P-07-39

Oskarshamn site investigation

Hydraulic interference tests, pumping borehole KLX20A

Subarea Laxemar

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December 2007

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ISSN 1651-4416
SKB P-07-39

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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 KLX20A in two different sections. During the pumping phase the pressure response in 6 observation boreholes was monitored in up to three different intervals per borehole, which were separated with packers. A 5 L water sample was taken by Golder at the end of each pumping phase. These samples were analysed according to the class 3 level. The tests are part of the general program for site investigations and specifically for the Laxemar subarea. Previous to the interference tests, hydraulic injection tests in 100 m and 20 m intervals were performed /Enachescu and Rohs 2007/. 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 to the selected lineament NS001. Data is subsequently delivered for the site descriptive model.

This report describes the results and primary data evaluation of the interference tests in borehole KLX20A performed between 13th and 26th of November 2006. 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 KLX20A i två sektioner. Under pumpningen har tryckresponsen uppmätts i 6 observationshål i upp till tio sektioner per borrhål med dubbelmanschett. I slutet av varje pumpfas togs av Golder ett 5 liters vattenprov för klass 3 analys. Interferenstesterna är en del av platsundersökningarna och specifikt för Laxemar området. Före interferenstesterna utfördes hydrauliska injektionstester om 100 och 20 m sektioner /Enachescu och Rohs 2007/. Hydraultestprogrammet har som mål att karakterisera berget utifrån dess hydrauliska egenskaper och interferenstesterna har som syfte att undersöka konnektiviteten mellan sprickzoner, särskilt till lineament NS001. Erhållna data utgör sedan indata för den platsspecifika modellen.

Följande rapport redovisar resultaten och primärdata från utvärderingen av interferenstesterna i borrhål KLX20A utförda mellan den 13 till den 26 november 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.

Innehåll

1 Introduction

A general program for site investigations presenting survey methods has been prepared /SKB 2001/ 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 KLX20A, which is one of the activities performed within the site investigation at Oskarshamn. The work was carried out in accordance with Activity Plan AP PS 400-06-112. In Table 1-1 controlling documents for performing this activity are listed. Both Activity Plan and Method Descriptions are SKB's internal controlling documents.

Hydraulic interference tests (pumping tests) have been performed in borehole KLX20A in two different sections with section lengths of 56 m and 80.5 m. The section of 56 m was separated with packers above and below, the section of 80.5 m was an open section with a packer at the bottom and the end of casing as top of section. Monitoring of pressure response was carried out by SKB in 5 additional boreholes plus two different sections in the pumped borehole KLX20A (see Figure 1-1), monitoring data were delivered by SKB for further analyses.

Measurements were carried out between 13th and 26th of November 2006 following the methodologies described in SKB MD 321.003 (pump tests), SKB MD 330.003 (interference tests), the Activity Plan AP PS 400-06-112 (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.

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 KLX20A. 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
Hydraulic pumping and injection tests in borehole KLX20A.	AP PS 400-06-112	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

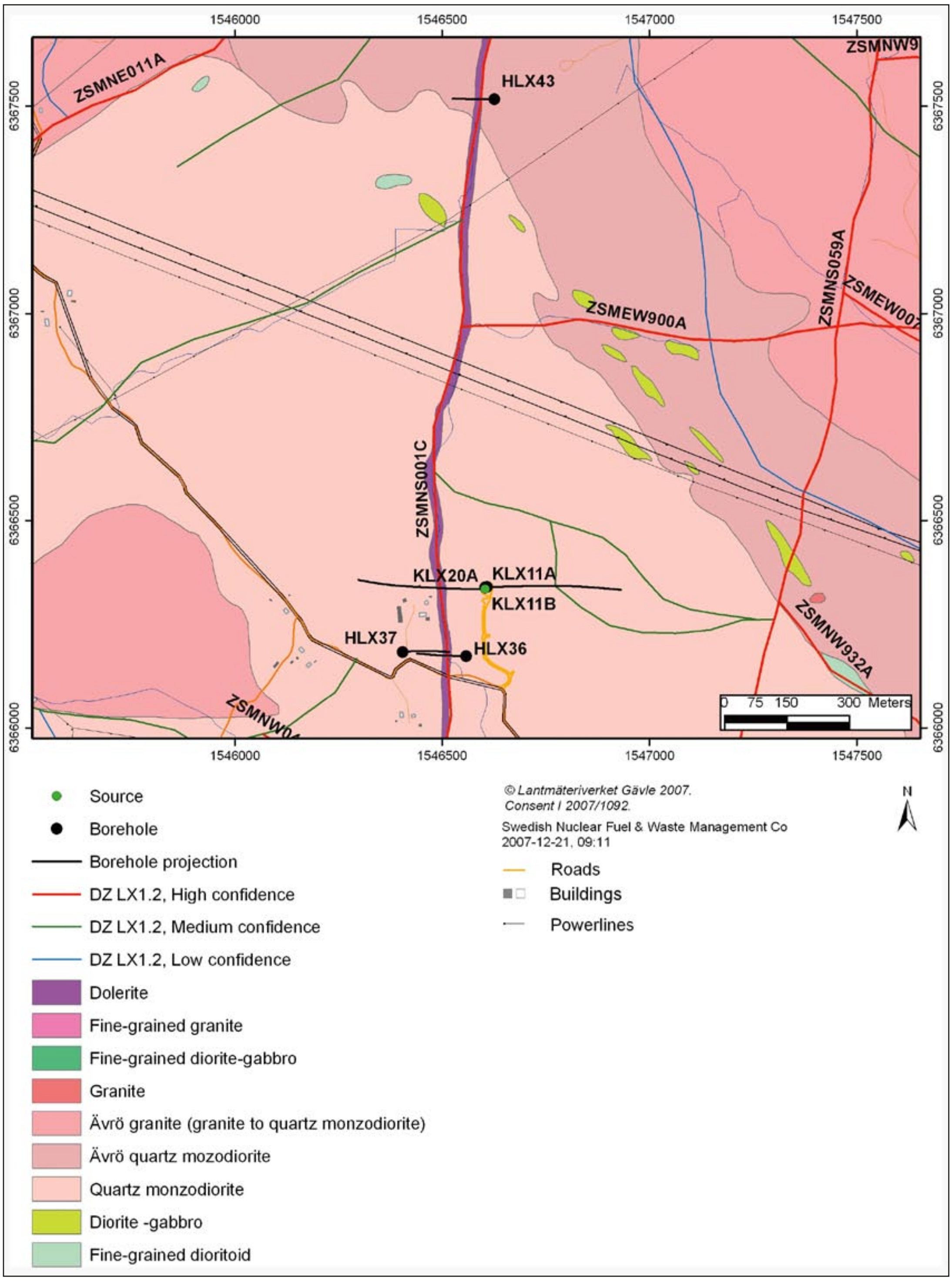

Figure 1-1. *The investigation area Laxemar, Oskarshamn with location of boreholes.*

Borehole KLX20A is situated in the Laxemar area approximately 4 km west of the nuclear power plant of Simpevarp, Figure 1-1. The borehole was drilled from February 2006 to April 2006 at 457.92 m length with an inner diameter of 76 mm and an inclination of –49.813°. The upper 99.50 m is cased with large diameter telescopic casing ranging from diameter (outer diameter) 208–323 mm.

2 Objective and scope

The major objective of the performed testing program was the interference testing in order to resolve the hydraulic connectivity of the fracture network. A special additional objective of the interference tests was to resolve the hydraulic properties of a Diorite dyke which is connected to the lineament NS001. Previous investigations indicated that this Diorite dyke may work as hydraulic barrier.

Further objective of the pumping interference tests was to take water samples after each test. The water samples were taken and delivered by SKB to the chemistry laboratory at Äspö for class 3 analysis. In addition, both phases of each pump test (perturbation and recovery) were analysed to provide more information to characterize the rock around the borehole (with special consideration of the mentioned Diorite dyke) and the hydraulic properties of the tested lineament NS001.

The scope of work consisted of preparation of the PSS2 tool which included cleaning of the pump and the pump basket, calibration and functional checks and pumping tests in two different sections (56 m and 80.5 m section length). The cleaning of the down-hole tools was done according to the required cleaning level 2 of SKB MD 600.004. The analysis and reporting for this report contains the measurements in KLX20A, as well as the data of the observation boreholes, recorded, collected and delivered by SKB.

Preparation for testing was done according to the Quality plan. This step mainly consists of functions checks of the equipment to be used, the PSS2 tool. Calibration checks and function checks were documented in the daily log and/or relevant documents.

The following pump tests were performed between 13th and 26th of November 2006.

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 KLX20A (source) the observed responses were influenced by following effects:

- all observation holes were influenced by earth-tidal effects,
- the pressure response in HLX37 is additionally influenced by investigations in adjacant boreholes.

Table 2-1. Performed test programme.

Borehole	Priority	Secup [mbToC]	Seclow [mbToC]	Seclen [m]	Duration pumping [h]	Duration recovery [h]
KLX20A		250.2	306.2	56.0	48.0	68.4
KLX20A		99.5	180.0	80.5	48.0	37.9
				Total:	96.0	106.3

2.2 Pumped borehole

Technical data of the borehole KLX20A 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. Information to the observed boreholes was not presented.

Table 2-2. Information about KLX20A (from SICADA 2006-09-15).

Title	Value				
Old idcode name(s):	KLX20A				
Comment:	No comment exists				
Borehole length (m):	457.920				
Reference level:	TOC				
Drilling period(s):	From date	To date	Secup (m)	Seclow (m)	Drilling type
	2006-02-22	2006-03-08	0.300	100.000	Percussion drilling
	2006-03-25	2006-04-24	99.910	457.920	Core drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (m.a.s.l.)	Coord system
(centerpoint of TOC)	0.000	6,366,334.571	1,546,604.889	27.242	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	270.605	–49.813	RT90–RHB70	
Borehole diameter:	Secup (m)	Seclow (m)	Hole diam (m)		
	0.300	6.000	0.340		
	6.000	99.900	0.253		
	99.900	99.910	0.162		
	99.910	100.900	0.086		
	100.900	457.920	0.076		
Core diameter:	Secup (m)	Seclow (m)	Core diam (m)		
	99.910	100.400	0.072		
	100.400	457.920	0.050		
Casing diameter:	Secup (m)	Seclow (m)	Case in (m)	Case out (m)	
	0.000	99.470	0.200	0.208	
	0.300	6.000	0.310	0.323	
	99.470	99.500	0.170	0.208	
Cone dimensions:	Secup (m)	Seclow (m)	Cone in (m)	Cone out (m)	
	96.080	99.090	0.100	0.104	
	99.090	100.900	0.080	0.084	
Grove milling:	Length (m)	Trace detectable			
	110.000	YES			
	150.000	YES			
	200.000	YES			
	250.000	YES			
	300.000	YES			
	350.000	YES			
	400.000	YES			
	430.000	YES			

2.3 Tests

The tests performed in KLX20A are listed in Table 2-4. They were conducted according to the Activity Plan AP PS 400-06-112 (SKB internal document). All tests were conducted as constant rate pump tests. Interference tests were carried out with additional installation of pressure transducers in selected monitoring boreholes. Groundwater data of further monitoring boreholes were provided by SKB.

At the end of each test, a 5 L water sample was taken by Golder and submitted to the SKB Äspö Laboratory for analysis.

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]
HLX36	2	60	HLX43	2	60	KLX11B	1	7,200
HLX37	3	60	KLX11A	1	7,200	KLX20A	4	sequence

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)
KLX20A	250.2–306.2	1B	1	2006-11-15 09:30:00	2006-11-20 13:23:00
KLX20A	99.5–180.0	1B	1	2006-11-21 10:08:00	2006-11-25 09:27:00

* 1B: 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.

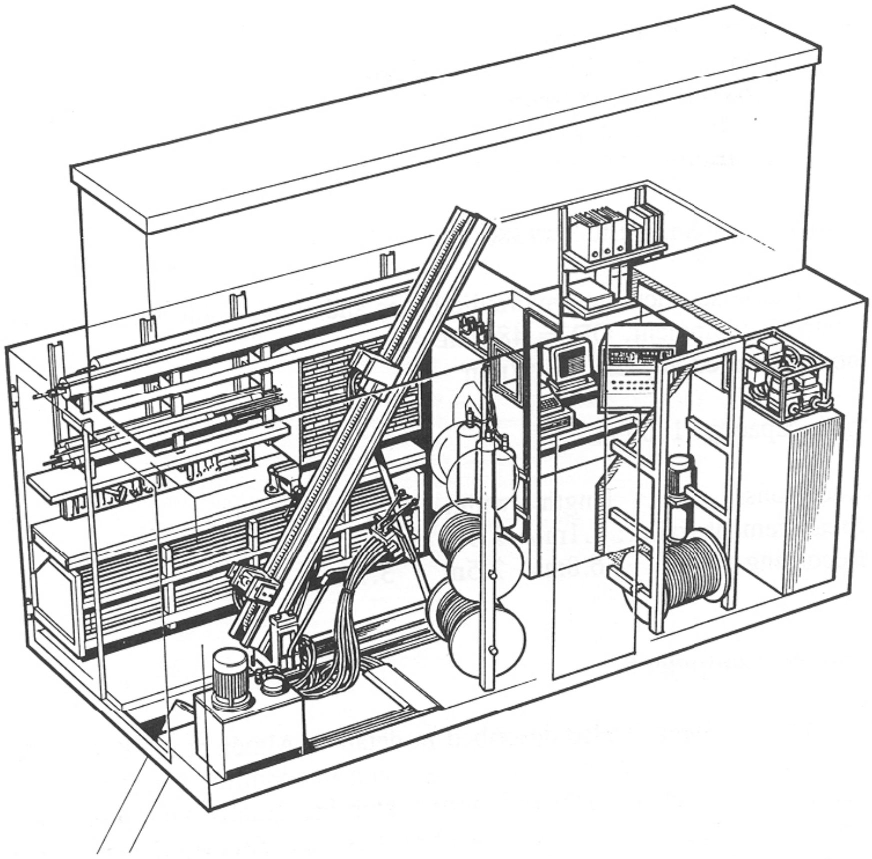

Figure 3-1. A view of the layout and equipment of PSS2.

Photo 1. *Hydraulic rig.*

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

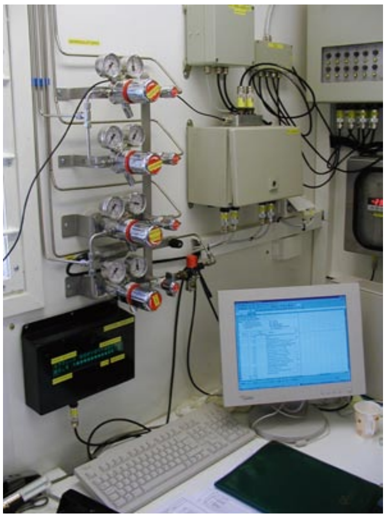

Photo 3. *Computer room, displays and gas regulators.*

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

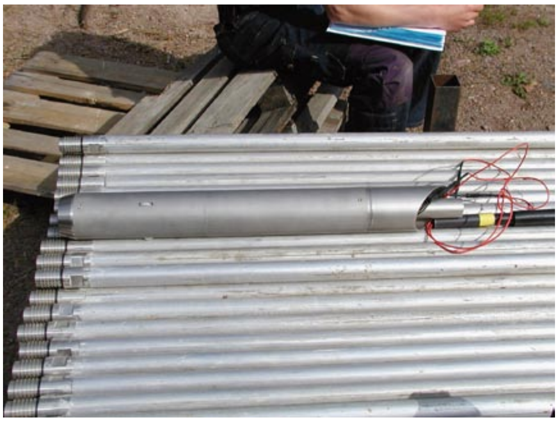

Photo 5. *Positioner, bottom end of down-in-hole string.*

Photo 6. *Packer and gauge carrier.*

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

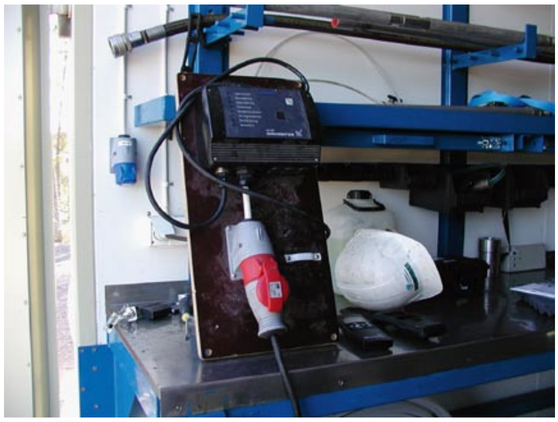

Photo 8. *Control board of the pump with remote control.*

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 3 kPa/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 3 kPa/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-50 L/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).

For the pump test in section 99.5–180.0 m the pump was placed in a pump basket in the test string with an open gauge carrier between the pump and the shut-in tool (test valve). This construction allowed pumping in the open section above the packer system and observing pressure data from three sections in the borehole (section above, interval and section below).

The tool scheme is presented in Figure 3-2.

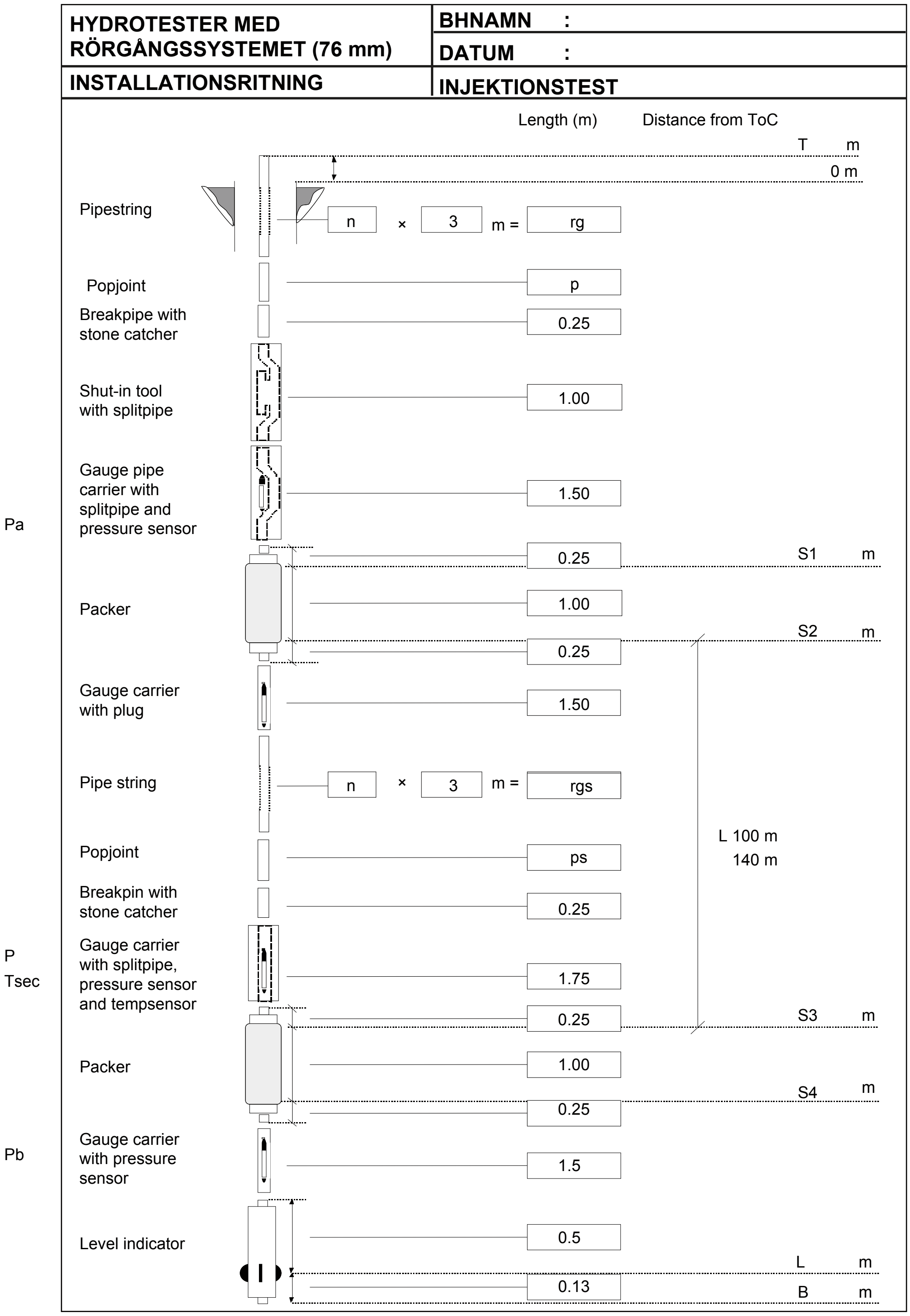

Figure 3-2. Schematic drawing of the down-hole equipment in the PSS2 system.

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 162-1464abs	9–30	VDC	
			4–20	mA	
			0–13.5	MPa	
			± 0.1	% of FS	
$T_{sec, surf, air}$	Temperature	BGI	18–24	VDC	
			4–20	mA	
			0–32	°C	
			± 0.1	°C	
Q_{big}	Flow	Micro motion	0–100	kg/min	Massflow
		Elite sensor	± 0.1	%	
Q_{small}	Flow	Micro motion	0–1.8	kg/min	Massflow
		Elite sensor	± 0.1	%	
p_{air}	Pressure	Druck PTX 630	9–30	VDC	
			4–20	mA	
			0–120	KPa	
			± 0.1	% of FS	
p_{pack}	Pressure	Druck PTX 630	9–30	VDC	
			4–20	mA	
			0–4	MPa	
			± 0.1	% of FS	
$p_{in,out}$	Pressure	Druck PTX 1400	9–28	VDC	
			4–20	mA	
			0–2.5	MPa	
			± 0.15	% 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)	Test no	Type	Position (m b ToC)	Position	Function	Outer diameter (mm)	Net water volume in test section (m³)
KLX20A	250.20–306.20	1	p_a	249.31	Test section	Signal cable	9.1	
			p	305.57		Pump string	33	0.201
			T	305.40		Packer line	6	
			p_b	308.21				
			L	309.45				
KLX20A	99.50–180.00	1	p_a	179.11	Test section	Signal cable	9.1	
			p	236.37		Pump string	33	0.289
			T	236.20		Packer line	6	
			p_b	239.01				
			L	240.25				

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.

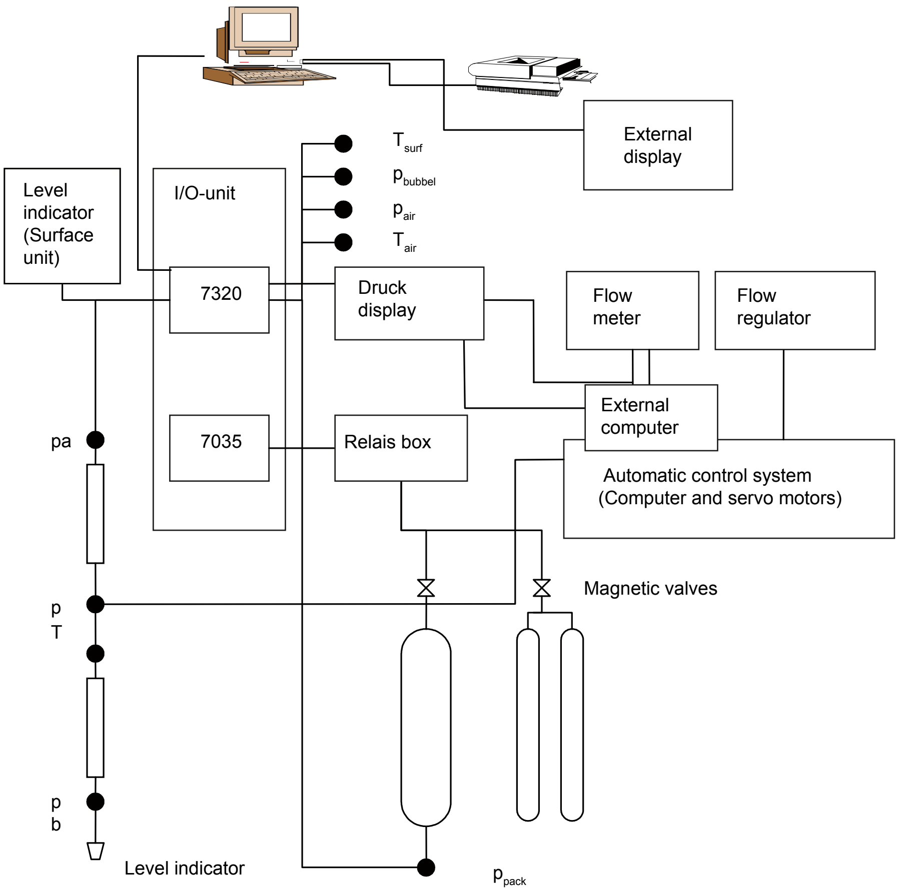

Figure 3-3. *Schematic drawing of the data acquisition system and the flow regulation control system in PSS2.*

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 and disinfected with alcohol according to cleaning level 2. 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 phase should have lasted 2 days and the recovery phase 1 day to 2–3 days respectively. The actual durations of the phases are shown in Table 2-1.

Observation wells

For evaluation as interference tests, several boreholes were used to monitor the pressure change in different intervals. Recording and data collection was done by SKB despite the data from the observed sections in KLX20A. SKB delivered the data as ASCII files (mio-format). An overview of the monitored boreholes and their intervals is given in Table 2-3.

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 KLX20A 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, no major rainfall happened during performance of the pump tests which may have disturbed the measurements. In some observation sections, influence of pumping in other sources were identified, e.g. in observation sections HLX37_1 and HLX37_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 1 minute. SKB delivered the ASCII data in mio-format. These files were imported and processed to Excel for further evaluation and analysis.

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

Bh ID	Section [mbToC]	Flow rate [L/min]	Drawdown* [kPa]
KLX20A	250.2–306.2	2.9	251
KLX20A	99.5–180.0	15.4	448

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

4.5 Analyses and interpretations

4.5.1 Analysis software

The pump tests were analysed using a type curve matching method. The analysis was performed using Golder's test analysis program FlowDim. FlowDim is an interactive analysis environment allowing the user to interpret constant pressure, constant rate and slug/pulse tests in source as well as observation boreholes. The program allows the calculation of type-curves for homogeneous, dual porosity and composite flow models in variable flow geometries from linear to spherical.

4.5.2 Analysis approach

Constant rate and pressure recovery tests are analysed using the method described by /Gringarten 1986, Bourdet et al. 1989/ by using type curve derivatives calculated for different flow models.

4.5.3 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. A non-linear regression algorithm is used to provide optimized model parameters in the latter stages.
- Non-linear regression in semi-log coordinates (superposition HORNER plot; /Horner 1951/). In this stage of the analysis, the static formation pressure is selected for regression.

The test analysis methodology is best explained in /Horne 1990/.

4.5.4 Correlation between storativity and skin factor

For the analysis of the conducted hydraulic tests below 100 m depth a storativity of $1 \cdot 10^{-6}$ is assumed (SKB MD 320.004e). Based on this assumption the skin will be calculated. In the following the correlation between storativity and skin for the relevant test phases will be explained in greater detail.

Pump and recovery phase (CRw and CRwr)

The wellbore storage coefficient (C) is determined by matching the early time data with the corresponding type curve. The derived C-value is introduced in the equation of the type curve parameter:

$$(C_D e^{2s})_M = \frac{C\,\rho\,g}{2\pi\, r_w^2\, S}\, e^{2s}$$

The equation above has two unknowns, the storativity (*S*) and the skin factor (*s*) which expresses the fact that for the case of constant rate and pressure recovery tests the storativity and the skin factor are 100% correlated. Therefore, the equation can only be either solved for skin by assuming that the storativity is known or solved for storativity by assuming the skin as known.

4.5.5 Steady state analysis

In addition to the type curve analysis, an interpretation based on the assumption of stationary conditions was performed as described by /Moye 1967/.

4.5.6 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 five cases a radial two shell composite flow model was used. One test phase was analysed using an infinite acting radial flow model.

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).

4.5.7 Calculation of the static formation pressure and equivalent freshwater head

The static formation pressure (p*) measured at transducer depth, was derived from the pressure recovery (CRwr) following the constant pressure injection phase by using:

(1) Straight line extrapolation in cases infinite acting radial flow (IARF) occurred.

(2) Type curve extrapolation in cases infinite acting radial flow (IARF) is unclear or was not reached.

The equivalent freshwater head (expressed in metres above sea level) was calculated from the extrapolated static formation pressure (p*), corrected for atmospheric pressure measured by the surface gauge and corrected for the vertical depth considering the inclination of the borehole, by assuming a water density of 1,000 kg/m^3 (freshwater). The equivalent freshwater head is the static water level an individual test interval would show if isolated and connected to the surface by tubing full of freshwater. Figure 4-1 shows the methodology schematically.

The freshwater head in metres above sea level is calculated as following:

$$head = \frac{(p^* - p_{atm})}{\rho \cdot g}$$

which is the p* value expressed in a water column of freshwater.

With consideration of the elevation of the reference point (RP) and the gauge depth (Gd), the freshwater head h_{iwf} is:

$$h_{iwf} = RP_{elev} - Gd + \frac{(p^* - p_{atm})}{\rho \cdot g} \cdot$$

4.5.8 Calculation of the radius of the inner zone

The radius of influence was calculated as follows:

$$ri = 1.89 \cdot \sqrt{\frac{T_{s1}}{S_T} \cdot t_2} \quad [\text{m}]$$

T_{s1} recommended inner zone transmissivity of the recovery phase [m²/s]

t_2 time when hydraulic formation properties changes [s]

S_T for the calculation of the ri the storage coefficient (S) is estimated from the transmissivity /Rhen 2005/:

$S_T = 0.007 \cdot T_T^{0.5}$ [–]

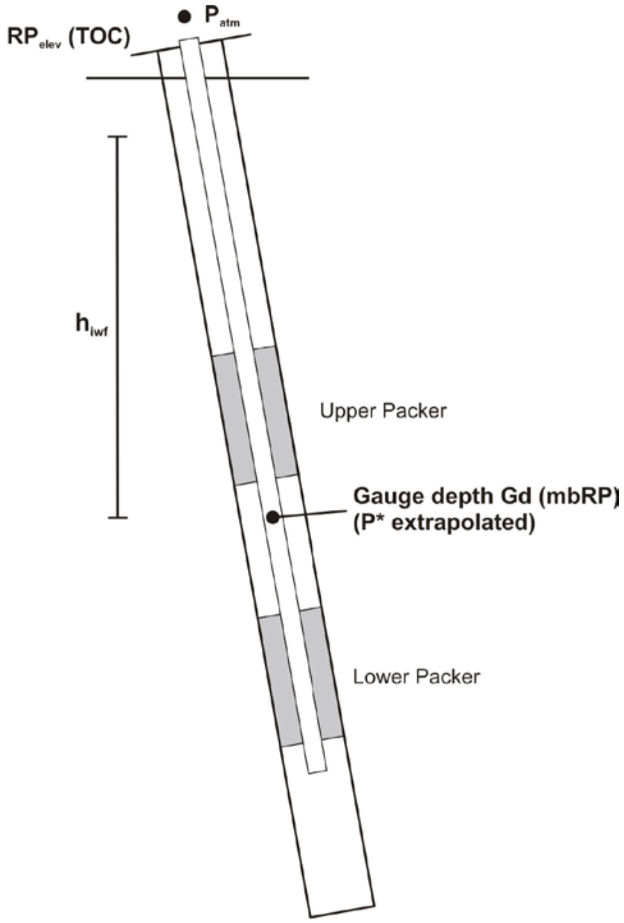

Figure 4-1. *Schematic methodologies for calculation of the freshwater head.*

4.5.9 Derivation of the recommended transmissivity and the confidence range

In all cases both test phases were analysed (CRw and CRwr). The parameter sets (i.e. transmissivities) derived from the individual analyses of a specific test usually differ. In the case when the differences are small the recommended transmissivity value is chosen from the test phase that shows the best data and derivative quality, which is most of the cases at the CRwr phase. In cases when a composite flow model was deemed to be most representative for the hydraulic behaviour of the specific test section, than the most representative zone transmissivity was selected as recommended value.

The confidence range of the transmissivity was derived using expert judgement. Factors considered were the range of transmissivities derived from the individual analyses of the test as well as additional sources of uncertainty such as noise in the flow rate measurement, numeric effects in the calculation of the derivative or possible errors in the measurement of the wellbore storage coefficient. No statistical calculations were performed to derive the confidence range of transmissivity.

4.6 Analysis and interpretation of the reponse in the observation holes

In 6 boreholes with a total of 13 sections (Table 2-3) the responses were monitored during the pumping tests in KLX20A. Those data were analysed according to the methodology description (SKB MD 330.003) to derive hydraulic connectivity parameters. Furthermore the data of the observation holes were analysed using a type curve matching method with Golder’s test analysis program FlowDim.

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 KLX08, 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 parameters and the calculated hydraulic connectivity parameters are shown in the tables in Chapter 5 and Appendix 6. The indices are calculated as follows:

Index 1:

r_s^2/dt_L = normalised distance r_s 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	
$10 < r_s^2/dt_L \leq 100$ m²/s	High	$3\cdot10^4 < s_p/Q_p \leq 1\cdot10^5$ s/m²	High	
$1 < r_s^2/dt_L \leq 10$ m²/s	Medium	$1\cdot10^4 < s_p/Q_p \leq 3\cdot10^4$ s/m²	Medium	
$0.1 < r_s^2/dt_L \leq 1$ m²/s	Low	$s_p/Q_p \leq 1\cdot10^4$ s/m²	Low	
		$s_p < 0.1$ m	No response	

Index 2 new ($(s_p/Q_p)\cdot\ln(r_s/r_0)$)		Colour code
$(s_p/Q_p)\cdot\ln(r_s/r_0) > 5\cdot10^5$ s/m²	Excellent	
$5\cdot10^4 < (s_p/Q_p)\cdot\ln(r_s/r_0) \leq 5\cdot10^5$ s/m²	High	
$5\cdot10^3 < (s_p/Q_p)\cdot\ln(r_s/r_0) \leq 5\cdot10^4$ s/m²	Medium	
$5\cdot10^2 < (s_p/Q_p)\cdot\ln(r_s/r_0) \leq 5\cdot10^3$ 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 (s_p) caused by pumping in the active section and the response time after start of pumping (dt_L) 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 KLX20A with a drawdown of at least 0.01 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 these performed tests relative small and of no 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 KLX20A 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. If neither start time nor stop time of pumping can provide reliable data for the response time 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 dt_L is defined as the time when the pressure response in an observation section is greater than ca 0.01 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.

For the calculation of the hydraulic diffusivity the recommended transmissivity T_T and Storativity S derived from the transient type curve analysis were used. No calculation based on dt_L was done, because of the often poor quality of dt_L and to ensure the consistency between the calculated diffusivity values.

Values of the hydraulic diffusivity are shown in Tables 5-2, 5-3 and 6-3.

4.6.3 Response analysis

To derive transmissivities and storativities from the sections of the observation boreholes Golder's analysis software FlowDim was used.

Analysis approach

The interference tests are analysed using cylindrical 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 4-2 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 4-3).

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 cylindrical source (i.e. finite wellbore radius).

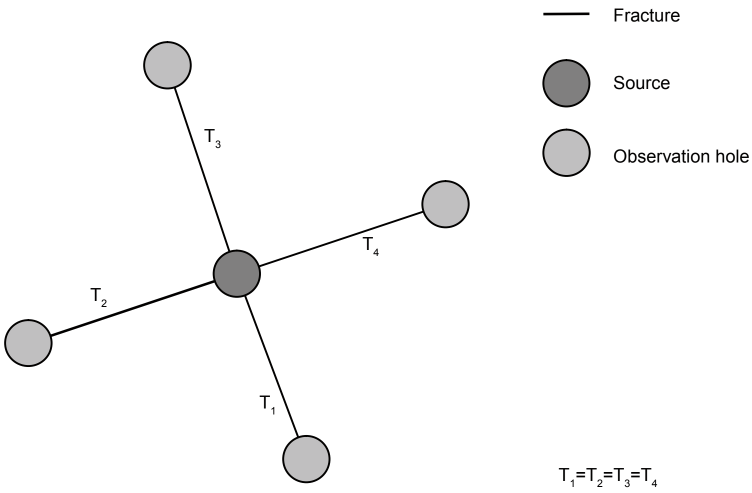

Figure 4-2. *Schematic sketch of a pumping hole (source) and observation holes.*

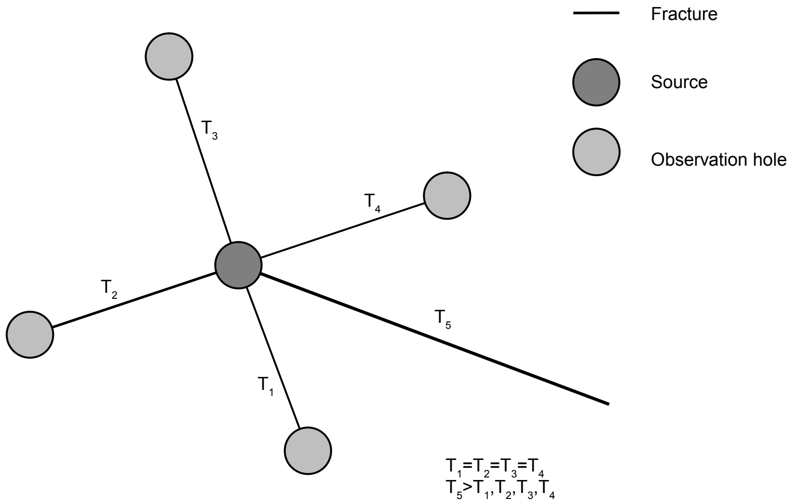

Figure 4-3. *Schematic sketch of a pumping hole (source) and observation holes with an added fracture.*

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).

4.7 Nonconformities

No nonconformities happened during performance of the pump tests in KLX20A.

5 Results

In the following, results of the pump tests conducted in KLX20A 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 3). No disturbing activities like heavy rainfall were observed during the pump tests in borehole KLX20A. The only disturbing effects observed were caused by tidal influence and in some observation sections, influence of pumping in other sources was identified, e.g. in observation sections HLX37_1 and HLX37_2 during running pump tests in KLX20A in both sections. 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 some 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 Results pump tests

5.1.1 Section 99.5–180.0 m, test no. 1, pumping

Comments to test

The test was composed of a constant rate pump test phase with a flow rate of 15.4 l/min and a pressure difference of 448 kPa, followed by a pressure recovery phase. No hydraulic connection between the test interval and the adjacent zones was observed. The flow rate during the pumping phase was constant at about 15.4 l/min during the whole pump phase with a pressure drawdown of ca. 448 kPa at the end of the perturbation phase, indicating a relatively high interval transmissivity. After approximate 48 hours of pumping, a water sample was taken by Golder. Both phases are 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. In case of the present test the CRw and CRwr phases show a flat derivative at late times, which is indicative of a flow dimension of 2 (radial flow). A homogeneous model with infinite acting radial flow was chosen for the analysis of the CRw and CRwr phases. The analysis is presented in Appendix 2-1.

Selected representative parameters

The recommended transmissivity of $1.5 \cdot 10^{-5}$ m²/s m²/s was derived from the analysis of the CRw phase, which shows the best data and derivative quality. The confidence range for the interval transmissivity is estimated to be $7 \cdot 10^{-6}$ m²/s to $4 \cdot 10^{-5}$ 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 straight line extrapolation in the Horner plot to a value of 1,361 kPa.

The analysis of the CRw and CRwr phases shows good consistency. No further analysis is recommended.

5.1.2 Section 250.2–306.2 m, test no. 1, pumping

Comments to test

The test was composed of a constant rate pump test phase with a flow rate of 2.9 l/min and a pressure difference of 251 kPa, followed by a pressure recovery phase. A slightly hydraulic connection between the test interval and the adjacent bottom zone was observed. The flow rate during the pumping phase was constant at about 2.9 l/min during the whole pump phase with a pressure drawdown of ca. 251 kPa at the end of the perturbation phase, indicating a medium interval transmissivity. After approximate 48 hours of pumping, a water sample was taken by Golder. Both phases are 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. In case of the present test the CRw and CRwr phases show a flat derivative at late times, which is indicative of a flow dimension of 2 (radial flow). A homogeneous model with infinite acting radial flow was chosen for the analysis of the CRw phase. The CRwr phase was analysed using a composite radial flow model. The analysis is presented in Appendix 2-2.

Selected representative parameters

The recommended transmissivity of $1.5 \cdot 10^{-6}$ m^2/s was derived from the analysis of the CRwr phase (outer zone), which shows the best data and derivative quality. The confidence range for the interval transmissivity is estimated to be $7 \cdot 10^{-7}$ m^2/s to $4 \cdot 10^{-6}$ 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 straight line extrapolation in the Horner plot to a value of 2,258 kPa.

The analysis of the CRw and CRwr phases shows good consistency. No further analysis is recommended.

5.2 Results response analysis

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 (Appendices 6 and 8).

Table 5-1 summarises all the tests and the observed boreholes. Furthermore it shows the response matrix based on the calculated indices 1 (r_s^2/dt_L), 2 (s_p/Q_p) and 2 new $(s_p/Q_p)\cdot\ln(r_s/r_0)$ (see Section 4.6.1).

5.3 KLX20A test section 99.50–180.00 m pumped

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 15.4 l/min with a drawdown of 448 kPa. In sum 4 observation sections responded due to the pumping. Table 5-2 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 KLX20A 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 5-1. Response matrix with Index 1, Index 2 and Index 2 new.

		Pumping hole	KLX20A			KLX20A		
		Section (m b TOC)	99.50–180.00			250.20–306.20		
		Flow rate (l/min)	15.4			2.9		
		Drawdown (kPa)	448			251		
Observation borehole	Sec no	Section (m)	Response indices					
			1	2	2 new	1	2	2 new
HLX36	1	50.00–199.80						
	2	6.10–49.00						
HLX37	1	149.00–199.80	L					
	2	118.00–148.00	L					
	3	12.10–117.00				L		
HLX43	1	21.00–170.50						
	2	6.00–20.00						
KLX11A	1	12.00–992.00	M					
KLX11B	1	2.50–00.00	M					
KLX20A	1	238.00–457.92				n/a	n/a	n/a
	2	181.00–237.00				n/a	n/a	n/a
KLX20A	1	307.20–457.92	n/a	n/a	n/a	M		
	3	99.50–249.20	n/a	n/a	n/a			

Index 1 (r^2/t_L)

$r_s^2/dt_L > 100$ m²/s	Excellent	E
$10 < r_s^2/dt_L \leq 100$ m²/s	High	H
$1 < r_s^2/dt_L \leq 10$ m²/s	Medium	M
$0.1 < r_s^2/dt_L \leq 1$ 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
$3 \cdot 10^4 < s_p/Q_p \leq 1 \cdot 10^5$ s/m²	High
$1 \cdot 10^4 < s_p/Q_p \leq 3 \cdot 10^4$ s/m²	Medium
$s_p/Q_p \leq 1 \cdot 10^4$ s/m²	Low
$s_p < 0.1$ m	No response indices but analysed

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
$5 \cdot 10^4 < (s_p/Q_p) \cdot \ln(r_s/r_0) \leq 5 \cdot 10^5$ s/m²	High
$5 \cdot 10^3 < (s_p/Q_p) \cdot \ln(r_s/r_0) \leq 5 \cdot 10^4$ s/m²	Medium
$5 \cdot 10^2 < (s_p/Q_p) \cdot \ln(r_s/r_0) \leq 5 \cdot 10^3$ s/m²	Low
$s_p < 0.1$ m	No response indices but analysed

blank = observed but no response at all

n/a = not applicable since it was not observed

Table 5-2. Responded test sections and selected parameters (Section 99.50–180.00 m pumped).

Source borehole		Section (m)	Flow rate Qm (l/min)	Draw-down (m)	r_{wf} (m)				
KLX20A	3	99.50–180.00	15.4	45.67	9.4E–4				
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)* $\ln(r_s/r_0)$ (s/m²)**	**Diffusivity η (m²/s)**
HLX36	1	50.00–199.80	163.0	n.r.	–	–	–	–	–
	2	6.10–49.00	181.0	n.r.	–	–	–	–	–
HLX37	1	149.00–199.80	161.0	0.17	28,047	0.92 L	674.29	3,426.34	3.98E–01
	2	118.00–148.00	157.0	0.16	32,235	0.76 L	634.63	3,208.82	3.41E–01
	3	12.10–117.00	161.0	n.r.	–	–	–	–	–
HLX43	1	21.00–170.50	1,182.0	n.r.	–	–	–	–	–
	2	6.00–20.00	1,189.0	n.r.	–	–	–	–	–
KLX11A	1	12.00–992.00	204.00	0.55	16,010	2.60 M	2,141.86	11,390.68	1.26E00
KLX11B	1	2.50–100.00	107.00	1.21	6,650	1.72 M	4,720.03	22,055.90	5.45E–01
KLX20A	1	238.00–457.92	130.0	n.r.	–	–	–	–	–
	2	181.00–237.00	75.0	n.r.	–	–	–	–	–

)* no response according to SKB 330.003 (Bilagor B); see Section 4.6.1 for greater detail.
n.r. no response due to pumping in source.
Key for Index 1.2 and 2 New, see Table 5-1.

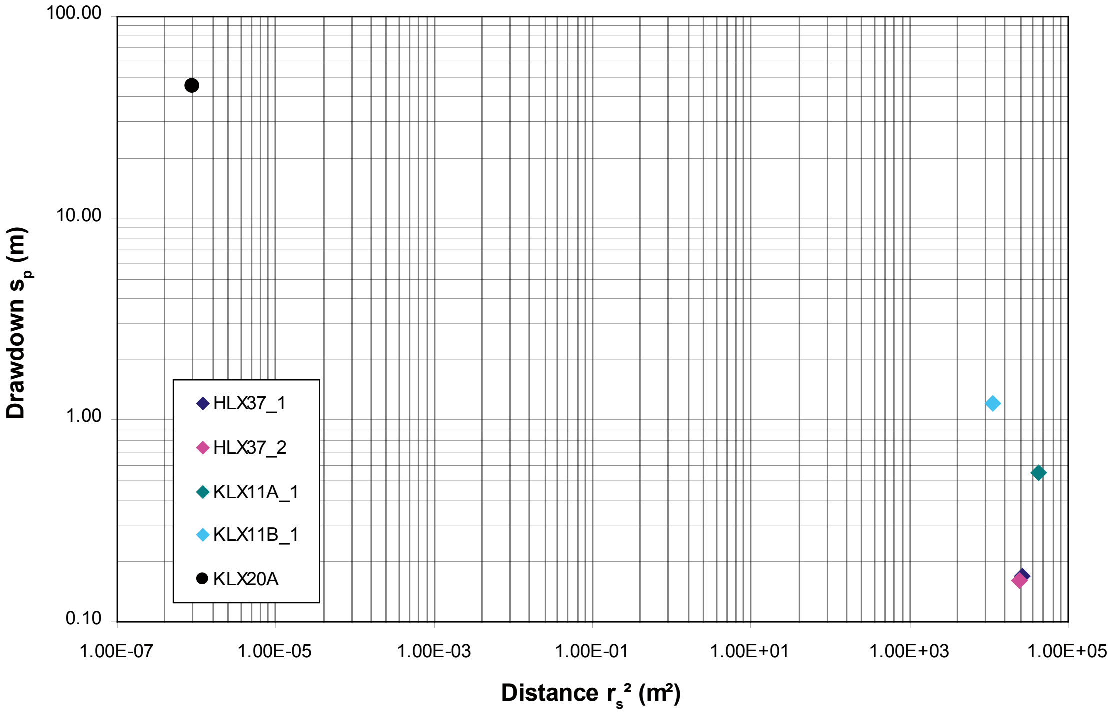

Figure 5-1. *Distance vs. Drawdown for the responding test sections, KLX20A Section 99.50-180.00 m pumped.*

5.3.1 Response HLX37, Section 1 (149.00–199.80 m)

Comments to test

A total drawdown during the flow period of 1.7 kPa (0.17 m) was observed in this section. A recovery of 0.01 m was reached after appr. 467.5 min. (28,047 s) after pump stop in KLX20A (99.50–180.00). The calculated index 1 (r_s^2/dt_L) is rated as "low response time", index 2 (s_p/Q_p) as "low response" and the new index 2 $(s_p/Q_p)\cdot\ln(r_s/r_0)$ as "low response".

The CRw phase was not analysable due to poor data quality but the CRwr 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 CRwr phase a homogeneous radial flow model was chosen. The analysis is presented in Appendix 7-1-1.

Selected representative parameters

The recommended transmissivity of $7.0\cdot10^{-5}$ m²/s was derived from the analysis of the CRwr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be $3.0\cdot10^{-5}$ m²/s to $2.0\cdot10^{-4}$ m²/s. The flow dimension during the test is 2. A static pressure measured at transducer depth was not possible to derive from the CRwr phase due to poor data quality.

The analyse of the CRwr phase show no problems. No further analysis recommended.

5.3.2 Response HLX37, Section 2 (118.00–148.00 m)

Comments to test

A total drawdown during the flow period of 1.6 kPa (0.16 m) was observed in this section. A recovery of 0.01 m was reached after appr. 537.3 min. (32,235 s) after pump stop in KLX20A (99.50–180.00). The calculated index 1 (r_s^2/dt_L) is rated as "low response time", index 2 (s_p/Q_p) as "low response" and the new index 2 $(s_p/Q_p)\cdot\ln(r_s/r_0)$ as "low response".

The CRw phase was not analysable due to poor data quality but the CRwr 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 CRwr phase a homogeneous radial flow model was chosen. The Analysis is presented in Appendix 7-1-2.

Selected representative parameters

The recommended transmissivity of $7.1\cdot10^{-5}$ m²/s was derived from the analysis of the CRwr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be $3.0\cdot10^{-5}$ m²/s to $2.0\cdot10^{-4}$ m²/s. The flow dimension during the test is 2. A static pressure measured at transducer depth was not possible to derive from the CRwr phase due to poor data quality.

The analyse of the CRwr phase show no problems. No further analysis recommended.

5.3.3 Response KLX11A, Section 1 (12.00–992.00 m)

Comments to test

A total drawdown during the flow period of 5.4 kPa (0.55 m) was observed in this section. A recovery of 0.01 m was reached after appr. 266.8 min. (16,010 s) after pump stop in KLX20A (99.50–180.00). The calculated index 1 (r_s^2/dt_L) is rated as "medium response time", index 2 (s_p/Q_p) as "low response" and the new index 2 (s_p/Q_p)·ln(r_s/r_0) as "medium response".

The CRw phase was not analysable due to poor data quality but the CRwr 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 CRwr phase a homogeneous radial flow model was chosen. The Analysis is presented in Appendix 7-1-3.

Selected representative parameters

The recommended transmissivity of $2.9 \cdot 10^{-5}$ m^2/s was derived from the analysis of the CRwr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be $7.0 \cdot 10^{-6}$ m^2/s to $7.0 \cdot 10^{-5}$ m^2/s. The flow dimension during the test is 2. A static pressure measured at transducer depth was not possible to derive from the CRwr phase due to poor data quality.

The analyse of the CRwr phase show no problems. No further analysis recommended.

5.3.4 Response KLX11B, Section 1 (2.50–100.00 m)

Comments to test

A total drawdown during the flow period of 11.9 kPa (1.21 m) was observed in this section. A recovery of 0.01 m was reached after appr. 110.8 min. (6,650 s) after pump stop in KLX20A (99.50–180.00). The calculated index 1 (r_s^2/dt_L) is rated as "medium response time", index 2 (s_p/Q_p) as "low response" and the new index 2 (s_p/Q_p)·ln(r_s/r_0) as "medium response".

The CRw and CRwr phases show no problems and are 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 and CRwr phases a homogeneous radial flow model was chosen. The Analysis is presented in Appendix 7-1-4.

Selected representative parameters

The recommended transmissivity of $1.9 \cdot 10^{-5}$ m^2/s was derived from the analysis of the CRwr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be $7.0 \cdot 10^{-6}$ m^2/s to $7.0 \cdot 10^{-5}$ m^2/s. The flow dimension during the test is 2. A static pressure measured at transducer depth was not possible to derive from the CRwr phase due to poor data quality.

The analyses of the CRw and CRwr phases show consistency. No further analysis recommended.

5.4 KLX20A test section 250.20–306.20 m pumped

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 2.9 l/min with a drawdown of 251 kPa. In sum 2 observation sections responded due to the pumping. Table 5-3 summarizes the responding test sections and selected parameters. Figure 5-2 shows the drawdown of the observed sections related to the distance. The pumped borehole KLX20A is shown with consideration of the effective borehole radius r_{wf}. In the following chapters the response analysis of each responded section is presented.

5.4.1 Response HLX37, Section 3 (12.10–117.00 m)

Comments to test

A total drawdown during the flow period of 3.3 kPa (0.34 m) was observed in this section. A recovery of 0.01 m was reached after appr. 750.4 min. (45,026 s) after pump stop in KLX20A (250.20–306.20). The calculated index 1 (r_s^2/dt_L) is rated as "low response time", index 2 (s_p/Q_p) as "low response" and the new index 2 (s_p/Q_p)·ln(r_s/r_0) as "medium response".

The CRw and CRwr phases show no problems and are 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 and CRwr phases a homogeneous radial flow model was chosen. The analysis is presented in Appendix 7-2-1.

Table 5-3. Responded test sections and selected parameters (Section 250.20–306.20 m pumped).

Source borehole		Section (m)	Flow rate Qm (l/min)	Draw-down (m)	r_{wf} (m)				
KLX20A	2	250.20–306.20	2.9	25.59	3.9E–02				
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)* $\ln(r_s/r_0)$ (s/m²)**	**Diffusivity η (m²/s)**
HLX36	1	50.00–199.80	196.0	n.r.	–	–	–	–	–
	2	6.10–49.00	265.0	n.r.	–	–	–	–	–
HLX37	1	149.00–199.80	178.0	n.r.	–	–	–	–	–
	2	118.00–148.00	182.0	n.r.	–	–	–	–	–
	3	12.10–117.00	190.0	0.34	45,026	0.80 **L**	6,964.63	36,543.56	5.68E–01
HLX43	1	21.00–170.50	1,192.0	n.r.	–	–	–	–	–
	2	6.00–20.00	1,207.0	n.r.	–	–	–	–	–
KLX11A	1	12.00–992.00	242.0	n.r.	–	–	–	–	–
KLX11B	1	2.50–100.00	234.0	n.r.	–	–	–	–	–
KLX20A	1	307.20–457.92	112.0	1.35	1,515	8.28 **M**	27,858.50	131,450.32	4.94E–01
	3	99.50–249.20	130.0	n.r.	–	–	–	–	–

)* no response according to SKB 330.003 (Bilagor B); see Section 4.6.1 for greater detail.
n.r. no response due to pumping in source.
Key for Index 1.2 and 2 New, see Table 5-1.

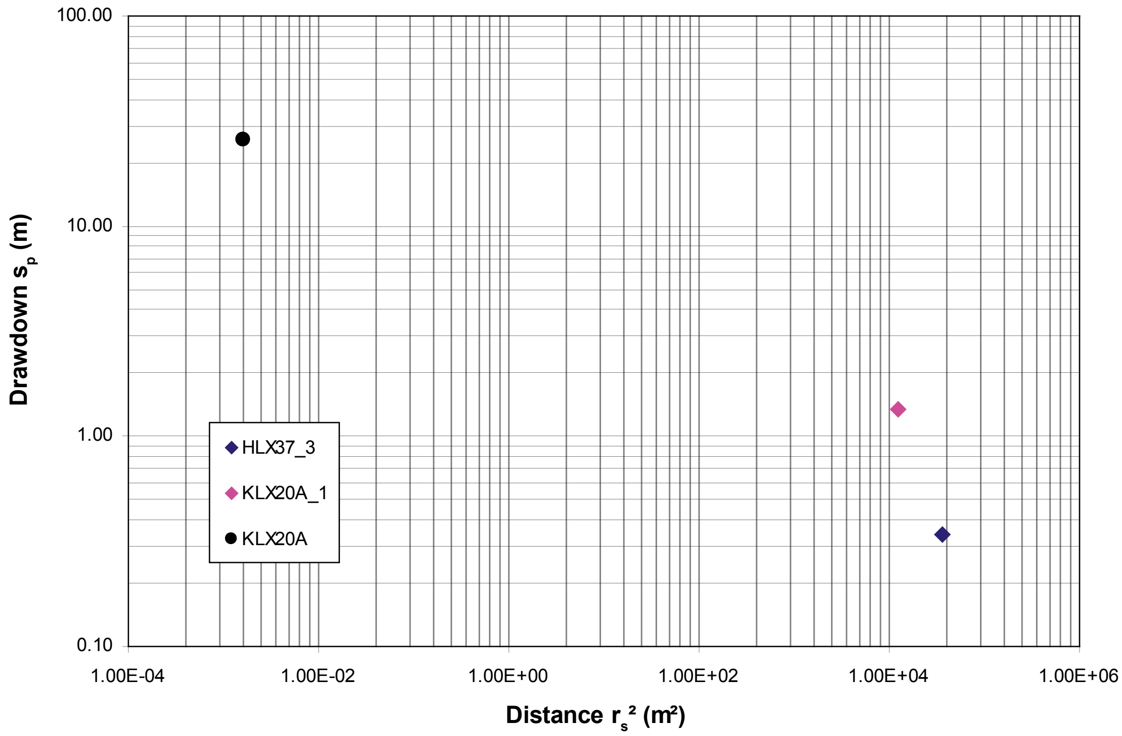

Figure 5-2. *Distance vs. Drawdown for the responding test sections, KLX20A Section 250.20–306.20 m pumped.*

Selected representative parameters

The recommended transmissivity of $4.5 \cdot 10^{-5}$ m²/s was derived from the analysis of the CRwr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be $9.0 \cdot 10^{-6}$ m²/s to $9.0 \cdot 10^{-5}$ m²/s. The flow dimension during the test is 2. A static pressure measured at transducer depth was not possible to derive from the CRwr phase due to poor data quality.

The analyses of the CRw and CRwr phases show consistency. No further analysis recommended.

5.4.2 Response KLX20A, Section 1 (307.20–457.92 m)

Comments to test

A total drawdown during the flow period of 13.2 kPa (1.35 m) was observed in this section. A recovery of 0.01 m was reached after appr. 25.3 min. (1,515 s) after pump stop in KLX20A (250.20–306.20). The calculated index 1 (r_s^2/dt_L) is rated as "medium response time", index 2 (s_p/Q_p) as "medium response" and the new index 2 $(s_p/Q_p) \cdot \ln(r_s/r_0)$ as "high response".

The CRw and CRwr phases show no problems and are 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 and CRwr phases a homogeneous radial flow model was chosen. The Analysis is presented in Appendix 7-2-2.

Selected representative parameters

The recommended transmissivity of $8.1 \cdot 10^{-6}$ 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 $4.0 \cdot 10^{-6}$ m²/s to $5.0 \cdot 10^{-5}$ m²/s. The flow dimension during the test is 2. A static pressure measured at transducer depth was not possible to derive from the CRwr phase due to poor data quality.

The analyses of the CRw and CRwr phases show consistency. No further analysis recommended.

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.

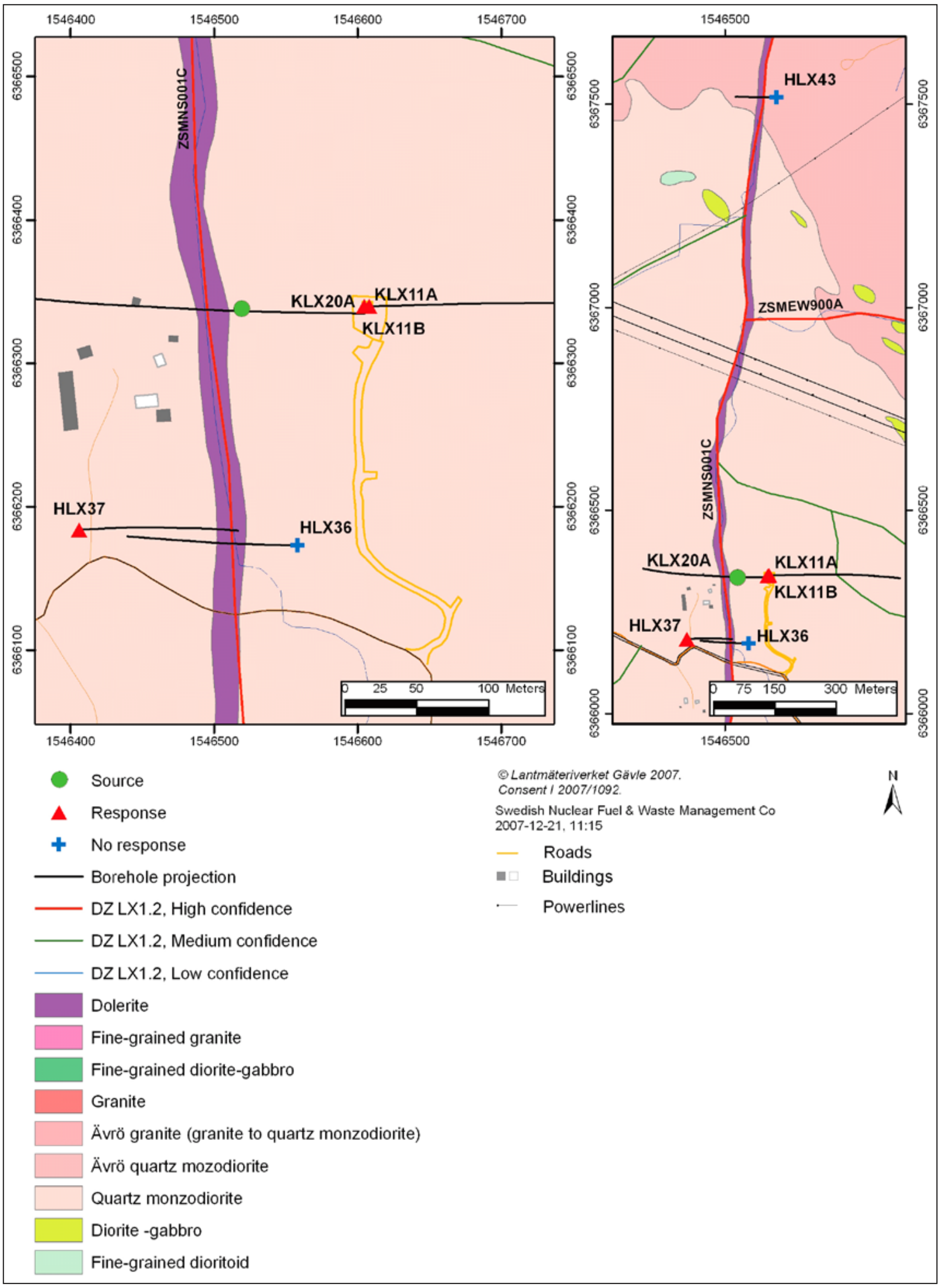

Figure 6-1. *Location of responding test sections while pumping in section 99.50–180.00 m.*

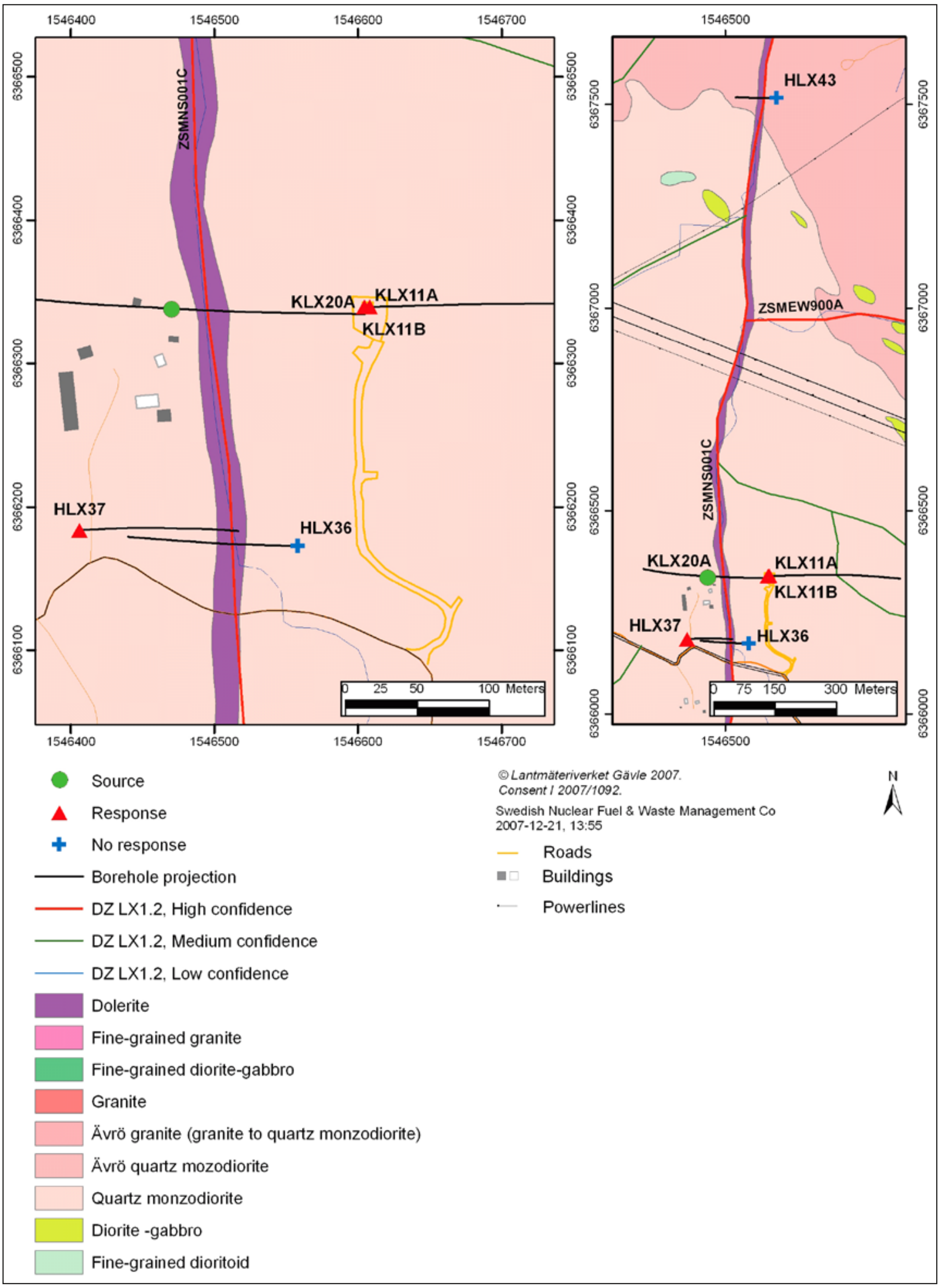

Figure 6-2. *Location of responding test sections while pumping in section 205.20–306.20 m.*

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	
KLX20A	99.50	180.00	20061121 10:08	20061125 09:27	2.55E–04	2.57E–04	172,800	136,260	1,331	1,276	883	1,350	#NV	**CRw**	**CRwr**
KLX20A	250.20	306.20	20061115 09:30	20061120 13:23	4.87E–05	4.83E–05	172,800	246,240	2,249	2,254	2,003	2,253	10.3	**CRw**	**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 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} m.a.s.l.
KLX20A	99.50	180.00	5.6E–06	7.1E–06	WBS2	WBS2	1.5E–05	#NV	2.2E–05	#NV	1.5E–05	7.0E–06	4.0E–05	5.6E–06	3.7	#NV	#NV	1,848	1,361.4	17.7
KLX20A	250.20	306.20	1.9E–06	2.3E–06	WBS2	WBS22	1.3E–06	#NV	5.8E–06	1.5E–06	1.5E–06	7.0E–07	4.0E–06	1.0E–09	0.0	67	1,980	222	2,258.4	14.8

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 (see Section 4.5.8).
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		Transient analysis												Index calculation			
				Flow regime		Formation parameter													
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)
KLX20A	99.50–180.00	HLX36_1	50.00–199.80	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX36_2	6.10–49.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX37_1	149.00–199.80	n.a.	2	n.a.	–	7.0E–05	–	7.0E–05	3.0E–05	2.0E–04	1.8E–04	n.a.	n.a.	0.92	674.29	3,426.3	4.0E–01
		HLX37_2	118.00–148.00	n.a.	2	n.a.	–	7.1E–05	–	7.1E–05	3.0E–05	2.0E–04	2.1E–04	n.a.	n.a.	0.76	634.63	3,208.8	3.4E–01
		HLX37_3	12.10–117.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX43_1	21.00–170.50	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX43_2	6.00–20.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		KLX11A_1	12.00–992.00	n.a	2	n.a.	–	2.9E–05	–	2.9E–05	7.0E–06	7.0E–05	2.3E–05	n.a.	n.a.	2.60	2,141.86	11,390.7	1.3E00
		KLX11B_1	2.50–100.00	2	2	2.1E–05	–	1.9E–05	–	1.9E–05	7.0E–06	7.0E–05	3.5E–05	n.a.	n.a.	1.72	4,720.03	22,055.9	5.5E–01
		KLX20A_1	238.00–457.92	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		KLX20A_2	181.00–237.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
KLX20A	250.20–306.20	HLX36_1	50.00–199.80	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX36_2	6.10–49.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX37_1	149.00–199.80	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX37_2	118.00–148.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX37_3	12.10–117.00	2	2	1.5E–05	–	4.5E–05	–	4.5E–05	9.0E–06	9.0E–05	7.9E–05	n.a.	n.a.	0.80	6,964.63	36,543.6	5.7E–01
		HLX43_1	21.00–170.50	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		HLX43_2	6.00–20.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		KLX11A_1	12.00–992.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		KLX11B_1	2.50–100.00	–	–	–	–	–	–	–	–	–	–	–	–	No response due to pumping			–
		KLX20A_1	307.20–457.92	2	2	8.1E–06	–	7.6E–06	–	8.1E–06	4.0E–06	5.0E–05	1.6E–05	n.a.	n.a.	8.28	27,858.50	131,450.3	4.9E–01
		KLX20A_2	99.50–249.20	–	–	–	–	–	–	–	–	–	–	–	–	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 (m^2/s) normalised distance r_s with respect to the response time.
Index 2	sp/Qp (s/m^2) normalised drawdown with respect to the pumping rate.
Index 2 new	$(sp/Qp)\cdot\ln(r_s/r_0)$ (s/m^2) ormalised drawdown with respect to the pumping rate and distance.
Diffusivity η	T_T/S (m^2/s).
n.a.	Not analysed due to strong natural fluctuations.

The Figures 6-3 to 6-5 present the transmissivity and conductivity profiles.

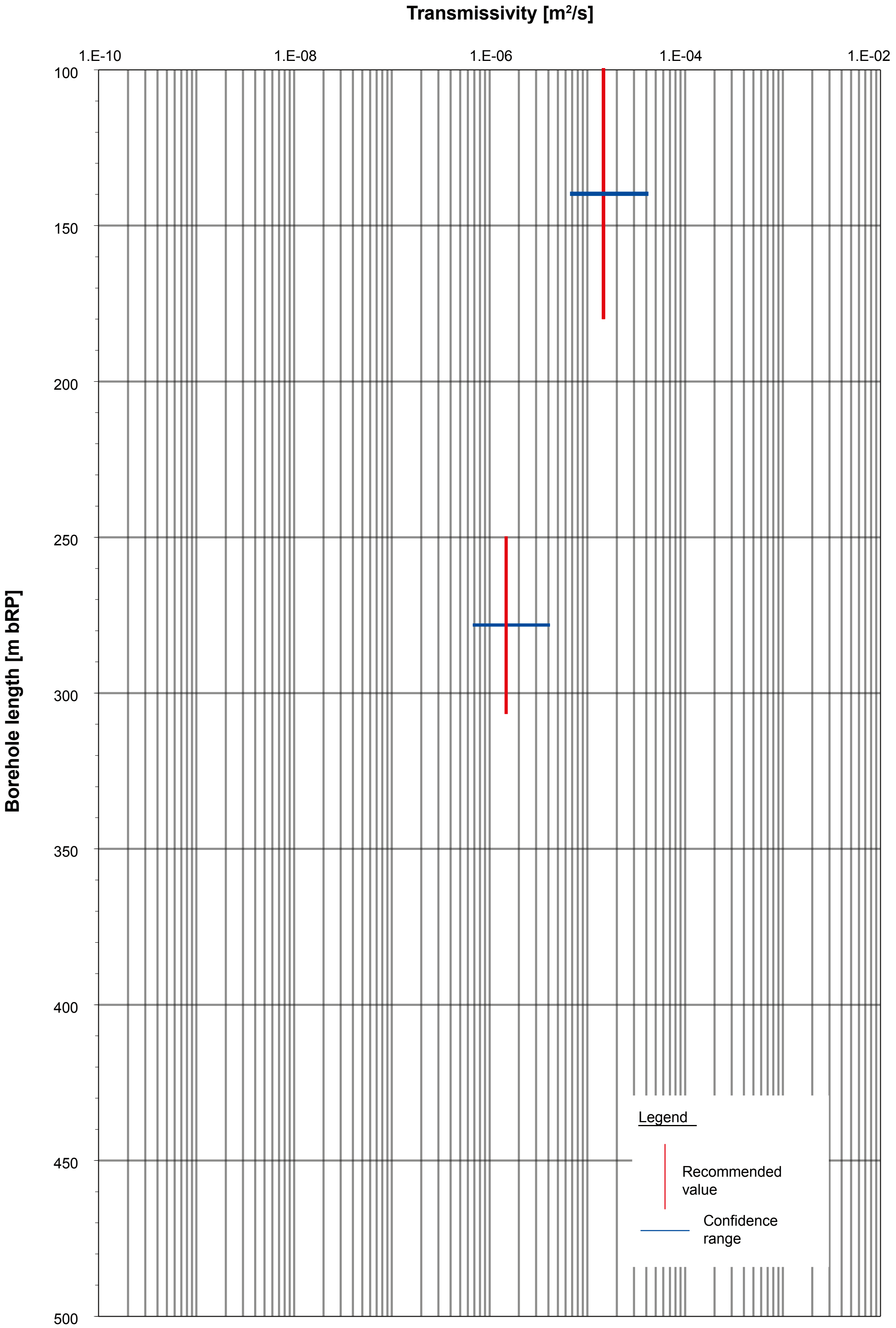

Figure 6-3. Results summary of KLX20A – profile of transmissivity, transmissivities derived from the pump tests.

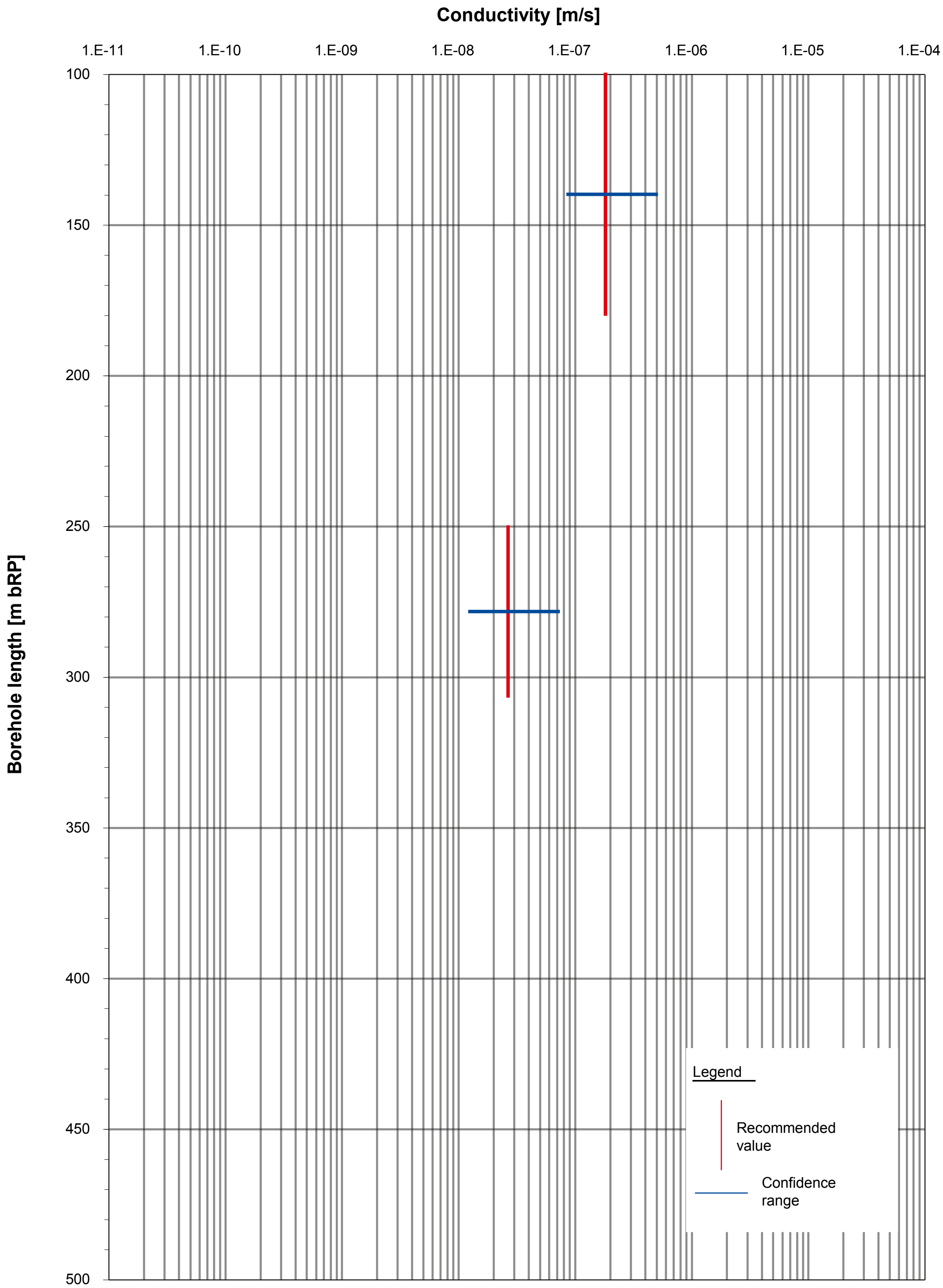

***Figure 6-4.** Results summary of KLX20A – profile of hydraulic conductivity, conductivity derived from the pump tests.*

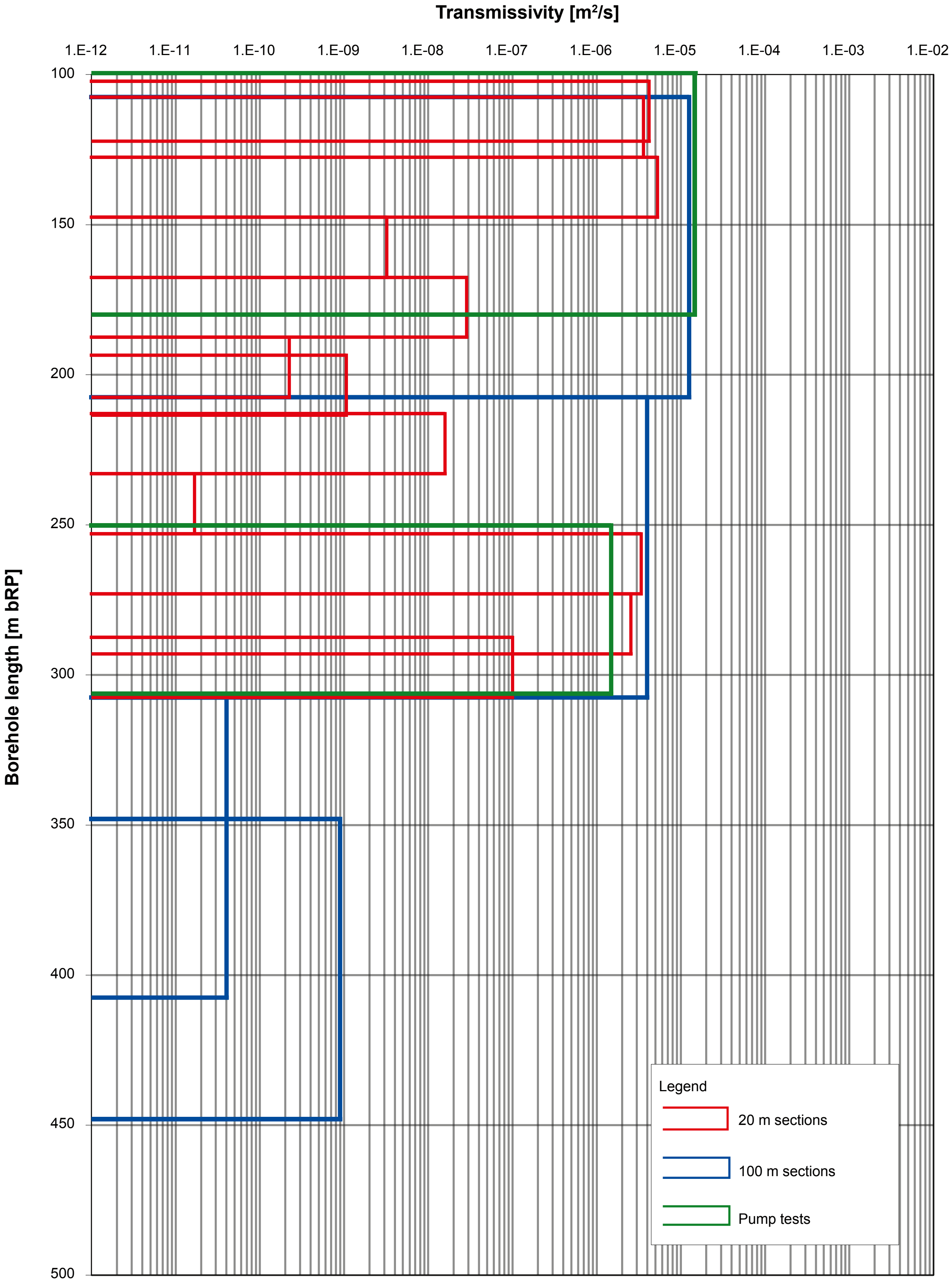

Figure 6-5. *Results summary of KLX20A – Comparison of the derived transmissivities of the injection and the pump tests.*

6.3 Correlation analysis

A correlation analysis was used with the aim of examining the consistency of results and deriving general condlusion regarding the testing and analysis methods used.

6.3.1 Comparison of steady state and transient analysis results

The steady state derived transmissivities (T_M and Q/s) were compared in a cross-plot with the recommended transmissivity values derived from the transient analysis for the pump tests (see following Figure 6-6).

The correlation analysis shows that all of the steady state derived transmissivities differ by less than one order of magnitude from the transmissivities derived from the transient analysis.

6.4 Conclusions

6.4.1 Transmissivity derived from the pump tests

Figure 6-3 presents a profile 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.

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. A composite model was chosen only for the recovery phase of the pump test performed in section 250.2–306.2 m. Depending on the quality of the data, the outer zone transmissivity of the recovery phase was recommended for this test.

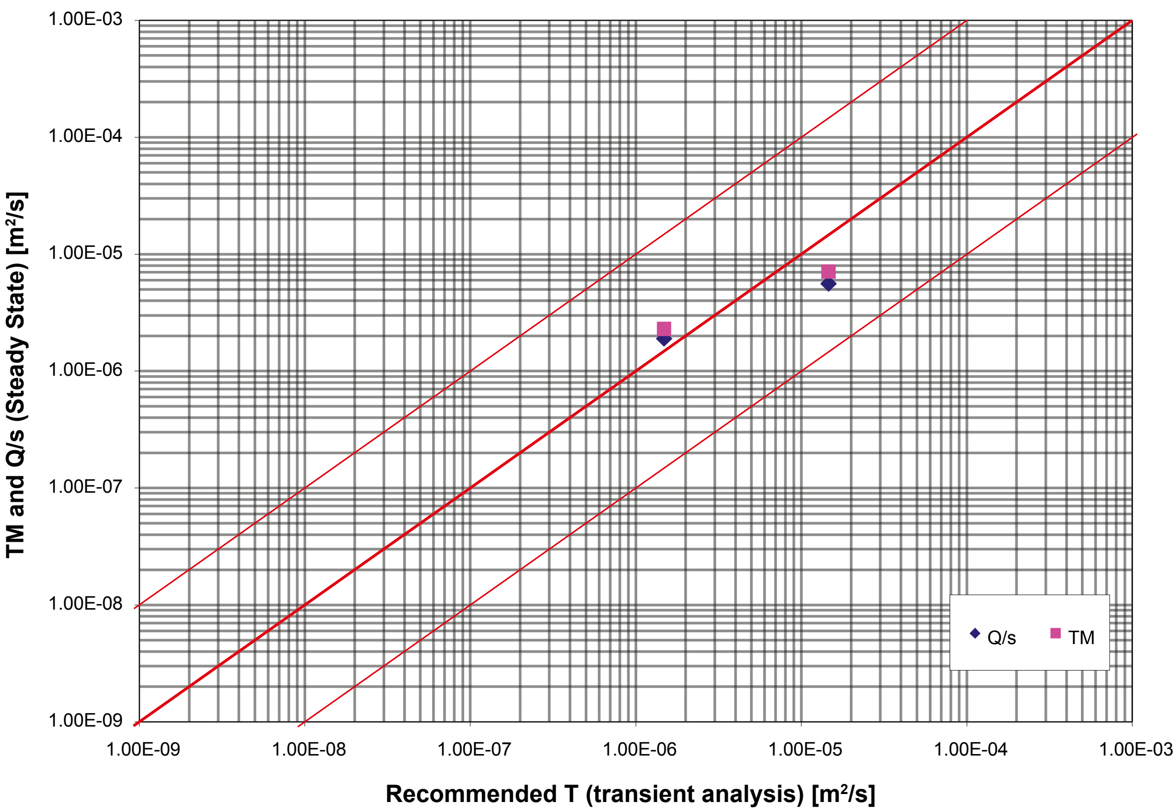

Figure 6-6. *Correlation analysis of transmissivities derived by steady state and transient methods for the pump tests.*

The transmissivity profile in Figure 6-3 shows transmissivities of $1.5\cdot10^{-06}$ m²/s and $1.5\cdot10^{-05}$ m²/s. The transmissivities derived from the pump tests are consistent with the results derived from the injection tests (see Figure 6-5).

6.4.2 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 all three 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 all cases it was possible to achieve to acceptable analysis results (good match quality) by using radial flow geometry (flow dimension of 2).

6.4.3 Interference tests and hydraulic connectivity

For the interference tests two constant rate pump tests were performed in KLX20A. 13 sections in 6 boreholes mainly along the lineament NS001 were monitored. 4 sections in 3 observation holes responded during the pump test in test section 99.50–180.00 m and 2 sections in 2 observation holes responded during the pump test in test section 250.20–306.20 m.

The responding observation sections are located in boreholes along the lineament NS001 up to approximately 800 m away from KLX20A. During the pump test in section 250.20–306.20 m, one other section downwards in the same borehole responded. During the pump test in the open section 99.50–180.00 m, none of the two deeper observation sections in the same borehole responded. The evaluation of the interference test data shows a response time ranging from low to medium response time and a low to high response drawdown.

The recommended transmissivities derived from the transient analysis range from $8.1\cdot10^{-06}$ m²/s to $7.1\cdot10^{-05}$ m²/s. A transmissivity of less than $1.0\cdot10^{-05}$ m²/s were derived only in one section of KLX20A in the pumped borehole adjacent down hole to the pumped section of 250.20–306.20 m.

6.4.4 Interpretation of the reponses

Preliminary evaluations indicate that the dolerite dyke acts as a hydraulic barrier. Pumping in KLX20A on the west side of the dolerite dyke in NS001 generates responses in borehole HLX37 west of the dolerite dyke in NS001 and no responses east of the dolerite dyke. When pumping in KLX20A on the east side of the dolerite dyke in NS001, responses are generated in borehole HLX37 east of the dolerite dyke in NS001 and no responses west of the dolerite dyke, see Figure 6-7. However, the test is of rather low quality which causes some uncertainty in the interpretation.

There was also an accidental interference from the pumping of KLX19A for the difference flow logging during the time of the KLX20A interference tests, to be reported in /SKB in prep/. This accidental interference indicate that probably deformation zone NS001 eastern part is hydraulically connected to NW0042 due to the responses in he lower section of HLX37, east of the dolerite dyke, as the response is clearly connected to the start and stop of the PFL-loggings in KLX19A, though with a time delay of about 1 hour, see Figure 6-8.

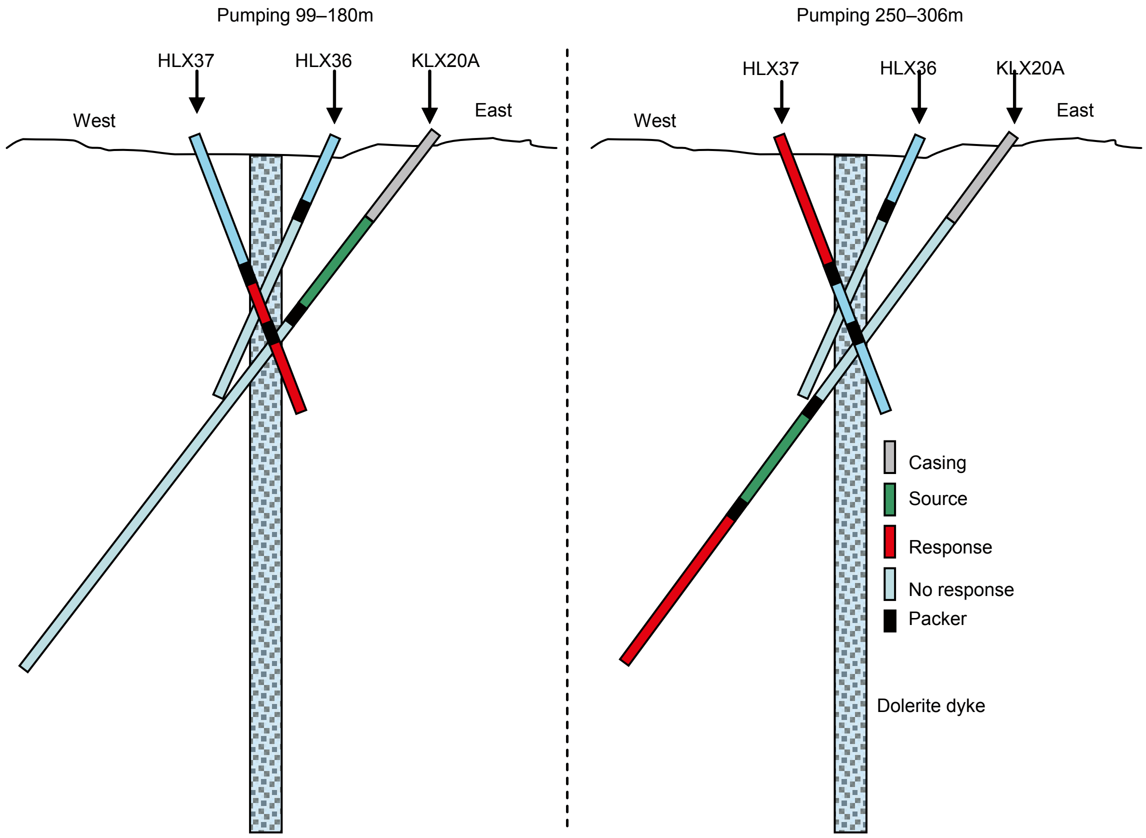

Figure 6-7. *Profile viewed from south of hydraulic responses along the dolerite dyke. Left figure show responses when pumping KLX20A 99–180 and right is when pumping KLX20A 250–306 m.*

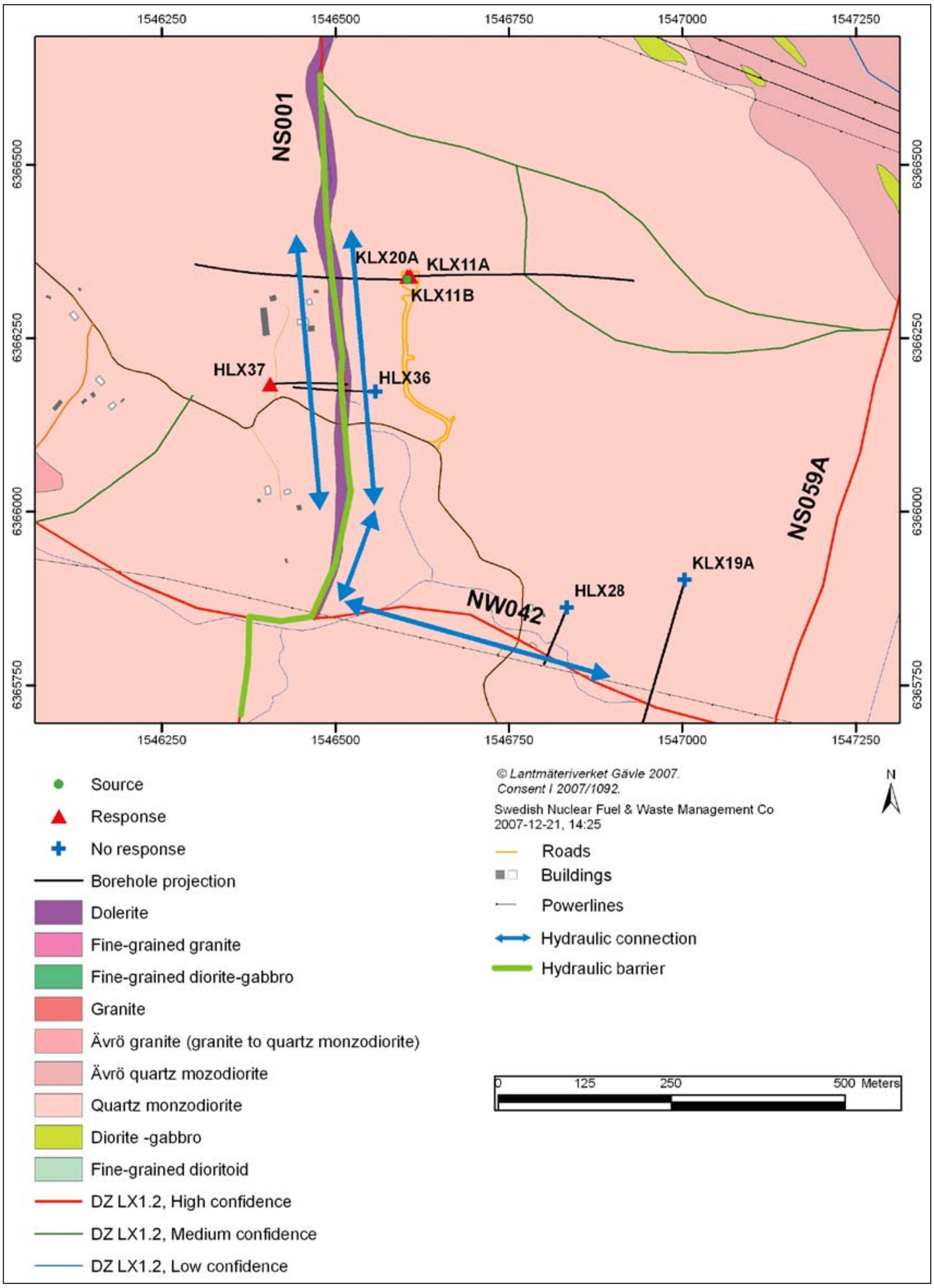

Figure 6-8. *Interpretation of observed hydraulic responses.*

7 References

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APPENDIX 1

File Description Table

HYDROTESTING WITH PSS					DRILLHOLE IDENTIFICATION NO.: KLX20A				
TEST- AND FILEPROTOCOL					**Testorder dated : 2006-11-13**				
Teststart		Interval boundaries		Name of Datafiles		Testtype	Copied to disk/CD	Plotted (date)	Sign.
Date	Time	Upper	Lower	(*.HT2-file)	(*.CSV-file)				
2006-11-15	09:30	250.20	306.20	__KLX20A_0250.20_200611150930.ht2	KLX20A_250.20-306.20_061115_1_CRwr_Q_r.csv	CRwr	2006-11-26	2006-11-21	
2006-11-21	10:08	99.50	180.00	__KLX20A_0099.50_200611211008.ht2	KLX20A_99.50-180.00_061121_1_CRwr_Q_r.csv	CRwr	2006-11-26	2006-11-25	

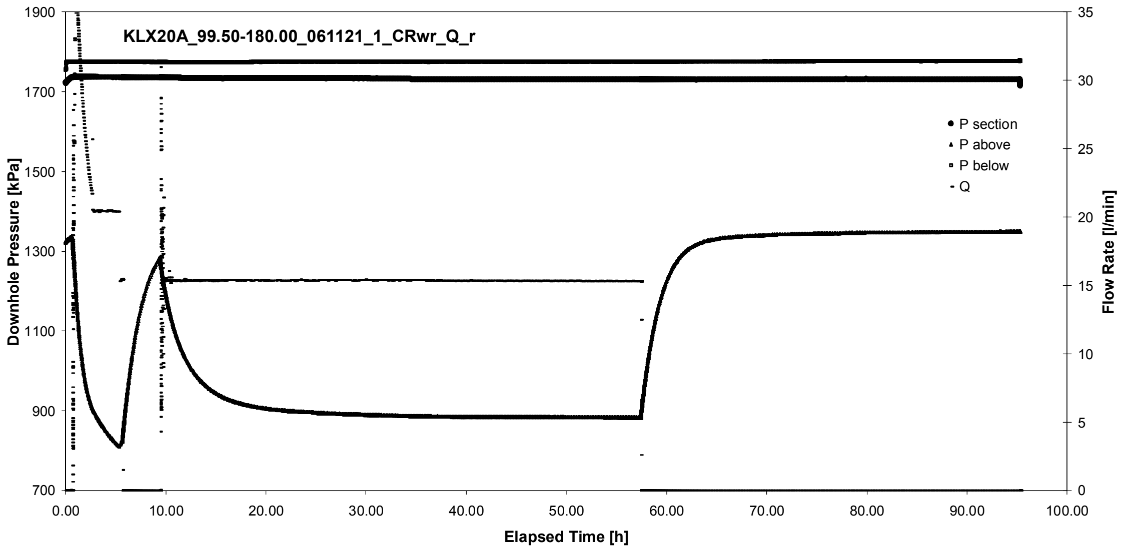
APPENDIX 2

Pump Test Analysis diagrams

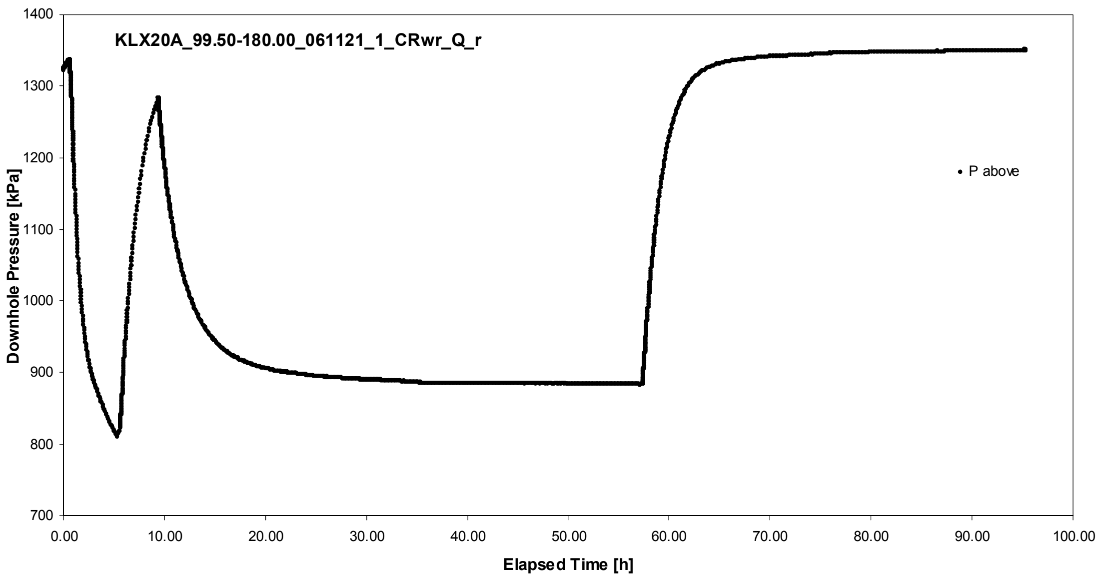
APPENDIX 2-1

Test 99.50 – 180.00 m

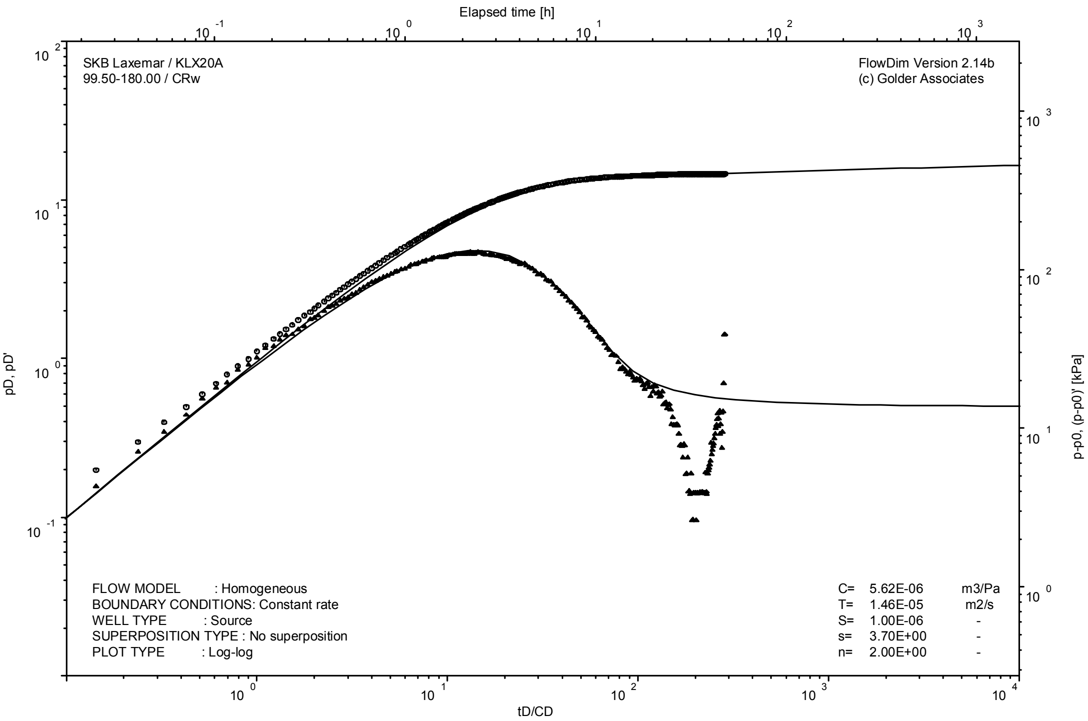
Pump Test Analysis diagrams



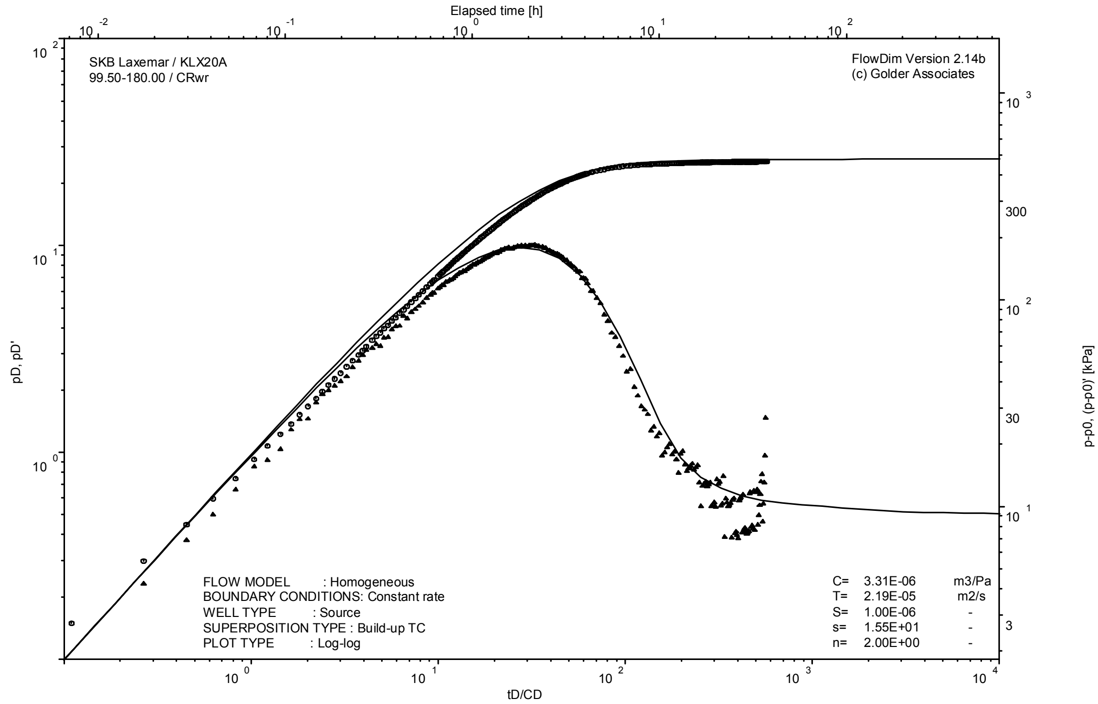
Pressure and flow rate vs. time; cartesian plot



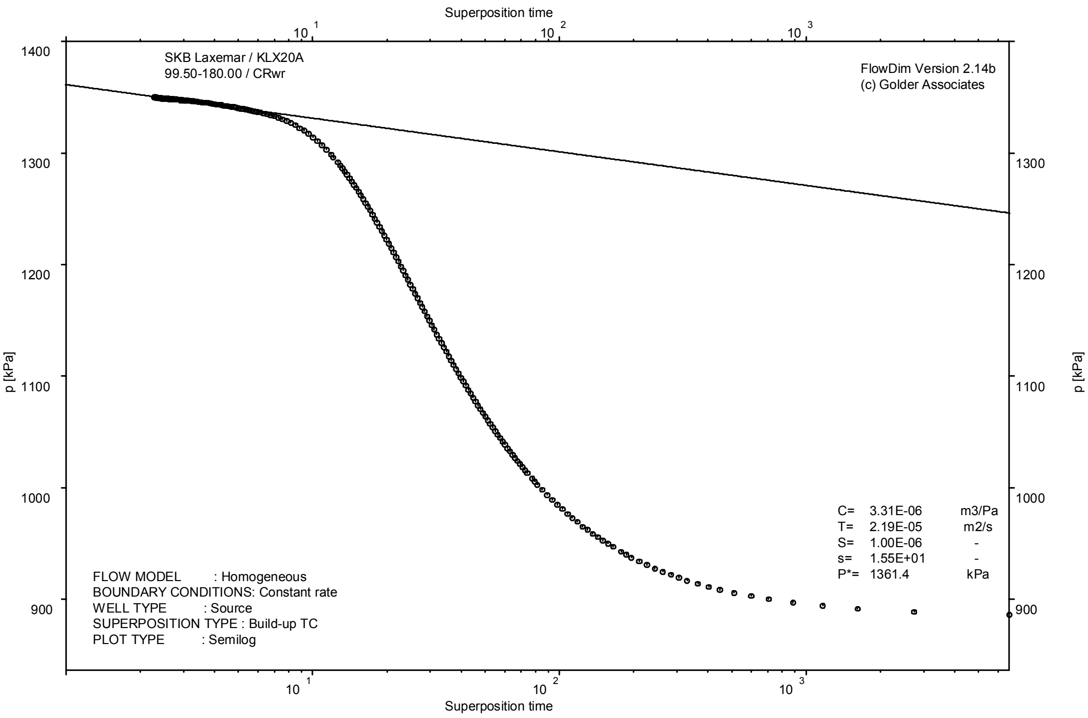
Pressure vs. time; cartesian plot



CRw phase; log-log match



CRwr phase; log-log match

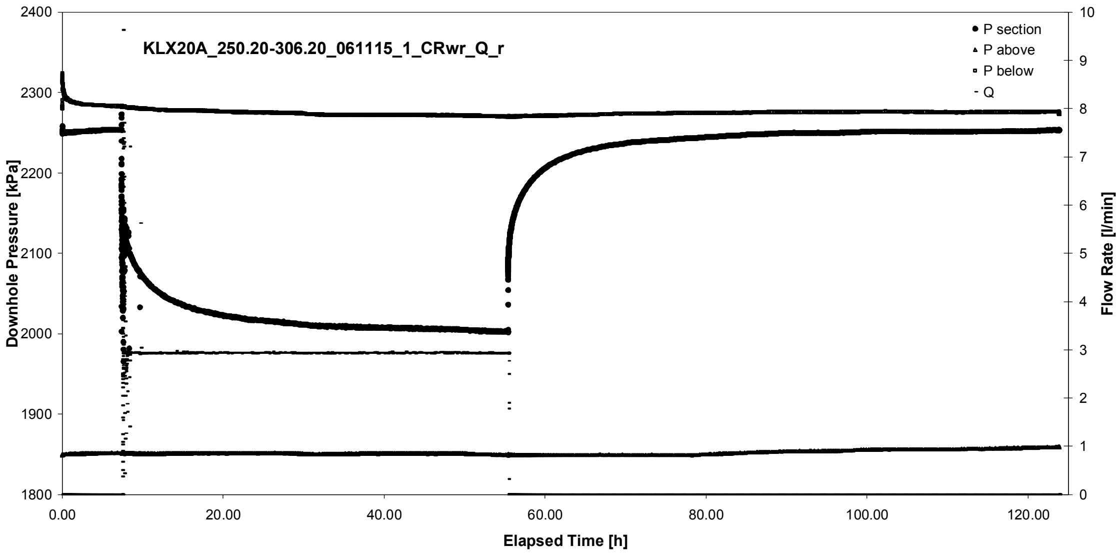


CRwr phase; HORNER match

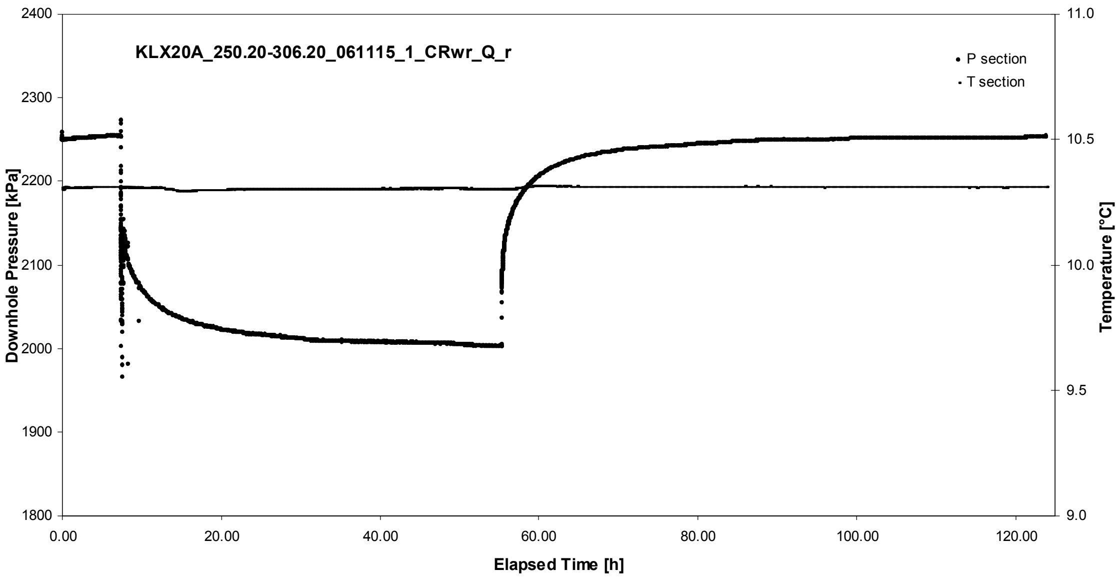
APPENDIX 2-2

Test 250.20 – 306.20 m

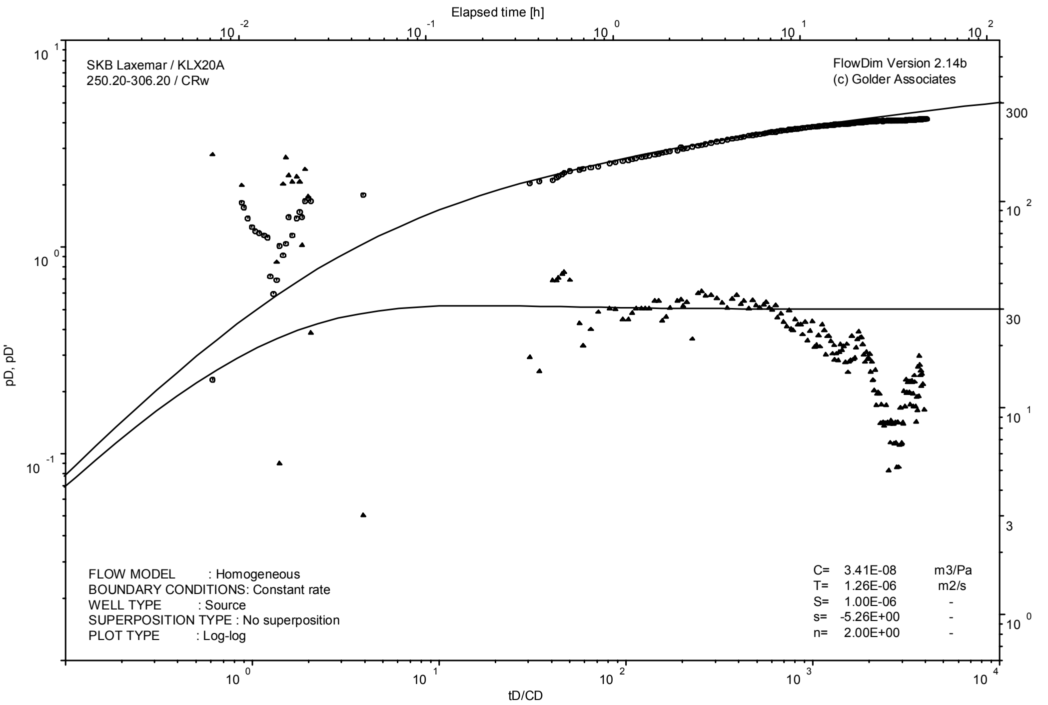
Pump Test Analysis diagrams



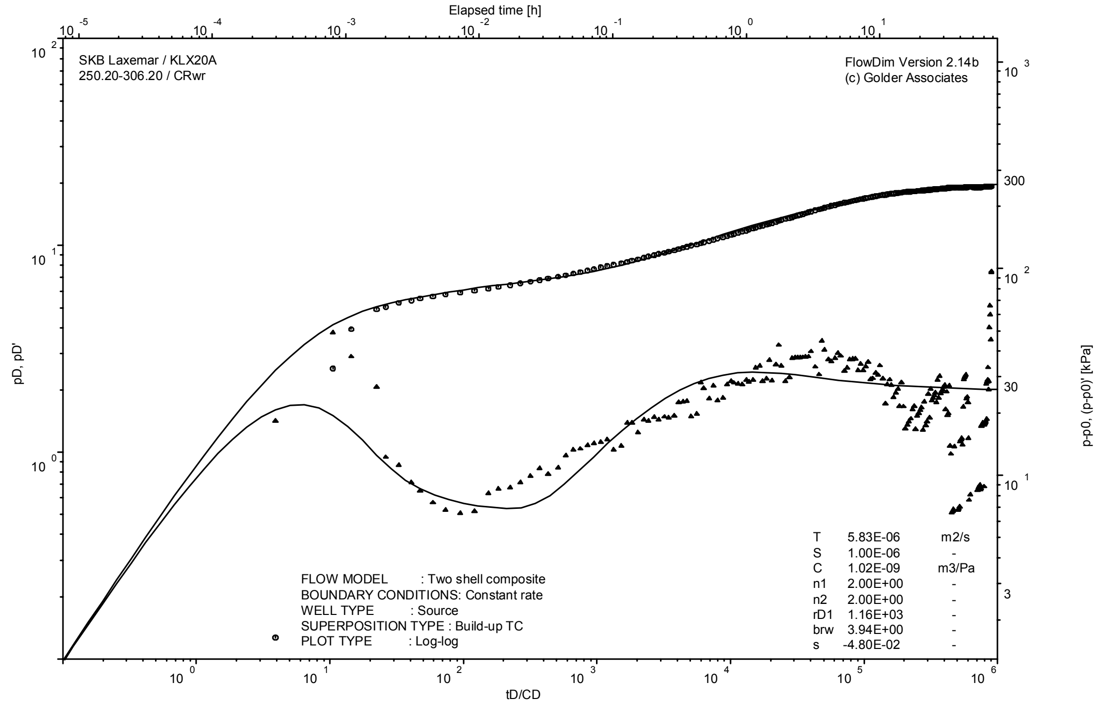
Pressure and flow rate vs. time; cartesian plot



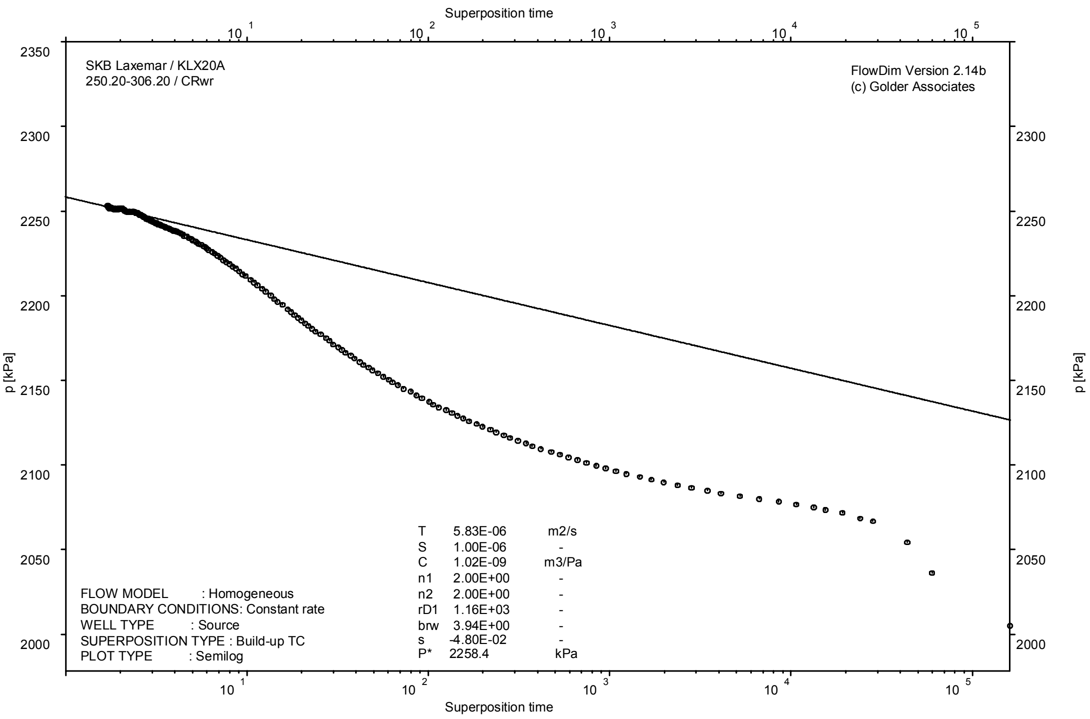
Interval pressure and temperature vs. time; cartesian plot



CRw phase; log-log match



CRwr phase; log-log match



CRwr phase; HORNER match

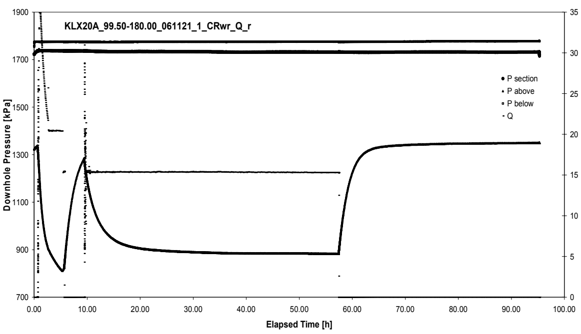
APPENDIX 3

Pump Test Summary Sheets

Test Summary Sheet

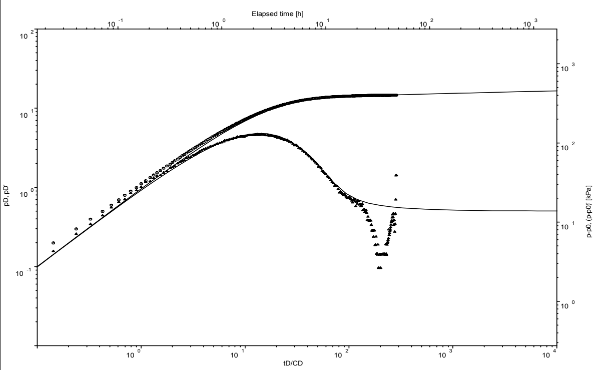
Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Laxemar	Test no:	1
Borehole ID:	KLX20A	Test start:	061121 10:08
Test section from - to (m):	99.50-180.00 m	Responsible for test execution:	Stephan Rohs
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	Cristian Enachescu

Linear plot Q and p

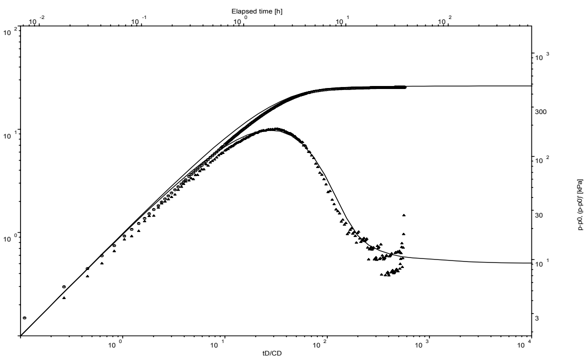


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	1331		
p_i (kPa) =	1276		
p_p(kPa) =	883	p_F (kPa) =	1350
Q_p (m^3/s)=	2.55E-04		
tp (s) =	172800	t_F (s) =	136260
S el S^* (-)=	1.00E-06	S el S^* (-)=	1.00E-06
EC_w (mS/m)=			
$Temp_w$(gr C)=	NA		
Derivative fact.=	0.02	Derivative fact.=	0.02
Results		**Results**	
Q/s (m^2/s)=	5.6E-06		
T_M (m^2/s)=	7.1E-06		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	NA	dt_1 (min) =	NA
dt_2 (min) =	NA	dt_2 (min) =	NA
T (m^2/s) =	1.5E-05	T (m^2/s) =	2.2E-05
S (-) =	1.0E-06	S (-) =	1.0E-06
K_s (m/s) =	1.8E-07	K_s (m/s) =	2.7E-07
S_s (1/m) =	1.2E-08	S_s (1/m) =	1.2E-08
C (m^3/Pa) =	5.6E-06	C (m^3/Pa) =	3.3E-06
C_D (-) =	6.2E+02	C_D (-) =	3.6E+02
ξ (-) =	3.7	ξ (-) =	15.5
T_{GRF}(m^2/s) =	NA	T_{GRF}(m^2/s) =	
S_{GRF}(-) =	NA	S_{GRF}(-) =	
D_{GRF} (-) =	NA	D_{GRF} (-) =	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.

dt_1 (min) =	NA	C (m^3/Pa) =	5.6E-06
dt_2 (min) =	NA	C_D (-) =	6.2E+02
T_T (m^2/s) =	1.5E-05	ξ (-) =	3.7
S (-) =	1.0E-06		
K_s (m/s) =	1.8E-07		
S_s (1/m) =	1.2E-08		

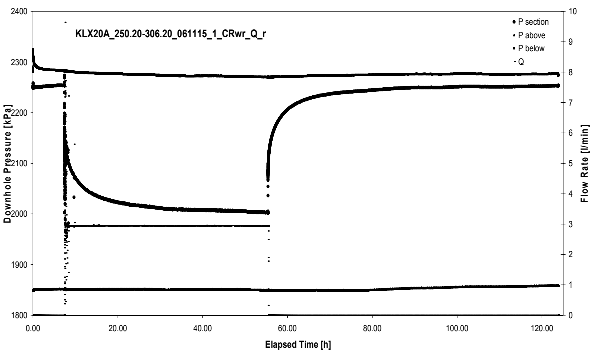
Comments:

The recommended transmissivity of 1.5E-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 interval transmissivity is estimated to be 7.0E-6 to 4.0E-5 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 straight line extrapolation in the Horner plot to a value of 1361 kPa.

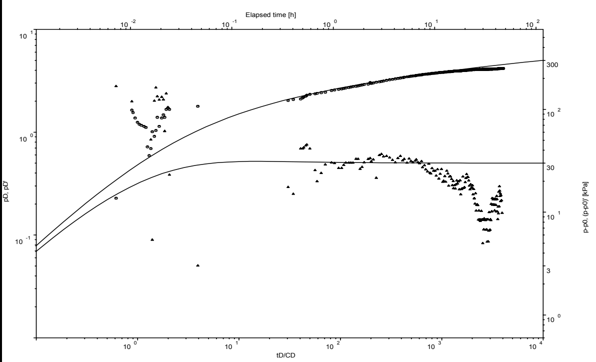
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Laxemar	Test no:	1
Borehole ID:	KLX20A	Test start:	061115 09:30
Test section from - to (m):	250.20-306.20 m	Responsible for test execution:	Stephan Rohs
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	Cristian Enachescu

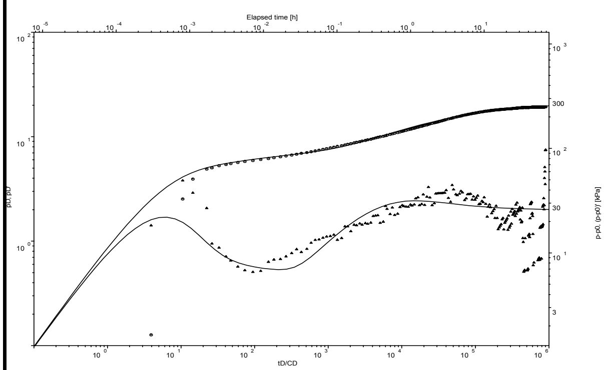
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	2249		
p_i (kPa) =	2254		
p_p(kPa) =	2003	p_F (kPa) =	2253
Q_p (m^3/s)=	4.87E-05		
tp (s) =	172800	t_F (s) =	246240
S el S^* (-)=	1.00E-06	S el S^* (-)=	1.00E-06
EC_w (mS/m)=			
$Temp_w$(gr C)=	10.3		
Derivative fact.=	0.02	Derivative fact.=	0.02
Results		**Results**	
Q/s (m^2/s)=	1.9E-06		
T_M (m^2/s)=	2.3E-06		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	NA	dt_1 (min) =	67.20
dt_2 (min) =	NA	dt_2 (min) =	1980.00
T (m^2/s) =	1.3E-06	T (m^2/s) =	5.8E-06
S (-) =	1.0E-06	S (-) =	1.0E-06
K_s (m/s) =	2.3E-08	K_s (m/s) =	1.0E-07
S_s (1/m) =	1.8E-08	S_s (1/m) =	1.8E-08
C (m^3/Pa) =	3.4E-08	C (m^3/Pa) =	1.0E-09
C_D (-) =	3.8E+00	C_D (-) =	1.1E-01
ξ (-) =	-5.3	ξ (-) =	0.0
T_{GRF}(m^2/s) =	NA	T_{GRF}(m^2/s) =	NA
S_{GRF}(-) =	NA	S_{GRF}(-) =	NA
D_{GRF} (-) =	NA	D_{GRF} (-) =	NA

Selected representative parameters.

dt_1 (min) =	67.20	C (m^3/Pa) =	1.0E-09
dt_2 (min) =	1980.00	C_D (-) =	1.1E-01
T_T (m^2/s) =	5.8E-06	ξ (-) =	0.0
S (-) =	1.0E-06		
K_s (m/s) =	1.0E-07		
S_s (1/m) =	1.8E-08		

Comments:

The recommended transmissivity of 1.5E-6 m2/s was derived from the analysis of the CRwr phase (outer zone), which shows the best data and derivative quality. The confidence range for the interval transmissivity is estimated to be 7.0E-7 to 4.0E-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 straight line extrapolation in the Horner plot to a value of 2258 kPa.

APPENDIX 4

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		^oC
Te_{w0}		Temperature in the test section during undisturbed conditions (taken from temperature logging).		^oC

Character	SICADA designation	Explanation	Dimension	Unit
Te_o		Temperature in the observation section (taken from temperature logging). Temperature		^oC
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”)		

Borehole: KLX20A

APPENDIX 5

SICADA data tables

(Pump tests)

(Simplified version v1.7)

SICADA/Data Import Template

SKB & Ergodata AB 2005

File Identity	
Created By	Stephan Rohs
Created	2006-12-11 10:00:00

File Time Zone

Compiled By	
Quality Check For Delivery	
Delivery Approval	

Activity Type	KLX20A KLX20A - Interference test

Project	AP PS 400-06-112

Activity Information						**Additional Activity Data**						
						C10	I160	P20	P200	P220	R240	R25
Idcode	**Start Date**	**Stop Date**	**Secup (m)**	**Seclow (m)**	**Section No**	**Company**	**Instrument**	**Field crew manager**	**Field crew**	**Person evaluating data**	**calibration type**	**Report**
KLX20A	2006-11-15 09:30:00	2006-11-20 13:23:00	250.20	306.20		Golder	PSS	Stephan Rohs	Stephan Rohs, Philipp Wolf	Cristian Enachescu, Stephan Rohs		
KLX20A	2006-11-21 10:08:00	2006-11-25 09:27:00	99.50	180.00		Golder	PSS	Stephan Rohs	Stephan Rohs, Philipp Wolf, Mesgena Gebrezghi	Cristian Enachescu, Stephan Rohs		

Table	plu_s_hole_test_d PLU Injection and pumping, General information		
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_type	CHAR		Test type code (1-7), see table description
formation_type	CHAR		1: Rock, 2: Soil (superficial deposits)
start_flow_period	DATE	yyyymmdd	Date & time of pumping/injection start (YYYY-MM-DD hh:mm:ss)
stop_flow_period	DATE	yyyymmdd	Date & time of pumping/injection stop (YYYY-MM-DD hh:mm:ss)
flow_rate_end_qp	FLOAT	m**3/s	Flow rate at the end of the flowing period
value_type_qp	CHAR		0:true value,-1<lower meas.limit1:>upper meas.limit
mean_flow_rate_qm	FLOAT	m**3/s	Arithmetic mean flow rate during flow period
q_measl__l	FLOAT	m**3/s	Estimated lower measurement limit of flow rate
q_measl__u	FLOAT	m**3/s	Estimated upper measurement limit of flow rate
tot_volume_vp	FLOAT	m**3	Total volume of pumped or injected water
dur_flow_phase_tp	FLOAT	s	Duration of the flowing period of the test
dur_rec_phase_tf	FLOAT	s	Duration of the recovery period of the test
initial_head_hi	FLOAT	m	Hydraulic head in test section at start of the flow period
head_at_flow_end_hp	FLOAT	m	Hydraulic head in test section at stop of the flow period.
final_head_hf	FLOAT	m	Hydraulic head in test section at stop of recovery period.
initial_press_pi	FLOAT	kPa	Groundwater pressure in test section at start of flow period
press_at_flow_end_pp	FLOAT	kPa	Groundwater pressure in test section at stop of flow period.
final_press_pf	FLOAT	kPa	Ground water pressure at the end of the recovery period.
fluid_temp_tew	FLOAT	oC	Measured section fluid temperature, see table description
fluid_elcond_ecw	FLOAT	mS/m	Measured section fluid el. conductivity,see table descr.
fluid_salinity_tdsw	FLOAT	mg/l	Total salinity of section fluid based on EC,see table descr.
fluid_salinity_tdswm	FLOAT	mg/l	Tot. section fluid salinity based on water sampling,see...
reference	CHAR		SKB report No for reports describing data and evaluation
comments	VARCHAR		Short comment to 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
lp	FLOAT	m	Hydraulic point of application

idcode	start_date	stop_date	(m) secup	(m) seclow	section_no	test_type	formation_type	(yyyymmdd) start_flow_period	(yyyymmdd) stop_flow_period	(m**3/s) flow_rate_end_qp	value_type_qp	(m**3/s) mean_flow_rate_qm	(m**3/s) q_measl__l	(m**3/s) q_measl__u	(m**3) tot_volume_vp
KLX20A	2006-11-21 10:08:00	2006-11-25 09:27:00	99.50	180.00	3	1B	1	2006-11-21 19:33:10	2006-11-23 19:33:10	2.55E-04	0	2.57E-04	1.67E-08	8.33E-04	4.4E+01
KLX20A	2006-11-15 09:30:00	2006-11-20 13:23:00	250.20	306.20	2	1B	1	2006-11-15 16:56:45	2006-11-17 16:56:45	4.87E-05	0	4.83E-05	1.67E-08	8.33E-04	8.4E+00

idcode	(m) secup	(m) seclow	(s) dur_flow_phase_tp	(s) dur_rec_phase_tf	(m) initial_head_hi	(m) head_at_flow_end_hp	(m) final_head_hf	(kPa) initial_press_pi	(kPa) press_at_flow_end_pp	(kPa) final_press_pf	(oC) fluid_temp_tew	(mS/m) fluid_elcond_ecw	(mg/l) fluid_salinity_tdsw	(mg/l) fluid_salinity_tdswm	reference	comments	(m) lp
KLX20A	99.50	180.00	172800	136260				1276	883	1350	#NV						140.00
KLX20A	250.20	306.20	172800	246240				2254	2003	2253	10.3						270.00

Table	plu_s_hole_test_ed1
	PLU Single hole tests, pumping/injection. Basic 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_type	CHAR		Test type code (1-7), see table description!
formation_type	CHAR		Formation type code. 1: Rock, 2: Soil (superficial deposits)
lp	FLOAT	m	Hydraulic point of application for test section, see descr.
seclen_class	FLOAT	m	Planned ordinary test interval during test campaign.
spec_capacity_q_s	FLOAT	m**2/s	Specific capacity (Q/s) of test section, see table descript.
value_type_q_s	CHAR		0:true value,-1:Q/s<lower meas.limit,1:Q/s>upper meas.limit
transmissivity_tq	FLOAT	m**2/s	Tranmissivity based on Q/s, see table description
value_type_tq	CHAR		0:true value,-1:TQ<lower meas.limit,1:TQ>upper meas.limit.
bc_tq	CHAR		Best choice code. 1 means TQ is best choice of T, else 0
transmissivity_moye	FLOAT	m**2/s	Transmissivity,TM, based on Moye (1967)
bc_tm	CHAR		Best choice code. 1 means Tmoye is best choice of T, else 0
value_type_tm	CHAR		0:true value,-1:TM<lower meas.limit,1:TM>upper meas.limit.
hydr_cond_moye	FLOAT	m/s	K_M: Hydraulic conductivity based on Moye (1967)
formation_width_b	FLOAT	m	b:Aquifer thickness repr. for T(generally b=Lw) ,see descr.
width_of_channel_b	FLOAT	m	B:Inferred width of formation for evaluated TB
tb	FLOAT	m**3/s	TB:Flow capacity in 1D formation of T & width B, see descr.
l_measl_tb	FLOAT	m**3/s	Estimated lower meas. limit for evaluated TB,see description
u_measl_tb	FLOAT	m**3/s	Estimated upper meas. limit of evaluated TB,see description
sb	FLOAT	m	SB:S=storativity,B=width of formation,1D model,see descript.
assumed_sb	FLOAT	m	SB* : Assumed SB,S=storativity,B=width of formation,see...
leakage_factor_lf	FLOAT	m	Lf:1D model for evaluation of Leakage factor
transmissivity_tt	FLOAT	m**2/s	TT:Transmissivity of formation, 2D radial flow model,see...
value_type_tt	CHAR		0:true value,-1:TT<lower meas.limit,1:TT>upper meas.limit,
bc_tt	CHAR		Best choice code. 1 means TT is best choice of T, else 0
l_measl_q_s	FLOAT	m**2/s	Estimated lower meas. limit for evaluated TT,see table descr
u_measl_q_s	FLOAT	m**2/s	Estimated upper meas. limit for evaluated TT,see description
storativity_s	FLOAT		S:Storativity of formation based on 2D rad flow,see descr.
assumed_s	FLOAT		Assumed Storativity,2D model evaluation,see table descr.
s_bc	FLOAT		Best choice of S (Storativity) ,see descr.
ri	FLOAT	m	Radius of influence
ri_index	CHAR		ri index=index of radius of influence :-1,0 or 1, see descr.
leakage_coeff	FLOAT	1/s	K'/b':2D rad flow model evaluation of leakage coeff,see desc
hydr_cond_ksf	FLOAT	m/s	Ksf:3D model evaluation of hydraulic conductivity,see desc.
value_type_ksf	CHAR		0:true value,-1:Ksf<lower meas.limit,1:Ksf>upper meas.limit,
l_measl_ksf	FLOAT	m/s	Estimated lower meas.limit for evaluated Ksf,see table desc.
u_measl_ksf	FLOAT	m/s	Estimated upper meas.limit for evaluated Ksf,see table descr
spec_storage_ssf	FLOAT	1/m	Ssf:Specific storage,3D model evaluation,see table descr.
assumed_ssf	FLOAT	1/m	Ssf*:Assumed Spec.storage,3D model evaluation,see table des.
c	FLOAT	m**3/pa	C: Wellbore storage coefficient; flow or recovery period
cd	FLOAT		CD: Dimensionless wellbore storage coefficient
skin	FLOAT		Skin factor;best estimate of flow/recovery period,see 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 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
p_horner	FLOAT	kPa	p*:Horner extrapolated pressure, see table description
transmissivity_t_nlr	FLOAT	m**2/s	T_NLR Transmissivity based on None Linear Regression...
storativity_s_nlr	FLOAT		S_NLR=storativity based on None Linear Regression,see..
value_type_t_nlr	CHAR		0:true value,-1:T_NLR<lower meas.limit,1:>upper meas.limit
bc_t_nlr	CHAR		Best choice code. 1 means T_NLR is best choice of T, else 0
c_nlr	FLOAT	m**3/pa	Wellbore storage coefficient, based on NLR, see descr.
cd_nlr	FLOAT		Dimensionless wellbore storage constant, see table descrip.
skin_nlr	FLOAT		Skin factor based on Non Linear Regression,see desc.
transmissivity_t_grf	FLOAT	m**2/s	T_GRF:Transmissivity based on Genelized Radial Flow,see...
value_type_t_grf	CHAR		0:true value,-1:T_GRF<lower meas.limit,1:>upper meas.limit
bc_t_grf	CHAR		Best choice code. 1 means T_GRF is best choice of T, else 0
storativity_s_grf	FLOAT		S_GRF:Storativity based on Generalized Radial Flow, see des.
flow_dim_grf	FLOAT		Inferred flow dimesion based on Generalized Rad. Flow model
comment	VARCHAR	no_unit	Short comment to the evaluated parameters
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	lp (m)	seclen_class (m)	spec_capacity_q_s (m**2/s)	value_type_q_s	transmissivity_tq (m**2/s)	value_type_tq	bc_tq	transmissivity_moye (m**2/s)	bc_tm	value_type_tm	hydr_cond_moye (m/s)	formation_width_b (m)	width_of_channel_b (m)
KLX20A	2006-11-21 10:08:00	2006-11-25 09:27:00	99.50	180.00		1B	1	140.00	80.50	5.58E-06	0				7.08E-06	0		8.80E-08		
KLX20A	2006-11-15 09:30:00	2006-11-20 13:23:00	250.20	306.20		1B	1	270.00	56.00	1.90E-06	0				2.30E-06	0		4.11E-08		

idcode	secup (m)	seclow (m)	tb (m**3/s)	l_measl_tb (m**3/s)	u_measl_tb (m**3/s)	sb (m)	assumed_sb (m)	leakage_factor_lf (m)	transmissivity_tt (m**2/s)	value_type_tt	bc_tt	l_measl_q_s (m**2/s)	u_measl_q_s (m**2/s)	storativity_s	assumed_s	s_bc	ri (m)	ri_index	leakage_coeff (1/s)	hydr_cond_ksf (m/s)	value_type_ksf	l_measl_ksf (m/s)	u_measl_ksf (m/s)	spec_storage_ssf (1/m)	assumed_ssf (1/m)
KLX20A	99.50	180.00							1.46E-05	0	1	7.00E-06	4.00E-05	1.00E-06	1.00E-06		1835.58	0							
KLX20A	250.20	306.20							1.48E-06	0	1	7.00E-07	4.00E-06	1.00E-06	1.00E-06		222.89	1							

idcode	secup (m)	seclow (m)	c (m**3/pa)	cd	skin	dt1 (s)	dt2 (s)	t1 (s)	t2 (s)	dte1 (s)	dte2 (s)	p_horner (kPa)	transmissivity_t_nlr (m**2/s)	storativity_s_nlr	value_type_t_nlr	bc_t_nlr	c_nlr (m**3/pa)	cd_nlr	skin_nlr	transmissivity_t_grf (m**2/s)	value_type_t_grf	bc_t_grf	storativity_s_grf	flow_dim_grf	comment (no_unit)
KLX20A	99.50	180.00	5.62E-06	6.19E+02	3.7	#NV	#NV					1361.4													
KLX20A	250.20	306.20	1.02E-09	1.12E-01	0.0	4032	118800					2258.4													

Borehole: KLX20A

APPENDIX 6

Index calculation

APPENDIX 6-1

Index calculation

KLX20A Section 99.50-180.00 m pumped

Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**99.50-180.00**
Test Start:	21.11.2006 10:08	Test Stop:	25.11.2006 09:27
Pump Start:	21.11.2006 19:33	Pump Stop:	23.11.2006 19:33
Flow Rate Q_p [m^3/s]:	2.57E-04		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	1276
Pressure in test section before stop of flowing:	p_p	kPa	883
Maximum pressure change during flowing period:	dp_p	kPa	393

Observation Hole:	**HLX36**	**Section no.:**	**HLX36_1**
		Section length:	50.00-199.80
Distance r_s [m]:	163.00	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	117.1
Pressure in test section before stop of flowing:	p_p	kPa	117.9
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**

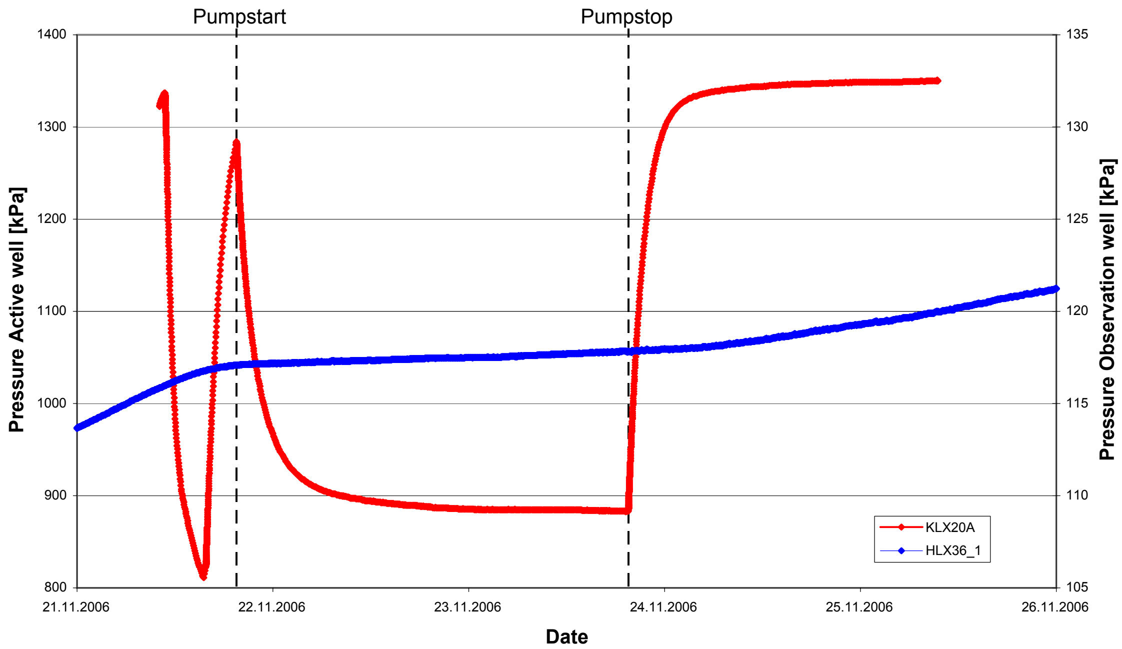
Normalized drawdown with respect to pumping flow rate

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 clear response due to pumping in source



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**99.50-180.00**
Test Start:	21.11.2006 10:08	Test Stop:	25.11.2006 09:27
Pump Start:	21.11.2006 19:33	Pump Stop:	23.11.2006 19:33
Flow Rate Q_p [m^3/s]:	2.57E-04		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	1276
Pressure in test section before stop of flowing:	p_p	kPa	883
Maximum pressure change during flowing period:	dp_p	kPa	393

Observation Hole:	**HLX36**	**Section no.:**	**HLX36_2**
		Section length:	6.10-49.00
Distance r_s [m]:	181.00	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	114.4
Pressure in test section before stop of flowing:	p_p	kPa	114.5
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**

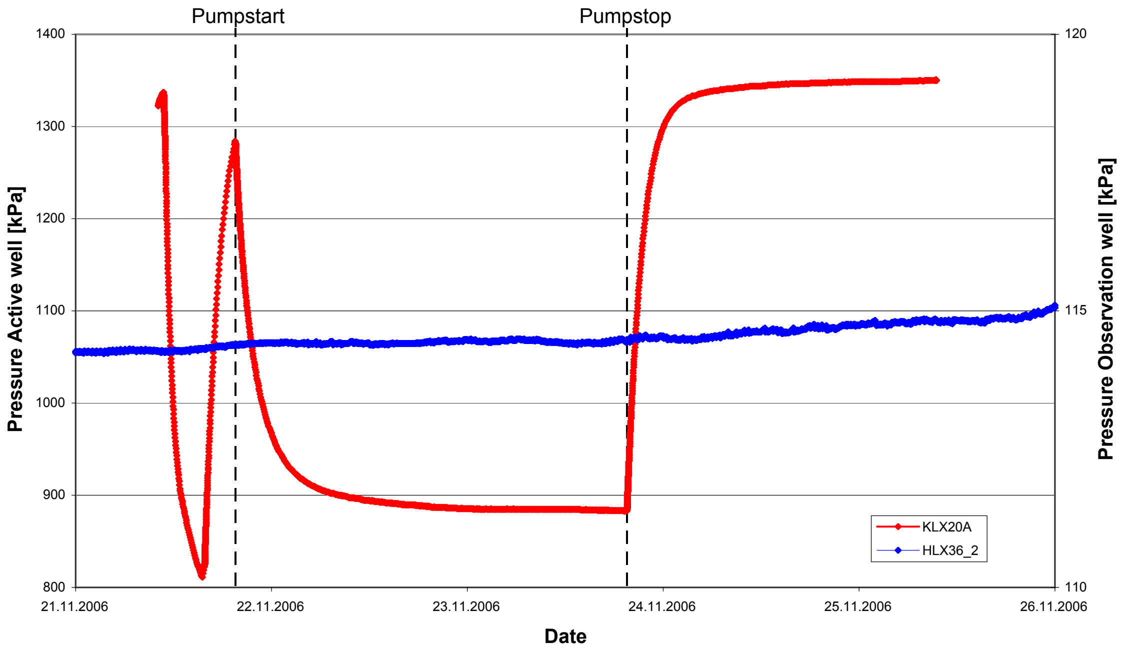
Normalized drawdown with respect to pumping flow rate

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 clear response due to pumping in source



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**99.50-180.00**
Test Start:	21.11.2006 10:08	Test Stop:	25.11.2006 09:27
Pump Start:	21.11.2006 19:33	Pump Stop:	23.11.2006 19:33
Flow Rate Q_p [m^3/s]:	2.57E-04		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	1276
Pressure in test section before stop of flowing:	p_p	kPa	883
Maximum pressure change during flowing period:	dp_p	kPa	393

Observation Hole:	**HLX37**	**Section no.:**	**HLX37_1**
		Section length:	149.00-199.80
Distance r_s [m]:	161.00	max. Drawdown s_p [m]:*	0.17
Response time dt_L [s]:	28047		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	126.4
Pressure in test section before stop of flowing:	p_p	kPa	124.7
Maximum pressure change during flowing period:*	dp_p	kPa	1.7

Normalized distance with respect to the response time

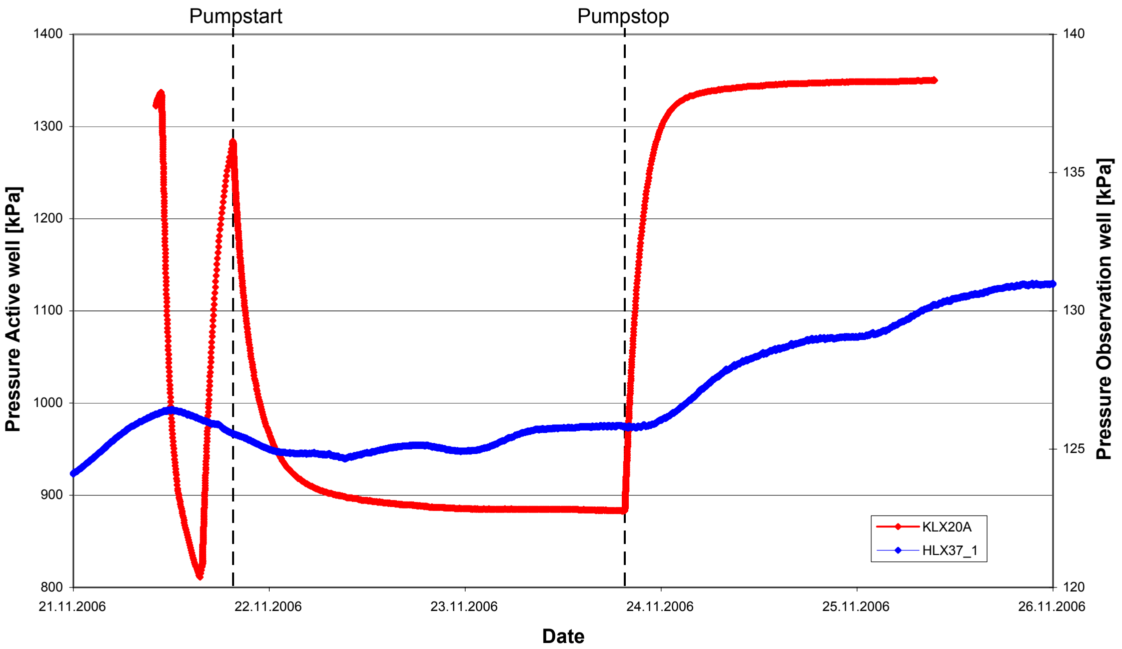
Index 1	**r_s^2/dt_L [m^2/s]:**	**0.92**	**Low**

Normalized drawdown with respect to pumping flow rate

Index 2	**s_p/Q_p [s/m^2]:**	**674.29**	**Low**
Index 2 New	**$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:**	**3426.34**	**Low**

* see comment

Comment: response due to pumping in source
pressure changes influenced additionally by natural fluctuations



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**99.50-180.00**
Test Start:	21.11.2006 10:08	Test Stop:	25.11.2006 09:27
Pump Start:	21.11.2006 19:33	Pump Stop:	23.11.2006 19:33
Flow Rate Q_p [m^3/s]:	2.57E-04		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	1276
Pressure in test section before stop of flowing:	p_p	kPa	883
Maximum pressure change during flowing period:	dp_p	kPa	393

Observation Hole:	**HLX37**	**Section no.:**	**HLX37_2**
		Section length:	118.00-148.00
Distance r_s [m]:	157.00	max. Drawdown s_p [m]:*	0.16
Response time dt_L [s]:	32235		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	126.4
Pressure in test section before stop of flowing:	p_p	kPa	124.8
Maximum pressure change during flowing period:*	dp_p	kPa	1.6

Normalized distance with respect to the response time

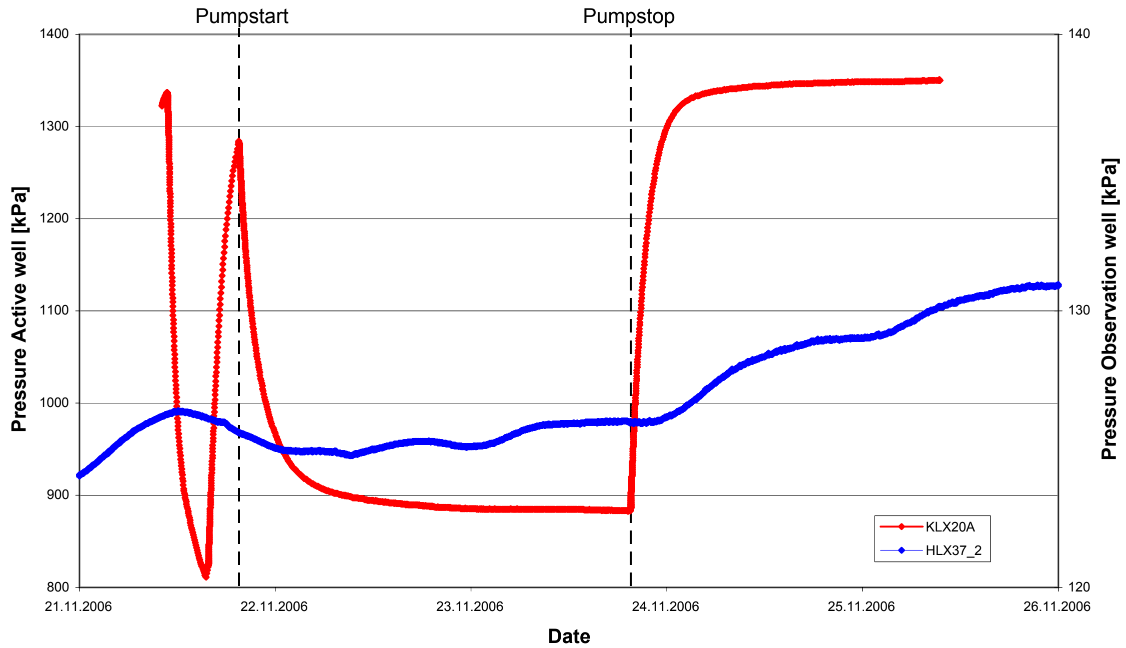
Index 1	**r_s^2/dt_L [m^2/s]:**	**0.76**	**Low**

Normalized drawdown with respect to pumping flow rate

Index 2	**s_p/Q_p [s/m^2]:**	**634.63**	**Low**
Index 2 New	**$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:**	**3208.82**	**Low**

* see comment

Comment: response due to pumping in source
pressure changes influenced additionally by natural fluctuations



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**99.50-180.00**
Test Start:	21.11.2006 10:08	Test Stop:	25.11.2006 09:27
Pump Start:	21.11.2006 19:33	Pump Stop:	23.11.2006 19:33
Flow Rate Q_p [m^3/s]:	2.57E-04		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	1276
Pressure in test section before stop of flowing:	p_p	kPa	883
Maximum pressure change during flowing period:	dp_p	kPa	393

Observation Hole:	**HLX37**	**Section no.:**	**HLX37_3**
		Section length:	12.10-117.00
Distance r_s [m]:	161.00	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	147.1
Pressure in test section before stop of flowing:	p_p	kPa	148.3
Maximum pressure change during flowing period:*	dp_p	kPa	1.1

Normalized distance with respect to the response time

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

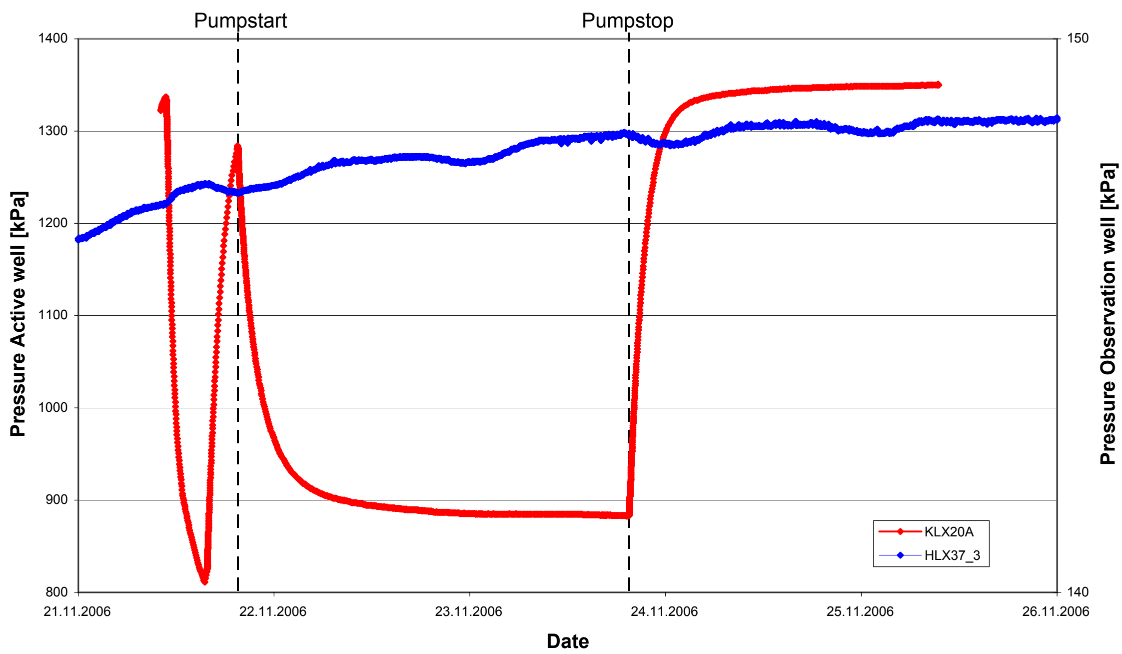
Normalized drawdown with respect to pumping flow rate

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 clear response due to pumping in source



Activityplan No.	AP PS 400-06-112

Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**99.50-180.00**
Test Start:	21.11.2006 10:08	Test Stop:	25.11.2006 09:27
Pump Start:	21.11.2006 19:33	Pump Stop:	23.11.2006 19:33
Flow Rate Q_p [m^3/s]:	2.57E-04		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	1276
Pressure in test section before stop of flowing:	p_p	kPa	883
Maximum pressure change during flowing period:	dp_p	kPa	393

Observation Hole:	**HLX43**	**Section no.:**	**HLX43_1**
		Section length:	21.00-170.50
Distance r_s [m]:	1182.00	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	169.9
Pressure in test section before stop of flowing:	p_p	kPa	169.7
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**

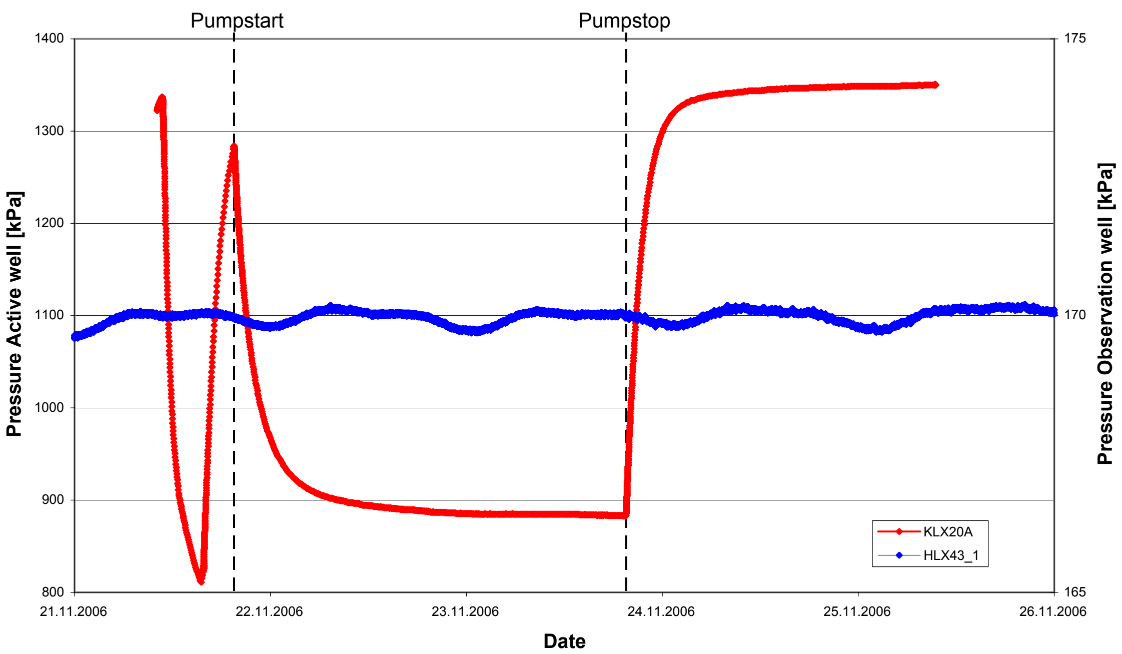
Normalized drawdown with respect to pumping flow rate

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 clear response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**99.50-180.00**
Test Start:	21.11.2006 10:08	Test Stop:	25.11.2006 09:27
Pump Start:	21.11.2006 19:33	Pump Stop:	23.11.2006 19:33
Flow Rate Q_p [m^3/s]:	2.57E-04		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	1276
Pressure in test section before stop of flowing:	p_p	kPa	883
Maximum pressure change during flowing period:	dp_p	kPa	393

Observation Hole:	**HLX43**	**Section no.:**	**HLX43_2**
		Section length:	6.00-20.00
Distance r_s [m]:	1189.00	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	189.7
Pressure in test section before stop of flowing:	p_p	kPa	191.7
Maximum pressure change during flowing period:*	dp_p	kPa	2.0

Normalized distance with respect to the response time

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

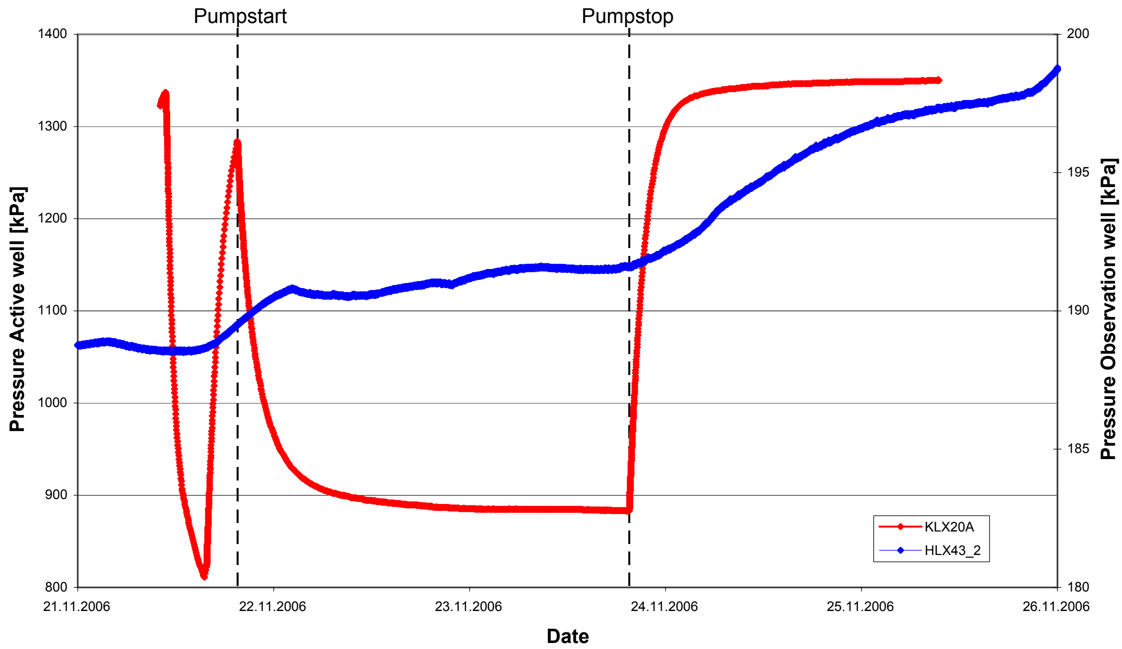
Normalized drawdown with respect to pumping flow rate

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 clear response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**99.50-180.00**
Test Start:	21.11.2006 10:08	Test Stop:	25.11.2006 09:27
Pump Start:	21.11.2006 19:33	Pump Stop:	23.11.2006 19:33
Flow Rate Q_p [m^3/s]:	2.57E-04		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	1276
Pressure in test section before stop of flowing:	p_p	kPa	883
Maximum pressure change during flowing period:	dp_p	kPa	393

Observation Hole:	**KLX11A**	**Section no.:**	**KLX11A**
		Section length:	12.00-992.00
Distance r_s [m]:	204.00	max. Drawdown s_p [m]:*	0.55
Response time dt_L [s]:	16010		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	378.7
Pressure in test section before stop of flowing:	p_p	kPa	373.3
Maximum pressure change during flowing period:*	dp_p	kPa	5.4

Normalized distance with respect to the response time

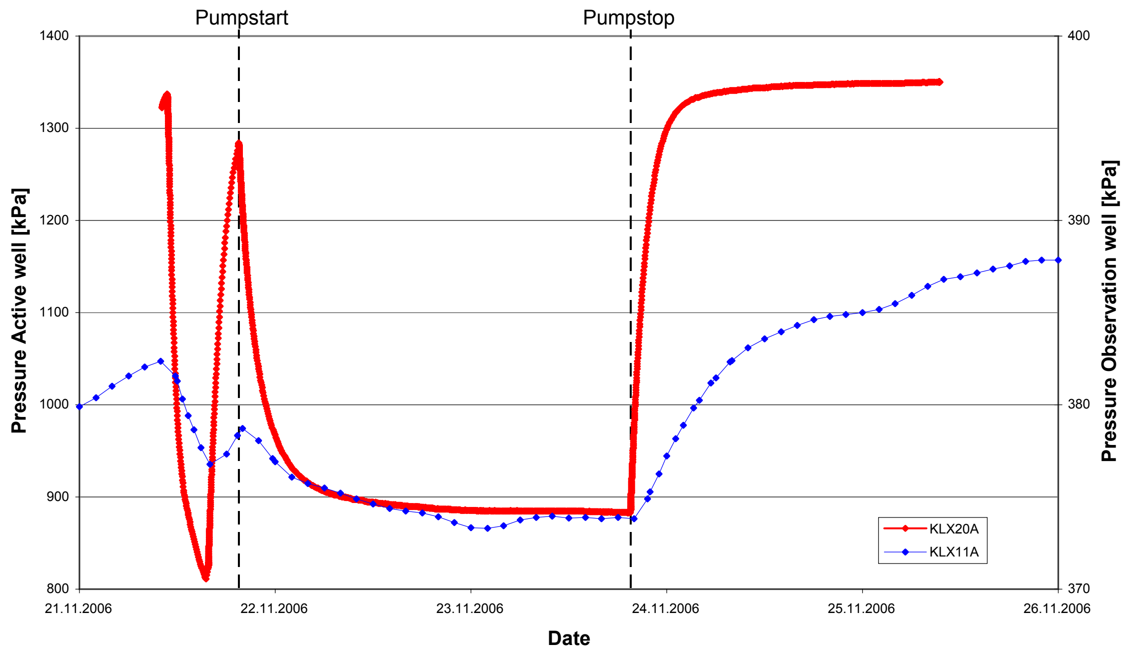
Index 1	**r_s^2/dt_L [m^2/s]:**	**2.60**	**Medium**

Normalized drawdown with respect to pumping flow rate

Index 2	**s_p/Q_p [s/m^2]:**	**2141.86**	**Low**
Index 2 New	**$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:**	**11390.68**	**Medium**

* see comment

Comment: response due to pumping in source



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**99.50-180.00**
Test Start:	21.11.2006 10:08	Test Stop:	25.11.2006 09:27
Pump Start:	21.11.2006 19:33	Pump Stop:	23.11.2006 19:33
Flow Rate Q_p [m^3/s]:	2.57E-04		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	1276
Pressure in test section before stop of flowing:	p_p	kPa	883
Maximum pressure change during flowing period:	dp_p	kPa	393

Observation Hole:	**KLX11B**	**Section no.:**	**KLX11B**
		Section length:	2.50-100.00
Distance r_s [m]:	107.00	max. Drawdown s_p [m]:*	1.21
Response time dt_L [s]:	6650		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	383.4
Pressure in test section before stop of flowing:	p_p	kPa	371.5
Maximum pressure change during flowing period:*	dp_p	kPa	11.9

Normalized distance with respect to the response time

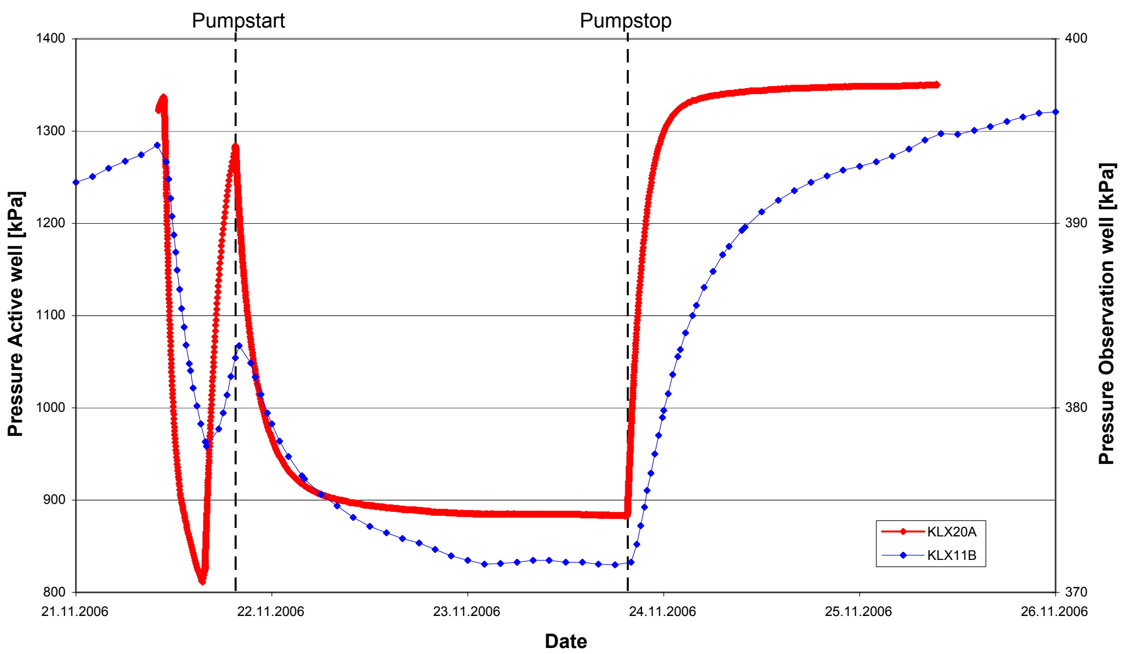
Index 1	**r_s^2/dt_L [m^2/s]:**	**1.72**	**Medium**

Normalized drawdown with respect to pumping flow rate

Index 2	**s_p/Q_p [s/m^2]:**	**4720.03**	**Low**
Index 2 New	**$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:**	**22055.90**	**Medium**

* see comment

Comment: response due to pumping in source



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**99.50-180.00**
Test Start:	21.11.2006 10:08	Test Stop:	25.11.2006 09:27
Pump Start:	21.11.2006 19:33	Pump Stop:	23.11.2006 19:33
Flow Rate Q_p [m^3/s]:	2.57E-04		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	1276
Pressure in test section before stop of flowing:	p_p	kPa	883
Maximum pressure change during flowing period:	dp_p	kPa	393

Observation Hole:	**KLX20A**	**Section no.:**	**KLX20A_1**
		Section length:	238.00-457.92
Distance r_s [m]:	130.00	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	1774.6
Pressure in test section before stop of flowing:	p_p	kPa	1775.7
Maximum pressure change during flowing period:*	dp_p	kPa	1.1

Normalized distance with respect to the response time

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

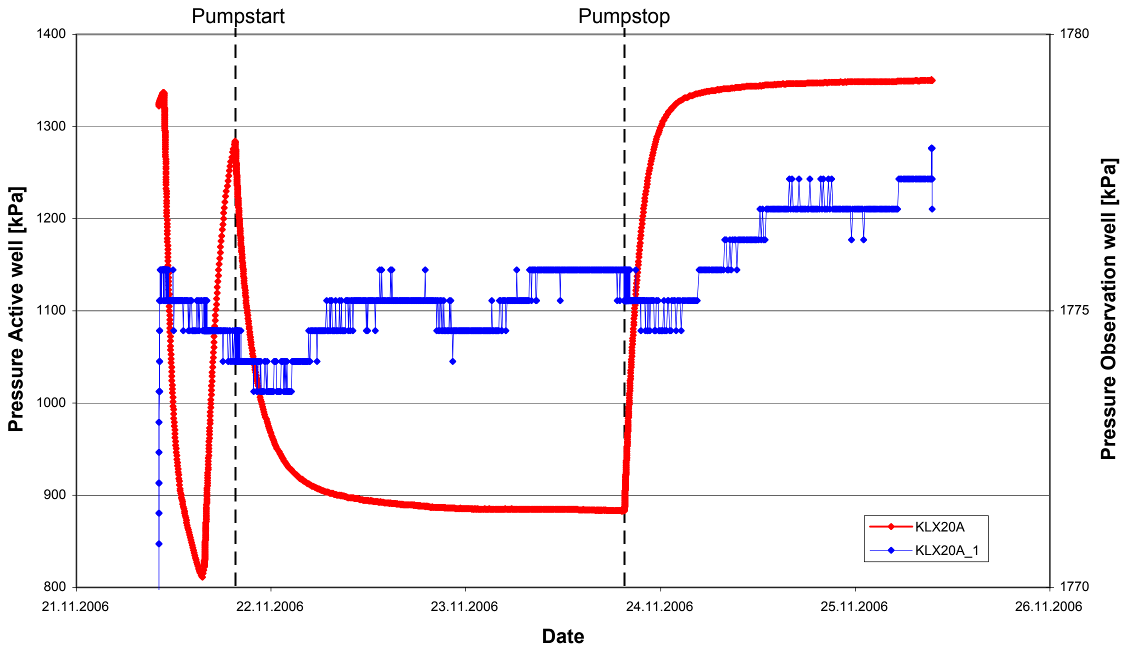
Normalized drawdown with respect to pumping flow rate

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 clear response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**99.50-180.00**
Test Start:	21.11.2006 10:08	Test Stop:	25.11.2006 09:27
Pump Start:	21.11.2006 19:33	Pump Stop:	23.11.2006 19:33
Flow Rate Q_p [m^3/s]:	2.57E-04		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	1276
Pressure in test section before stop of flowing:	p_p	kPa	883
Maximum pressure change during flowing period:	dp_p	kPa	393

Observation Hole:	**KLX20A**	**Section no.:**	**KLX20A_2**
		Section length:	181.00-237.00
Distance r_s [m]:	75.00	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	1736.5
Pressure in test section before stop of flowing:	p_p	kPa	1731.6
Maximum pressure change during flowing period:*	dp_p	kPa	4.9

Normalized distance with respect to the response time

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

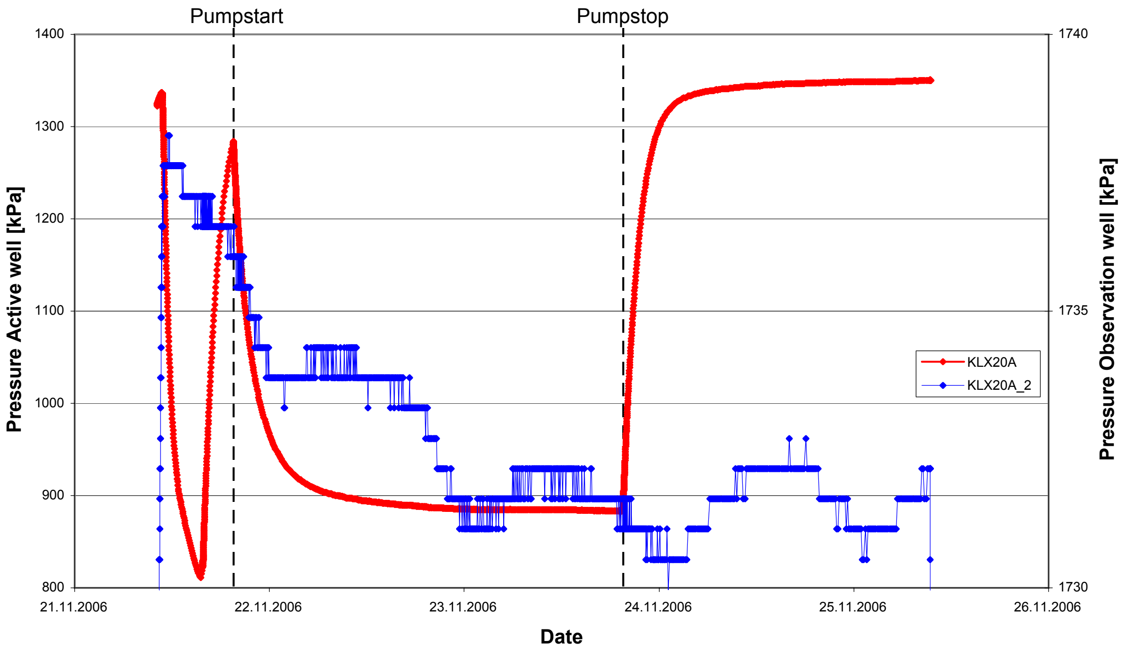
Normalized drawdown with respect to pumping flow rate

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 clear response due to pumping in source
pressure changes mainly caused by natural fluctuations (e.g. tidal effects)



APPENDIX 6-2

Index calculation

KLX20A Section 250.20-306.20 m pumped

Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**250.20-306.20**
Test Start:	15.11.2006 09:30	Test Stop:	20.11.2006 13:23
Pump Start:	15.11.2006 16:56	Pump Stop:	17.11.2006 16:56
Flow Rate Q_p [m^3/s]:	4.83E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	2254
Pressure in test section before stop of flowing:	p_p	kPa	2003
Maximum pressure change during flowing period:	dp_p	kPa	251

Observation Hole:	**HLX36**	**Section no.:**	**HLX36_1**
		Section length:	50.00-199.80
Distance r_s [m]:	196.00	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	107.2
Pressure in test section before stop of flowing:	p_p	kPa	103.9
Maximum pressure change during flowing period:*	dp_p	kPa	3.3

Normalized distance with respect to the response time

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

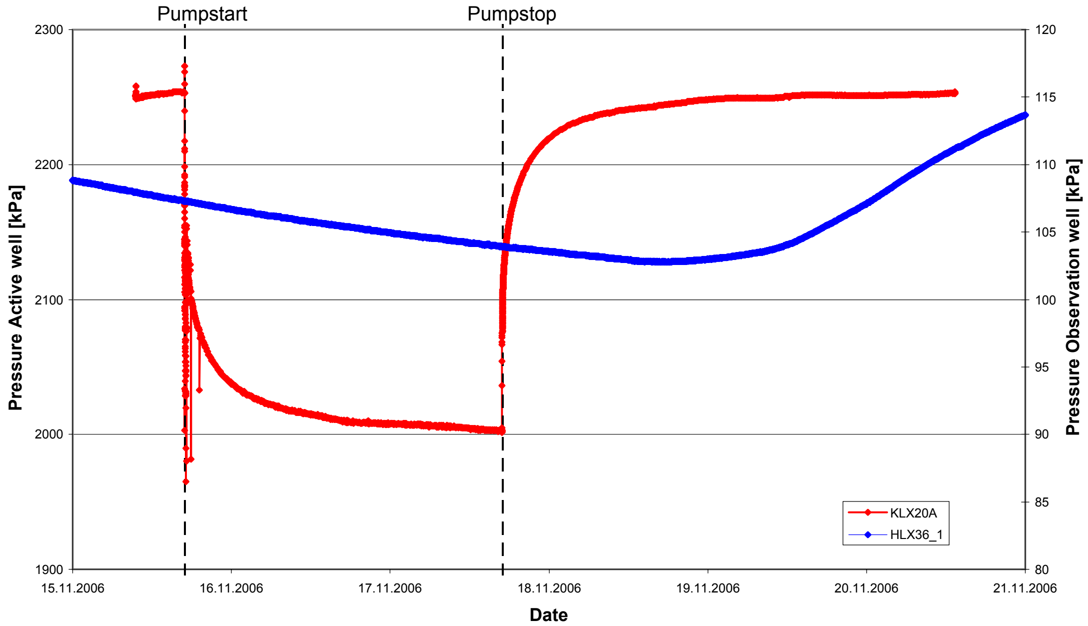
Normalized drawdown with respect to pumping flow rate

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 clear response due to pumping in source



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**250.20-306.20**
Test Start:	15.11.2006 09:30	Test Stop:	20.11.2006 13:23
Pump Start:	15.11.2006 16:56	Pump Stop:	17.11.2006 16:56
Flow Rate Q_p [m^3/s]:	4.83E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	2254
Pressure in test section before stop of flowing:	p_p	kPa	2003
Maximum pressure change during flowing period:	dp_p	kPa	251

Observation Hole:	**HLX36**	**Section no.:**	**HLX36_2**
		Section length:	6.10-49.00
Distance r_s [m]:	265.00	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	114.3
Pressure in test section before stop of flowing:	p_p	kPa	113.7
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**

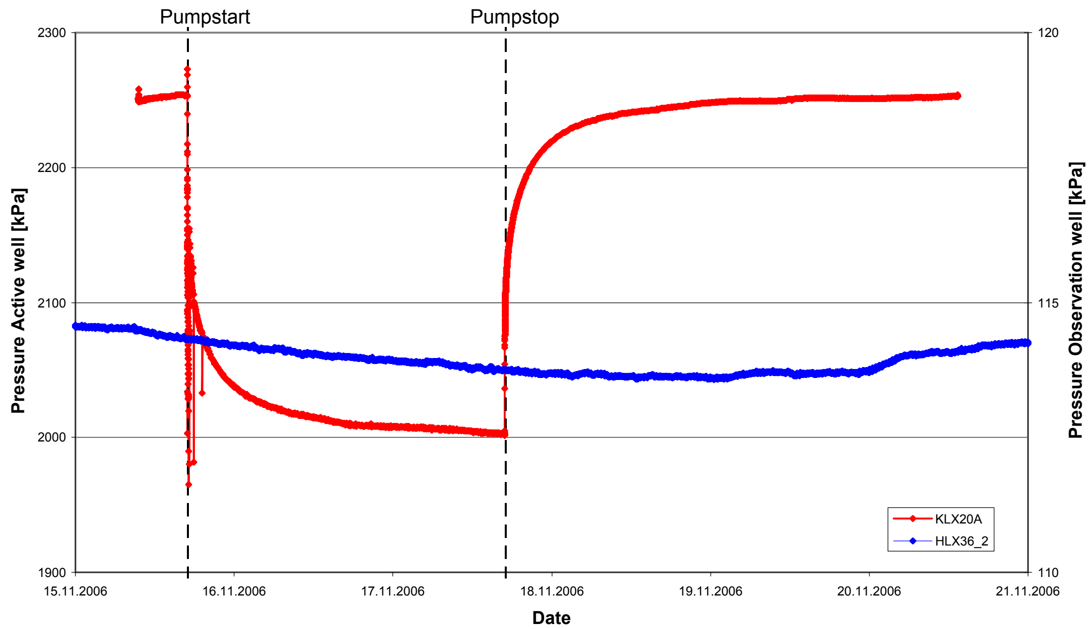
Normalized drawdown with respect to pumping flow rate

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 clear response due to pumping in source



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**250.20-306.20**
Test Start:	15.11.2006 09:30	Test Stop:	20.11.2006 13:23
Pump Start:	15.11.2006 16:56	Pump Stop:	17.11.2006 16:56
Flow Rate Q_p [m^3/s]:	4.83E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	2254
Pressure in test section before stop of flowing:	p_p	kPa	2003
Maximum pressure change during flowing period:	dp_p	kPa	251

Observation Hole:	**HLX37**	**Section no.:**	**HLX37_1**
		Section length:	149.00-199.80
Distance r_s [m]:	178.00	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	95.0
Pressure in test section before stop of flowing:	p_p	kPa	93.9
Maximum pressure change during flowing period:*	dp_p	kPa	1.1

Normalized distance with respect to the response time

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

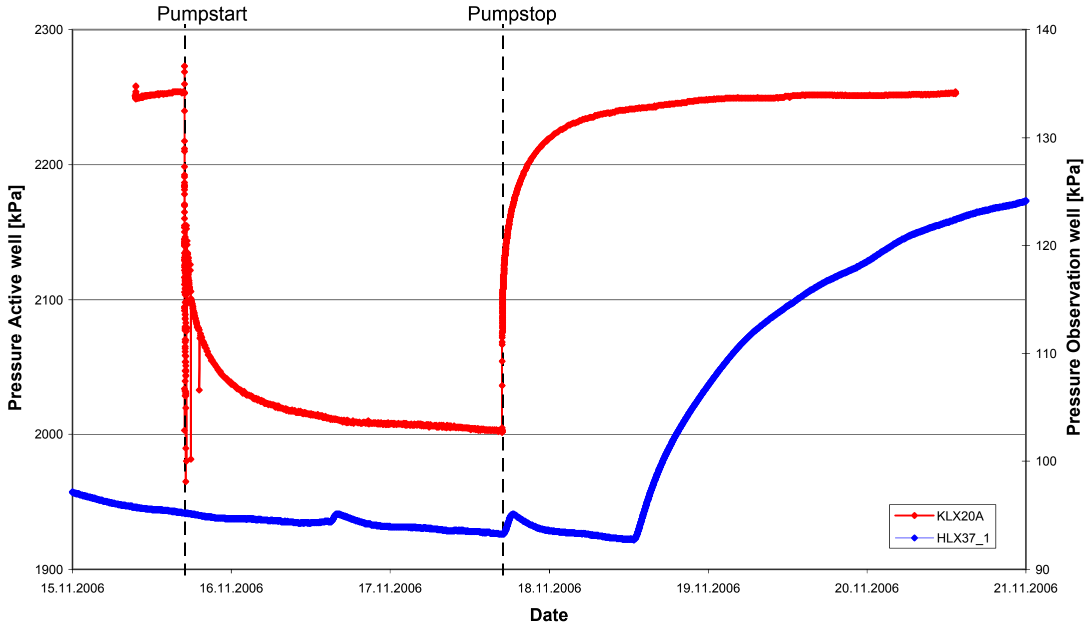
Normalized drawdown with respect to pumping flow rate

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 clear response due to pumping in source
response probably to pumping in another source



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**250.20-306.20**
Test Start:	15.11.2006 09:30	Test Stop:	20.11.2006 13:23
Pump Start:	15.11.2006 16:56	Pump Stop:	17.11.2006 16:56
Flow Rate Q_p [m^3/s]:	4.83E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	2254
Pressure in test section before stop of flowing:	p_p	kPa	2003
Maximum pressure change during flowing period:	dp_p	kPa	251

Observation Hole:	**HLX37**	**Section no.:**	**HLX37_2**
		Section length:	118.00-148.00
Distance r_s [m]:	182.00	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	94.8
Pressure in test section before stop of flowing:	p_p	kPa	93.3
Maximum pressure change during flowing period:*	dp_p	kPa	1.5

Normalized distance with respect to the response time

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

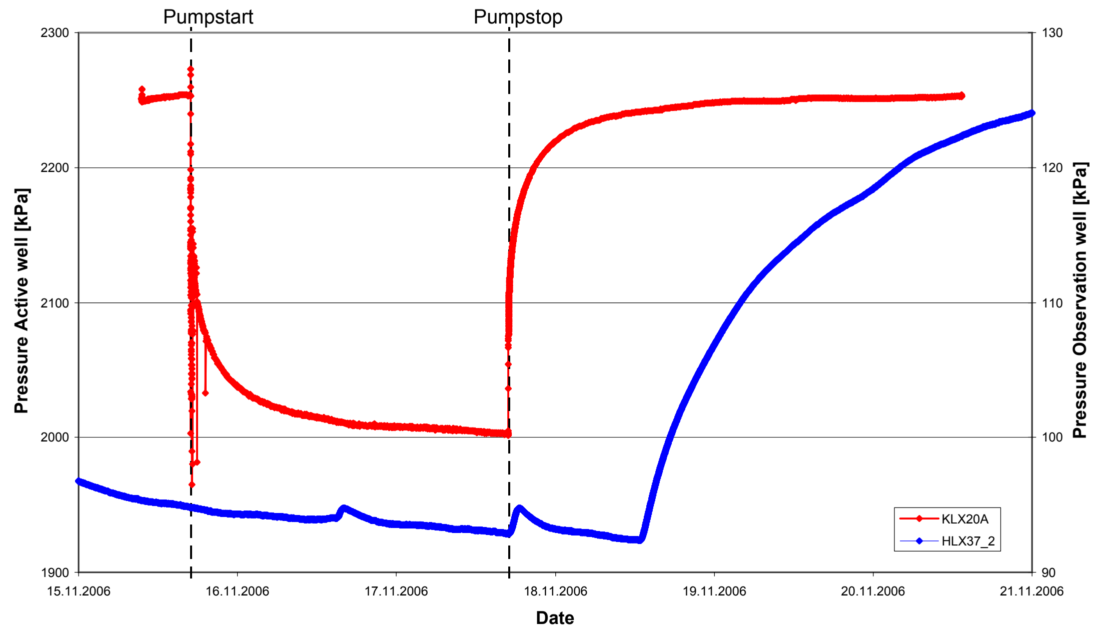
Normalized drawdown with respect to pumping flow rate

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 clear response due to pumping in source
response probably to pumping in another source



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**250.20-306.20**
Test Start:	15.11.2006 09:30	Test Stop:	20.11.2006 13:23
Pump Start:	15.11.2006 16:56	Pump Stop:	17.11.2006 16:56
Flow Rate Q_p [m^3/s]:	4.83E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	2254
Pressure in test section before stop of flowing:	p_p	kPa	2003
Maximum pressure change during flowing period:	dp_p	kPa	251

Observation Hole:	**HLX37**	**Section no.:**	**HLX37_3**
		Section length:	12.10-117.00
Distance r_s [m]:	190.00	max. Drawdown s_p [m]:*	0.34
Response time dt_L [s]:	45026		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	147.0
Pressure in test section before stop of flowing:	p_p	kPa	143.7
Maximum pressure change during flowing period:*	dp_p	kPa	3.3

Normalized distance with respect to the response time

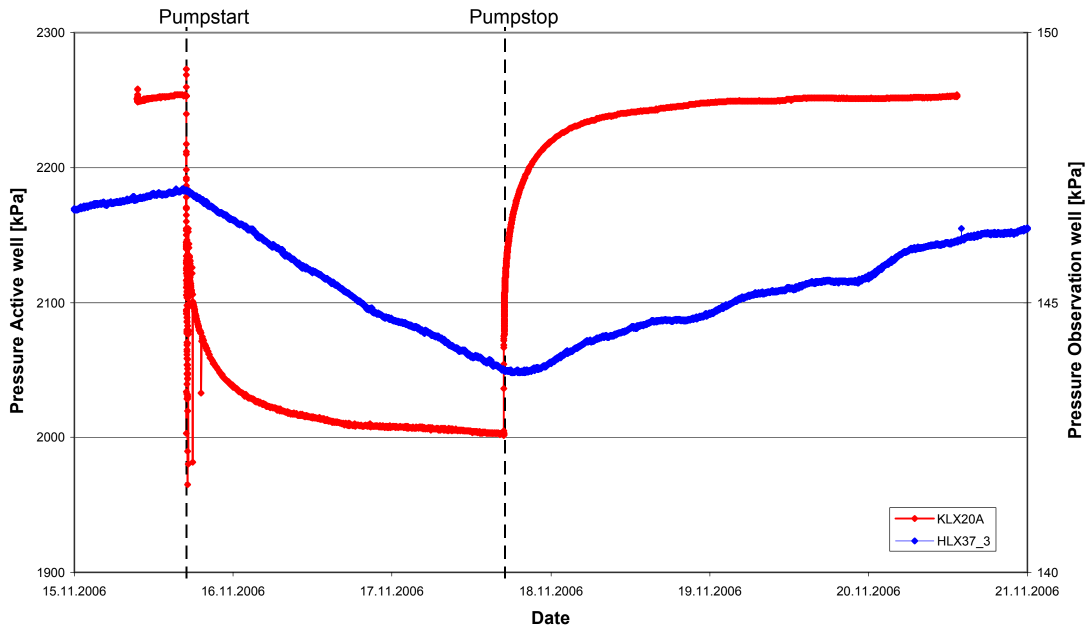
Index 1	r_s^2/dt_L [m^2/s]:	**0.80**	**Low**

Normalized drawdown with respect to pumping flow rate

Index 2	s_p/Q_p [s/m^2]:	**6964.63**	**Low**
Index 2 New	$(s_p/Q_p)*\ln(r_s/r_0)$ [s/m^2]:	**36543.56**	**Medium**

* see comment

Comment: response due to pumping in source



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**250.20-306.20**
Test Start:	15.11.2006 09:30	Test Stop:	20.11.2006 13:23
Pump Start:	15.11.2006 16:56	Pump Stop:	17.11.2006 16:56
Flow Rate Q_p [m^3/s]:	4.83E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	2254
Pressure in test section before stop of flowing:	p_p	kPa	2003
Maximum pressure change during flowing period:	dp_p	kPa	251

Observation Hole:	**HLX43**	**Section no.:**	**HLX43_1**
		Section length:	21.00-170.50
Distance r_s [m]:	1192.00	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	170.0
Pressure in test section before stop of flowing:	p_p	kPa	169.8
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**

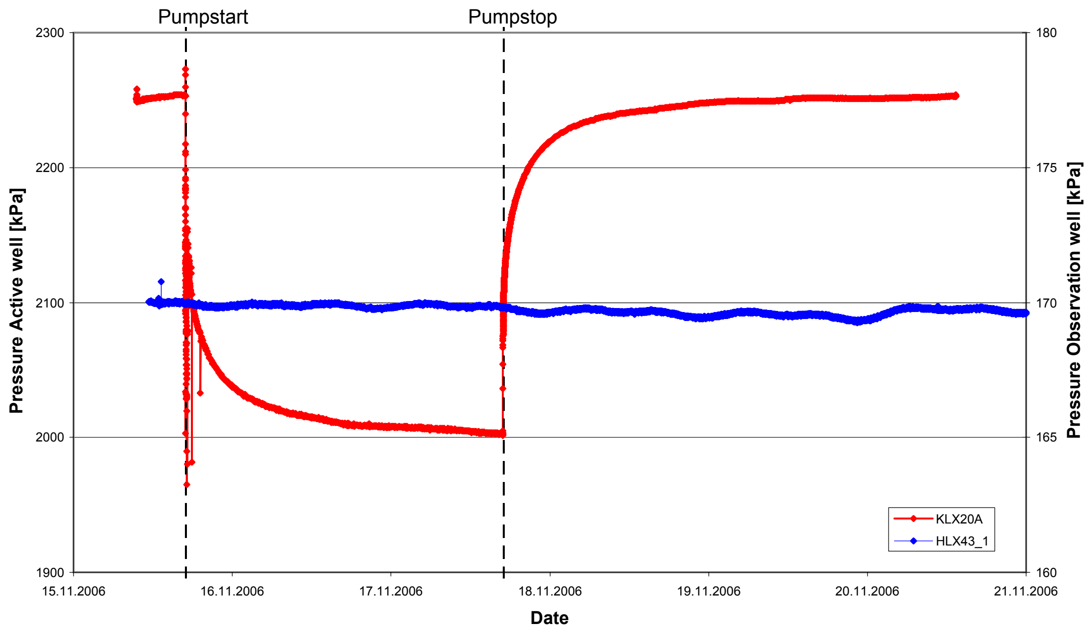
Normalized drawdown with respect to pumping flow rate

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



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**250.20-306.20**
Test Start:	15.11.2006 09:30	Test Stop:	20.11.2006 13:23
Pump Start:	15.11.2006 16:56	Pump Stop:	17.11.2006 16:56
Flow Rate Q_p [m^3/s]:	4.83E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	2254
Pressure in test section before stop of flowing:	p_p	kPa	2003
Maximum pressure change during flowing period:	dp_p	kPa	251

Observation Hole:	**HLX43**	**Section no.:**	**HLX43_2**
		Section length:	6.00-20.00
Distance r_s [m]:	1207.00	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	177.6
Pressure in test section before stop of flowing:	p_p	kPa	181.7
Maximum pressure change during flowing period:*	dp_p	kPa	4.1

Normalized distance with respect to the response time

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

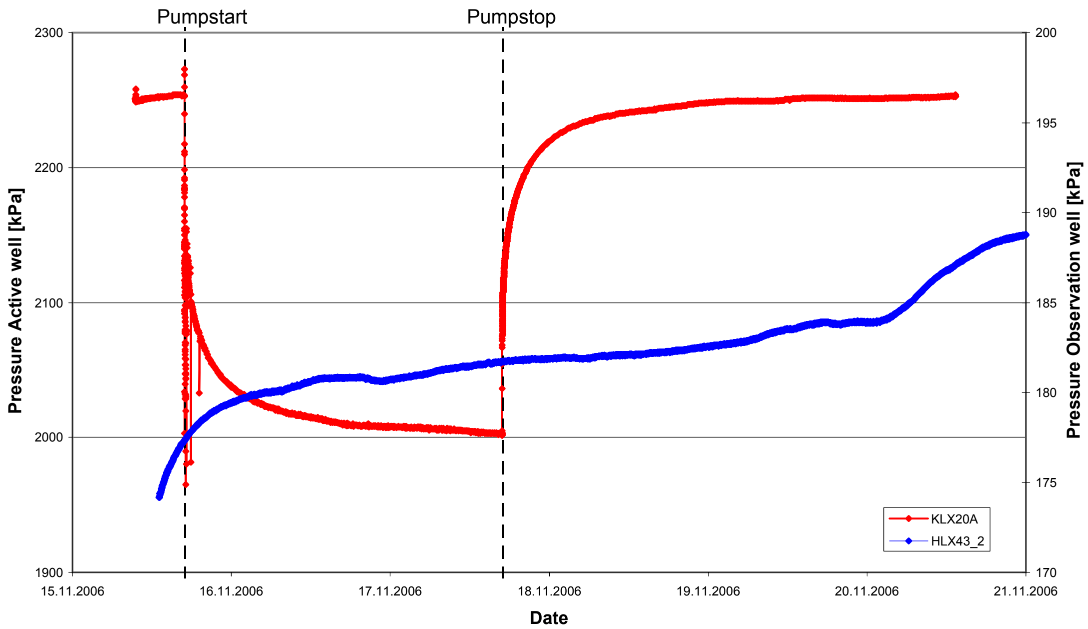
Normalized drawdown with respect to pumping flow rate

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



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**250.20-306.20**
Test Start:	15.11.2006 09:30	Test Stop:	20.11.2006 13:23
Pump Start:	15.11.2006 16:56	Pump Stop:	17.11.2006 16:56
Flow Rate Q_p [m^3/s]:	4.83E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	2254
Pressure in test section before stop of flowing:	p_p	kPa	2003
Maximum pressure change during flowing period:	dp_p	kPa	251

Observation Hole:	**KLX11A**	**Section no.:**	**KLX11A**
		Section length:	12.00-992.00
Distance r_s [m]:	242.00	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	367.4
Pressure in test section before stop of flowing:	p_p	kPa	365.4
Maximum pressure change during flowing period:*	dp_p	kPa	2.0

Normalized distance with respect to the response time

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

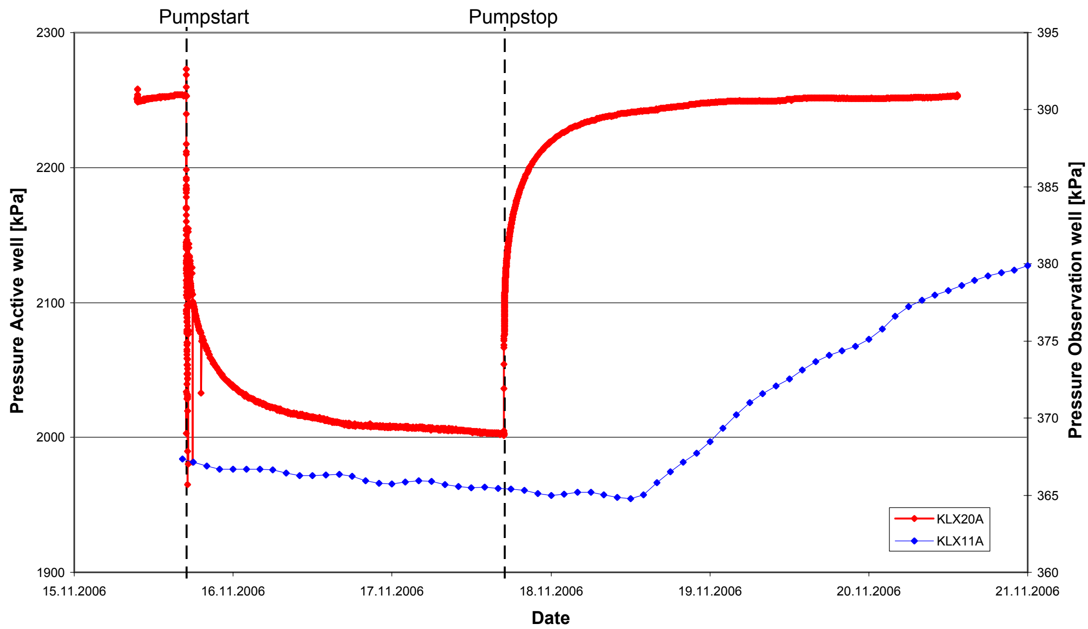
Normalized drawdown with respect to pumping flow rate

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
response probably to pumping in another source



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**250.20-306.20**
Test Start:	15.11.2006 09:30	Test Stop:	20.11.2006 13:23
Pump Start:	15.11.2006 16:56	Pump Stop:	17.11.2006 16:56
Flow Rate Q_p [m^3/s]:	4.83E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	2254
Pressure in test section before stop of flowing:	p_p	kPa	2003
Maximum pressure change during flowing period:	dp_p	kPa	251

Observation Hole:	**KLX11B**	**Section no.:**	**KLX11B**
		Section length:	2.50-100.00
Distance r_s [m]:	234.00	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	383.8
Pressure in test section before stop of flowing:	p_p	kPa	382.3
Maximum pressure change during flowing period:*	dp_p	kPa	1.5

Normalized distance with respect to the response time

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

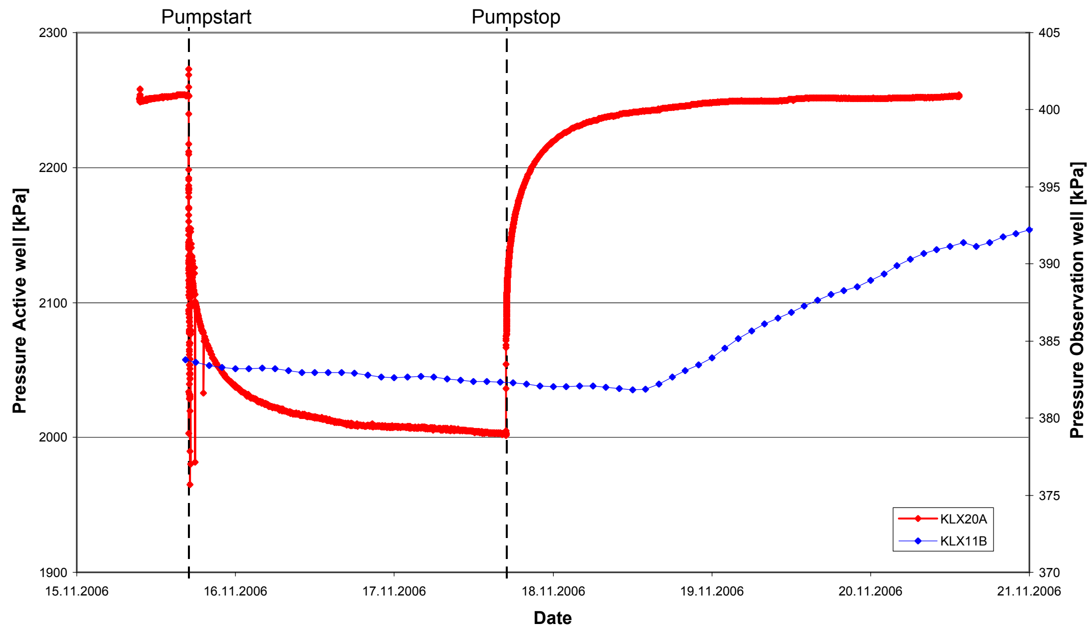
Normalized drawdown with respect to pumping flow rate

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
response probably to pumping in another source



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**250.20-306.20**
Test Start:	15.11.2006 09:30	Test Stop:	20.11.2006 13:23
Pump Start:	15.11.2006 16:56	Pump Stop:	17.11.2006 16:56
Flow Rate Q_p [m^3/s]:	4.83E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	2254
Pressure in test section before stop of flowing:	p_p	kPa	2003
Maximum pressure change during flowing period:	dp_p	kPa	251

Observation Hole:	**KLX20A**	**Section no.:**	**KLX20A_1**
		Section length:	307.20-457.92
Distance r_s [m]:	112.00	max. Drawdown s_p [m]:*	1.35
Response time dt_L [s]:	1515		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	2283.0
Pressure in test section before stop of flowing:	p_p	kPa	2269.8
Maximum pressure change during flowing period:*	dp_p	kPa	13.2

Normalized distance with respect to the response time

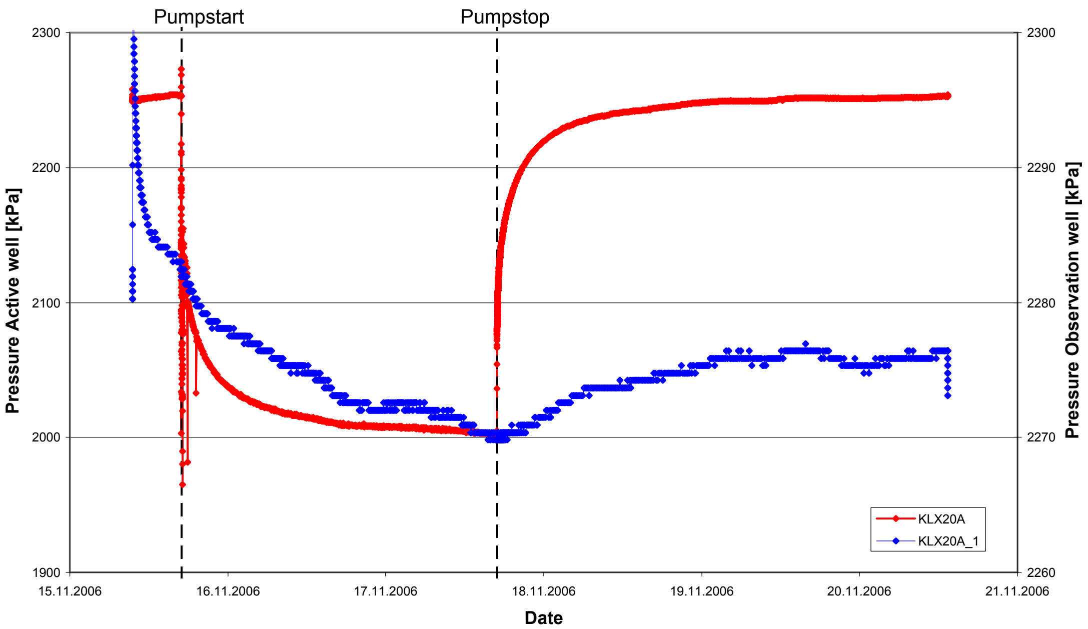
Index 1	r_s^2/dt_L **[m²/s]:**	**8.28**	**Medium**

Normalized drawdown with respect to pumping flow rate

Index 2	s_p/Q_p **[s/m²]:**	**27858.50**	**Medium**
Index 2 New	$(s_p/Q_p)*\ln(r_s/r_0)$ **[s/m²]:**	**131450.32**	**High**

* see comment

Comment: response due to pumping in source



Activityplan No.	AP PS 400-06-112		
Pumping Hole:	**KLX20A**	**Pumping Section [m bToC]:**	**250.20-306.20**
Test Start:	15.11.2006 09:30	Test Stop:	20.11.2006 13:23
Pump Start:	15.11.2006 16:56	Pump Stop:	17.11.2006 16:56
Flow Rate Q_p [m^3/s]:	4.83E-05		

Pressure data	**Nomenclature**	**Unit**	**Value**
Pressure in test section before start of flowing:	p_i	kPa	2254
Pressure in test section before stop of flowing:	p_p	kPa	2003
Maximum pressure change during flowing period:	dp_p	kPa	251

Observation Hole:	**KLX20A**	**Section no.:**	**KLX20A_3**
		Section length:	99.50-249.20
Distance r_s [m]:	130.00	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	1851.1
Pressure in test section before stop of flowing:	p_p	kPa	1849.5
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**

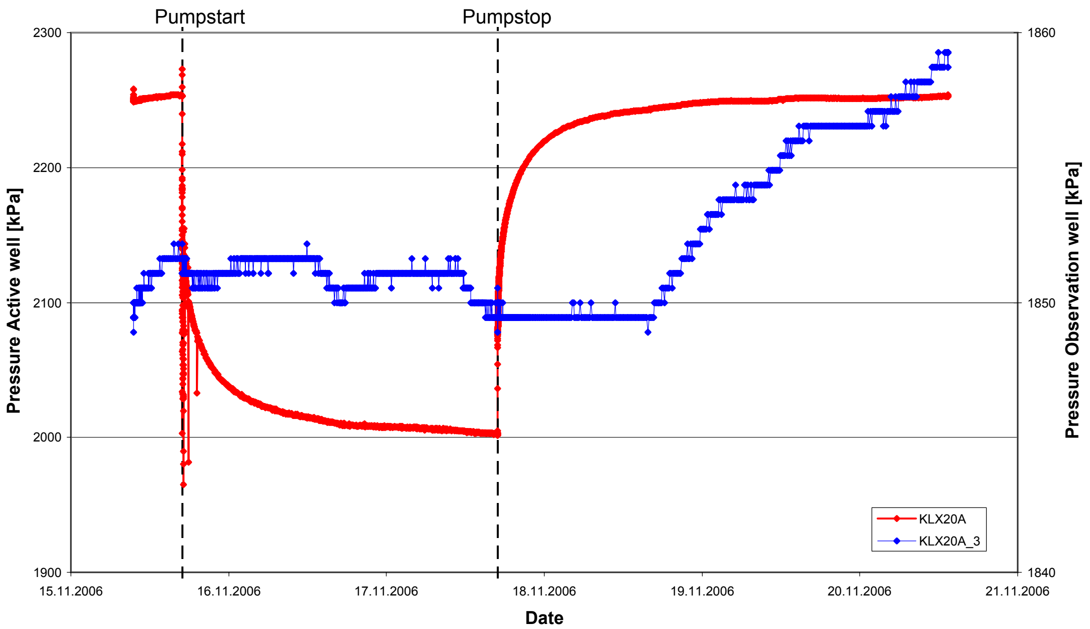
Normalized drawdown with respect to pumping flow rate

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



Borehole: KLX20A

APPENDIX 7

Observation hole
Test Analysis diagrams

APPENDIX 7-1

KLX20A Section 99.50-180.20 m pumped

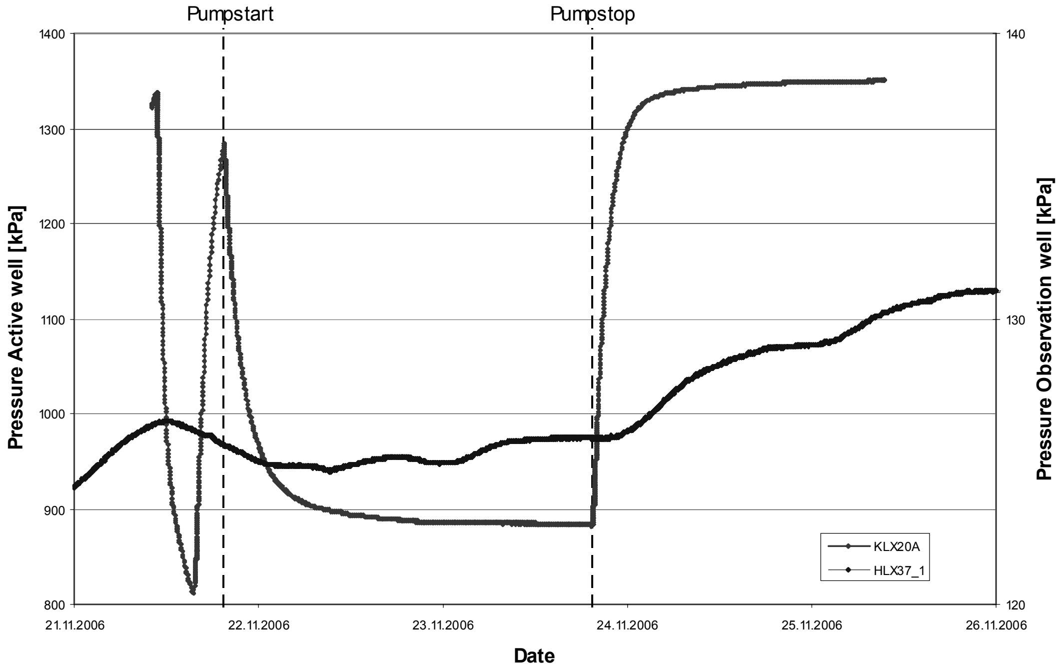
Observation hole
Test Analysis diagrams

APPENDIX 7-1-1

KLX20A Section 99.50-180.00 m pumped
HLX37_1 149.00-199.80 m observed

Observation hole
Test Analysis diagrams

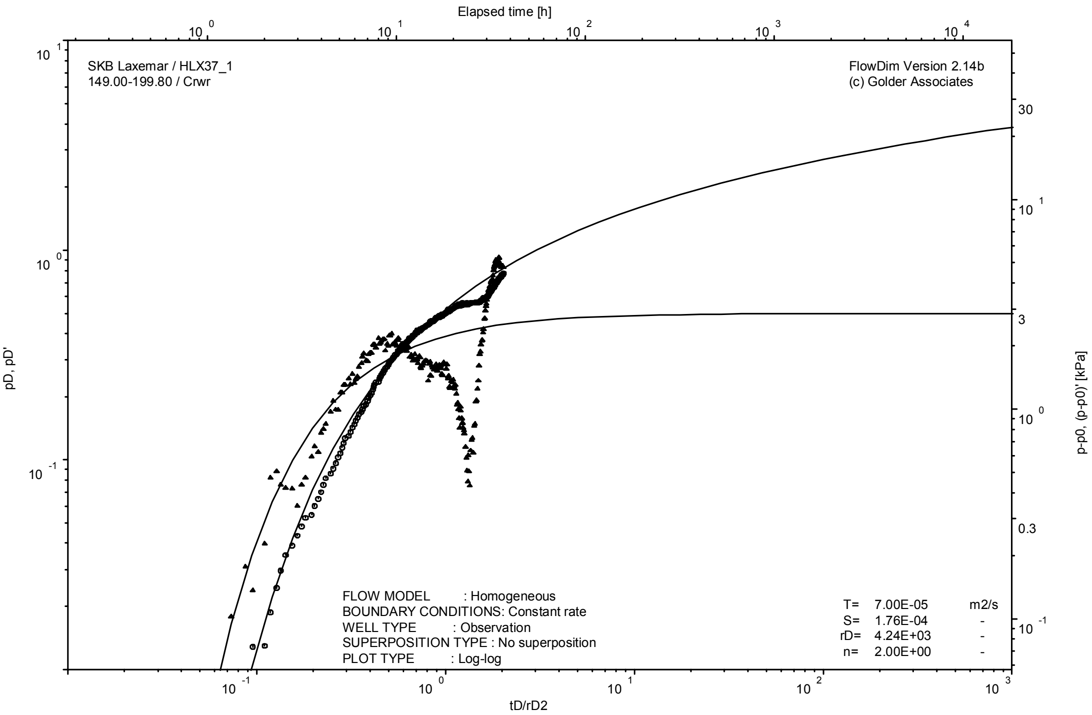
Pumped: KLX20A 99.50-180.00 m
Observed: HLX37_1 149.00-199.80 m



Pressure vs. time; KLX20A 99.50-180.00 m pumped and HLX37_1 149.00-199.80 m observed

Not analysable

CRw phase; log-log match; KLX20A 99.50-180.00 m pumped and HLX37_1 149.00-199.80 m observed

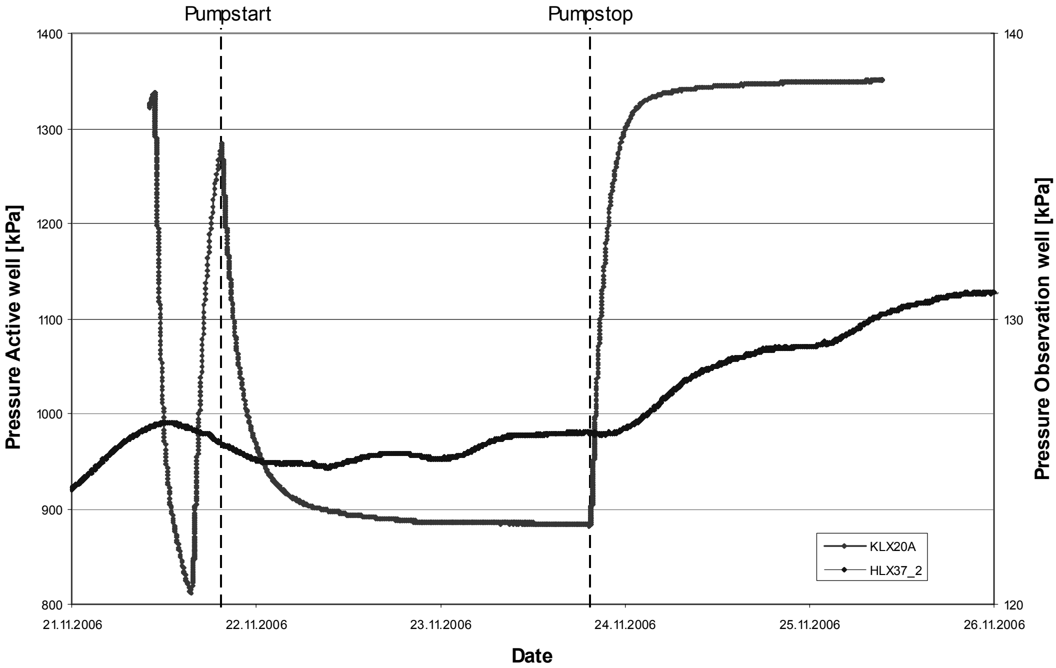


CRwr phase; log-log match; KLX20A 99.50-180.00 m pumped and HLX37_1 149.00-199.80 m observed

APPENDIX 7-1-2

KLX20A Section 99.50-180.00 m pumped
HLX37_2 118.00-148.00 m observed

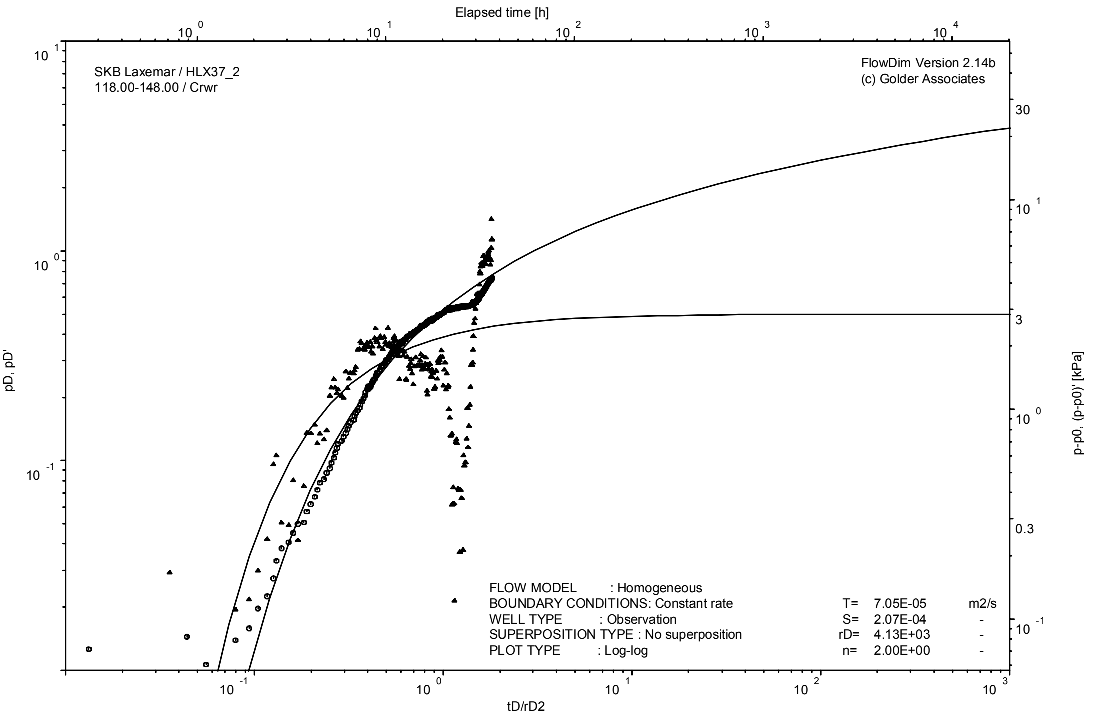
Observation hole
Test Analysis diagrams



Pressure vs. time; KLX20A 99.50-180.00 m pumped and HLX37_2 118.00-148.00 m observed

Not analysable

CRw phase; log-log match; KLX20A 99.50-180.00 m pumped and HLX37_2 118.00-148.00 m observed

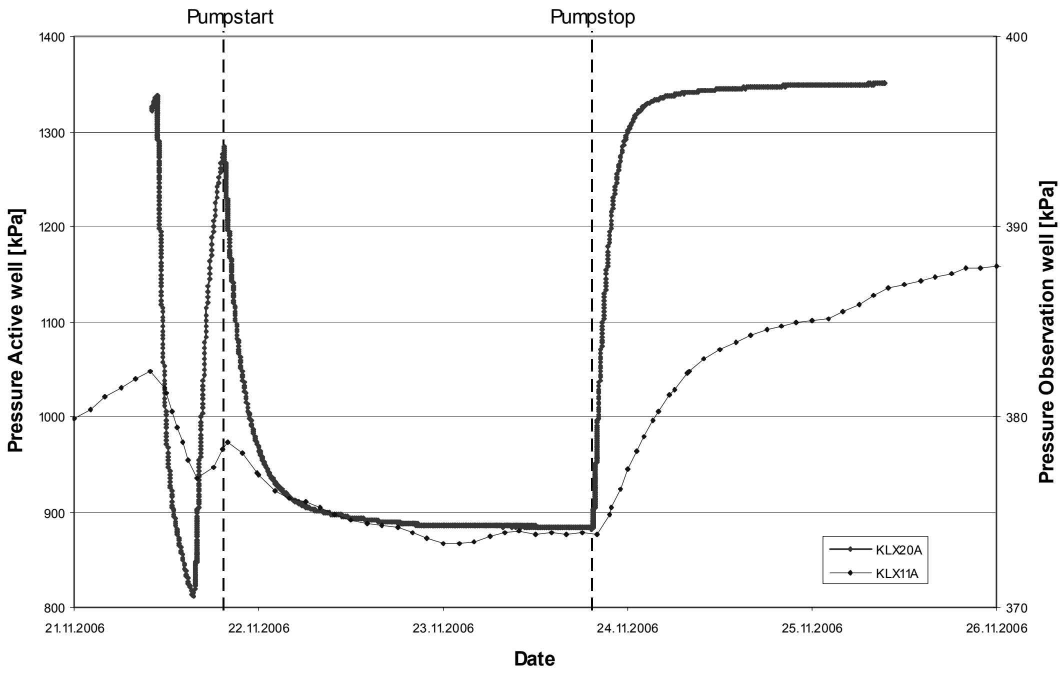


CRwr phase; log-log match; KLX20A 99.50-180.00 m pumped and HLX37_2 118.00-148.00 m observed

APPENDIX 7-1-3

KLX20A Section 99.50-180.00 m pumped
KLX11A 12.00-992.00 m observed

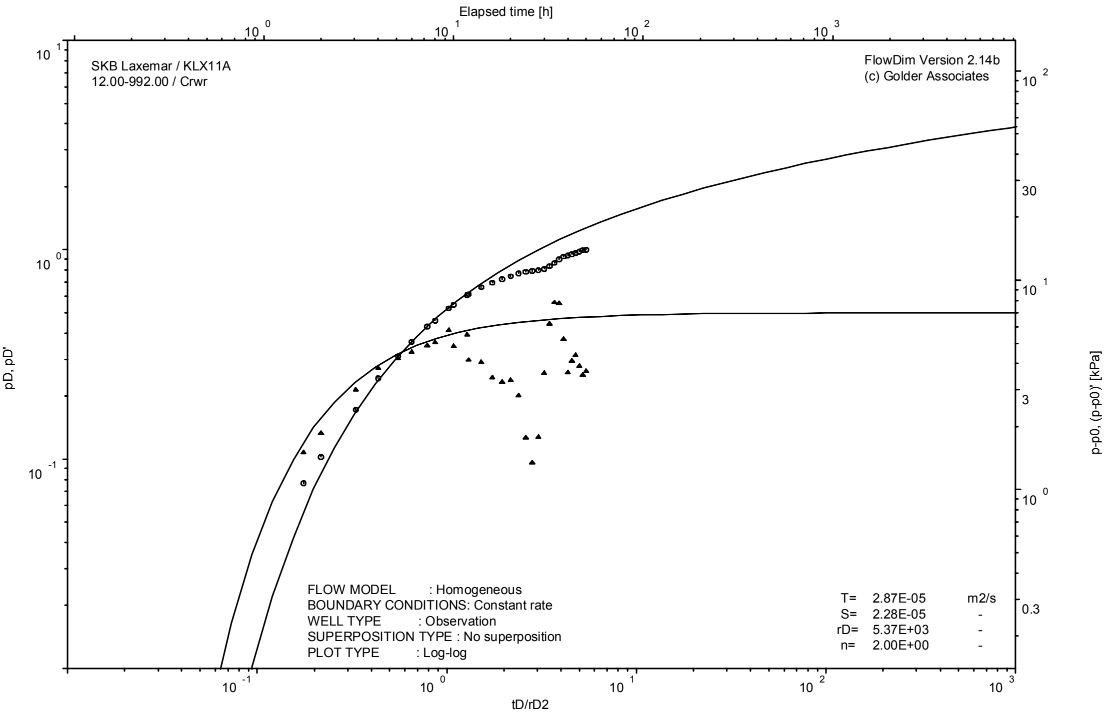
Observation hole
Test Analysis diagrams



Pressure vs. time; KLX20A 99.50-180.00 m pumped and KLX11A 12.00-992.00 m observed

Not analysable

CRw phase; log-log match; KLX20A 99.50-180.00 m pumped and KLX11A 12.00-992.00 m observed

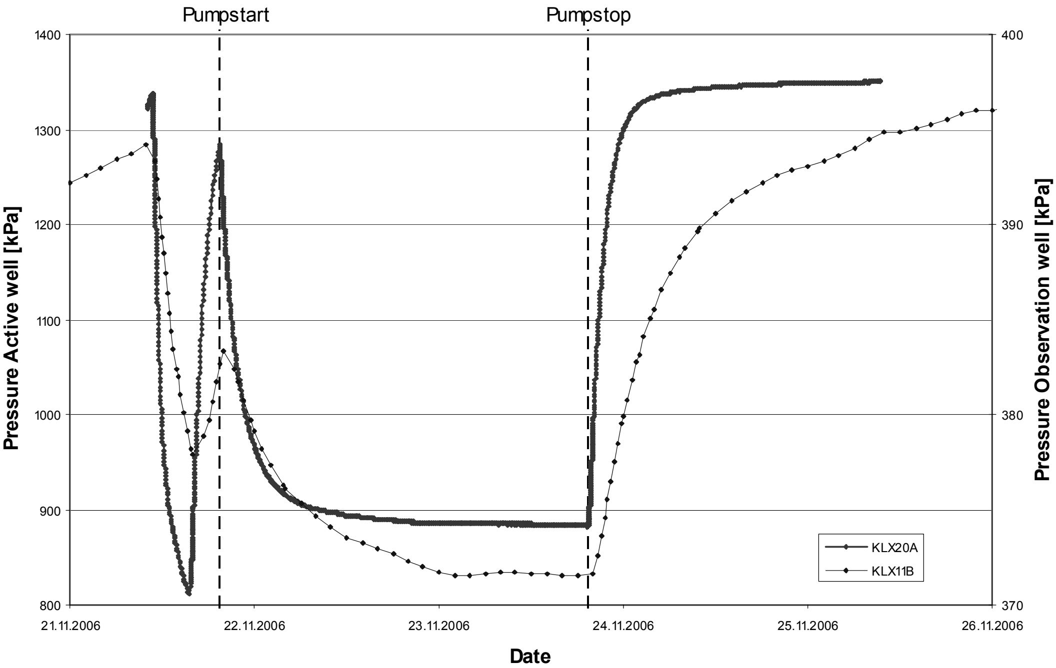


CRwr phase; log-log match; KLX20A 99.50-180.00 m pumped and KLX11A 12.00-992.00 m observed

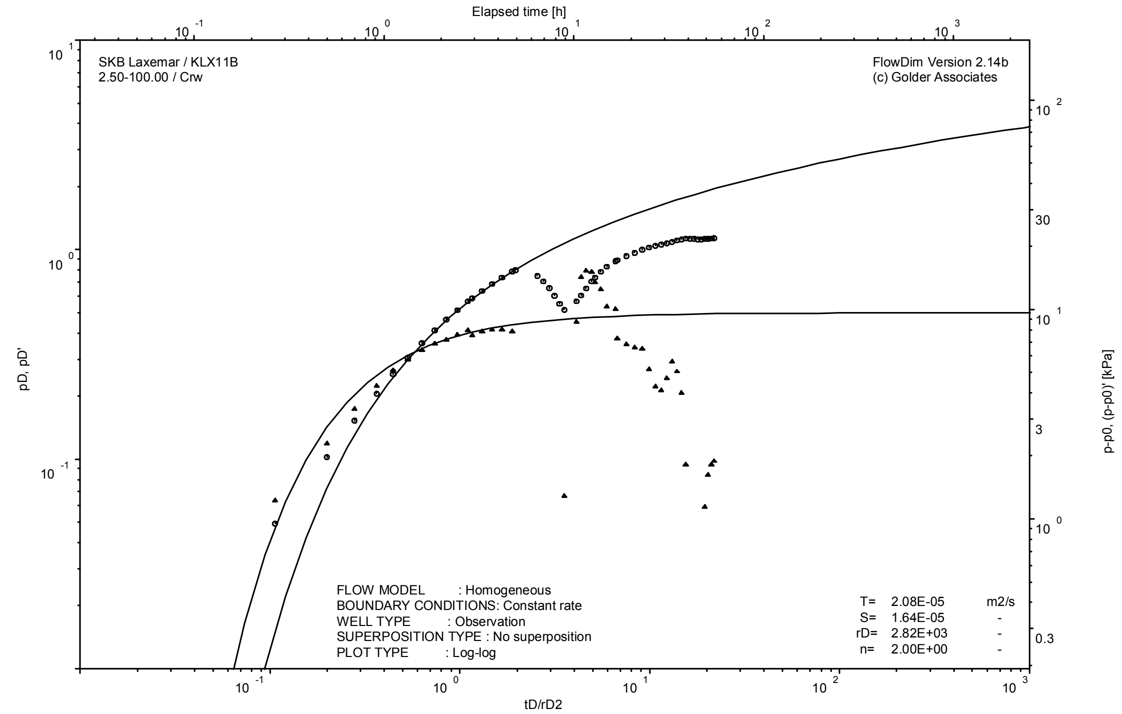
APPENDIX 7-1-4

KLX20A Section 99.50-180.00 m pumped
KLX11B 2.50-100.00 m observed

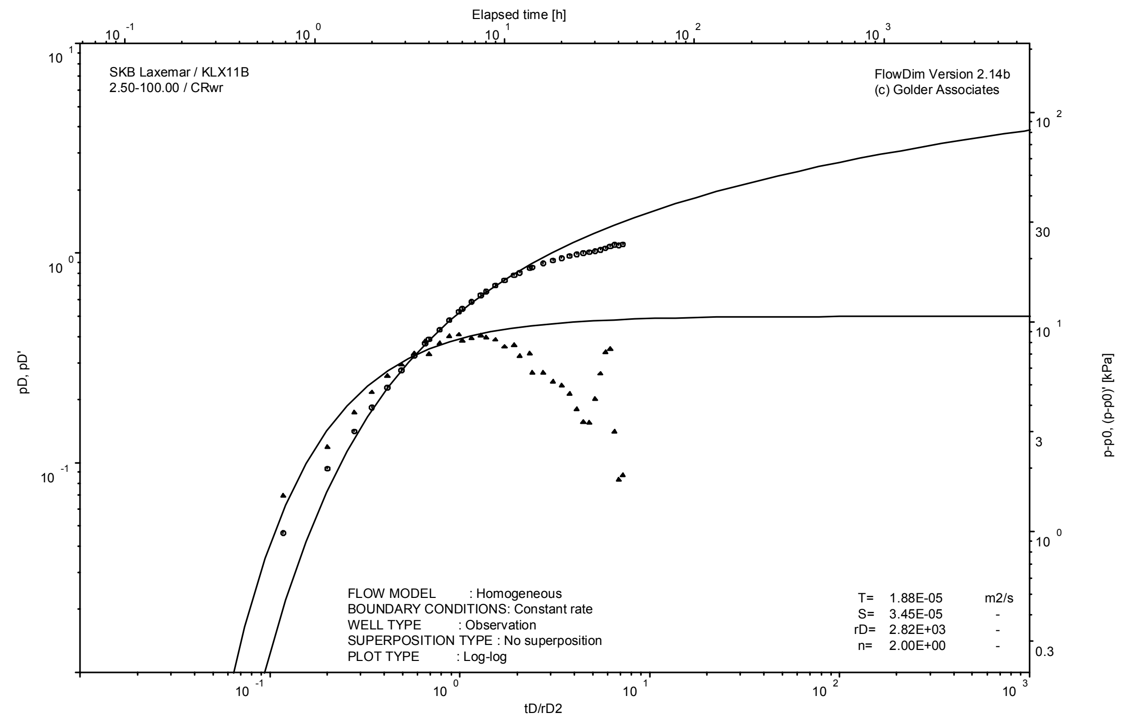
Observation hole
Test Analysis diagrams



Pressure vs. time; KLX20A 99.50-180.00 m pumped and KLX11B 2.50-100.00 m observed



CRw phase; log-log match; KLX20A 99.50-180.00 m pumped and KLX11B 2.50-100.00 m observed



CRwr phase; log-log match; KLX20A 99.50-180.00 m pumped and KLX11B 2.50-100.00 m observed

APPENDIX 7-2

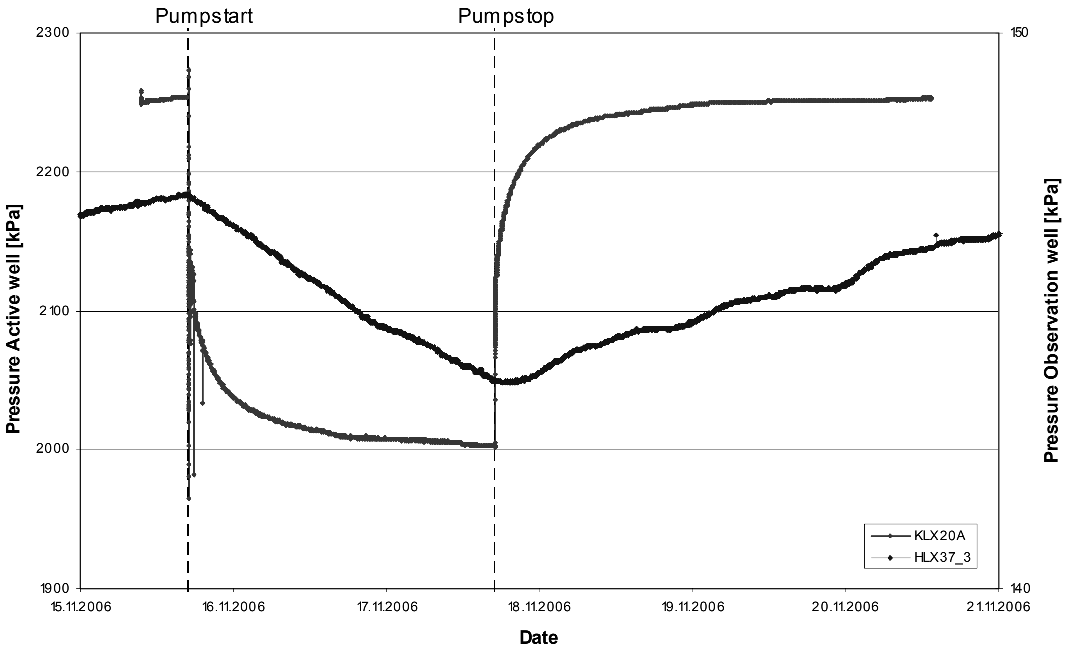
KLX20A Section 250.20-306.20 m pumped

Observation hole
Test Analysis diagrams

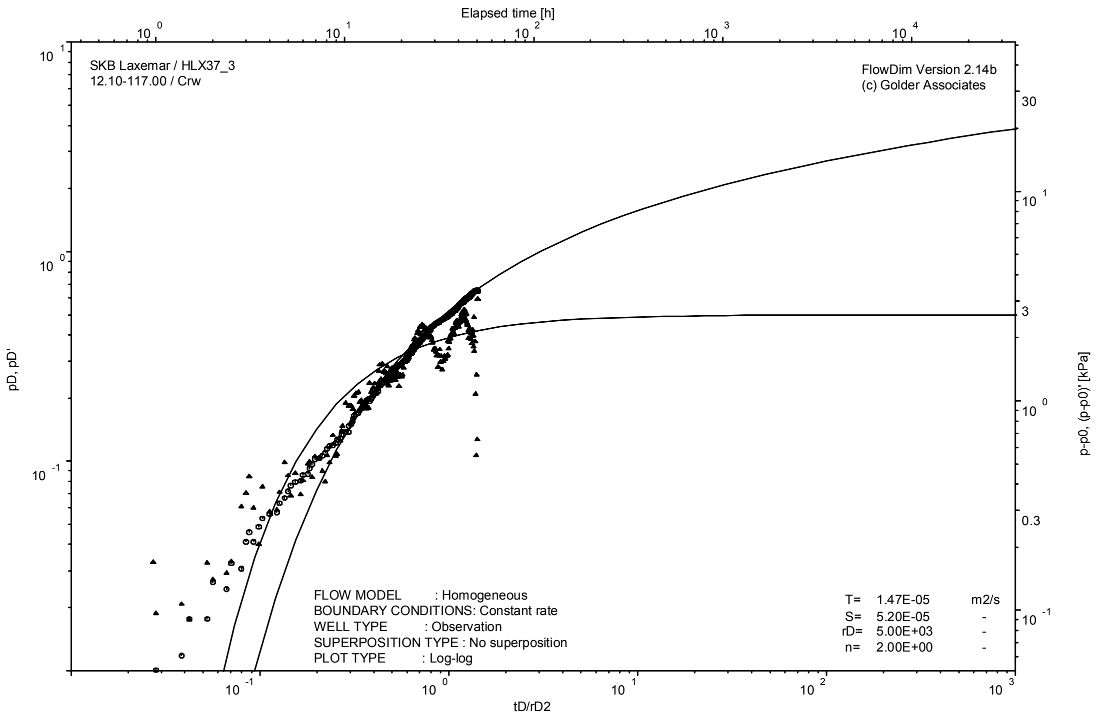
APPENDIX 7-2-1

KLX20A Section 250.20-306.20 m pumped
HLX37_3 12.10-117.00 m observed

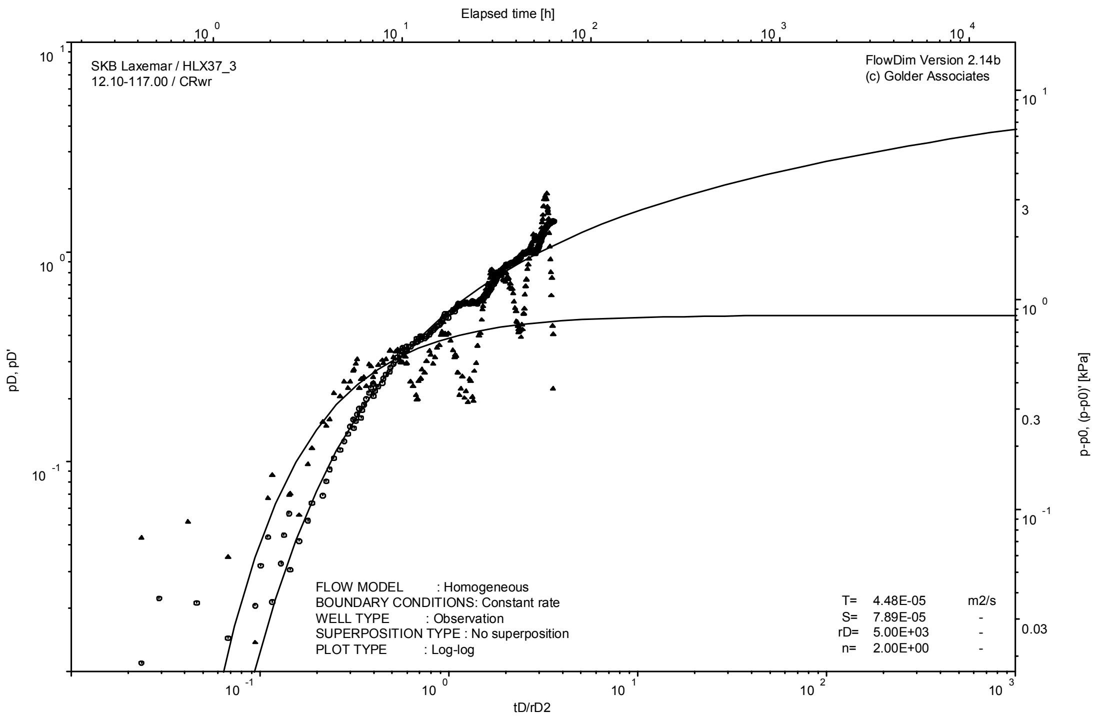
Observation hole
Test Analysis diagrams



Pressure vs. time; KLX20A 250.20-306.20 m pumped and HLX36_3 12.10-117.00 m observed



CRw phase; log-log match; KLX20A 250.20-306.20 m pumped and HLX36_3 12.10-117.00 m observed

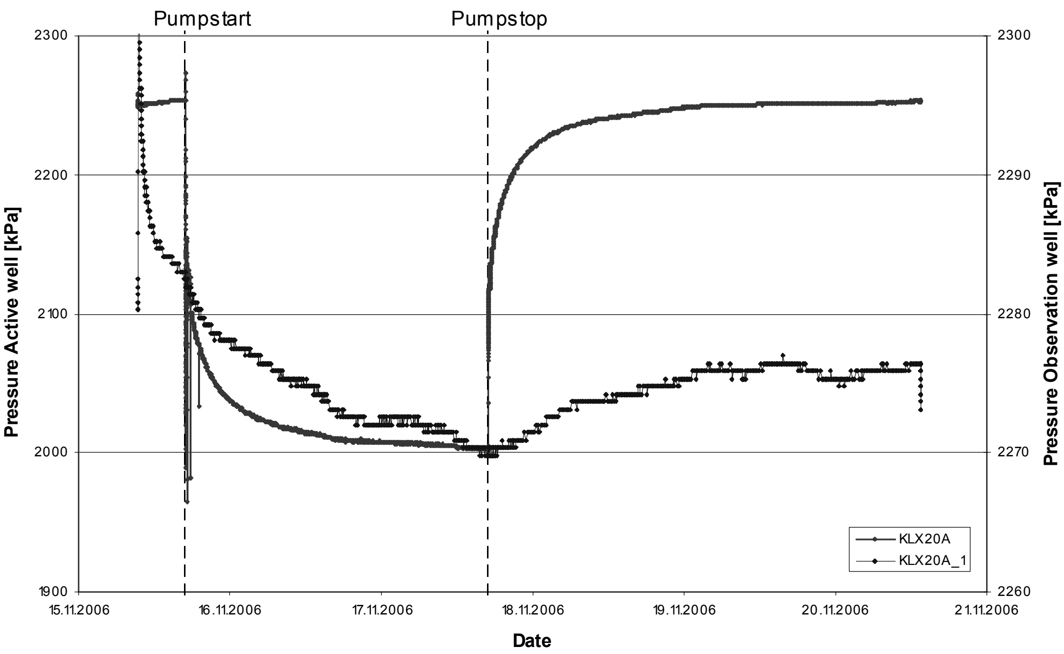


CRwr phase; log-log match; KLX20A 250.20-306.20 m pumped and HLX36_3 12.10-117.00 m observed

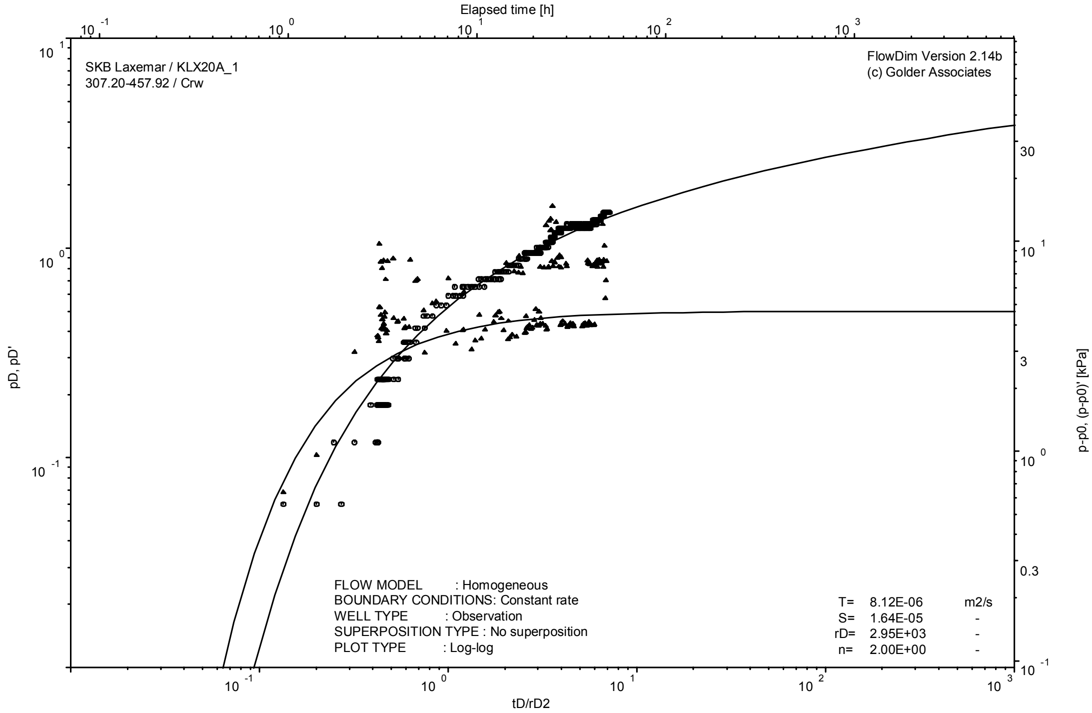
APPENDIX 7-2-2

KLX20A Section 250.20-306.20 m pumped
KLX20A_1 306.20-457.92 m observed

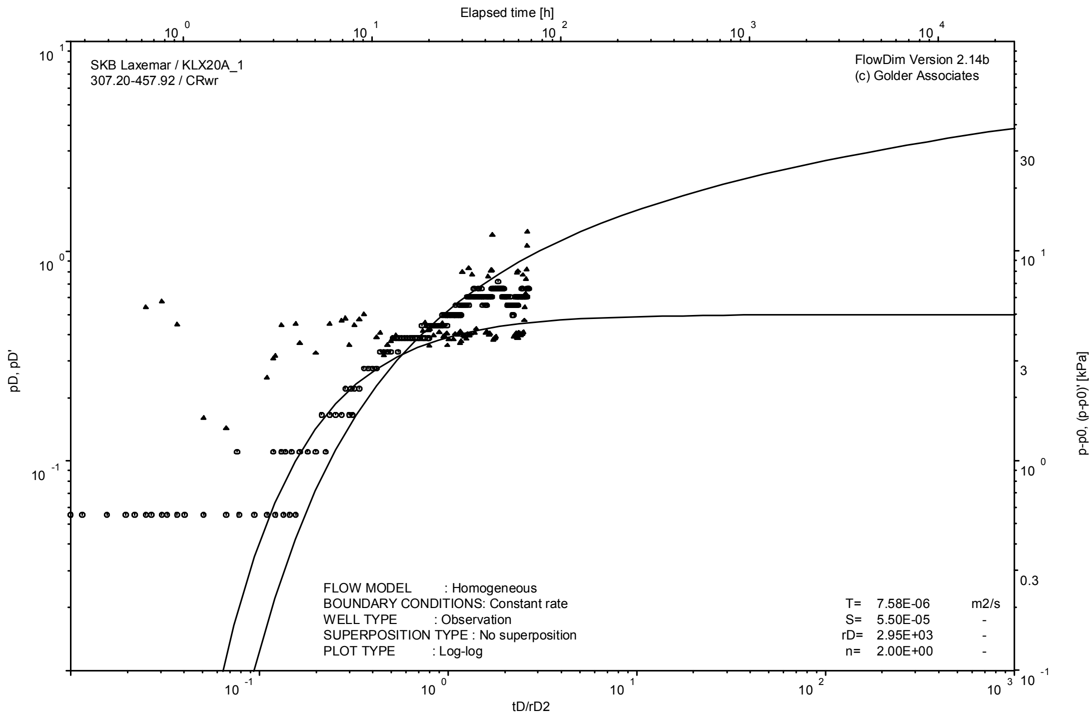
Observation hole
Test Analysis diagrams



Pressure vs. time; KLX20A 250.20-306.20 m pumped and KLX20A_1 307.20-457.92 m observed



CRw phase; log-log match; KLX20A 250.20-306.20 m pumped and KLX20A_1 307.20-457.92 m observed



CRwr phase; log-log match; KLX20A 250.20-306.20 m pumped and KLX20A_1 307.20-457.92 m observed

APPENDIX 8

Observation Hole
Test Summary Sheets

APPENDIX 8-1

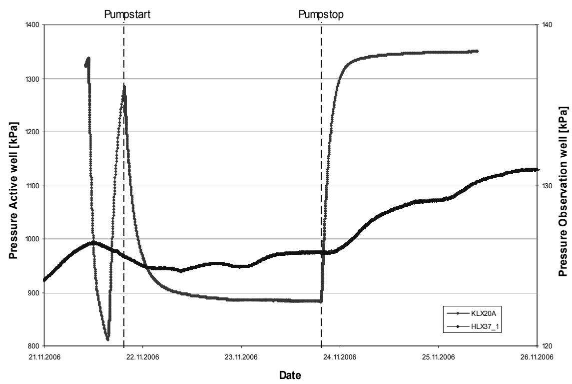
KLX20A Section 99.50 - 180.00 m pumped

Observation Hole
Test Summary Sheets

Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr Observation hole
Area:	Laxemar	Test no:	1
Borehole ID:	HLX37_1 (KLX20A 99.50-180.00 pumped)	Test start:	211106 10:08
Test section from - to (m):	149.00-199.80	Responsible for test execution:	Stephan Rohs
Distance (m):	161.00	Responsible for test evaluation:	Cristian Enachescu

Linear plot Q and p

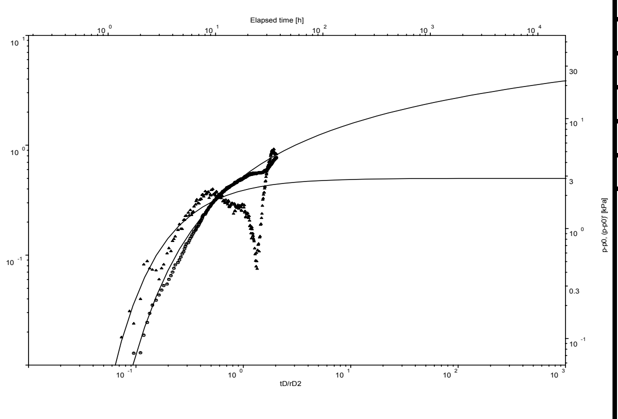


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =			
p_i (kPa) =			
p_p(kPa) =		p_F (kPa) =	
Q_p (m^3/s)=	2.57E-04		
tp (s) =	172800	t_F (s) =	136260
S el S^* (-)=		S el S^* (-)=	
EC_w (mS/m)=			
$Temp_w$(gr C)=			
Derivative fact.=	NA	Derivative fact.=	0.05
Results		**Results**	
Q/s (m^2/s)=	NA		
T_M (m^2/s)=	NA		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	NA	dt_1 (min) =	NA
dt_2 (min) =	NA	dt_2 (min) =	NA
T (m^2/s) =	NA	T (m^2/s) =	7.0E-05
S (-) =	NA	S (-) =	1.8E-04
K_s (m/s) =	NA	K_s (m/s) =	1.4E-06
S_s (1/m) =	NA	S_s (1/m) =	3.5E-06
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

Not analysable

Log-Log plot incl. derivatives- recovery 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) =	7.0E-05	ξ (-) =	NA
S (-) =	1.8E-04		
K_s (m/s) =	1.4E-06		
S_s (1/m) =	3.5E-06		

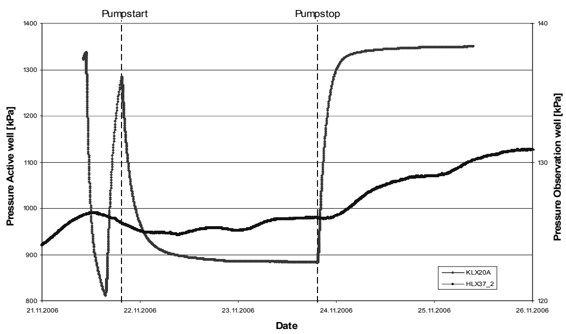
Comments:

The recommended transmissivity of 7.0•10-5 m2/s was derived from the analysis of the CRwr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 3.0•10-5 m²/s to 2.0•10-4 m²/s. The flow dimension during the test is 2. A static pressure measured at transducer depth was not possible to derive from the CRwr phase due to poor data quality.

Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr Observation hole
Area:	Laxemar	Test no:	1
Borehole ID:	HLX37_2 (KLX20A 99.50-180.00 pumped)	Test start:	211106 10:08
Test section from - to (m):	118.00-148.00	Responsible for test execution:	Stephan Rohs
Distance (m):	157.00	Responsible for test evaluation:	Cristian Enachescu

Linear plot Q and p

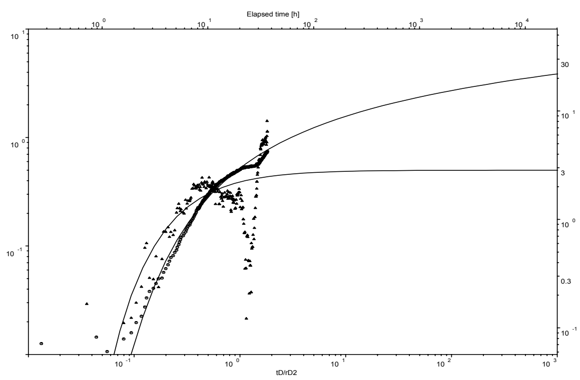


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =			
p_i (kPa) =			
p_p(kPa) =		p_F (kPa) =	
Q_p (m^3/s)=	2.57E-04		
tp (s) =	172800	t_F (s) =	136260
S el S^* (-)=		S el S^* (-)=	
EC_w (mS/m)=			
$Temp_w$(gr C)=			
Derivative fact.=	NA	Derivative fact.=	0.05
Results		**Results**	
Q/s (m^2/s)=	NA		
T_M (m^2/s)=	NA		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	NA	dt_1 (min) =	NA
dt_2 (min) =	NA	dt_2 (min) =	NA
T (m^2/s) =	NA	T (m^2/s) =	7.1E-05
S (-) =	NA	S (-) =	2.1E-04
K_s (m/s) =	NA	K_s (m/s) =	2.4E-06
S_s (1/m) =	NA	S_s (1/m) =	6.9E-06
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

Not analysable

Log-Log plot incl. derivatives- recovery 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) =	7.1E-05	ξ (-) =	NA
S (-) =	2.1E-04		
K_s (m/s) =	2.4E-06		
S_s (1/m) =	6.9E-06		

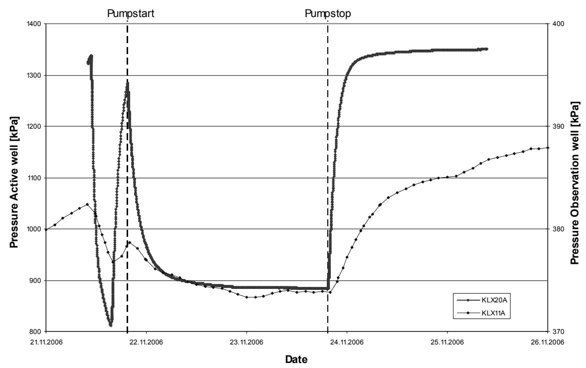
Comments:

The recommended transmissivity of 7.1•10-5 m2/s was derived from the analysis of the CRwr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 3.0•10-5 m²/s to 2.0•10-4 m²/s. The flow dimension during the test is 2. A static pressure measured at transducer depth was not possible to derive from the CRwr phase due to poor data quality.

Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr Observation hole
Area:	Laxemar	Test no:	1
Borehole ID:	KLX11A (KLX20A 99.50-180.00 pumped)	Test start:	211106 10:08
Test section from - to (m):	12.00-992.00	Responsible for test execution:	Stephan Rohs
Distance (m):	204.00	Responsible for test evaluation:	Cristian Enachescu

Linear plot Q and p

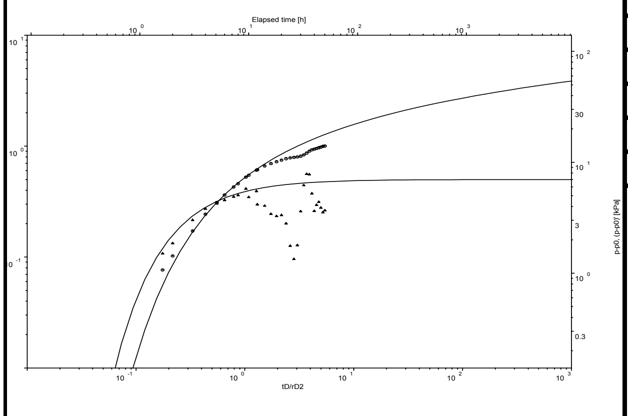


Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa) =			
p_i (kPa) =			
p_p(kPa) =		p_F (kPa) =	
Q_p (m^3/s)=	2.57E-04		
tp (s) =	172800	t_F (s) =	136260
S el S^* (-)=		S el S^* (-)=	
EC_w (mS/m)=			
$Temp_w$(gr C)=			
Derivative fact.=	NA	Derivative fact.=	0.02
Results		**Results**	
Q/s (m^2/s)=	NA		
T_M (m^2/s)=	NA		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	NA	dt_1 (min) =	NA
dt_2 (min) =	NA	dt_2 (min) =	NA
T (m^2/s) =	NA	T (m^2/s) =	2.9E-05
S (-) =	NA	S (-) =	2.3E-05
K_s (m/s) =	NA	K_s (m/s) =	2.9E-08
S_s (1/m) =	NA	S_s (1/m) =	2.3E-08
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

Not analysable

Log-Log plot incl. derivatives- recovery 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) =	2.9E-05	ξ (-) =	NA
S (-) =	2.3E-05		
K_s (m/s) =	2.9E-08		
S_s (1/m) =	2.3E-08		

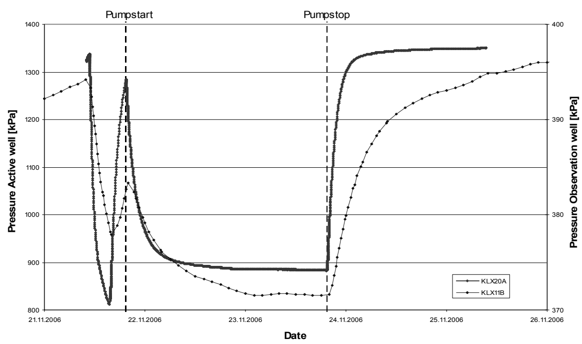
Comments:

The recommended transmissivity of 2.9•10-5 m2/s was derived from the analysis of the CRwr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 7.0•10-6 m²/s to 7.0•10-5 m²/s. The flow dimension during the test is 2. A static pressure measured at transducer depth was not possible to derive from the CRwr phase due to poor data quality.

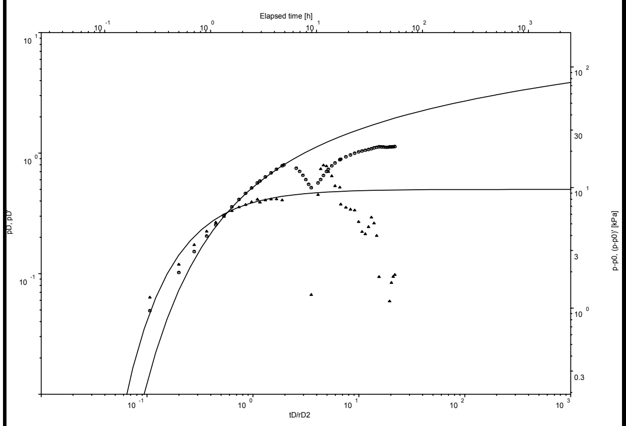
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr Observation hole
Area:	Laxemar	Test no:	1
Borehole ID:	KLX11B (KLX20A 99.50-180.00 pumped)	Test start:	211106 10:08
Test section from - to (m):	2.50-992.00	Responsible for test execution:	Stephan Rohs
Distance (m):	107.00	Responsible for test evaluation:	Cristian Enachescu

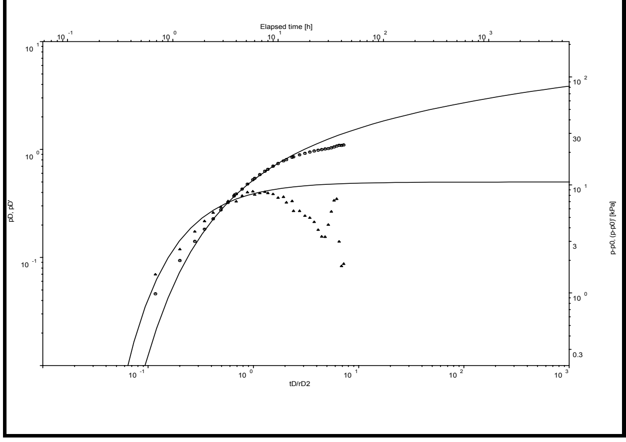
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =			
p_i (kPa) =			
p_p(kPa) =		p_F (kPa) =	
Q_p (m^3/s)=	2.57E-04		
tp (s) =	172800	t_F (s) =	136260
S el S* (-)=		S el S* (-)=	
EC_w (mS/m)=			
$Temp_w$(gr C)=			
Derivative fact.=	0.02	Derivative fact.=	0.02
Results		**Results**	
Q/s (m^2/s)=	NA		
T_M (m^2/s)=	NA		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	NA	dt_1 (min) =	NA
dt_2 (min) =	NA	dt_2 (min) =	NA
T (m^2/s) =	2.1E-05	T (m^2/s) =	1.9E-05
S (-) =	1.6E-05	S (-) =	3.5E-05
K_s (m/s) =	2.1E-07	K_s (m/s) =	1.9E-07
S_s (1/m) =	1.7E-07	S_s (1/m) =	3.5E-07
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

Selected representative parameters.

dt_1 (min) =	NA	C (m^3/Pa) =	NA
dt_2 (min) =	NA	C_D (-) =	NA
T_T (m^2/s) =	1.9E-05	ξ (-) =	NA
S (-) =	3.5E-05		
K_s (m/s) =	1.9E-07		
S_s (1/m) =	3.5E-07		

Comments:

The recommended transmissivity of 1.9•10-5 m2/s was derived from the analysis of the CRwr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 7.0•10-6 m²/s to 7.0•10-5 m²/s. The flow dimension during the test is 2. A static pressure measured at transducer depth was not possible to derive from the CRwr phase due to poor data quality.

APPENDIX 8-2

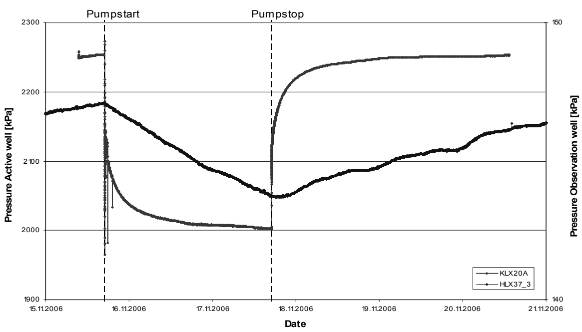
KLX20A Section 250.20 - 306.20 m pumped

Observation Hole
Test Summary Sheets

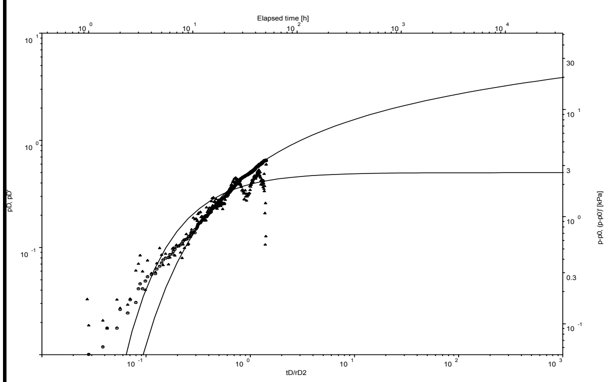
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr Observation hole
Area:	Laxemar	Test no:	1
Borehole ID:	HLX37_3 (KLX20A 99.50-180.00 pumped)	Test start:	211106 10:08
Test section from - to (m):	12.10-117.00	Responsible for test execution:	Stephan Rohs
Distance (m):	190.00	Responsible for test evaluation:	Cristian Enachescu

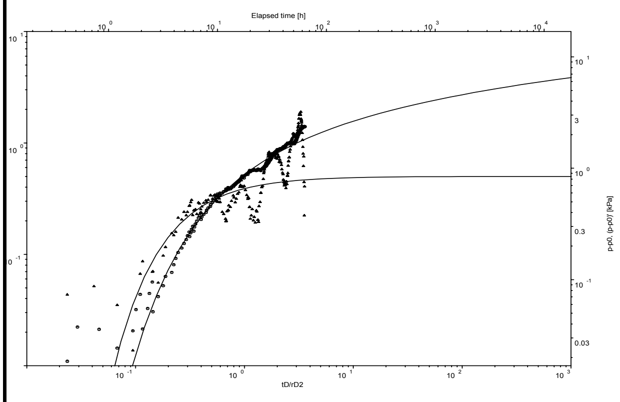
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =			
p_i (kPa) =			
p_p(kPa) =		p_F (kPa) =	
Q_p (m^3/s)=	4.83E-05		
tp (s) =	172800	t_F (s) =	246240
S el S^* (-)=		S el S^* (-)=	
EC_w (mS/m)=			
$Temp_w$(gr C)=			
Derivative fact.=	0.03	Derivative fact.=	0.06
Results		**Results**	
Q/s (m^2/s)=	NA		
T_M (m^2/s)=	NA		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	NA	dt_1 (min) =	NA
dt_2 (min) =	NA	dt_2 (min) =	NA
T (m^2/s) =	1.5E-05	T (m^2/s) =	4.5E-05
S (-) =	5.2E-05	S (-) =	7.9E-05
K_s (m/s) =	1.4E-07	K_s (m/s) =	4.3E-07
S_s (1/m) =	5.0E-07	S_s (1/m) =	7.5E-07
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

Selected representative parameters.

dt_1 (min) =	NA	C (m^3/Pa) =	NA
dt_2 (min) =	NA	C_D (-) =	NA
T_T (m^2/s) =	4.5E-05	ξ (-) =	NA
S (-) =	7.9E-05		
K_s (m/s) =	4.3E-07		
S_s (1/m) =	7.5E-07		

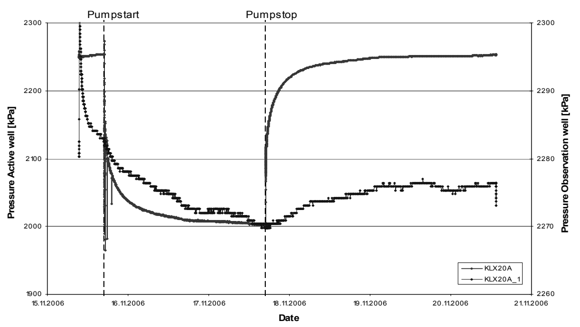
Comments:

The recommended transmissivity of 4.5•10-5 m2/s was derived from the analysis of the CRwr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 9.0•10-6 m²/s to 9.0•10-5 m²/s. The flow dimension during the test is 2. A static pressure measured at transducer depth was not possible to derive from the CRwr phase due to poor data quality.

Test Summary Sheet

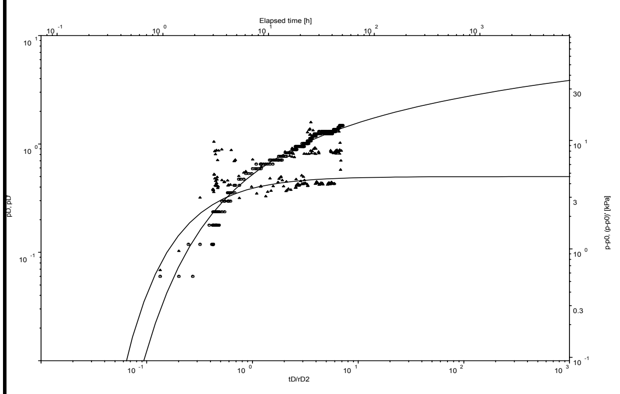
Project:	Oskarshamn site investigation	Test type:[1]	CRwr Observation hole
Area:	Laxemar	Test no:	1
Borehole ID:	KLX20A_1 (KLX20A 99.50-180.00 pumped)	Test start:	211106 10:08
Test section from - to (m):	307.20-457.92	Responsible for test execution:	Stephan Rohs
Distance (m):	112.00	Responsible for test evaluation:	Cristian Enachescu

Linear plot Q and p

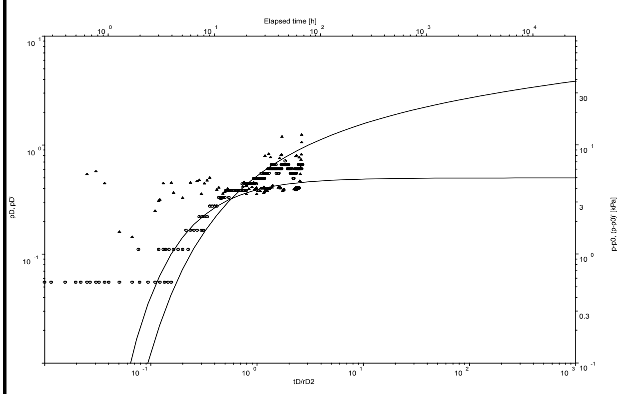


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =			
p_i (kPa) =			
p_p(kPa) =		p_F (kPa) =	
Q_p (m^3/s)=	4.83E-05		
tp (s) =	172800	t_F (s) =	246240
S el S^* (-)=		S el S^* (-)=	
EC_w (mS/m)=			
$Temp_w$(gr C)=			
Derivative fact.=	0.02	Derivative fact.=	0.02
Results		**Results**	
Q/s (m^2/s)=	NA		
T_M (m^2/s)=	NA		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	NA	dt_1 (min) =	NA
dt_2 (min) =	NA	dt_2 (min) =	NA
T (m^2/s) =	8.1E-06	T (m^2/s) =	7.6E-06
S (-) =	1.6E-05	S (-) =	5.5E-05
K_s (m/s) =	5.4E-08	K_s (m/s) =	5.0E-08
S_s (1/m) =	1.1E-07	S_s (1/m) =	3.6E-07
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



Log-Log plot incl. derivatives- recovery 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) =	8.1E-06	ξ (-) =	NA
S (-) =	1.6E-05		
K_s (m/s) =	5.4E-08		
S_s (1/m) =	1.1E-07		

Comments:

The recommended transmissivity of 8.1•10-6 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 4.0•10-6 m²/s to 5.0•10-5 m²/s. The flow dimension during the test is 2. A static pressure measured at transducer depth was not possible to derive from the CRwr phase due to poor data quality.

APPENDIX 9

SICADA data tables

(Observation boreholes)

(Simplified version v1.7)

SICADA/Data Import Template

SKB & Ergodata AB 2005

File Identity		**File Time Zone**	
Created By	Stephan Rohs		
Created	2006-12-04 16:00:00		

Compiled By	
Quality Check For Delivery	
Delivery Approval	

Activity Type	KLX20A KLX20A Interference test-obs.holes
Project	AP PS 400-06-112

Activity Information						**Additional Activity Data**				
						C30	C40	I160	P20	P200
Idcode	**Start Date**	**Stop Date**	**Secup (m)**	**Seclow (m)**	**Section No**	**evaluating data**	**performing field work**	**Instrument**	**Field crew manager**	**Field crew**
HLX36	2006-11-15 09:30:00	2006-11-25 09:27:00	50.00	199.80	1	Golder				
HLX36	2006-11-15 09:30:00	2006-11-25 09:27:00	6.10	49.00	2	Golder				
HLX37	2006-11-15 09:30:00	2006-11-25 09:27:00	149.00	199.80	1	Golder				
HLX37	2006-11-15 09:30:00	2006-11-25 09:27:00	118.00	148.00	2	Golder				
HLX37	2006-11-15 09:30:00	2006-11-25 09:27:00	12.10	117.00	3	Golder				
HLX43	2006-11-15 09:30:00	2006-11-25 09:27:00	21.00	170.50	1	Golder				
HLX43	2006-11-15 09:30:00	2006-11-25 09:27:00	6.00	20.00	2	Golder				
KLX11A	2006-11-15 09:30:00	2006-11-25 09:27:00	12.00	992.00	1	Golder				
KLX11B	2006-11-15 09:30:00	2006-11-25 09:27:00	2.50	100.00	1	Golder				
KLX20A	2006-11-21 10:08:00	2006-11-25 09:27:00	238.00	457.92	1	Golder				
KLX20A	2006-11-21 10:08:00	2006-11-25 09:27:00	181.00	237.00	2	Golder				
KLX20A	2006-11-15 09:30:00	2006-11-20 13:23:00	307.20	457.92	3	Golder				
KLX20A	2006-11-15 09:30:00	2006-11-20 13:23:00	99.50	249.20	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_hp	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_pp	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

			(m)	(m)				(yyyymmdd)	(yyyymmdd)		(m)	(m)	(m)	(m)	(m)	(m)	(m)	
idcode	start_date	stop_date	secup	seclow	section_no	test_type	formation_type	start_flow_period	stop_flow_period	test_borehole	test_secup	test_seclow	lp	radial_distance_rs	initial_head_hi	head_at_flow_end_hp	final_head_hf	comment
HLX36	2006-11-15 09:30:00	2006-11-20 13:23:00	50.00	199.80	1	2	1	061115 16:56:45	061117 16:56:45	KLX20A	250.20	306.20	125.00	196.00	10.93	10.59	11.31	no response due to pumping in source
HLX36	2006-11-15 09:30:00	2006-11-20 13:23:00	6.10	49.00	2	2	1	061116 16:56:45	061118 16:56:45	KLX20A	250.20	306.20	27.00	265.00	11.65	11.59	11.63	no response due to pumping in source
HLX37	2006-11-15 09:30:00	2006-11-20 13:23:00	149.00	199.80	1	2	1	061117 16:56:45	061119 16:56:45	KLX20A	250.20	306.20	175.00	178.00	9.68	9.57	12.55	no response due to pumping in source
HLX37	2006-11-15 09:30:00	2006-11-20 13:23:00	118.00	148.00	2	2	1	061118 16:56:45	061120 16:56:45	KLX20A	250.20	306.20	132.00	182.00	9.66	9.51	12.54	no response due to pumping in source
HLX37	2006-11-15 09:30:00	2006-11-20 13:23:00	12.10	117.00	3	2	1	061119 16:56:45	061121 16:56:45	KLX20A	250.20	306.20	100.00	190.00	14.98	14.65	14.91	response due to pumping in source
HLX43	2006-11-15 09:30:00	2006-11-20 13:23:00	21.00	170.50	1	2	1	061120 16:56:45	061122 16:56:45	KLX20A	250.20	306.20	83.00	1192.00	17.33	17.31	17.31	no response due to pumping in source
HLX43	2006-11-15 09:30:00	2006-11-20 13:23:00	6.00	20.00	2	2	1	061121 16:56:45	061123 16:56:45	KLX20A	250.20	306.20	13.00	1207.00	18.10	18.52	19.12	no response due to pumping in source
KLX11A	2006-11-15 09:30:00	2006-11-20 13:23:00	12.00	992.00	1	2	1	061122 16:56:45	061124 16:56:45	KLX20A	250.20	306.20	250.00	242.00				no response due to pumping in source
KLX11B	2006-11-15 09:30:00	2006-11-20 13:23:00	2.50	100.00	1	2	1	061123 16:56:45	061125 16:56:45	KLX20A	250.20	306.20	50.00	234.00				no response due to pumping in source
KLX20A	2006-11-15 09:30:00	2006-11-20 13:23:00	307.20	457.92	1	2	1	061124 16:56:45	061126 16:56:45	KLX20A	250.20	306.20	382.00	112.00				response due to pumping in source
KLX20A	2006-11-15 09:30:00	2006-11-20 13:23:00	99.50	249.20	3	2	1	061125 16:56:45	061127 16:56:45	KLX20A	250.20	306.20	140.00	130.00				no response due to pumping in source
HLX36	2006-11-21 10:08:00	2006-11-25 09:27:00	50.00	199.80	1	2	1	061121 19:33:00	061123 19:33:00	KLX20A	99.50	180.00	125.00	163.00	11.94	12.02	12.23	no response due to pumping in source
HLX36	2006-11-22 10:08:00	2006-11-26 09:27:00	6.10	49.00	2	2	1	061121 19:33:00	061123 19:33:00	KLX20A	99.50	180.00	27.00	181.00	11.66	11.67	11.70	no response due to pumping in source
HLX37	2006-11-23 10:08:00	2006-11-27 09:27:00	149.00	199.80	1	2	1	061121 19:33:00	061123 19:33:00	KLX20A	99.50	180.00	175.00	161.00	12.88	12.71	13.27	response due to pumping in source
HLX37	2006-11-24 10:08:00	2006-11-28 09:27:00	118.00	148.00	2	2	1	061121 19:33:00	061123 19:33:00	KLX20A	99.50	180.00	132.00	157.00	12.88	12.72	13.27	response due to pumping in source
HLX37	2006-11-25 10:08:00	2006-11-29 09:27:00	12.10	117.00	3	2	1	061121 19:33:00	061123 19:33:00	KLX20A	99.50	180.00	100.00	161.00	14.99	15.12	15.14	no response due to pumping in source
HLX43	2006-11-26 10:08:00	2006-11-30 09:27:00	21.00	170.50	1	2	1	061121 19:33:00	061123 19:33:00	KLX20A	99.50	180.00	83.00	1182.00	17.32	17.30	17.33	no response due to pumping in source
HLX43	2006-11-27 10:08:00	2006-12-01 09:27:00	6.00	20.00	2	2	1	061121 19:33:00	061123 19:33:00	KLX20A	99.50	180.00	13.00	1189.00	19.34	19.54	20.11	no response due to pumping in source
KLX11A	2006-11-28 10:08:00	2006-12-02 09:27:00	12.00	992.00	1	2	1	061121 19:33:00	061123 19:33:00	KLX20A	99.50	180.00	250.00	204.00				response due to pumping in source
KLX11B	2006-11-29 10:08:00	2006-12-03 09:27:00	2.50	100.00	1	2	1	061121 19:33:00	061123 19:33:00	KLX20A	99.50	180.00	50.00	107.00				response due to pumping in source
KLX20A	2006-11-30 10:08:00	2006-12-04 09:27:00	238.00	457.92	1	2	1	061121 19:33:00	061123 19:33:00	KLX20A	99.50	180.00	270.00	130.00				no response due to pumping in source
KLX20A	2006-12-01 10:08:00	2006-12-05 09:27:00	181.00	237.00	2	2	1	061121 19:33:00	061123 19:33:00	KLX20A	99.50	180.00	215.00	75.00				

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

idcode	start_date	stop_date	secup (m)	seclow (m)	section_no	test_borehole	test_secup (m)	test_seclow (m)	formation_width_b (m)	lp (m)	width_of_channel_b (m)	tbo (m**3/s)	l_measl_tbo (m**3/s)	u_measl_tbo (m**3/s)	sbo (m)	leakage_factor_lof (m)	transmissivity_to (m**2/s)	value_type_to
HLX37	2006-11-15 09:30:00	2006-11-20 13:23:00	12.10	117.00	3	KLX20A	250.20	306.20		100.00							4.48E-05	0
KLX20A	2006-11-15 09:30:00	2006-11-20 13:23:00	307.20	467.90	1	KLX20A	250.20	306.20		382.00							8.10E-06	0
HLX37	2006-11-21 10:08:00	2006-11-25 09:27:00	149.00	199.80	1	KLX20A	99.50	180.00		175.00							7.00E-05	0
HLX37	2006-11-21 10:08:00	2006-11-25 09:27:00	118.00	148.00	2	KLX20A	99.50	180.00		132.00							7.05E-05	0
KLX11A	2006-11-21 10:08:00	2006-11-25 09:27:00	12.00	992.00	1	KLX20A	99.50	180.00		250.00							2.87E-05	0
KLX11B	2006-11-21 10:08:00	2006-11-25 09:27:00	2.50	100.00	1	KLX20A	99.50	180.00		50.00							1.88E-05	0

idcode	secup (m)	seclow (m)	l_measl_to (m**2/s)	u_measl_to (m**2/s)	storativity_so	leakage_coeff_o (1/s)	hydr_cond_kosf (m/s)	l_measl_kosf (m/s)	u_measl_kosf (m/s)	spec_storage_sosf (1/m)	dt1 (s)	dt2 (s)	t1 (s)	t2 (s)	dte1 (s)	dte2 (s)	transmissivity_to_nlr (m**2/s)	value_type_to_nlr	storativity_so_nlr	transmissivity_to_grf (m**2/s)	value_type_to_grf	storativity_so_grf	flow_dim_grf_o	comments
HLX37	12.10	117.00	9.00E-06	9.00E-05	7.89E-05						#NV	#NV												
KLX20A	307.20	467.90	4.00E-06	5.00E-05	1.64E-05						#NV	#NV												
HLX37	149.00	199.80	3.00E-05	2.00E-04	1.76E-04						#NV	#NV												
HLX37	118.00	148.00	3.00E-05	2.00E-04	2.07E-04						#NV	#NV												
KLX11A	12.00	992.00	7.00E-06	7.00E-05	2.28E-05						#NV	#NV												
KLX11B	2.50	100.00	7.00E-06	7.00E-05	3.45E-05						#NV	#NV												