P-08-15

Oskarshamn site investigation

Evaluation of hydraulic interference tests, pumping borehole KLX19A

Subarea Laxemar

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Keywords: Site/project, Hydrogeology, Hydraulic tests, Pump tests, Interference tests, Hydraulic parameters, Transmissivity.

Abstract

Hydraulic interference tests have been performed at the Laxemar area in the active pumping borehole KLX19A in two different sections. During the pumping phase the pressure response in 15 observation boreholes was monitored in up to three different intervals per borehole, which were separated with packers. The tests are part of the general program for site investigations and specifically for the Laxemar subarea. Subsequent to the interference tests, hydraulic injection tests in 100 m, 20 m and 5 m intervals were performed (see report P-07-90). The hydraulic testing programme has the aim to characterise the rock with respect to its hydraulic properties and the interference tests have the purpose to resolve hydraulic connectivity in the fracture network, especially related to the major fracture zone NW042. Data is subsequently delivered for the site descriptive model.

This report describes the results and primary data evaluation of the interference tests in borehole KLX19A performed between 28th of November 2006 and 09th of January 2007. The data of the observation boreholes were delivered by SKB.

The main objective of the interference testing was to characterize the rock around the borehole with special respect to connectivity of lineaments. Transient evaluation of the flow and recovery period of the constant rate interference pump tests provided additional information such as transmissivities, flow regimes and hydraulic boundaries.

Sammanfattning

Hydrauliska interferenstester har utförts i Laxemarområdet med pumpning i borrhål KLX19A i två sektioner. Under pumpningen har tryckresponsen uppmätts i 15 observationshål i upp till tio sektioner per borrhål med dubbelmanschett. Före interferenstesterna utfördes hydrauliska injektionstester om 100 m, 20 m och 5 m sektioner (se rapport P-07-90). Hydraultestprogrammet har som mål att karakterisera berget utifrån dess hydrauliska egenskaper och interferenstesterna har som syfte att undersöka konnektiviteten mellan sprickzoner. Erhållna data utgör sedan indata för den platsspecifika modellen.

Följande rapport redovisar resultaten och primärdata från utvärderingen av interferenstesterna i borrhål KLX19A utförda mellan den 28 November 2006 till den 09 Januari 2006. Data från observationshålen levererades av SKB.

Huvudsyftet med interferenstesterna var att karakterisera berget i anslutning till borrhålet med avseende på konnektivitet mellan olika lineament. Transient utvärdering av flödes- och återhämtningsfasen för pumptesterna utförda med konstant flöde vid interferenstesten har givit ytterligare information med avseende på transmissivitet, flödesregim och hydrauliska gränser.

Contents

1 Introduction

A general program for site investigations presenting survey methods has been prepared /SKB 2001a/ as well as a site specific program for the investigations in the Laxemar area /SKB 2006/. The hydraulic interference tests form part of the site characterization program in the work breakdown structure of the execution program /SKB 2002/. The execution of the investigations is basically controlled through a general program /SKB 2001a/ and a program specifically for the Oskarshamn location /SKB 2001b/.

This document reports the results gained by the hydraulic interference tests (pumping tests) performed in borehole KLX19A, which is one of the activities performed within the site investigation at Oskarshamn. The pump tests were carried out in accordance with activity plan (AP PS 400-06-144). The evaluation of the tests was carried out in accordance with activity plan AP PS 400-07-72. In Table 1-1 controlling documents for performing the work are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

Hydraulic interference tests (pumping tests) have been performed in borehole KLX19A in two different sections with section lengths of 20 m and 5 m. Both sections were separated with packers above and below. Monitoring of pressure response was carried out by SKB in 15 additional boreholes (see Figure 1-1), monitoring data were delivered by SKB for further analyses.

Measurements were carried out between 28th of November 2006 and 9th of January 2007 following the methodologies described in SKB MD 321.003 (pump tests), SKB MD 330.003 (interference tests), the activity plan AP PS 400-07-72 (SKB internal controlling documents) specifying in detail the interference tests campaign. Data and results were delivered to the SKB site characterization database SICADA where they are traceable by the activity plan number /Enachescu et al. 2007/.

The hydraulic testing programme has the aim to characterise the rock with respect to its hydraulic properties of the fractured zones and rock mass between them. This report describes the results and primary data evaluation of the interference tests in borehole KLX19A. The commission was conducted by Golder Associates AB and Golder Associates GmbH.

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

Activity plan	Number	Version
Utvärdering och rapportering av interferenstester I KLX27A och KLX19A	AP PS 400-07-72	1.0
Hydraulic injection tests and water sampling in borehole KLX19A	AP PS 400-06-144	1.0
Method descriptions	**Number**	**Version**
Analysis of injection and single-hole pumping tests	SKB MD 320.004e	1.0
Hydraulic injection tests	SKB MD 323.001	1.0
Metodbeskrivning för Interferenstester	SKB MD 330.003	1.0
Metodbeskrivning för hydrauliska enhålspumptester	SKB MD 321.003	1.0
Instruktion för rengöring av borrhålsutrustning och viss markbaserad utrustning.	SKB MD 600.004	1.0
Instruktion för längdkalibrering vid undersökningar i kärnborrhål	SKB MD 620.010	1.0
Allmäna ordning-, skydds- och miljöregler för platsundersökningar Oskarshamn.	SKB SDPO-003	1.0
Miljökontrollprogram Platsundersökningar	SKB SDP-301	1.0
Hantering av primärdata vid platsundersökningar	SKB SDP-508	1.0

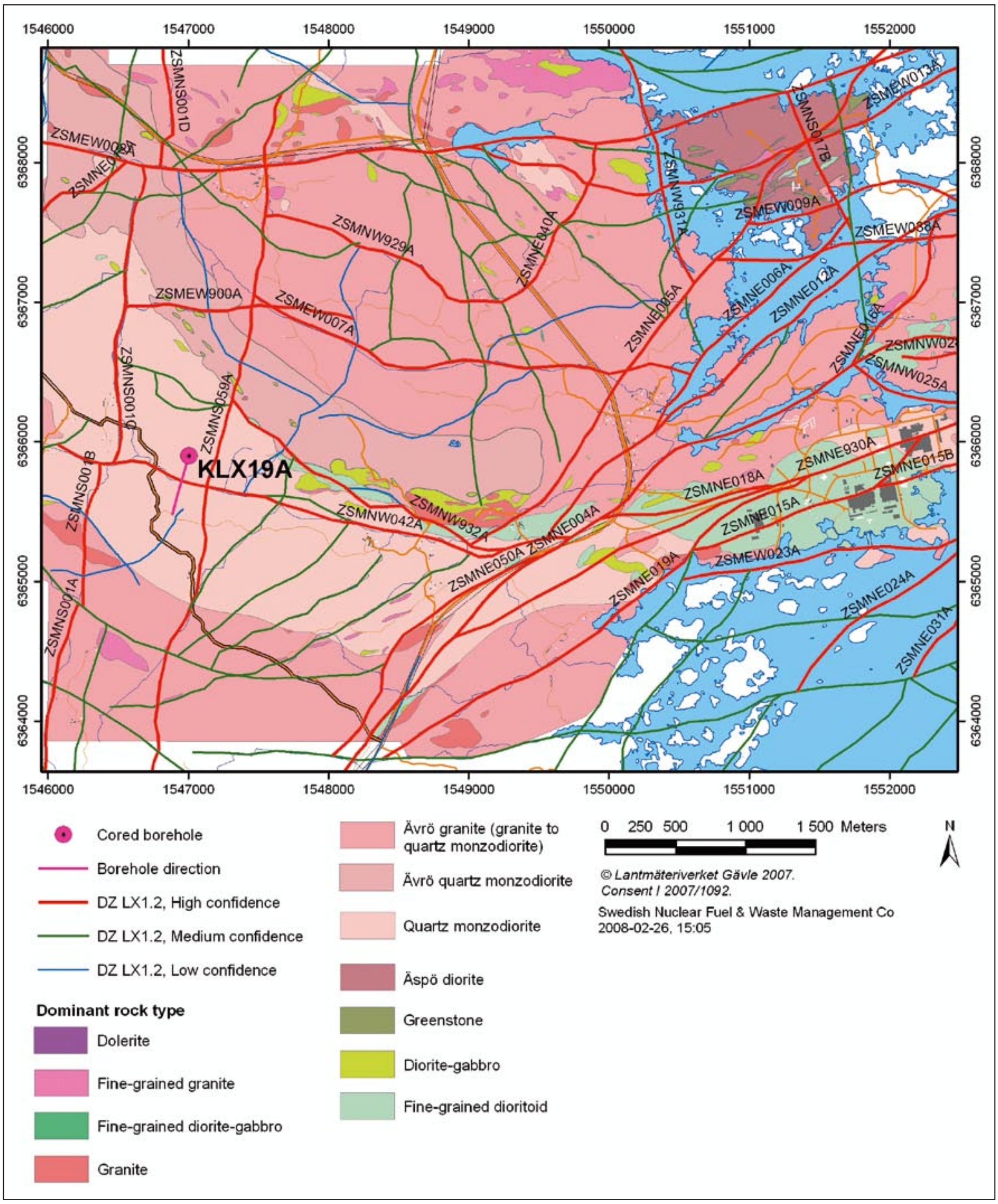

Figure 1-1. *The investigation area Laxemar, Oskarshamn with location of borehole KLX19A.*

Borehole KLX19A is situated in the Laxemar area approximately 3 km west of the nuclear power plant of Simpevarp, Figure 1-1. The borehole was drilled from May 2006 to September 2006 at 800.07 m length with an inner diameter of 76 mm and an inclination of –57.78°. The upper 98.75 m is cased with large diameter telescopic casing ranging from diameter (outer diameter) 210–323 mm.

2 Objective and scope

The major objective with the pumping was to collect water samples, and as a spinn off the interference tests was allowed to resolve the hydraulic connectivity of the fracture network. A special additional objective of the interference tests was to resolve the hydraulic properties of the lineament NW042.

The scope of work consisted of the analysis and reporting for measurements in the observation boreholes, recorded, collected and delivered by SKB.

The following interference tests were performed between 28th of November 2006 and 09th of January 2007.

2.1 Conditions that possibly affect the observed responses besides responses due to the source intended to study

Besides the response due to the pumping in KLX19A (source) the observed responses were influenced by following effects:

- all observation holes were influenced by earth-tidal effects,
- some observed sections close to the surface were affected by a major rainfall on 01st of January 2007.

2.2 Pumped borehole

Technical data of the borehole KLX19A is shown in Table 2-2. The reference point in the borehole is the centre of top of casing (ToC), given as Elevation in the table below. The Swedish National coordinate system (RT90) is used in the x-y direction and RHB70 in the z-direction. Northing and Easting refer to the top of the boreholes at the ground surface.

Table 2-1. Performed test programme.

Borehole	Priority	Secup [mbToC]	Seclow [mbToC]	Seclen [m]	Duration Pumping [h]	Duration Recovery [h]
KLX19A	1	764.0	769.0	5.0	160.7	2.7
KLX19A	2	495.0	515.0	20.0	785.3	3.6
				Total:	946.0	6.3

Table 2-2. Information about KLX19A (from SICADA 2006-11-23).

Title	Value				
Old idcode name (s):	KLX19A				
Comment:	No comment exists				
Borehole length (m):	800.07				
Reference level:	TOC				
Drilling Period (s):	From date	To date	Secup (m)	Seclow (m)	Drilling type
	2006-05-10	2006-05-22	0.20	99.33	Percussion drilling
	2006-06-03	2006-09-20	99.33	800.07	Core drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (m.a.s.l.)	Coord System
(centerpoint of TOC)	0.000	6,365,901.42	1,547,004.62	16.87	RT90-RHB70
	3.00	6,365,899.89	1,547,004.15	14.33	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	197.13	–57.78	RT90-RHB70	
Borehole diameter:	Secup (m)	Seclow (m)	Hole diam (m)		
	0.20	6.30	0.339		
	6.30	70.00	0.254		
	70.00	99.33	0.253		
	99.33	100.73	0.086		
	100.23	800.07	0.076		
	520.30	522.50	0.084		
Core diameter:	Secup (m)	Seclow (m)	Core diam (m)		
	99.33	100.23	0.072		
	100.23	800.07	0.050		
Casing diameter:	Secup (m)	Seclow (m)	Case in (m)	Case out (m)	
	0.000	92.75	0.200	0.208	
	0.20	6.20	0.310	0.323	
	6.20	6.30	0.280	0.323	
	92.75	98.70	0.200	0.210	
	98.70	98.75	0.170	0.210	
	520.40	522.40	0.076	0.082	
Cone dimensions:	Secup (m)	Seclow (m)	Cone in (m)	Cone out (m)	
	96.03	99.03	0.100	0.104	
	99.03	100.73	0.080	0.084	
Grove milling:	Length (m)	Trace detectable			
	110.000	YES			
	150.000	YES			
	200.000	YES			
	250.000	YES			
	303.000	YES			
	350.000	YES			
	403.000	YES			
	447.000	YES			
	507.000	YES			
	547.000	YES			
	597.000	YES			
	647.000	YES			
	697.000	YES			
	748.000	YES			
	778.000	YES			

2.3 Tests

The interference tests performed in KLX19A are listed in Table 2-4. They were conducted according to the Activity Plan AP PS 400-06-144 (SKB internal document). All tests were conducted as constant rate pump tests. Hydraulic responses were monitored with pressure transducers in selected observation boreholes. Pressure data of further monitoring boreholes were provided by SKB.

Observations were made in the following boreholes (Table 2-3):

2.4 Control of equipment

Control of equipment was mainly performed according to the Quality plan. The basis for equipment handling is described in the "Mätssystembeskrivning" SKB MD 345.101–123 which is composed of two parts 1) management description, 2) drawings and technical documents of the modified PSS2 tool.

Function checks were performed before and during the tests. Among these pressure sensors were checked at ground level and while running in the hole calculated to the static head. Temperature was checked at ground level and while running in.

Any malfunction was recorded, and measures were taken accordingly for proper operation. Approval was made according to SKB site manager, or Quality plan and the "Mätssystembeskrivning".

Table 2-3. Observation boreholes – see Table 5-2 and 5-3 for distances and responses.

Bh ID	No of Intervals monitored	Log time [s]	Bh ID	No of Intervals monitored	Log time [s]	Bh ID	No of Intervals monitored	Log time [s]
HLX27	2	600	HLX37	3	600	KLX11E	1	300
HLX28	1	600	HLX38	1	600	KLX20A	1	600
HLX32	1	600	HLX42	2	600			
HLX36	2	600	KLX11A	1	7,200			

Table 2-4. Tests performed.

Bh ID	Test section (mbToC)	Test type*	Test no	Test start Date, time (yyyy-mm-dd hh:mm:ss)	Test stop Date, time (yyyy-mm-dd hh:mm:ss)
KLX19A	764.0–769.0	1B	1	2006-11-28 19:53:00	2006-12-05 15:52:00
KLX19A	495.0–515.0	1B	1	2006-12-07 15:07:00	2007-01-09 12:28:00

* pumping test-submersible pump

3 Equipment

3.1 Description of equipment/interpretation tools

The equipment called PSS2 (Pipe String System 2) is a highly integrated tool for testing boreholes at great depth (see conceptual drawing in the next Figure 3-1). The system is built inside a container suitable for testing at any weather. Briefly, the components consists of a hydraulic rig, down-hole equipment including packers, pressure gauges, shut-in tool and level indicator, racks for pump, gauge carriers, breakpins, etc shelfs and drawers for tools and spare parts.

There are three spools for a multi-signal cable, a test valve hose and a packer inflation hose. There is a water tank for injection purposes, pressure vessels for injection of packers, to open test valve and for low flow injection. The PSS2 has been upgraded with a computerized flow regulation system. The office part of the container consists of a computer, regulation valves for the nitrogen system, a 24 V back-up system in case of power shut-offs and a flow regulation board.

PSS2 is documented in photographs 1–8.

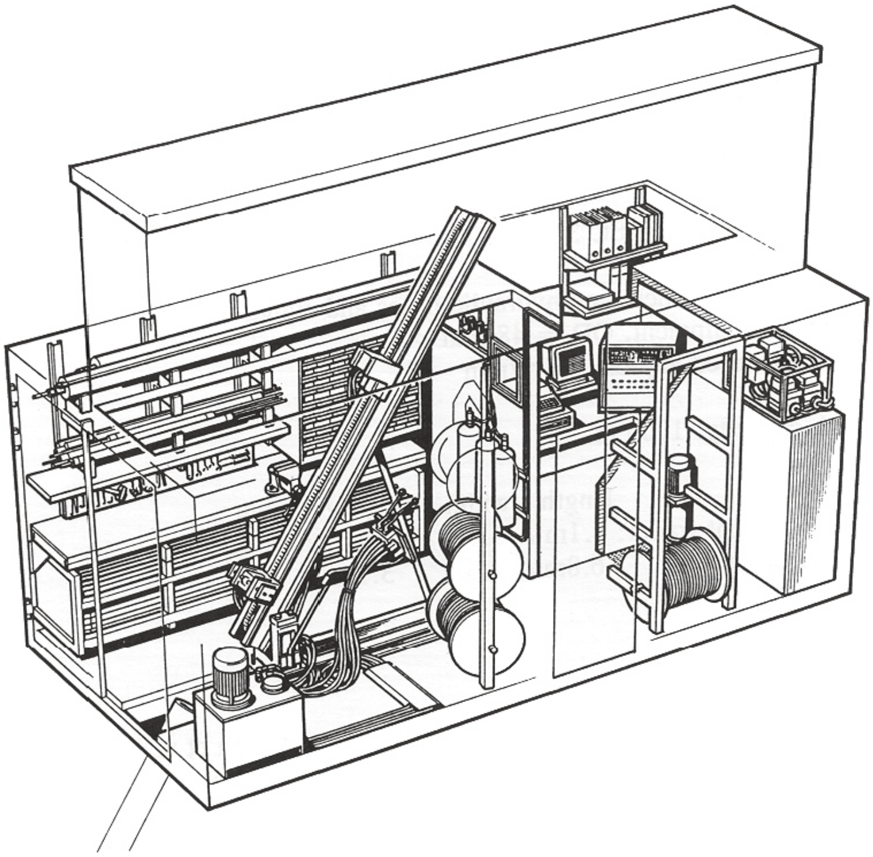

Figure 3-1. *A view of the layout and equipment of PSS2.*

Photo 1. *Hydraulic rig.*

Photo 2. *Rack for pump, down-hole equipment, workbench and drawers for tools.*

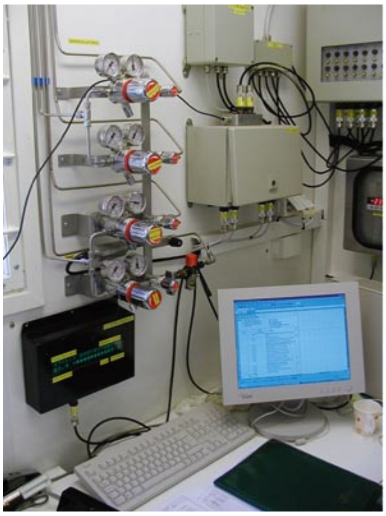

Photo 3. *Computer room, displays and gas regulators.*

Photo 4. *Pressure vessels for test valve, packers and injection.*

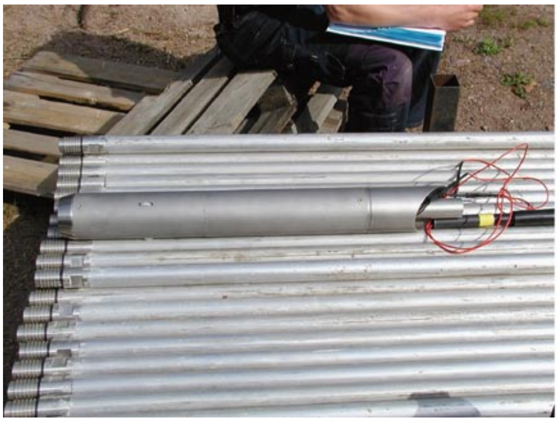

Photo 5. *Positioner, bottom end of down-in-hole string.*

Photo 6. *Packer and gauge carrier.*

Photo 7. *Top of test string with shunt valve and nylon line down to the pump basket.*

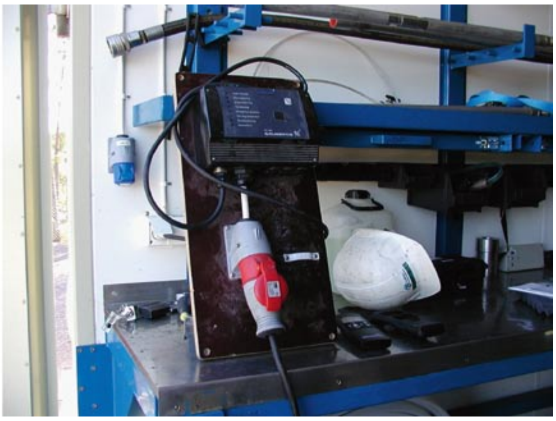

Photo 8. *Control board of the pump with remote control.*

The down-hole equipment consists from bottom to top of the following equipment:

- Level indicator – SS 630 mm pipe with OD 73 mm with 3 plastic wheels connected to a Hallswitch.
- Gauge carrier – SS 1.5 m carrying bottom section pressure transducer and connections from positioner.
- Lower packer – SS and PUR 1.5 m with OD 72 mm, stiff ends, tightening length 1.0 m, maximum pressure 6.5 MPa, working pressure 1.6 MPa.
- Gauge carrier with breakpin – SS 1.75 m carrying test section pressure transducer, temperature sensor and connections for sensors below. Breakpin with maximum load of 47.3 (+ 1.0) kN. The gauge carrier is covered by split pipes and connected to a stone catcher on the top.
- Pop joint – SS 1.0 or 0.5 m with OD 33 mm and ID 21 mm, double O-ring fittings, trapezoid thread, friction loss of 3kPa/m at 50 L/min.
- Pipe string – SS 3.0 m with OD 33 mm and ID 21 mm, double O-ring fittings, trapezoid thread, friction loss of 3kPa/m at 50 L/min.
- Contact carrier – SS 1.0 m carrying connections for sensors below.
- Upper packer – SS and PUR 1.5 m with OD 72 mm, fixed ends, seal length 1.0 m, maximum pressure 6.5 MPa, working pressure 1.6 MPa.
- Breakpin – SS 250 mm with OD 33.7 mm. Maximum load of 47.3 (+ 1.0) kN.
- Gauge carrier – SS 1.5 m carrying top section pressure transducer, connections from sensors below. Flow pipe is double bent at both ends to give room for sensor equipment. The pipe gauge carrier is covered by split pipes.
- Shut-in tool (test valve) – SS 1.0 m with a OD of 48 mm, Teflon coated valve piston, friction loss of 11 kPa at 10 L/min (260 kPa-50L/min). Working pressure 2.8–4.0 MPa. Breakpipe with maximum load of 47.3 (+ 1.0) kN. The shut-in tool is covered by split pipes and connected to a stone catcher on the top.

The 3"-pump is placed in a pump basket and connected to the test string at about 50–90 m below ToC. The pumping frequency of the pump is set with a remote control on surface. The flow can be regulated additionally with a shunt-valve on top of the test string, a nylon line connects the valve with the pump basket, so that the water can circulate and the pump cannot run out of water (Photo 7).

The tool scheme is presented in Figure 3-2.

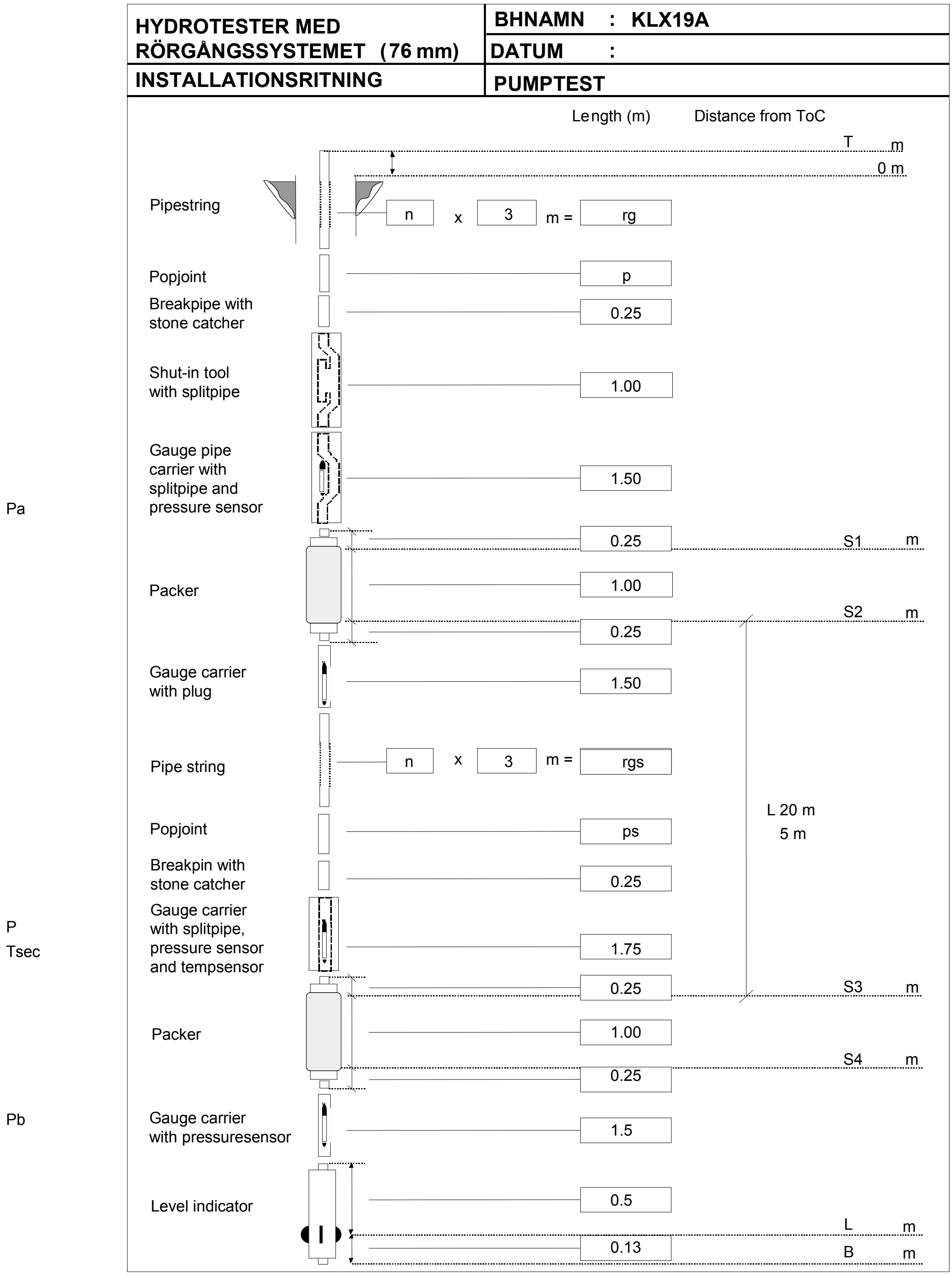

Figure 3-2. Schematic drawing of the down-hole equipment in the PSS2 system.

3.2 Sensors

Calibration of the sensors was performed by Geosigma in October 2006. Actual calibration values were taken from the calibration protocols and inserted to the data acquisition system and the regulation unit as documented in the PSS protocol.

Table 3-1. Technical specifications of sensors.

Keyword	Sensor	Name	Value/Range	Unit	Comments
$P_{sec,a,b}$	Pressure	Druck PTX 162–1464 abs	9–30 4–20 0–13.5 ± 0.1	VDC mA MPa % of FS	
$T_{sec,surf,air}$	Temperature	BGI	18–24 4–20 0–32 ± 0.1	VDC mA °C °C	
Q_{big}	Flow	Micro motion Elite sensor	0–100 ± 0.1	kg/min %	Massflow
Q_{small}	Flow	Micro motion Elite sensor	0–1.8 ± 0.1	kg/min %	Massflow
p_{air}	Pressure	Druck PTX 630	9–30 4–20 0–120 ± 0.1	VDC mA KPa % of FS	
p_{pack}	Pressure	Druck PTX 630	9–30 4–20 0–4 ± 0.1	VDC mA MPa % of FS	
$p_{in,out}$	Pressure	Druck PTX 1400	9–28 4–20 0–2.5 ± 0.15	VDC mA MPa % of FS	
L	Level Indicator				Length correction

Table 3-2. Sensor positions and wellbore storage (WBS) controlling factors.

Borehole information			Sensors		Equipment affecting WBS coefficient		
ID	Test section (m)	Volume in test section (m³)	Type	Position (m fr ToC)	Position	Function	Outer diameter (mm)
KLX19A	764.00–769.00	0.023	p_a p T p_b L	762.11 768.37 768.20 771.01 771.25	Test section	Signal cable Pump string Packer line	9.1 33 6
KLX19A	495.00–515.00	0.091	p_a p T p_b L	493.11 514.37 514.20 517.01 517.25	Test section	Signal cable Pump string Packer line	9.1 33 6

3.3 Data acquisition system

The data acquisition system in the PSS2 container contains a stationary PC with the software Orchestrator, pump- and injection test parameters such as pressure, temperature and flow are monitored and sensor data collected. A second laptop PC is connected to the stationary PC through a network containing evaluation software, Flowdim. While testing, data from previously tested section is converted with IPPlot and entered in Flowdim for evaluation.

The data acquisition system starts and stops the test automatically or can be disengaged for manual operation of magnetic and regulation valves within the injection/pumping system. The flow regulation board is used for differential pressure and valve settings prior testing and for monitoring valves during actual test. An outline of the data acquisition system is outlined in Figure 3-3.

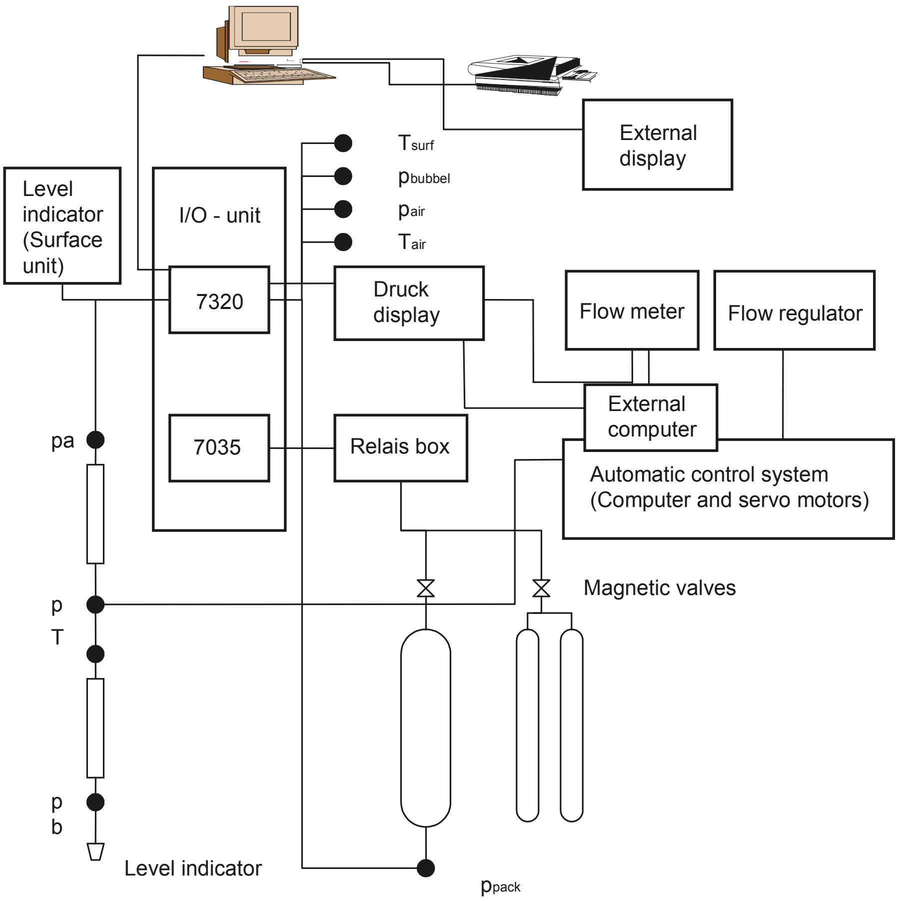

Figure 3-3. Schematic drawing of the data acquisition system and the flow regulation control system in PSS2.

4 Execution

4.1 General

Testing, analyses and reporting were carried out according to SKB's methodology as outlined in the internal SKB document SKB MD 330.003. The activity involves the following components:

- Prepararions.
- Function control of transmitters and data system.
- Pumping/interference testing.
- Analyses of hydraulic tests.
- Reporting.

The basic testing sequence for the pumping tests was to perform a constant rate withdrawal followed by a pressure recovery.

4.2 Preparations

The container was placed on pallets with adjustments made according to the inclination of the borehole. Cables, hoses and down-hole equipment (including pump and pump basket) were cleaned with hot steam according to cleaning level 1. Calibration constants were entered in the data acquisition system and the regulation unit and function checks of the sensors, level indicator, shut in tool and flow meters were made. As result of the function checks, all sensors and components of the testing system worked well.

By running in with the test tool, a level indicator is incorporated at the bottom of the tool. The level indicator is able to record groves milled into the borehole wall. The depths of these groves are given by SKB in the activity plan (see Table 2-2) and the measured depth is counter checked against the number/length of the tubes build in. The achieved correction value, based on linear interpolation between the reference marks, is used to adjust the location of the packers for the test sections to avoid wrong placements and minimize elongation effects of the test string.

4.3 Execution of field work

4.3.1 Test principle

Pump tests

The pump tests were conducted as constant flow rate tests (CRw phase) followed by a pressure recovery period (CRwr phase). The intention was to achieve a drawdown as high as possible, which is limited by several factors like flow capacity of the valves at the regulation unit, maximum flow rate and depth of the pump, head loss due to friction inside the tubing, etc. According to the Activity Plan, the pump phases should have lasted until reaching an acceptable uranine concentration. The actual durations of the phases are shown in Table 2-1.

Observation wells

For evaluation as interference tests, a total number of 10 boreholes were used to monitor the pressure change in up to three intervals. Recording and data collection was done by SKB. SKB delivered the data as ASCII files (mio-format). An overview of the monitored boreholes and their intervals is given in Table 2-3. Observation borehole HLX32_1 was monitored only for the pump section 495.00–515.00 in KLX19A.

4.3.2 Test procedure

A test cycle includes the following phases: 1) Transfer of down-hole equipment to the section. 2) Packer inflation. 3) Pressure stabilisation. 4) Constant rate withdrawal. 5) Pressure recovery. 6) Packer deflation. The pump tests in KLX19A have been carried out by applying a constant rate withdrawal with a drawdown as high as possible. The flow rates and resulting drawdowns are summarised in Table 4-1.

Before start of the pumping tests, approximately stable pressure conditions prevailed in the test section. After the perturbation period, the pressure recovery in the section was measured. Tidal effects were observed as disturbances of the pressure responses. A major rainfall (9 mm within 24 hours) happened on 01st of January 2007 during performance of the pump test in section 495.00–515.00 which may have disturbed the measurements. In some observation sections close to the surface, influence of this rainfall was identified, e.g. in observation sections HLX36_2 and HLX42_2.

The extracted water was collected in tanks, which were removed by SKB and discharged into the sea.

4.4 Data handling/post processing

Pump tests

The data handling followed several stages. The data acquisition software (Orchestrator) produced an ASCII raw data file (*.ht2) which contains the data in voltage and milliampere format plus calibration coefficients. The *.ht2 files were processed to *.dat files using the SKB program called IPPlot. These files contain the time, pressure, flow rate and temperature data. The *.dat files were synthesised in Excel to a *.xls file for plotting purposes. Finally, the test data to be delivered to SKB were exported from Excel in *.csv format. These files were also used for the subsequent test analysis.

Observation wells

SKB was responsible for recording and collecting the data of the observation boreholes. The sample rate in those boreholes was between 5 minutes and 2 hours. SKB delivered the ASCII data in mio-format. These files were imported and processed to Excel for further evaluation and analysis. In addition, barometric data were delivered by SKB to eliminate barometric fluctuations from the observation data. Even by consideration of barometric pressure changes, the observation data showed still major disturbance by natural fluctuation.

Table 4-1. Flow rate and drawdown of pumping tests.

Bh ID	Section [mbToC]	Flow rate [L/min]	Drawdown* [kPa]
KLX19A	764.00–769.00	0.8	241
KLX19A	495.00–515.00	2.1	125

* Difference between pressure just before start and immediately before stop of pumping.

4.5 Analysis of the pump tests

The test analysis of the pump tests was already performed and documented in the report P-07-90 /Enachescu et al. 2007/, printed in October 2007.

4.6 Analysis and Interpretation of the response in the observation holes

In 10 boreholes with a total of 15 sections (Table 2-3) the responses were monitored during the pumping tests in KLX19A. Those data were analysed according to the methodology description (SKB MD 330.003) to derive hydraulic connectivity parameters (Indices 1, 2 and 2new).
As only one of the monitored sections (HLX32_1) showed a clear response to the performed pump tests, a type curve matching method with Paradigm's Interpret 2006 software package was performed only for this section.

4.6.1 Hydraulic connectivity parameters

Calculation of the indices

For the interference test analysis, the data of the pumping hole and the observation holes were compared. Therefore both data sets were plotted in one graph to decide if the observation borehole shows a response which is related to the pumping. In case of a response in the observation sections due to pumping in KLX19A, the response time (dt_L) and the maximum drawdown (s_p) in these sections were calculated. The 3D distance between the point of application in the pumping borehole and the observation borehole (r_s) was provided by SKB. These parameters combined with the pumping flow rate (Q_p) are the variables used to calculate the indices, which characterize the hydraulic connectivity between the pumping and the observed section.
The response parameters and the calculated hydraulic connectivity parameters are shown in the tables in section 5 and Appendix 2. The indices are calculated as follows:

Index 1:
rs^2/dt_L = normalised distance rs with respect to the response time [m²/s],

Index 2:
s_p/Q_p = normalised drawdown with respect to the pumping rate [s/m²].

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

Index 2 new:
$(s_p/Q_p)\cdot\ln(r_s/r_0)$ $r_0=1$ and for the pumped borehole $r_s=e^1$
(fictive borehole radius of 2.718).

The classification based on the indices is given as follows:

Index 1 (r_s^2/dt_L)		**Index 2 (s_p/Q_p)**		**Colour code**
$r_s^2/dt_L > 100$ m²/s	Excellent	$s_p/Q_p > 1\cdot10^5$ s/m²	Excellent	
$10 < r_s^2/dt_L \le 100$ m²/s	High	$3\cdot10^4 < s_p/Q_p \le 1\cdot10^5$ s/m²	High	
$1 < r_s^2/dt_L \le 10$ m²/s	Medium	$1\cdot10^4 < s_p/Q_p \le 3\cdot10^4$ s/m²	Medium	
$0.1 < r_s^2/dt_L \le 1$ m²/s	Low	$s_p/Q_p \le 1\cdot10^4$ s/m²	Low	
		$s_p < 0.1$ m	No response	

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

Calculated response indexes are given in Tables 5-2, 5-3 and 6-3.

Derivation of the indices and limitations

To evaluate the hydraulic connectivity between the active and the observed section, the drawdown in the observation section (sp) caused by pumping in the active section and the response time after start of pumping (dtL) is needed.

To get these two values the data of both sections are plotted in one graph. The time, the observation hole needed to react to the pumping in KLX19A with a drawdown of at least 0.1 m and the amount of drawdown at the end of the pumping were taken out of the graph. Often it is not really clear if the section responds to the pumping or if the drawdown is based on natural processes exclusively. In unclear cases, the data sets were regarded in total to better differentiate between those effects. By looking at the pressure response of the days before and after the pumping phase, it is easier to distinguish between natural fluctuations and those induced by pumping. Furthermore it should be pointed out, that some of the responses could be caused by the drawdown in the section above or below of the same observation borehole.

All observation data are influenced by natural fluctuations of the groundwater level such as tidal effects and long term trends. The pressure changes due to tidal effects are different for the observation boreholes but in case of the performed tests relative large and of major importance for the data evaluation.

The pressure changes in the observation sections generated by the pumping are often very marginal. In general, it is a combination of natural processes and the pumping in KLX19A producing the pressure changes in the monitored sections. If there is a reaction, it shows – in most of the cases – not a sharp but a smooth transition from undisturbed to disturbed (by pumping) behaviour, which makes it more difficult to determine the response time exactly. As in the case of the evaluated response data, neither start time nor stop time of pumping can provide reliable data for the response time, therefore Index 1 was not calculated.

4.6.2 Approximate calculation of hydraulic diffusivity

The distance r_s between different borehole sections has been calculated as the spherical distance using co-ordinates for the mid-chainage of each section. The calculation of the hydraulic diffusivity is based on radial flow:

$$\eta = T / S = r_s^2 / [\,4 \cdot dt_L \cdot (1 + dt_L / tp) \cdot \ln(1 + tp / dt_L)]$$

The time lag dtL is defined as the time when the pressure response in an observation section is greater than ca 0.1 metres (The time difference between a certain first observable response in the observation section and the stop of the pumping). The pumping time is included as tp. /Streltsova 1988/.

The estimates of the hydraulic diffusivity according to above should be seen as indicative values of the hydraulic diffusivity. Observation sections straddling a planar, major conductive feature that also intersects the pumping section should provide reliable estimates of the hydraulic diffusivity, but these cases have to be judged based on the geological model of the site.

In case of the interference tests related to pumping in KLX19A, a calculation of the hydraulic diffusivity was performed due to the poor quality and the relative high uncertainty of the response in most of the observed data only for the data of HLX32_1.

4.6.3 Response Analysis

To derive transmissivities and storativities from the sections of the observation boreholes Paradigm's analysis software Interpret 2006 was used. Interpret 2006 is an interactive program that uses a constant rate solution to provide optimized hydraulic parameters for a wide range of potential reservoir models. Some of the features of Interpret 2006 include extensive superposition of constant rate events, non-linear regression and multi-event rate normalized plots. Multi-event plots allow the relevant phases to be presented on a single plot to evaluate for consistency of the formation response throughout the test. Additionally, it can accommodate changing wellbore storage and skin between the test periods.

Analysis approach

The interference tests are analysed using line source type curves calculated for different flow models as identified from the log-log derivative of the pressure response.

Assumptions

To understand the assumption used in the analysis of observation zone data it is useful to imagine in a first instance a source zone connected with the observation zones through fractures of equal transmissivity (T_1 to T_4). In Figure 4-1 the case of a source zone connected with 4 observation zones is presented.

If we note the flow rate at the source as q, each of the response in each of the observation zones will be influenced by a flow rate of q/4 because the transmissivities of the 4 fractures are equal, so the rate will be evenly distributed between the fractures as well.

We complicate now the system by adding a new fracture of much higher transmissivity (T_5) to the system (see Figure 4-2).

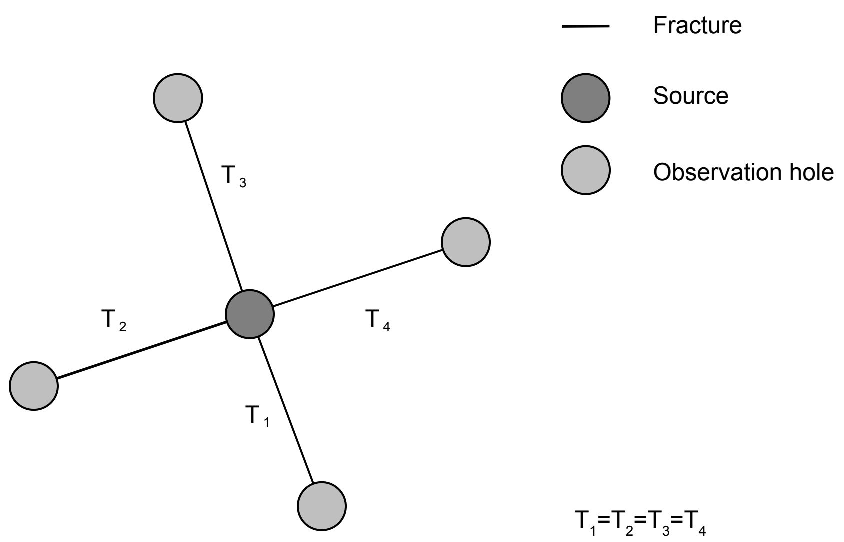

Figure 4-1. *Schematic sketch of a pumping hole (source) and observation holes.*

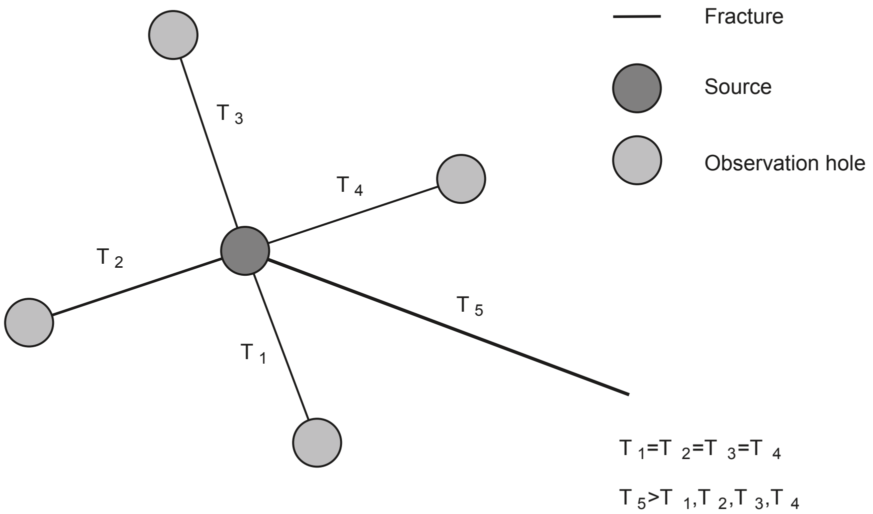

Figure 4-2. *Schematic sketch of a pumping hole (source) and observation holes with an added fracture.*

Because of the larger transmissivity, most of the flow rate of the source will be captured by this fracture, so the other 4 fractures will receive less flow. Because of this, the magnitude of the response at the 4 observation zones will be higher than in the first case. The pathway transmissivity derived from the analysis of the observation zones will be in the second case much higher than in the first case. However, the pathway transmissivity between source and any of the observation zones did not change. The transmissivity derived in the second case is false because the analysis is conducted under the assumption that the flow rate of the source is evenly distributed in space. This assumption is clearly not valid in the second case. In reality, the flow rate around the source will be distributed inversely proportional to the transmissivity of the individual pathways:

$$q = q_1 + q_2 + \ldots + q_n$$

$$\frac{T_1}{q_1} = \frac{T_2}{q_2} = \ldots = \frac{T_n}{q_n}$$

The analysis of observation zones (i.e. interference test analysis) assumes that:

$q_1 = q_2 = \ldots = q_n$.

This assumption will typically result in similar transmissivities:

$T_1 = T_2 = \ldots = T_n$.

The distance used for the analysis is the shortest way between the source and the observation hole and no pathway tortuosity was considered. This assumption influences the storativity derived from the transient analysis.

Methodology

Each of the relevant test phases is subsequently analyzed using the following steps:

Identification of the flow model by evaluation of the derivative on the log-log diagnostic plot. Initial estimates of the model parameters are obtained by conventional straight-line analysis.

Superposition type curve matching in log-log coordinates. The type curves are based on /THEIS 1935/ calculated for a line source (i.e. finite wellbore radius).

Flow models used for analysis

The flow models used in analysis were derived from the shape of the pressure derivative calculated with respect to log time and plotted in log-log coordinates.

In the most cases a homogenous flow model was used, otherwise a two shell composite flow model was chosen for the analysis.

If there were different flow models matching the data in comparable quality, the simplest model was preferred.

The flow dimension displayed by the test can be diagnosed from the slope of the pressure derivative. A slope of 0.5 indicates linear flow, a slope of 0 (horizontal derivative) indicates radial flow and a slope of –0.5 indicates spherical flow. The flow dimension diagnosis was commented for each of the tests. All tests were analysed using a flow dimension of two (radial flow).

In case of the present interference tests with pumping in KLX19A, only the response of HLX32_1 was analysed, this with a homogenous model with infinite acting radial flow.

4.7 Nonconformities

Deviating from the relating Activity Plan for the pumptests in KLX19A, the 20 m pumping section was shifted by 4 m due to difficulties finding appropriate packer positions. The interval was moved from 499.00 to 519.00 meter below top of casing (m b TOC) to 495.00 to 515.00 m after clearance with SKB.

5 Results

In the following, results of the pump tests conducted in KLX19A are presented and analysed. The results are given as general comments to test performance, the identified flow regimes and calculated parameters and finally the parameters which are considered as most representative are chosen and justification is given. All results are also summarized in the Tables 6-1 to 6-3 of the synthesis chapter and in the summary sheets (Appendix 1). Heavy rainfall was observed during the pump tests in borehole KLX19A on 01^{st} of January 2007 when pumping in section 495.00 to 515.00 m bTOC. Other disturbing effects observed were caused by tidal influence. As at both performed pump tests the derivative is flat at late times, both pump tests were evaluated using a flow dimension of 2. In both cases, there was a flat derivative at middle times at a different level. In these cases, a composite model was chosen with a change of transmissivity in some distance from the borehole to match the different flat parts of the derivative and the connecting slope.

5.1 Pumped sections

In the following, the results from the two pumped sections in borehole KLX19A are presented and analysed in 5.1.1 and 5.1.2 respectivelly. An overview of the results obtained from the pump tests can be found in Appendix 1 (Pump test summary sheets). See also /Enachescu et al. 2007/.

5.1.1 Section 495.00–515.00 m, test no. 1, pumping

Comments to test

The test was conducted as a constant rate pump test phase with a flow rate of 2.1 L/min, followed by a pressure recovery phase. The maximum drawdown just before stop of flowing was about 12.74 m. All pressures are influenced by natural phenomena (e.g. tidal effects). A hydraulic connection between the test interval and the bottom zone was observed. The flow rate during the pumping phase of about 2.1 L/min and the resulting drawdown of about 120 kPa indicate a relatively moderate o high interval transmissivity. After approximate 786 hours of pumping, a water sample was taken. The CRw phase is noisy and unstable and therefore not analysable. The CRwr phase is very short compared to the perturbation phase. However, the recovery is of good quality and amenable for quantitative analysis.

Flow regime and calculated parameters

The flow dimension is interpreted from the slope of the semi-log derivative plotted in log-log coordinates. In case of the present test the CRwr phase shows a relatively long transition period from wellbore storage and skin dominated flow to pure formation flow. This is probably caused by the hydraulic communication to the bottom section. At late middle times and late times the derivative is flat, which is indicative for radial flow (flow dimension of 2). A radial composite flow model with increasing transmissivity at some distance to the borehole was chosen for the analysis of the CRwr phase.

Selected representative parameters

The recommended transmissivity of $5.8 \cdot 10^{-6}$ m^2/s was derived from the analysis of the CRwr phase. Due to the hydraulic communication to the bottom zone, the derived value should be regarded as at the upper limit of the confidence range. The confidence range for the interval transmissivity is estimated to be $1.0 \cdot 10^{-6}$ to $6.0 \cdot 10^{-6}$ m^2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRwr phase using type curve extrapolation in the Horner plot to a value of 4,331.2 kPa. Due to the short duration of the recovery compared to the pumping time, this value is slightly uncertain.

5.1.2 Section 764.00–769.00 m, test no. 1, pumping

Comments to test

The test was conducted as a constant rate pump test phase with a flow rate of 0.8 L/min, followed by a pressure recovery phase. The maximum drawdown just before stop of flowing was about 24.57 m. A hydraulic connection between the test interval and the bottom zone was observed. Between approximately 14 and 20.5 hours elapsed time, the flow rate and the pressure in the test section became very noisy. The reason for this is unknown. The flow rate during the pumping phase of about 0.8 L/min and the resulting drawdown of about 235 kPa indicate a relatively moderate to low interval transmissivity. Due to malfunction of the bottom transducer, the reaction in the bottom zone could not be observed earlier. After approximate 160 hours of pumping, a water sample was taken. The CRw phase is very noisy and unstable and not analysable. The CRwr phase is relatively short compared to the perturbation phase. However, the recovery is of good quality and amenable for quantitative analysis.

Flow regime and calculated parameters

The flow dimension is interpreted from the slope of the semi-log derivative plotted in log-log coordinates. In case of the present test the CRwr phase shows a gently inclined derivative at middle times, followed by a downward trend at late times, indicating either a change in flow dimension or in transmissivity. A radial composite flow model with increasing transmissivity at some distance to the borehole was chosen for the analysis of the CRwr phase.

Selected representative parameters

The recommended transmissivity of $2.9 \cdot 10^{-7}$ m^2/s was derived from the analysis of the CRwr phase. Due to the hydraulic communication to the bottom zone, the derived value should be regarded as at the upper limit of the confidence range. The confidence range for the interval transmissivity is estimated to be $5.0 \cdot 10^{-8}$ to $3.0 \cdot 10^{-7}$ m^2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRwr phase using type curve extrapolation in the Horner plot to a value of 6,404.6 kPa. Due to the short duration of the recovery compared to the pumping time, this value is slightly uncertain.

5.2 Observation sections

In the following, the data of the observation zones which responded to pumping are presented and analysed. The results of the analysis are also summarized in the Table 6-3 of the summary chapter and in the summary sheets (Appendix 4 and 5).

Table 5-1 summarises all the tests and the observed boreholes. Furthermore it shows the response matrix based on the calculated indices 1 (rs^2/dt_L), 2 (s_p/Q_p) and 2 new $(s_p/Q_p) \cdot \ln(r_s/r_0)$ (see Chapter 4.5.1).

Table 5-1. Response matrix with Index 1, Index 2 and Index 2 new.

		Pumping Hole	KLX19A			KLX19A		
		Section (m b TOC)	764.00–769.00			495.00–515.00		
		Flow rate (l/min)	0.8			2.1		
		Drawdown (kPa)	241			125		
Observation borehole	**Sec No**	**Section (m)**	**Response indices**					
			1	**2**	**2 new**	**1**	**2**	**2 new**
HLX27	1	133.00–164.70						
	2	0.00–132.00						
HLX28	1	0.00–154.00				n.c.		
HLX32	1	0.00–163.00	n.o.	n.o.	n.o.	n.c.		
HLX36	1	50.00–199.50						
	2	0.00–49.00						
HLX37	1	149.00–199.80				n.c.		
	2	118.00–148.00				n.c.		
	3	0.00–117.00						
HLX38	1	0.00–199.50						
HLX42	1	30.00–152.60						
	2	0.00–29.00						
KLX11A	1	0.00–992.00						
KLX11E	1	2.00–121.00						
KLX20A	1	0.00–457.00						

Index 1 (r^2/t_L)

$r_s^2/dt_L > 100$ m²/s	Excellent	E
$10 < r_s^2/dt_L \le 100$ m²/s	High	H
$1 < r_s^2/dt_L \le 10$ m²/s	Medium	M
$0.1 < r_s^2/dt_L \le 1$ m²/s	Low	L
Not calculated due to strong natural fluctuations		n.c.

Index 2 (s_p/Q_p)

$s_p/Q_p > 1 \cdot 10^5$ s/m²	Excellent
$3 \cdot 10^4 < s_p/Q_p \le 1 \cdot 10^5$ s/m²	High
$1 \cdot 10^4 < s_p/Q_p \le 3 \cdot 10^4$ s/m²	Medium
$s_p/Q_p \le 1 \cdot 10^4$ s/m²	Low
$s_p < 0.1$ m	No response

Index 2 new ($(s_p/Q_p) \cdot \ln(r_s/r_0)$)

$(s_p/Q_p) \cdot \ln(r_s/r_0) > 5 \cdot 10^5$ s/m²	Excellent
$5 \cdot 10^4 < (s_p/Q_p) \cdot \ln(r_s/r_0) \le 5 \cdot 10^5$ s/m²	High
$5 \cdot 10^3 < (s_p/Q_p) \cdot \ln(r_s/r_0) \le 5 \cdot 10^4$ s/m²	Medium
$5 \cdot 10^2 < (s_p/Q_p) \cdot \ln(r_s/r_0) \le 5 \cdot 10^3$ s/m²	Low
$s_p < 0.1$ m	No response

blank = observed but no response at all

n.o. = not observed

5.2.1 Responses when pumping KLX19A section 764.00–769.00 m

This test was conducted as constant rate pump test phase followed by a recovery pressure phase in the source section. The mean flow rate was 0.8 l/min with a drawdown of 24.57 m. In sum none of the 14 observed sections responded due to the pumping. Table 5-2 summarizes the test sections and selected parameters.

Table 5-2. Test sections and selected parameters (section 764.00–769.00 m pumped).

Source borehole		Section (m)	Flow rate Qm (l/min)	Draw-down (m)	r_{wf} (m)				
KLX19A	1	764.00–769.00	0.8	24.57	3.8				
Observation borehole	**Sec No**	**Section (m)**	**Distance r_s (m)**	**Draw-down s_p (m)**	**dt_L (s)**	**Index 1 r_s^2/dt_L (m^2/s)**	**Index 2 s_p/Q_p (s/m^2)**	**Index 2 New $(s_p/Q_p)\cdot\ln(r_s/r_0)$ (s/m^2)**	**Diffusivity η (m^2/s)**
HLX27	1	133.00–164.70	1,099	n.r.	–	–	–	–	–
	2	0.00–132.00	1,123	n.r.	–	–	–	–	–
HLX28	1	0.00–154.00	661	n.r.	–	–	–	–	–
HLX32	1	0.00–163.00	634	n.o.	–	–	–	–	–
HLX36	1	50.00–199.50	958	n.r.	–	–	–	–	–
	2	0.00–49.00	979	n.r.	–	–	–	–	–
HLX37	1	149.00–199.80	930	n.r.	–	–	–	–	–
	2	118.00–148.00	962	n.r.	–	–	–	–	–
	3	0.00–117.00	983	n.r.	–	–	–	–	–
HLX38	1	0.00–199.50	722	n.r.	–	–	–	–	–
HLX42	1	30.00–152.60	988	n.r.	–	–	–	–	–
	2	0.00–29.00	1,071	n.r.	–	–	–	–	–
KLX11A	1	0.00–992.00	872	n.r.	–	–	–	–	–
KLX11E	1	2.00–121.00	1,057	n.r.	–	–	–	–	–
KLX20A	1	0.00–457.00	1,060	n.r.	–	–	–	–	–

n.r. no response due to pumping in source
n.o. no observed
Key for Index 1,2 and 2 New see Table 5-1

5.2.2 Responses when pumping KLX19A section 495.00–515.00 m.

This interference test was conducted as constant rate pump test phase followed by a recovery pressure phase in the source section. The mean flow rate was 2.1 l/min with a drawdown of 12.74 m. In sum 4 observation sections responded due to the pumping. Table 5-3 summarizes the responding test sections and selected parameters. Figure 5-1 shows the drawdown of the observed sections related to the distance. The pumped borehole KLX19A is shown with consideration of the effective borehole radius r_{wf}, calculation based on the skin factor.

$$r_{wf} = r_w \cdot e^{-\xi}$$

In the following chapters the response analysis of each responded section is presented.

Table 5-3. Test sections and selected parameters (section 495.00–515.00 m pumped).

Source borehole		Section (m)	Flow rate Qm (l/min)	Draw-down (m)	r_{wf} (m)				
KLX19A	2	495.00–515.00	2.1	12.74	3.3E-01				
Observation borehole	**Sec No**	**Section (m)**	**Distance r_s (m)**	**Draw-down s_p (m)**	**dt_L (s)**	**Index 1 r_s^2/dt_L (m²/s)**	**Index 2 s_p/Q_p (s/m²)**	**Index 2 New $(s_p/Q_p)\cdot\ln(r_s/r_0)$ (s/m²)**	**Diffusivity η (m²/s)**
HLX27	1	133.00–164.70	989	n.r.	–	–	–	–	–
	2	0.00–132.00	1,002	n.r.	–	–	–	–	–
HLX28	1	0.00–154.00	413	0.24	–	–	6,989.95	42,103.61	n.a.
HLX32	1	0.00–163.00	401	0.25	–	–	7,281.20	43,643.23	3.01
HLX36	1	50.00–199.50	764	n.r.	–	–	–	–	–
	2	0.00–49.00	770	n.r.	–	–	–	–	–
HLX37	1	149.00–199.80	745	0.18	–	–	5,242.46	34,670.43	n.a.
	2	118.00–148.00	775	0.19	–	–	5,533.71	36,815.03	n.a.
	3	0.00–117.00	795	n.r.	–	–	–	–	–
HLX38	1	0.00–199.50	478	n.r.	–	–	–	–	–
HLX42	1	30.00–152.60	970	n.r.	–	–	–	–	–
	2	0.00–29.00	1,043	n.r.	–	–	–	–	–
KLX11A	1	0.00–992.00	724	n.r.	–	–	–	–	–
KLX11E	1	2.00–121.00	846	n.r.	–	–	–	–	–
KLX20A	1	0.00–457.00	883	n.r.	–	–	–	–	–

n.a. not analysed due to strong natural fluctuations
n.r. no response due to pumping in source
Key for Index 1,2 and 2 New see Table 5-1

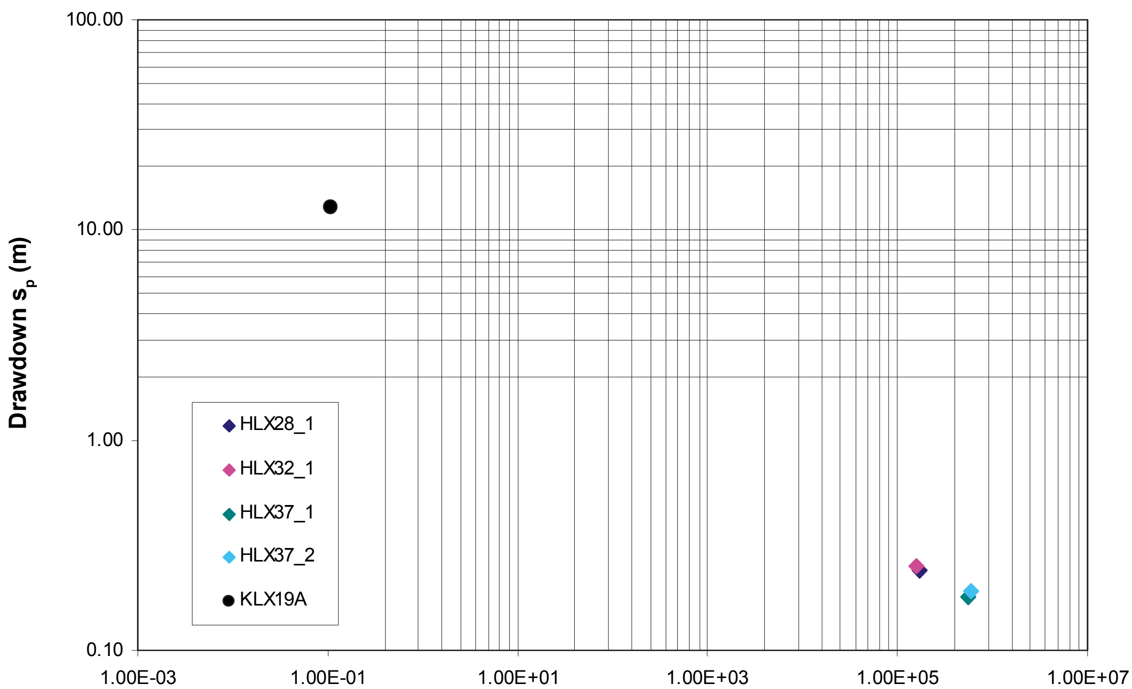

Figure 5-1. *Distance vs. Drawdown for the responding test sections, KLX19A section 495.00–515.00 m pumped.*

Response in HLX28, section 1 (0.00–154.00 m)

Comments to test

A total drawdown during the flow period of 2.4 kPa (0.24 m) was observed in this section. The index 1 1 (r_s^2/dt^L) was not calculated due to effects of natural fluctuation, index 2 (s_p/Q_p) was calculated as "low response" and the new index 2 ($(s_p/Q_p)\cdot\ln(r_s/r_0)$) as "medium response". Both phases (CRw and CRwr) are strongly disturbed by natural fluctuations and could not be used for further interpretation.

Flow regime and calculated parameters

Due to the influence of natural fluctuations the recorded data of the pressure response is very noisy and does not allow flow model identification.

Selected representative parameters

No hydraulic parameters could be derived from the pressure response.

Response in HLX32, section 1 (0.00–163.00 m)

Comments to test

A total drawdown during the flow period of 2.5 kPa (0.25 m) was observed in this section. The recovery was very much disturbed by natural fluctuations and could not be used for further interpretation. The index 1 (r_s^2/dt^L) was not calculated due to effects of natural fluctuation, index 2 (s_p/Q_p) was calculated as "low response" and the new index 2 ($(s_p/Q_p)\cdot\ln(r_s/r_0)$ as "medium response".

The CRw phase shows no problems and is adequate for quantitative analysis.

Flow regime and calculated parameters

The flow dimension is interpreted from the slope of the semi-log derivative plotted in log-log coordinates. For the analysis of the CRw phase a homogeneous radial flow model was chosen. The Analysis is presented in Appendix 3-1.

Selected representative parameters

The recommended transmissivity of $4.3\cdot10^{-5}$ m^2/s was derived from the analysis of the CRw phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be $2.0\cdot10^{-5}$ m^2/s to $1.0\cdot10^{-4}$ m^2/s. The flow dimension during the test is 2. No further analysis recommended.

Response in HLX37, section 1 (149.00–199.80 m)

Comments to test

A total drawdown during the flow period of 1.8 kPa (0.18 m) was observed in this section. The index 1 1 (r_s^2/dt^L) was not calculated due to effects of natural fluctuation, index 2 (s_p/Q_p) was calculated as "low response" and the new index 2 ($(s_p/Q_p)\cdot\ln(r_s/r_0)$) as "medium response". Both phases (CRw and CRwr) are strongly disturbed by natural fluctuations and could not be used for further interpretation.

Flow regime and calculated parameters

Due to the influence of natural fluctuations the recorded data of the pressure response is very noisy and does not allow flow model identification.

Selected representative parameters

No hydraulic parameters could be derived from the pressure response.

Response in HLX37, section 2 (118.00–148.00 m)

Comments to test

A total drawdown during the flow period of 1.9 kPa (0.19 m) was observed in this section. The index 1 1 (r_s^2/dt^L) was not calculated due to effects of natural fluctuation, index 2 (s_p/Q_p) was calculated as “low response” and the new index 2 $(s_p/Q_p)\cdot\ln(r_s/r_0)$ as “medium response”. Both phases (CRw and CRwr) are strongly disturbed by natural fluctuations and could not be used for further interpretation.

Flow regime and calculated parameters

Due to the influence of natural fluctuations the recorded data of the pressure response is very noisy and does not allow flow model identification.

Selected representative parameters

No hydraulic parameters could be derived from the pressure response.

6 Summary and conclusions

The summary and conclusions chapter summarizes the basic test parameters and analysis results.

6.1 Location of responding test section

The following figures are showing the location of the responding test sections in relationship with the pumping section.

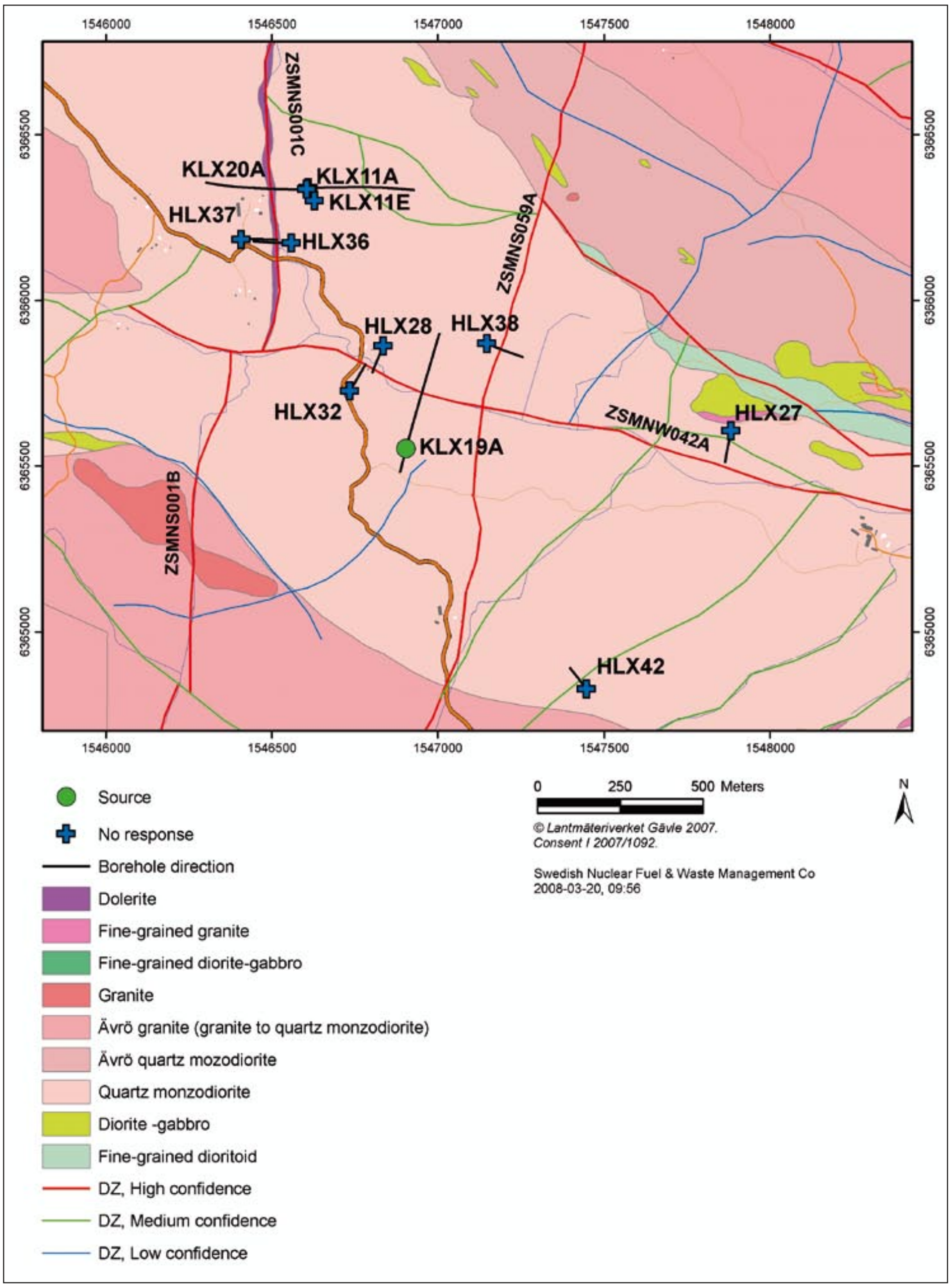

Figure 6-1. *Location of responding test sections while pumping in section 764.00–769.00 m.*

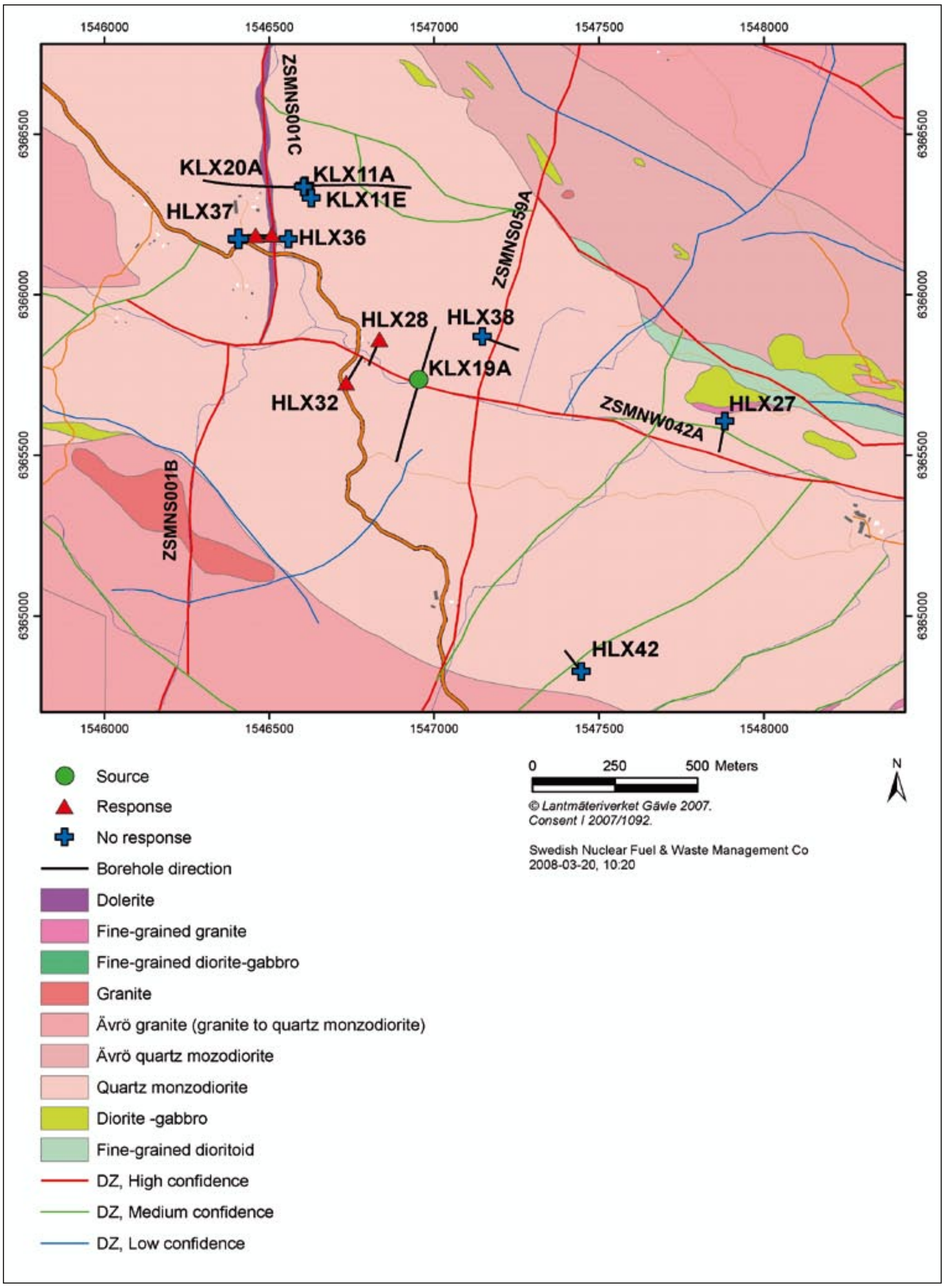

Figure 6-2. *Location of responding test sections while pumping in section 495.00–515.00 m.*

6.2 Summary of results

Table 6-1. General test data from constant rate pump tests.

Borehole ID	Borehole secup (m)	Borehole Seclow (m)	Date and time Test start YYYYMMDD hh:mm	Date and time Test stop YYYYMMDD hh:mm	Q_p (m³/s)	Q_m (m³/s)	tp (s)	t_F (s)	p_0 (kPa)	p_i (kPa)	p_p (kPa)	p_F (kPa)	Te_w (°C)	Test phases measured *Analysed test phases marked **bold***
KLX19A	495.00	515.00	20061207 15:07	20070109 12:28	3.50E-05	3.57E-05	2827044	12780	4316	4311	4186	4306	13.3	– **CRwr**
KLX19A	764.00	769.00	20061128 19:53	20061205 15:52	1.33E-05	1.33E-05	578490	9588	6404	6391	6150	6347	16.8	– **CRwr**

Nomenclature

Q_p	Flow in test section immediately before stop of flow [m³/s]
Q_m	Arithmetical mean flow during perturbation phase [m³/s]
t_p	Duration of perturbation phase [s]
t_f	Duration of recovery phase [s]
p_0	Pressure in borehole before packer inflation [kPa]
p_i	Pressure in test section before start of flowing [kPa]
p_p	Pressure in test section before stop of flowing [kPa]
p_F	Pressure in test section at the end of the recovery [kPa]
Te_w	Temperature in test section
Test phases	CRw: constant rate pump (withdrawal) phase
	CRwr: recovery phase following the constant rate pump (withdrawal) phase

Table 6-2. Results from analysis of the constant rate pump tests.

Interval position			Stationary flow parameters		Transient analysis															
					Flow regime		Formation parameters												Static conditions	
Borehole ID	up m btoc	low m btoc	Q/s m^2/s	T_M m^2/s	Perturb. Phase	Recovery Phase	T_{f1} m^2/s	T_{f2} m^2/s	T_{s1} m^2/s	T_{s2} m^2/s	T_T m^2/s	T_{TMIN} m^2/s	T_{TMAX} m^2/s	C m^3/Pa	ξ –	dt_1 min	dt_2 min	r_{inner} m	p* kPa	h_{wif} masl
KLX19A	495.00	515.00	2.7E-06	2.9E-06	#NV	WBS22	#NV	#NV	2.6E-06	5.8E-06	5.8E-06	1.0E-06	6.0E-06	6.8E-09	–2.2	11.4	95.5	19.4	4,331	16.38
KLX19A	764.00	769.00	5.4E-07	4.5E-07	#NV	WBS22	#NV	#NV	2.9E-07	7.2E-07	2.9E-07	5.0E-08	3.0E-07	9.7E-10	–4.6	0.6	23.3	19.6	6,405	16.37

Nomenclature

Q/s	Specific capacity.
T_M	Transmissivity according to /Moye 1967/.
Flow regime	The flow regime description refers to the recommended model used in the transient analysis. WBS denotes wellbore storage and skin and is followed by a set of numbers describing the flow dimension used in the analysis (1 = linear flow, 2 = radial flow, 3 = spherical flow). If only one number is used (e.g. WBS2 or 2) a homogeneous flow model (1 composite zone) was used in the analysis, if two numbers are given (WBS22 or 22) a 2 zones composite model was used.
T_f	Transmissivity derived from the analysis of the perturbation phase (CRw). In case a homogeneous flow model was used only one T_f value is reported, in case a two zone composite flow model was used both T_{f1} (inner zone) and T_{f2} (outer zone) are given.
T_s	Transmissivity derived from the analysis of the recovery phase (CRwr). In case a homogeneous flow model was used only one T_s value is reported, in case a two zone composite flow model was used both T_{s1} (inner zone) and T_{s2} (outer zone) are given.
T_T	Recommended transmissivity.
T_{TMIN} / T_{TMAX}	Confidence range lower/upper limit.
C	Wellbore storage coefficient.
ξ	Skin factor (calculated based on a Storativity of $1 \cdot 10^{-6}$).
dt_1 / dt_2	Estimated start/stop time of evaluation for the recommended transmissivity (T_T).
r_{inner}	Radius of the inner zone.
p*	The parameter p* denoted the static formation pressure (measured at transducer depth) and was derived from the HORNER plot of the CHir phase using straight line or type-curve extrapolation.
h_{wif}	Fresh-water head (based on transducer depth and p*).
#NV	Not analysed/no values.

Table 6-3. Results from analysis of the interference tests.

Pumped section		Observation borehole		Flow regime		Transient analysis Formation Parameter										Index calculation			
Borehole ID	Section m btoc	Borehole ID_Sec.	Section m btoc	Pertub. Phase	Rec. Phase	T_{f1} m^2/s	T_{f2} m^2/s	T_{s1} m^2/s	T_{s2} m^2/s	T_T m^2/s	T_{TMIN} m^2/s	T_{TMAX} m^2/s	S	dt_1 s	dt_2 s	Index 1 r_s^2/dt_L	Index 2 s_p/Q_p	Index 2 new $(sp/Qp)^*\ln(r_s/r_0)$	Diffusivity η (T/S)
KLX19A	495.00–515.00	HLX27_1	133.00–164.70	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX27_2	0.00–132.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX28_1	0.00–154.00	n.a.	n.a.	–	–	–	–	–	–	–	–	–	–	n.a.	6,990	42,104	n.a.
		HLX32_1	0.00–163.00	2	n.a.	4.3E–05	–	n.a.	n.a.	4.3E–05	2.0E–05	1.0E–04	1.4E–05	2.8E05	1.5E06	n.a.	7,281	43,643	3.01
		HLX36_1	50.00–199.50	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX36_2	0.00–49.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX37_1	149.00–199.80	n.a.	n.a.	–	–	–	–	–	–	–	–	–	–	n.a.	5,242	34,670	n.a.
		HLX37_2	118.00–148.00	n.a.	n.a.	–	–	–	–	–	–	–	–	–	–	n.a.	5,534	36,815	n.a.
		HLX37_3	0.00–117.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX38_1	0.00–199.50	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX42_1	30.00–152.60	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX42_2	0.00–29.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		KLX11A_1	0.00–992.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		KLX11E_1	2.00–121.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		KLX20A_1	0.00–457.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			
KLX19A	764.00–769.00	HLX27_1	133.00–164.70	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX27_2	0.00–132.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX28_1	0.00–154.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX32_1	0.00–163.00	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.	n.o.			n.o.
		HLX36_1	50.00–199.50	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX36_2	0.00–49.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX37_1	149.00–199.80	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
KLX19A	764.00–769.00	HLX37_2	118.00–148.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX37_3	0.00–117.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX38_1	0.00–199.50	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX42_1	30.00–152.60	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX42_2	0.00–29.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		KLX11A_1	0.00–992.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		KLX11E_1	2.00–121.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		KLX20A_1	0.00–457.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–

Nomenclature

Flow regime	The flow regime description refers to the recommended model used in the transient analysis. WBS denotes wellbore storage and skin and is followed by a set of numbers describing the flow dimension used in the analysis (1 = linear flow, 2 = radial flow, 3 = spherical flow). If only one number is used (e.g. WBS2 or 2) a homogeneous flow model (1 composite zone) was used in the analysis, if two numbers are given (WBS22 or 22) a 2 zones composite model was used.
T_f	Transmissivity derived from the analysis of the perturbation phase (CRw). In case a homogeneous flow model was used only one T_f value is reported, in case a two zone composite flow model was used both T_{f1} (inner zone) and T_{f2} (outer zone) are given.
T_s	Transmissivity derived from the analysis of the recovery phase (CRwr). In case a homogeneous flow model was used only one T_s value is reported, in case a two zone composite flow model was used both T_{s1} (inner zone) and T_{s2} (outer zone) are given.
T_T	Recommended transmissivity.
T_{TMIN} / T_{TMAX}	Confidence range lower/upper limit.
S	Storativity.
dt_1 / dt_2	Estimated start/stop time of evaluation of the recommended transmissivity (T_T).
Index 1	r_s^2/dt_L (m²/s) normalised distance r_s with respect to the response time.
Index 2	sp/Qp (s/m²) normalised drawdown with respect to the pumping rate.
Index 2 new	$(sp/Qp)*\ln(r_s/r_0)$ (s/m²) normalised drawdown with respect to the pumping rate and distance.
Diffusivity η	T_T/S (m²/s)
n.a.	Not analysed due to strong natural fluctuations.
n.o.	No observation data available.

6.3 Conclusions

6.3.1 Transmissivity derived from the pump tests

Table 6-2 presents numbers of transmissivities, including the confidence range derived from the transient analysis. The method used for deriving the recommended transmissivity and its confidence range is described in Section 4.5.9 of the report No. P-07-90.

Whenever possible, the transmissivities derived are representative for the “undisturbed formation” further away from the borehole. The borehole vicinity was typically described using a skin effect. Due to the noisy and unstable CRw phases of both pump tests, only the CRwr phases were analysed. A composite model was chosen for both of the CRwr phases. Depending on the quality of the data, the outer zone transmissivity of the recovery phase was recommended for the test section 495.00–515.00 m ($5.8 \cdot 10^{-06}$ m²/s) and the inner zone transmissivity for the test section 764.00–769.00 m ($2.9 \cdot 10^{-07}$ m²/s).

6.3.2 Flow regimes encountered

The flow models used in the analysis were derived from the shape of the pressure derivative calculated with respect to log time and plotted in log-log coordinates.

In both pump tests, the pressure derivative suggests a change of transmissivity with increased distance from the borehole. In these cases a composite flow model was used in the analysis.

The flow dimension displayed by the tests can be diagnosed from the slope of the pressure derivative. A slope of 0.5 indicates linear flow, a slope of 0 (horizontal derivative) indicates radial flow and a slope of –0.5 indicates spherical flow. The flow dimension diagnosis was commented for each of the tests. However, in both cases it was possible to achieve to acceptable analysis results (good match quality) by using radial flow geometry (flow dimension of 2).

6.3.3 Interference tests and hydraulic connectivity

For the interference tests two constant rate pump tests were performed in KLX19A. Up to 15 sections in 10 boreholes mainly along the lineament NW042 and NS001 were monitored. 4 sections in 3 observation holes responded during the pump test in section 495.00–515.00 m and no section responded during the pump test in section 764.00–769.00 m.

The responding observation sections are located in two boreholes along the lineament NW042 up to approximately 400 m away from KLX19A and in one of the boreholes along the lineament NS001 up to approximately 775 m away from KLX19A. Due to the background noise of the response test data, it was not possible to derive a response time, the response drawdown range from low to medium.

The recommended transmissivity derived from the transient analysis of the responding section in borehole HLX32 is at $4.3 \cdot 10^{-5}$ m^2/s. Due to major natural fluctuations affecting the data of the other three responding sections, no further analysis of test data was possible.

6.3.4 Interpretation of the responses

Preliminary evaluations indicate that the lineament NW042 acts as a hydraulic connection, whereas the dolerite dyke connected to NS001 acts as a hydraulic barrier. Pumping in KLX19A in section 495.00–515.00 m generates responses in boreholes HLX28 and HLX32 connected to NW042 and in two lower sections in HLX37 east of and covering the dolerite dyke. The upper section in HLX37 above (west) of the dolerite dyke does not respond to the pumping in KLX19A. The second pump test section in KLX19A at 764.00–769.00 which is not direct connected to the lineament NW042 generated no response in any of the observation boreholes at all.

The tests also show that there is no hydraulic connection from the lineament NW042 to lineament NS059 as the observation borehole HLX38 shows no response to both of the pump tests in KLX19A.

7 References

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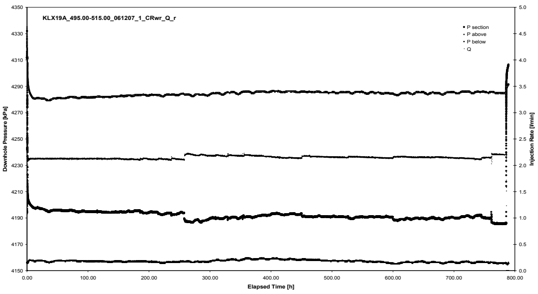
Pump Test Summary Sheets

Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	Crwr
Area:	Laxemar	Test no:	1
Borehole ID:	KLX19A	Test start:	061207 15:07
Test section from - to (m):	495.00-515.00 m	Responsible for test execution:	Stephan Rohs Philipp Wolf
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	Cristian Enachescu

Linear plot Q and p

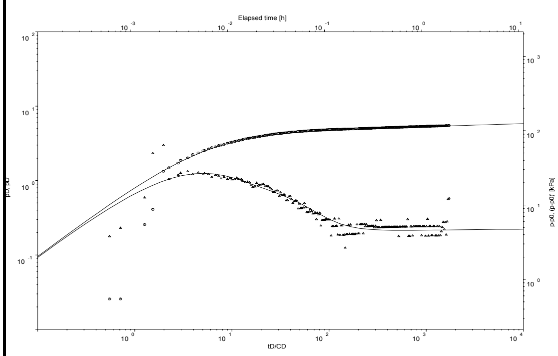


Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa) =	4316		
p_i (kPa) =	4311		
p_p(kPa) =	4186	p_F (kPa) =	4306
Q_p (m^3/s)=	3.50E-05		
tp (s) =	2827044	t_F (s) =	12780
S el S^* (-)=	1.00E-06	S el S^* (-)=	1.00E-06
EC_w (mS/m)=			
$Temp_w$(gr C)=	13.3		
Derivative fact.=	NA	Derivative fact.=	0.08
Results		**Results**	
Q/s (m^2/s)=	2.7E-06		
T_M (m^2/s)=	2.9E-06		
Flow regime:	NA	Flow regime:	transient
dt_1 (min) =	NA	dt_1 (min) =	11.44
dt_2 (min) =	NA	dt_2 (min) =	95.51
T (m^2/s) =	NA	T (m^2/s) =	5.8E-06
S (-) =	NA	S (-) =	1.0E-06
K_s (m/s) =	NA	K_s (m/s) =	2.9E-07
S_s (1/m) =	NA	S_s (1/m) =	5.0E-08
C (m^3/Pa) =	NA	C (m^3/Pa) =	6.8E-09
C_D (-) =	NA	C_D (-) =	7.4E-01
ξ (-) =	NA	ξ (-) =	-2.15
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	

Log-Log plot incl. derivates- flow period

not analysed

Log-Log plot incl. derivatives- recovery period



Selected representative parameters.			
dt_1 (min) =	11.44	C (m^3/Pa) =	6.8E-09
dt_2 (min) =	95.51	C_D (-) =	7.4E-01
T_T (m^2/s) =	5.8E-06	ξ (-) =	-2.15
S (-) =	1.0E-06		
K_s (m/s) =	2.9E-07		
S_s (1/m) =	5.0E-08		

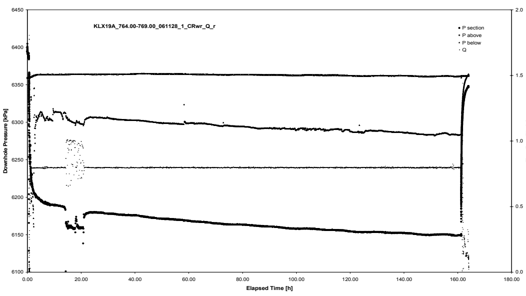
Comments:

The recommended transmissivity of 5.8•10-6 m2/s was derived from the analysis of the CRwr phase. Due to the hydraulic communication to the bottom zone, the derived value should be regarded as at the upper limit of the confidence range. The confidence range for the interval transmissivity is estimated to be 1.0•10-6 to 6.0•10-6 m2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRwr phase using type curve extrapolation in the Horner plot to a value of 4,331.2 kPa. Due to the short duration of the recovery compared to the pumping time, this value is slightly uncertain

Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Laxemar	Test no:	1
Borehole ID:	KLX19A	Test start:	061128 19:53
Test section from - to (m):	764.00-769.00	Responsible for test execution:	Stephan Rohs Philipp Wolf
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	Cristian Enachescu

Linear plot Q and p

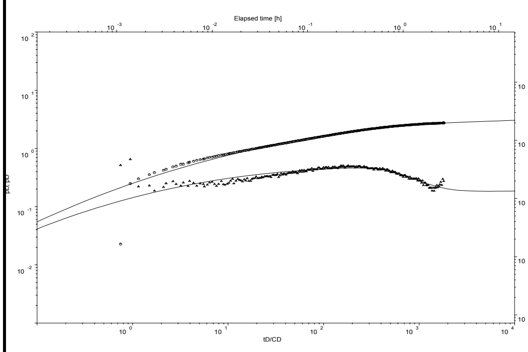


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	6404		
p_i (kPa) =	6391		
p_p(kPa) =	6150	p_F (kPa) =	6347
Q_p (m^3/s)=	1.33E-05		
tp (s) =	578490	t_F (s) =	9588
S el S^* (-)=	1.00E-06	S el S^* (-)=	1.00E-06
EC_w (mS/m)=			
$Temp_w$(gr C)=	16.8		
Derivative fact.=	NA	Derivative fact.=	0.06
Results		**Results**	
Q/s (m^2/s)=	5.4E-07		
T_M (m^2/s)=	4.5E-07		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	NA	dt_1 (min) =	0.60
dt_2 (min) =	NA	dt_2 (min) =	23.34
T (m^2/s) =	NA	T (m^2/s) =	2.9E-07
S (-) =	NA	S (-) =	1.0E-06
K_s (m/s) =	NA	K_s (m/s) =	5.7E-08
S_s (1/m) =	NA	S_s (1/m) =	2.0E-07
C (m^3/Pa) =	NA	C (m^3/Pa) =	9.7E-10
C_D (-) =	NA	C_D (-) =	1.1E-01
ξ (-) =	NA	ξ (-) =	-4.6
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	

Log-Log plot incl. derivates- flow period

Not analysed

Log-Log plot incl. derivatives- recovery period



Selected representative parameters.

dt_1 (min) =	0.60	C (m^3/Pa) =	9.7E-10
dt_2 (min) =	23.34	C_D (-) =	1.1E-01
T_T (m^2/s) =	2.9E-07	ξ (-) =	-4.6
S (-) =	1.0E-06		
K_s (m/s) =	5.7E-08		
S_s (1/m) =	2.0E-07		

Comments:

The recommended transmissivity of 2.9E-7 m2/s was derived from the analysis of the CRwr phase. Due to the hydraulic communication to the bottom zone, the derived value should be regarded as at the upper limit of the confidence range. The confidence range for the interval transmissivity is estimated to be 5.0E-8 to 3.0E-7 m2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRwr phase using type curve extrapolation in the Horner plot to a value of 6,404.6 kPa. Due to the short duration of the recovery compared to the pumping time, this value is slightly uncertain.

Index calculation

Interference analysis

APPENDIX 2-1

Index calculation

KL19A Section 495.00-515.00 m pumped

Activityplan No.	AP PS 400-07-72		

Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:	09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:	09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	4311
Pressure in test section before stop of flowing:	p_p	kPa	4186
Maximum pressure change during flowing period:	dp_p	kPa	125

Observation Hole:	**HLX27**	**Section no.:**	**HLX27_1**
		Section length:	133.0-164.7
Distance r_s [m]:	989.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	68.9
Pressure in test section before stop of flowing:	p_p	kPa	68.5
Maximum pressure change during flowing period:*	dp_p	kPa	0.4

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

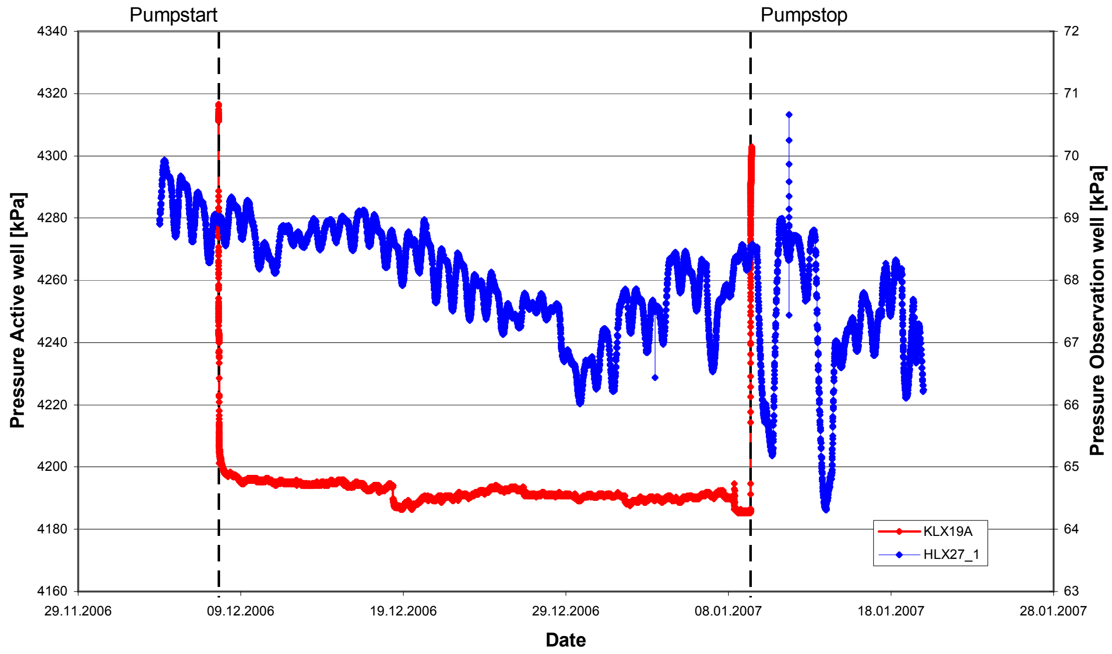
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes due to natural fluctuations (e.g. tidal effects) only
no index calculated



Activityplan No.	AP PS 400-07-72		

Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:	09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:	09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	4311
Pressure in test section before stop of flowing:	p_p	kPa	4186
Maximum pressure change during flowing period:	dp_p	kPa	125

Observation Hole:	**HLX27**	**Section no.:**	**HLX27_2**
		Section length:	0.0-132.0
Distance r_s [m]:	1002.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	69.0
Pressure in test section before stop of flowing:	p_p	kPa	68.5
Maximum pressure change during flowing period:*	dp_p	kPa	0.5

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

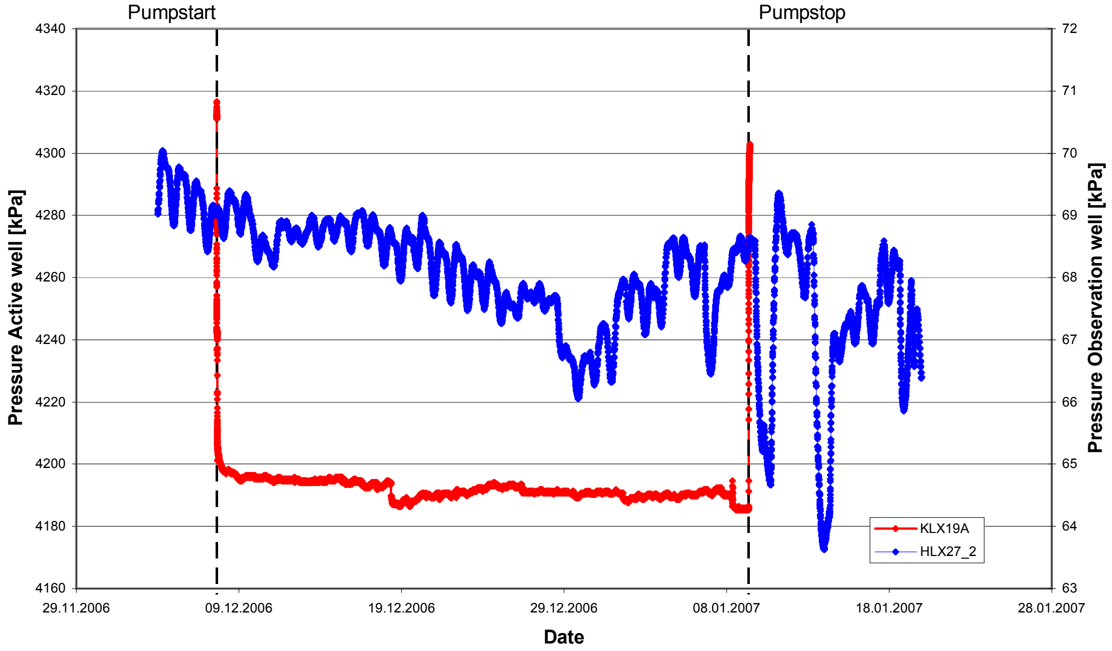
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes due to natural fluctuations (e.g. tidal effects) only
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:	09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:	09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	4311
Pressure in test section before stop of flowing:	p_p	kPa	4186
Maximum pressure change during flowing period:	dp_p	kPa	125

Observation Hole:	**HLX28**	**Section no.:**	**HLX28_1**
		Section length:	0.0-154.0
Distance r_s [m]:	413.00	max. Drawdown s_p [m]:*	0.24
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	133.2
Pressure in test section before stop of flowing:	p_p	kPa	130.8
Maximum pressure change during flowing period:*	dp_p	kPa	2.4

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

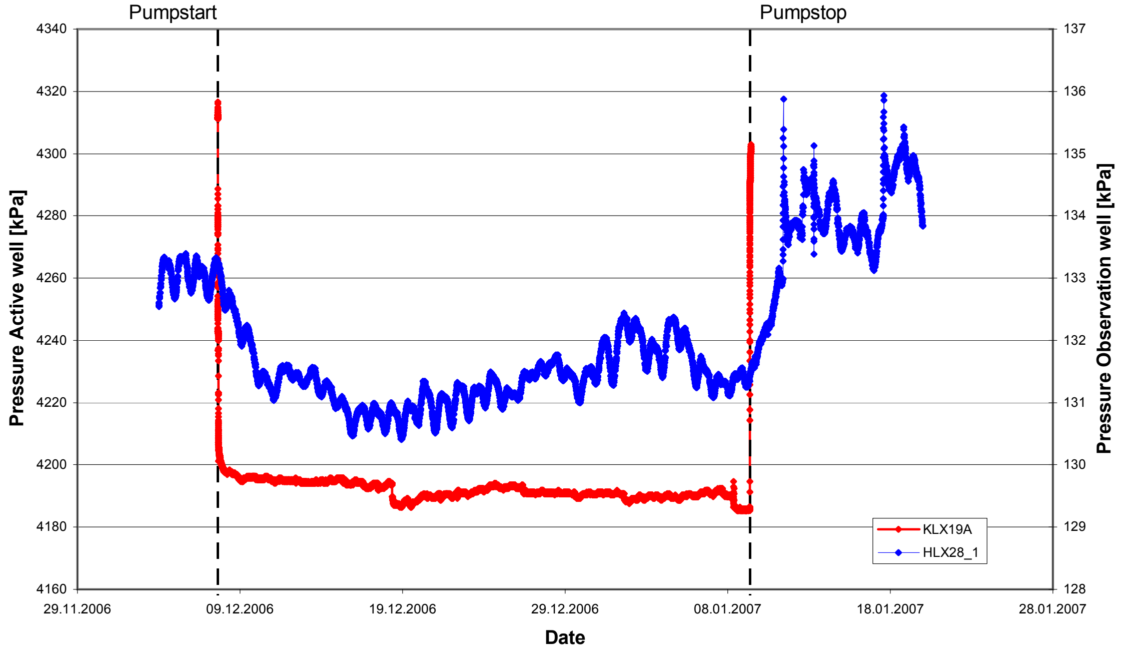
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **6989.95** **Low**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **42103.61** **Medium**

* see comment

Comment: no clear response due to pumping in source
pressure changes influenced additionally by natural fluctuations
(e.g. tidal effects)



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:	09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:	09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	4311
Pressure in test section before stop of flowing:	p_p	kPa	4186
Maximum pressure change during flowing period:	dp_p	kPa	125

Observation Hole:	**HLX32**	**Section no.:**	**HLX32_1**
		Section length:	0.0-163.0
Distance r_s [m]:	401.00	max. Drawdown s_p [m]:*	0.25
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	79.1
Pressure in test section before stop of flowing:	p_p	kPa	76.6
Maximum pressure change during flowing period:*	dp_p	kPa	2.5

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

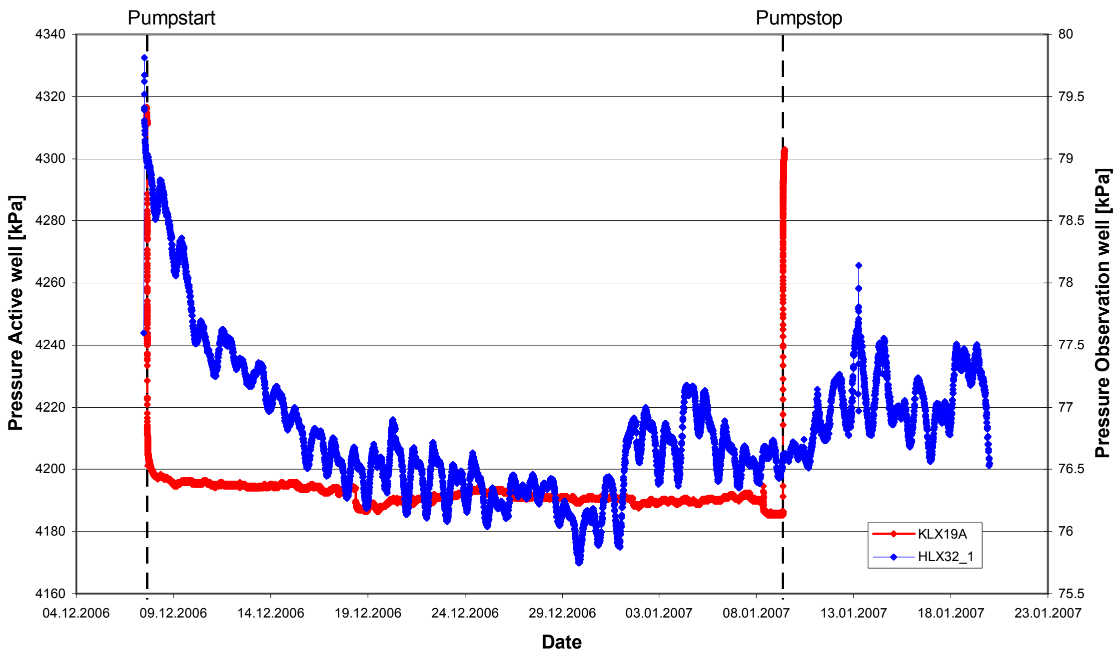
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **7281.20** **Low**

Index 2 New **$(s_p/Q_p)*ln(r_s/r_0)$ [s/m^2]:** **43643.23** **Medium**

* see comment

Comment: no clear response due to pumping in source
pressure changes influenced additionally by natural fluctuations
(e.g. tidal effects)



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:	09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:	09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	4311
Pressure in test section before stop of flowing:	p_p	kPa	4186
Maximum pressure change during flowing period:	dp_p	kPa	125

Observation Hole:	**HLX36**	**Section no.:**	**HLX36_1**
		Section length:	50.0-199.5
Distance r_s [m]:	764.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	136.7
Pressure in test section before stop of flowing:	p_p	kPa	137.3
Maximum pressure change during flowing period:*	dp_p	kPa	0.6

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

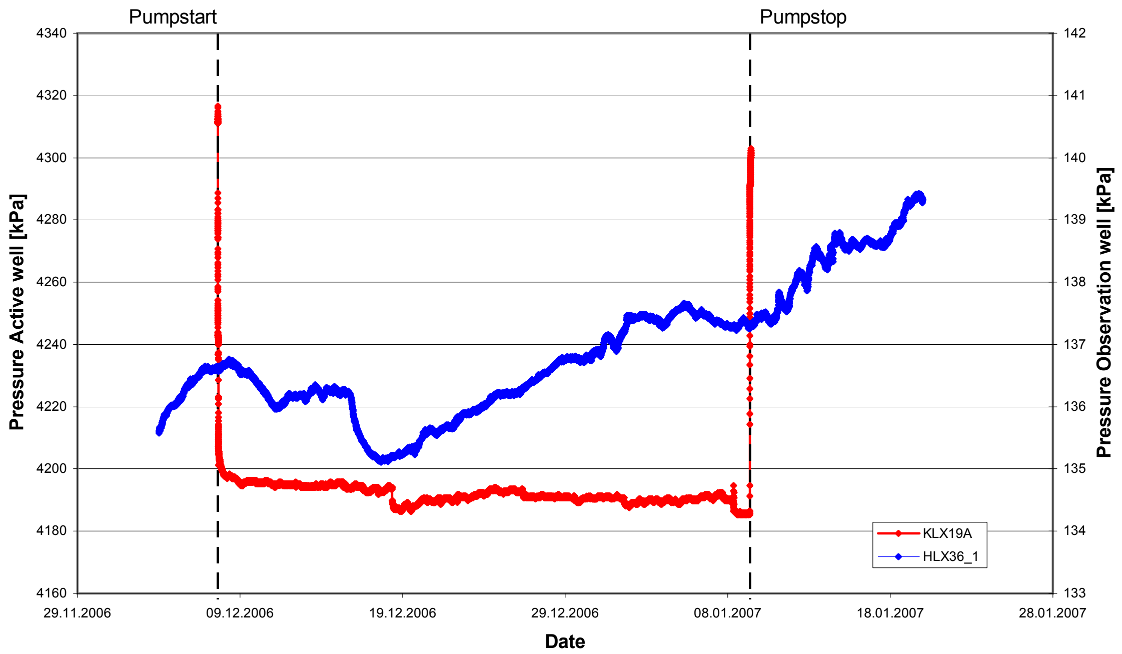
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes due to natural fluctuations (e.g. tidal effects) only
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:	09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:	09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	4311
Pressure in test section before stop of flowing:	p_p	kPa	4186
Maximum pressure change during flowing period:	dp_p	kPa	125

Observation Hole:	**HLX36**	**Section no.:**	**HLX36_2**
		Section length:	0.0-49.0
Distance r_s [m]:	770.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	104.2
Pressure in test section before stop of flowing:	p_p	kPa	104.4
Maximum pressure change during flowing period:*	dp_p	kPa	0.2

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

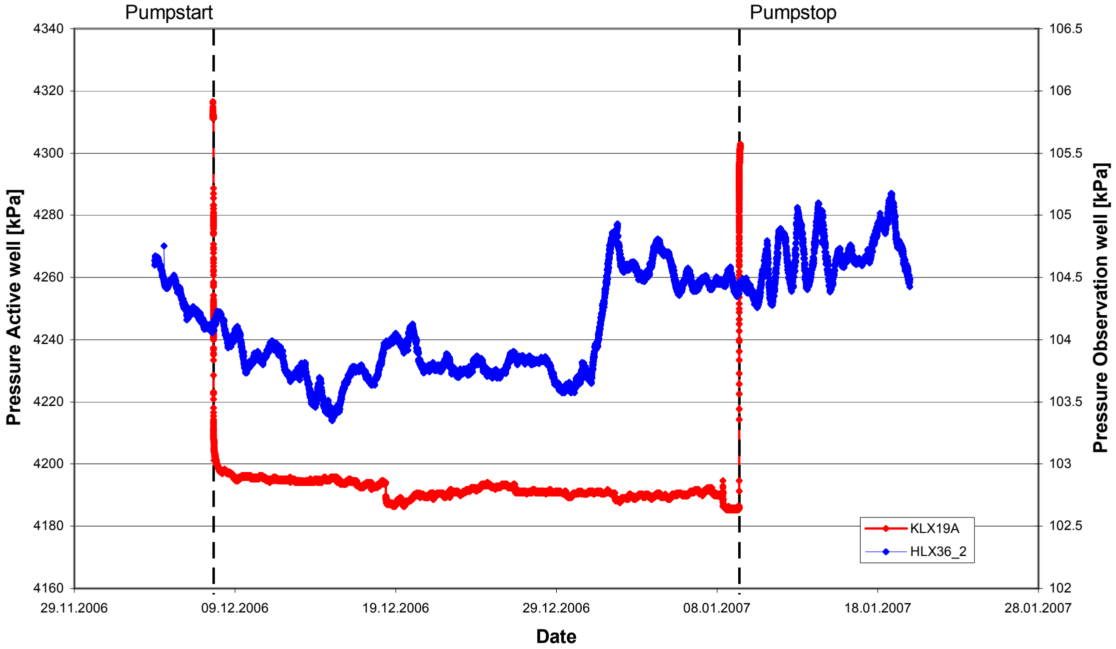
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes due to natural fluctuations (e.g. tidal effects) only
no index calculated



Activityplan No.	AP PS 400-07-72			
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**		**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:		09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:		09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05			

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	4311
Pressure in test section before stop of flowing:	p_p	kPa	4186
Maximum pressure change during flowing period:	dp_p	kPa	125

Observation Hole:	**HLX37**	**Section no.:**	**HLX37_1**
		Section length:	149.0-199.8
Distance r_s [m]:	745.00	max. Drawdown s_p [m]:*	0.18
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	135.3
Pressure in test section before stop of flowing:	p_p	kPa	133.5
Maximum pressure change during flowing period:*	dp_p	kPa	1.8

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

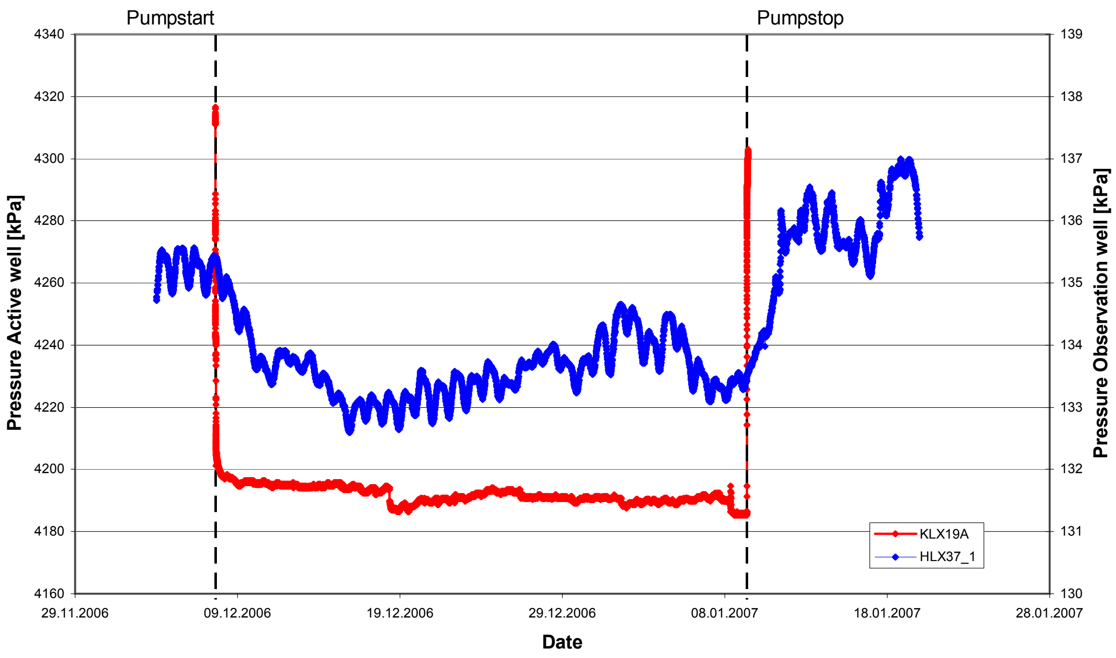
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **5242.46** **Low**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **34670.43** **Medium**

* see comment

Comment: clear response due to pumping in source
pressure changes influenced additionally by natural fluctuations
(e.g. tidal effects)



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:	09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:	09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	4311
Pressure in test section before stop of flowing:	p_p	kPa	4186
Maximum pressure change during flowing period:	dp_p	kPa	125

Observation Hole:	**HLX37**	**Section no.:**	**HLX37_2**
		Section length:	118.0-148.0
Distance r_s [m]:	775.00	max. Drawdown s_p [m]:*	0.19
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	135.2
Pressure in test section before stop of flowing:	p_p	kPa	133.3
Maximum pressure change during flowing period:*	dp_p	kPa	1.9

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

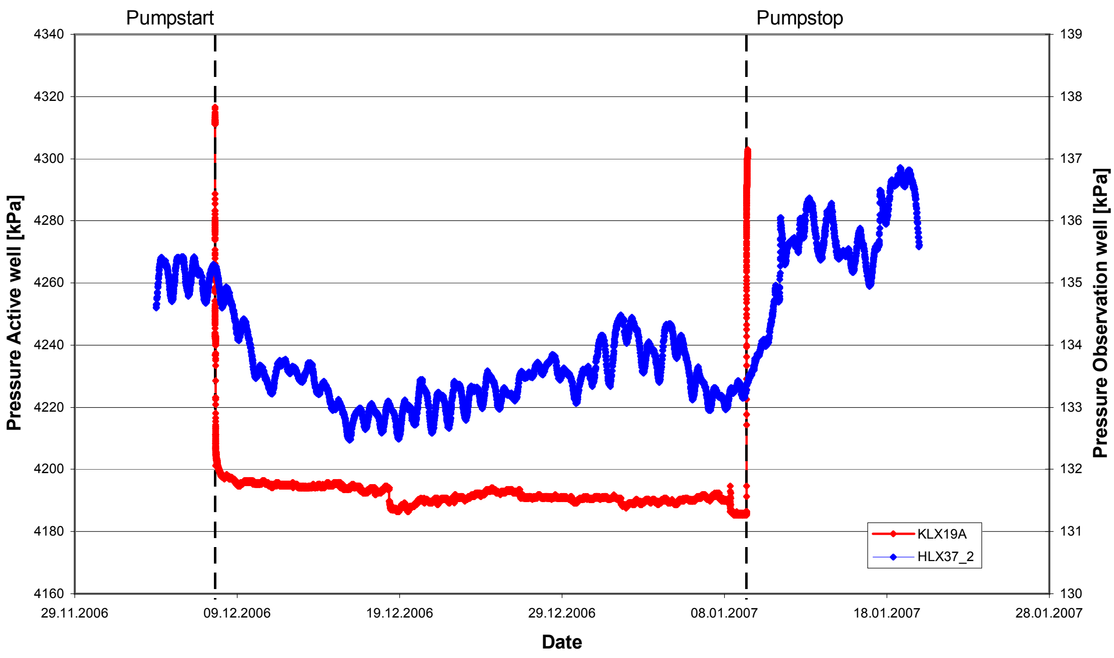
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **5533.71** **Low**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **36815.03** **Medium**

* see comment

Comment: clear response due to pumping in source
pressure changes influenced additionally by natural fluctuations
(e.g. tidal effects)



Activityplan No.	AP PS 400-07-72				
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**			**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:			09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:			09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05				
Pressure data		**Nomenclature**	**Unit**		**Value**
Pressure in test section before start of flowing:		p_i	kPa		4311
Pressure in test section before stop of flowing:		p_p	kPa		4186
Maximum pressure change during flowing period:		dp_p	kPa		125
Observation Hole:	**HLX37**	**Section no.:**			**HLX37_3**
		Section length:			0.0-117.0
Distance r_s [m]:	795.00	max. Drawdown s_p [m]:*			#NV
Response time dt_L [s]:	#NV				
Pressure data		**Nomenclature**	**Unit**		**Value**
Pressure in test section before start of flowing:		p_i	kPa		148.5
Pressure in test section before stop of flowing:		p_p	kPa		148.6
Maximum pressure change during flowing period:*		dp_p	kPa		0.1

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

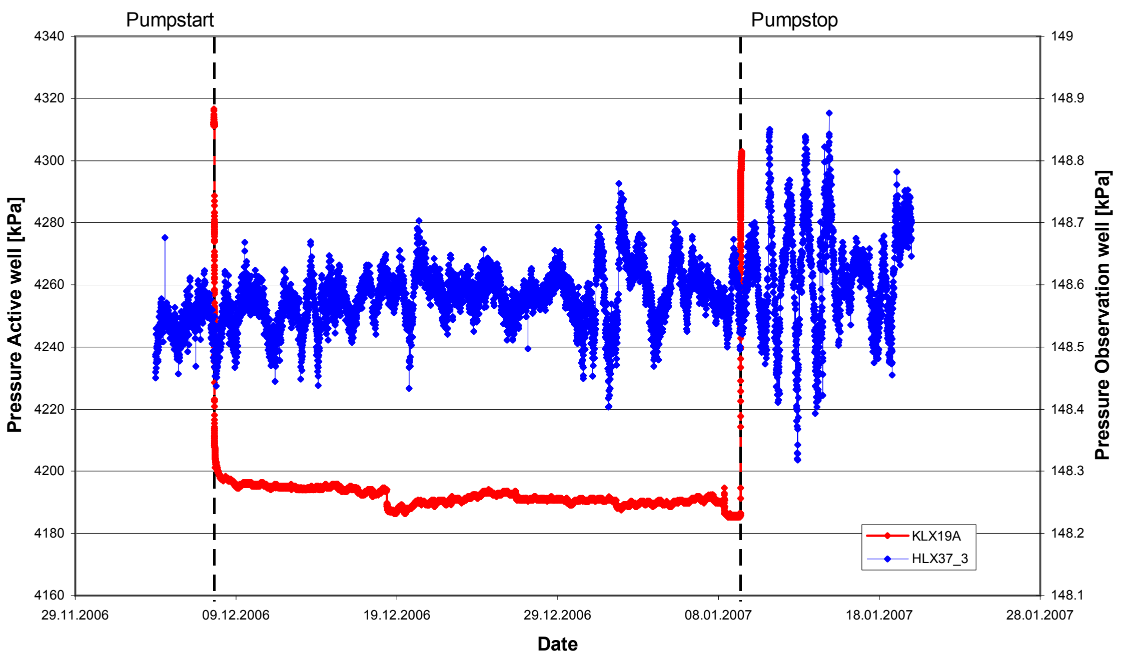
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes due to natural fluctuations (e.g. tidal effects) only
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:	09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:	09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	4311
Pressure in test section before stop of flowing:	p_p	kPa	4186
Maximum pressure change during flowing period:	dp_p	kPa	125

Observation Hole:	**HLX38**	**Section no.:**	**HLX38_1**
		Section length:	0.0-199.5
Distance r_s [m]:	478.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	56.6
Pressure in test section before stop of flowing:	p_p	kPa	56.6
Maximum pressure change during flowing period:*	dp_p	kPa	0.0

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

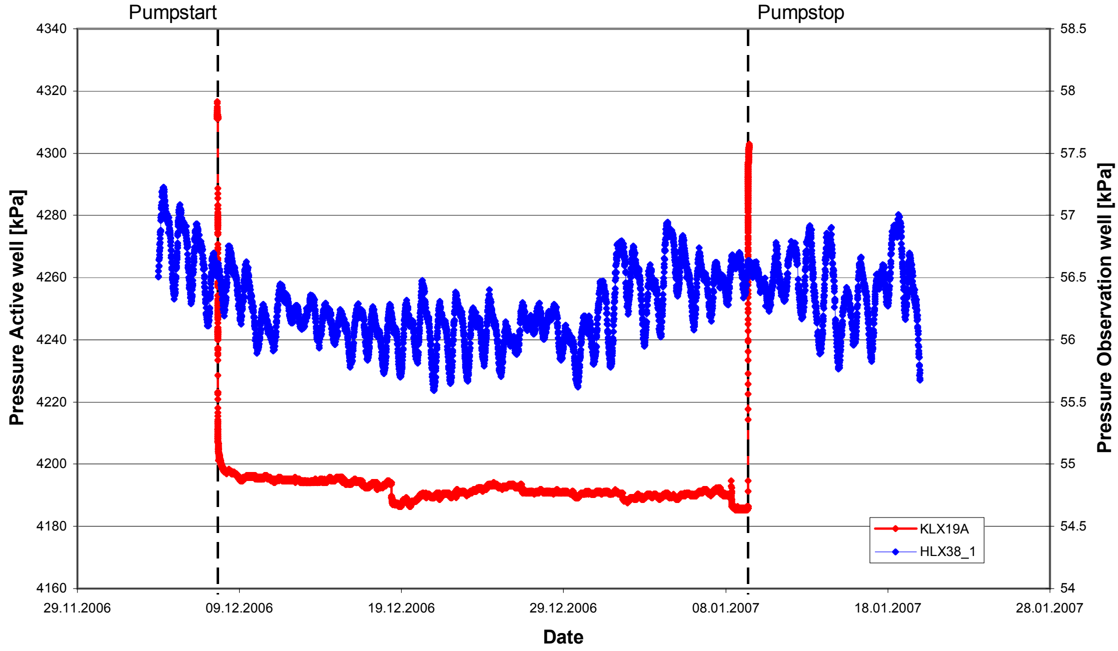
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes due to natural fluctuations (e.g. tidal effects) only
no index calculated



Activityplan No.	AP PS 400-07-72			

Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:	09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:	09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	4311
Pressure in test section before stop of flowing:	p_p	kPa	4186
Maximum pressure change during flowing period:	dp_p	kPa	125

Observation Hole:	**HLX42**	**Section no.:**	**HLX42_1**
		Section length:	30.0-152.6
Distance r_s [m]:	970.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	105.2
Pressure in test section before stop of flowing:	p_p	kPa	103.4
Maximum pressure change during flowing period:*	dp_p	kPa	1.8

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

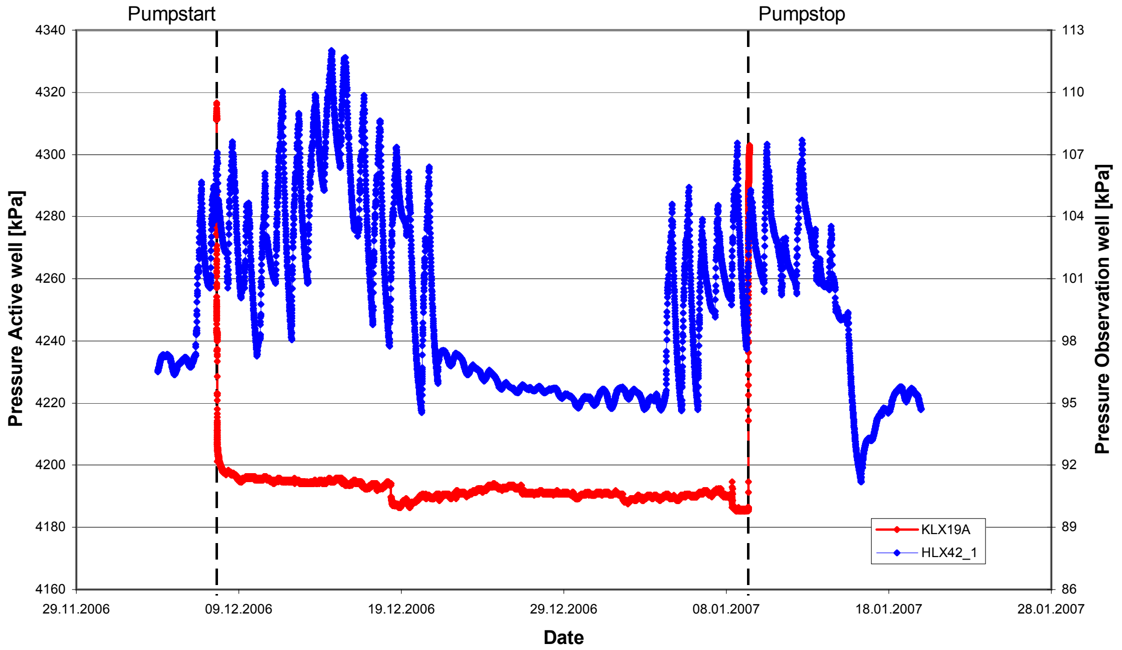
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes due to natural fluctuations (e.g. tidal effects) only
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:	09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:	09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	4311
Pressure in test section before stop of flowing:	p_p	kPa	4186
Maximum pressure change during flowing period:	dp_p	kPa	125

Observation Hole:	**HLX42**	**Section no.:**	**HLX42_2**
		Section length:	0.0-29.0
Distance r_s [m]:	1043.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	118.8
Pressure in test section before stop of flowing:	p_p	kPa	118.0
Maximum pressure change during flowing period:*	dp_p	kPa	0.8

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

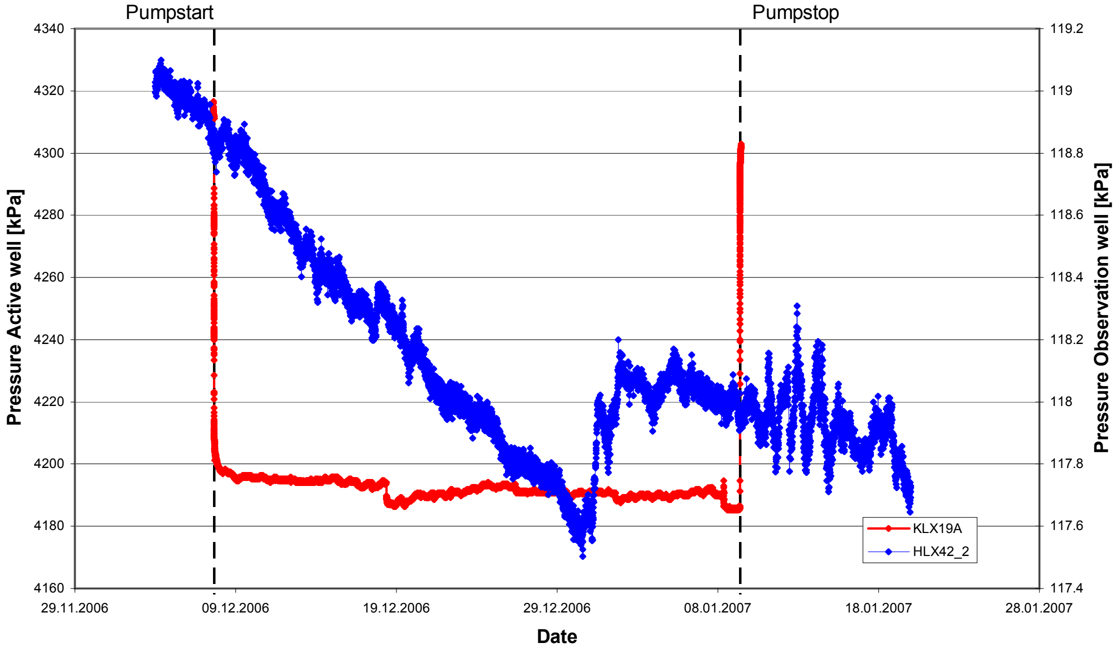
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes due to natural fluctuations (e.g. tidal effects) only
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:	09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:	09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	4311
Pressure in test section before stop of flowing:	p_p	kPa	4186
Maximum pressure change during flowing period:	dp_p	kPa	125

Observation Hole:	**KLX11**	**Section no.:**	**KLX11A_1**
		Section length:	0.0-992.0
Distance r_s [m]:	724.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	142.4
Pressure in test section before stop of flowing:	p_p	kPa	141.0
Maximum pressure change during flowing period:*	dp_p	kPa	1.4

Normalized distance with respect to the response time

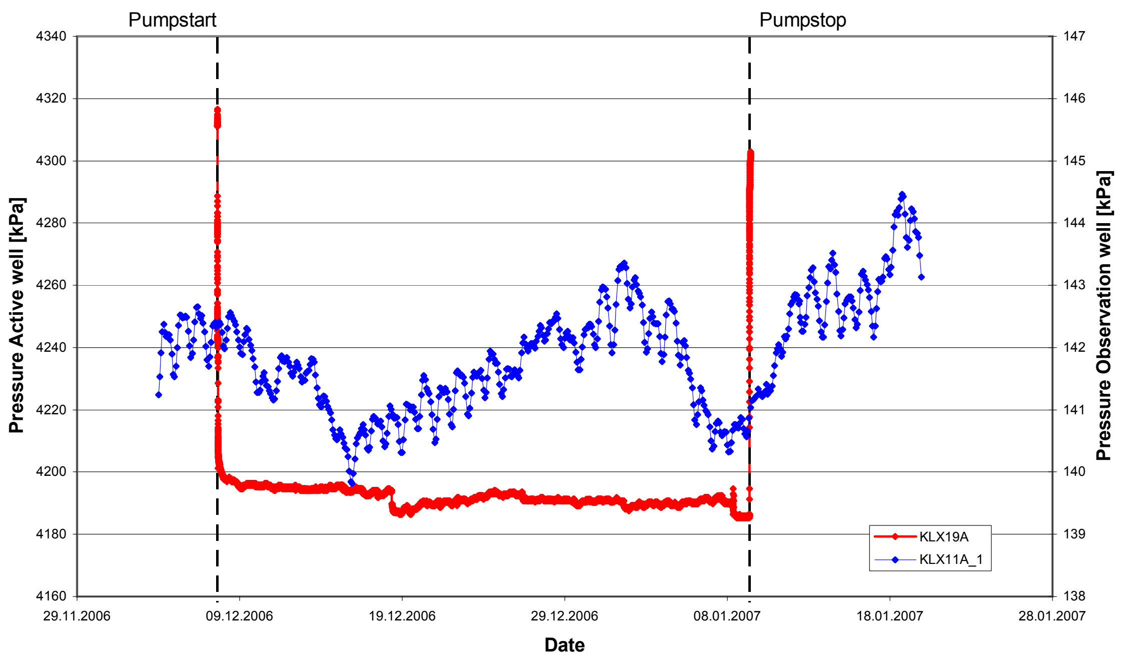
Index 1	**r_s^2/dt_L [m^2/s]:**	**#NV**

Normalized drawdown with respect to pumping flow rate

Index 2	**s_p/Q_p [s/m^2]:**	**#NV**
Index 2 New	**$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:**	**#NV**

* see comment

Comment: no response due to pumping in source
pressure changes due to natural fluctuations (e.g. tidal effects) only
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:	09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:	09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	4311
Pressure in test section before stop of flowing:	p_p	kPa	4186
Maximum pressure change during flowing period:	dp_p	kPa	125

Observation Hole:	**KLX11**	**Section no.:**	**KLX11E_1**
		Section length:	2.0-121.0
Distance r_s [m]:	846.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	149.3
Pressure in test section before stop of flowing:	p_p	kPa	147.4
Maximum pressure change during flowing period:*	dp_p	kPa	1.9

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

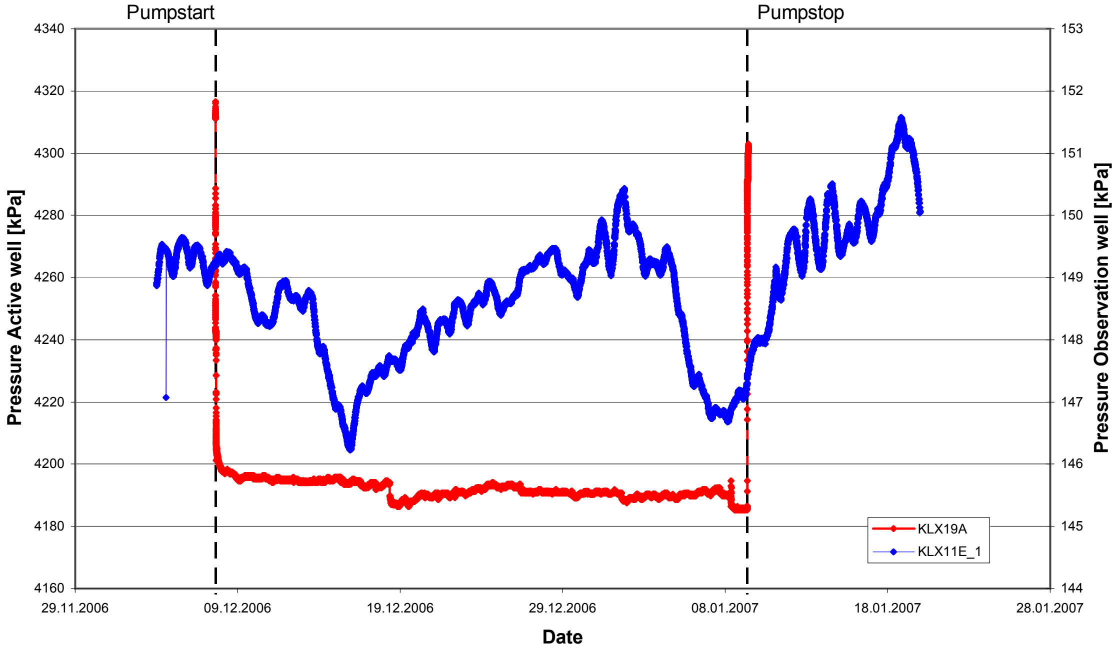
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes due to natural fluctuations (e.g. tidal effects) only
no index calculated



Activityplan No.	AP PS 400-07-72			
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**		**495.00-515.00**
Test Start:	07.12.2006 15:07	Test Stop:		09.01.2007 12:28
Pump Start:	07.12.2006 15:38	Pump Stop:		09.01.2007 08:56
Flow Rate Q_p [m^3/s]:	3.50E-05			
Pressure data		**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:		p_i	kPa	4311
Pressure in test section before stop of flowing:		p_p	kPa	4186
Maximum pressure change during flowing period:		dp_p	kPa	125
Observation Hole:	**KLX20**	**Section no.:**		**KLX20A_1**
		Section length:		0.0-457.0
Distance r_s [m]:	883.00	max. Drawdown s_p [m]:*		#NV
Response time dt_L [s]:	#NV			
Pressure data		**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:		p_i	kPa	150.4
Pressure in test section before stop of flowing:		p_p	kPa	148.8
Maximum pressure change during flowing period:*		dp_p	kPa	1.6

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

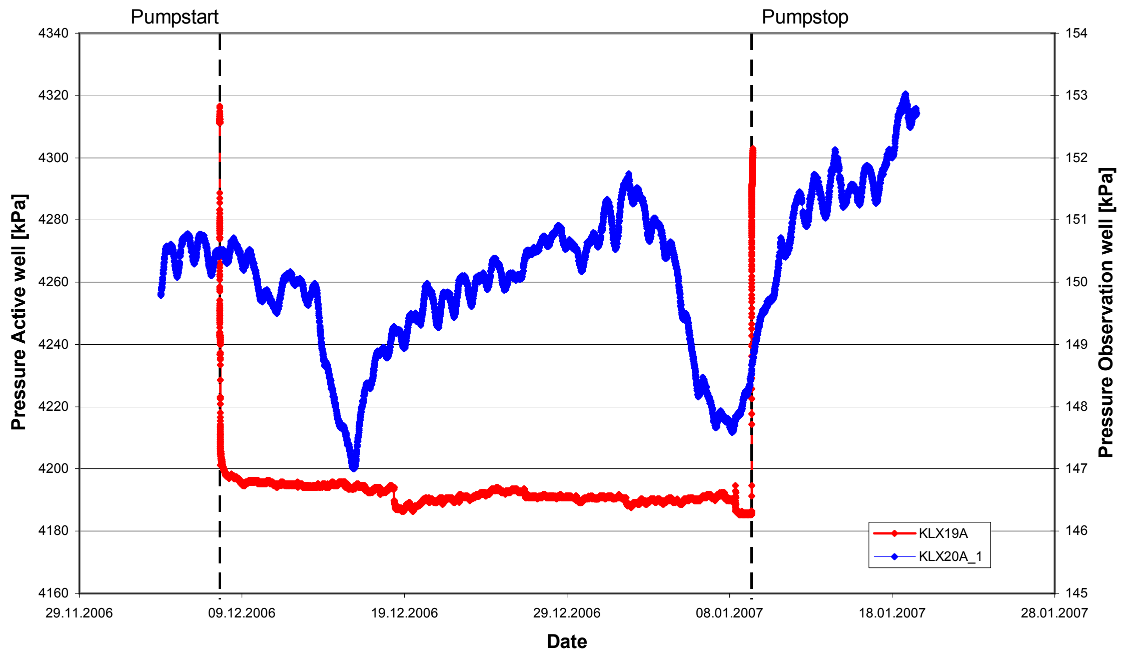
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes due to natural fluctuations (e.g. tidal effects) only
no index calculated



APPENDIX 2-2

Index calculation

KLX19A Section 764.00-769.00 m pumped

Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**HLX27**	**Section no.:**	**HLX27_1**
		Section length:	133.00-164.70
Distance r_s [m]:	1099.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	69.3
Pressure in test section before stop of flowing:	p_p	kPa	69.5
Maximum pressure change during flowing period:*	dp_p	kPa	0.2

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

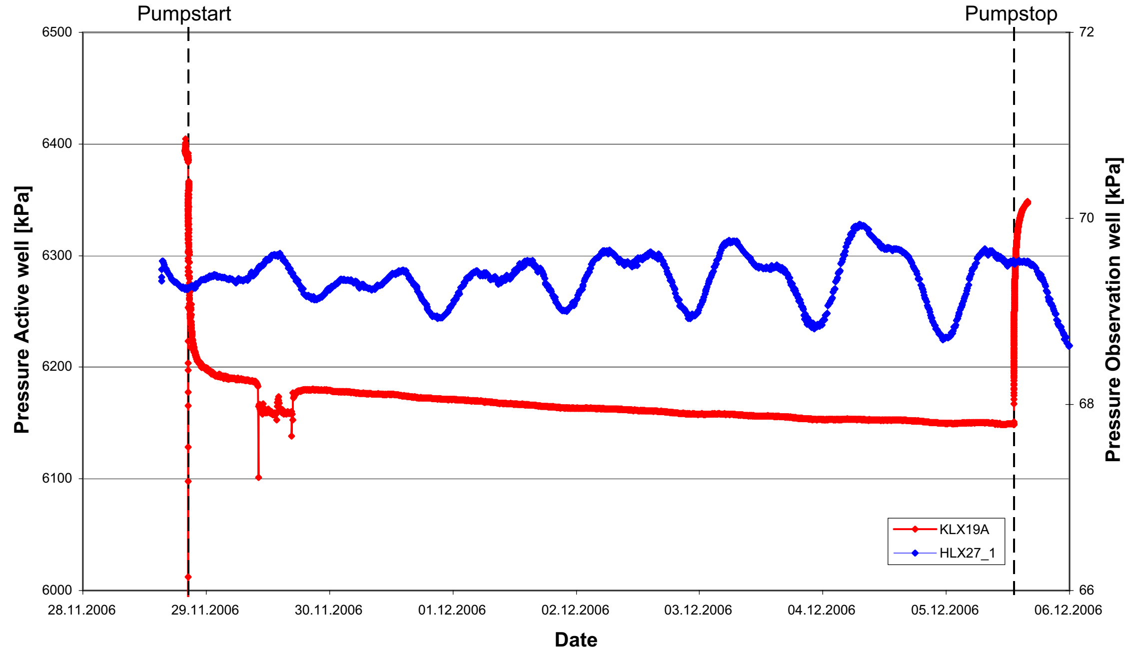
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**HLX27**	**Section no.:**	**HLX27_2**
		Section length:	0.00-132.00
Distance r_s [m]:	1123.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	69.3
Pressure in test section before stop of flowing:	p_p	kPa	69.7
Maximum pressure change during flowing period:*	dp_p	kPa	0.4

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

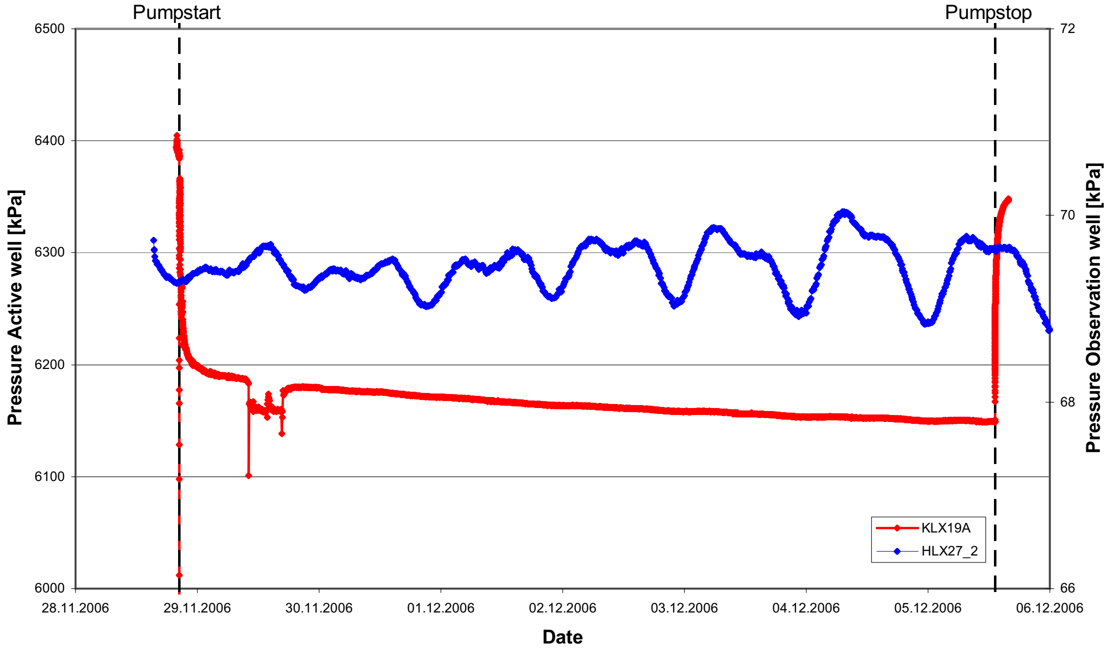
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**HLX28**	**Section no.:**	**HLX28_1**
		Section length:	0.00-154.00
Distance r_s [m]:	661.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	131.6
Pressure in test section before stop of flowing:	p_p	kPa	133.4
Maximum pressure change during flowing period:*	dp_p	kPa	1.8

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

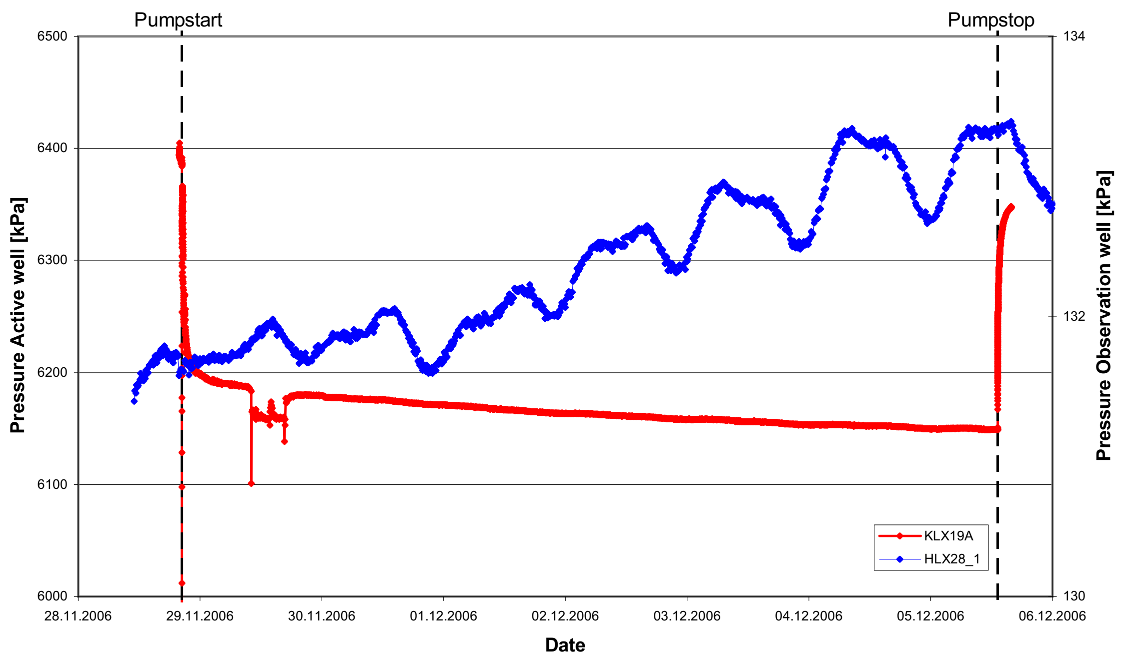
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**HLX32**	**Section no.:**	**HLX32_1**
		Section length:	0.00-163.00
Distance r_s [m]:	634.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	#NV
Pressure in test section before stop of flowing:	p_p	kPa	#NV
Maximum pressure change during flowing period:*	dp_p	kPa	#NV

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

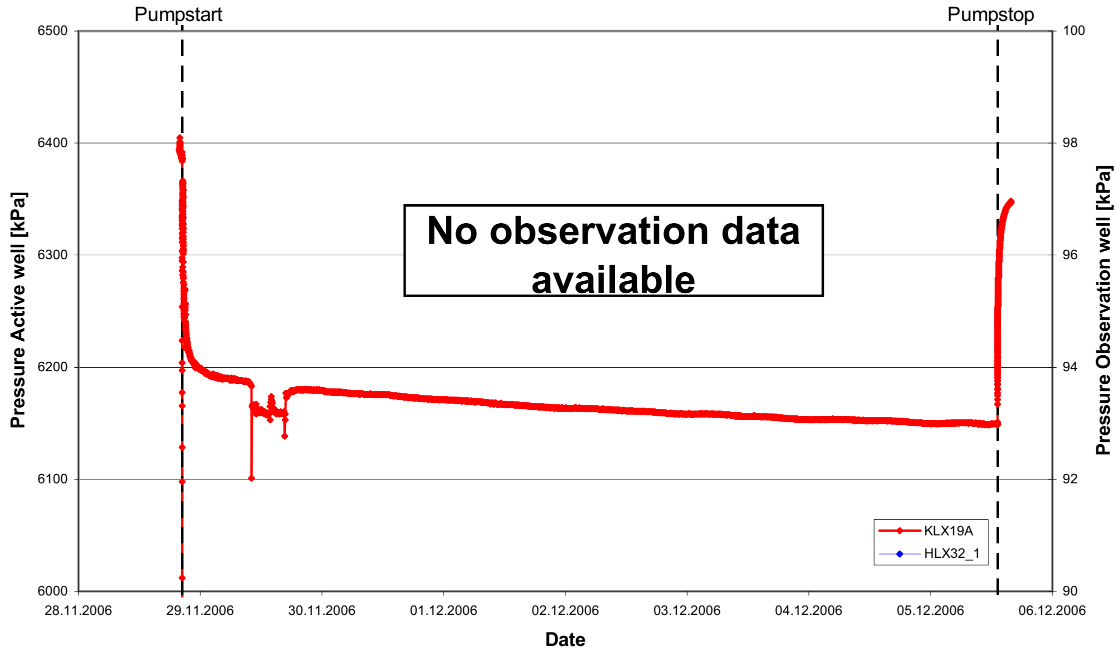
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment:



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**HLX36**	**Section no.:**	**HLX36_1**
		Section length:	50.00-199.50
Distance r_s [m]:	958.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	133.4
Pressure in test section before stop of flowing:	p_p	kPa	136.3
Maximum pressure change during flowing period:*	dp_p	kPa	2.9

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

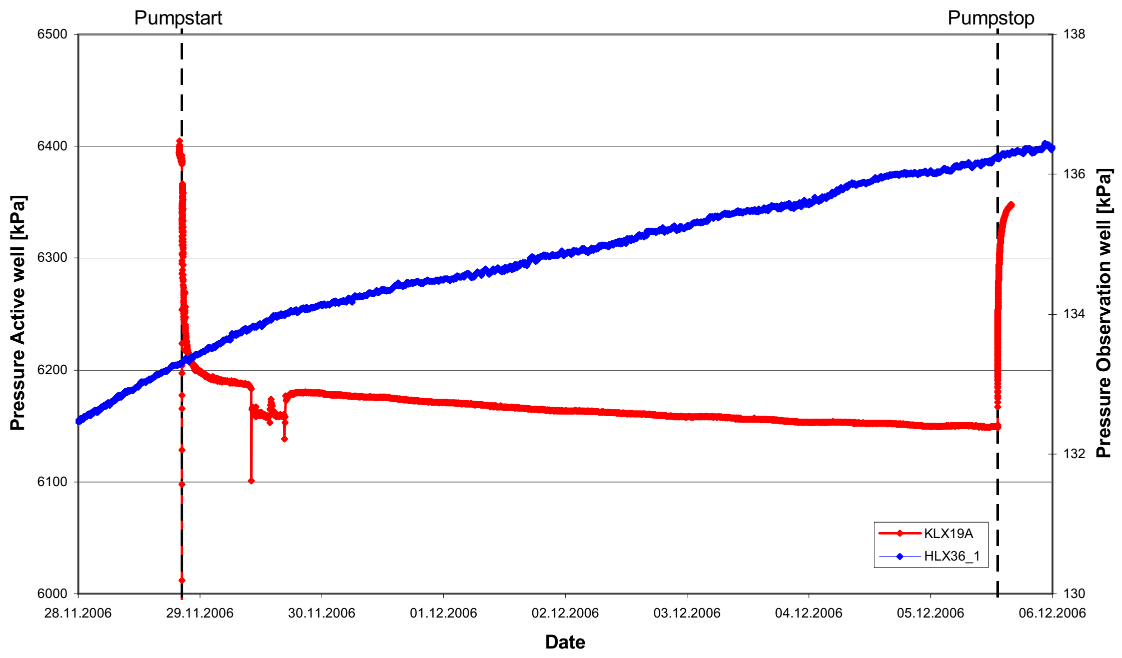
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**HLX36**	**Section no.:**	**HLX36_2**
		Section length:	0.00-49.00
Distance r_s [m]:	979.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	104.7
Pressure in test section before stop of flowing:	p_p	kPa	104.4
Maximum pressure change during flowing period:*	dp_p	kPa	0.3

Normalized distance with respect to the response time

Index 1 r_s^2/dt_L [m^2/s]: **#NV**

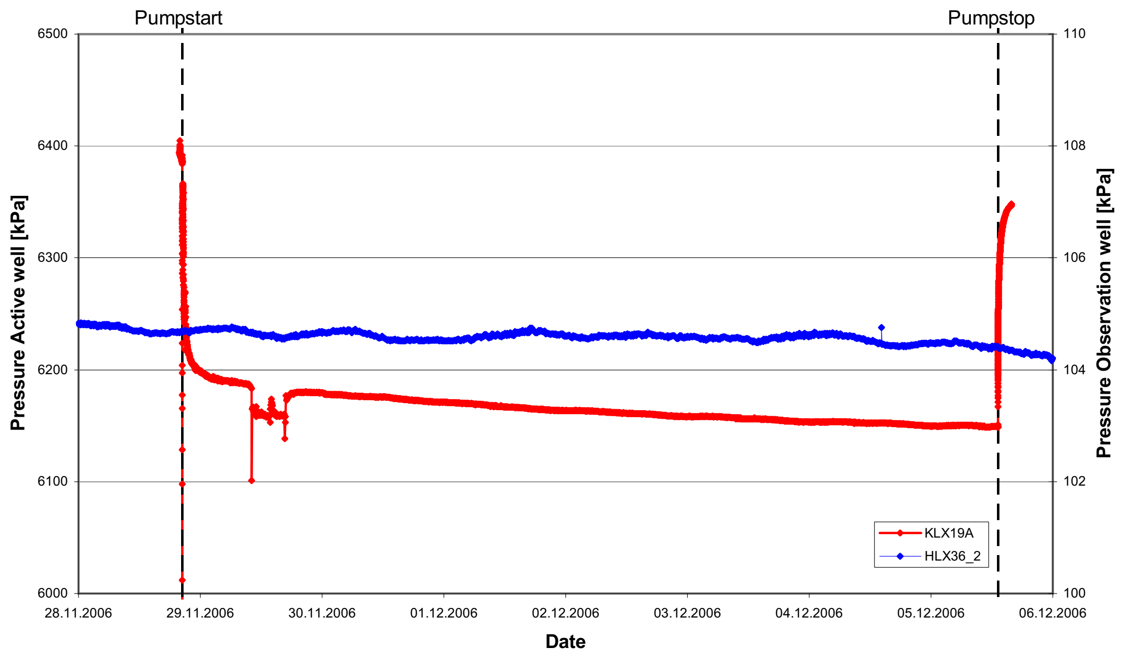
Normalized drawdown with respect to pumping flow rate

Index 2 s_p/Q_p [s/m^2]: **#NV**

Index 2 New $(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]: **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**HLX37**	**Section no.:**	**HLX37_1**
		Section length:	149.00-199.80
Distance r_s [m]:	930.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	133.7
Pressure in test section before stop of flowing:	p_p	kPa	135.6
Maximum pressure change during flowing period:*	dp_p	kPa	1.9

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

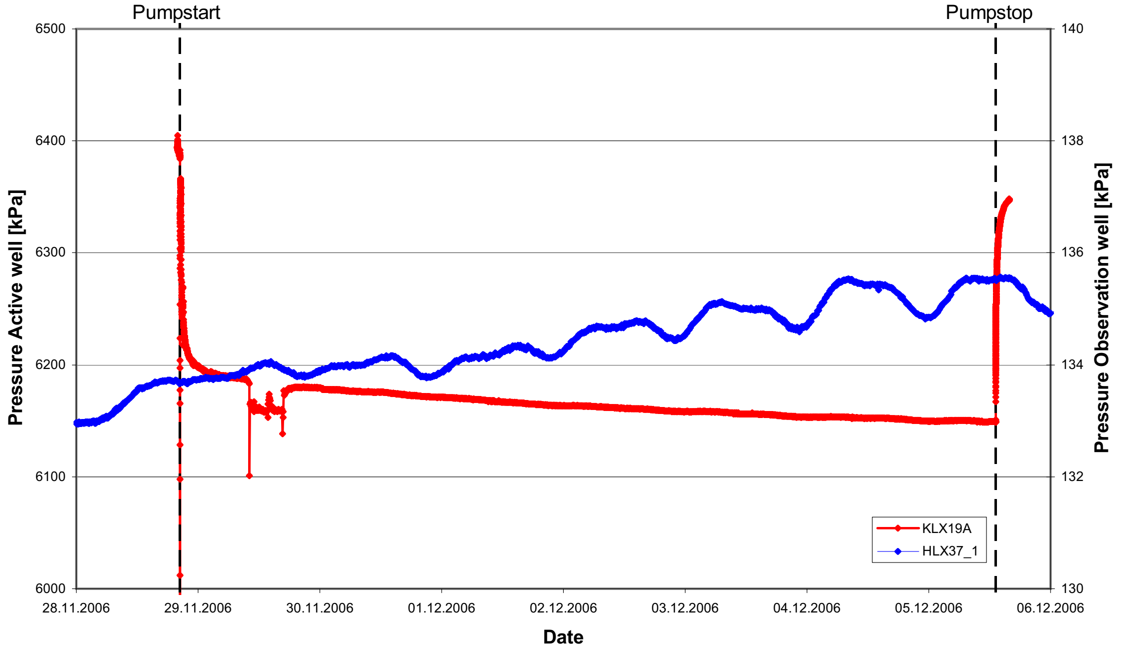
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**HLX37**	**Section no.:**	**HLX37_2**
		Section length:	118.00-148.00
Distance r_s [m]:	962.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	133.6
Pressure in test section before stop of flowing:	p_p	kPa	135.4
Maximum pressure change during flowing period:*	dp_p	kPa	1.8

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

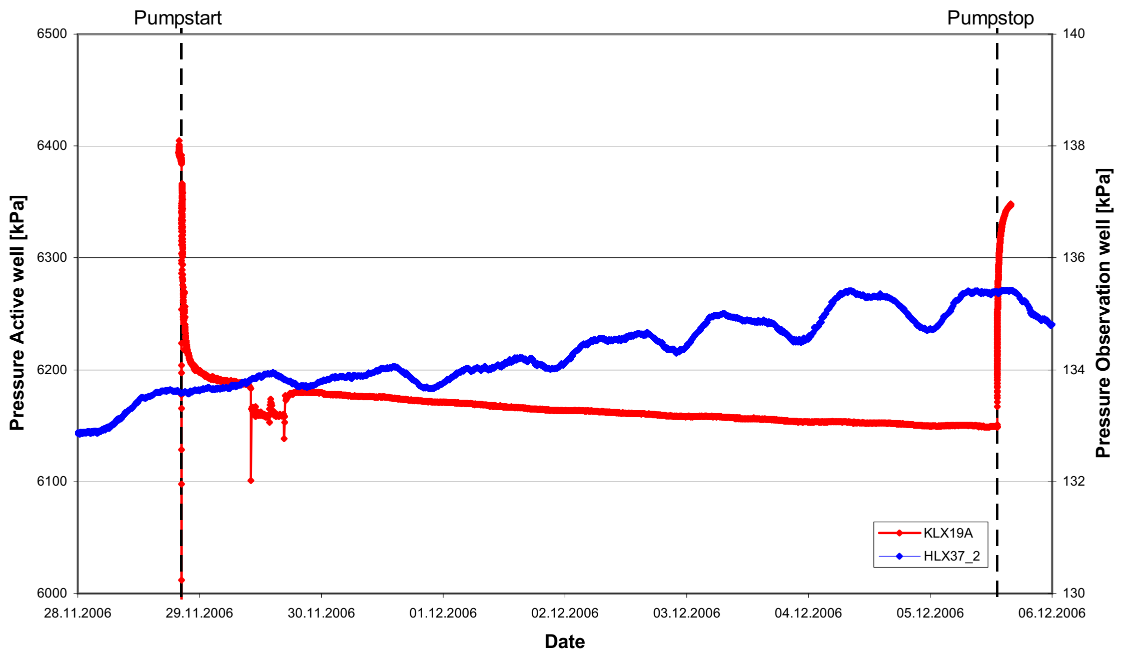
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**HLX37**	**Section no.:**	**HLX37_3**
		Section length:	0.00-117.00
Distance r_s [m]:	983.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	148.5
Pressure in test section before stop of flowing:	p_p	kPa	148.5
Maximum pressure change during flowing period:*	dp_p	kPa	0.0

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

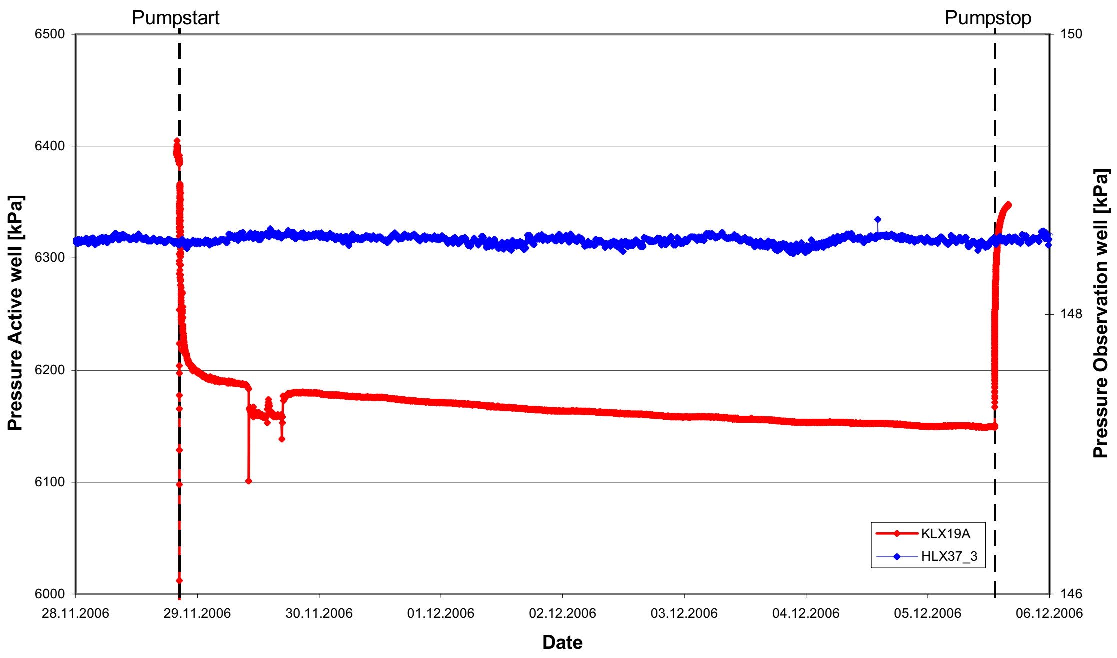
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**HLX38**	**Section no.:**	**HLX38_1**
		Section length:	0.00-199.50
Distance r_s [m]:	722.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	56.9
Pressure in test section before stop of flowing:	p_p	kPa	56.9
Maximum pressure change during flowing period:*	dp_p	kPa	0.0

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

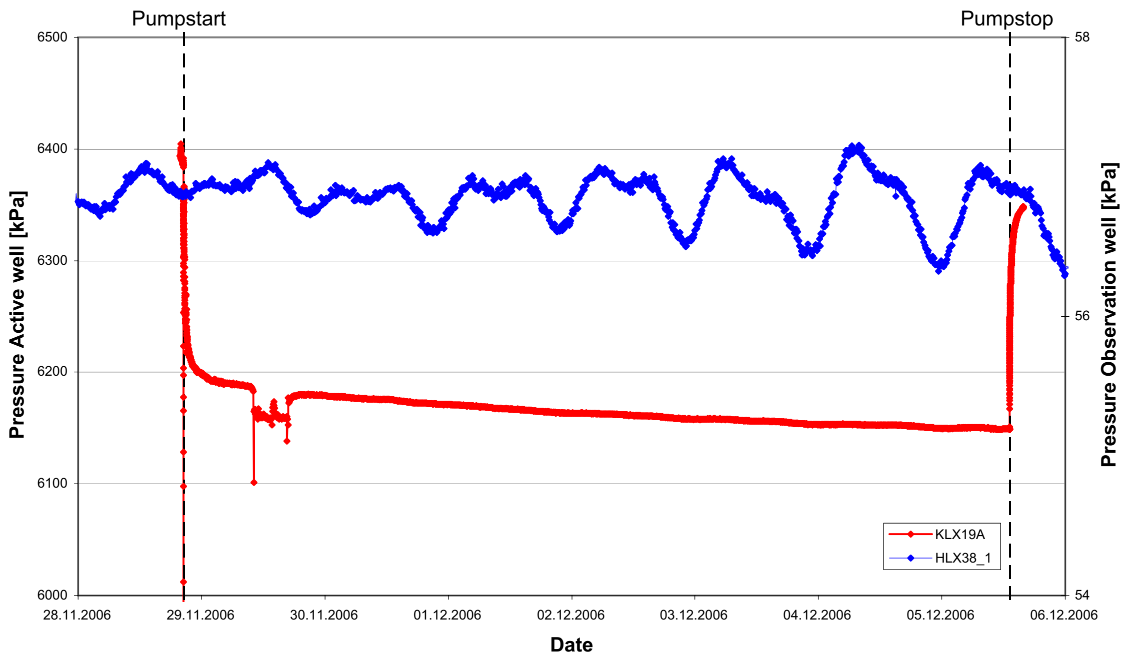
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **(s_p/Q_p)*ln(r_s/r_0) [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



Activityplan No.	AP PS 400-07-72			
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**		**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:		05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:		05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05			

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**HLX42**	**Section no.:**	**HLX42_1**
		Section length:	30.00-152.60
Distance r_s [m]:	988.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	96.1
Pressure in test section before stop of flowing:	p_p	kPa	97.1
Maximum pressure change during flowing period:*	dp_p	kPa	1.0

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

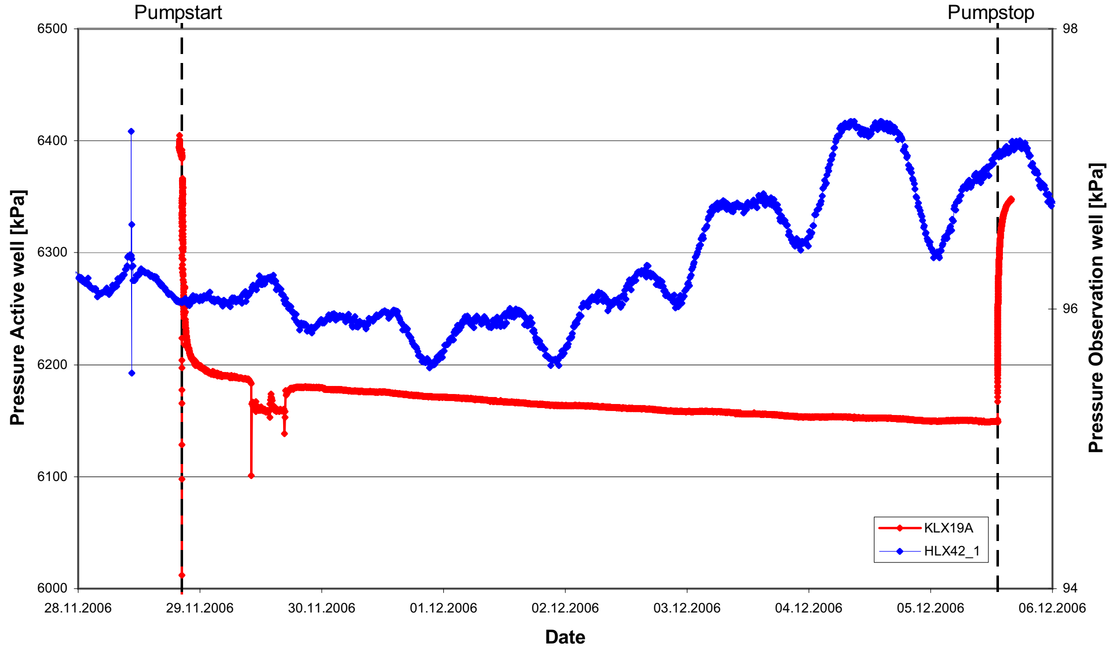
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**HLX42**	**Section no.:**	**HLX42_2**
		Section length:	0.00-29.00
Distance r_s [m]:	1071.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	119.3
Pressure in test section before stop of flowing:	p_p	kPa	119.0
Maximum pressure change during flowing period:*	dp_p	kPa	0.3

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

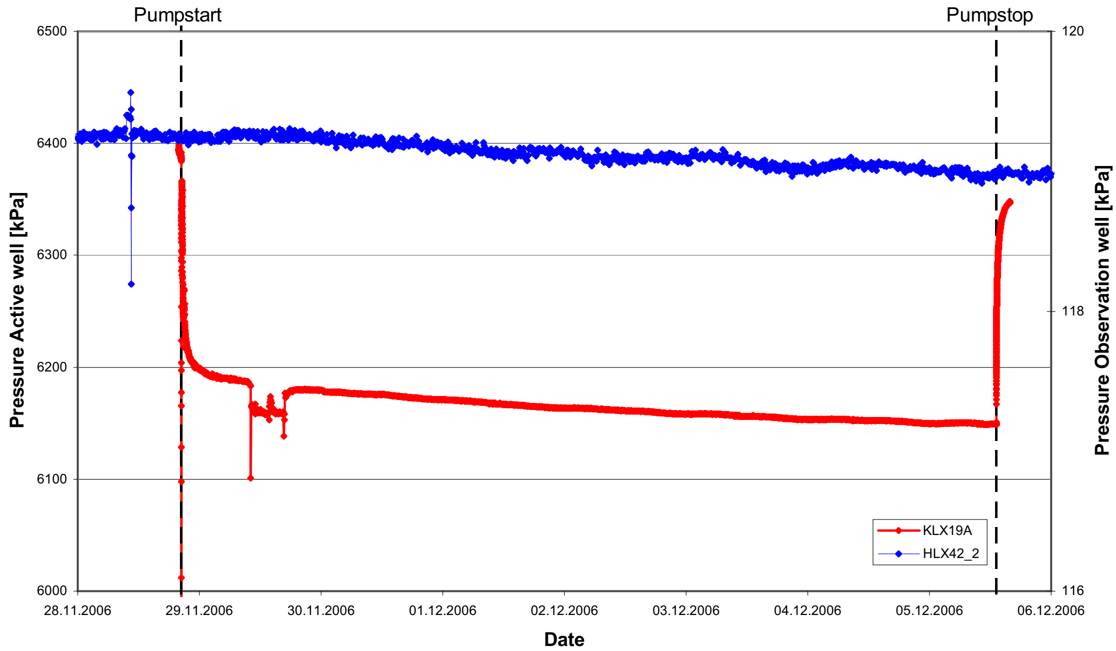
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **(s_p/Q_p)*$\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



Activityplan No.	AP PS 400-07-72		

Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**KLX11A**	**Section no.:**	**KLX11A_1**
		Section length:	0.00-992.00
Distance r_s [m]:	872.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	138.3
Pressure in test section before stop of flowing:	p_p	kPa	142.5
Maximum pressure change during flowing period:*	dp_p	kPa	4.2

Normalized distance with respect to the response time

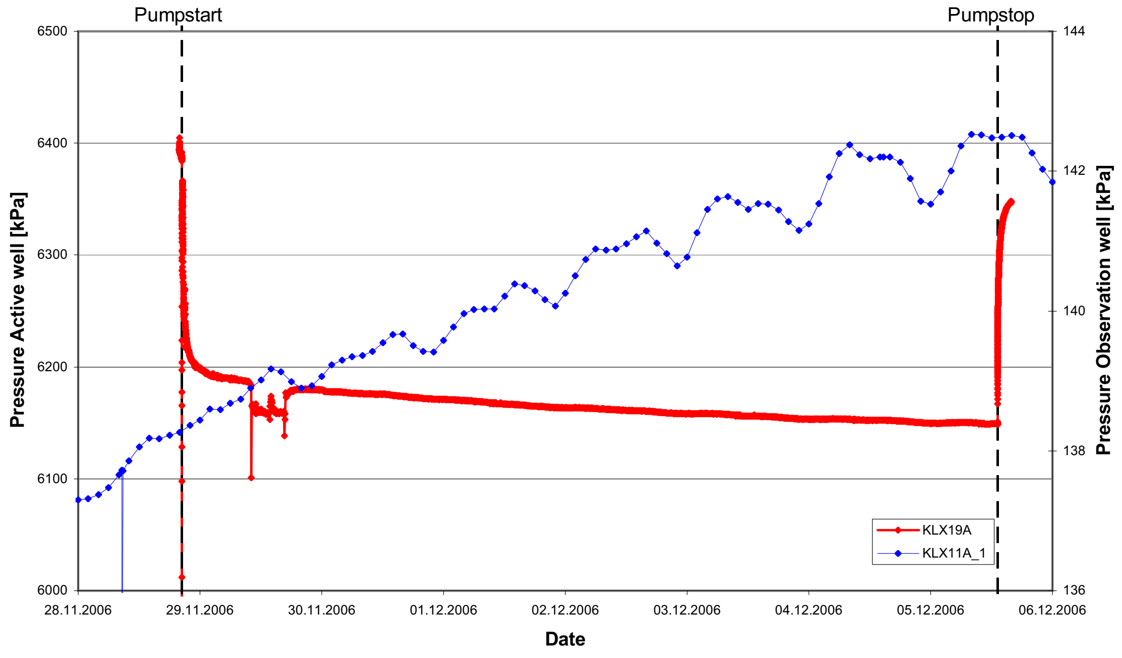
Index 1	**r_s^2/dt_L [m^2/s]:**	**#NV**

Normalized drawdown with respect to pumping flow rate

Index 2	**s_p/Q_p [s/m^2]:**	**#NV**
Index 2 New	**$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:**	**#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**KLX11E**	**Section no.:**	**KLX11E_1**
		Section length:	2.00-121.00
Distance r_s [m]:	1057.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	146.2
Pressure in test section before stop of flowing:	p_p	kPa	149.6
Maximum pressure change during flowing period:*	dp_p	kPa	3.4

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

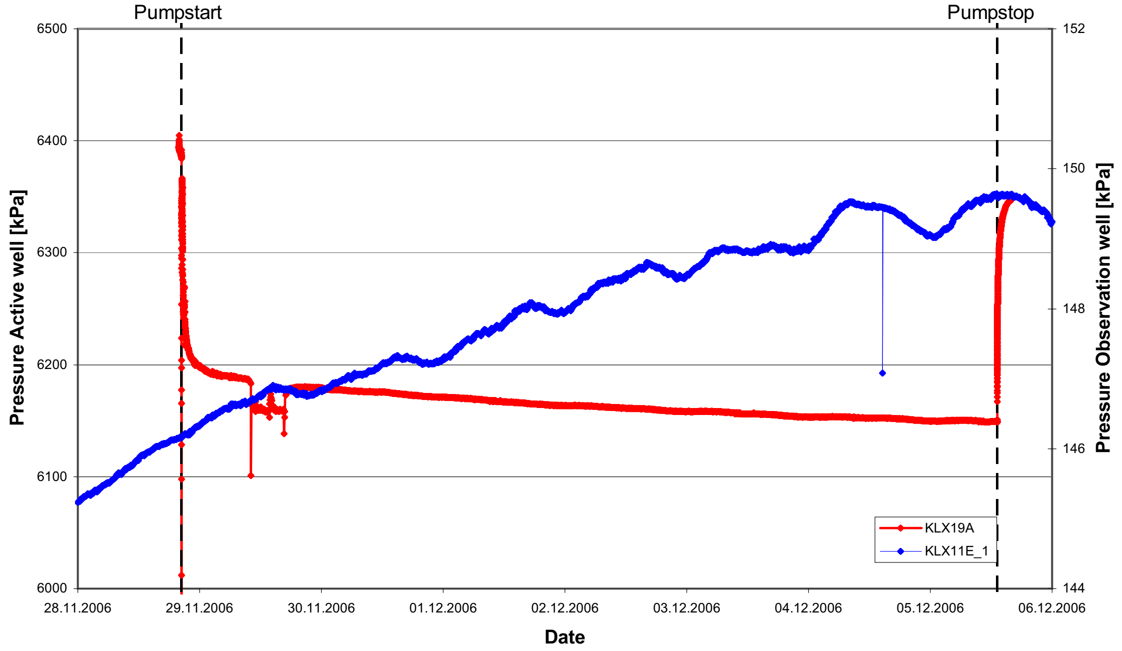
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



Activityplan No.	AP PS 400-07-72		
Pumping Hole:	**KLX19A**	**Pumping Section [m bToC]:**	**764.00-769.00**
Test Start:	28.11.2006 19:53	Test Stop:	05.12.2006 15:52
Pump Start:	28.11.2006 20:28	Pump Stop:	05.12.2006 13:10
Flow Rate Q_p [m^3/s]:	1.33E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	6391
Pressure in test section before stop of flowing:	p_p	kPa	6150
Maximum pressure change during flowing period:	dp_p	kPa	241

Observation Hole:	**KLX20A**	**Section no.:**	**KLX20A_1**
		Section length:	2.00-121.00
Distance r_s [m]:	1060.00	max. Drawdown s_p [m]:*	#NV
Response time dt_L [s]:	#NV		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	147.7
Pressure in test section before stop of flowing:	p_p	kPa	150.7
Maximum pressure change during flowing period:*	dp_p	kPa	3.0

Normalized distance with respect to the response time

Index 1 **r_s^2/dt_L [m^2/s]:** **#NV**

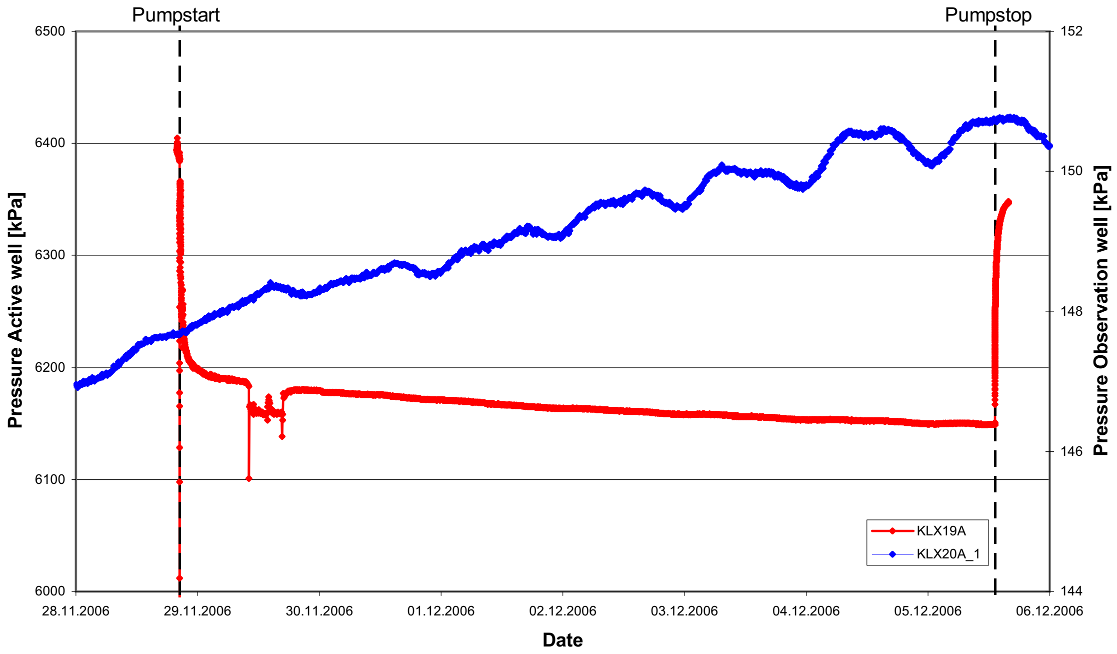
Normalized drawdown with respect to pumping flow rate

Index 2 **s_p/Q_p [s/m^2]:** **#NV**

Index 2 New **$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:** **#NV**

* see comment

Comment: no response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)
no index calculated



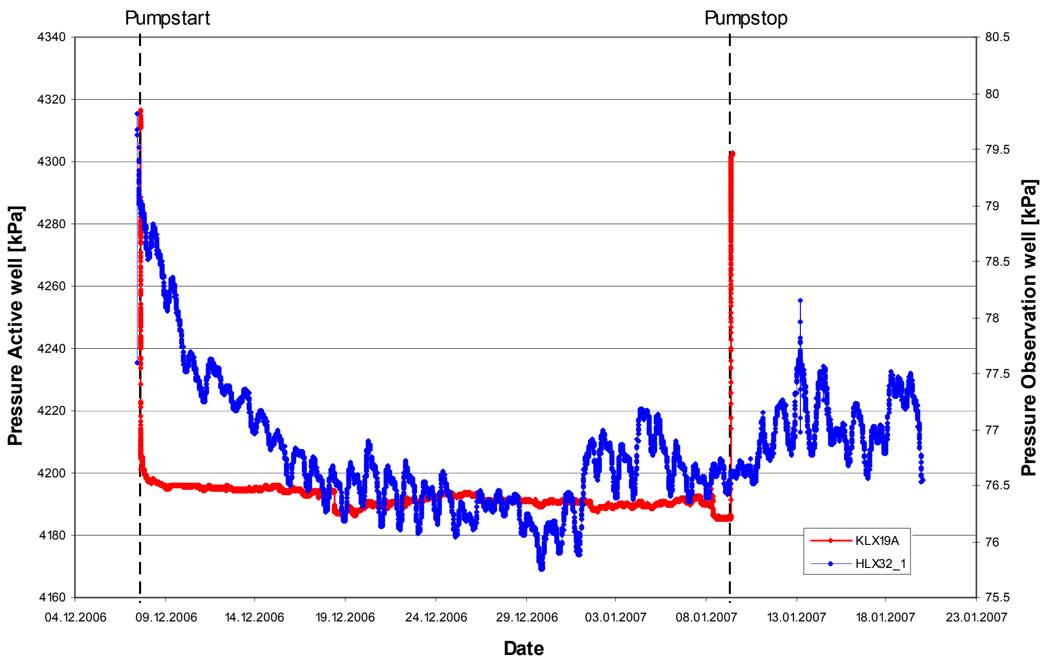
Observation Holes Test Analyses Diagrams

Interference analysis
HLX32_1 observed

APPENDIX 3-1

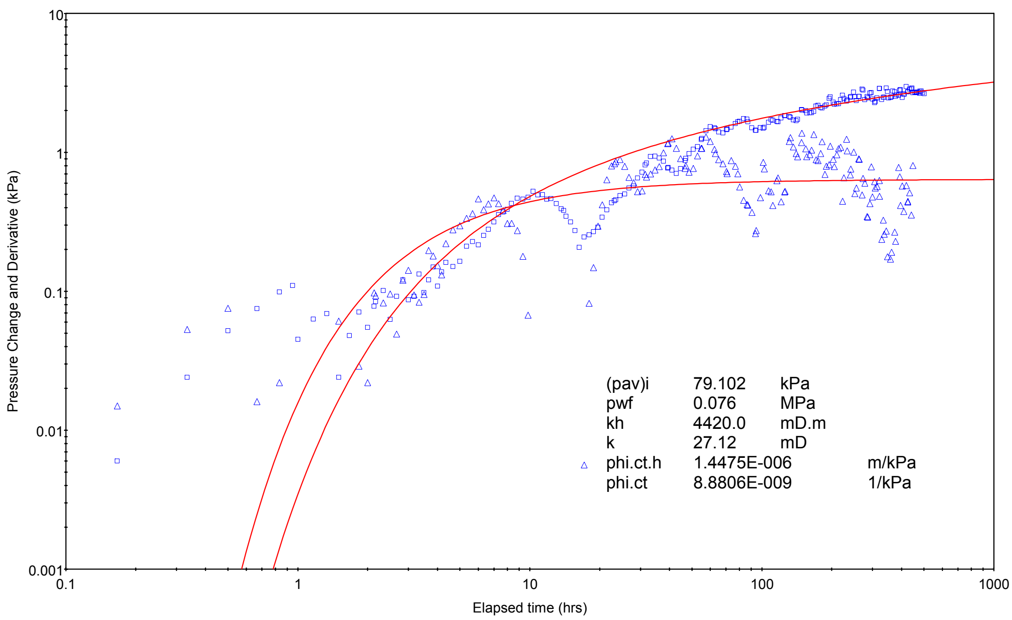
KLX19A Section 495.00-515 m pumped
HLX32_1 0.00-163.00 observed

Observation hole
Test analysis diagrams



Pressure vs. time; log-log match; KLX19A 495.00-515.00 m pumped and HLX32_1 0.00-163.00 observed

Log-Log Match - Flow Period 2



CRw phase; log-log match; KLX19A 495.00-515.00 m pumped and HLX32_1 0.00-163.00 observed

Not analysable

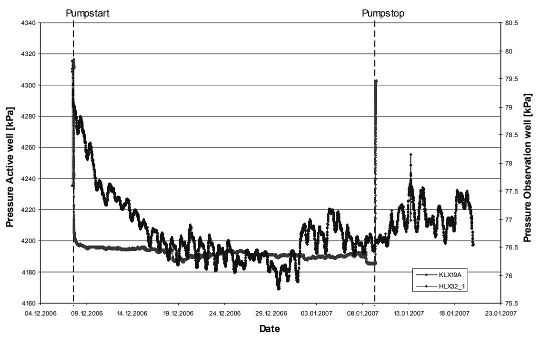
CRwr phase; log-log match; KLX19A 495.00-515.00 m pumped and HLX32_1 0.00-163.00 observed

Appendix 4

Observation Holes Test Summary Sheets

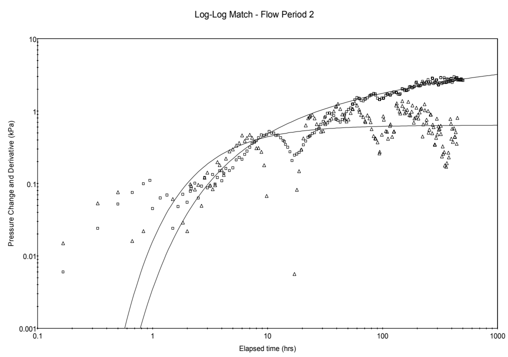
Test Summary Sheet			
Project:	Oskarshamn site investigation	Test type:[1]	CRwr Observation hole
Area:	Laxemar	Test no:	1
Borehole ID:	HLX32_1 (KLX19A 495.00-515.00 pumped)	Test start:	061207 15:07
Test section from - to (m):	0.00-163.00	Responsible for test execution:	Stephan Rohs
Distance (m):	401.00	Responsible for test evaluation:	Cristian Enachescu

Linear plot Q and p



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =			
p_i (kPa) =			
p_p(kPa) =		p_F (kPa) =	
Q_p (m^3/s)=	3.50E-05		
tp (s) =	2827044	t_F (s) =	12780
S el S^* (-)=		S el S^* (-)=	
EC_w (mS/m)=			
$Temp_w$(gr C)=			
Derivative fact.=	0	Derivative fact.=	NA
Results		**Results**	
Q/s (m^2/s)=	NA		
T_M (m^2/s)=	NA		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	4674.0	dt_1 (min) =	NA
dt_2 (min) =	24978.0	dt_2 (min) =	NA
T (m^2/s) =	4.3E-05	T (m^2/s) =	NA
S (-) =	1.4E-05	S (-) =	NA
K_s (m/s) =	2.6E-07	K_s (m/s) =	NA
S_s (1/m) =	8.7E-08	S_s (1/m) =	NA
C (m^3/Pa) =	NA	C (m^3/Pa) =	NA
C_D (-) =	NA	C_D (-) =	NA
ξ (-) =	NA	ξ (-) =	NA
T_{GRF}(m^2/s) =	NA	T_{GRF}(m^2/s) =	NA
S_{GRF}(-) =	NA	S_{GRF}(-) =	NA
D_{GRF} (-) =	NA	D_{GRF} (-) =	NA

Log-Log plot incl. derivates- flow period



Selected representative parameters.			
dt_1 (min) =	NA	C (m^3/Pa) =	NA
dt_2 (min) =	NA	C_D (-) =	NA
T_T (m^2/s) =	4.3E-05	ξ (-) =	NA
S (-) =	1.4E-05		
K_s (m/s) =	2.6E-07		
S_s (1/m) =	8.7E-08		

Log-Log plot incl. derivatives- recovery period

Not analysable

Comments:

The recommended transmissivity of 4.3E-5 m2/s was derived from the analysis of the CRw phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 2.0E-5 m²/s to 1.0E-4 m²/s. The flow dimension during the test is 2.
No further analysis recommendded.

Appendix 5

SICADA Data Tables (Observation holes)

(Simplified version v1.7)

SICADA/Data Import Template

SKB & Ergodata AB 2005

File Identity	
Created By	Stephan Rohs
Created	

File Time Zone

Compiled By	
Quality Check For Delivery	
Delivery Approval	

Activity Type	KLX19A KLX19A Interference test-obs.holes

Project	AP PS 400-07-72

Activity Information						**Additional Activity Data**				
						C30	C40	I160	P20	P200
Idcode	**Start Date**	**Stop Date**	**Secup (m)**	**Seclow (m)**	**Section No**	**Company evaluating data**	**performing field work**	**Instrument**	**Field crew manager**	**Field crew**
HLX27	2006-11-28 00:00:00	2007-01-09 12:28:00	133.00	164.70	1	Golder				
HLX27	2006-11-28 00:00:00	2007-01-09 12:28:00	0.00	132.00	2	Golder				
HLX28	2006-11-28 00:00:00	2007-01-09 12:28:00	0.00	154.00	1	Golder				
HLX32	2006-11-28 00:00:00	2007-01-09 12:28:00	0.00	163.00	1	Golder				
HLX36	2006-11-28 00:00:00	2007-01-09 12:28:00	50.00	199.50	1	Golder				
HLX36	2006-11-28 00:00:00	2007-01-09 12:28:00	0.00	49.00	2	Golder				
HLX37	2006-11-28 00:00:00	2007-01-09 12:28:00	149.00	199.80	1	Golder				
HLX37	2006-11-28 00:00:00	2007-01-09 12:28:00	118.00	148.00	2	Golder				
HLX37	2006-11-28 00:00:00	2007-01-09 12:28:00	149.00	199.80	3	Golder				
HLX38	2006-11-28 00:00:00	2007-01-09 12:28:00	0.00	199.50	1	Golder				
HLX42	2006-11-28 00:00:00	2007-01-09 12:28:00	30.00	152.60	1	Golder				
HLX42	2006-11-28 00:00:00	2007-01-09 12:28:00	0.00	29.00	2	Golder				
KLX11A	2006-11-28 00:00:00	2007-01-09 12:28:00	0.00	992.00	1	Golder				
KLX11E	2006-11-28 00:00:00	2007-01-09 12:28:00	2.00	121.00	1	Golder				
KLX20A	2006-11-28 00:00:00	2007-01-09 12:28:00	0.00	457.00	1	Golder				

Table	plu_inf_test_obs_d PLU interference test, Observation section data		
Column	**Datatype**	**Unit**	**Column Description**
site	CHAR		Investigation site name
activity_type	CHAR		
start_date	DATE		
stop_date	DATE		
project	CHAR		project code
idcode	CHAR		Object or borehole identification code
secup	FLOAT	m	Upper section limit (m)
seclow	FLOAT	m	Lower section limit (m)
section_no	INTEGER	number	Section number
test_type	CHAR		Test type code, one of 7, see table description
formation_type	CHAR		1: Rock, 2: Soil (superficial deposits)
start_flow_period	DATE	yyyymmdd	Date and time start of pumping/injection(YYMMDDhhmmss)
stop_flow_period	DATE	yyyymmdd	Date and time stop of pumping/injection(YYMMDDhhmmss)
test_borehole	CHAR		Idcode of pumped/injected borehole
test_secup	FLOAT	m	Upper limit of pumped/injected section
test_seclow	FLOAT	m	Lower limit of pumped/injected section
lp	FLOAT	m	Hydraulic point of application, see table description
radial_distance_rs	FLOAT	m	Radial distance:test sec.-obs.sec., see table description
shortest_distance_rt	FLOAT	m	Shortest distance: test sec.-obs.sec., see table description
time_lag_press_dtl	FLOAT	s	Time lag, pressure response obs. hole. See table description
initial_head_hi	FLOAT	m	Hydraulic head in observationsection,at start of flow period
head_at_flow_end_h	FLOAT	m	Hydraulic head in observation section at stop of flow period
final_head_hf	FLOAT	m	Hydraulic head in obs. section at end of recovery period.
initial_press_pi	FLOAT	kPa	Groundwater pressure in obs.section at start of flow period
press_at_flow_end_	FLOAT	kPa	Groundwater pressure in obs. section at stop of flow period
final_press_pf	FLOAT	kPa	Groundwater pressure in obs.section at stop of the recovery
fluid_temp_teo	FLOAT	oC	Measured fluid temperature in obs.section,see descr.
fluid_elcond_eco	FLOAT	mS/m	Measured fluid el. conductivity in obs.section,see descr.
fluid_salinity_tdso	FLOAT	mg/l	Total dissolved solids of section fluid,based on EC see desc
fluid_salinity_tdsom	FLOAT	mg/l	Tot disolved solids of section fluid based on analysis,see..
reference	CHAR		SKB report No for reports describing data and evaluation
comment	CHAR		Short comment to evaluated data.
error_flag	CHAR		If error_flag = "*" then an error occured and an error
in_use	CHAR		If in_use = "*" then the activity has been selected as
sign	CHAR		Activity QA signature

idcode	start_date	stop_date	secup (m)	seclow (m)	section_no	test_type	formation_type	start_flow_period (yyyymmdd)	stop_flow_period (yyyymmdd)	test_borehole	test_secup (m)	test_seclow (m)	lp (m)	radial_distance_rs (m)	shortest_distance_rt (m)	time_lag_press_dtl (s)	initial_head_hi (m)	head_at_flow_end_hp (m)	final_head_hf (m)
HLX27	2006.12.07 15:07	2007.01.09 12:28	133.00	164.70	1	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	158.00	989.00			7.02	8.82	6.99
HLX27	2006.12.07 15:07	2007.01.09 12:28	0.00	132.00	2	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	107.00	1002.00			7.03	6.68	6.99
HLX28	2006.12.07 15:07	2007.01.09 12:28	0.00	154.00	1	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	80.00	413.00			13.58	13.33	13.41
HLX32	2006.12.07 15:07	2007.01.09 12:28	0.00	163.00	1	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	95.00	401.00			8.06	7.81	7.81
HLX36	2006.12.07 15:07	2007.01.09 12:28	50.00	199.50	1	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	105.00	764.00			13.93	14.00	14.00
HLX36	2006.12.07 15:07	2007.01.09 12:28	0.00	49.00	2	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	25.00	770.00			10.62	10.64	10.64
HLX37	2006.12.07 15:07	2007.01.09 12:28	149.00	199.80	1	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	175.00	745.00			13.79	13.61	13.62
HLX37	2006.12.07 15:07	2007.01.09 12:28	118.00	148.00	2	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	130.00	775.00			13.78	13.59	13.60
HLX37	2006.12.07 15:07	2007.01.09 12:28	149.00	199.80	3	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	100.00	795.00			15.14	15.15	15.15
HLX38	2006.12.07 15:07	2007.01.09 12:28	0.00	199.50	1	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	103.00	478.00			5.77	5.77	5.77
HLX42	2006.12.07 15:07	2007.01.09 12:28	30.00	152.60	1	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	100.00	970.00			10.72	10.54	10.63
HLX42	2006.12.07 15:07	2007.01.09 12:28	0.00	29.00	2	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	10.00	1043.00			12.11	12.03	12.03
KLX11A	2006.12.07 15:07	2007.01.09 12:28	0.00	992.00	1	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	500.00	724.00			14.52	14.37	14.38
KLX11E	2006.12.07 15:07	2007.01.09 12:28	2.00	121.00	1	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	70.00	846.00			15.22	15.03	15.05
KLX20A	2006.12.07 15:07	2007.01.09 12:28	0.00	457.00	1	2	1	061207 15:38:00	070109 08:56:00	KLX19A	495.00	515.00	230.00	883.00			15.33	15.17	15.18
HLX27	2006.11.28 19:53	2006.12.05 15:52	133.00	164.70	1	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	158.00	1099.00			7.06	7.08	7.08
HLX27	2006.11.28 19:53	2006.12.05 15:52	0.00	132.00	2	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	107.00	1123.00			7.06	7.10	7.10
HLX28	2006.11.28 19:53	2006.12.05 15:52	0.00	154.00	1	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	80.00	661.00			13.41	13.60	13.60
HLX36	2006.11.28 19:53	2006.12.05 15:52	50.00	199.50	1	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	105.00	958.00			13.60	13.89	13.89
HLX36	2006.11.28 19:53	2006.12.05 15:52	0.00	49.00	2	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	25.00	979.00			10.67	10.64	10.63
HLX37	2006.11.28 19:53	2006.12.05 15:52	149.00	199.80	1	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	175.00	930.00			13.63	13.82	13.80
HLX37	2006.11.28 19:53	2006.12.05 15:52	118.00	148.00	2	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	130.00	962.00			13.62	13.80	13.79
HLX37	2006.11.28 19:53	2006.12.05 15:52	149.00	199.80	3	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	100.00	983.00			15.14	15.14	15.14
HLX38	2006.11.28 19:53	2006.12.05 15:52	0.00	199.50	1	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	103.00	722.00			5.80	5.80	5.80
HLX42	2006.11.28 19:53	2006.12.05 15:52	30.00	152.60	1	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	100.00	988.00			9.80	9.90	9.91
HLX42	2006.11.28 19:53	2006.12.05 15:52	0.00	29.00	2	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	10.00	1071.00			12.16	12.13	12.13
KLX11A	2006.11.28 19:53	2006.12.05 15:52	0.00	992.00	1	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	500.00	872.00			14.10	14.53	14.53
KLX11E	2006.11.28 19:53	2006.12.05 15:52	2.00	121.00	1	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	70.00	1057.00			14.90	15.25	15.24
KLX20A	2006.11.28 19:53	2006.12.05 15:52	0.00	457.00	1	2	1	061128 20:28:00	061205 13:10:00	KLX19A	764.00	769.00	230.00	1060.00			15.06	15.36	15.36

idcode	start_date	stop_date	secup (m)	seclow (m)	section_no	test_type	initial_press_pi (kPa)	press_at_flow_end_pp (kPa)	final_press_pf (kPa)	fluid_temp_teo (oC)	fluid_elcond_eco (mS/m)	fluid_salinity_tdso (mg/l)	fluid_salinity_tdsom (mg/l)	reference	comment
HLX27	2006.12.07 15:07	2007.01.09 12:28	133.00	164.70	1	2									no response due to pumping in source
HLX27	2006.12.07 15:07	2007.01.09 12:28	0.00	132.00	2	2									no response due to pumping in source
HLX28	2006.12.07 15:07	2007.01.09 12:28	0.00	154.00	1	2									response due to pumping in source
HLX32	2006.12.07 15:07	2007.01.09 12:28	0.00	163.00	1	2									response due to pumping in source
HLX36	2006.12.07 15:07	2007.01.09 12:28	50.00	199.50	1	2									no response due to pumping in source
HLX36	2006.12.07 15:07	2007.01.09 12:28	0.00	49.00	2	2									no response due to pumping in source
HLX37	2006.12.07 15:07	2007.01.09 12:28	149.00	199.80	1	2									response due to pumping in source
HLX37	2006.12.07 15:07	2007.01.09 12:28	118.00	148.00	2	2									response due to pumping in source
HLX37	2006.12.07 15:07	2007.01.09 12:28	149.00	199.80	3	2									no response due to pumping in source
HLX38	2006.12.07 15:07	2007.01.09 12:28	0.00	199.50	1	2									no response due to pumping in source
HLX42	2006.12.07 15:07	2007.01.09 12:28	30.00	152.60	1	2									no response due to pumping in source
HLX42	2006.12.07 15:07	2007.01.09 12:28	0.00	29.00	2	2									no response due to pumping in source
KLX11A	2006.12.07 15:07	2007.01.09 12:28	0.00	992.00	1	2									no response due to pumping in source
KLX11E	2006.12.07 15:07	2007.01.09 12:28	2.00	121.00	1	2									no response due to pumping in source
KLX20A	2006.12.07 15:07	2007.01.09 12:28	0.00	457.00	1	2									no response due to pumping in source
HLX27	2006.11.28 19:53	2006.12.05 15:52	133.00	164.70	1	2									no response due to pumping in source
HLX27	2006.11.28 19:53	2006.12.05 15:52	0.00	132.00	2	2									no response due to pumping in source
HLX28	2006.11.28 19:53	2006.12.05 15:52	0.00	154.00	1	2									no response due to pumping in source
HLX36	2006.11.28 19:53	2006.12.05 15:52	50.00	199.50	1	2									no response due to pumping in source
HLX36	2006.11.28 19:53	2006.12.05 15:52	0.00	49.00	2	2									no response due to pumping in source
HLX37	2006.11.28 19:53	2006.12.05 15:52	149.00	199.80	1	2									no response due to pumping in source
HLX37	2006.11.28 19:53	2006.12.05 15:52	118.00	148.00	2	2									no response due to pumping in source
HLX37	2006.11.28 19:53	2006.12.05 15:52	149.00	199.80	3	2									no response due to pumping in source
HLX38	2006.11.28 19:53	2006.12.05 15:52	0.00	199.50	1	2									no response due to pumping in source
HLX42	2006.11.28 19:53	2006.12.05 15:52	30.00	152.60	1	2									no response due to pumping in source
HLX42	2006.11.28 19:53	2006.12.05 15:52	0.00	29.00	2	2									no response due to pumping in source
KLX11A	2006.11.28 19:53	2006.12.05 15:52	0.00	992.00	1	2									no response due to pumping in source
KLX11E	2006.11.28 19:53	2006.12.05 15:52	2.00	121.00	1	2									no response due to pumping in source
KLX20A	2006.11.28 19:53	2006.12.05 15:52	0.00	457.00	1	2									no response due to pumping in source

Table **plu_inf_test_obs_ed**

PLU interference test,Observation section evaluation

Column	Datatype	Unit	Column Description
site	CHAR		Investigation site name
activity_type	CHAR		Activity type code
start_date	DATE		Date (yymmdd hh:mm:ss)
stop_date	DATE		Date (yymmdd hh:mm:ss)
project	CHAR		project code
idcode	CHAR		Object or borehole identification code
secup	FLOAT	m	Upper section limit (m)
seclow	FLOAT	m	Lower section limit (m)
section_no	INTEGER	number	Section number
test_borehole	CHAR		Idcode of pumped/injected borehole
test_secup	FLOAT	m	Upper limit of pumped/injected section
test_seclow	FLOAT	m	Lower limit of pumped/injected section
formation_width_b	FLOAT	m	b:Aqifer thickness repr. for T(generally b=Lo),see descrip.
lp	FLOAT	m	Hydraulic point of application, see table descr.
width_of_channel_b	FLOAT	m	B:Inferred width of formation for evaluated TB
tbo	FLOAT	m**3/s	TBo,T=transmissivity,B= width of formation, see table descr.
l_measl_tbo	FLOAT	m**3/s	Estimated lower limit for evaluated TB, see table descript.
u_measl_tbo	FLOAT	m**3/s	Estimated upper limit for evaluated TB,see table descript.
sbo	FLOAT	m	Storage capacity of 1D formation(flow or recovery),see descr
leakage_factor_lof	FLOAT	m	Lof: 1D model for evaluation of leakage factor,see descr.
transmissivity_to	FLOAT	m**2/s	To=transmissivity,2D radial flow model, see table descr.
value_type_to	CHAR		0:true value (To),-1:<lower meas.limit,1:>upper meaus.limit
l_measl_to	FLOAT	m**2/s	Estimated lower limit for evaluated To,see table descript.
u_measl_to	FLOAT	m**2/s	Estimated upper limit of evaluated To,see table description
storativity_so	FLOAT		So:Storativity, 2D rad flow model, see table descr.
leakage_coeff_o	FLOAT	1/s	K´/b´:Leakage coefficient,2D rad flow model,see descr.
hydr_cond_kosf	FLOAT	m/s	3D model evaluation of hydraulic conductivity,see table des.
l_measl_kosf	FLOAT	m/s	Estimated lowermeas. limit of Ks,see table description
u_measl_kosf	FLOAT	m/s	Estimated upper meas. limit of Ks,see table description
spec_storage_sosf	FLOAT	1/m	3D model for evaluation of specific storage,se table descr.
dt1	FLOAT	s	Estimated start time of evaluation, see table description
dt2	FLOAT	s	Estimated stop time of evaluation, see table description
t1	FLOAT	s	Start time for evaluated parameter from start of flow period
t2	FLOAT	s	Stop time for evaluated parameter from start of flow period
dte1	FLOAT	s	Start time for evaluated parameter from start of recovery
dte2	FLOAT	s	Stop time for evaluated parameter from start of recovery
transmissivity_to_nlr	FLOAT	m**2/s	ToNLR:Transmissivity,based on Non Linear Regression,see desc
value_type_to_nlr	CHAR		0:true value (ToNLR),-1:<lower meas.limit,1:>uppermeas.limit
storativity_so_nlr	FLOAT		So_NLR:Storativity based on None Linear Regression, see des.
transmissivity_to_grf	FLOAT	m**2/s	ToGRF=transmissivity based on Generalized Radial Flow,see...
value_type_to_grf	CHAR		0:true value (ToGRF),-1:<lower meas.limit,1:>upp meaus.limit
storativity_so_grf	FLOAT		So_GRF:Storativity based on Generalized Rad. Flow, see des.
flow_dim_grf_o	FLOAT		Inferred flow dimension based on Generalized Rad. Flow model
comments	CHAR		short comment to the evaluated parameters(0ptional)
error_flag	CHAR		If error_flag = "*" then an error occured and an error
in_use	CHAR		If in_use = "*" then the activity has been selected as
sign	CHAR		Activity QA signature

			(m)	(m)			(m)	(m)	(m)	(m)	(m)	(m**3/s)	(m**3/s)	(m**3/s)	(m)	(m)	(m**2/s)		(m**2/s)	(m**2/s)	
idcode	start_date	stop_date	secup	seclow	section_no	test_borehole	test_secup	test_seclow	formation_width_b	lp	width_of_channel_b	tbo	l_measl_tbo	u_measl_tbo	sbo	leakage_factor_lof	transmissivity_to	value_type_to	l_measl_to	u_measl_to	storativity_so
HLX32	2006.12.07 15:07	2007.01.09 12:28	0.00	163.00	1	KLX19A	495.00	515.00		95.00							4.30E-05	0	2.00E-05	1.00E-04	1.41E-04

			(m)	(m)		(1/s)	(m/s)	(m/s)	(m/s)	(1/m)	(s)	(s)	(s)	(s)	(s)	(s)	(m**2/s)			(m**2/s)				
idcode	start_date	stop_date	secup	seclow	section_no	leakage_coeff_o	hydr_cond_kosf	l_measl_kosf	u_measl_kosf	spec_storage_sosf	dt1	dt2	t1	t2	dte1	dte2	transmissivity_to_nlr	value_type_to_nlr	storativity_so_nlr	transmissivity_to_grf	value_type_to_grf	storativity_so_grf	flow_dim_grf_o	comments
HLX32	2006.12.07 15:07	2007.01.09 12:28	0.00	163.00	1						280440	1498680												

Appendix 6

Nomenclature

Character	SICADA designation	Explanation	Dimension	Unit
Variables, constants				
A_w		Horizontal area of water surface in open borehole, not including area of signal cables, etc.	$[L^2]$	m^2
b		Aquifer thickness (Thickness of 2D formation)	[L]	m
B		Width of channel	[L]	m
L		Corrected borehole length	[L]	m
L_0		Uncorrected borehole length	[L]	m
L_p		Point of application for a measuring section based on its centre point or centre of gravity for distribution of transmissivity in the measuring section.	[L]	m
L_w		Test section length.	[L]	m
dL		Step length, Positive Flow Log - overlapping flow logging. (step length, PFL)	[L]	m
r		Radius	[L]	m
r_w		Borehole, well or soil pipe radius in test section.	[L]	m
r_{we}		Effective borehole, well or soil pipe radius in test section. (Consideration taken to skin factor)	[L]	m
r_s		Distance from test section to observation section, the shortest distance.	[L]	m
r_t		Distance from test section to observation section, the **interpreted** shortest distance via conductive structures.	[L]	m
r_D		Dimensionless radius, $r_D=r/r_w$	-	-
z		Level above reference point	[L]	m
z_r		Level for reference point on borehole	[L]	m
z_{wu}		Level for test section (section that is being flowed), upper limitation	[L]	m
z_{wl}		Level for test section (section that is being flowed), lower limitation	[L]	m
z_{ws}		Level for sensor that measures response in test section (section that is flowed)	[L]	m
z_{ou}		Level for observation section, upper limitation	[L]	m
z_{ol}		Level for observation section, lower limitation	[L]	m
z_{os}		Level for sensor that measures response in observation section	[L]	m
E		Evaporation: hydrological budget:	$[L^3/(T\ L^2)]$ $[L^3/T]$	mm/y, mm/d, m^3/s
ET		Evapotranspiration hydrological budget:	$[L^3/(T\ L^2)]$ $[L^3/T]$	mm/y, mm/d, m^3/s
P		Precipitation hydrological budget:	$[L^3/(T\ L^2)]$ $[L^3/T]$	mm/y, mm/d, m^3/s
R		Groundwater recharge hydrological budget:	$[L^3/(T\ L^2)]$ $[L^3/T]$	mm/y, mm/d, m^3/s
D		Groundwater discharge hydrological budget:	$[L^3/(T\ L^2)]$ $[L^3/T]$	mm/y, mm/d, m^3/s
Q_R		Run-off rate	$[L^3/T]$	m^3/s
Q_p		Pumping rate	$[L^3/T]$	m^3/s
Q_I		Infiltration rate	$[L^3/T]$	m^3/s
Q		Volumetric flow. Corrected flow in flow logging ($Q_1 – Q_0$) (Flow rate)	$[L^3/T]$	m^3/s
Q_0		Flow in test section during undisturbed conditions (flow logging).	$[L^3/T]$	m^3/s
Q_p		Flow in test section immediately before stop of flow. Stabilised pump flow in flow logging.	$[L^3/T]$	m^3/s

Character	SICADA designation	Explanation	Dimension	Unit
Q_m		Arithmetical mean flow during perturbation phase.	$[L^3/T]$	m^3/s
Q_1		Flow in test section during pumping with pump flow Q_{p1}, (flow logging).	$[L^3/T]$	m^3/s
Q_2		Flow in test section during pumping with pump flow Q_{p1}, (flow logging).	$[L^3/T]$	m^3/s
ΣQ	SumQ	Cumulative volumetric flow along borehole	$[L^3/T]$	m^3/s
ΣQ_0	SumQ0	Cumulative volumetric flow along borehole, undisturbed conditions (ie, not pumped)	$[L^3/T]$	m^3/s
ΣQ_1	SumQ1	Cumulative volumetric flow along borehole, with pump flow Q_{p1}	$[L^3/T]$	m^3/s
ΣQ_2	SumQ2	Cumulative volumetric flow along borehole, with pump flow Q_{p2}	$[L^3/T]$	m^3/s
ΣQ_{C1}	SumQC1	Corrected cumulative volumetric flow along borehole, ΣQ_1-ΣQ_0	$[L^3/T]$	m^3/s
ΣQ_{C2}	SumQC2	Corrected cumulative volumetric flow along borehole, ΣQ_2-ΣQ_0	$[L^3/T]$	m^3/s
q		Volumetric flow per flow passage area (Specific discharge (Darcy velocity, Darcy flux, Filtration velocity)).	$([L^3/T*L^2]$	m/s
V		Volume	$[L^3]$	m^3
V_w		Water volume in test section.	$[L^3]$	m^3
V_p		Total water volume injected/pumped during perturbation phase.	$[L^3]$	m^3
v		Velocity	$([L^3/T*L^2]$	m/s
v_a		Mean transport velocity (Average linear velocity (Average linear groundwater velocity, Mean microscopic velocity));. $v_a=q/n_e$	$([L^3/T*L^2]$	m/s
t		Time	[T]	hour,min,s
t_0		Duration of rest phase before perturbation phase.	[T]	s
t_p		Duration of perturbation phase. (from flow start as far as p_p).	[T]	s
t_F		Duration of recovery phase (from p_p to p_F).	[T]	s
t_1, t_2 etc		Times for various phases during a hydro test.	[T]	hour,min,s
dt		Running time from start of flow phase and recovery phase respectively.	[T]	s
dt_e		dt_e = (dt · tp) / (dt + tp) Agarwal equivalent time with dt as running time for recovery phase.	[T]	s
t_D		$t_D = T{\cdot}t / (S{\cdot} r_w^2)$. Dimensionless time	-	-
p		Static pressure; including non-dynamic pressure which depends on water velocity. Dynamic pressure is normally ignored in estimating the potential in groundwater flow relations.	$[M/(LT)^2]$	kPa
p_a		Atmospheric pressure	$[M/(LT)^2]$	kPa
p_t		Absolute pressure; $p_t=p_a+p_g$	$[M/(LT)^2]$	kPa
p_g		Gauge pressure; Difference between absolute pressure and atmospheric pressure.	$[M/(LT)^2]$	kPa
p_0		Initial pressure before test begins, prior to packer expansion.	$[M/(LT)^2]$	kPa
p_i		Pressure in measuring section before start of flow.	$[M/(LT)^2]$	kPa
p_f		Pressure during perturbation phase.	$[M/(LT)^2]$	kPa
p_s		Pressure during recovery.	$[M/(LT)^2]$	kPa
p_p		Pressure in measuring section before flow stop.	$[M/(LT)^2]$	kPa
p_F		Pressure in measuring section at end of recovery.	$[M/(LT)^2]$	kPa
p_D		$p_D=2\pi{\cdot}T{\cdot}p/(Q{\cdot}\rho_w g)$, Dimensionless pressure	-	-
dp		Pressure difference, drawdown of pressure surface between two points of time.	$[M/(LT)^2]$	kPa

Character	SICADA designation	Explanation	Dimension	Unit
dp_f		$dp_f = p_i - p_f$ or $= p_f - p_i$, drawdown/pressure increase of pressure surface between two points of time during perturbation phase. dp_f usually expressed positive.	$[M/(LT)^2]$	kPa
dp_s		$dp_s = p_s - p_p$ or $= p_p - p_s$, pressure increase/drawdown of pressure surface between two points of time during recovery phase. dp_s usually expressed positive.	$[M/(LT)^2]$	kPa
dp_p		$dp_p = p_i - p_p$ or $= p_p - p_i$, **maximal** pressure increase/drawdown of pressure surface between two points of time during perturbation phase. dp_p expressed positive.	$[M/(LT)^2]$	kPa
dp_F		$dp_F = p_p - p_F$ or $= p_F - p_p$, **maximal** pressure increase/drawdown of pressure surface between two points of time during recovery phase. dp_F expressed positive.	$[M/(LT)^2]$	kPa
H		Total head; (potential relative a reference level) (indication of h for phase as for p). $H=h_e+h_p+h_v$	[L]	m
h		Groundwater pressure level (hydraulic head (piezometric head; possible to use for level observations in boreholes, static head)); (indication of h for phase as for p). $h=h_e+h_p$	[L]	m
h_e		Height of measuring point (Elevation head); Level above reference level for measuring point.	[L]	m
h_p		Pressure head; Level above reference level for height of measuring point of stationary column of water giving corresponding static pressure at measuring point	[L]	m
h_v		Velocity head; height corresponding to the lifting for which the kinetic energy is capable (usually neglected in hydrogeology)	[L]	m
s		Drawdown; Drawdown from undisturbed level (same as dh_p, positive)	[L]	m
s_p		Drawdown in measuring section before flow stop.	[L]	m
			[L]	
h_0		Initial above reference level before test begins, prior to packer expansion.	[L]	m
h_i		Level above reference level in measuring section before start of flow.	[L]	m
h_f		Level above reference level during perturbation phase.	[L]	m
h_s		Level above reference level during recovery phase.	[L]	m
h_p		Level above reference level in measuring section before flow stop.	[L]	m
h_F		Level above reference level in measuring section at end of recovery.	[L]	m
dh		Level difference, drawdown of water level between two points of time.	[L]	m
dh_f		$dh_f = h_i - h_f$ or $= h_f - h_i$, drawdown/pressure increase of pressure surface between two points of time during perturbation phase. dh_f usually expressed positive.	[L]	m
dh_s		$dh_s = h_s - h_p$ or $= h_p - h_s$, pressure increase/drawdown of pressure surface between two points of time during recovery phase. dh_s usually expressed positive.	[L]	m
dh_p		$dh_p = h_i - h_p$ or $= h_p - h_i$, maximal pressure increase/drawdown of pressure surface between two points of time during perturbation phase. dh_p expressed positive.	[L]	m
dh_F		$dh_F = h_p - h_F$ or $= h_F - h_p$, maximal pressure increase/drawdown of pressure surface between two points of time during perturbation phase. dh_F expressed positive.	[L]	m
Te_w		Temperature in the test section (taken from temperature logging). Temperature		°C
Te_{w0}		Temperature in the test section during undisturbed conditions (taken from temperature logging).		°C

Character	SICADA designation	Explanation	Dimension	Unit
Te_o		Temperature in the observation section (taken from temperature logging). Temperature		°C
EC_w		Electrical conductivity of water in test section.		mS/m
EC_{w0}		Electrical conductivity of water in test section during undisturbed conditions.		mS/m
EC_o		Electrical conductivity of water in observation section		mS/m
TDS_w		Total salinity of water in the test section.	$[M/L^3]$	mg/L
TDS_{w0}		Total salinity of water in the test section during undisturbed conditions.	$[M/L^3]$	mg/L
TDS_o		Total salinity of water in the observation section.	$[M/L^3]$	mg/L
g		Constant of gravitation (9.81 $m*s^{-2}$) (Acceleration due to gravity)	$[L/T^2]$	m/s^2
π	pi	Constant (approx 3.1416).	[-]	
r		Residual. $r= p_c-p_m$, $r= h_c-h_m$, etc. Difference between measured data (p_m, h_m, etc) and estimated data (p_c, h_c, etc)		
ME		Mean error in residuals. $ME = \frac{1}{n}\sum_{i=1}^{n} r_i$		
NME		Normalized ME. $NME=ME/(x_{MAX}-x_{MIN})$, x: measured variable considered.		
MAE		Mean absolute error. $MAE = \frac{1}{n}\sum_{i=1}^{n} \lvert r_i \rvert$		
NMAE		Normalized MAE. $NMAE=MAE/(x_{MAX}-x_{MIN})$, x: measured variable considered.		
RMS		Root mean squared error. $RMS = \left(\frac{1}{n}\sum_{i=1}^{n} r_i^2\right)^{0.5}$		
NRMS		Normalized RMR. $NRMR=RMR/(x_{MAX}-x_{MIN})$, x: measured variable considered.		
SDR		Standard deviation of residual. $SDR = \left(\frac{1}{n-1}\sum_{i=1}^{n} (r_i - ME)^2\right)^{0.5}$		
SEMR		Standard error of mean residual. $SEMR = \left(\frac{1}{n(n-1)}\sum_{i=1}^{n} (r_i - ME)^2\right)^{0.5}$		
Parameters				
Q/s		Specific capacity $s=dp_p$ or $s=s_p=h_0-h_p$ (open borehole)	$[L^2/T]$	m^2/s
D		Interpreted flow dimension according to Barker, 1988.	[-]	-
dt_1		Time of starting for semi-log or log-log evaluated characteristic counted from start of flow phase and recovery phase respectively.	[T]	s
dt_2		End of time for semi-log or log-log evaluated characteristic counted from start of flow phase and recovery phase respectively.	[T]	s
dt_L		Response time to obtain 0.1 m (or 1 kPa) drawdown in observation section counted from start of recovery phase.	[T]	s
TB		Flow capacity in a one-dimensional structure of width B and transmissivity T. Transient evaluation of one-dimensional structure	$[L^3/T]$	m^3/s
T		Transmissivity	$[L^2/T]$	m^2/s
T_M		Transmissivity according to Moye (1967)	$[L^2/T]$	m^2/s
T_Q		Evaluation based on Q/s and regression curve between Q/s and T, as example see Rhén et al (1997) p. 190.	$[L^2/T]$	m^2/s
T_S		Transmissivity evaluated from slug test	$[L^2/T]$	m^2/s

Character	SICADA designation	Explanation	Dimension	Unit
T_D		Transmissivity evaluated from PFL-Difference Flow Meter	$[L^2/T]$	m^2/s
T_I		Transmissivity evaluated from Impeller flow log	$[L^2/T]$	m^2/s
T_{Sf}, T_{Lf}		Transient evaluation based on semi-log or log-log diagram for perturbation phase in injection or pumping.	$[L^2/T]$	m^2/s
T_{Ss}, T_{Ls}		Transient evaluation based on semi-log or log-log diagram for recovery phase in injection or pumping.	$[L^2/T]$	m^2/s
T_T		Transient evaluation (log-log or lin-log). Judged best evaluation of T_{Sf}, T_{Lf}, T_{Ss}, T_{Ls}	$[L^2/T]$	m^2/s
T_{NLR}		Evaluation based on non-linear regression.	$[L^2/T]$	m^2/s
T_{Tot}		Judged most representative transmissivity for particular test section and (in certain cases) evaluation time with respect to available data (made by SKB at a later stage).	$[L^2/T]$	m^2/s
K		Hydraulic conductivity	[L/T]	m/s
K_s		Hydraulic conductivity based on spherical flow model	[L/T]	m/s
K_m		Hydraulic conductivity matrix, intact rock	[L/T]	m/s
k		Intrinsic permeability	$[L^2]$	m^2
kb		Permeability-thickness product: kb=k·b	$[L^3]$	m^3
SB		Storage capacity in a one-dimensional structure of width B and storage coefficient S. Transient evaluation of one-dimensional structure	[L]	m
SB*		Assumed storage capacity in a one-dimensional structure of width B and storage coefficient S. Transient evaluation of one-dimensional structure	[L]	m
S		Storage coefficient, (Storativity)	[-]	-
S*		Assumed storage coefficient	[-]	-
S_y		Theoretical specific yield of water (Specific yield; unconfined storage. Defined as total porosity (n) minus retention capacity (S_r)	[-]	-
S_{ya}		Specific yield of water (Apparent specific yield); unconfined storage, field measuring. Corresponds to volume of water achieved on draining saturated soil or rock in free draining of a volumetric unit. S_{ya}= S_y (often called S_y in literature)	[-]	-
S_r		Specific retention capacity, (specific retention of water, field capacity) (Specific retention); unconfined storage. Corresponds to water volume that the soil or rock has left after free draining of saturated soil or rock.	[-]	-
S_f		Fracture storage coefficient	[-]	-
S_m		Matrix storage coefficient	[-]	-
S_{NLR}		Storage coefficient, evaluation based on non-linear regression	[-]	-
S_{Tot}		Judged most representative storage coefficient for particular test section and (in certain cases) evaluation time with respect to available data (made by SKB at a later stage).	[-]	-
S_s		Specific storage coefficient; confined storage.	[1/L]	1/m
S_s*		Assumed specific storage coefficient; confined storage.	[1/L]	1/m
c_f		Hydraulic resistance: The hydraulic resistance is an aquitard with a flow vertical to a two-dimensional formation. The inverse of c is also called Leakage coefficient. c_f=b´/K´ where b´ is thickness of the aquitard and K´ its hydraulic conductivity across the aquitard.	[T]	s
L_f		Leakage factor: $L_f = (K \cdot b \cdot c_f)^{0.5}$ where K represents characteristics of the aquifer.	[L]	m
ξ	Skin	Skin factor	[-]	-

Character	SICADA designation	Explanation	Dimension	Unit
ξ^*	Skin	Assumed skin factor	[-]	-
C		Wellbore storage coefficient	$[(LT^2)\cdot M^2]$	m^3/Pa
C_D		$C_D = C\cdot\rho_w g /(2\pi\cdot S\cdot r_w^2)$, Dimensionless wellbore storage coefficient	[-]	-
ω	Stor-ratio	$\omega = S_f /(S_f + S_m)$, storage ratio (Storativity ratio); the ratio of storage coefficient between that of the fracture and total storage.	[-]	-
λ	Interflow-coeff	$\lambda = \alpha\cdot (K_m / K_f) \cdot r_w^2$ interporosity flow coefficient.	[-]	-
T_{GRF}		Transmissivity interpreted using the GRF method	$[L^2/T]$	m^2/s
S_{GRF}		Storage coefficient interpreted using the GRF method	[1/L]	1/m
D_{GRF}		Flow dimension interpreted using the GRF method	[-]	-
c_w		Water compressibility; corresponding to β in hydrogeological literature.	$[(LT^2)/M]$	1/Pa
c_r		Pore-volume compressibility, (rock compressibility); Corresponding to α/n in hydrogeological literature.	$[(LT^2)/M]$	1/Pa
c_t		$c_t = c_r + c_w$, total compressibility; compressibility per volumetric unit of rock obtained through multiplying by the total porosity, n. (Presence of gas or other fluids can be included in c_t if the degree of saturation (volume of respective fluid divided by n) of the pore system of respective fluid is also included)	$[(LT^2)/M]$	1/Pa
nc_t		Porosity-compressibility factor: $nc_t = n\cdot c_t$	$[(LT^2)/M]$	1/Pa
$nc_t b$		Porosity-compressibility-thickness product: $nc_t b = n\cdot c_t\cdot b$	$[(L^2T^2)/M]$	m/Pa
n		Total porosity	-	-
n_e		Kinematic porosity, (Effective porosity)	-	-
e		Transport aperture. $e = n_e\cdot b$	[L]	m
ρ	Density	Density	$[M/L^3]$	$kg/(m^3)$
ρ_w	Density-w	Fluid density in measurement section during pumping/injection	$[M/L^3]$	$kg/(m^3)$
ρ_o	Density-o	Fluid density in observation section	$[M/L^3]$	$kg/(m^3)$
ρ_{sp}	Density-sp	Fluid density in standpipes from measurement section	$[M/L^3]$	$kg/(m^3)$
μ	my	Dynamic viscosity	[M/LT]	Pa s
μ_w	my	Dynamic viscosity (Fluid density in measurement section during pumping/injection)	[M/LT]	Pa s
FC_T		Fluid coefficient for intrinsic permeability, transference of k to K; $K=FC_T\cdot k$; $FC_T=\rho_w\cdot g/\mu_w$	[1/LT]	1/(ms)
FC_S		Fluid coefficient for porosity-compressibility, transference of c_t to S_s ; $S_s=FC_S\cdot n\cdot c_t$; $FC_S=\rho_w\cdot g$	$[M/T^2L^2]$	Pa/m
Index on K, T and S				
S		S: semi-log		
L		L: log-log		
f		Pump phase or injection phase, designation following S or L (withdrawal)		
s		Recovery phase, designation following S or L (recovery)		
NLR		NLR: Non-linear regression. Performed on the entire test sequence, perturbation and recovery		
M		Moye		
GRF		Generalised Radial Flow according to Barker (1988)		
m		Matrix		
f		Fracture		
T		Judged best evaluation based on transient evaluation.		

Character	SICADA designation	Explanation	Dimension	Unit
Tot		Judged most representative parameter for particular test section and (in certain cases) evaluation time with respect to available data (made by SKB at a later stage).		
b		Bloch property in a numerical groundwater flow model		
e		Effective property (constant) within a domain in a numerical groundwater flow model.		
Index on p and Q				
0		Initial condition, undisturbed condition in open holes		
i		Natural, "undisturbed" condition of formation parameter		
f		Pump phase or injection phase (withdrawal, flowing phase)		
s		Recovery, shut-in phase		
p		Pressure or flow in measuring section at end of perturbation period		
F		Pressure in measuring section at end of recovery period.		
m		Arithmetical mean value		
c		Estimated value. The index is placed last if index for “where” and “what” are used. Simulated value		
m		Measured value. The index is placed last if index for “where” and “what” are used. Measured value		
Some miscellaneous indexes on p and h				
w		Test section (final difference pressure during flow phase in test section can be expressed dp_{wp}; First index shows “where” and second index shows “what”)		
o		Observation section (final difference pressure during flow phase in observation section can be expressed dp_{op}; First index shows “where” and second index shows “what”)		
f		Fresh-water head. Water is normally pumped up from section to measuring hoses where pressure and level are observed. Density of the water is therefore approximately the same as that of the measuring section. Measured groundwater level is therefore normally represented by what is defined as point-water head. If pressure at the measuring level is recalculated to a level for a column of water with density of fresh water above the measuring point it is referred to as fresh-water head and h is indicated last by an f. Observation section (final level during flow phase in observation section can be expressed h_{opf}; the first index shows “where” and the second index shows “what” and the last one “recalculation”)		