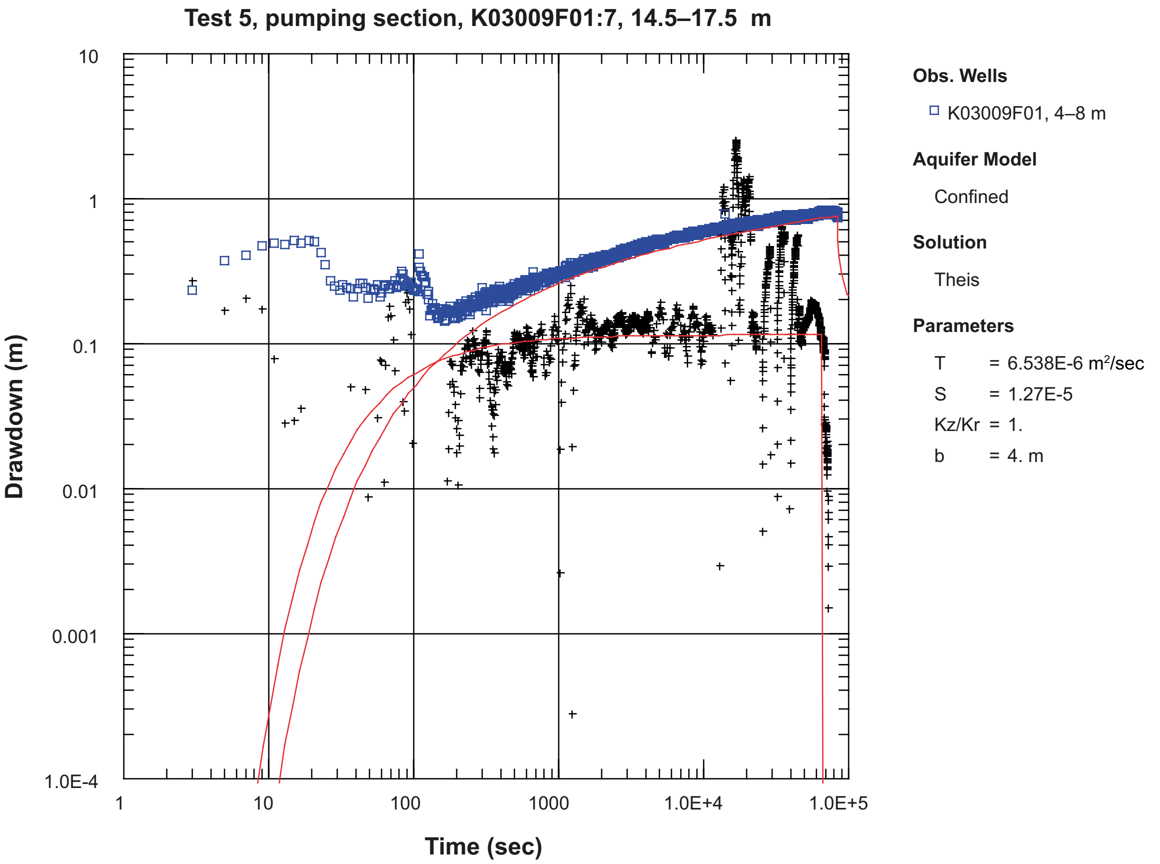


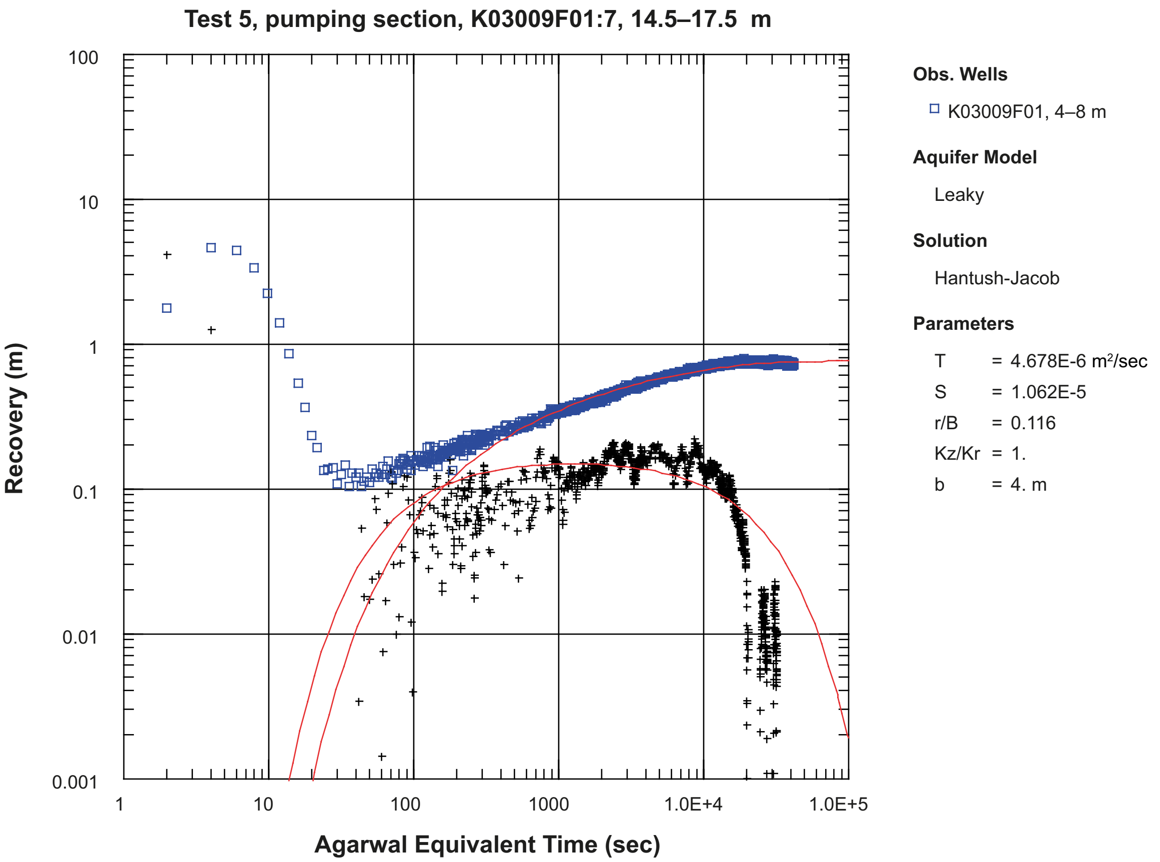
Test 4, interference test in K03009F01 27.5–40 m
Drawdown (m)
Time (sec)
10
1
0.1
0.01
0.001
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:4, 37–39 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 4.693E-6 m²/sec
S = 5.5E-5
Kz/Kr = 1.
b = 2. m

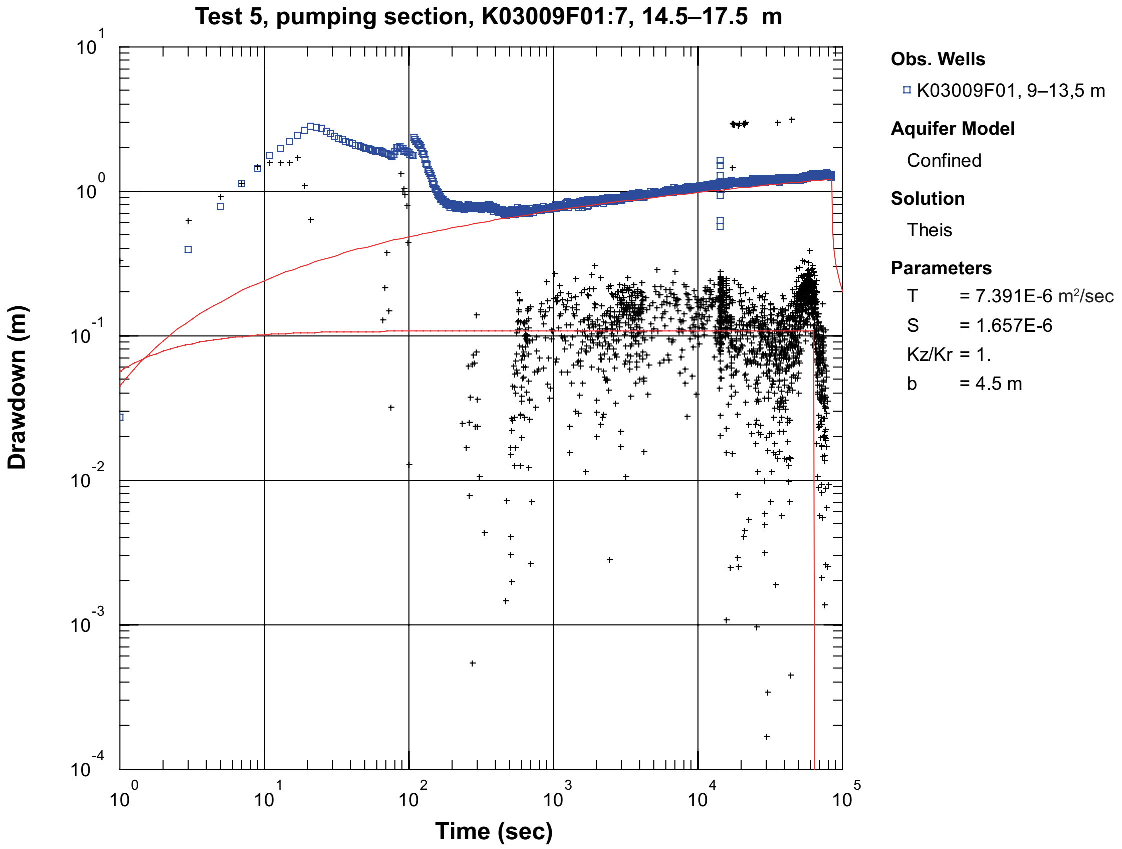


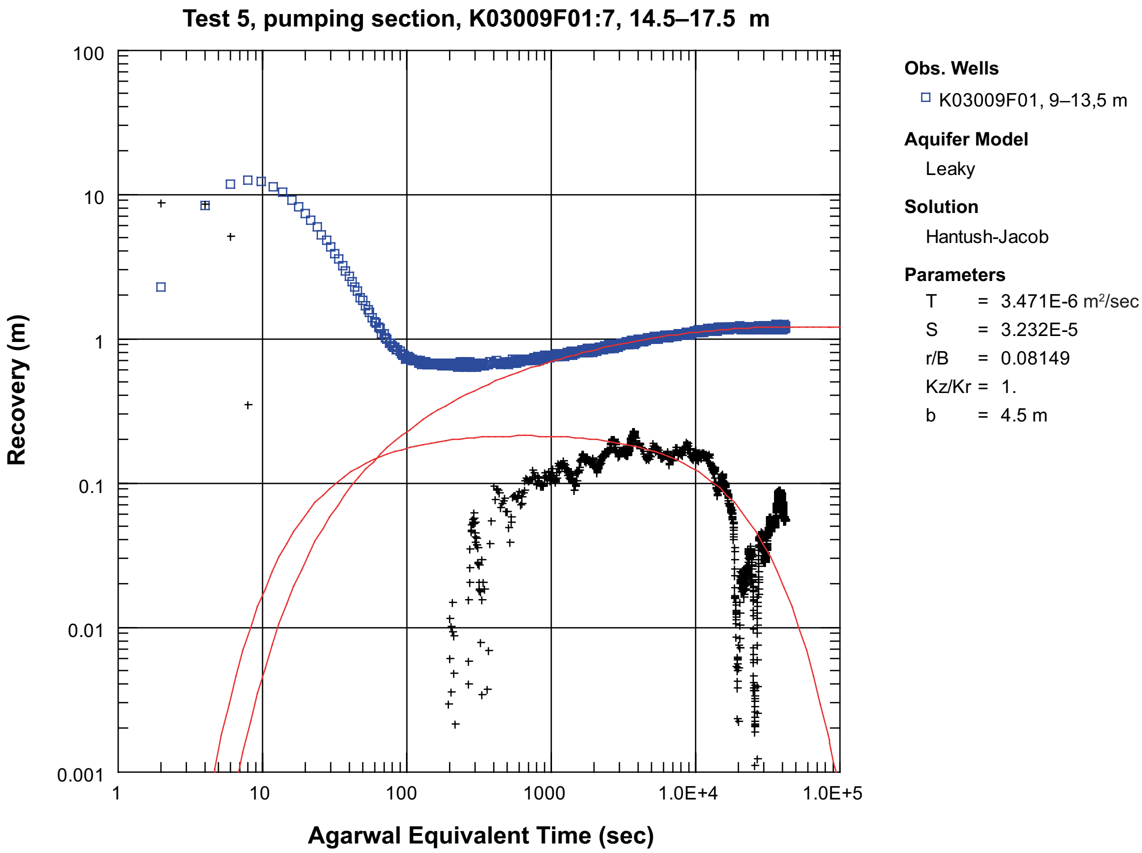
Test 4, interference test in K03009F01 27.5–40 m
Recovery (m)
Agarwal Equivalent Time (sec)
10
1
0.1
0.01
0.001
1.0E-4
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:4, 37–39 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 8.997E-6 m²/sec
S = 5.384E-5
Kz/Kr = 1.
b = 2. m

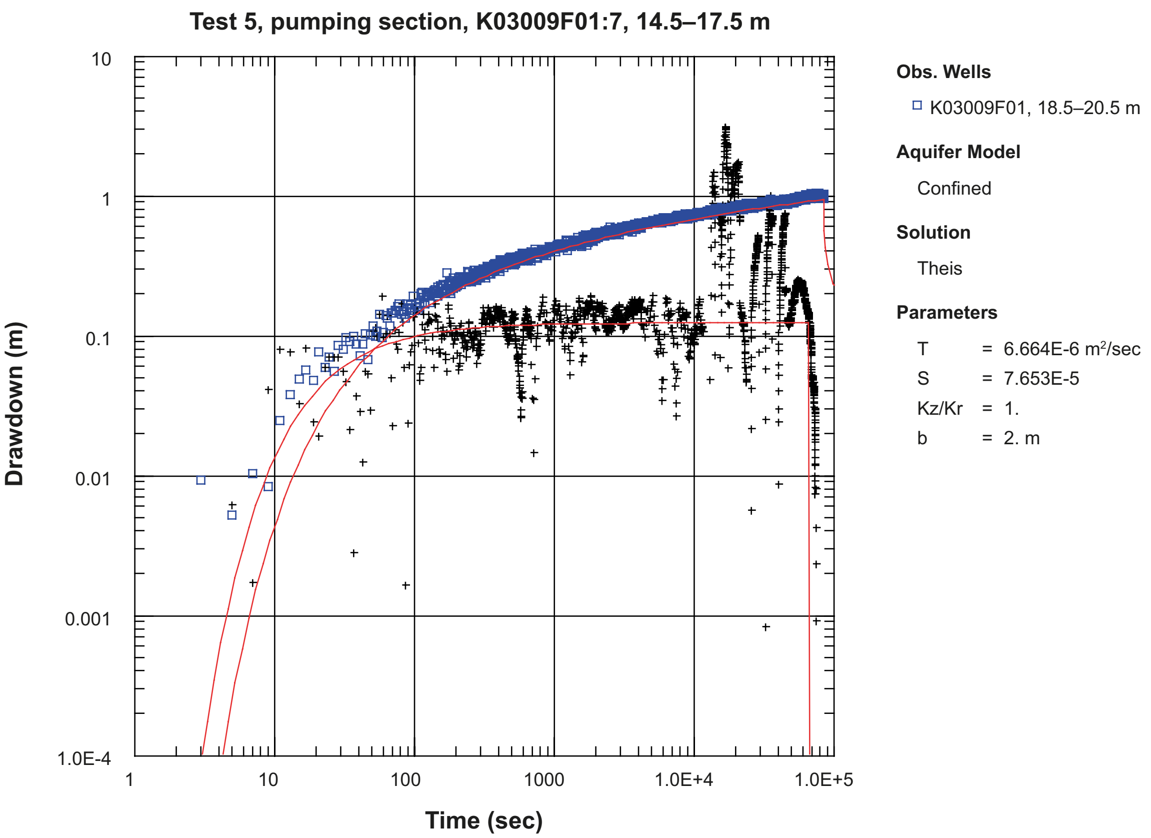
Test no 5. Interference test in K03009F01 14.5–17.5 m



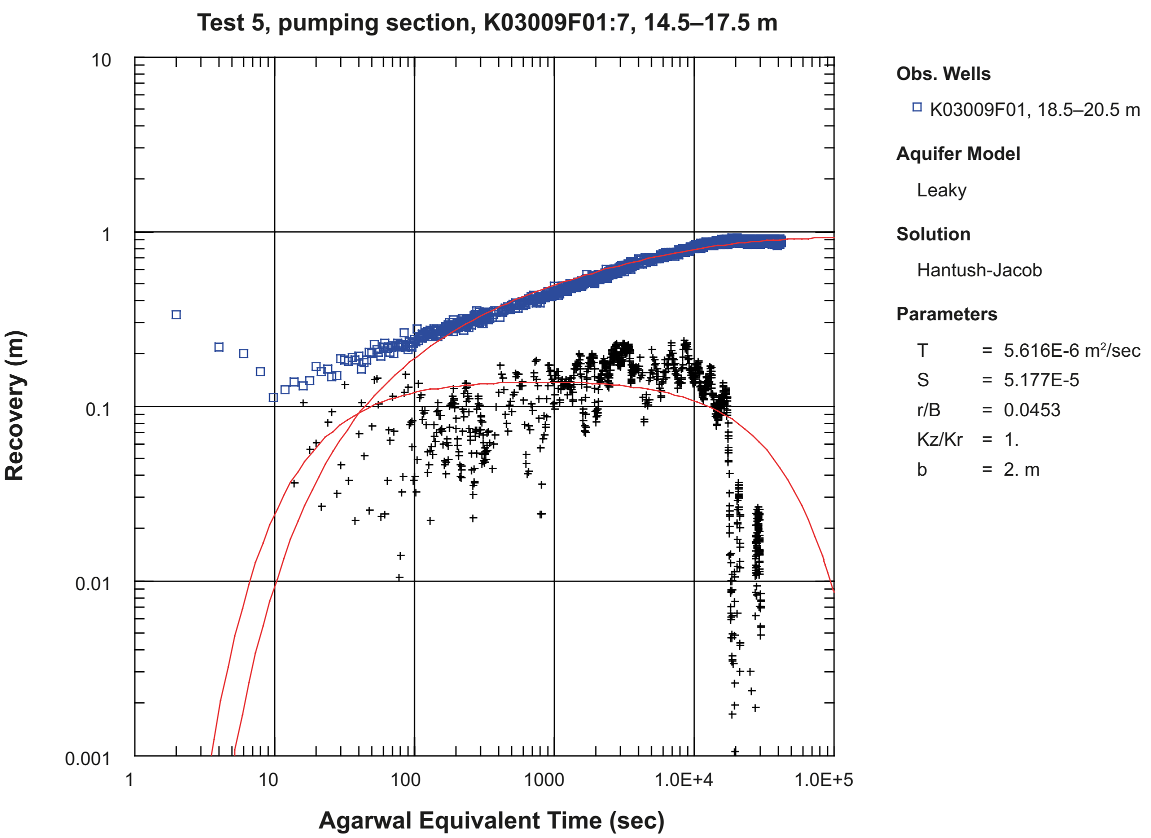



Test 5, pumping section, K03009F01:7, 14.5–17.5 m
Drawdown (m)
Time (sec)
Obs. Wells
K03009F01, 9–13,5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 7.391E-6 m²/sec
S = 1.657E-6
Kz/Kr = 1.
b = 4.5 m

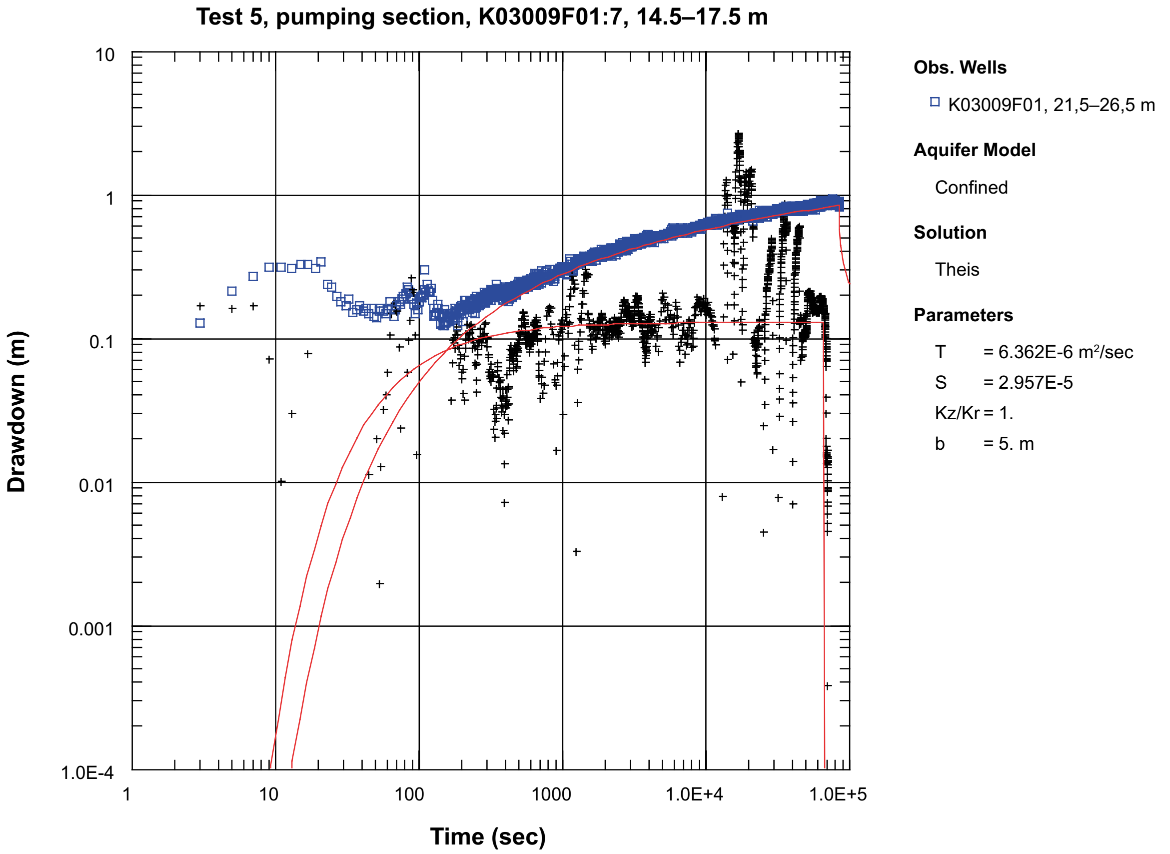

Test 5, pumping section, K03009F01:7, 14.5–17.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
Obs. Wells
K03009F01, 9–13,5 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 3.471E-6 m²/sec
S = 3.232E-5
r/B = 0.08149
Kz/Kr = 1.
b = 4.5 m



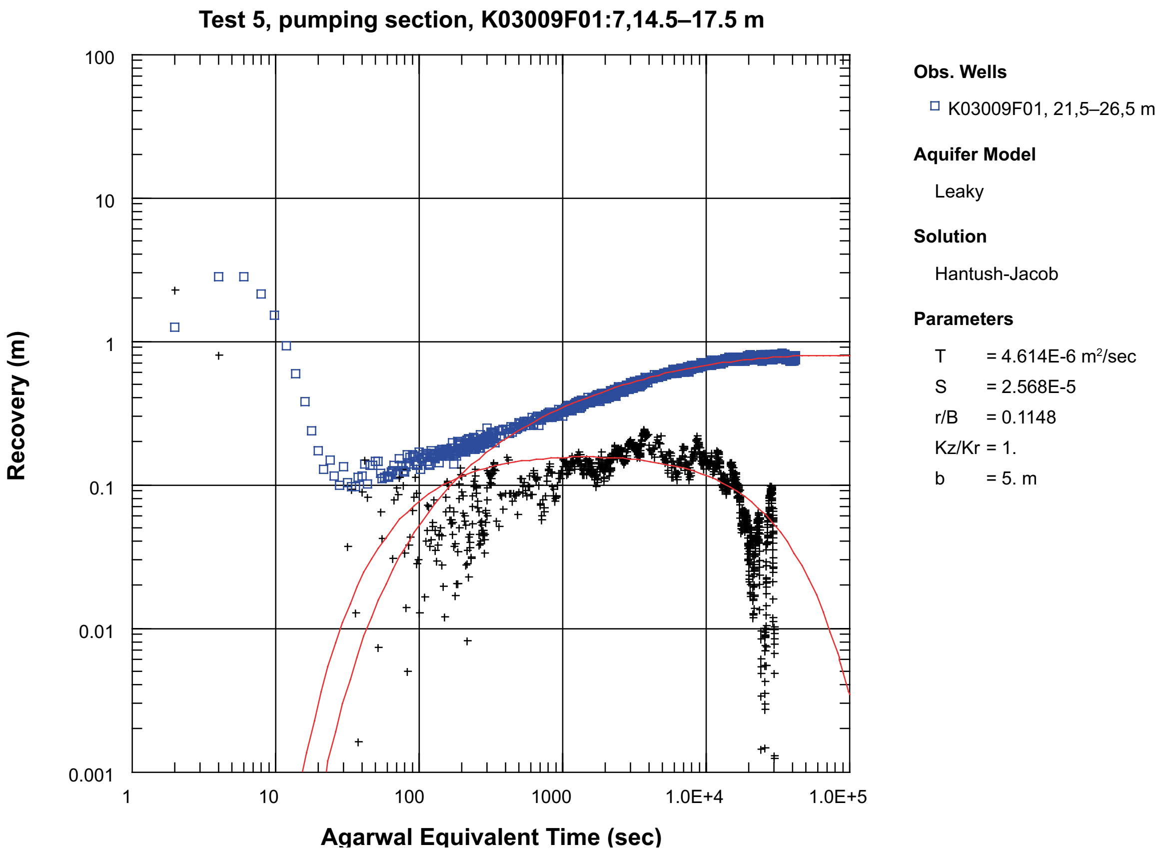
Test 5, pumping section, K03009F01:7, 14.5–17.5 m
Drawdown (m)
Time (sec)
10
1
0.1
0.01
0.001
1.0E-4
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01, 18.5–20.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.664E-6 m²/sec
S = 7.653E-5
Kz/Kr = 1.
b = 2. m



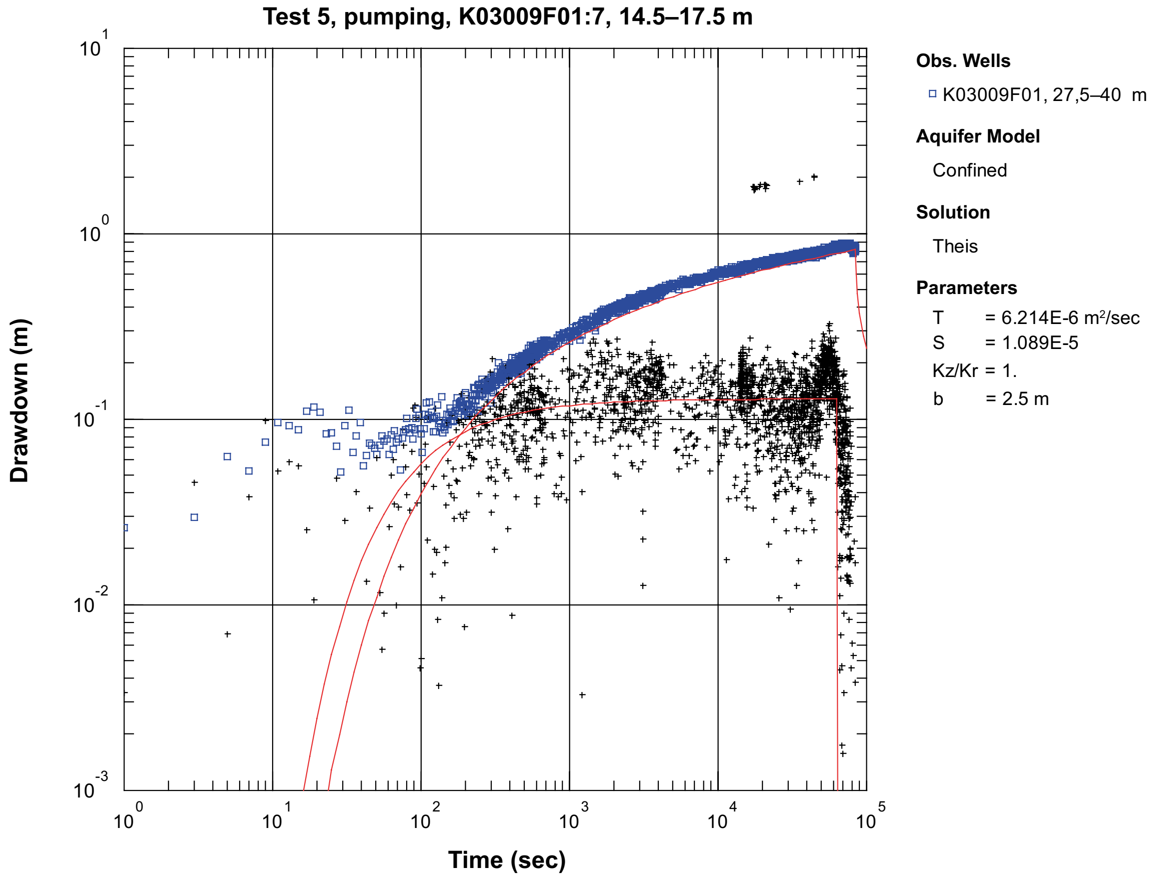
Test 5, pumping section, K03009F01:7, 14.5–17.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01, 18.5–20.5 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 5.616E-6 m²/sec
S = 5.177E-5
r/B = 0.0453
Kz/Kr = 1.
b = 2. m



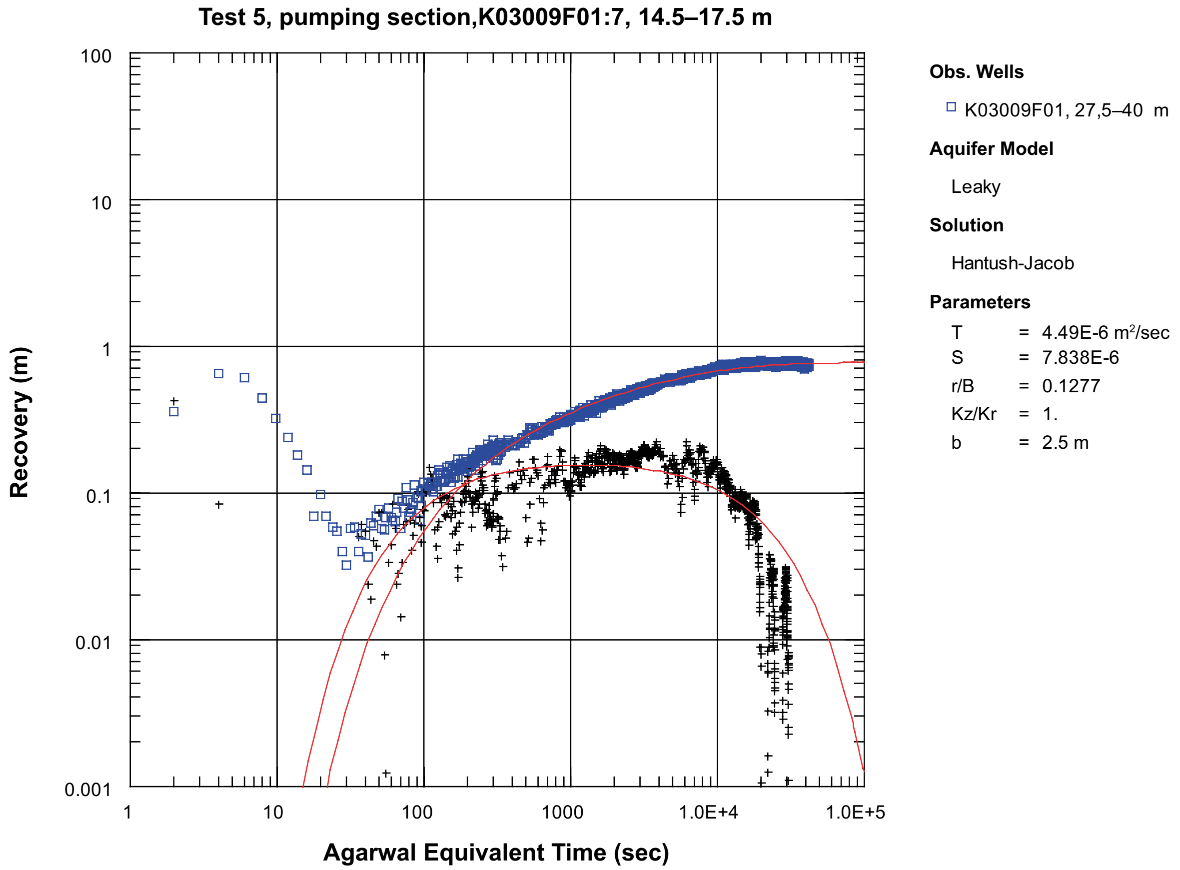
Test 5, pumping section, K03009F01:7, 14.5–17.5 m
Drawdown (m)
Time (sec)
10
1
0.1
0.01
0.001
1.0E-4
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01, 21,5–26,5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.362E-6 m²/sec
S = 2.957E-5
Kz/Kr = 1.
b = 5. m



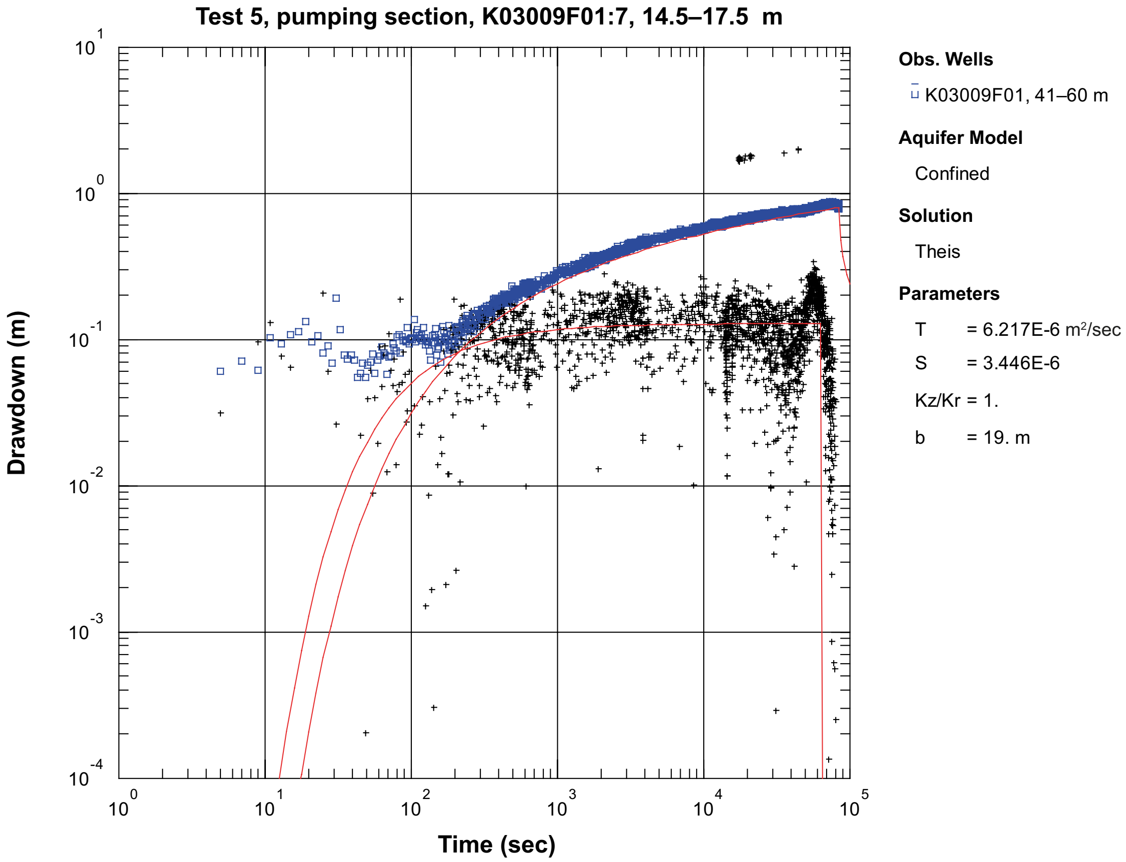
Test 5, pumping section, K03009F01:7,14.5–17.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
100
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01, 21,5–26,5 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 4.614E-6 m²/sec
S = 2.568E-5
r/B = 0.1148
Kz/Kr = 1.
b = 5. m

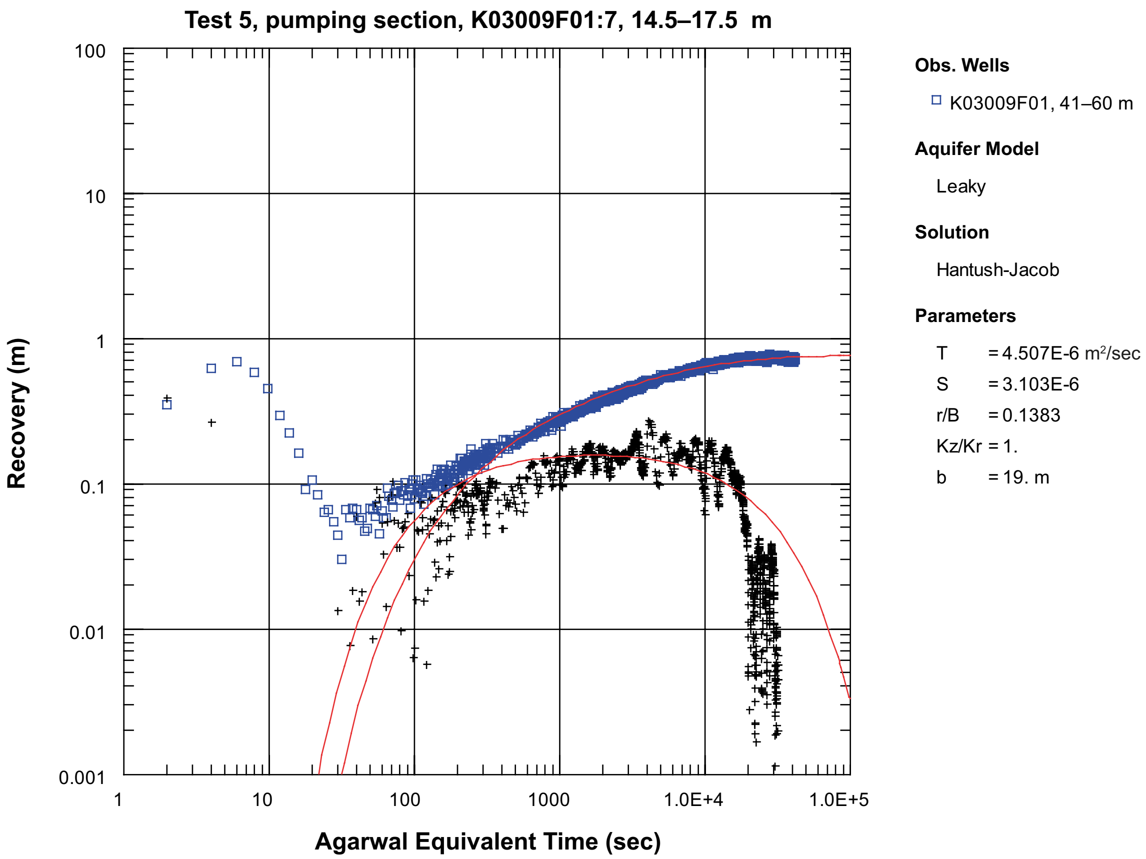


Test 5, pumping, K03009F01:7, 14.5–17.5 m
Drawdown (m)
Time (sec)
Obs. Wells
K03009F01, 27,5–40 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.214E-6 m²/sec
S = 1.089E-5
Kz/Kr = 1.
b = 2.5 m

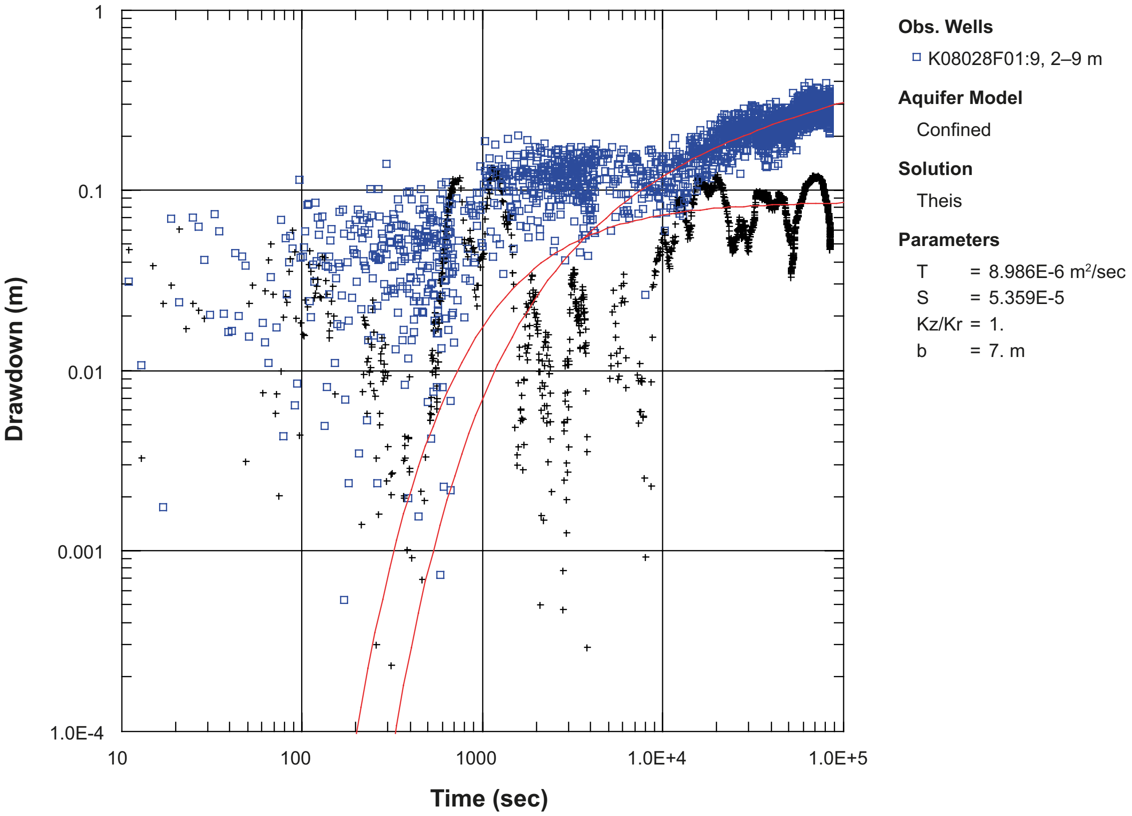


Test 5, pumping section,K03009F01:7, 14.5–17.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
Obs. Wells
K03009F01, 27,5–40 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 4.49E-6 m²/sec
S = 7.838E-6
r/B = 0.1277
Kz/Kr = 1.
b = 2.5 m

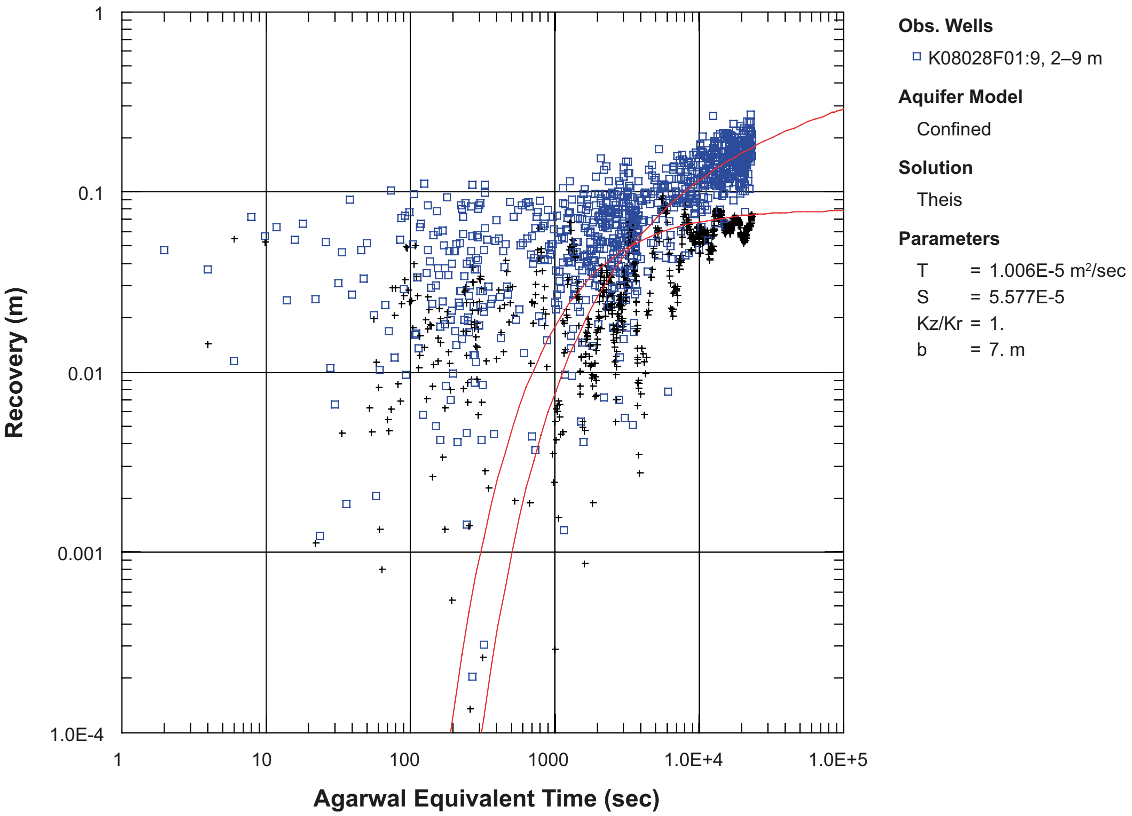

Test 5, pumping section, K03009F01:7, 14.5–17.5 m
Drawdown (m)
Time (sec)
Obs. Wells
K03009F01, 41–60 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.217E-6 m²/sec
S = 3.446E-6
Kz/Kr = 1.
b = 19. m

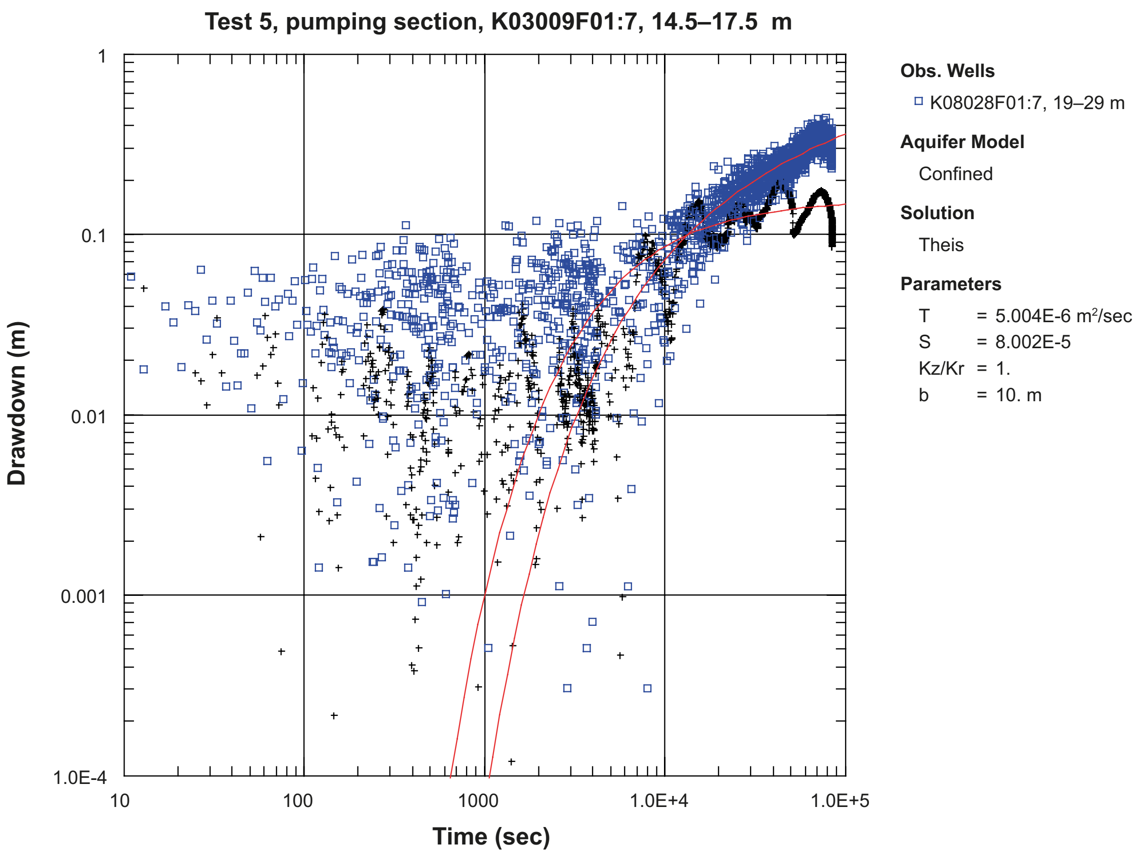

Test 5, pumping section, K03009F01:7, 14.5–17.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
Obs. Wells
K03009F01, 41–60 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 4.507E-6 m²/sec
S = 3.103E-6
r/B = 0.1383
Kz/Kr = 1.
b = 19. m

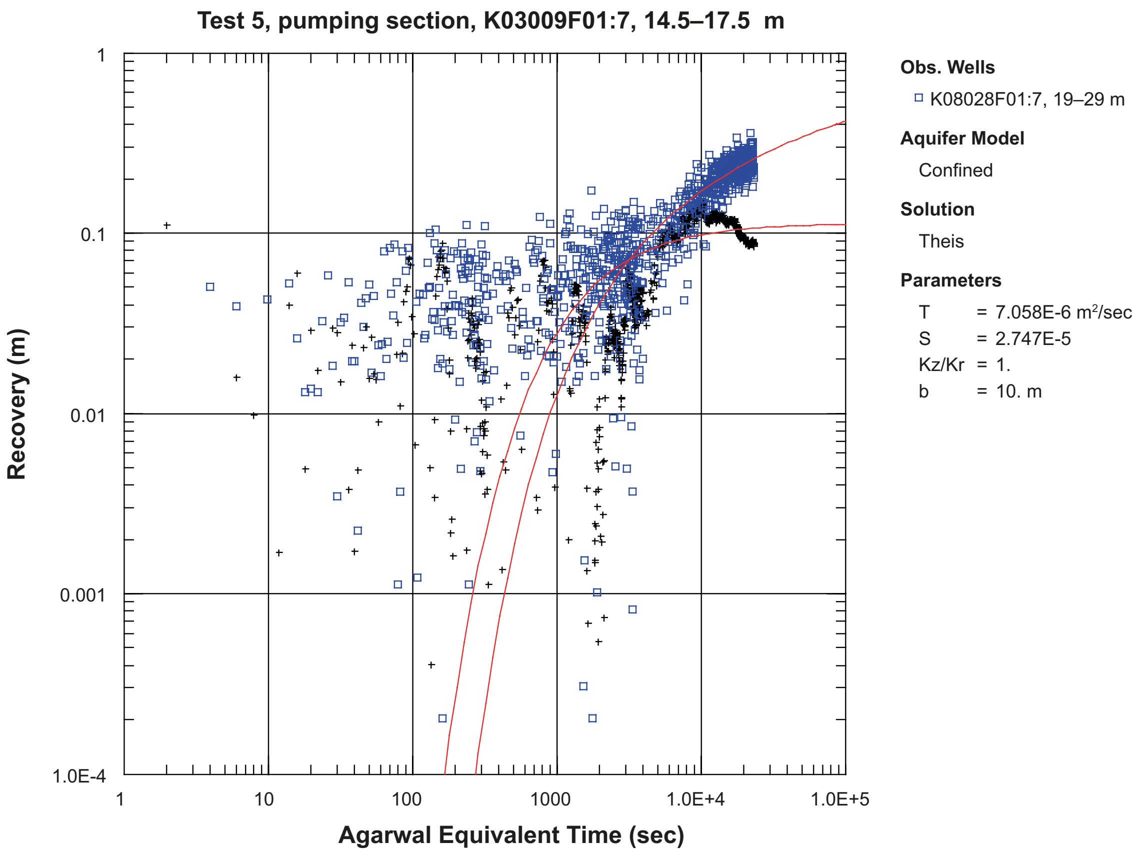
Test 5, pumping section, K03009F01:7, 14.5–17.5 m

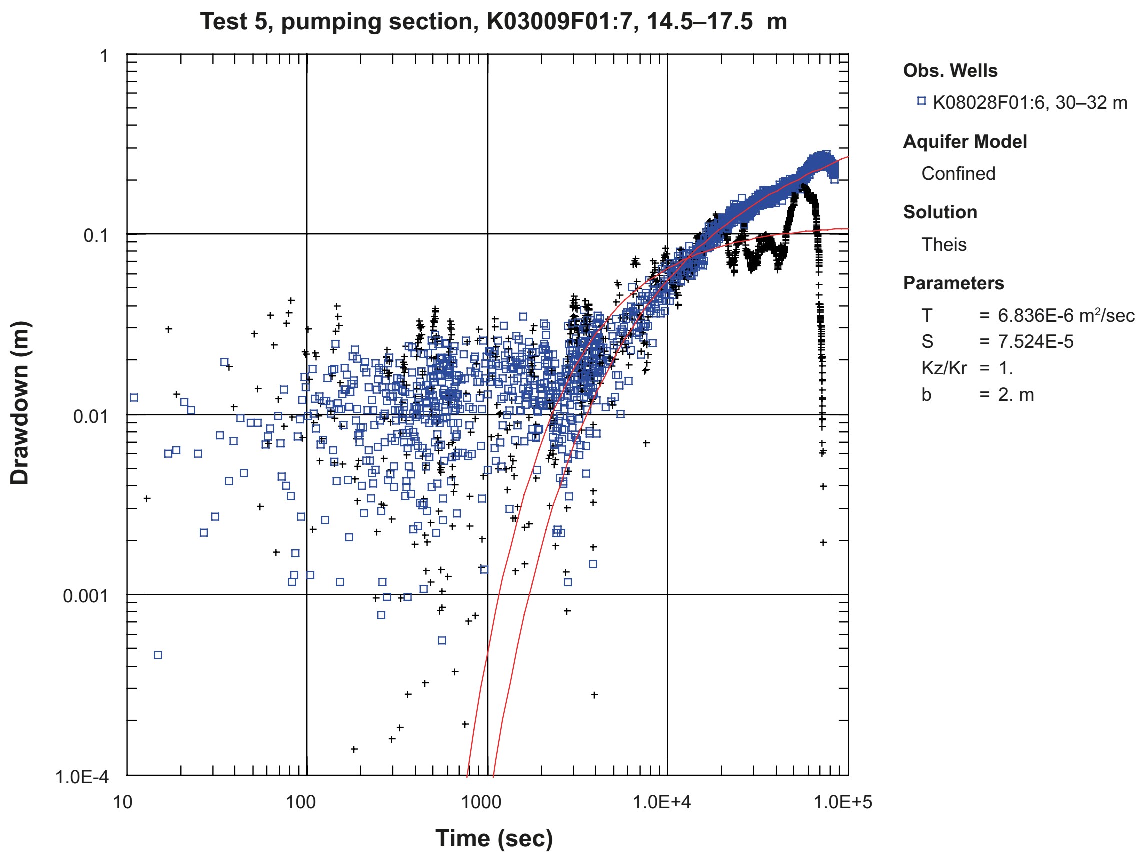


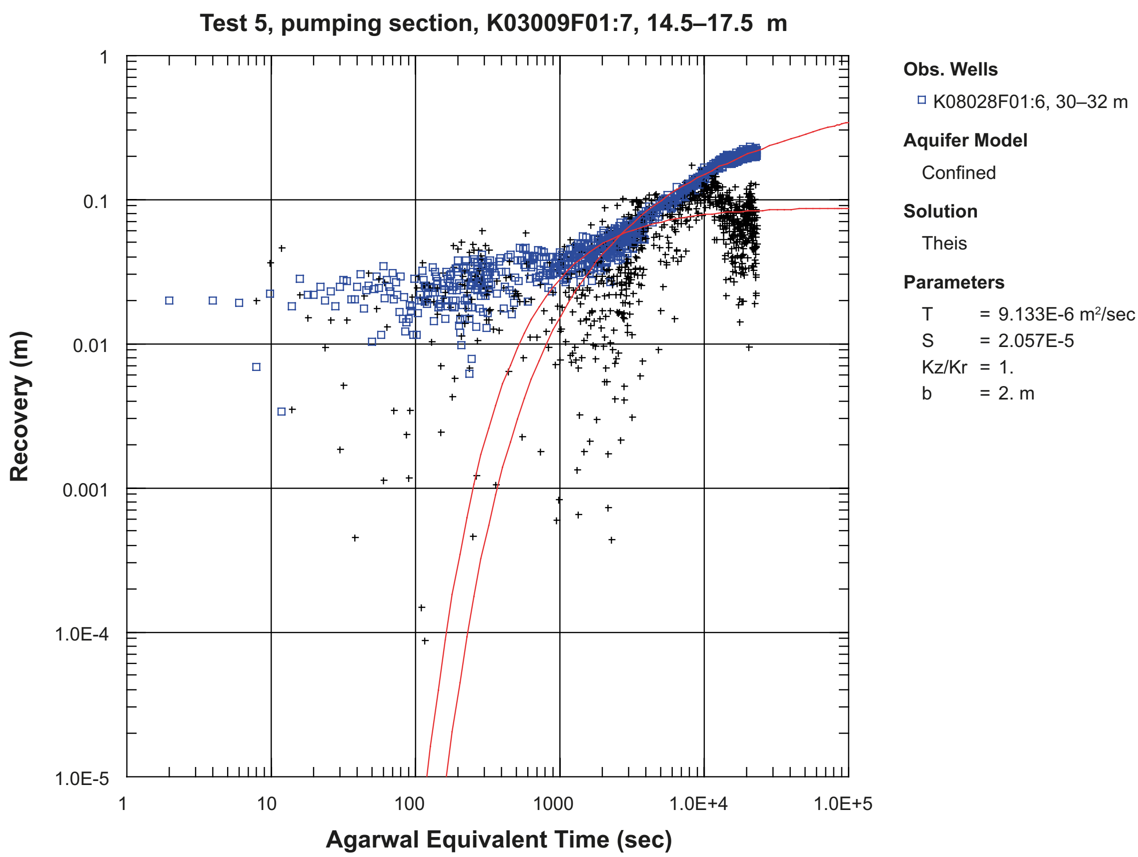
Test 5, pumping section, K03009F01:7, 14.5–17.5 m

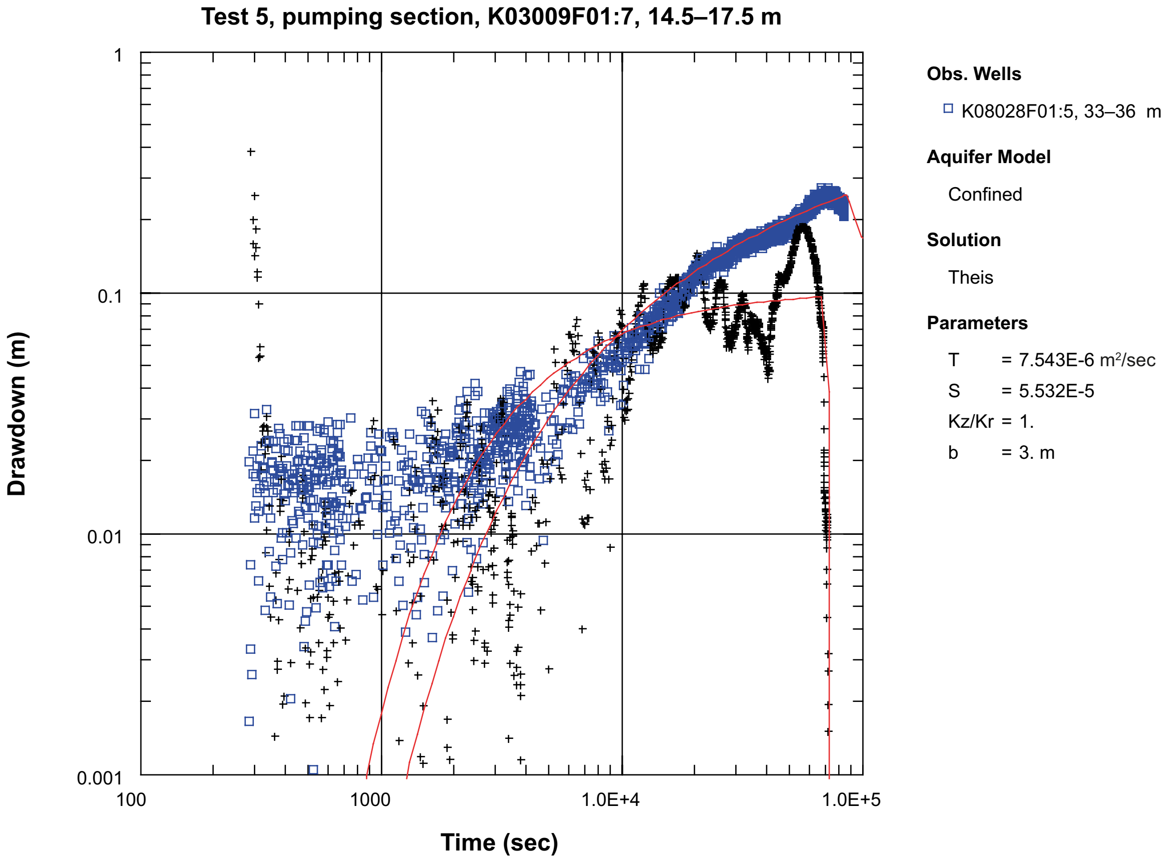



Test 5, pumping section, K03009F01:7, 14.5–17.5 m
Drawdown (m)
Time (sec)
1
0.1
0.01
0.001
1.0E-4
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:7, 19–29 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.004E-6 m²/sec
S = 8.002E-5
Kz/Kr = 1.
b = 10. m

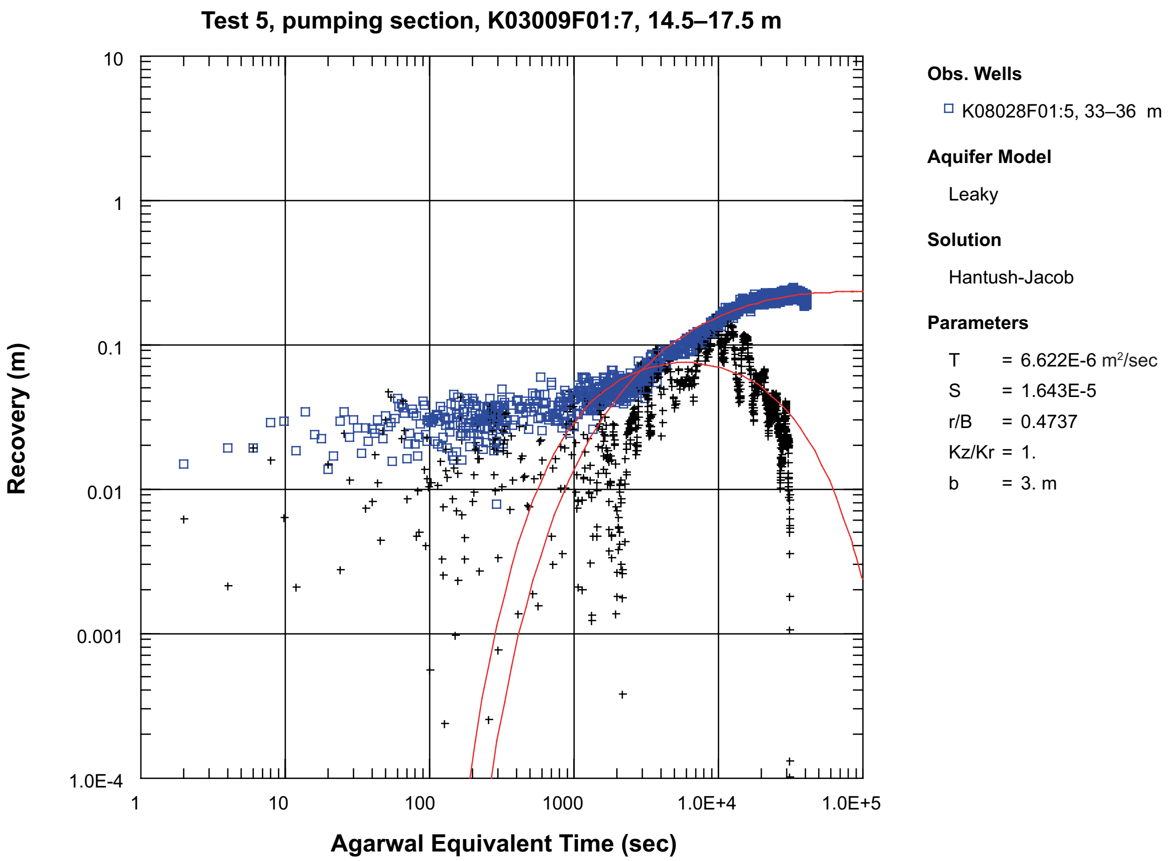

Test 5, pumping section, K03009F01:7, 14.5–17.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
1
0.1
0.01
0.001
1.0E-4
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:7, 19–29 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 7.058E-6 m²/sec
S = 2.747E-5
Kz/Kr = 1.
b = 10. m


Test 5, pumping section, K03009F01:7, 14.5–17.5 m
Drawdown (m)
Time (sec)
1
0.1
0.01
0.001
1.0E-4
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:6, 30–32 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.836E-6 m²/sec
S = 7.524E-5
Kz/Kr = 1.
b = 2. m


Test 5, pumping section, K03009F01:7, 14.5–17.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
1
0.1
0.01
0.001
1.0E-4
1.0E-5
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:6, 30–32 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 9.133E-6 m²/sec
S = 2.057E-5
Kz/Kr = 1.
b = 2. m

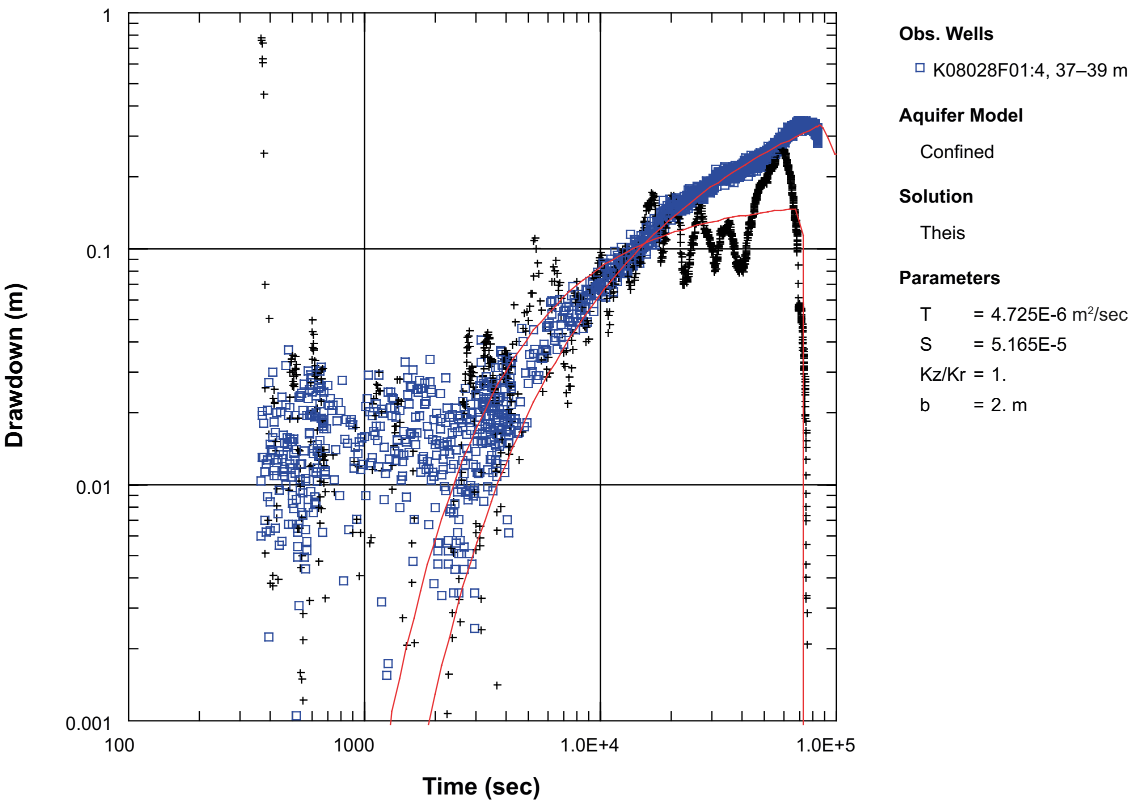


Test 5, pumping section, K03009F01:7, 14.5–17.5 m
Drawdown (m)
Time (sec)
1
0.1
0.01
0.001
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:5, 33–36 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 7.543E-6 m²/sec
S = 5.532E-5
Kz/Kr = 1.
b = 3. m

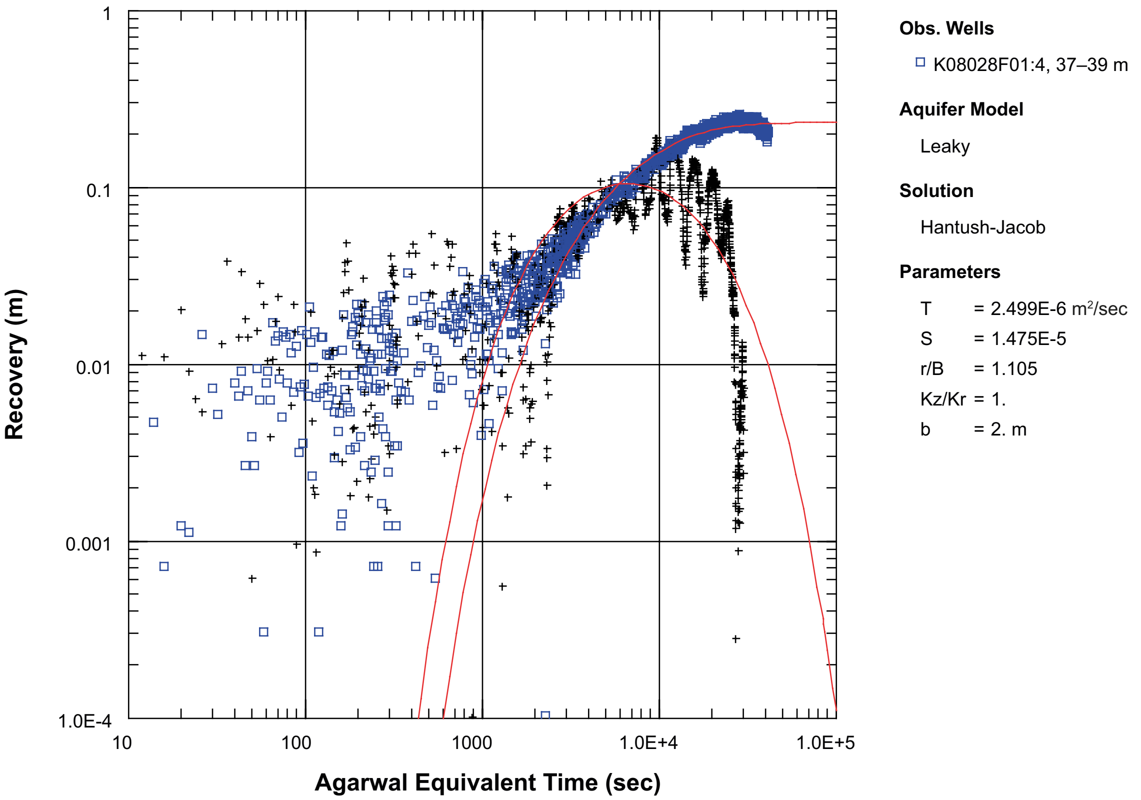


Test 5, pumping section, K03009F01:7, 14.5–17.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
10
1
0.1
0.01
0.001
1.0E-4
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:5, 33–36 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 6.622E-6 m²/sec
S = 1.643E-5
r/B = 0.4737
Kz/Kr = 1.
b = 3. m

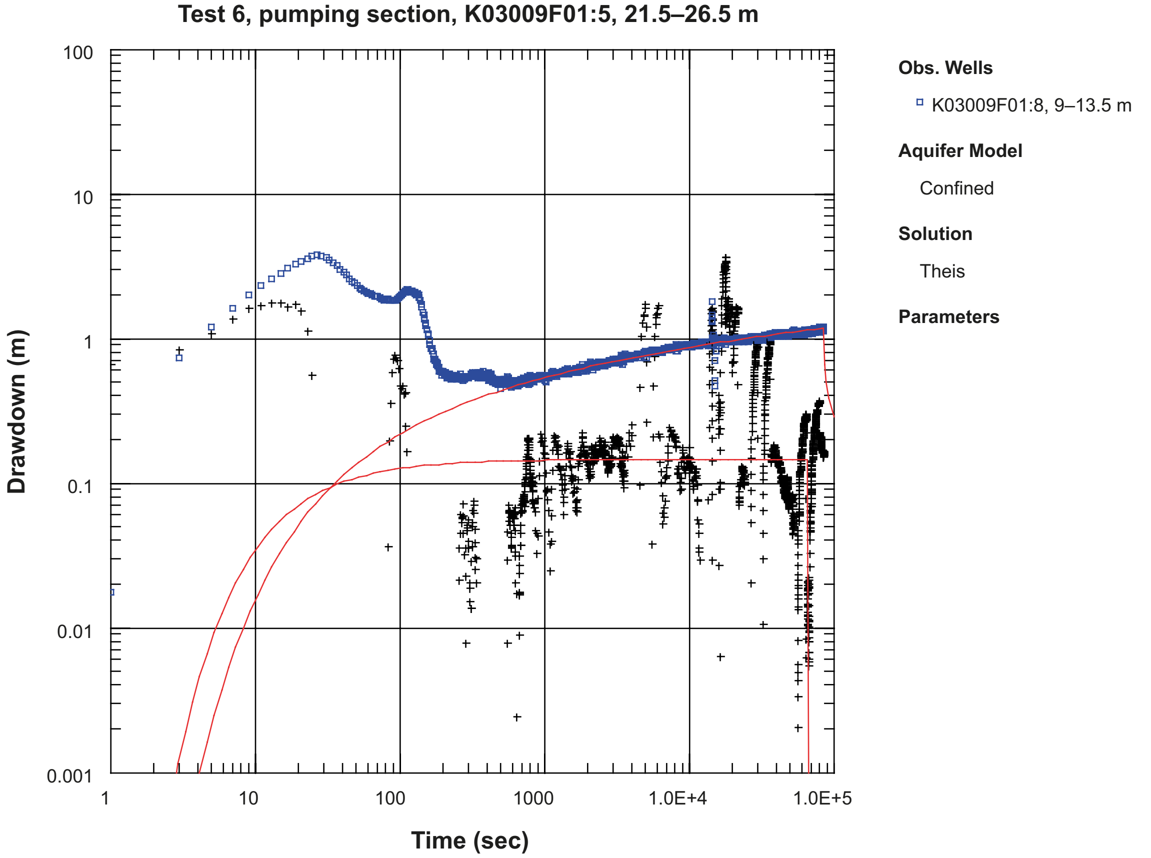
Test 5, pumping section, K03009F01:7, 14.5–17.5 m

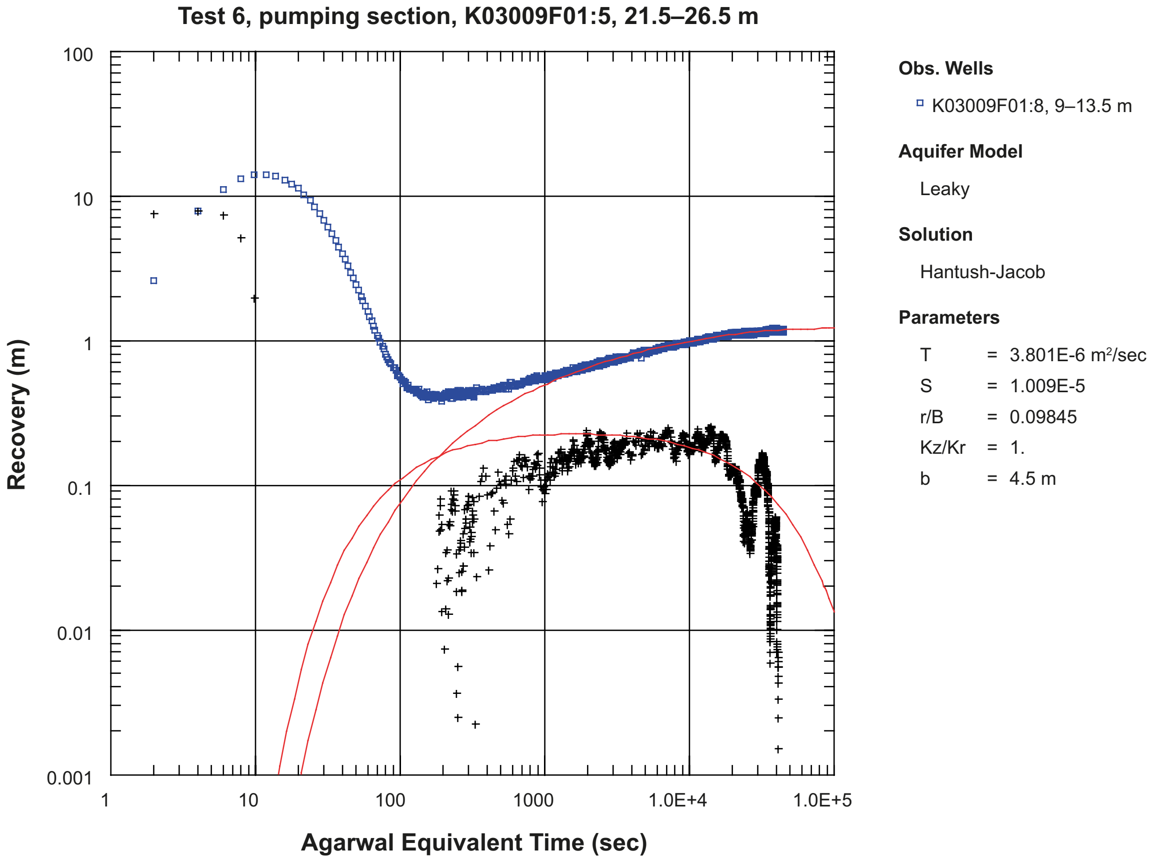


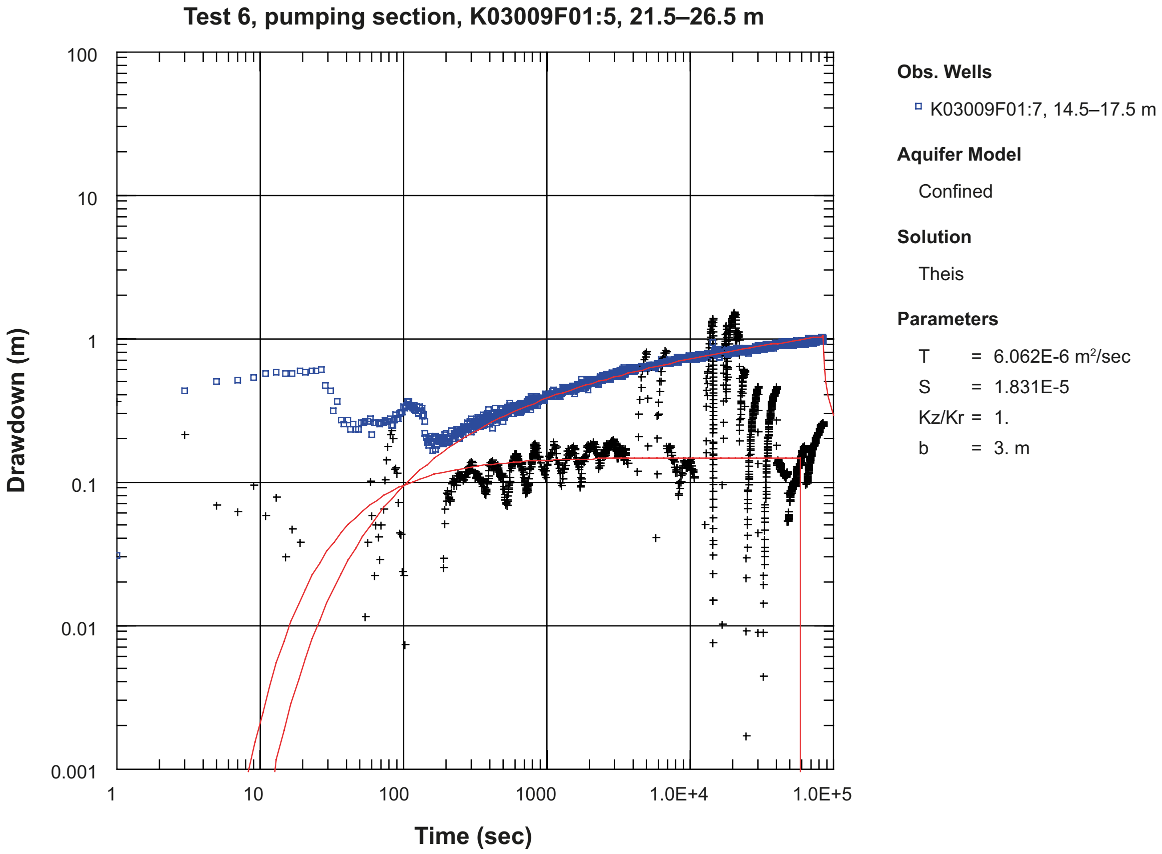
Test 5, pumping section, K03009F01:7, 14.5–17.5 m

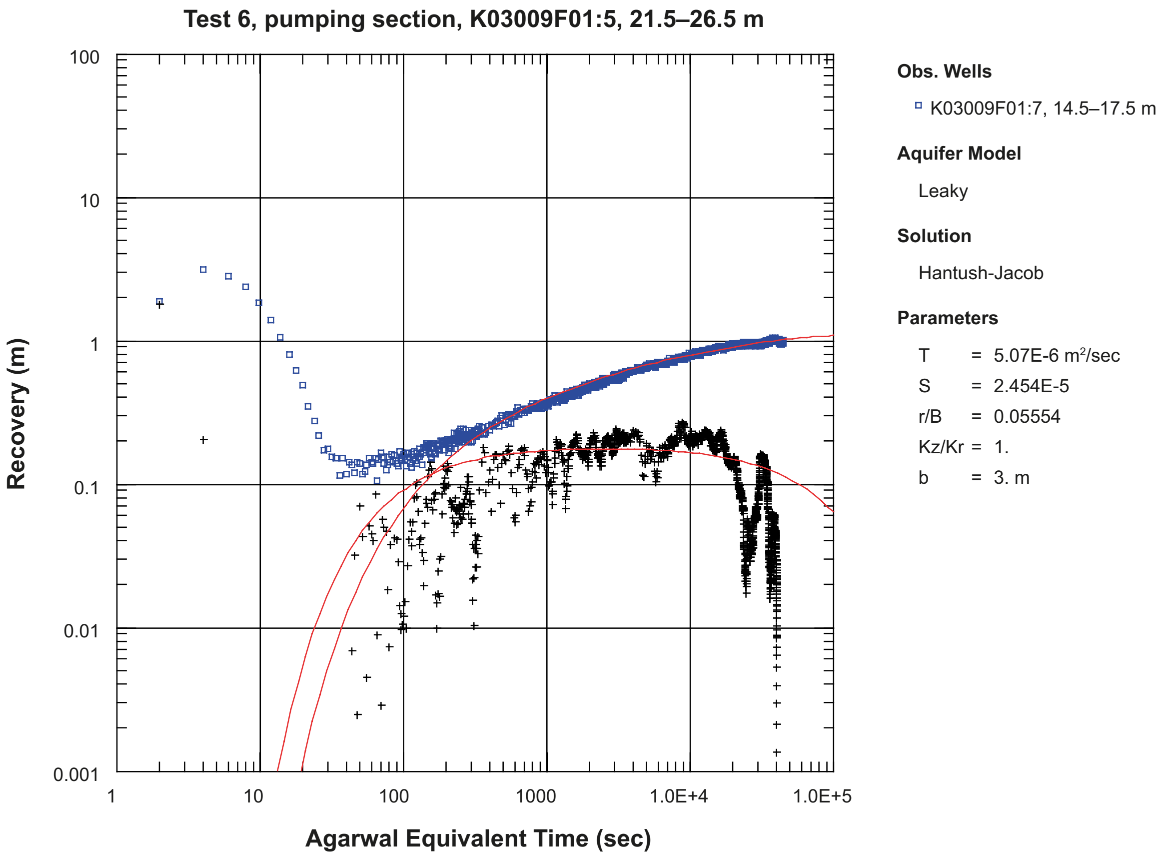


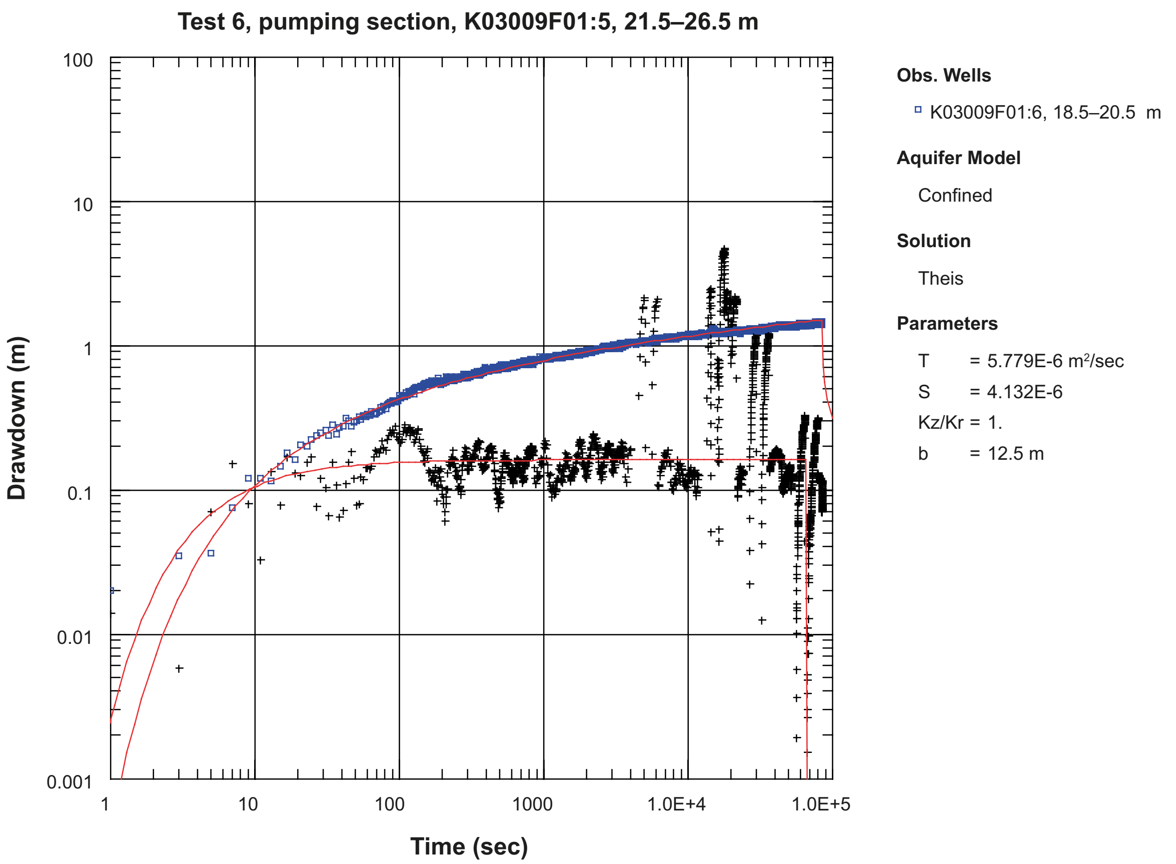
Test no 6. Interference test in K03009F01 21.5–24.5 m



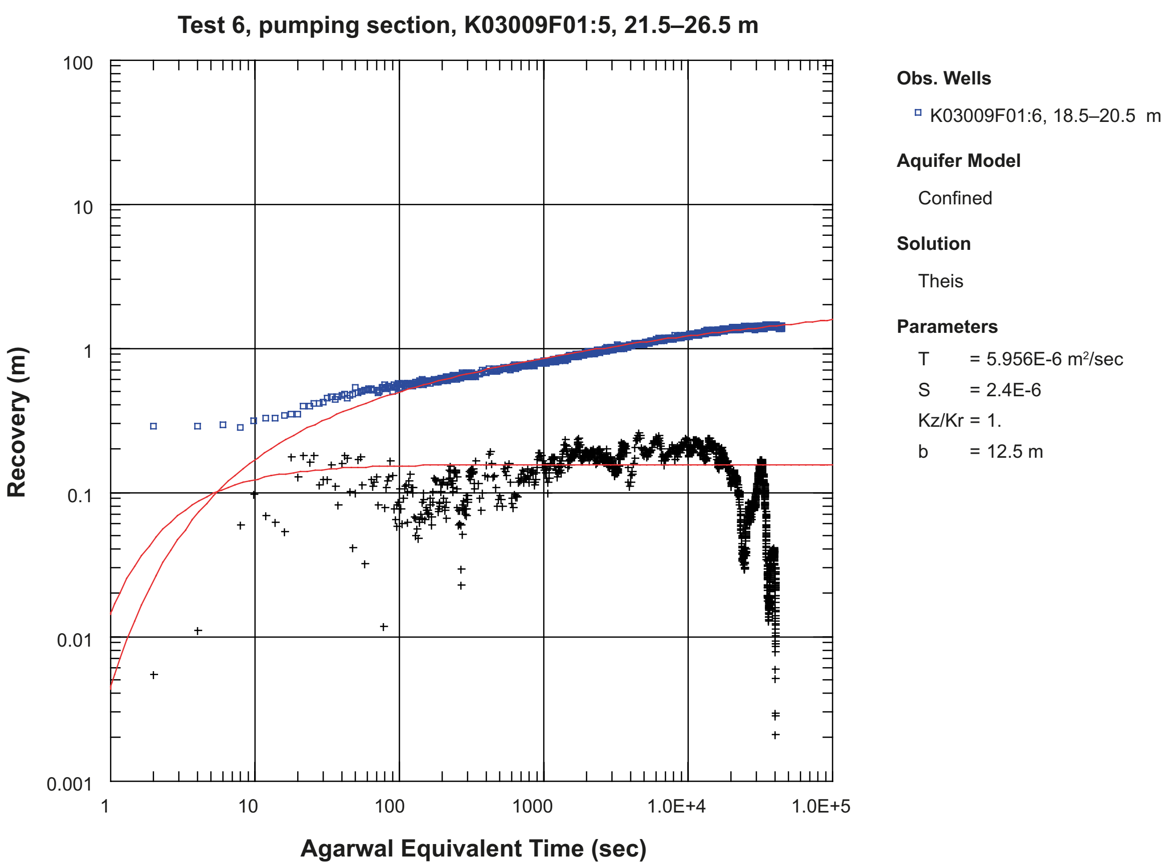



Test 6, pumping section, K03009F01:5, 21.5–26.5 m
100
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5
Drawdown (m)
Time (sec)
Obs. Wells
K03009F01:7, 14.5–17.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.062E-6 m²/sec
S = 1.831E-5
Kz/Kr = 1.
b = 3. m

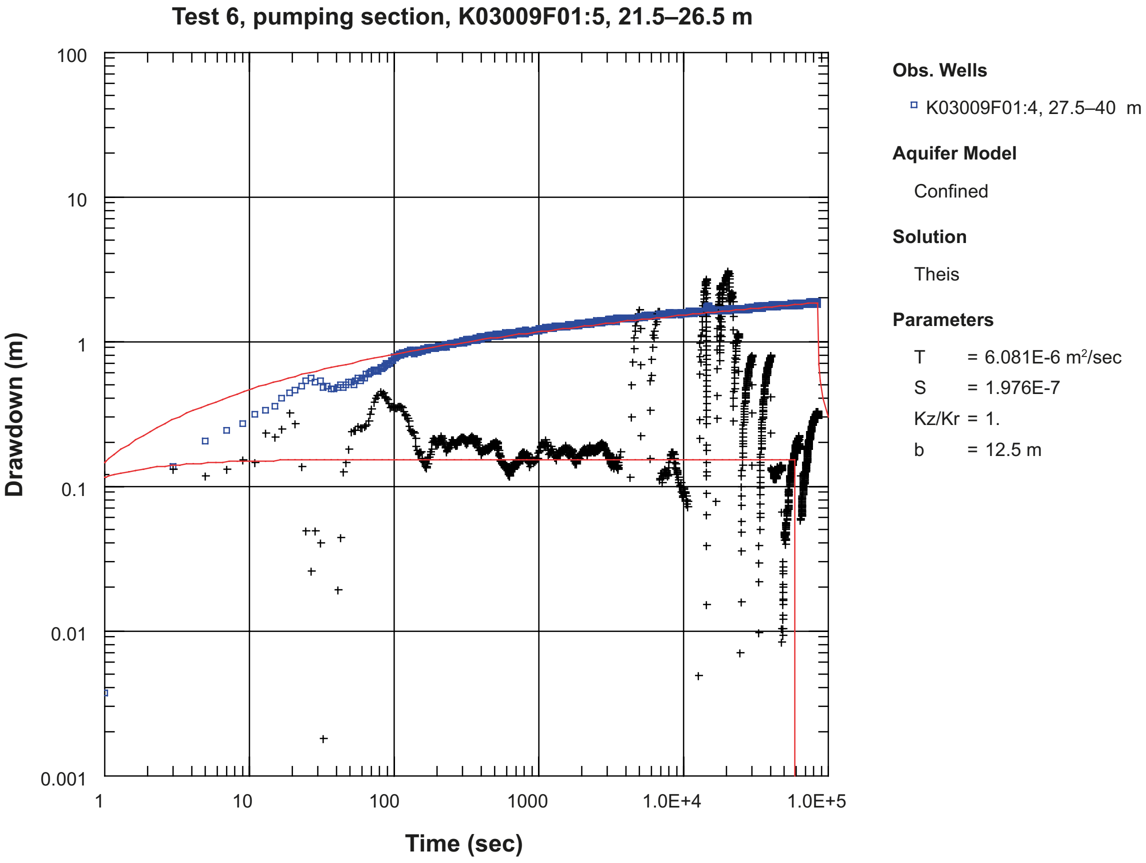

Test 6, pumping section, K03009F01:5, 21.5–26.5 m
100
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5
Recovery (m)
Agarwal Equivalent Time (sec)
Obs. Wells
K03009F01:7, 14.5–17.5 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 5.07E-6 m²/sec
S = 2.454E-5
r/B = 0.05554
Kz/Kr = 1.
b = 3. m

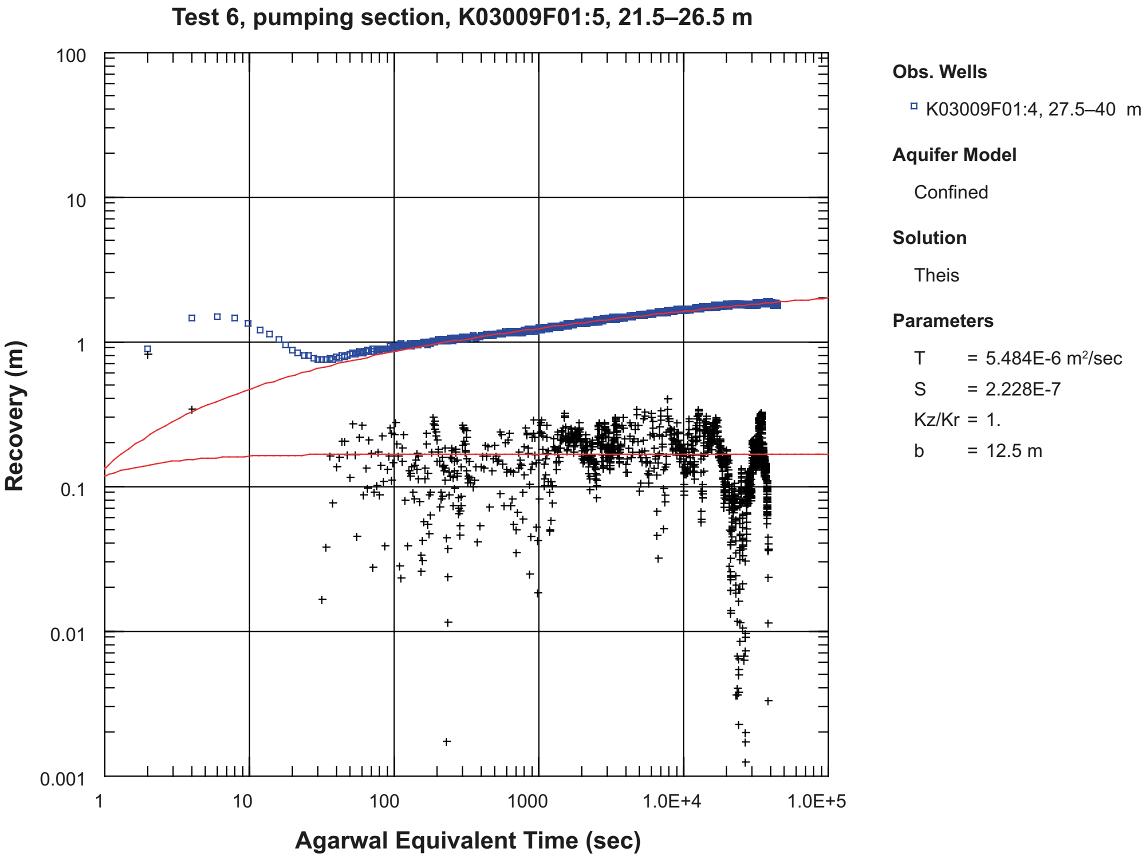


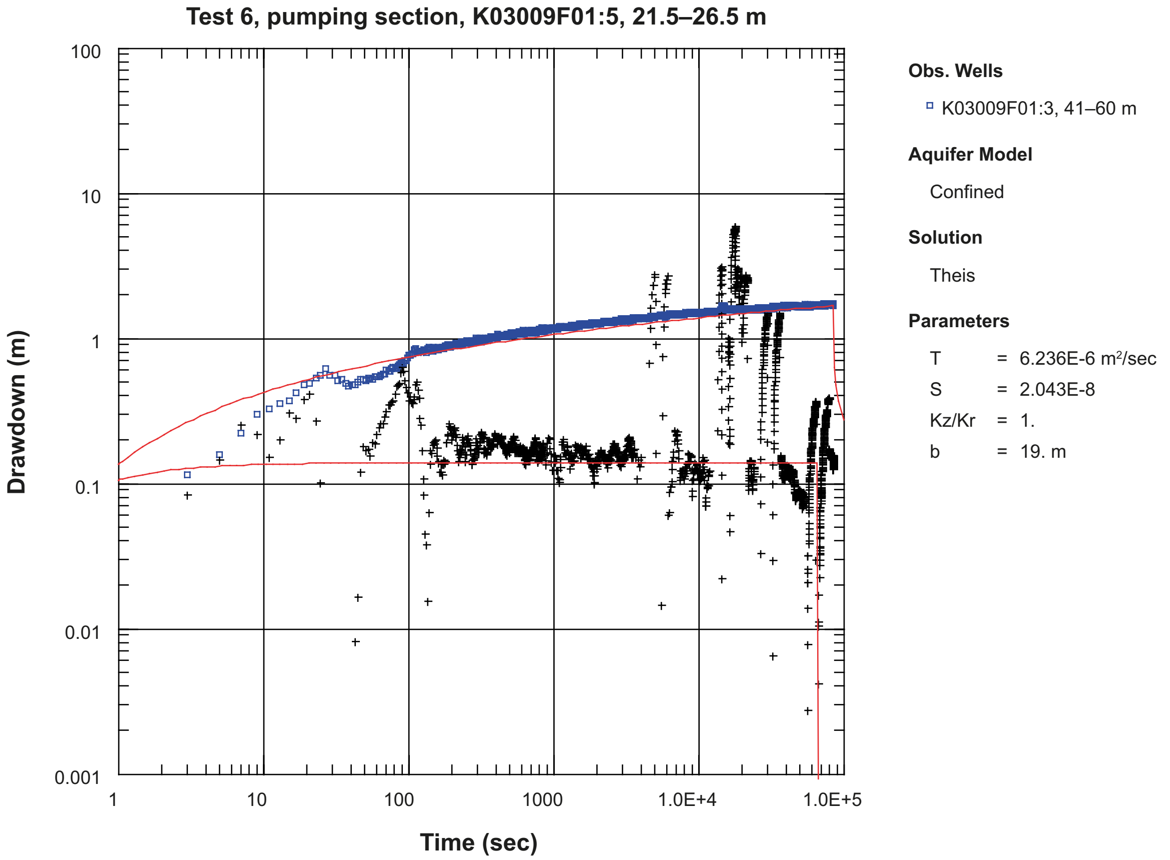
Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Drawdown (m)
Time (sec)
100
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01:6, 18.5–20.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.779E-6 m²/sec
S = 4.132E-6
Kz/Kr = 1.
b = 12.5 m

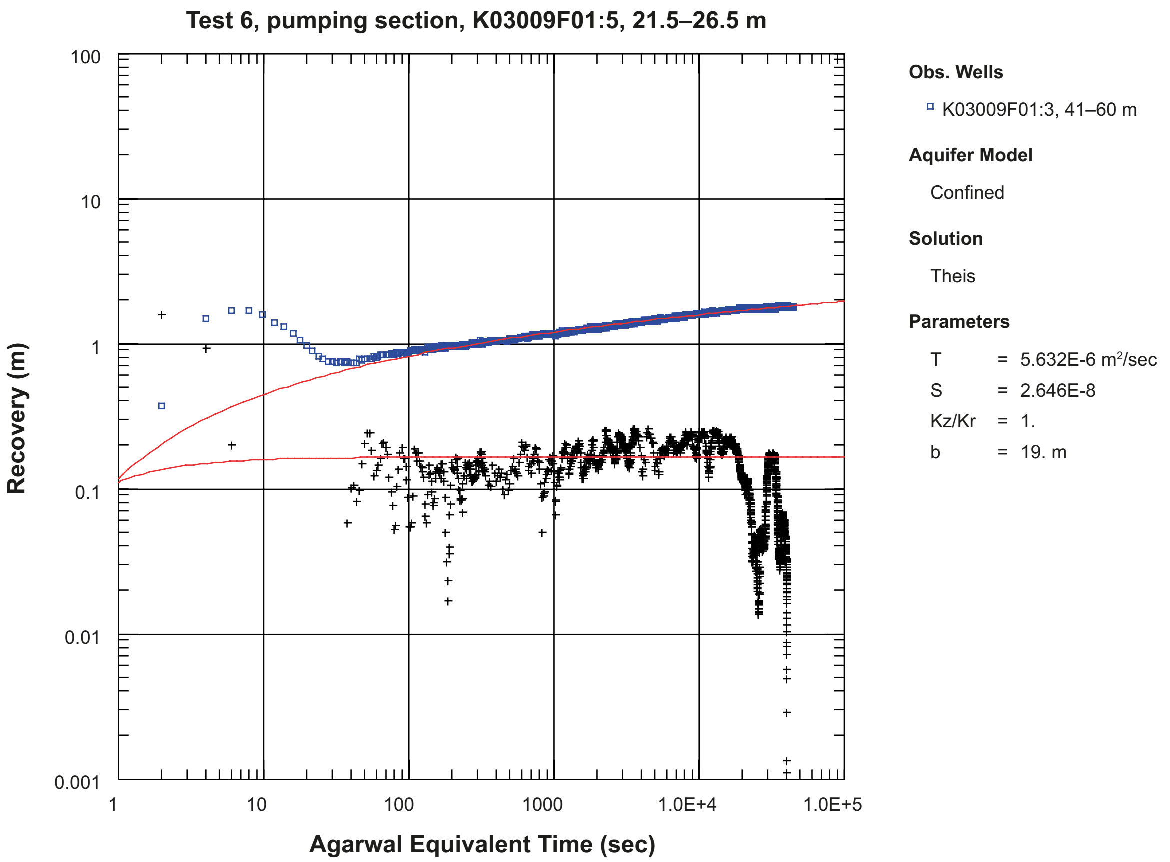


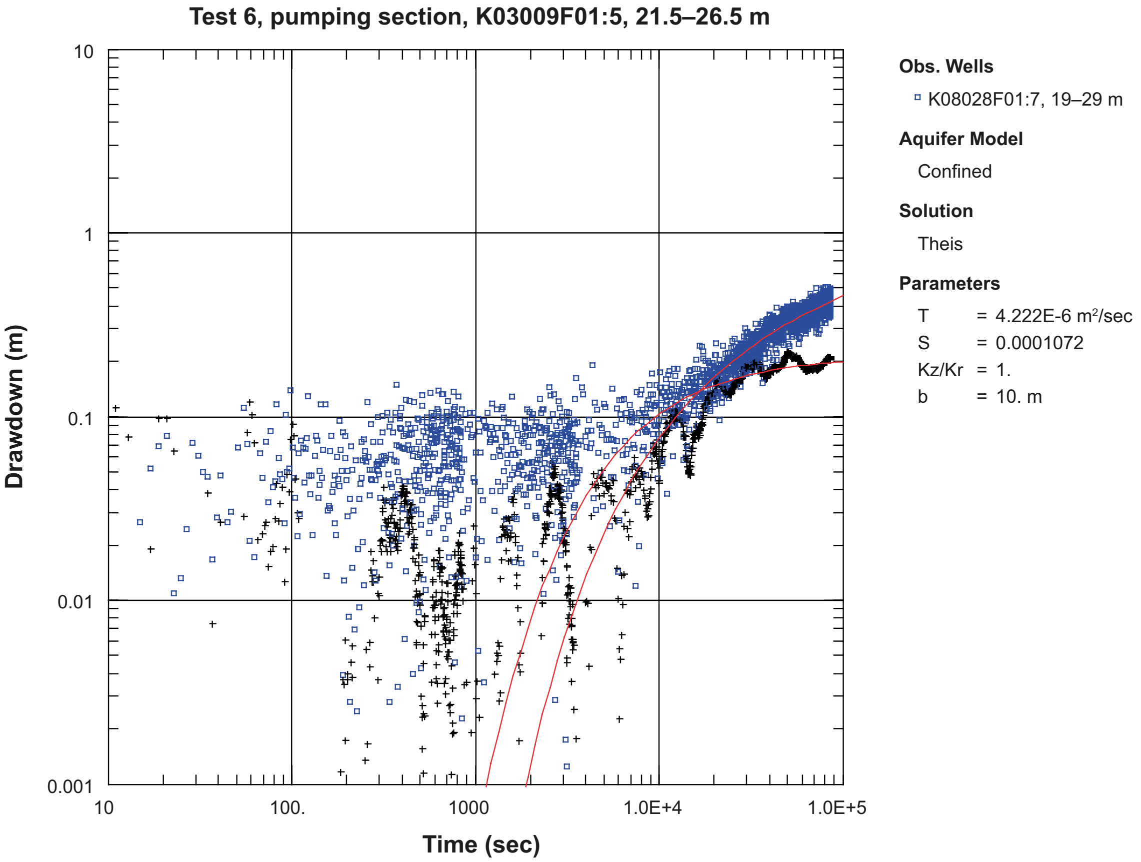
Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
100
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01:6, 18.5–20.5 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.956E-6 m²/sec
S = 2.4E-6
Kz/Kr = 1.
b = 12.5 m


Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Drawdown (m)
Time (sec)
100
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01:4, 27.5–40 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.081E-6 m²/sec
S = 1.976E-7
Kz/Kr = 1.
b = 12.5 m

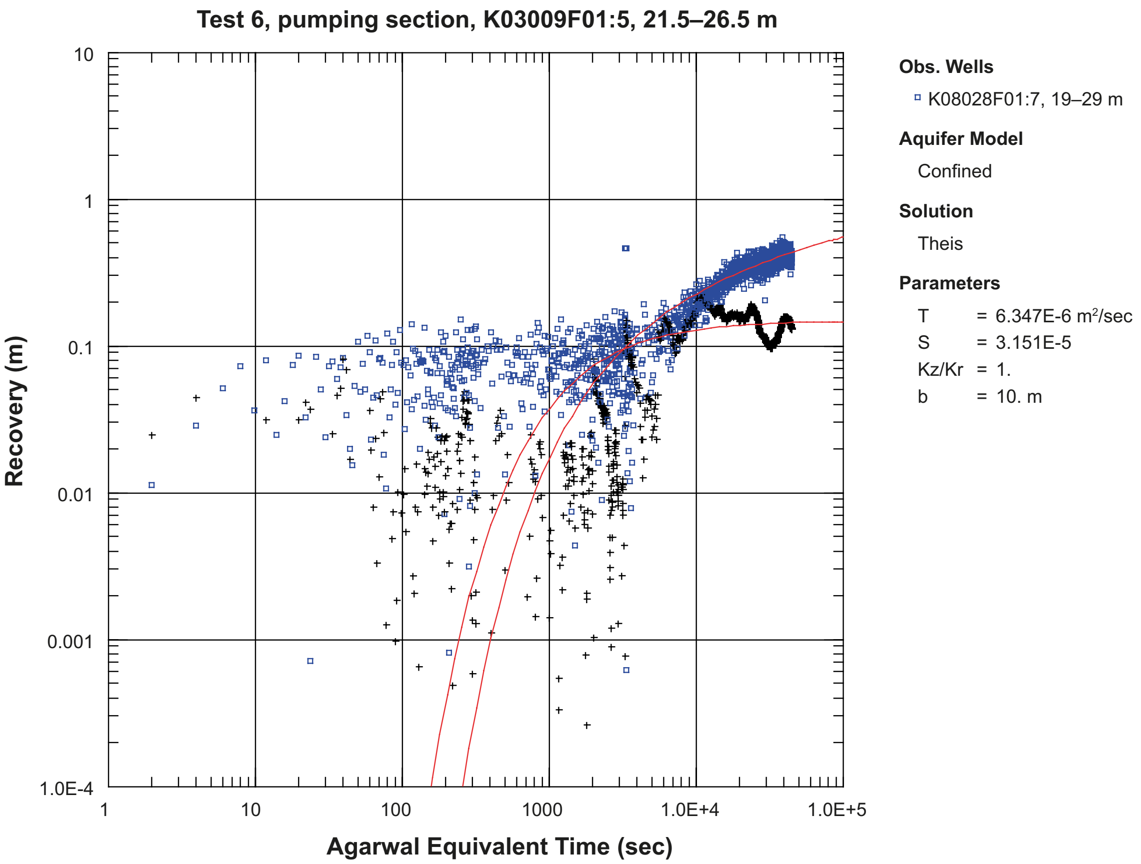

Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
100
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01:4, 27.5–40 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.484E-6 m²/sec
S = 2.228E-7
Kz/Kr = 1.
b = 12.5 m


Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Drawdown (m)
Time (sec)
100
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01:3, 41–60 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.236E-6 m²/sec
S = 2.043E-8
Kz/Kr = 1.
b = 19. m

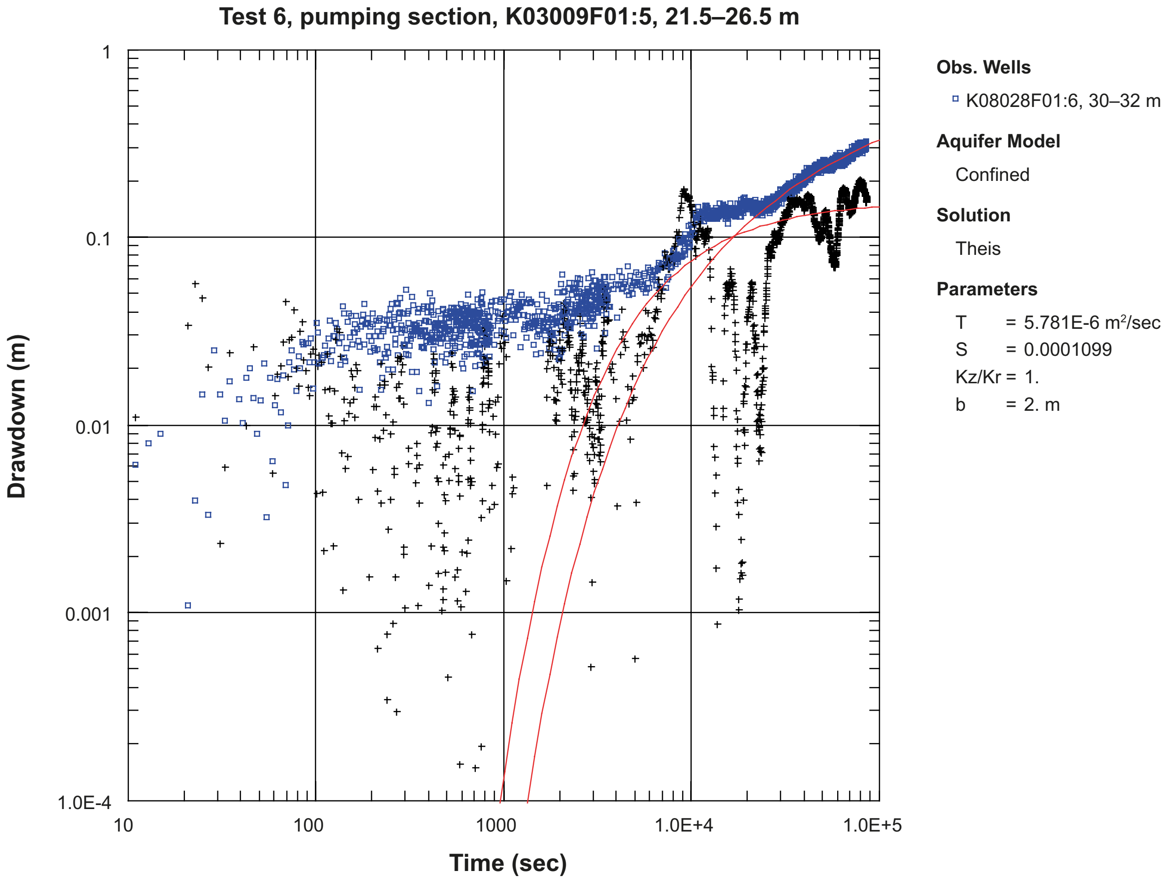

Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
100
10
1
0.1
0.01
0.001
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01:3, 41–60 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.632E-6 m²/sec
S = 2.646E-8
Kz/Kr = 1.
b = 19. m

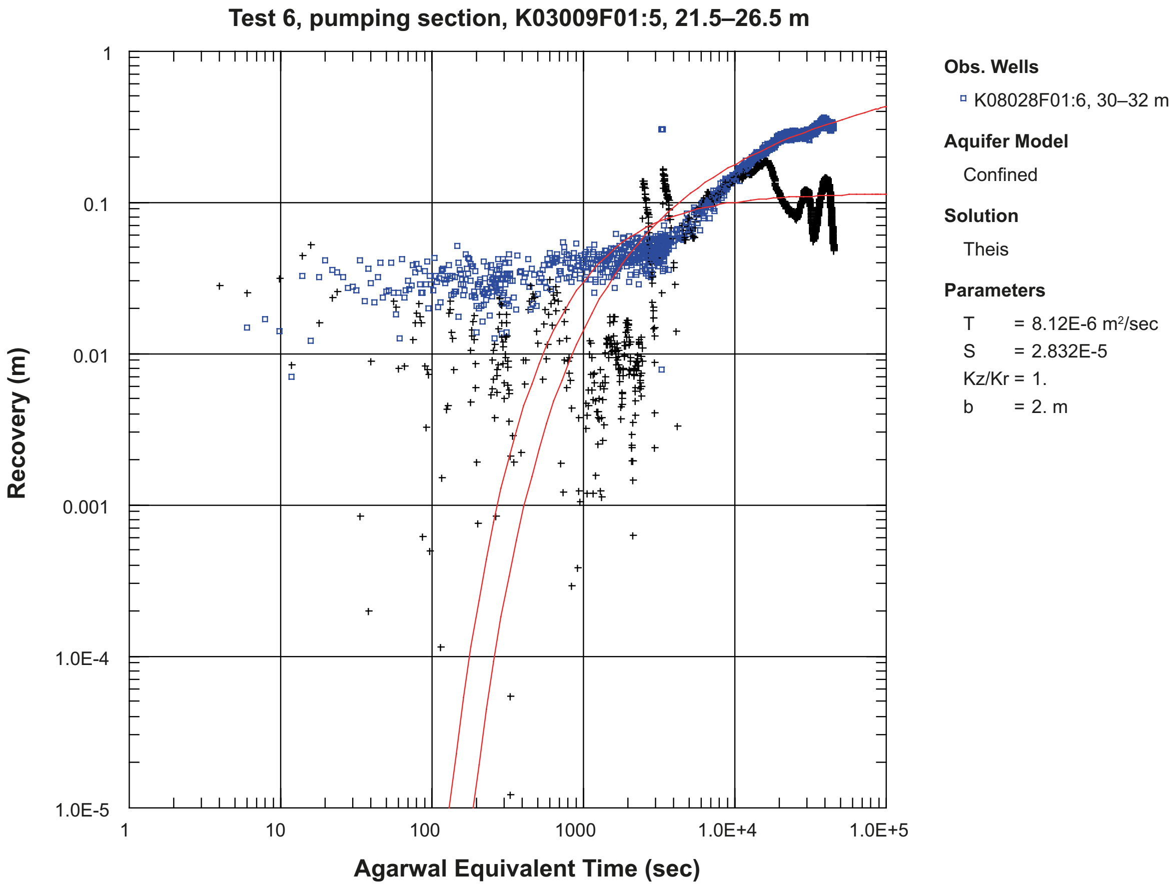


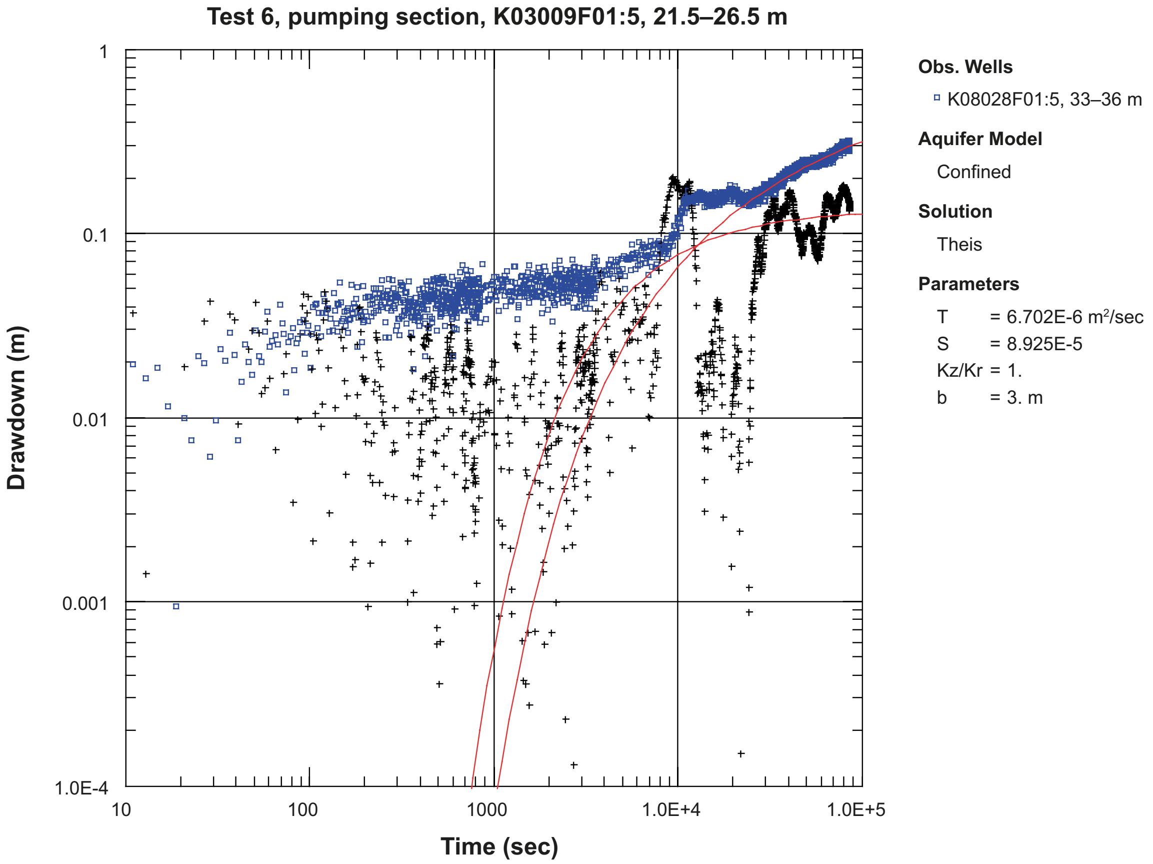
Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Drawdown (m)
Time (sec)
10
1
0.1
0.01
0.001
10
100.
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:7, 19–29 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 4.222E-6 m²/sec
S = 0.0001072
Kz/Kr = 1.
b = 10. m

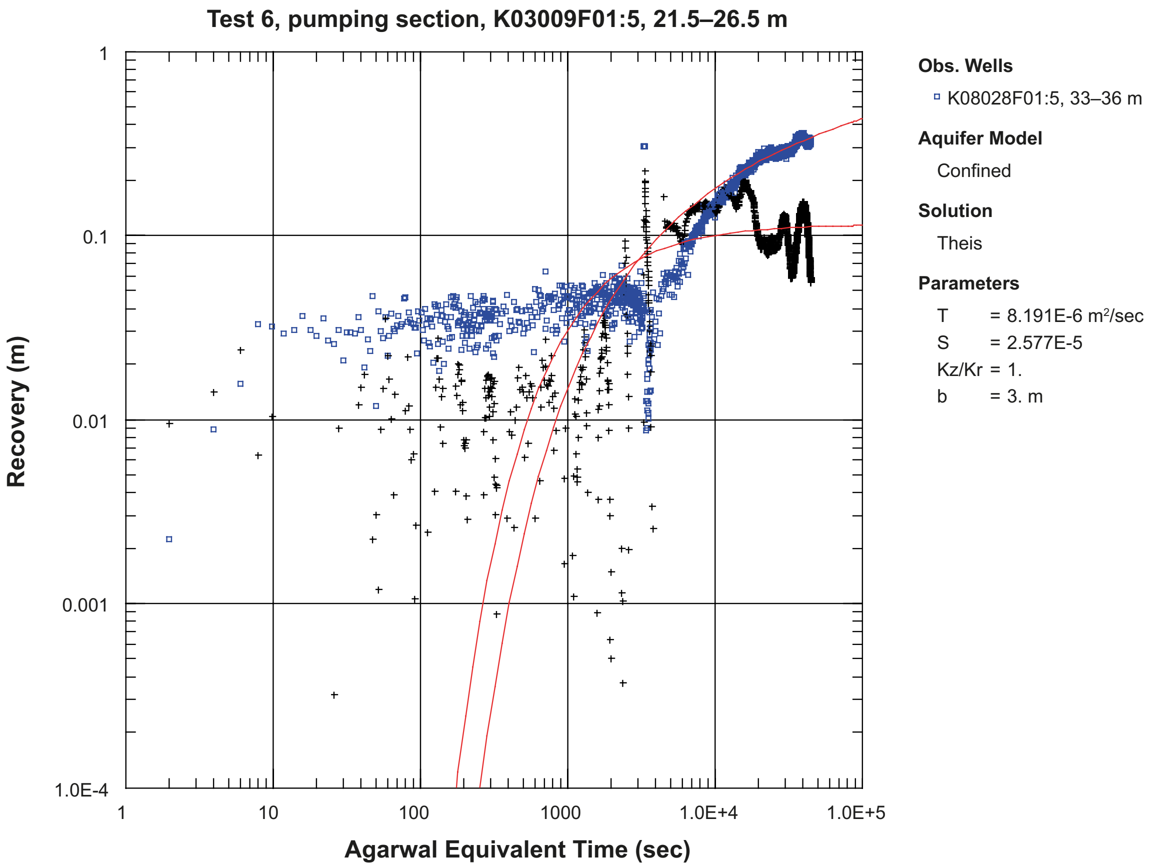


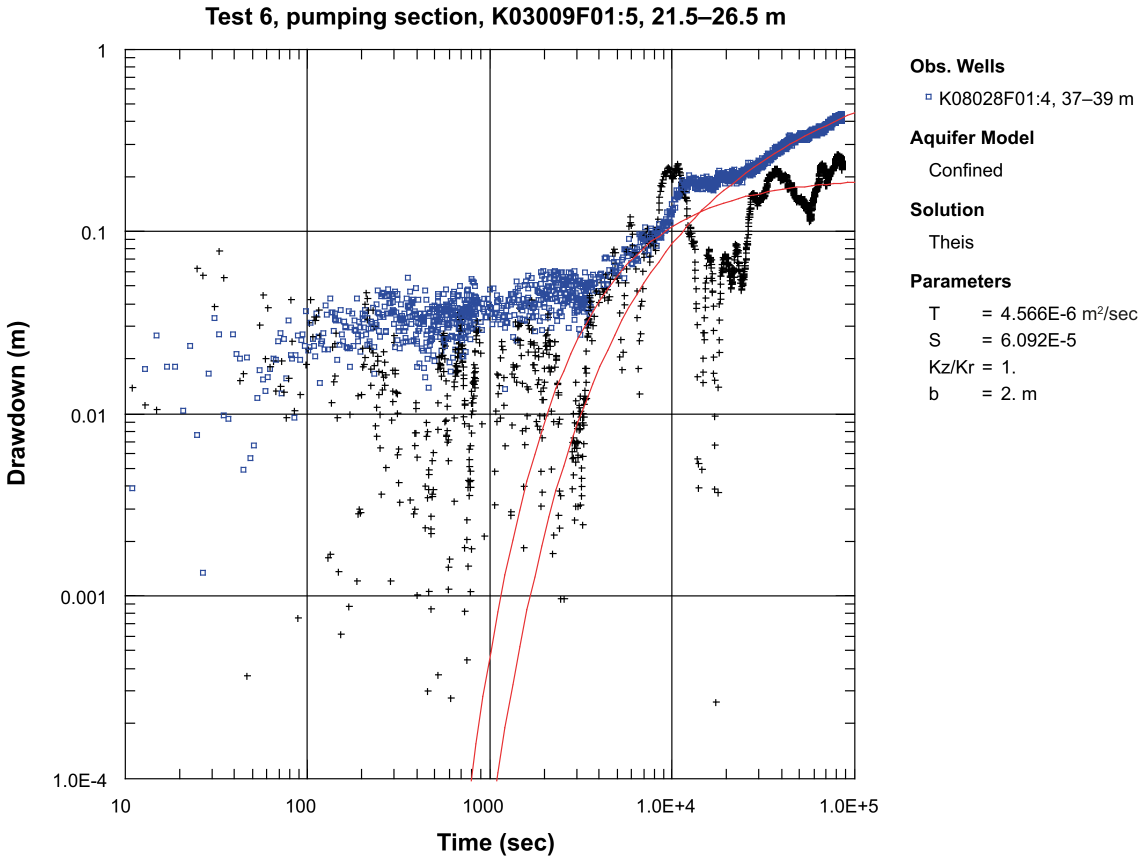
Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
10
1
0.1
0.01
0.001
1.0E-4
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:7, 19–29 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.347E-6 m²/sec
S = 3.151E-5
Kz/Kr = 1.
b = 10. m

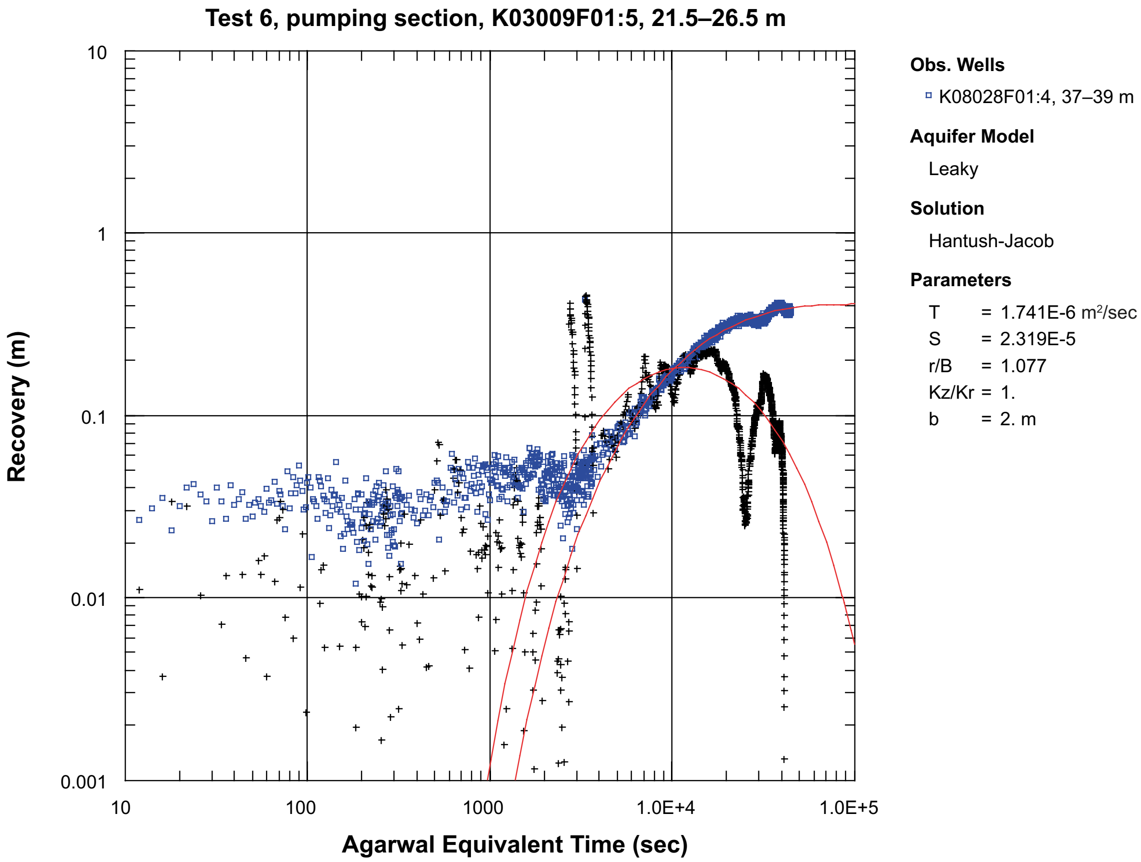

Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Drawdown (m)
Time (sec)
1
0.1
0.01
0.001
1.0E-4
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:6, 30–32 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 5.781E-6 m²/sec
S = 0.0001099
Kz/Kr = 1.
b = 2. m


Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
1
0.1
0.01
0.001
1.0E-4
1.0E-5
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:6, 30–32 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 8.12E-6 m²/sec
S = 2.832E-5
Kz/Kr = 1.
b = 2. m

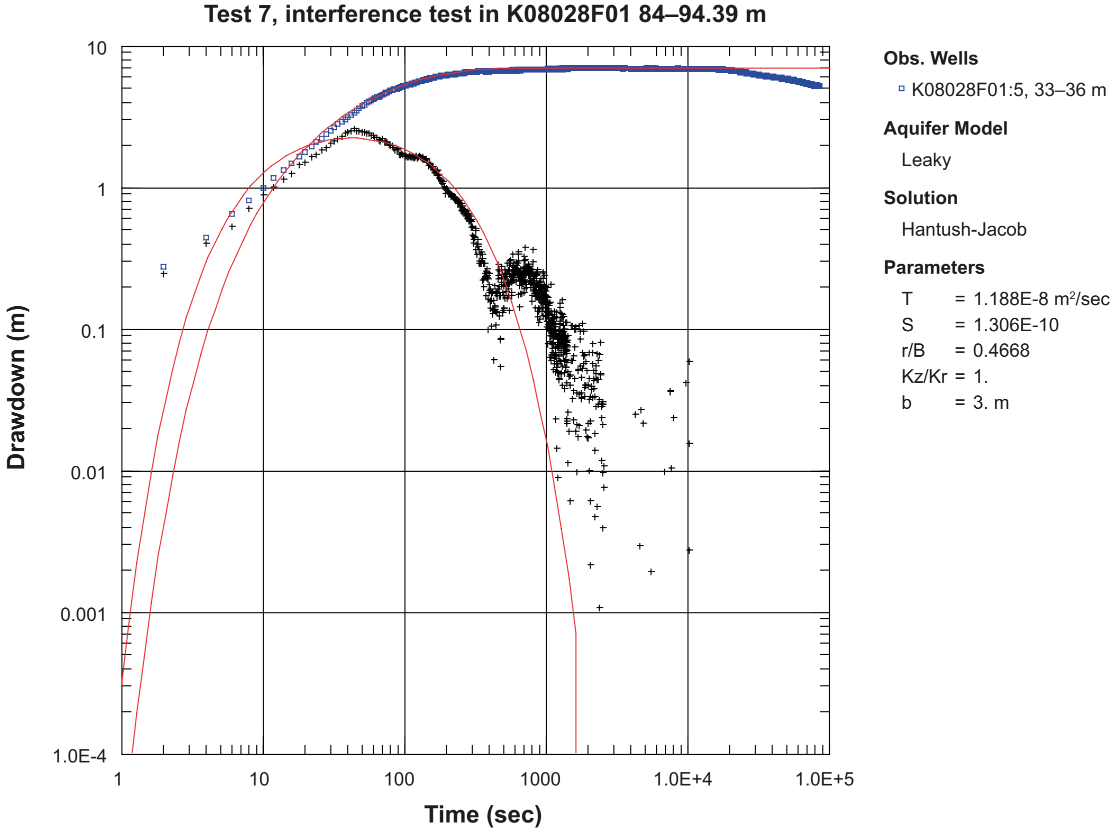

Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Drawdown (m)
Time (sec)
1
0.1
0.01
0.001
1.0E-4
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:5, 33–36 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 6.702E-6 m²/sec
S = 8.925E-5
Kz/Kr = 1.
b = 3. m

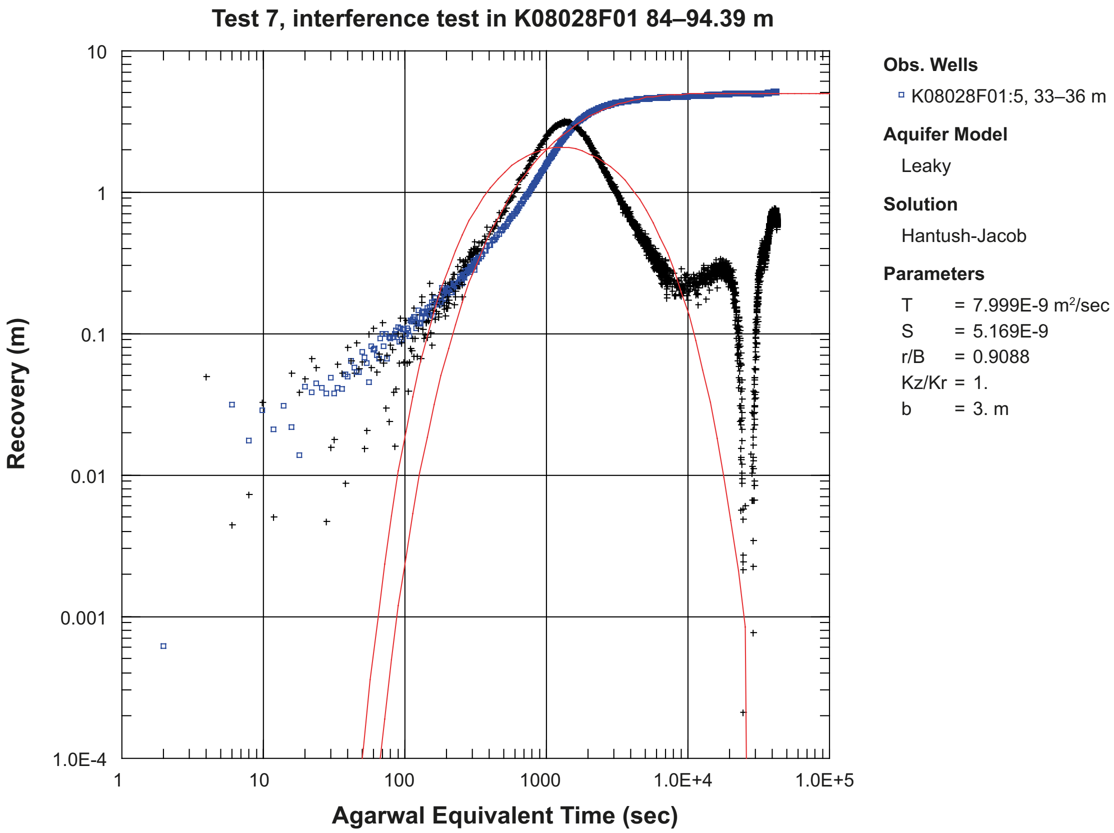

Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Recovery (m)
Agarwal Equivalent Time (sec)
1
0.1
0.01
0.001
1.0E-4
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K08028F01:5, 33–36 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 8.191E-6 m²/sec
S = 2.577E-5
Kz/Kr = 1.
b = 3. m

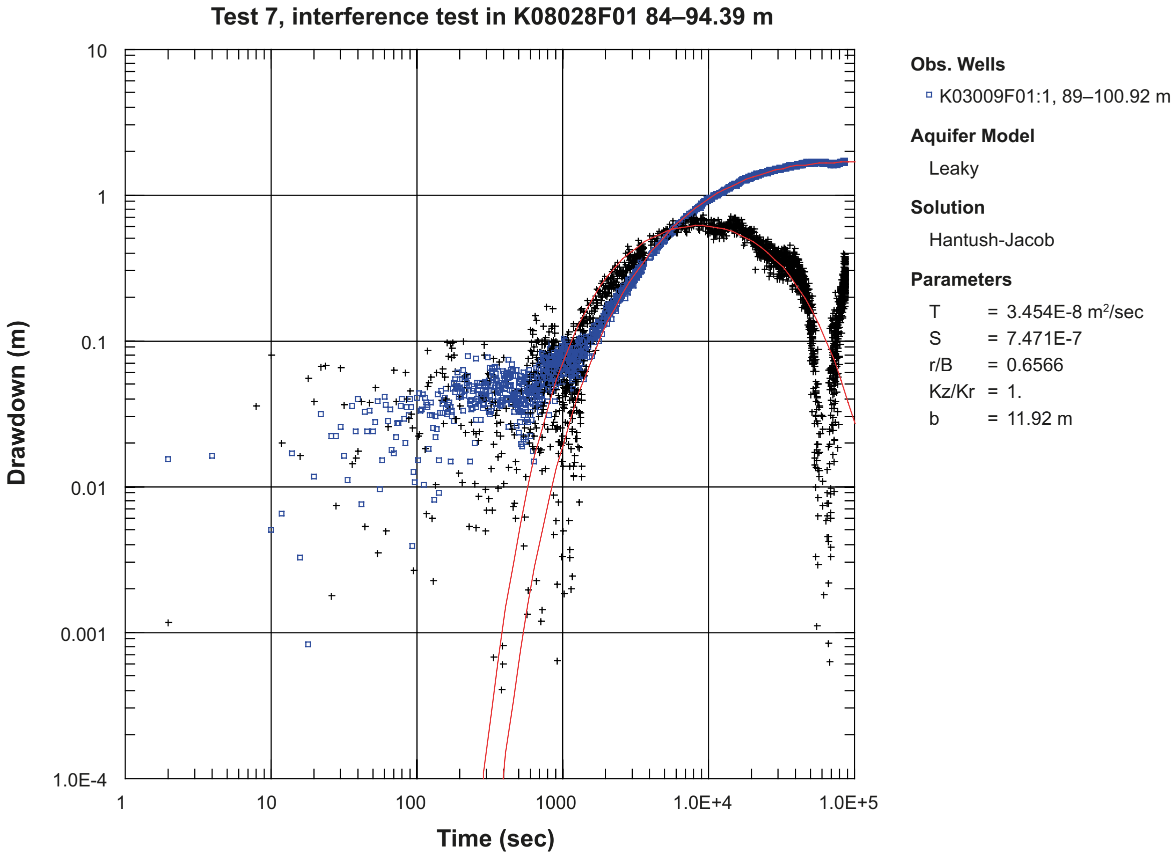

Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Drawdown (m)
1
0.1
0.01
0.001
1.0E-4
10
100
1000
1.0E+4
1.0E+5
Time (sec)
Obs. Wells
K08028F01:4, 37–39 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 4.566E-6 m²/sec
S = 6.092E-5
Kz/Kr = 1.
b = 2. m


Test 6, pumping section, K03009F01:5, 21.5–26.5 m
Recovery (m)
10
1
0.1
0.01
0.001
10
100
1000
1.0E+4
1.0E+5
Agarwal Equivalent Time (sec)
Obs. Wells
K08028F01:4, 37–39 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 1.741E-6 m²/sec
S = 2.319E-5
r/B = 1.077
Kz/Kr = 1.
b = 2. m

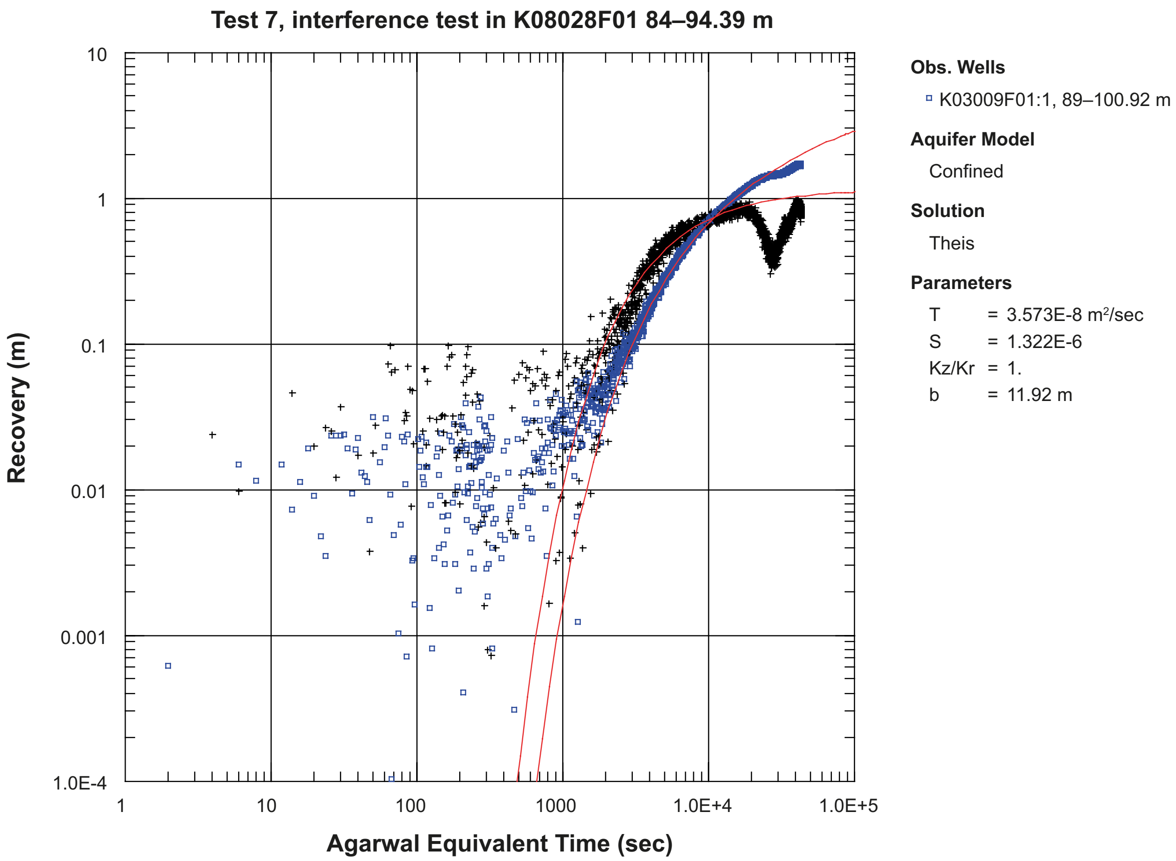
Test no 7. Interference test in K08028F01 84–94.39 m





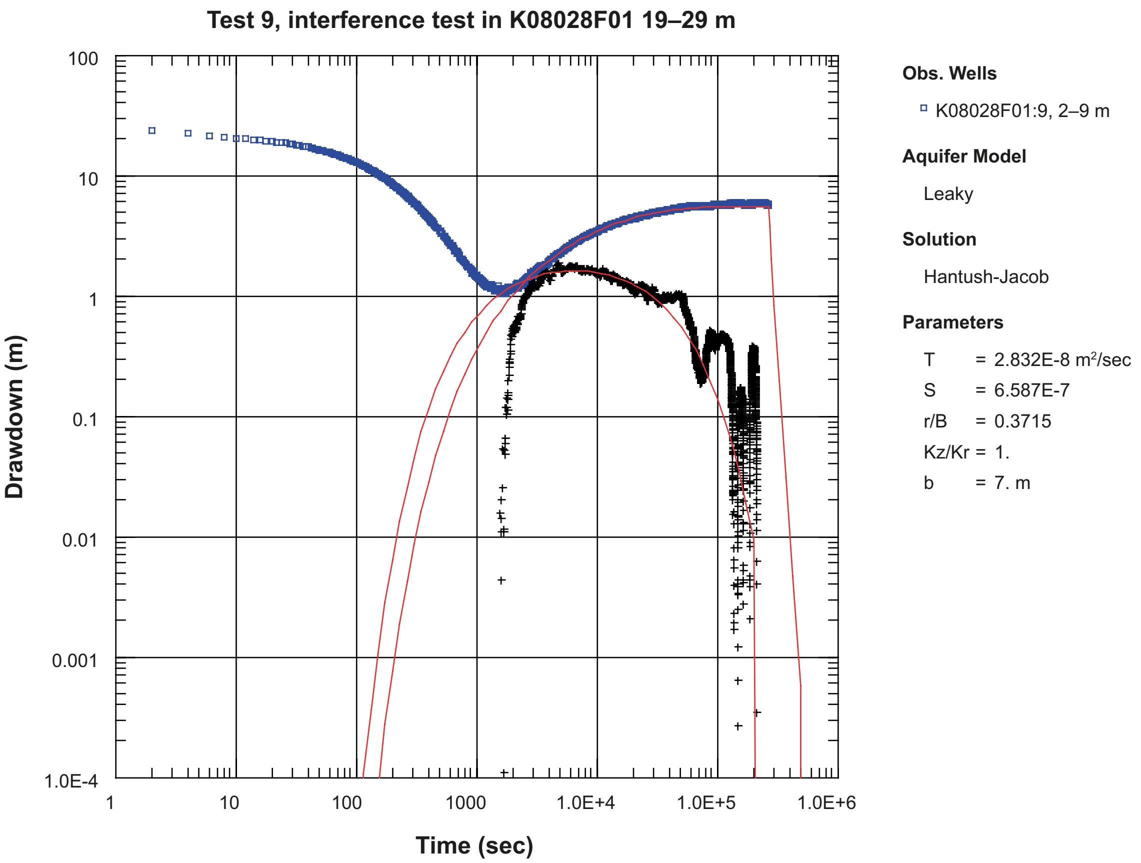


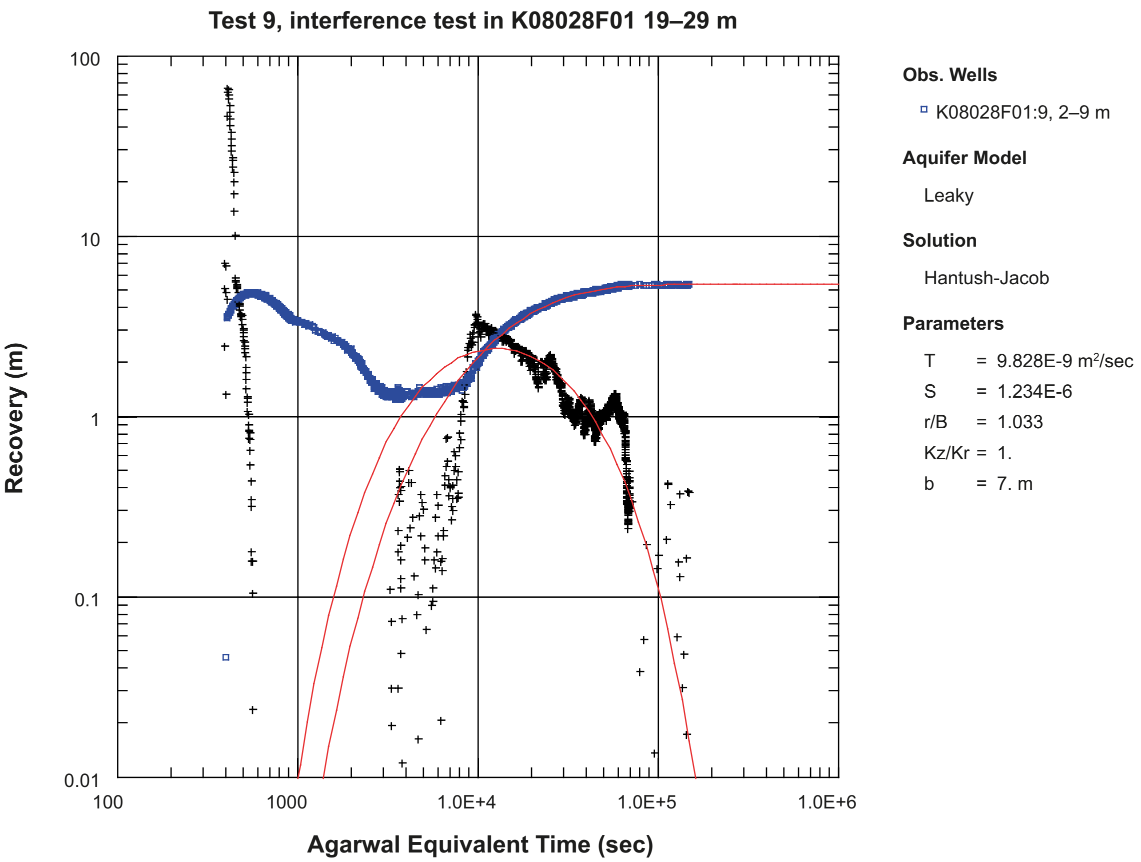
Test 7, interference test in K08028F01 84–94.39 m
Drawdown (m)
Time (sec)
10
1
0.1
0.01
0.001
1.0E-4
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01:1, 89–100.92 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 3.454E-8 m²/sec
S = 7.471E-7
r/B = 0.6566
Kz/Kr = 1.
b = 11.92 m

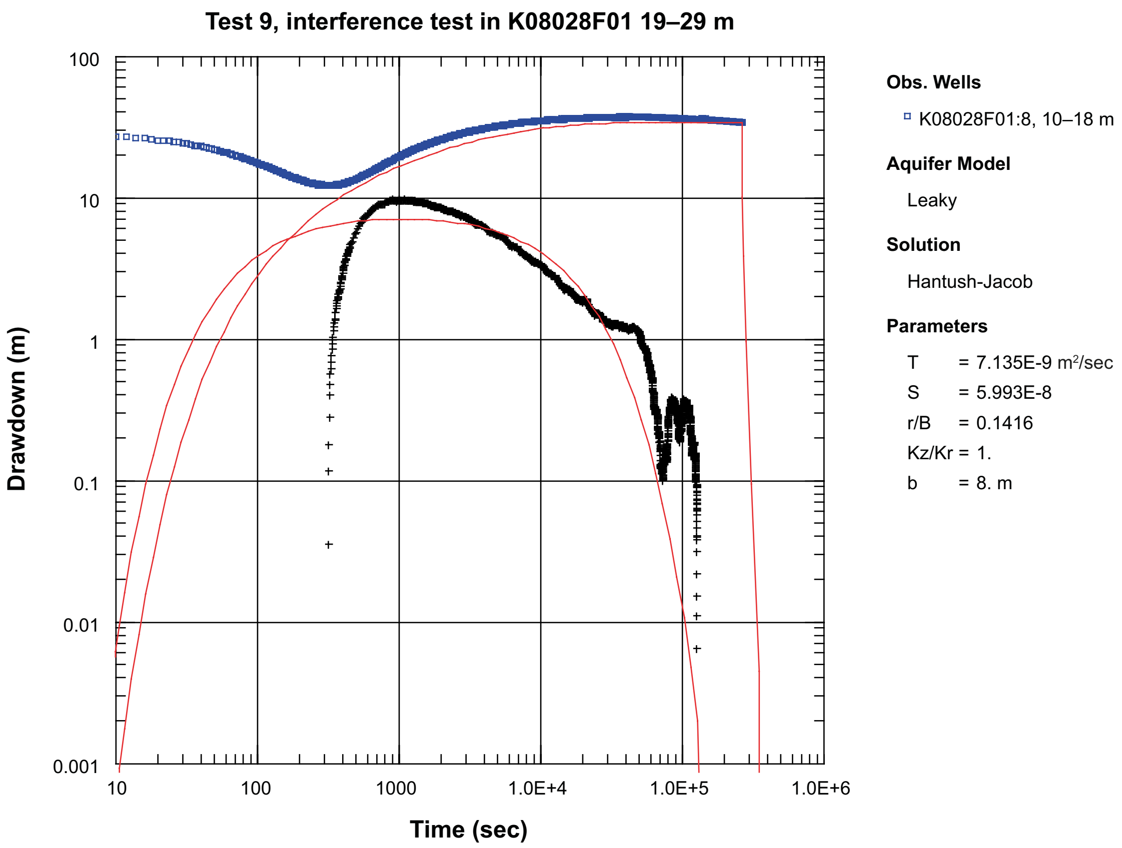


Test 7, interference test in K08028F01 84–94.39 m
Recovery (m)
Agarwal Equivalent Time (sec)
10
1
0.1
0.01
0.001
1.0E-4
1
10
100
1000
1.0E+4
1.0E+5
Obs. Wells
K03009F01:1, 89–100.92 m
Aquifer Model
Confined
Solution
Theis
Parameters
T = 3.573E-8 m²/sec
S = 1.322E-6
Kz/Kr = 1.
b = 11.92 m

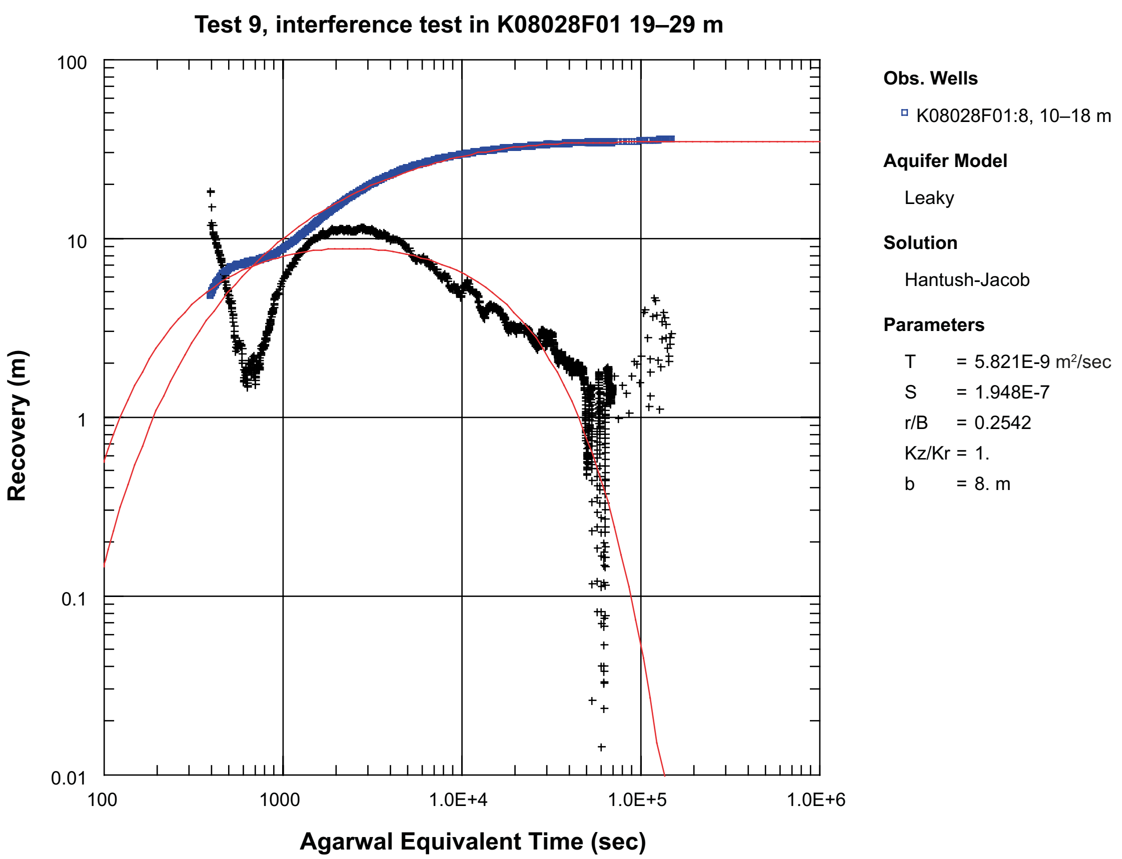
Test no 9. Interference test in K08028F01 19–29 m



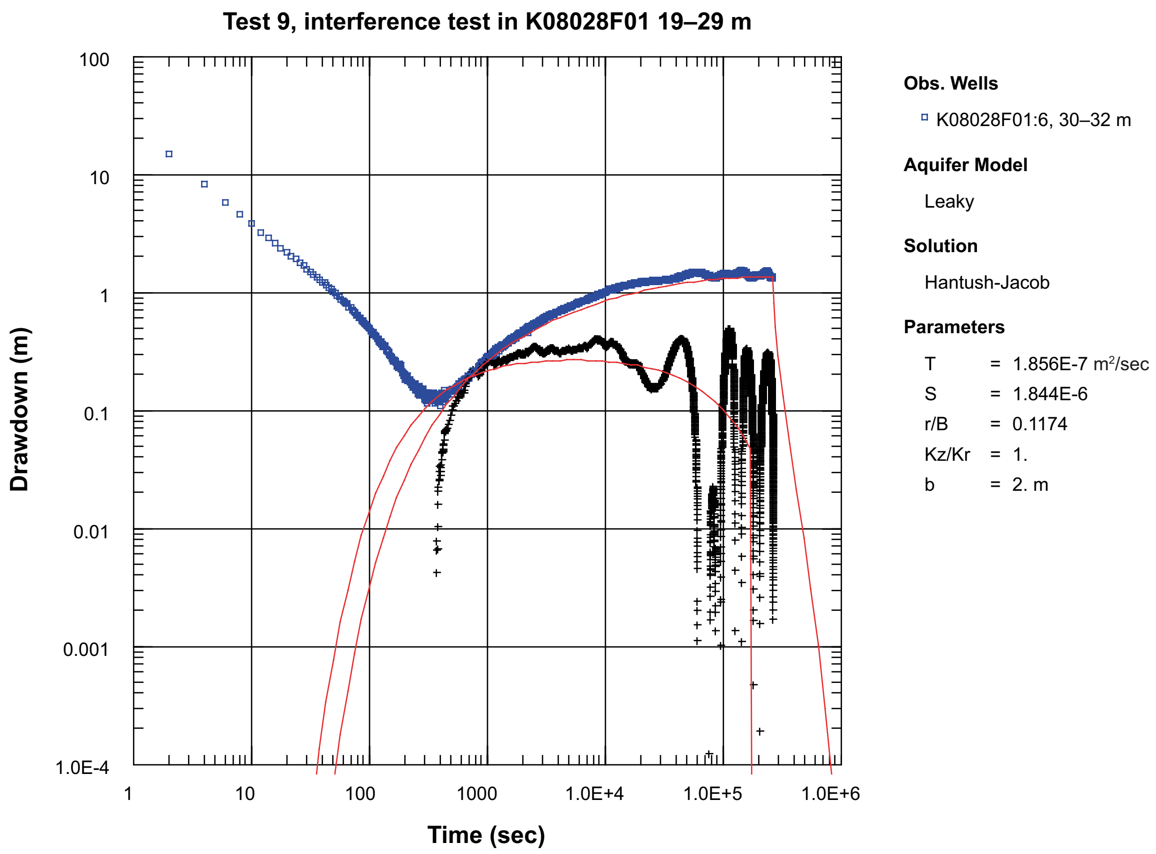


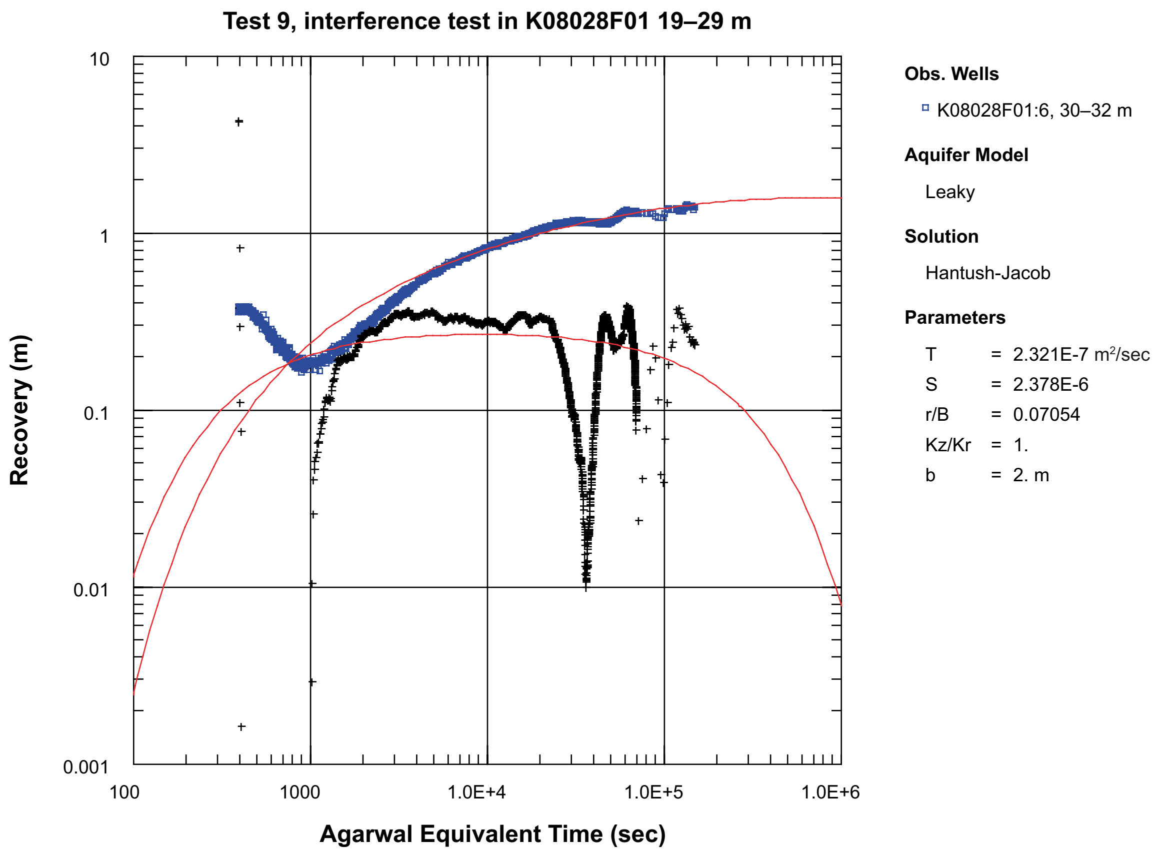


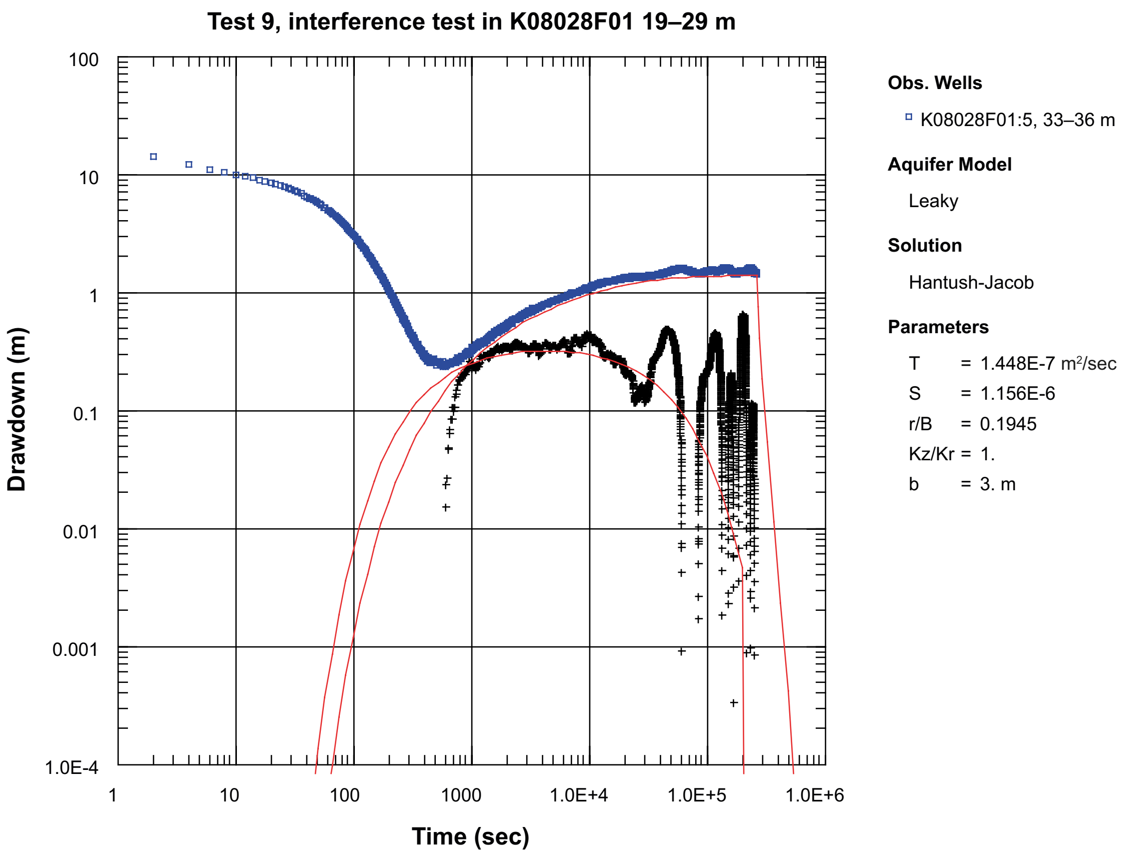
Test 9, interference test in K08028F01 19–29 m
Drawdown (m)
Time (sec)
100
10
1
0.1
0.01
0.001
10
100
1000
1.0E+4
1.0E+5
1.0E+6
Obs. Wells
K08028F01:8, 10–18 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 7.135E-9 m²/sec
S = 5.993E-8
r/B = 0.1416
Kz/Kr = 1.
b = 8. m

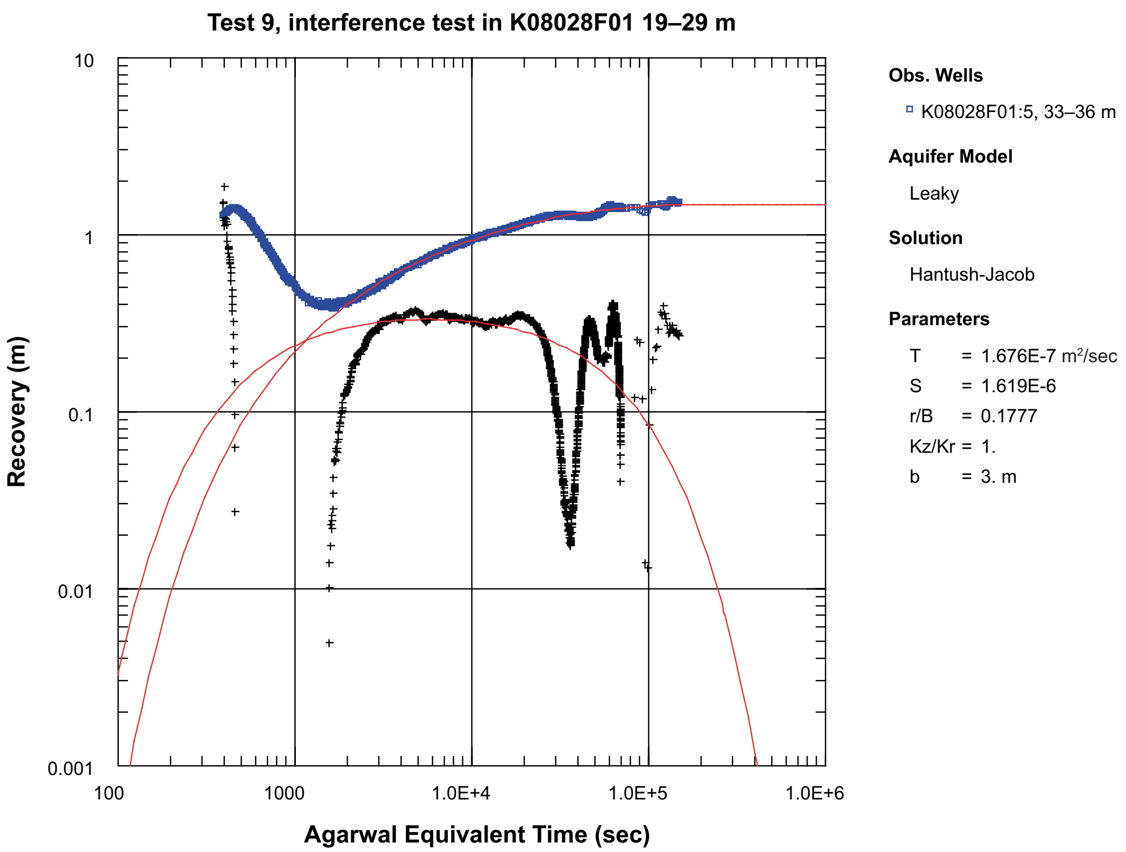


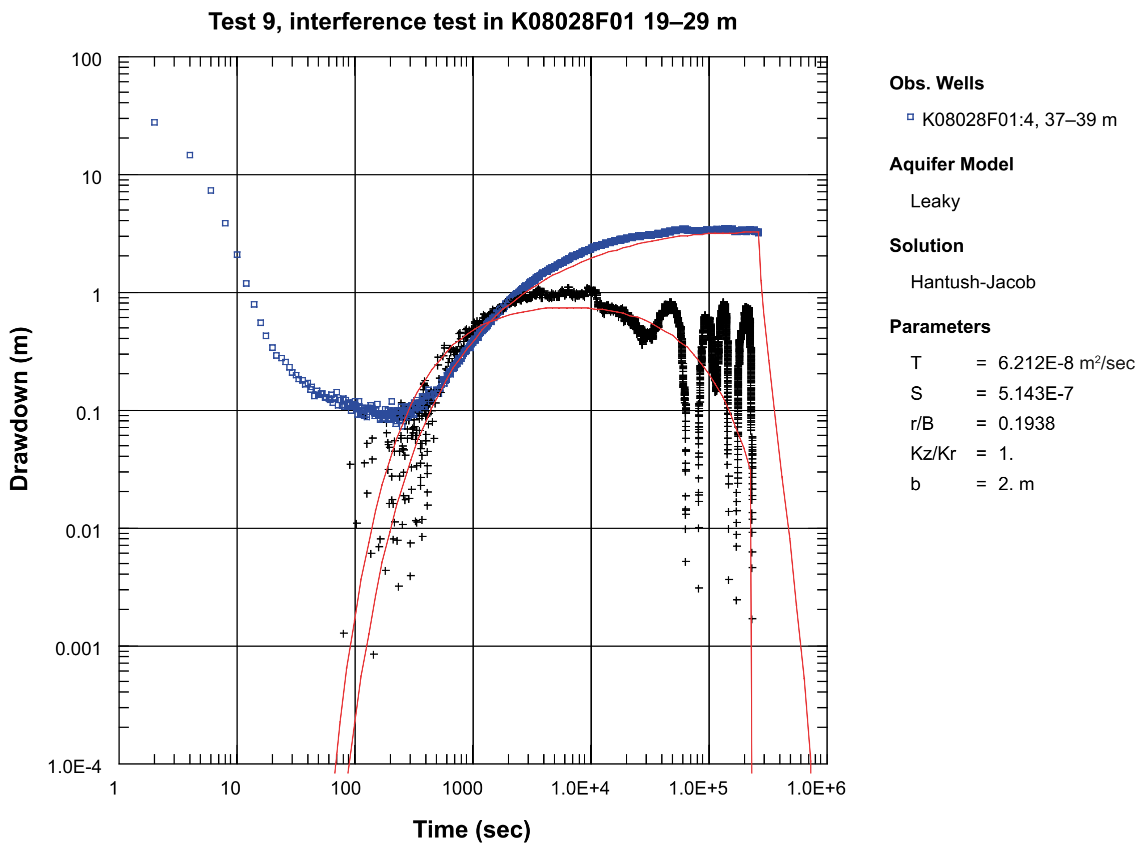
Test 9, interference test in K08028F01 19–29 m
Recovery (m)
Agarwal Equivalent Time (sec)
100
10
1
0.1
0.01
100
1000
1.0E+4
1.0E+5
1.0E+6
Obs. Wells
K08028F01:8, 10–18 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 5.821E-9 m²/sec
S = 1.948E-7
r/B = 0.2542
Kz/Kr = 1.
b = 8. m

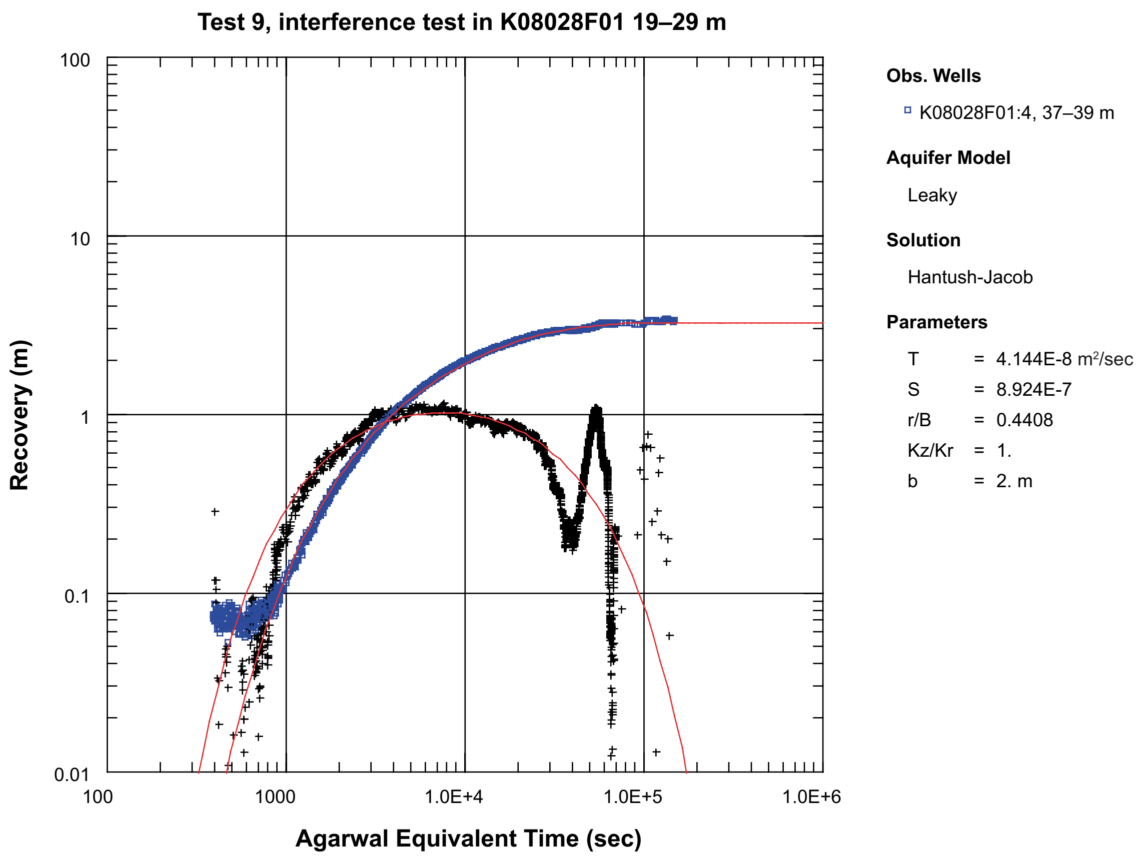

Test 9, interference test in K08028F01 19–29 m
Drawdown (m)
Time (sec)
100
10
1
0.1
0.01
0.001
1.0E-4
1
10
100
1000
1.0E+4
1.0E+5
1.0E+6
Obs. Wells
K08028F01:6, 30–32 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 1.856E-7 m²/sec
S = 1.844E-6
r/B = 0.1174
Kz/Kr = 1.
b = 2. m


Test 9, interference test in K08028F01 19–29 m
Recovery (m)
Agarwal Equivalent Time (sec)
10
1
0.1
0.01
0.001
100
1000
1.0E+4
1.0E+5
1.0E+6
Obs. Wells
K08028F01:6, 30–32 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 2.321E-7 m²/sec
S = 2.378E-6
r/B = 0.07054
Kz/Kr = 1.
b = 2. m


Test 9, interference test in K08028F01 19–29 m
Drawdown (m)
100
10
1
0.1
0.01
0.001
1.0E-4
1
10
100
1000
1.0E+4
1.0E+5
1.0E+6
Time (sec)
Obs. Wells
K08028F01:5, 33–36 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 1.448E-7 m²/sec
S = 1.156E-6
r/B = 0.1945
Kz/Kr = 1.
b = 3. m


Test 9, interference test in K08028F01 19–29 m
Recovery (m)
10
1
0.1
0.01
0.001
100
1000
1.0E+4
1.0E+5
1.0E+6
Agarwal Equivalent Time (sec)
Obs. Wells
K08028F01:5, 33–36 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 1.676E-7 m²/sec
S = 1.619E-6
r/B = 0.1777
Kz/Kr = 1.
b = 3. m


Test 9, interference test in K08028F01 19–29 m
Drawdown (m)
100
10
1
0.1
0.01
0.001
1.0E-4
1
10
100
1000
1.0E+4
1.0E+5
1.0E+6
Time (sec)
Obs. Wells
K08028F01:4, 37–39 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 6.212E-8 m²/sec
S = 5.143E-7
r/B = 0.1938
Kz/Kr = 1.
b = 2. m


Test 9, interference test in K08028F01 19–29 m
Recovery (m)
100
10
1
0.1
0.01
100
1000
1.0E+4
1.0E+5
1.0E+6
Agarwal Equivalent Time (sec)
Obs. Wells
K08028F01:4, 37–39 m
Aquifer Model
Leaky
Solution
Hantush-Jacob
Parameters
T = 4.144E-8 m²/sec
S = 8.924E-7
r/B = 0.4408
Kz/Kr = 1.
b = 2. m

Pressure responses in surrounding boreholes during the interference tests

Table A4-1. Pressure responses in surrounding boreholes during the interference tests. Y (green) indicates sections with a clear response, P (indigo) indicates sections with a probable response and N (grey) indicates sections with no response. For test nr 1–2 and 7–9 performed with pumping in K08028F01 and K03009F01:1 no pressure responses were found in any of the surrounding boreholes.

Pumping section	Test nr	3	4	5	6
	Borehole ID	K03009F01	K03009F01	K03009F01	K03009F01
	Secno	6	4	7	5
	Secup	18.5	25.5	14.5	21.5
	Seclow	20.5	38	17.5	24.5
Observation section					
Borehole	**Secno**				
KA2050A	1	Y	Y	Y	Y
KA2050A	2	Y	Y	Y	Y
KA2050A	3	Y	Y	Y	Y
KA2051A1	1	P	N	N	N
KA2051A1	2	Y	N	P	P
KA2051A1	3	Y	N	P	P
KA2051A1	4	Y	P	P	P
KA2051A1	5	Y	Y	Y	Y
KA2051A1	6	Y	Y	Y	Y
KA2051A1	7	Y	Y	Y	Y
KA2051A1	8	Y	Y	Y	Y
KA2051A1	9	Y	P	P	P
KA2051A1	10	P	P	P	Y
KA2058A	2	N	N	N	N
KA2862A	1	P	N	N	N
KA3005A	1	Y	Y	Y	Y
KA3105A	1	Y	Y	Y	Y
KA3105A	2	Y	N	N	N
KA3105A	3	Y	N	N	N
KA3105A	4	Y	N	N	N
KA3105A	5	N	N	N	N
KA3110A	1	N	N	N	N
KA3110A	2	N	N	N	N
KXTT1	1	Y	Y	Y	Y
KXTT1	2	Y	Y	Y	Y
KXTT1	3	Y	P	N	N
KXTT1	4	N	N	N	N
KXTT2	1	Y	Y	Y	Y
KXTT2	2	Y	Y	Y	Y
KXTT2	3	Y	Y	Y	N
KXTT2	4	Y	P	P	N
KXTT2	5	Y	Y	P	N
KTT5	1	Y	Y	Y	Y
KTT5	2	Y	Y	Y	Y
KTT5	3	Y	Y	Y	Y
KTT5	4	Y	Y	P	P
HAS06	1	N	N	N	N
KA1755A	1	N	N	N	N

Pumping section	**Test nr**	3	4	5	6
	Borehole ID	K03009F01	K03009F01	K03009F01	K03009F01
	Secno	6	4	7	5
	Secup	18.5	25.5	14.5	21.5
	Seclow	20.5	38	17.5	24.5
Observation section					
Borehole	**Secno**				
KA1755A	2	N	N	N	N
KA1755A	3	N	N	N	N
KA1755A	4	N	N	N	N
KA2048B	1	N	N	N	N
KA2048B	2	N	N	N	N
KA2048B	3	N	N	N	N
KA2048B	4	N	N	N	N

Arkitektkopia AB, Bromma, 2016

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