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Äspö Hard Rock Laboratory

Prototype Repository

Hydraulic tests and deformation measurements during operation phase

Test campaign 8

Single hole test

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SWECO VIAK

December 2007

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Abstract

The Prototype Repository Test is focused on testing and demonstrating the function of the SKB deep repository system. Activities aimed at contributing to development and testing of the practical, engineering measures required to rationally perform the steps of a deposition sequence are also included in the project but are also part of other projects.

The objective of the single-hole tests is to estimate the transmissivity of the Hydro Mechanical (HM) test sections equipped with deformation sensors.

Single hole tests are done in 8 boreholes of the Prototype Repository tunnel. In some of the holes several tests are made. The pressure change (dp_p) is limited to approximately 100 metres of water, 200 metres of water and finally a maximum possible pressure change (i.e open the flow control valves entirely) respectively.

There are two HM sections in KA3544G01 and KA3550G01, which however could not be tested due to packer system failure. In the G-tunnel there is a hole with a HM-equipped section used as a reference hole. The results are shown in the table below.

The evaluation method according to (Dougherty, Babu, 1984) was used using the software AQTESOLV ver. 4.5. The result from test campaign 8 using the method is shown in the table below.

Table 1. Results from the test campaign 8. (1) Indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign.

Section	HM section	dp_p (m)	Specific capacity (m^2/s)	T_{MOYE} (m^2/s)	T_{eval} (Dougherty & Babu) (m^2/s)	Skin factor (Dougherty & Babu) (-)
KA3550G01:2	X	(1)	(1)	(1)	(1)	(1)
KA3552G01:2	X	max	$1.2 \cdot 10^{-9}$	$8.0 \cdot 10^{-10}$	$8.2 \cdot 10^{-10}$	0
KA3554G01:2	X	~100	$6.6 \cdot 10^{-7}$	$4.2 \cdot 10^{-7}$	$2.7 \cdot 10^{-6}$	18
KA3554G01:2	X	~200	$2.0 \cdot 10^{-7}$	$1.3 \cdot 10^{-7}$	$1.8 \cdot 10^{-6}$	47
KA3554G01:2	X	max	$1.4 \cdot 10^{-7}$	$8.7 \cdot 10^{-8}$	$1.3 \cdot 10^{-6}$	54
KA3554G02:4	X	~100	$1.4 \cdot 10^{-9}$	$9.1 \cdot 10^{-10}$	$1.0 \cdot 10^{-8}$	45
KA3554G02:4	X	max	$2.1 \cdot 10^{-9}$	$1.4 \cdot 10^{-9}$	$1.2 \cdot 10^{-8}$	32
KA3548A01:3	X	~100	$2.4 \cdot 10^{-7}$	$1.6 \cdot 10^{-7}$	$1.2 \cdot 10^{-7}$	-2.8
KA3548A01:3	X	~200	$1.8 \cdot 10^{-7}$	$1.2 \cdot 10^{-7}$	$1.3 \cdot 10^{-7}$	-1.8
KA3548A01:3	X	max	$1.5 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$	$2.2 \cdot 10^{-7}$	-2.2
KA3542G01:3	X	~100	$8.4 \cdot 10^{-8}$	$5.5 \cdot 10^{-8}$	$6.6 \cdot 10^{-8}$	-1.1
KA3542G01:3	X	~200	$6.4 \cdot 10^{-8}$	$4.2 \cdot 10^{-8}$	$7.7 \cdot 10^{-8}$	1.4
KA3542G01:3	X	max	$5.9 \cdot 10^{-8}$	$3.9 \cdot 10^{-8}$	$6.9 \cdot 10^{-8}$	-1.5
KA3544G01:2	X	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	X	~100	$1.0 \cdot 10^{-9}$	$6.5 \cdot 10^{-10}$	$9.6 \cdot 10^{-10}$	0.4
KA3542G02:2	X	max	$9.9 \cdot 10^{-10}$	$6.4 \cdot 10^{-10}$	$9.4 \cdot 10^{-10}$	0
KA3563G:4	-	max	(2)	(2)	(2)	(2)
KA3546G01:2	X	max	$5.3 \cdot 10^{-10}$	$3.4 \cdot 10^{-10}$	$1.2 \cdot 10^{-9}$	10
KA3566G01:2	-	max	(2)	(2)	(2)	(2)
KA3572G01:2	-	max	(2)	(2)	(2)	(2)
KA3574G01:3	-	max	(2)	(2)	(2)	(2)
KA3539G:2	X	~100	$2.5 \cdot 10^{-7}$	$1.6 \cdot 10^{-7}$	$9.1 \cdot 10^{-7}$	-0.5
KA3539G:2	X	max	$2.4 \cdot 10^{-7}$	$1.6 \cdot 10^{-7}$	$9.0 \cdot 10^{-7}$	0

Sammanfattning

Huvudsyftet med prototypförvaret är att testa och demonstrera funktionen av en del av SKB:s djupförvarssystem. Aktiviteter som syftar till utveckling och försök av praktiska och ingenjörsmässiga lösningar, som krävs för att på ett rationellt sätt kunna stegvis utföra deponeringen av kapslar med kärnbränsle, är inkluderade i projektet för prototypförvaret men även i andra projekt.

Målsättningen med enhålstesterna är att få en uppskattning av transmissiviteten hos de hydromekaniska testsektionerna, (HM), som är utrustade med sprickdeformationssensorer.

Enhålstester gjordes i totalt 8 stycken borrhål. Ett nionde och tionde borrhål är utrustad med HM sensorer men har inte kunnat testas på grund av läckageproblem med de hydrauliska manschetterna. I G-tunneln finns ytterligare ett borrhål med en HM sensor installerad. Det hålet används som referenshål. Resultaten från denna testomgång presenteras i tabellen nedan.

Metodiken enligt (Dougherty, Babu, 1984), har använts i samband med utvärderingen av denna testkampanj. Programvaran AQTESOLV ver. 4.5 har använts vid denna utvärdering. Resultat för testomgång 8 presenteras i tabellen nedan

Tabell 1. Resultat från testomgång 8. [(1)] indikerar läckageproblem med manschetterna, "-" indikerar att inget värde kunnat beräknas med valt utvärderingsmetod. [(2)] indikerar att ingen test gjordes i detta borrhål denna testkampanj.

Sektion	**HM sektion**	**dp_p (m)**	**Specifik kapacitet ($m^3/s \cdot m$)**	**T_{MOYE} (m^2/s)**	**T_{eval} (Dougherty & Babu) (m^2/s)**	**Skinfaktor (Dougherty & Babu) (-)**
KA3550G01:2	X	(1)	(1)	(1)	(1)	(1)
KA3552G01:2	X	max	$1.2 \cdot 10^{-9}$	$8.0 \cdot 10^{-10}$	$8.2 \cdot 10^{-10}$	0
KA3554G01:2	X	~100	$6.6 \cdot 10^{-7}$	$4.2 \cdot 10^{-7}$	$2.7 \cdot 10^{-6}$	18
KA3554G01:2	X	~200	$2.0 \cdot 10^{-7}$	$1.3 \cdot 10^{-7}$	$1.8 \cdot 10^{-6}$	47
KA3554G01:2	X	max	$1.4 \cdot 10^{-7}$	$8.7 \cdot 10^{-8}$	$1.3 \cdot 10^{-6}$	54
KA3554G02:4	X	~100	$1.4 \cdot 10^{-9}$	$9.1 \cdot 10^{-10}$	$1.0 \cdot 10^{-8}$	45
KA3554G02:4	X	max	$2.1 \cdot 10^{-9}$	$1.4 \cdot 10^{-9}$	$1.2 \cdot 10^{-8}$	32
KA3548A01:3	X	~100	$2.4 \cdot 10^{-7}$	$1.6 \cdot 10^{-7}$	$1.2 \cdot 10^{-7}$	-2.8
KA3548A01:3	X	~200	$1.8 \cdot 10^{-7}$	$1.2 \cdot 10^{-7}$	$1.3 \cdot 10^{-7}$	-1.8
KA3548A01:3	X	max	$1.5 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$	$2.2 \cdot 10^{-7}$	-2.2
KA3542G01:3	X	~100	$8.4 \cdot 10^{-8}$	$5.5 \cdot 10^{-8}$	$6.6 \cdot 10^{-8}$	-1.1
KA3542G01:3	X	~200	$6.4 \cdot 10^{-8}$	$4.2 \cdot 10^{-8}$	$7.7 \cdot 10^{-8}$	1.4
KA3542G01:3	X	max	$5.9 \cdot 10^{-8}$	$3.9 \cdot 10^{-8}$	$6.9 \cdot 10^{-8}$	-1.5
KA3544G01:2	X	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	X	~100	$1.0 \cdot 10^{-9}$	$6.5 \cdot 10^{-10}$	$9.6 \cdot 10^{-10}$	0.4
KA3542G02:2	X	max	$9.9 \cdot 10^{-10}$	$6.4 \cdot 10^{-10}$	$9.4 \cdot 10^{-10}$	0
KA3563G:4	-	max	(2)	(2)	(2)	(2)
KA3546G01:2	X	max	$5.3 \cdot 10^{-10}$	$3.4 \cdot 10^{-10}$	$1.2 \cdot 10^{-9}$	10
KA3566G01:2	-	max	(2)	(2)	(2)	(2)
KA3572G01:2	-	max	(2)	(2)	(2)	(2)
KA3574G01:3	-	max	(2)	(2)	(2)	(2)
KA3539G:2	X	~100	$2.5 \cdot 10^{-7}$	$1.6 \cdot 10^{-7}$	$9.1 \cdot 10^{-7}$	-0.5
KA3539G:2	X	max	$2.4 \cdot 10^{-7}$	$1.6 \cdot 10^{-7}$	$9.0 \cdot 10^{-7}$	0

Executive Summary

In Tables 1 to 4 below is a summary of the test results of the single hole tests so far. In the heading of each test campaign column is indicated the number of days since the heaters in canister hole 5 (DA3551G01) were turned on.

An evaluation method (Dougherty, Babu, 1984) has replaced the earlier used method. The software AQTESOLV ver. 4.5 has been used. All data from the earlier test campaigns 1–7 were re-evaluated using Dougherty & Babu model and presented in (Forsmark, 2007) and are considered as the results that should prevail from now on (2007).

Table 1. Specific capacity. For each test campaign is indicated the number of days since starting of the heaters in canister hole 5 (2003-05-08). (1) indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign.

Section	dp_p (m)	Test campaign 1 (-0 days) (m^3/s·m)	Test campaign 2 (-166 days) (m^3/s·m)	Test campaign 3 (-270 days) (m^3/s·m)	Test campaign 4 (-461 days) (m^3/s·m)	Test campaign 5 (-622 days) (m^3/s·m)	Test campaign 6 (-935 days) (m^3/s·m)	Test campaign 7 (-1236 days) (m^3/s·m)	Test campaign 8 (-1625 days) (m^3/s·m)
KA3550G01:2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3552G01:2	max	$9.4 \cdot 10^{-9}$	$1.6 \cdot 10^{-9}$	$1.4 \cdot 10^{-9}$	$5.8 \cdot 10^{-9}$	$1.4 \cdot 10^{-9}$	$1.5 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$
KA3554G01:2	~100	(2)	(2)	(2)	$1.0 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$9.7 \cdot 10^{-8}$	$1.1 \cdot 10^{-7}$	$6.6 \cdot 10^{-7}$
KA3554G01:2	~200	(2)	(2)	(2)	$8.8 \cdot 10^{-8}$	$8.9 \cdot 10^{-8}$	$8.4 \cdot 10^{-8}$	$9.3 \cdot 10^{-8}$	$2.0 \cdot 10^{-7}$
KA3554G01:2	max	$8.2 \cdot 10^{-8}$	$8.3 \cdot 10^{-8}$	$7.8 \cdot 10^{-8}$	$7.9 \cdot 10^{-8}$	$7.7 \cdot 10^{-8}$	$7.7 \cdot 10^{-8}$	$8.1 \cdot 10^{-8}$	$1.4 \cdot 10^{-7}$
KA3554G02:4	~100	(2)	(2)	(2)	$1.2 \cdot 10^{-9}$	$1.3 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.3 \cdot 10^{-9}$	$1.4 \cdot 10^{-9}$
KA3554G02:4	max	$1.3 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.4 \cdot 10^{-9}$	$1.8 \cdot 10^{-9}$	$2.1 \cdot 10^{-9}$
KA3548A01:3	~100	(2)	(2)	(2)	(2)	$1.1 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$	$2.4 \cdot 10^{-7}$
KA3548A01:3	~200	(2)	(2)	(2)	(2)	$1.1 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$	$9.3 \cdot 10^{-8}$	$1.8 \cdot 10^{-7}$
KA3548A01:3	max	$1.1 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$9.8 \cdot 10^{-8}$	$1.0 \cdot 10^{-7}$	$9.3 \cdot 10^{-8}$	$8.8 \cdot 10^{-8}$	$1.5 \cdot 10^{-7}$
KA3542G01:3	~100	(2)	(2)	(2)	$5.8 \cdot 10^{-8}$	$5.9 \cdot 10^{-8}$	$6.9 \cdot 10^{-8}$	$5.2 \cdot 10^{-8}$	$8.4 \cdot 10^{-8}$
KA3542G01:3	~200	(2)	(2)	(2)	$4.9 \cdot 10^{-8}$	$5.4 \cdot 10^{-8}$	$5.4 \cdot 10^{-8}$	$5.0 \cdot 10^{-8}$	$6.4 \cdot 10^{-8}$
KA3542G01:3	max	$5.4 \cdot 10^{-8}$	$4.9 \cdot 10^{-8}$	$4.7 \cdot 10^{-8}$	$4.5 \cdot 10^{-8}$	$4.7 \cdot 10^{-8}$	$4.4 \cdot 10^{-8}$	$4.6 \cdot 10^{-8}$	$5.9 \cdot 10^{-8}$
KA3544G01:2	(1)	$7.8 \cdot 10^{-10}$	$5.9 \cdot 10^{-10}$	(1)	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	~100	(2)	(2)	(2)	(2)	$9.5 \cdot 10^{-10}$	$9.5 \cdot 10^{-10}$	$9.5 \cdot 10^{-10}$	$1.0 \cdot 10^{-9}$
KA3542G02:2	max	$5.4 \cdot 10^{-10}$	$4.9 \cdot 10^{-10}$	$1.0 \cdot 10^{-9}$	$9.8 \cdot 10^{-10}$	$9.9 \cdot 10^{-10}$	$9.7 \cdot 10^{-10}$	$1.1 \cdot 10^{-9}$	$9.9 \cdot 10^{-10}$
KA3563G:4	max	$1.7 \cdot 10^{-8}$	(2)	(2)	(2)	$9.3 \cdot 10^{-9}$	(2)	(2)	(2)
KA3546G01:2	max	$6.1 \cdot 10^{-10}$	$6.0 \cdot 10^{-10}$	$6.4 \cdot 10^{-10}$	$5.7 \cdot 10^{-10}$	$5.9 \cdot 10^{-11}$	$5.1 \cdot 10^{-10}$	$5.2 \cdot 10^{-10}$	$5.3 \cdot 10^{-10}$
KA3566G01:2	max	$6.8 \cdot 10^{-10}$	(2)	(2)	(2)	$6.4 \cdot 10^{-11}$	(2)	(2)	(2)
KA3572G01:2	max	$1.9 \cdot 10^{-10}$	(2)	(2)	(2)	$2.3 \cdot 10^{-10}$	(2)	(2)	(2)
KA3574G01:3	max	$8.7 \cdot 10^{-10}$	(2)	(2)	(2)	$1.9 \cdot 10^{-10}$	(2)	(2)	(2)
KA3539G:2	~100	(2)	(2)	(2)	$2.3 \cdot 10^{-7}$	$2.2 \cdot 10^{-7}$	$2.1 \cdot 10^{-7}$	$1.9 \cdot 10^{-7}$	$2.5 \cdot 10^{-7}$
KA3539G:2	max	$1.9 \cdot 10^{-7}$	$3.0 \cdot 10^{-7}$	$2.2 \cdot 10^{-7}$	$2.3 \cdot 10^{-7}$	$1.5 \cdot 10^{-7}$	$1.9 \cdot 10^{-7}$	$1.7 \cdot 10^{-7}$	$2.4 \cdot 10^{-7}$

Table 2. T_{MOYE} . For each test campaign is indicated the number of days since the starting of the heaters in canister hole 5 (2003-05-08). (1) indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign.

Section	dp_p (m)	Test campaign 1 (-0 days) (m^2/s)	Test campaign 2 (-166 days) (m^2/s)	Test campaign 3 (-270 days) (m^2/s)	Test campaign 4 (-461 days) (m^2/s)	Test campaign 5 (-622 days) (m^2/s)	Test campaign 6 (-935 days) (m^2/s)	Test campaign 7 (-1236 days) (m^2/s)	Test campaign 8 (-1625 days) (m^2/s)
KA3550G01:2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3552G01:2	max	$8.8 \cdot 10^{-9}$	$1.0 \cdot 10^{-9}$	$8.8 \cdot 10^{-10}$	$3.8 \cdot 10^{-9}$	$8.9 \cdot 10^{-10}$	$9.9 \cdot 10^{-10}$	$8.0 \cdot 10^{-10}$	$8.0 \cdot 10^{-10}$
KA3554G01:2	~100	(2)	(2)	(2)	$6.5 \cdot 10^{-8}$	$7.2 \cdot 10^{-8}$	$6.2 \cdot 10^{-8}$	$7.1 \cdot 10^{-8}$	$4.2 \cdot 10^{-7}$
KA3554G01:2	~200	(2)	(2)	(2)	$5.6 \cdot 10^{-8}$	$5.7 \cdot 10^{-8}$	$5.4 \cdot 10^{-8}$	$6.0 \cdot 10^{-8}$	$1.3 \cdot 10^{-7}$
KA3554G01:2	max	$5.2 \cdot 10^{-8}$	$5.3 \cdot 10^{-8}$	$5.0 \cdot 10^{-8}$	$5.1 \cdot 10^{-8}$	$4.9 \cdot 10^{-8}$	$4.9 \cdot 10^{-8}$	$5.2 \cdot 10^{-8}$	$8.7 \cdot 10^{-8}$
KA3554G02:4	~100	(2)	(2)	(2)	$8.2 \cdot 10^{-10}$	$8.2 \cdot 10^{-10}$	$7.5 \cdot 10^{-10}$	$8.6 \cdot 10^{-10}$	$9.1 \cdot 10^{-10}$
KA3554G02:4	max	$8.2 \cdot 10^{-10}$	$7.9 \cdot 10^{-10}$	$7.9 \cdot 10^{-10}$	$7.5 \cdot 10^{-10}$	$8.0 \cdot 10^{-10}$	$9.1 \cdot 10^{-10}$	$1.2 \cdot 10^{-9}$	$1.4 \cdot 10^{-9}$
KA3548A01:3	~100	(2)	(2)	(2)	(2)	$7.4 \cdot 10^{-8}$	$7.5 \cdot 10^{-8}$	$6.8 \cdot 10^{-8}$	$1.6 \cdot 10^{-7}$
KA3548A01:3	~200	(2)	(2)	(2)	(2)	$7.7 \cdot 10^{-8}$	$6.8 \cdot 10^{-8}$	$6.3 \cdot 10^{-8}$	$1.2 \cdot 10^{-7}$
KA3548A01:3	max	$7.1 \cdot 10^{-8}$	$6.9 \cdot 10^{-8}$	$6.9 \cdot 10^{-8}$	$6.6 \cdot 10^{-8}$	$6.9 \cdot 10^{-8}$	$6.3 \cdot 10^{-8}$	$5.9 \cdot 10^{-8}$	$1.0 \cdot 10^{-7}$
KA3542G01:3	~100	(2)	(2)	(2)	$3.8 \cdot 10^{-8}$	$3.9 \cdot 10^{-8}$	$4.5 \cdot 10^{-8}$	$3.4 \cdot 10^{-8}$	$5.5 \cdot 10^{-8}$
KA3542G01:3	~200	(2)	(2)	(2)	$3.3 \cdot 10^{-8}$	$3.5 \cdot 10^{-8}$	$3.5 \cdot 10^{-8}$	$3.3 \cdot 10^{-8}$	$4.2 \cdot 10^{-8}$
KA3542G01:3	max	$3.6 \cdot 10^{-8}$	$3.2 \cdot 10^{-8}$	$3.1 \cdot 10^{-8}$	$3.1 \cdot 10^{-8}$	$3.0 \cdot 10^{-8}$	$2.9 \cdot 10^{-8}$	$3.0 \cdot 10^{-8}$	$3.9 \cdot 10^{-8}$
KA3544G01:2	(1)	$5.1 \cdot 10^{-10}$	$3.6 \cdot 10^{-10}$	(1)	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	~100	(2)	(2)	(2)	(2)	$6.1 \cdot 10^{-10}$	$6.1 \cdot 10^{-10}$	$6.1 \cdot 10^{-10}$	$6.5 \cdot 10^{-10}$
KA3542G02:2	max	$3.5 \cdot 10^{-10}$	$3.1 \cdot 10^{-10}$	$6.4 \cdot 10^{-10}$	$6.3 \cdot 10^{-10}$	$6.4 \cdot 10^{-10}$	$6.2 \cdot 10^{-10}$	$6.8 \cdot 10^{-10}$	$6.4 \cdot 10^{-10}$
KA3563G:4	max	$5.6 \cdot 10^{-9}$	(2)	(2)	(2)	$5.9 \cdot 10^{-9}$	(2)	(2)	(2)
KA3546G01:2	max	$3.9 \cdot 10^{-10}$	$3.9 \cdot 10^{-10}$	$4.1 \cdot 10^{-10}$	$3.6 \cdot 10^{-10}$	$3.6 \cdot 10^{-11}$	$3.3 \cdot 10^{-10}$	$3.3 \cdot 10^{-10}$	$3.4 \cdot 10^{-10}$
KA3566G01:2	max	$4.4 \cdot 10^{-10}$	(2)	(2)	(2)	$4.1 \cdot 10^{-11}$	(2)	(2)	(2)
KA3572G01:2	max	$1.3 \cdot 10^{-10}$	(2)	(2)	(2)	$1.6 \cdot 10^{-10}$	(2)	(2)	(2)
KA3574G01:3	max	$6.1 \cdot 10^{-10}$	(2)	(2)	(2)	$1.4 \cdot 10^{-10}$	(2)	(2)	(2)
KA3539G:2	~100	(2)	(2)	(2)	$1.5 \cdot 10^{-7}$	$1.4 \cdot 10^{-7}$	$1.4 \cdot 10^{-7}$	$1.2 \cdot 10^{-7}$	$1.6 \cdot 10^{-7}$
KA3539G:2	max	$1.3 \cdot 10^{-7}$	$2.0 \cdot 10^{-7}$	$1.5 \cdot 10^{-7}$	$1.5 \cdot 10^{-7}$	$1.0 \cdot 10^{-7}$	$1.3 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$1.6 \cdot 10^{-7}$

Table 3. Transmissivity – transient evaluation according to (Dougherty, Babu, 1984). For each test campaign is indicated the number of days since the starting of the heaters in canister hole 5 (2003-05-08). (1) indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign.

Section	dp_p (m)	Test campaign 1 (-0 days) (m^2/s)	Test campaign 2 (-166 days) (m^2/s)	Test campaign 3 (-270 days) (m^2/s)	Test campaign 4 (-461 days) (m^2/s)	Test campaign 5 (-622 days) (m^2/s)	Test campaign 6 (-935 days) (m^2/s)	Test campaign 7 (-1236 days) (m^2/s)	Test campaign 8 (-1625 days) (m^2/s)
KA3550G01:2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3552G01:2	max	$4.2 \cdot 10^{-9}$	$1.3 \cdot 10^{-9}$	$9.5 \cdot 10^{-10}$	$8.1 \cdot 10^{-10}$	$7.4 \cdot 10^{-10}$	$4.5 \cdot 10^{-10}$	$8.0 \cdot 10^{-10}$	$8.2 \cdot 10^{-10}$
KA3554G01:2	~100	(2)	(2)	(2)	$5.7 \cdot 10^{-7}$	$5.3 \cdot 10^{-7}$	$5.3 \cdot 10^{-7}$	$5.3 \cdot 10^{-7}$	$2.7 \cdot 10^{-6}$
KA3554G01:2	~200	(2)	(2)	(2)	$5.3 \cdot 10^{-7}$	$4.9 \cdot 10^{-7}$	$4.8 \cdot 10^{-7}$	$4.6 \cdot 10^{-7}$	$1.8 \cdot 10^{-6}$
KA3554G01:2	max	$6.4 \cdot 10^{-7}$	$6.4 \cdot 10^{-7}$	$5.8 \cdot 10^{-7}$	$4.9 \cdot 10^{-7}$	$4.6 \cdot 10^{-7}$	$4.5 \cdot 10^{-7}$	$4.4 \cdot 10^{-7}$	$1.3 \cdot 10^{-6}$
KA3554G02:4	~100	(2)	(2)	(2)	$7.0 \cdot 10^{-9}$	$9.0 \cdot 10^{-9}$	$1.7 \cdot 10^{-8}$	$1.1 \cdot 10^{-8}$	$1.0 \cdot 10^{-8}$
KA3554G02:4	max	$2.1 \cdot 10^{-8}$	$2.0 \cdot 10^{-8}$	$1.9 \cdot 10^{-8}$	$1.2 \cdot 10^{-8}$	$1.1 \cdot 10^{-8}$	$1.7 \cdot 10^{-8}$	$1.1 \cdot 10^{-8}$	$1.2 \cdot 10^{-8}$
KA3548A01:3	~100	(2)	(2)	(2)	(2)	$1.0 \cdot 10^{-7}$	$9.0 \cdot 10^{-8}$	$8.0 \cdot 10^{-8}$	$1.2 \cdot 10^{-7}$
KA3548A01:3	~200	(2)	(2)	(2)	(2)	$1.2 \cdot 10^{-7}$	$1.2 \cdot 10^{-7}$	$8.3 \cdot 10^{-8}$	$1.3 \cdot 10^{-7}$
KA3548A01:3	max	$1.1 \cdot 10^{-7}$	$1.3 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$1.1 \cdot 10^{-7}$	$9.1 \cdot 10^{-8}$	$8.6 \cdot 10^{-8}$	$2.2 \cdot 10^{-7}$
KA3542G01:3	~100	(2)	(2)	(2)	$4.4 \cdot 10^{-8}$	$5.8 \cdot 10^{-8}$	$6.6 \cdot 10^{-8}$	$4.7 \cdot 10^{-8}$	$6.6 \cdot 10^{-8}$
KA3542G01:3	~200	(2)	(2)	(2)	$4.8 \cdot 10^{-8}$	$4.2 \cdot 10^{-8}$	$6.5 \cdot 10^{-8}$	$4.0 \cdot 10^{-8}$	$7.7 \cdot 10^{-8}$
KA3542G01:3	max	$4.5 \cdot 10^{-8}$	$3.0 \cdot 10^{-8}$	$5.5 \cdot 10^{-8}$	$3.1 \cdot 10^{-8}$	$3.5 \cdot 10^{-8}$	$4.4 \cdot 10^{-8}$	$3.8 \cdot 10^{-8}$	$6.9 \cdot 10^{-8}$
KA3544G01:2	(1)	$1.1 \cdot 10^{-8}$	$7.4 \cdot 10^{-9}$	(1)	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	~100	(2)	(2)	(2)	(2)	$1.0 \cdot 10^{-9}$	$9.6 \cdot 10^{-10}$	$9.0 \cdot 10^{-10}$	$9.6 \cdot 10^{-10}$
KA3542G02:2	max	$3.6 \cdot 10^{-10}$	$2.7 \cdot 10^{-10}$	$9.3 \cdot 10^{-10}$	$8.7 \cdot 10^{-10}$	$8.6 \cdot 10^{-10}$	$6.1 \cdot 10^{-10}$	$4.6 \cdot 10^{-10}$	$9.4 \cdot 10^{-10}$
KA3563G:4	max	$1.7 \cdot 10^{-7}$	(2)	(2)	(2)	$5.1 \cdot 10^{-8}$	(2)	(2)	(2)
KA3546G01:2	max	$6.8 \cdot 10^{-10}$	$1.4 \cdot 10^{-9}$	$1.2 \cdot 10^{-9}$	$1.1 \cdot 10^{-9}$	$1.3 \cdot 10^{-9}$	$1.4 \cdot 10^{-9}$	$9.6 \cdot 10^{-10}$	$1.2 \cdot 10^{-9}$
KA3566G01:2	max	*$1.3 \cdot 10^{-10}$*	(2)	(2)	(2)	*$3.3 \cdot 10^{-10}$*	(2)	(2)	(2)
KA3572G01:2	max	*$3.5 \cdot 10^{-9}$*	(2)	(2)	(2)	*$1.4 \cdot 10^{-8}$*	(2)	(2)	(2)
KA3574G01:3	max	-	(2)	(2)	(2)	-	(2)	(2)	(2)
KA3539G:2	~100	(2)	(2)	(2)	$1.1 \cdot 10^{-6}$	$1.2 \cdot 10^{-6}$	$8.8 \cdot 10^{-7}$	$6.3 \cdot 10^{-7}$	$9.1 \cdot 10^{-7}$
KA3539G:2	max	$1.3 \cdot 10^{-6}$	$1.5 \cdot 10^{-6}$	$1.1 \cdot 10^{-6}$	$1.0 \cdot 10^{-6}$	$9.8 \cdot 10^{-7}$	$9.6 \cdot 10^{-7}$	$7.2 \cdot 10^{-7}$	$9.0 \cdot 10^{-7}$

Table 4. Skin factor – according to (Dougherty, Babu, 1984). For each test campaign is indicated the number of days since the starting of the heaters in canister hole 5 (2003-05-08). (1) indicates packer system failure, "-" indicates it is not possible to evaluate any value with selected method. (2) indicates no tests are done this test campaign.

Section	dp_p (m)	Test campaign 1 (-0 days) (-)	Test campaign 2 (-166 days) (-)	Test campaign 3 (-270 days) (-)	Test campaign 4 (-461 days) (-)	Test campaign 5 (-622 days) (-)	Test campaign 6 (-935 days) (-)	Test campaign 7 (-1236 days) (-)	Test campaign 8 (-1625 days) (-)
KA3550G01:2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
KA3552G01:2	max	1.1	-0.5	-0.7	-0.9	-0.4	-1.9	-0.2	0
KA3554G01:2	~100	(2)	(2)	(2)	26	24	25	20	18
KA3554G01:2	~200	(2)	(2)	(2)	30	28	28	22	47
KA3554G01:2	max	43	42	39	32	30	29	26	54
KA3554G02:4	~100	(2)	(2)	(2)	30	38	90	50	45
KA3554G02:4	max	100	95	94	58	73	68	35	32
KA3548A01:3	~100	(2)	(2)	(2)	(2)	-1.4	-2.1	-2.5	-2.8
KA3548A01:3	~200	(2)	(2)	(2)	(2)	-1.1	-0.6	-1.8	-1.8
KA3548A01:3	max	0.2	1.1	-1.2	-0.1	-0.4	-1	-1.3	-2.2
KA3542G01:3	~100	(2)	(2)	(2)	-1	-0.1	-1	-1.5	-1.1
KA3542G01:3	~200	(2)	(2)	(2)	0.3	-0.9	1.1	-1.5	1.4
KA3542G01:3	max	0.1	-1	1.5	-0.9	-0.7	0.2	-0.7	-1.5
KA3544G01:2	(1)	90	100	(1)	(1)	(1)	(1)	(1)	(1)
KA3542G02:2	~100	(2)	(2)	(2)	(2)	0.8	-0.1	0.6	0.4
KA3542G02:2	max	0.4	-0.5	0.1	0.1	-0.1	-0.9	-1.1	0
KA3563G:4	max	-	(2)	(2)	(2)	31	(2)	(2)	(2)
KA3546G01:2	max	6	10	7	8	9	11	8	10
KA3566G01:2	max	-	(2)	(2)	(2)	0.1	(2)	(2)	(2)
KA3572G01:2	max	-	(2)	(2)	(2)	-	(2)	(2)	(2)
KA3574G01:3	max	-	(2)	(2)	(2)	-	(2)	(2)	(2)
KA3539G:2	~100	(2)	(2)	(2)	1.8	2.1	-0.6	-1.5	-0.5
KA3539G:2	max	3.6	5.7	2.7	1.7	1	0.7	-0.8	0

Contents

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1 Background

1.1 Äspö Hard Rock Laboratory

In order to prepare for the localization and licensing of a spent fuel repository SKB has constructed an underground research laboratory.

In the autumn of 1990, SKB began the construction of Äspö Hard Rock Laboratory (Äspö HRL), see Figure 1-1, near Oskarshamn in the southeastern part of Sweden. A 3.6 km long tunnel was excavated in crystalline rock down to a depth of approximately 460 m.

The laboratory was completed in 1995 and research concerning the disposal of nuclear waste in crystalline rock has since then been carried out.

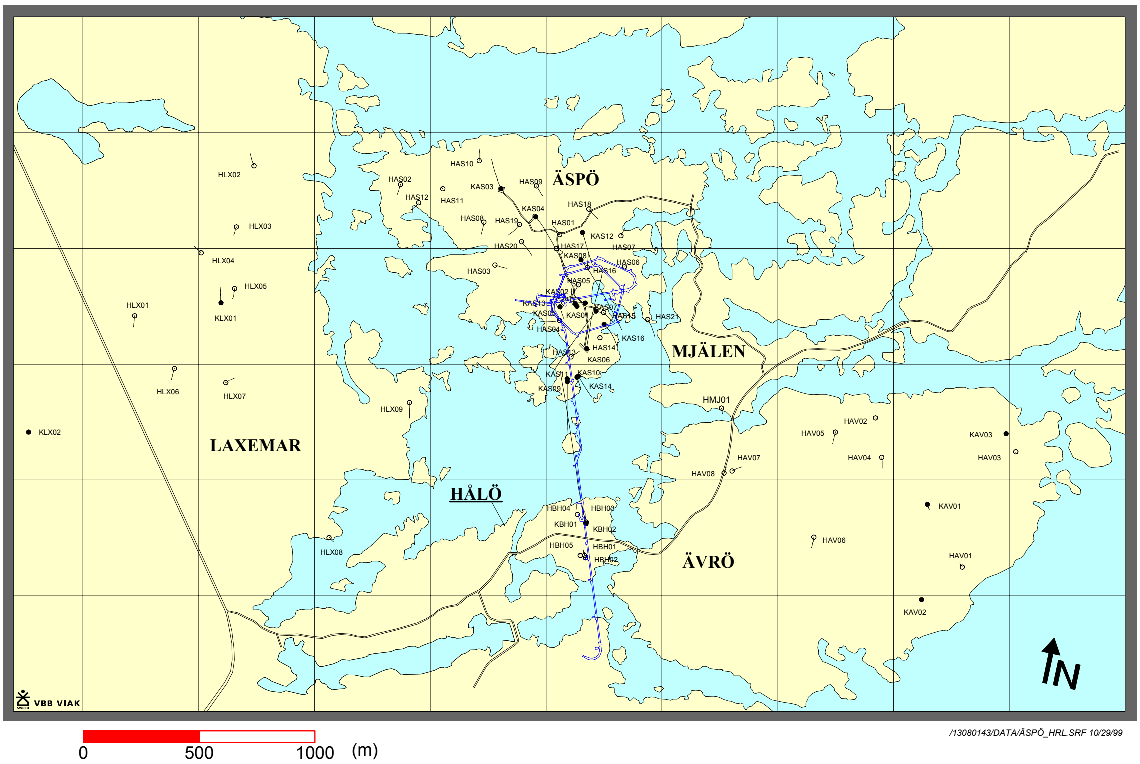


Figure 1-1. Äspö Hard Rock Laboratory.

1.2 Prototype Repository

The Äspö Hard Rock Laboratory is an essential part of the research, development, and demonstration work performed by SKB in preparation for construction and operation of the deep repository for spent fuel. Within the scope of the SKB program for RD&D 1995, SKB has decided to carry out a project with the designation "Prototype Repository Test". The aim of the project is to test important components in the SKB deep repository system in full scale and in a realistic environment.

The Prototype Repository Test is focused on testing and demonstrating the function of the SKB deep repository system. Activities aimed at contributing to development and testing of the practical, engineering measures required to rationally perform the steps of a deposition sequence are also included. However, efforts in this direction are limited, since these matters are addressed in the Demonstration of Repository Technology project and to some extent in the Backfill and Plug Test.

1.2.1 General objectives

The Prototype Repository should simulate as many aspects as possible a real repository, for example regarding geometry, materials, and rock environment. The Prototype Repository is a demonstration of the integrated function of the repository components. Results will be compared with models and assumptions to their validity.

The major objectives for the Prototype Repository are:

- To test and demonstrate the integrated function of the repository components under realistic conditions in full scale and to compare results with models and assumptions.
- To develop, test and demonstrate appropriate engineering standards and quality assurance methods.
- To simulate appropriate parts of the repository design and construction process.

The objective for the operation phase program is:

- To monitor processes and properties in the canister, buffer material, backfill and near-field rock mass

2 Objective

The objective of the single-hole tests is to estimate the transmissivity of the Hydro Mechanical (HM) test sections equipped with deformation sensors, *(Alm et al, 2005)*.

3 Scope

Single hole tests are done in 8 boreholes of the Prototype Repository tunnel. There are two more HM sections in KA3544G01 and KA3550G01, which however could not be tested due to packer system failure. In the G-tunnel there is a hole with a HM-equipped section to be used as a reference hole. The tested intervals and basic test data are listed in Table 3-1. The first figure in the test number indicates this being the seventh single hole test campaign, while the second number indicates the chronological order of the single hole tests. The same numbering of the tests as used during test campaign 1 to 7 is used *(Forsmark et al, 2004), (Forsmark, Rhén, 2004a, 2004b, 2004c, 2005a, 2005b, 2005c), (Forsmark,2006), (Forsmark. 2007)*. Also indicated in the table are the sections where Hydro Mechanical (HM) measurements are done. In chapter 6 the results of the tests are presented.

In some of the holes several tests are made. The pressure change (dp_p) is limited to approximately 100 metres of water, approximately 200 metres of water and finally a maximum possible pressure change (i.e open the flow control valves entirely) respectively.

Table 3-1. Single hole tests during the campaign in October 2007.
(1) indicates packer system failure, "X" indicates that section is equipped with HM sensors. (2) indicates no test is done in this campaign.

Bore hole	Section (m)	HM section	Single hole test no.	Date of test	Start of test	Flow start	Flow stop	Test stop
KA3550G01:2(1)	5.20-7.30	X	- (1)	-	-	-	-	-
KA3552G01:2	4.35-6.05	X	8:1	2007-10-18	07:30:00	08:30:30	10:30:00	11:30:00
KA3554G01:2	22.60-24.15	X	8:2a	2007-10-15	14:40:00	15:41:00	17:40:00	18:40:00
KA3554G01:2	22.60-24.15	X	8:2b	2007-10-16	09:00:00	10:00:00	12:00:00	13:00:00
KA3554G01:2	22.60-24.15	X	8:2c	2007-10-17	07:30:00	08:30:00	10:30:00	11:30:00
KA3554G02:4	10.50-12.20	X	8:3a	2007-10-16	06:00:00	07:00:00	09:00:00	10:00:00
KA3554G02:4	10.50-12.20	X	8:3b	2007-10-17	10:30:00	11:30:00	13:30:00	14:30:00
KA3548A01:3	8.80-10.75	X	8:4a	2007-10-16	14:20:00	15:20:00	16:20:00	17:20:00
KA3548A01:3	8.80-10.75	X	8:4b	2007-10-17	05:30:00	06:30:00	07:30:00	08:30:00
KA3548A01:3	8.80-10.75	X	8:4c	2007-10-18	05:30:00	06:30:00	07:30:00	08:30:00
KA3542G01:3	18.60-20.30	X	8:5a	2007-10-15	19:40:00	20:40:00	21:40:00	23:40:00
KA3542G01:3	18.60-20.30	X	8:5b	2007-10-16	19:20:00	20:20:00	21:20:00	23:20:00
KA3542G01:3	18.60-20.30	X	8:5c	2007-10-17	15:35:00	16:35:00	17:35:00	19:35:00
KA3544G01:2(1)	8.90-10.65	X	- (1)	-	-	-	-	-
KA3542G02:2	25.60-27.20	X	8:7a	2007-10-18	13:30:00	14:30:00	17:30:00	19:00:00
KA3542G02:2	25.60-27.20	X	8:7b	2007-10-19	04:50:00	05:50:00	08:50:00	10:20:00
KA3563G:4	1.50-3.00	-	- (2)	-	-	-	-	-
KA3546G01:2	6.75-8.30	X	8:9	2007-10-17	10:35:00	11:35:00	14:35:05	16:05:00
KA3566G01:2	20.00-21.50	-	- (2)	-	-	-	-	-
KA3572G01:2	2.70-5.30	-	- (2)	-	-	-	-	-
KA3574G01:3	1.80-4.10	-	- (2)	-	-	-	-	-
KA3539G:2	15.85-17.60	X	8:13a	2007-10-15	17:40:00	18:40:00	19:40:00	20:40:00
KA3539G:2	15.85-17.60	X	8:13b	2007-10-16	12:00:00	13:00:00	14:00:00	15:00:00

4 Equipment

4.1 Description of equipment

A large number of boreholes are instrumented with one or several packers. In all packed-off sections, the water pressure is measured. Each borehole section is connected to a tube of polyamide that via lead-through holes ends in the G-tunnel. All pressure transducers are placed in the G-tunnel to facilitate easy calibration and exchange of transducers that are out of order. The transducers are connected to the HMS system at Äspö Laboratory and it is a flexible system for changing the sampling frequency, see Figure 4-1. The maximum scan frequency is every third second. During periods with no hydraulic tests, the sampling (storing a value in the data base) frequency will be every second hour with an automatic increase of the sampling frequency if the pressure change since last registration is larger than 2kPa. During hydraulic tests, the sampling frequency may be up to every third second.

Figure 4-1. *All pressure transducers are connected to the HMS system. In the G-tunnel there is a computer in the HMS system where logging frequencies easily can be changed.*

4.2 Pressure sensors

The pressure in a borehole is transmitted via a plastic tube directly to a pressure transducer, *see* Figure 4-2.

The pressure transducers are either of the type DRUCK PTX 500 series or DRUCK PTX 600 series with a pressure range of 0 – 50 bar (absolute).

According to the manufacturer the uncertainty for these transducers is +/-0.2 % (type 500) and +/-0.08 % (type 600) of full scale (F.S) for the best straight line (B.S.L.). For the 600 series types the time drift is given to max. 0.05 % F.S., while no figure is given for the 500 series types. Normally, a pressure value is scanned once every third second. If the change since the latest stored value exceeds a “change value” of approximately 2 kPa the newly scanned value is stored. A value is always stored once every second hour, regardless of any changes.

***Figure 4-2**. Pressure transducers connections.*

4.3 Flowmeter equipment

A new kind of flow meter, see Figure 4-3, is used in order to obtain continously flow measurements during the tests. The equipment system used was originally developed by Micro Motion, Inc. in USA, and is comprised of a sensor and a signal processing transmitter. It is called a Coriolis mass flow meter and measures mass flow directly. The volume flow can be obtained when knowing the temperature, the pressure and finally the density of the fluid (water).

The fluid enters the sensor and travels through the sensor´s flow tubes, which vibrate and twist. The twisting characteristic is called the Coriolis effect. According to Newton's Second Law of Motion, the amount of sensor tube twist is directly proportional to the mass flow rate of the fluid flowing through the tube.

The equipment unit consists of two flow meters with different measurement ranges. The measurement range for the large flow meter is 0 to appr. 36 kg/min and for the small flow meter is 0 to approx. 1.8 kg/min.

Figure 4-3. *The equipment for flow rate measurement with Micro Motion Coriolis mass flow meter system.*

4.4 Deformation measurements

During storage of nuclear waste in the rock mass the temperature will increase due to the heat loss from the canisters with spent fuel. This will increase the rock stresses and the fractures will generally close, but may locally open due to the stress situation (*Alm et al, 2005).*

It is of interest to investigate the magnitude of this effect on the fracture transmissivity since the fracture transmissivity is essential of two reasons. First, enough transmissivity is needed to provide the bentonite buffer with water if no artificial moistening of the buffer is arranged. Secondly, the transmissivity should be as low as possible in order to minimise the hydraulic contact with the canisters. The increased temperature will decrease the transmissivity, which in principal is positive in perspective of Safety Assessment. The last effect is however limited in time and may not be of any greater importance in Safety Assessment.

Displacement measurements are done continuously. Hydraulic tests will be made a number of times during the operation period for the ten measurement sections. An extra section is also equipped with hydro mechanical measurements equipment and is used as a reference hole (KG0010B01). Most tests have been planned to be made during the first years of operation when the largest displacements are expected to occur. This report details the interference results from the fifth test campaign. They are done in order to provide hydrogeological data useful for setting up a hydrogeological model of the rock volume around the TBM tunnel.

In order to investigate the hydro mechanical response of the fractures as a result of the increased thermal load, two different approaches are considered.

The first approach is to measure the change of the fracture width as function of temperature and time. The displacement is both measured for the intact rock as for a section with one or more fractures.

The second approach implies that the mechanical response is evaluated indirect by using the results from hydraulic tests. Single hole hydro tests are performed in the same sections as the mechanical measurements are made (*Forsmark, Rhén, 2004a, 2004b, 2004c, 2005a and 2005c*), *(Forsmark,2006), (Forsmark, 2007)*.

All results from the hydro mechanical measurements will be documented in separate documents.

4.4.1 Measurement equipment

In order to measure the fracture deformation (and to separate the fracture deformation from the deformation of the intact rock) due to the increased temperature a measurement equipment has been developed.

The equipment consists of two hydraulic packers, which hydraulically isolate the test section. Between the packers three anchors are placed. These anchors are fixed to the borehole wall and in the sections between the anchors sensors (strain gage) are mounted. These sections are called mechanical measurement sections. The sensors will register any relative movement between the anchors; see Figure 4-4 and 4-5. The temperature is also measured in each sensor by a thermistor.

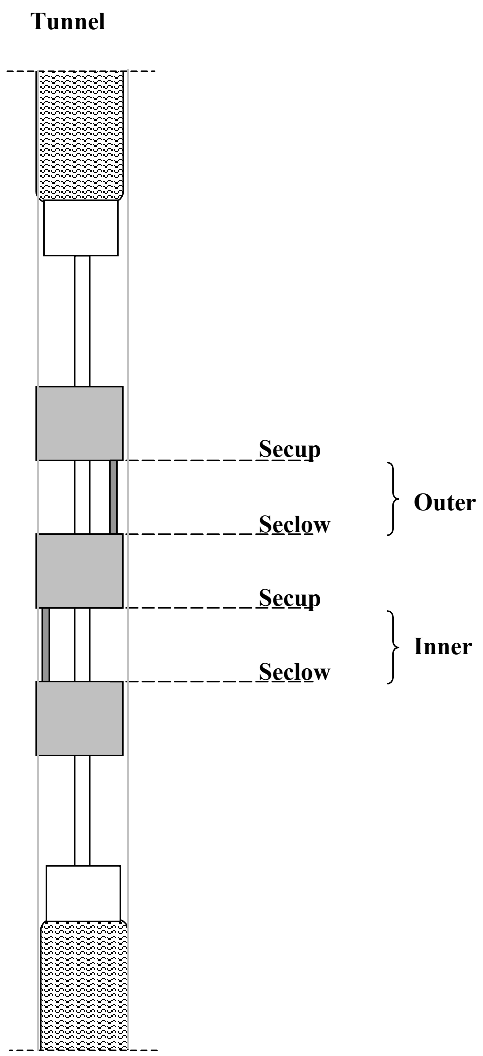


Figure 4-4. *A schematic figure that shows the different parts of the test equipment and also the definitions of the terms outer and inner.*

The deformation is measured in two sections in each borehole. One mechanical measurement section is placed over a fracture (or fractures) and the other mechanical measurement section is placed over intact rock. That makes it possible to separate the fracture deformation from the deformation of the intact rock.

Of all boreholes in the prototype tunnel, ten are equipped as described above. Five of the measurement sections are placed over a single fracture and the rest are placed over two to six fractures, see Table 4-1.

Since hydraulic packers isolate the test sections and the test sections have contact with the tunnel (atmospheric pressure) via tubes and valves it is possible to perform hydraulic tests in the sections.

Table 4-1. Data of the deformation measurement sections (sensors, length, number of fractures etc).

Label	Cable mark	Sensor S/N	Position	Secup	Seclow	Section length (m)	Number of fractures
KA3539G-2-1	HRA 1121	3511	Inner	16.77	16.97	0.20	2
KA3539G-2-2	HRA 1122	3510	Outer	16.47	16.67	0.20	0
KA3542G01-3-1	HRA 1231	3513	Inner	19.47	19.67	0.20	0
KA3542G01-3-2	HRA 1232	3512	Outer	19.17	19.37	0.20	1
KA3542G02-2-1	HRA 1321	3515	Inner	26.50	26.70	0.20	1
KA3542G02-2-2	HRA 1322	3514	Outer	26.20	26.40	0.20	0
KA3544G01-2-1	HRA 1621	3509	Inner	9.82	10.02	0.20	1
KA3544G01-2-2	HRA 1622	3508	Outer	9.52	9.72	0.20	0
KA3546G01-2-1	HRA 1721	3517	Inner	7.67	7.87	0.20	1
KA3546G01-2-2	HRA 1722	3516	Outer	7.37	7.57	0.20	0
KA3548A01-3-1	HRA 1831	3526	Inner	9.70	10.15	0.45	2
KA3548A01-3-2	HRA 1832	3518	Outer	9.40	9.60	0.20	0
KA3550G01-2-1	HRA 2121	3527	Inner	6.10	6.70	0.60	6
KA3550G01-2-2	HRA 2122	3519	Outer	5.80	6.00	0.20	0
KA3552G01-2-1	HRA 2521	3521	Inner	5.25	5.45	0.20	0
KA3552G01-2-2	HRA 2522	3520	Outer	4.95	5.15	0.20	2
KA3554G01-2-1	HRA 2821	3525	Inner	23.54	23.80	0.26	2
KA3554G01-2-2	HRA 2822	3522	Outer	23.24	23.44	0.20	0
KA3554G02-4-1	HRA 2941	3524	Inner	11.40	11.60	0.20	0
KA3554G02-4-2	HRA 2942	3523	Outer	11.10	11.30	0.20	1
KG0010B01-1-1	-	3238	Inner	3.66	3.86	0.20	-
KG0010B01-1-2	-	3507	Outer	3.36	3.56	0.20	-

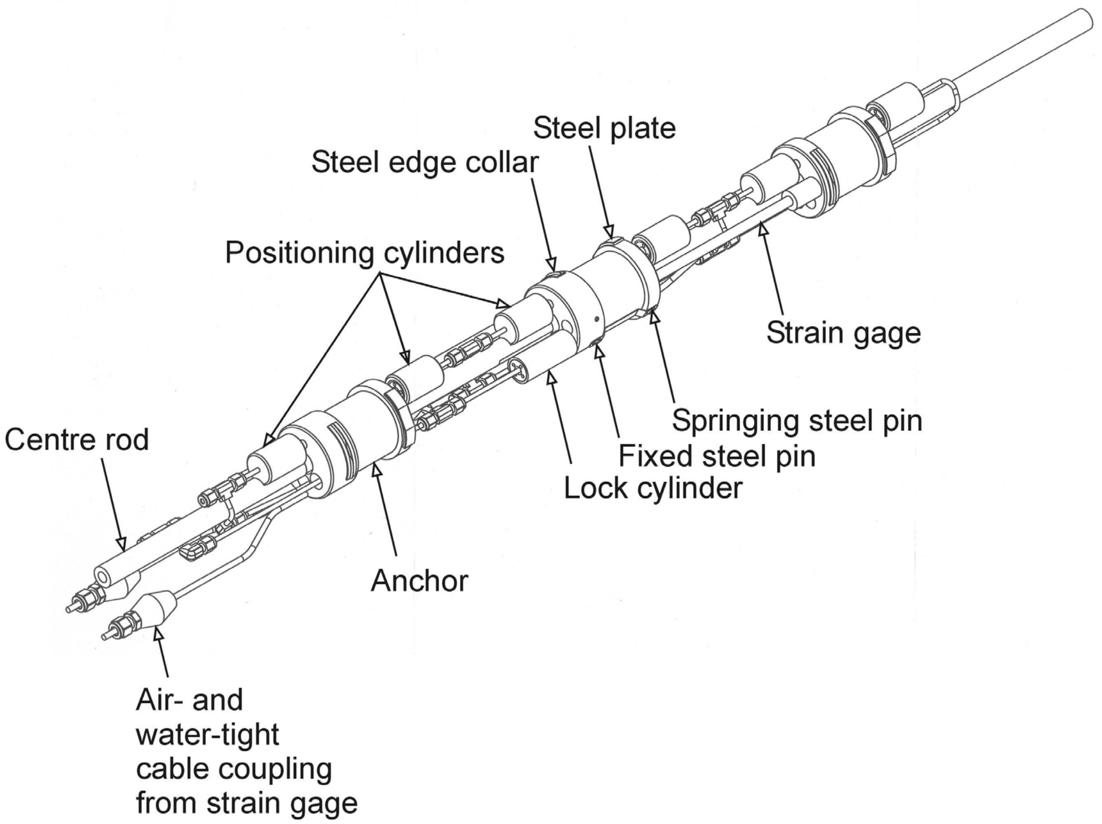


Figure 4-5. *A detailed figure of the three anchors, sensors (strain gage), positioning cylinder etc.*

5 Execution

5.1 Preparations

Planning is an important step in the preparation stage. No other activities, which may cause pressure responses, must occur in the neighbourhood of the test area. Such activities include drilling, blasting and flowing of boreholes.

Preparations also include checking of equipment to be used in the tests. The equipment included

- measuring glasses of various sizes
- synchronizing watches with the HMS system (only normal time)
- protocols for flow measurements
- water sampling bottles
- hand calculator
- flow rate measurement equipment with Micro Motion flow meter system

5.2 Execution of tests/measurements

5.2.1 Test principle

The main purpose of a single hole pressure build-up test is to do a test, which makes it possible to evaluate the hydraulic properties of the bedrock around the tested borehole section.

5.2.2 Test procedure

The following measurement cycle is used:

- Initialising of the HMS system 30 minutes before flow start with logging interval of 5 minutes
- A couple of minutes before flow start and until 5 minutes after flow start the highest logging interval of 3 seconds are used. Thereafter the logging interval is 30 seconds which is used until 30 minutes after flow start and a logging interval of 5 minutes is then used once again
- The flow is measured manually 2-3 times the first 5 minutes after flow start, 2-3 times the following 60 minutes and 3 times shortly before flow stop
- From shortly before flow stop until 5 minutes after flow stop the highest logging interval of 3 seconds are used. Thereafter the logging frequency is 30 seconds which is used until 30 minutes after flow start and a logging frequency of 5 minutes is then used
- The valve shutting is done as swiftly as possible

5.3 Data handling

The test operator is keeping a diary during the test period. Data from the hydro tests includes:

- Daily logs in accordance with Äspö Hard Rock Laboratory routines
- Protocols from flow measurements

The project coordinator collected all data and delivered it to the data handling responsible person at Äspö for further SICADA handling.

5.4 Analyses and interpretation

5.4.1 Single hole tests

The following description applies to the analysis in this report. The analysis done is for the recovery phase only.

The specific capacity is as mentioned above, Q/s, where Q is the calculated average water flow before shutting the valve and s is the maximum change of pressure, in metres, during the test.

The Moye formula can be used for interpretation of stationary tests in order to get an estimate of the transmissivity

$$T_{Moye} = Q \cdot (1 + \ln(L/(2 \cdot r_w))) / (2 \cdot \pi \cdot \Delta h) \quad \text{where}$$

$\Delta h = (p_0 - p_p) / (\rho_w \cdot g)$ [m]

L = test section length [m]

r_w = borehole radius [m]

p_0 = absolute pressure in test section before start of flow period [Pa]

p_p = absolute pressure in test section before stop of flow period [Pa]

ρ_w = water density [kg/m^3]

g = acceleration of gravity [m/s^2]

While plotting the data, three different kinds of graphs are produced. The first plot is made in a linear scale. The time, date and hours is indicated on the horizontal axis. The pressure (p), expressed in bar or metres of water head is indicated on the vertical axis. The second plot is made in a semi-logarithmic diagram, where the pressure change, ∆p, is plotted versus the equivalent time, dt_e, in minutes. The equivalent time, dt_e, (*Spane, Wurstner, 1993*) is defined as

$$dt_e = (t_p \cdot dt) / (t_p + dt) \qquad \text{where}$$

t_p = the flowing time of the borehole before shutting the valve

dt = the time after shutting the valve

The pressure change ∆p is calculated as

$\Delta p = p(dt) - p(t_p)$

p(dt) = measured pressure at time dt after shutting the valve

$p(t_p)$ = measured pressure just before shutting the valve

The third plot is made in a logarithmic diagram, where the change of pressure, ∆p, is plotted versus the equivalent time, dt_e, in minutes. The derivative of the pressure is also plotted in this diagram.

The pressure normally is signed using the p and a change of pressure using a ∆p. In the diagrams the pressure can be expressed in bar, kPa or in metres of water head. In the formulas below however the praxis is to use the s for the change of water head and ∆s for the difference of pressure over one decade in a logarithmic diagram. The s or ∆s values shall be expressed in metres before used in the formulas.

Hydrologic test analysis based on the derivative of pressure (i.e., rate of pressure change) with respect to the natural logarithm of time has been shown to significantly improve the diagnostic and quantitative analysis of slug and constant-rate discharge tests (i.e., pumping tests) (*Spane, Wurstner, 1993*). The improvement in hydrologic test analysis is attributed to the sensitivity of the derivative response to small variations in the rate of pressure change that occurs during testing, which would otherwise be less obvious with standard pressure change versus time analysis techniques. The sensitivity of pressure derivatives to pressure change responses facilitates their use in identifying the presence of wellbore storage, boundaries, and establishment of flow conditions, as e.g. radial flow, within the test data record. Specifically, pressure derivative analysis can be used to:

- diagnostically determine formation response (homogeneous vs. heterogeneous) and boundary conditions (impermeable or constant head) that are evident during the test,
- determine when radial flow conditions are established and, therefore, when straight-line solution analysis of drawdown data is valid, and
- assist in log-log type-curve matching to determine hydraulic properties for test data exhibiting wellbore storage and/or leakage effects.

In a fracture, different flow regimes may be observed at different times, *(Horne, 1995)*. At very early time only a linear flow regime occur within the fracture. At early time, there is linear flow within the fracture and linear flow into the fracture from the rock formation. The combination of these two linear flows gives rise to a bilinear flow period. This part of the pressure response is characterized by a straight line with slope 1:4 at early time on a log-log plot of pressure drop against time. Following the bilinear flow period, finite conductivity fracture responses generally enter a transition after bilinear flow, but reach radial flow before ever achieving linear flow, recognizeable by the upward bending of the pressure response curve towards a 1:2 slope on the log-log plot. In practice, the 1:2 slope is rarely seen except in fractures where the conductivity is infinite. The above described methodology is used in chapter 6.

The tests are evaluated using the software AQTESOLV ver. 4.50, and results are reported in chapter 6 and in the executive summary. AQTESOLV is the all-in-one software package for the design and analysis of aquifer tests including pumping tests, step-drawdown tests, variable-rate tests, recovery tests, single-well tests, slug tests and constant-head tests. The software is developed by HydroSOLVE, Inc., USA.

The solution used in these analysis is the Dougherty-Babu model for a pumping test in a confined aquifer (Dougherty, Babu, 1984). The model assumes radial flow in a porous medium. AQTESOLV uses the principle of superposition in time to simulate variable-rate tests including recovery with the solution. The result consist of

- Transmissivity, T (m^2/s)
- Skinfactor, Sw (-)

It is of uttermost importance when evaluation the hydraulic tests within the scope of this report that all tests are evaluated using the <u>same approach</u> between the test campaigns. This is important to be able to evaluate the <u>relative difference</u> of the transmissivity from one test campaign to another.

It is however important as well to observe any significant changes of the pressure plot from on time to another. If changes have occurred another matching of the data to a chosen model may be necessary.

6 Results

6.1 Single hole tests

6.1.1 KA3552G01:2, test No 8:1

General test data for the pressure build-up test in the interval 4.35-6.05 m of borehole KA3552G01 are presented in Table 6-1.

Table 6-1. General test data for the pressure build-up test in section 4.35-6.05 m of borehole KA3552G01.

General test data			
Borehole section	KA3552G01:2		
Test No	8:1		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = max)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	4.35
Test section- seclow	Seclow	m	6.05
Test section length	L_w	m	1.70
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071018 07:30:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071018 08:30:30
Stop of flow period		yymmdd hh:mm:ss	20071018 10:30:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071018 11:30:00
Total flow time	t_p	min	120
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	721.0	
Absolute pressure in test section before stop of flow	p_p	kPa	97.7	
Absolute pressure in test section at stop of recovery period	p_f	kPa	653.6	
Maximal pressure change during flow period	dp_p	kPa	623.3	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$7.58 \cdot 10^{-8}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$9.58 \cdot 10^{-8}$
Total volume discharged during flow period	V_p	m^3	$6.90 \cdot 10^{-4}$

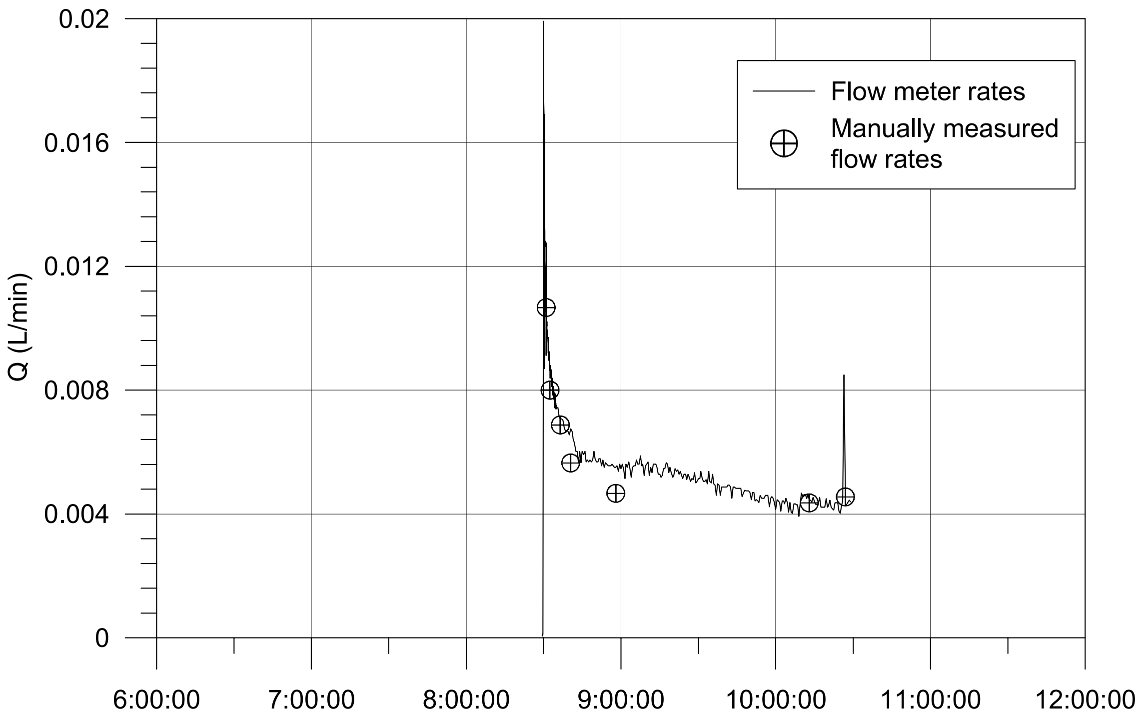


Figure 6-1. *Flow rates during draw down in KA3552G01:2.*

Comments to the test

Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

Interpreted flow regimes

0 – 2	minutes	Well Bore Storage (WBS)
2 – 30	minutes	Transition period
30 –	minutes	Radial flow period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

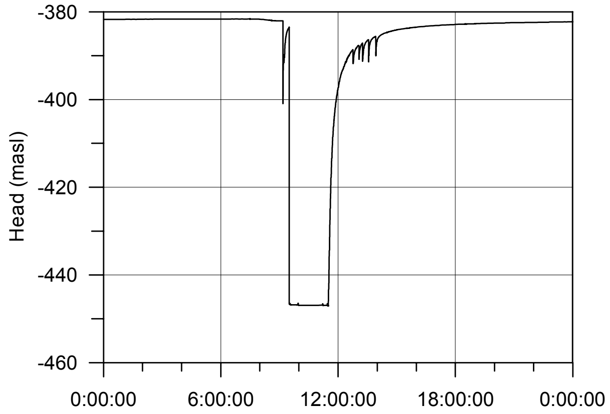
Selected representative parameters

The selected representative parameters from the test in the interval 4.35-6.05 m in KA3552G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

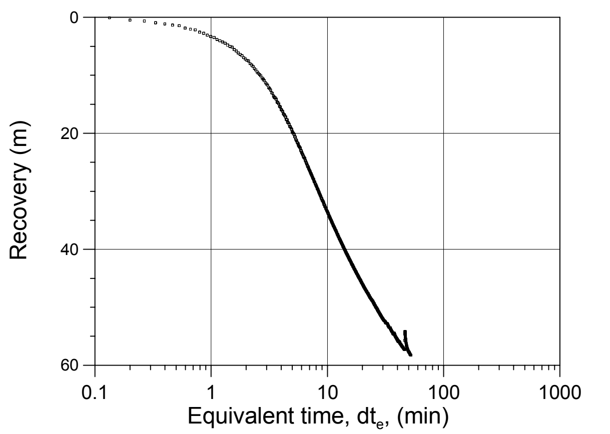
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:1
Borehole ID:	KA3552G01	Test start:	2007-10-18 07:30
Test section (m):	4.35-6.05	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



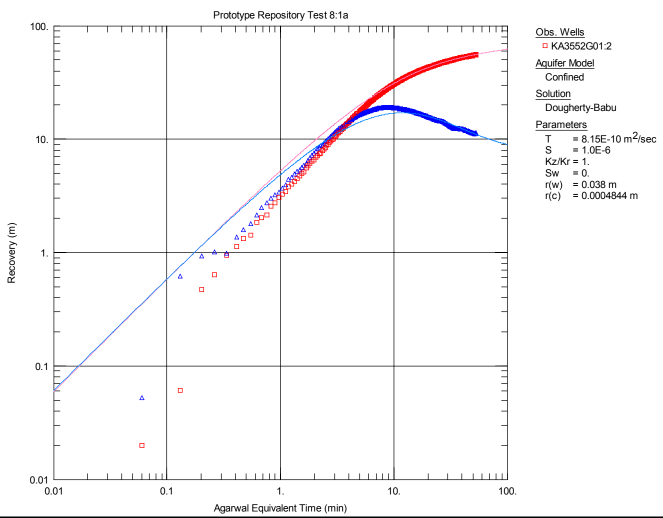
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	721.0		
p_i (kPa)			
p_p(kPa)	97.7	p_F (kPa)	653.6
Q_p (m^3/s)	$7.58 \cdot 10^{-8}$		
tp (min)	120	t_F (min)	60
S*	$1 \cdot 10^{-6}$	S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$1.2 \cdot 10^{-9}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$8.0 \cdot 10^{-10}$	dt_{e1} (min)	30
Flow regime:		dt_{e2} (min)	40
dt_1 (min)		T (m^2/s)	$8.2 \cdot 10^{-10}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	0
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	30	C_D (-)	
dt_2 (min)	40	ξ (-)	0
T_T (m^2/s)	$8.2 \cdot 10^{-10}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

6.1.2 KA3554G01:2 , test No 8:2a

General test data for the pressure build-up test in the interval 22.60-24.15 m of borehole KA3554G01 are presented in Table 6-2.

Table 6-2. General test data for the pressure build-up test in section 22.60-24.15 m of borehole KA3554G01.

General test data			
Borehole section	KA3554G01:2		
Test No	8:2a		
Field crew	A. Blom (SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approx. 100 m)		
	Nomen-clature	Unit	Value
Test section- secup	Secup	m	22.60
Test section- seclow	Seclow	m	24.15
Test section length	L_w	m	1.55
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071015 14:40:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071015 15:41:00
Stop of flow period		yymmdd hh:mm:ss	20071015 17:40:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071015 18:40:00
Total flow time	t_p	min	119
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1936.2	
Absolute pressure in test section before stop of flow	p_p	kPa	1834.9	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1934.6	
Maximal pressure change during flow period	dp_p	kPa	101.3	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$6.67 \cdot 10^{-6}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$6.57 \cdot 10^{-6}$
Total volume discharged during flow period	V_p	m^3	0.0473

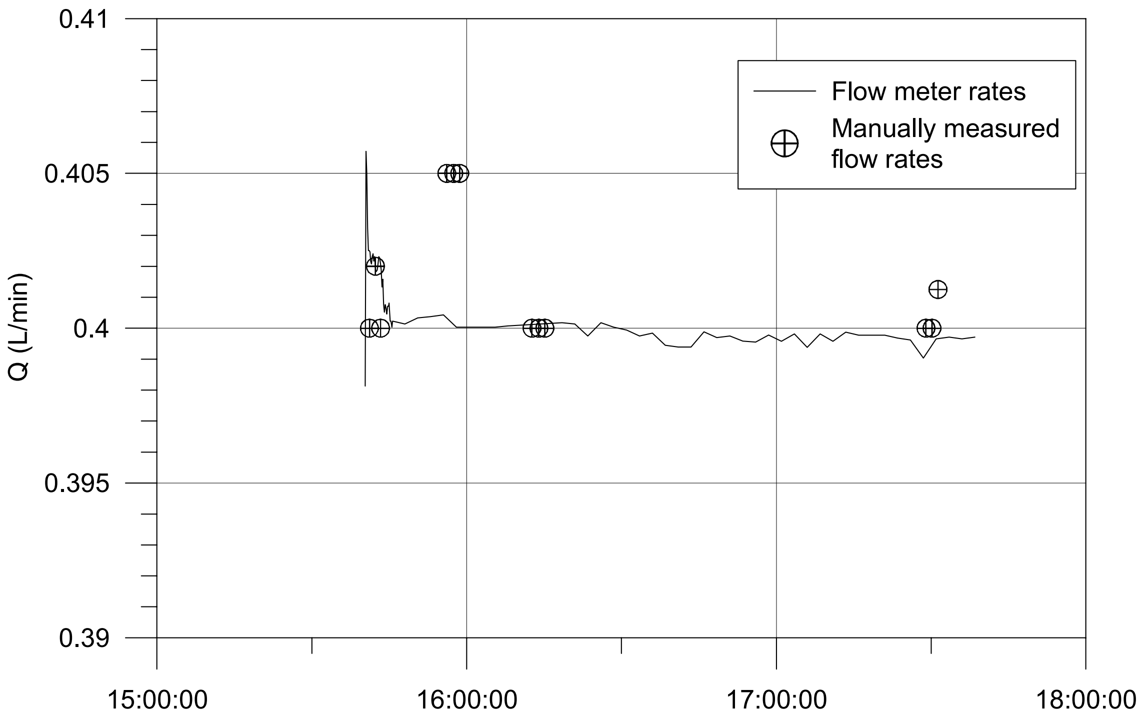


Figure 6-2. *Flow rates during draw down in KA3554G01:2.*

Comments to the test

Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The results of this test indicate increased transmissivity to the south side of the Prototype repository since earlier test-campigns.

Interpreted flow regimes

0 – 0.3	minutes	Well Bore Storage (WBS)
0.3 – 1	minutes	Transition period
1 – 20	minutes	Radial flow period
20 –	minutes	Transition period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

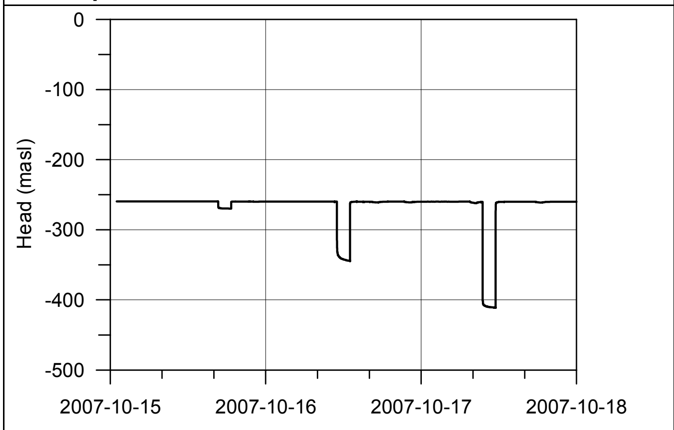
Selected representative parameters

The selected representative parameters from the test in the interval 22.60-24.15 m in KA3554G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

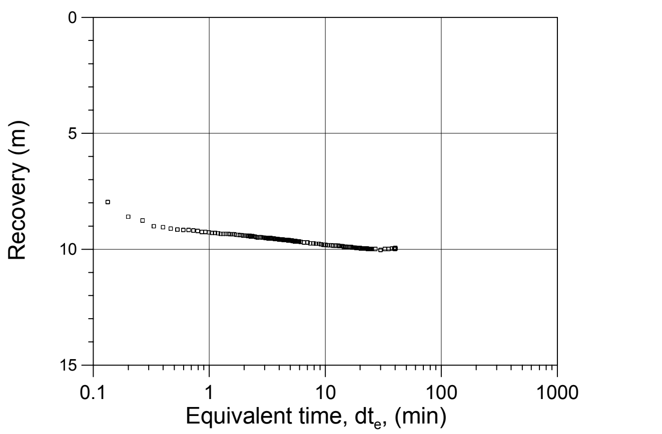
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:2a
Borehole ID:	KA3554G01	Test start:	2007-10-15 14:40
Test section (m):	22.60-24.15	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



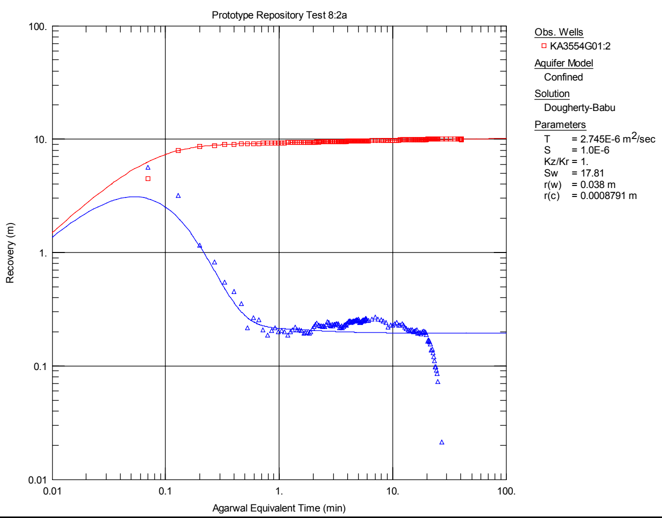
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1936.2		
p_i (kPa)			
p_p(kPa)	1834.9	p_F (kPa)	1934.6
Q_p (m^3/s)	$6.67 \cdot 10^{-6}$		
tp (min)	120	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$6.6 \cdot 10^{-7}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$4.2 \cdot 10^{-7}$	dt_{e1} (min)	1
Flow regime:		dt_{e2} (min)	20
dt_1 (min)		T (m^2/s)	$2.7 \cdot 10^{-6}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	18
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	1	C_D (-)	
dt_2 (min)	20	ξ (-)	18
T_T (m^2/s)	$2.7 \cdot 10^{-6}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The results of this test indicate increased transmissivity to the south side of the Prototype repository since earlier test-campigns.

6.1.3 KA3554G01:2 , test No 8:2b

General test data for the pressure build-up test in the interval 22.60-24.15 m of borehole KA3554G01 are presented in Table 6-3.

Table 6-3. General test data for the pressure build-up test in section 22.60-24.15 m of borehole KA3554G01.

General test data			
Borehole section	KA3554G01:2		
Test No	8:2b		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp$_p$ = approx. 200 m)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	22.60
Test section- seclow	Seclow	m	24.15
Test section length	L_w	m	1.55
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071016 09:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071016 10:00:00
Stop of flow period		yymmdd hh:mm:ss	20071016 12:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071016 13:00:00
Total flow time	t_p	min	120
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1933.8	
Absolute pressure in test section before stop of flow	p_p	kPa	1102.8	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1931.7	
Maximal pressure change during flow period	dp_p	kPa	831.0	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.66 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$1.70 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.122

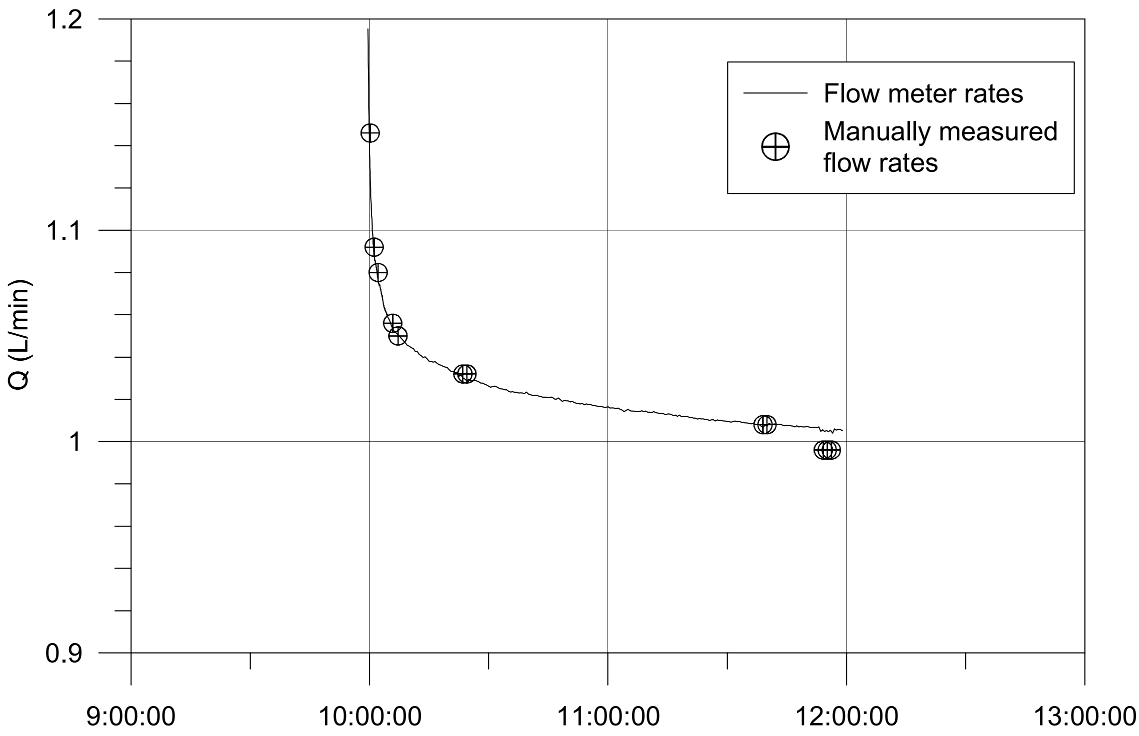


***Figure 6-3.** Flow rates during draw down in KA3554G01:2.*

Comments to the test

Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The results of this test indicate increased transmissivity to the south side of the Prototype repository since earlier test-campigns.

Interpreted flow regimes

0 – 0.2	minutes	Well Bore Storage (WBS)
0.2 – 4	minutes	Transition period
4 – 8	minutes	Radial flow period
8 –	minutes	Transition period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

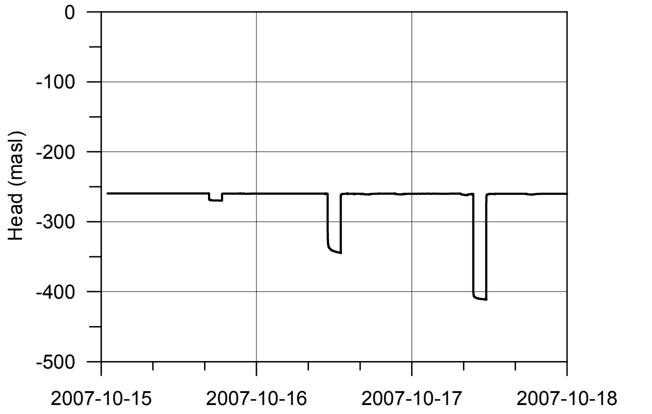
Selected representative parameters

The selected representative parameters from the test in the interval 22.60-24.15 m in KA3554G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

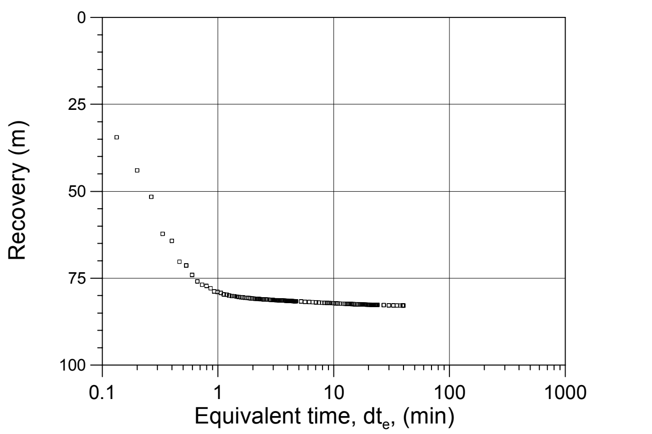
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:2b
Borehole ID:	KA3554G01	Test start:	2007-10-16 09:00
Test section (m):	22.60-24.15	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



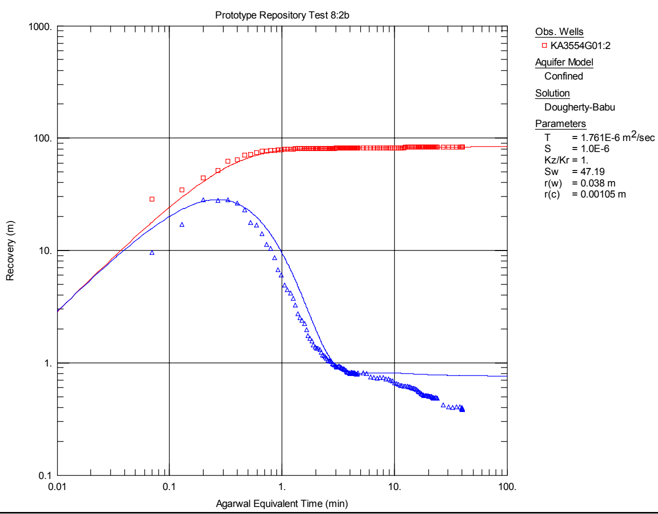
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1933.8		
p_i (kPa)			
p_p(kPa)	1102.8	p_F (kPa)	1931.7
Q_p (m^3/s)	$1.66 \cdot 10^{-5}$		
tp (min)	120	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$2.0 \cdot 10^{-7}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$1.3 \cdot 10^{-7}$	dt_{e1} (min)	4
Flow regime:		dt_{e2} (min)	8
dt_1 (min)		T (m^2/s)	$1.8 \cdot 10^{-6}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	47
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	4	C_D (-)	
dt_2 (min)	8	ξ (-)	47
T_T (m^2/s)	$1.8 \cdot 10^{-6}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The results of this test indicate increased transmissivity to the south side of the Prototype repository since earlier test-campigns.

6.1.4 KA3554G01:2 , test No 8:2c

General test data for the pressure build-up test in the interval 22.60-24.15 m of borehole KA3554G01 are presented in Table 6-4.

Table 6-4. General test data for the pressure build-up test in section 22.60-24.15 m of borehole KA3554G01.

General test data			
Borehole section	KA3554G01:2		
Test No	8:2c		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = max)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	22.60
Test section- seclow	Seclow	m	24.15
Test section length	L_w	m	1.55
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071017 07:30:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071017 08:30:00
Stop of flow period		yymmdd hh:mm:ss	20071017 10:30:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071017 11:30:00
Total flow time	t_p	min	120
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1929.3	
Absolute pressure in test section before stop of flow	p_p	kPa	448.9	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1929.3	
Maximal pressure change during flow period	dp_p	kPa	1480.4	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$2.01 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$2.08 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.150

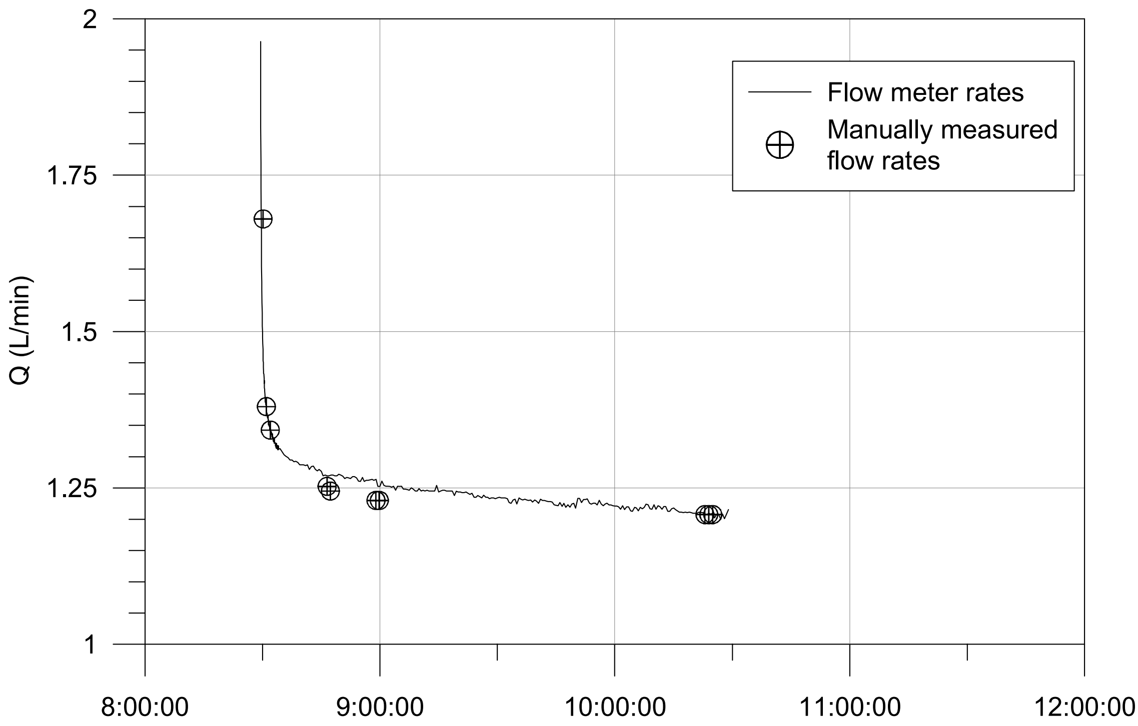


Figure 6-4. *Flow rates during draw down in KA3554G01:2.*

Comments to the test

Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The results of this test indicate increased transmissivity to the south side of the Prototype repository since earlier test-campigns.

Interpreted flow regimes

0 – 0.3	minutes	Well Bore Storage (WBS)
0.3 – 9	minutes	Transition period
9 – 10	minutes	Radial flow period
10 –	minutes	Transition period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

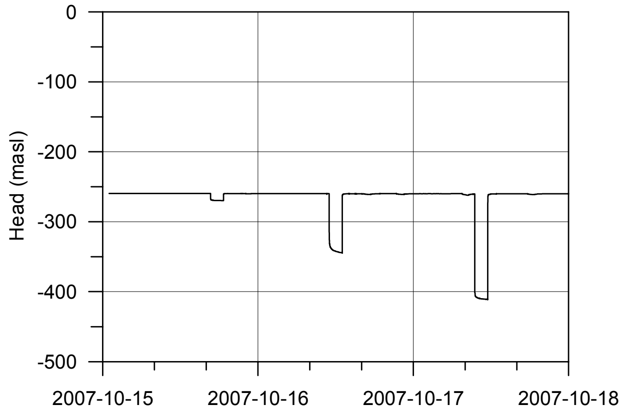
Selected representative parameters

The selected representative parameters from the test in the interval 22.60-24.15 m in KA3554G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

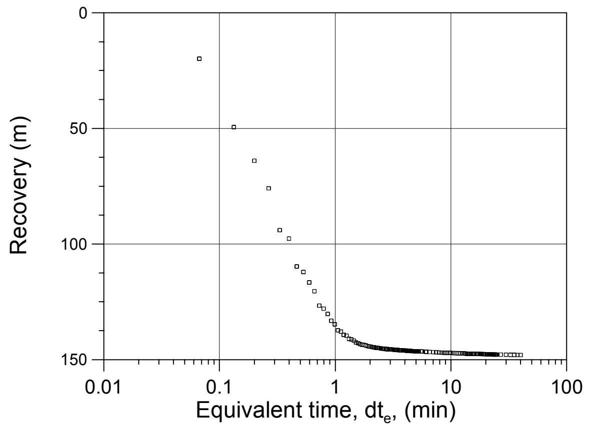
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:2c
Borehole ID:	KA3554G01	Test start:	2007-10-17 07:30
Test section (m):	22.60-24.15	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



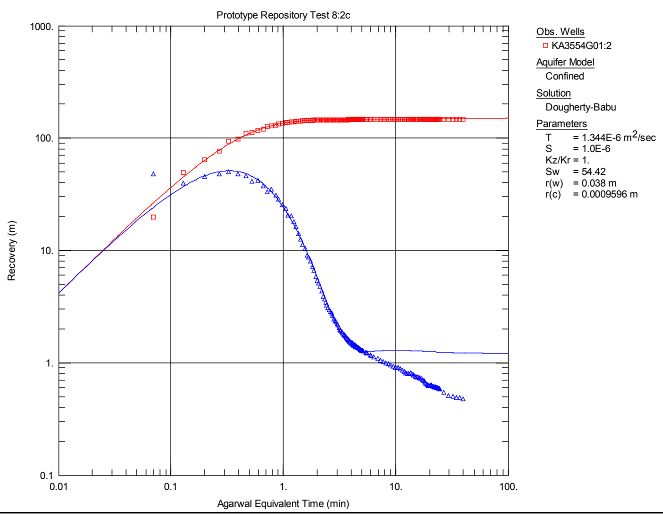
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1929.3		
p_i (kPa)			
p_p(kPa)	448.9	p_F (kPa)	1929.3
Q_p (m^3/s)	$2.01 \cdot 10^{-5}$		
tp (min)	120	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$1.4 \cdot 10^{-7}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$8.7 \cdot 10^{-8}$	dt_{e1} (min)	9
Flow regime:		dt_{e2} (min)	10
dt_1 (min)		T (m^2/s)	$1.3 \cdot 10^{-6}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	54
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.			
Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	9	C_D (-)	
dt_2 (min)	10	ξ (-)	54
T_T (m^2/s)	$1.3 \cdot 10^{-6}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The results of this test indicate increased transmissivity to the south side of the Prototype repository since earlier test-campigns.

6.1.5 KA3554G02:4, test No 8:3a

General test data for the pressure build-up test in the interval 10.50-12.20 m of borehole KA3554G02 are presented in Table 6-5.

Table 6-5. General test data for the pressure build-up test in section 10.50-12.20 m of borehole KA3554G02.

General test data			
Borehole section	KA3554G02:4		
Test No	8:3a		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approx. 100 m)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	10.50
Test section- seclow	Seclow	m	12.20
Test section length	L_w	m	1.70
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071016 06:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071016 08:00:00
Stop of flow period		yymmdd hh:mm:ss	20071016 09:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071016 10:00:00
Total flow time	t_p	min	120
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	987.9	
Absolute pressure in test section before stop of flow	p_p	kPa	520.8	
Absolute pressure in test section at stop of recovery period	p_f	kPa	993.8	
Maximal pressure change during flow period	dp_p	kPa	467.1	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$6.47 \cdot 10^{-8}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$7.22 \cdot 10^{-8}$
Total volume discharged during flow period	V_p	m^3	$5.20 \cdot 10^{-4}$

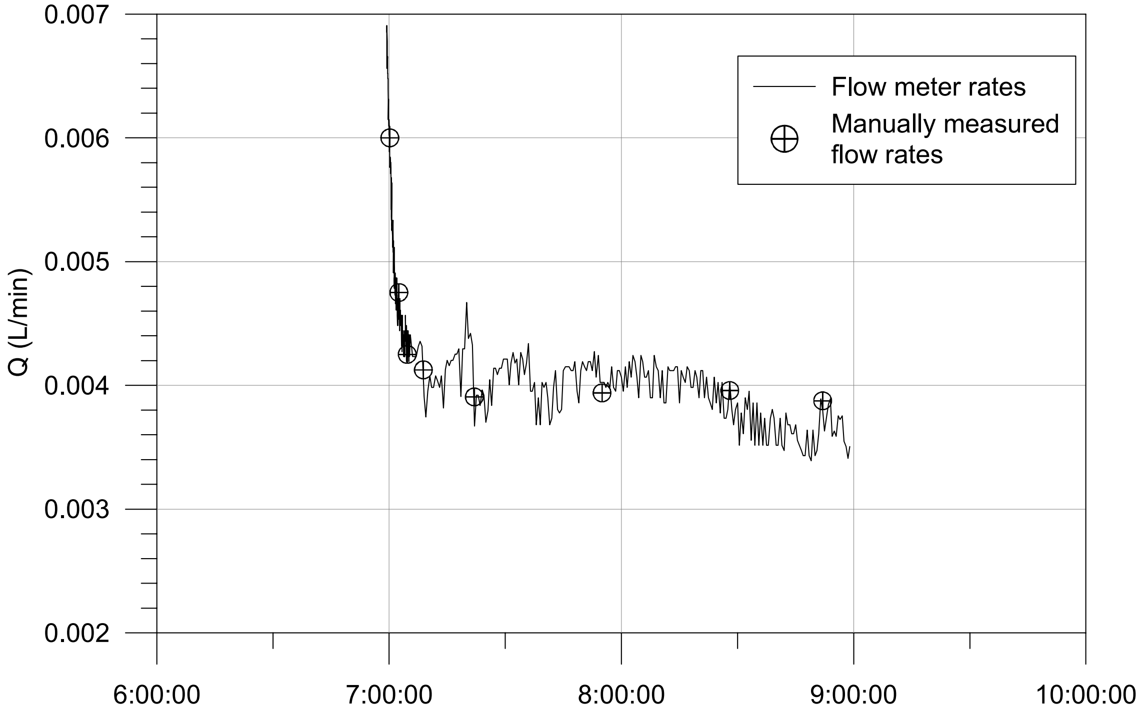


Figure 6-5. *Flow rates during draw down in KA3554G02:4.*

Comments to the test

Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The radial flow period is uncertain.

Interpreted flow regimes

0 – 1	minutes	Well Bore Storage (WBS)
1 – 30	minutes	Transition period
30 –	minutes	Possible radial flow period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

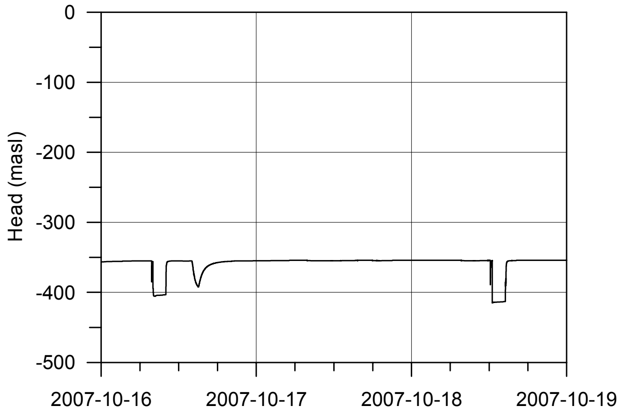
Selected representative parameters

The selected representative parameters from the test in the interval 10.50-12.20 m in KA3554G02 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

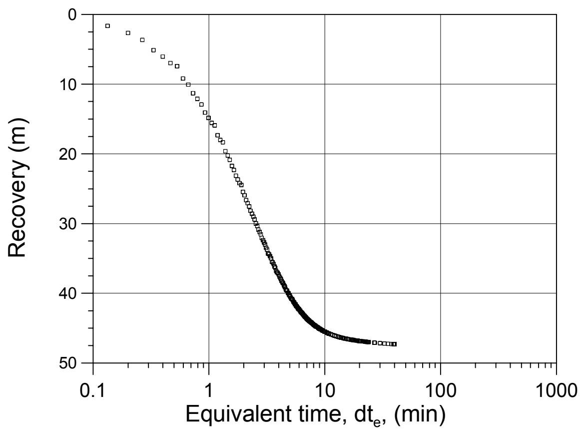
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:3a
Borehole ID:	KA3554G02	Test start:	2007-10-16 06:00
Test section (m):	10.50-12.20	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



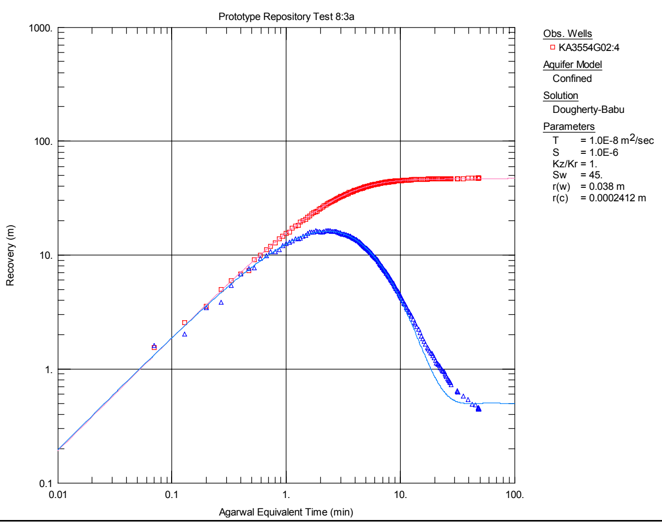
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	987.9		
p_i (kPa)			
p_p(kPa)	520.8	p_F (kPa)	993.8
Q_p (m^3/s)	$6.47 \cdot 10^{-8}$		
tp (min)	120	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$1.4 \cdot 10^{-9}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$9.1 \cdot 10^{-10}$	dt_{e1} (min)	30
Flow regime:		dt_{e2} (min)	40
dt_1 (min)		T (m^2/s)	$1.0 \cdot 10^{-8}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	45
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	30	C_D (-)	
dt_2 (min)	40	ξ (-)	45
T_T (m^2/s)	$1.0 \cdot 10^{-8}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

6.1.6 KA3554G02:4 , test No 8:3b

General test data for the pressure build-up test in the interval 10.50-12.20 m of borehole KA3554G02 are presented in Table 6-6.

Table 6-6. General test data for the pressure build-up test in section 10.50-12.20 m of borehole KA3554G02.

General test data			
Borehole section	KA3554G02:4		
Test No	8:3b		
Field crew	A. Blom (SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = max)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	10.50
Test section- seclow	Seclow	m	12.20
Test section length	L_w	m	1.70
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071017 10:30:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071017 11:30:00
Stop of flow period		yymmdd hh:mm:ss	20071017 13:30:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071017 14:30:00
Total flow time	t_p	min	120
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	999.9	
Absolute pressure in test section before stop of flow	p_p	kPa	424.6	
Absolute pressure in test section at stop of recovery period	p_f	kPa	999.5	
Maximal pressure change during flow period	dp_p	kPa	575.3	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.20 \cdot 10^{-7}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$1.26 \cdot 10^{-7}$
Total volume discharged during flow period	V_p	m^3	$9.08 \cdot 10^{-4}$

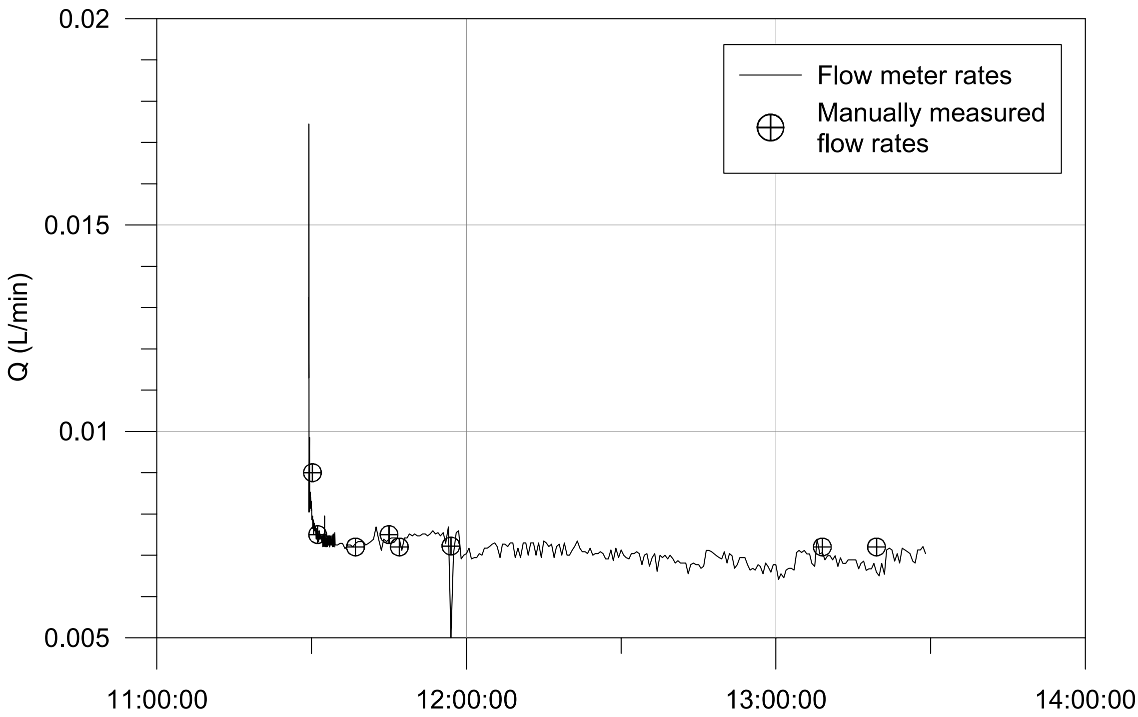


__Figure 6-6.__ Flow rates during draw down in KA3554G02:4.

Comments to the test

Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The radial flow period is uncertain.

Interpreted flow regimes

0 – 1	minutes	Well Bore Storage (WBS)
1? – 30	minutes	Transition period
30 –	minutes	Probable radial flow period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

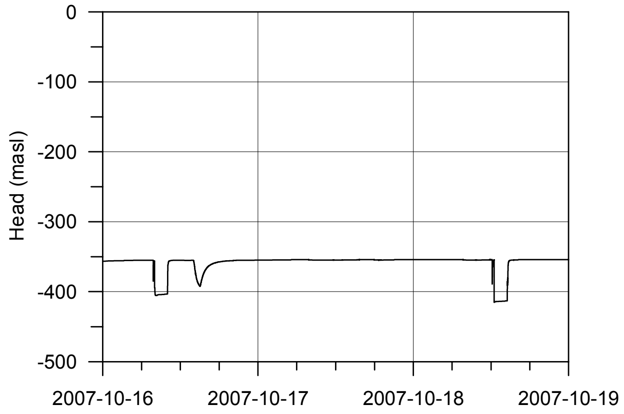
Selected representative parameters

The selected representative parameters from the test in the interval 10.50-12.20 m in KA3554G02 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

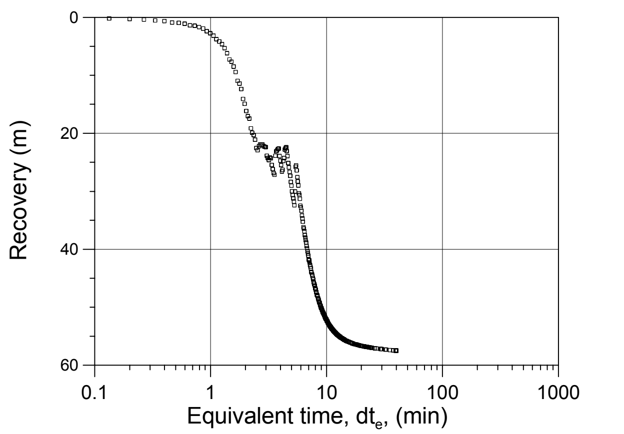
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:3b
Borehole ID:	KA3554G02	Test start:	2007-10-17 10:30
Test section (m):	10.50-12.20	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



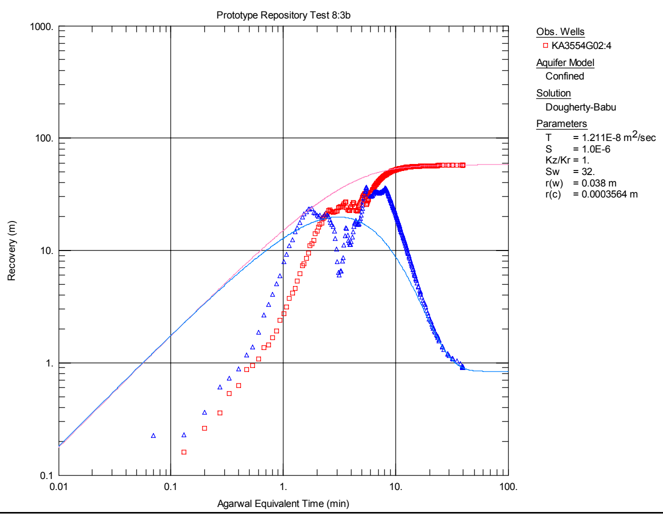
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	999.9		
p_i (kPa)			
p_p(kPa)	424.6	p_F (kPa)	999.5
Q_p (m^3/s)	$1.20 \cdot 10^{-7}$		
tp (min)	120	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$2.1 \cdot 10^{-9}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$1.4 \cdot 10^{-9}$	dt_{e1} (min)	30
Flow regime:		dt_{e2} (min)	40
dt_1 (min)		T (m^2/s)	$1.2 \cdot 10^{-8}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	32
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	30	C_D (-)	
dt_2 (min)	40	ξ (-)	32
T_T (m^2/s)	$1.2 \cdot 10^{-8}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: The reason to the pressure disturbance during recovery is not known. However, the later part of the recovery is considered as reliable. Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

6.1.7 KA3548A01:3 , test No 8:4a

General test data for the pressure build-up test in the interval 8.80-10.75 m of borehole KA3548A01 are presented in Table 6-7.

Table 6-7. General test data for the pressure build-up test in section 8.80-10.75 m of borehole KA3548A01.

General test data			
Borehole section	KA3548A01:3		
Test No	8:4a		
Field crew	A. Blom (SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp$_p$ = approx. 100 m)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	8.80
Test section- seclow	Seclow	m	10.75
Test section length	L_w	m	1.95
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071016 14:20:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071016 15:20:00
Stop of flow period		yymmdd hh:mm:ss	20071016 16:20:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071016 17:20:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1898.9	
Absolute pressure in test section before stop of flow	p_p	kPa	1547.6	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1890.7	
Maximal pressure change during flow period	dp_p	kPa	351.3	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$8.50 \cdot 10^{-6}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$8.54 \cdot 10^{-6}$
Total volume discharged during flow period	V_p	m^3	0.0307

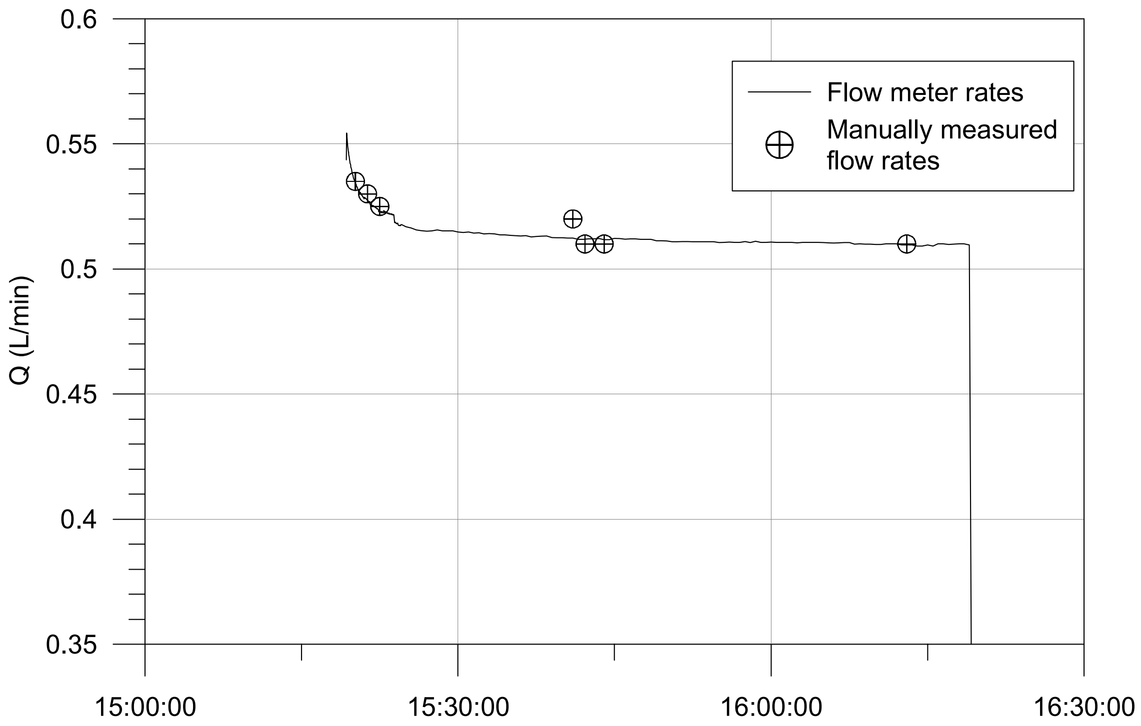


Figure 6-7. *Flow rates during draw down in KA3548A01:3.*

Comments to the test

The radial flow period occurs early in the test. Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The results of this test indicate increased transmissivity to the south side of the Prototype repository since earlier test-campigns.

Interpreted flow regimes

0 – 0.1	minutes	Well Bore Storage (WBS)
0.1 – 0.5	minutes	Transition period
0.5 – 2	minutes	Radial flow period
2 –	minutes	Transition period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

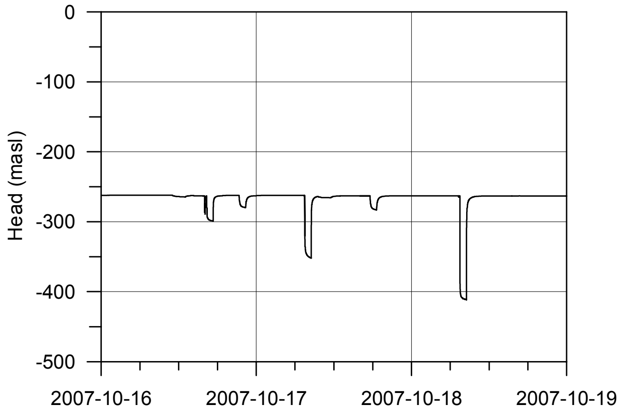
Selected representative parameters

The selected representative parameters from the test in the interval 8.80-10.75 m in KA3548A01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

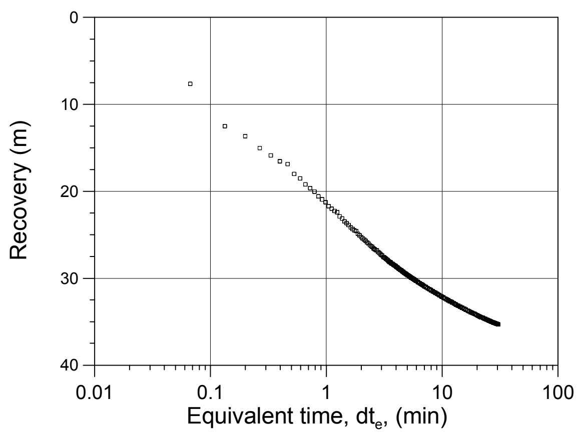
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:4a
Borehole ID:	KA3548A01	Test start:	2007-10-16 14:20
Test section (m):	8.80-10.75	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



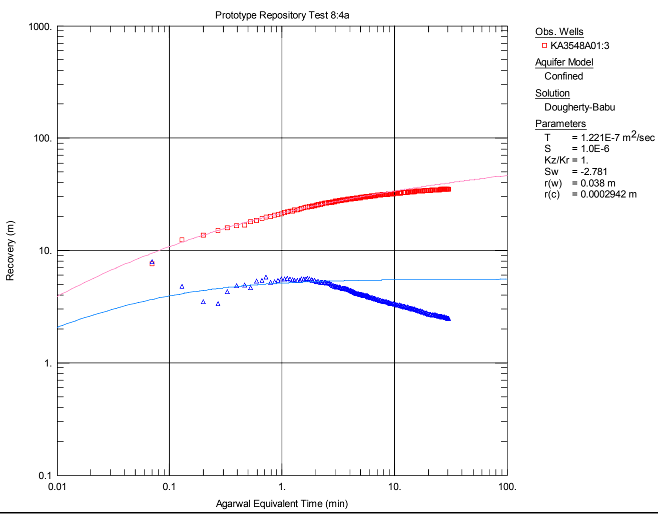
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1898.9		
p_i (kPa)			
p_p(kPa)	1547.6	p_F (kPa)	1890.7
Q_p (m^3/s)	$8.50 \cdot 10^{-6}$		
tp (min)	60	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$2.4 \cdot 10^{-7}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$1.6 \cdot 10^{-7}$	dt_{e1} (min)	0.6
Flow regime:		dt_{e2} (min)	2
dt_1 (min)		T (m^2/s)	$1.2 \cdot 10^{-7}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-3
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.			
Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	0.5	C_D (-)	
dt_2 (min)	2	ξ (-)	-3
T_T (m^2/s)	$1.2 \cdot 10^{-7}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: The radial flow period occurs early in the test. Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The results of this test indicate increased transmissivity to the south side of the Prototype repository since earlier test-campigns.

6.1.8 KA3548A01:3 , test No 8:4b

General test data for the pressure build-up test in the interval 8.80-10.75 m of borehole KA3548A01 are presented in Table 6-8.

Table 6-8. General test data for the pressure build-up test in section 8.80-10.75 m of borehole KA3548A01.

General test data			
Borehole section	KA3548A01:3		
Test No	8:4b		
Field crew	A. Blom (SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp$_p$ = approximate 200 m)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	8.80
Test section- seclow	Seclow	m	10.75
Test section length	L_w	m	1.95
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071017 05:30:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071017 06:30:00
Stop of flow period		yymmdd hh:mm:ss	20071017 07:30:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071017 08:30:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1906.4	
Absolute pressure in test section before stop of flow	p_p	kPa	1028.3	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1891.5	
Maximal pressure change during flow period	dp_p	kPa	878.1	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.62 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$1.66 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.0598

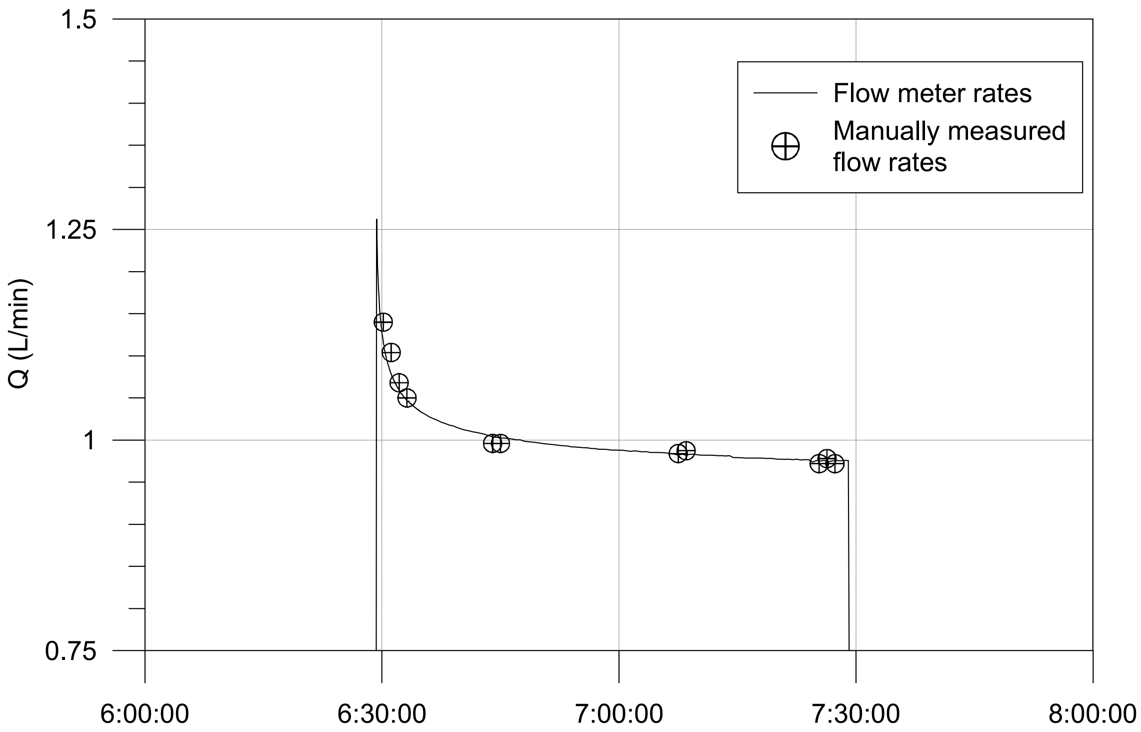


Figure 6-8. *Flow rates during draw down in KA3548A01:3.*

Comments to the test

The radial flow period occurs early in the test. Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The results of this test indicate increased transmissivity to the south side of the Prototype repository since earlier test-campigns.

Interpreted flow regimes

0 – 0.07	minutes	Well Bore Storage (WBS)
0.07 – 0.5	minutes	Transition period
0.5 – 2	minutes	Radial flow period
2 –	minutes	Transition period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

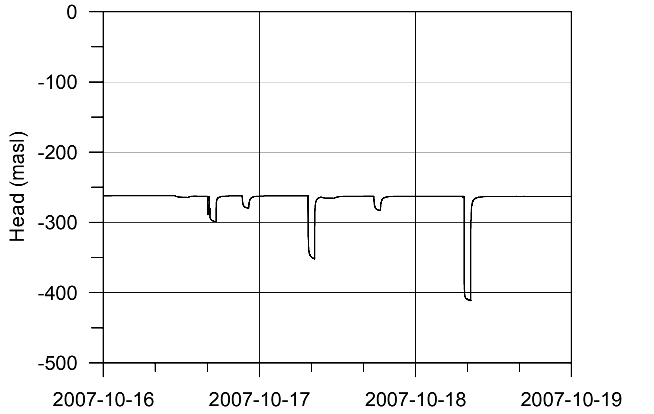
Selected representative parameters

The selected representative parameters from the test in the interval 8.80-10.75 m in KA3548A01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

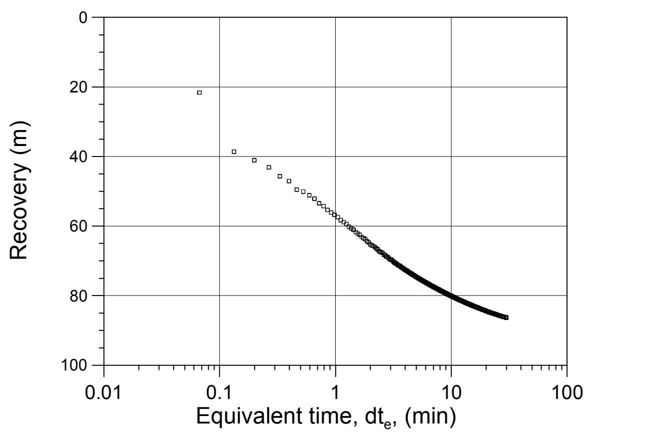
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:4b
Borehole ID:	KA3548A01	Test start:	2007-10-17 05:30
Test section (m):	8.80-10.75	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



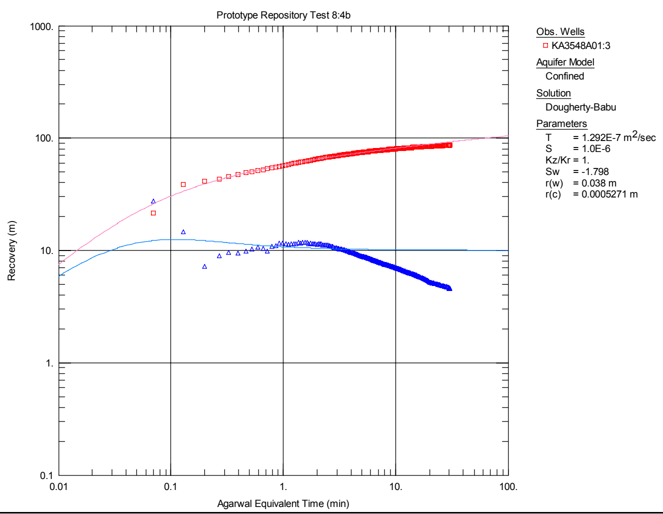
Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)	1906.4		
p_i (kPa)			
p_p(kPa)	1028.3	p_F (kPa)	1891.5
Q_p (m^3/s)	$1.62 \cdot 10^{-5}$		
tp (min)	60	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$1.8 \cdot 10^{-7}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$1.2 \cdot 10^{-7}$	dt_{e1} (min)	0.5
Flow regime:		dt_{e2} (min)	2
dt_1 (min)		T (m^2/s)	$1.3 \cdot 10^{-7}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-2
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.			
Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	0.5	C_D (-)	
dt_2 (min)	2	ξ (-)	-2
T_T (m^2/s)	$1.3 \cdot 10^{-7}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: The radial flow period occurs early in the test. Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The results of this test indicate increased transmissivity to the south side of the Prototype repository since earlier test-campings.

6.1.9 KA3548A01:3 , test No 8:4c

General test data for the pressure build-up test in the interval 8.80-10.75 m of borehole KA3548A01 are presented in Table 6-9.

Table 6-9. General test data for the pressure build-up test in section 8.80-10.75 m of borehole KA3548A01.

General test data			
Borehole section	KA3548A01:3		
Test No	8:4c		
Field crew	A. Blom (SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp$_p$ = max)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	8.80
Test section- seclow	Seclow	m	10.75
Test section length	L_w	m	1.95
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071018 05:30:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071018 06:30:00
Stop of flow period		yymmdd hh:mm:ss	20071018 07:30:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071018 08:30:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1902.1	
Absolute pressure in test section before stop of flow	p_p	kPa	445.6	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1883.1	
Maximal pressure change during flow period	dp_p	kPa	1456.5	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$2.15 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$2.33 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.0842

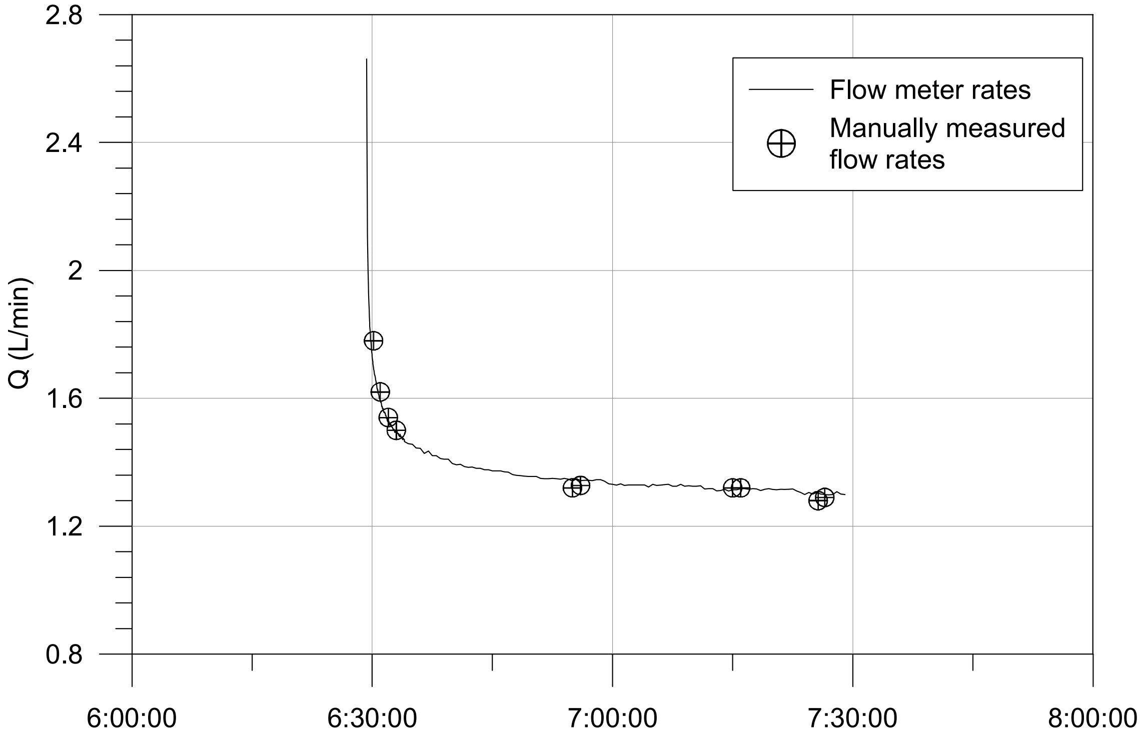


Figure 6-9. *Flow rates during draw down in KA3548A01:3.*

Comments to the test

Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The results of this test indicate increased transmissivity to the south side of the Prototype repository since earlier test-campigns.

Interpreted flow regimes

0 – 0.2	minutes	Well Bore Storage (WBS)
0.2 – 1	minutes	Transition period
1 – 3	minutes	Radial flow period
3 –	minutes	Transition period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log and log-log diagrams according to the methods described in Section 5.4.1.

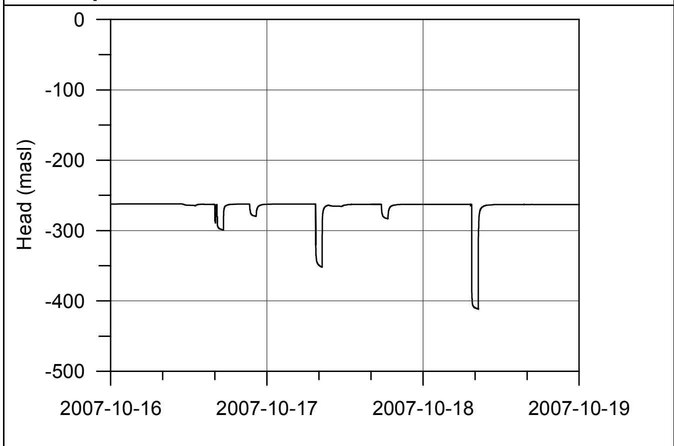
Selected representative parameters

The selected representative parameters from the test in the interval 8.80-10.75 m in KA3548A01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

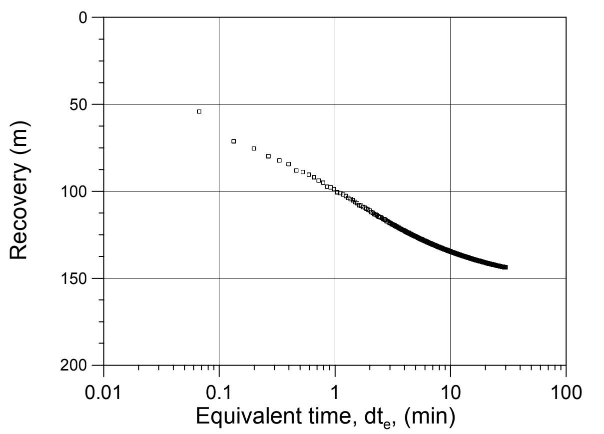
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:4c
Borehole ID:	KA3548A01	Test start:	2007-10-18 05:30
Test section (m):	8.80-10.75	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



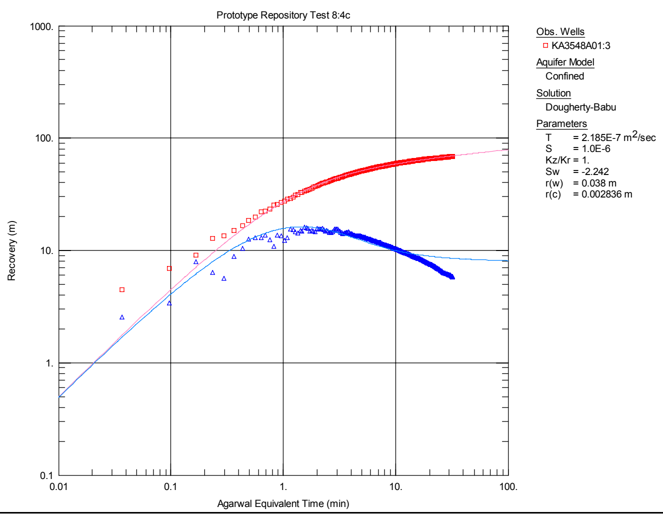
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1902.1		
p_i (kPa)			
p_p(kPa)	445.6	p_F (kPa)	1883.1
Q_p (m^3/s)	$2.15 \cdot 10^{-5}$		
tp (min)	60	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$1.5 \cdot 10^{-7}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$1.0 \cdot 10^{-7}$	dt_{e1} (min)	1
Flow regime:		dt_{e2} (min)	3
dt_1 (min)		T (m^2/s)	$2.2 \cdot 10^{-7}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-2
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	1	C_D (-)	
dt_2 (min)	3	ξ (-)	-2
T_T (m^2/s)	$2.2 \cdot 10^{-7}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method. The results of this test indicate increased transmissivity to the south side of the Prototype repository since earlier test-campigns.

6.1.10 KA3542G01:3 , test No 8:5a

General test data for the pressure build-up test in the interval 18.60-20.30 m of borehole KA3542G01 are presented in Table 6-10.

Table 6-10. General test data for the pressure build-up test in section 18.60-20.30 m of borehole KA3542G01.

General test data			
Borehole section	KA3542G01:3		
Test No	8:5a		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approx. 100 m)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	18.60
Test section- seclow	Seclow	m	20.30
Test section length	L_w	m	1.70
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071015 19:40:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071015 20:40:00
Stop of flow period		yymmdd hh:mm:ss	20071015 21:40:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071015 23:40:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	120

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1884.0	
Absolute pressure in test section before stop of flow	p_p	kPa	1514.7	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1888.5	> p_0
Maximal pressure change during flow period	dp_p	kPa	369.3	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$3.12 \cdot 10^{-6}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$3.52 \cdot 10^{-6}$
Total volume discharged during flow period	V_p	m^3	0.0127

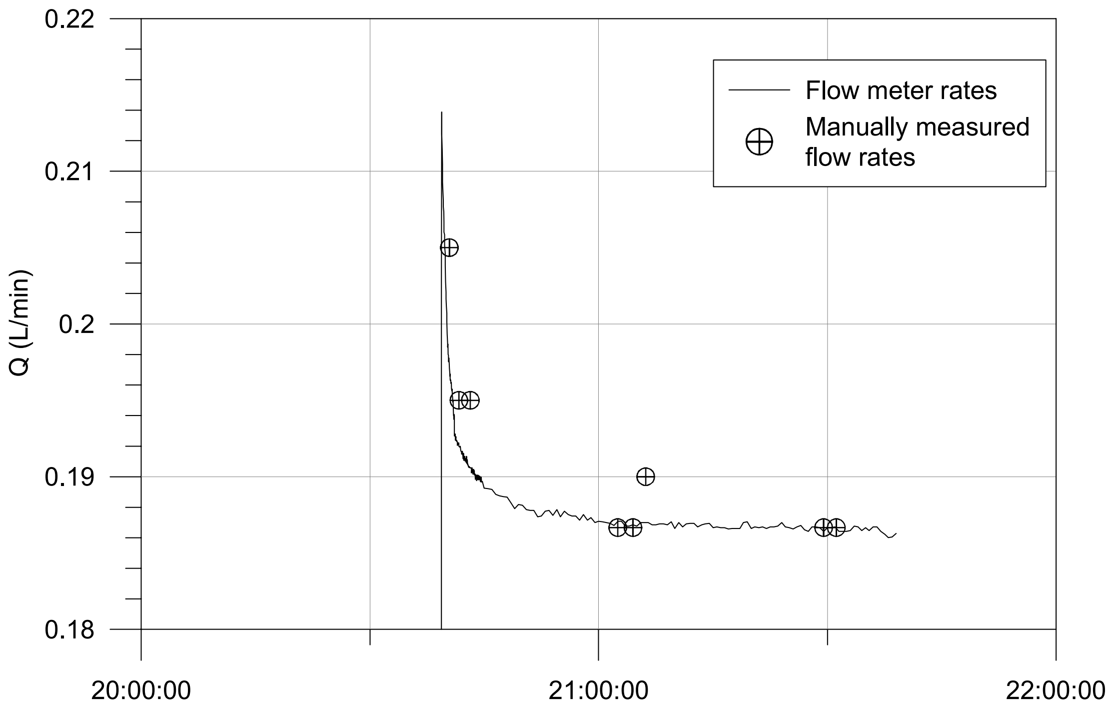


Figure 6-10. *Flow rate during draw down in KA3542G01:3.*

Comments to the test

Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

Interpreted flow regimes

0 – 0.1	minutes	Well Bore Storage (WBS)
0.1 – 0.8	minutes	Transition period
0.8 – 3	minutes	Radial flow period
3 –	minutes	Transition period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

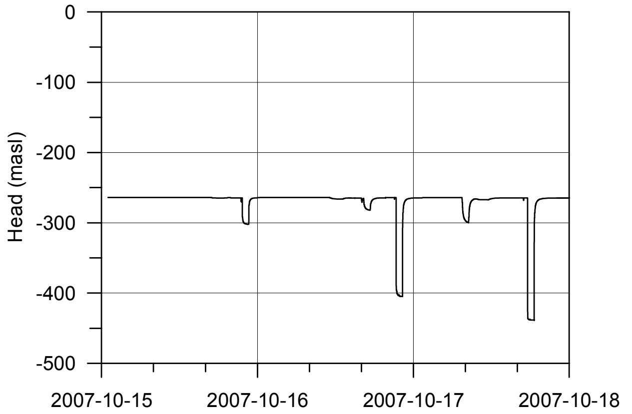
Selected representative parameters

The selected representative parameters from the test in the interval 18.60-20.30 m in KA3542G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

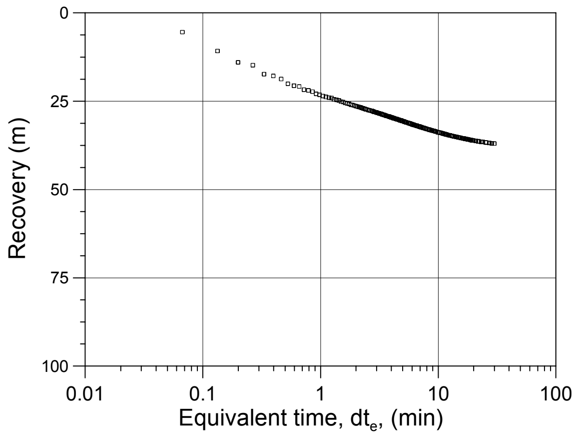
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:5a
Borehole ID:	KA3542G01	Test start:	2007-10-15 19:40
Test section (m):	18.60-20.30	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



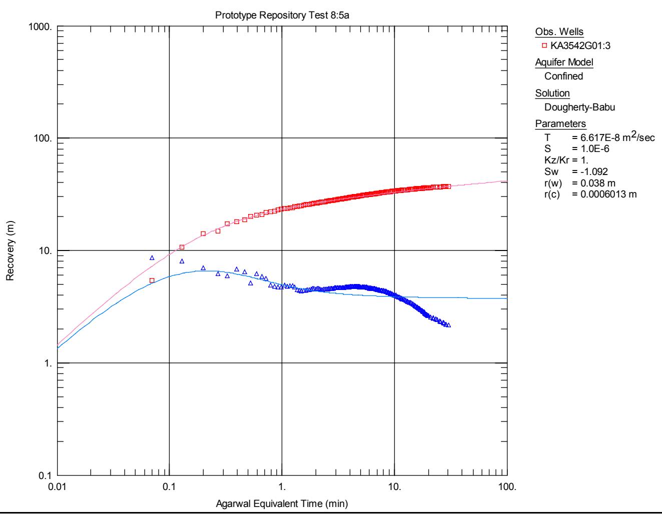
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1884.0		
p_i (kPa)			
p_p(kPa)	1514.7	p_F (kPa)	1888.5
Q_p (m^3/s)	$3.12 \cdot 10^{-6}$		
tp (min)	60	t_F (min)	120
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		Results	
Q/s (m^2/s)	$8.4 \cdot 10^{-8}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$5.5 \cdot 10^{-8}$	dt_{e1} (min)	0.8
Flow regime:		dt_{e2} (min)	3
dt_1 (min)		T (m^2/s)	$6.6 \cdot 10^{-8}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-1
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	0.8	C_D (-)	
dt_2 (min)	3	ξ (-)	-1
T_T (m^2/s)	$6.6 \cdot 10^{-8}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

6.1.11 KA3542G01:3 , test No 8:5b

General test data for the pressure build-up test in the interval 18.60-20.30 m of borehole KA3542G01 are presented in Table 6-11.

Table 6-11. General test data for the pressure build-up test in section 18.60-20.30 m of borehole KA3542G01.

General test data			
Borehole section	KA3542G01:3		
Test No	8:5b		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approx. 200 m)		
	Nomencl ature	Unit	Value
Test section- secup	Secup	m	18.60
Test section- seclow	Seclow	m	20.30
Test section length	L_w	m	1.70
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071016 19:20:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071016 20:20:00
Stop of flow period		yymmdd hh:mm:ss	20071016 21:20:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071016 23:20:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	120

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1887.7	
Absolute pressure in test section before stop of flow	p_p	kPa	507.1	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1885.3	
Maximal pressure change during flow period	dp_p	kPa	1380.6	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$8.83 \cdot 10^{-6}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$9.31 \cdot 10^{-6}$
Total volume discharged during flow period	V_p	m^3	0.0335

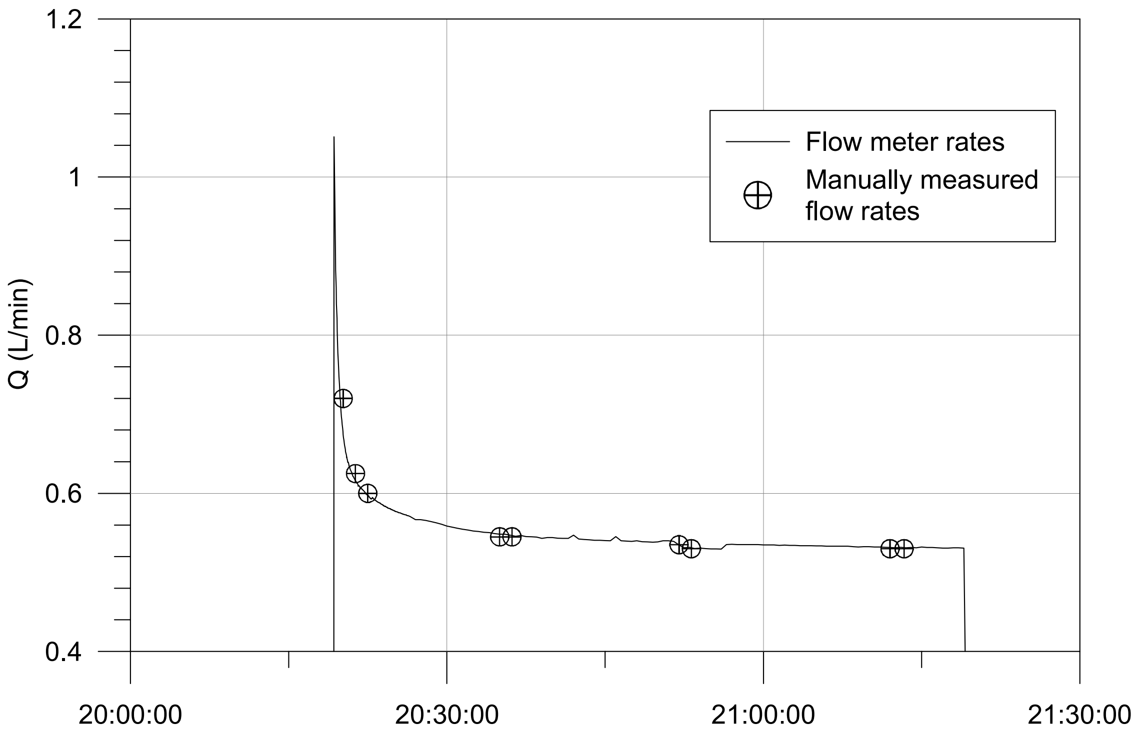


Figure 6-11. *Flow rate during draw down in KA3542G01:3.*

Comments to the test

Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

Interpreted flow regimes

0 – 0.15	minutes	Well Bore Storage (WBS)
0.15 – 2	minutes	Transition period
2 – 5	minutes	Radial flow period
5 –	minutes	Transition period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

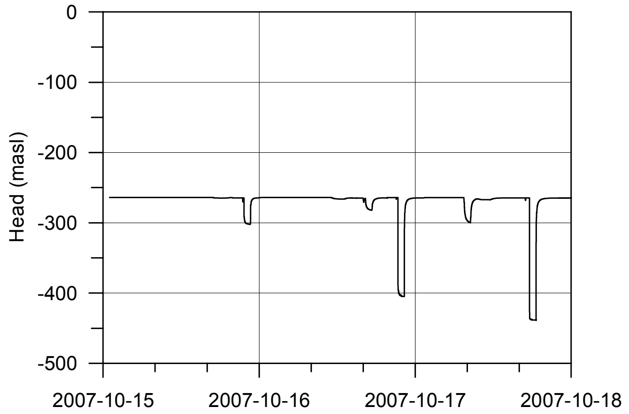
Selected representative parameters

The selected representative parameters from the test in the interval 18.60-20.30 m in KA3542G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

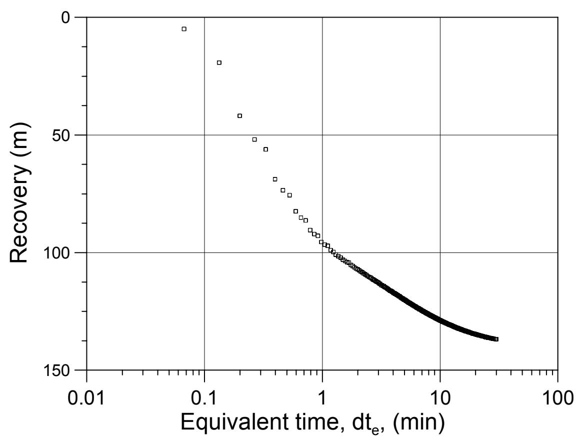
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:5b
Borehole ID:	KA3542G01	Test start:	2007-10-16 16:00
Test section (m):	18.60-20.30	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



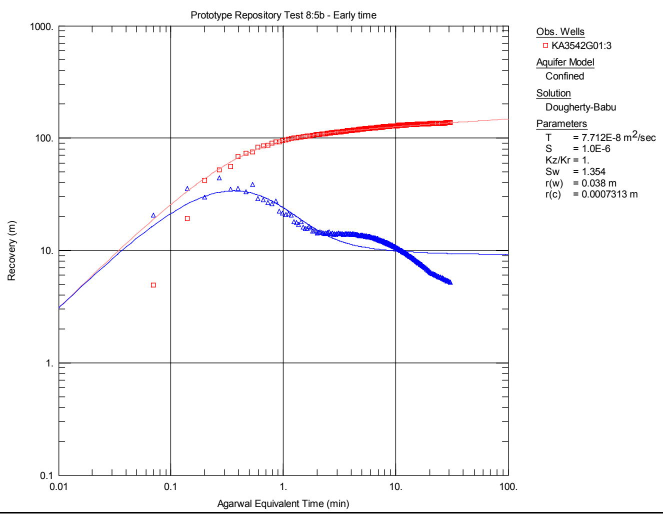
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1887.7		
p_i (kPa)			
p_p(kPa)	507.1	p_F (kPa)	1885.3
Q_p (m^3/s)	$8.83 \cdot 10^{-6}$		
tp (min)	60	t_F (min)	120
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		Results	
Q/s (m^2/s)	$6.4 \cdot 10^{-8}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$4.2 \cdot 10^{-8}$	dt_{e1} (min)	2
Flow regime:		dt_{e2} (min)	5
dt_1 (min)		T (m^2/s)	$7.7 \cdot 10^{-8}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	1
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	2	C_D (-)	
dt_2 (min)	5	ξ (-)	1
T_T (m^2/s)	$7.7 \cdot 10^{-8}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

6.1.12 KA3542G01:3 , test No 8:5c

General test data for the pressure build-up test in the interval 18.60-20.30 m of borehole KA3542G01 are presented in Table 6-12.

Table 6-12. General test data for the pressure build-up test in section 18.60-20.30 m of borehole KA3542G01.

General test data			
Borehole section	KA3542G01:3		
Test No	8:5c		
Field crew	A. Blom (SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = max)		
	Nomen-clature	Unit	Value
Test section- secup	Secup	m	18.60
Test section- seclow	Seclow	m	20.30
Test section length	L_w	m	1.70
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071017 15:35:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071017 16:35:00
Stop of flow period		yymmdd hh:mm:ss	20071017 17:35:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071017 19:35:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	120

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1885.5	
Absolute pressure in test section before stop of flow	p_p	kPa	179.7	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1879.9	
Maximal pressure change during flow period	dp_p	kPa	1705.8	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.01 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$1.11 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.0400

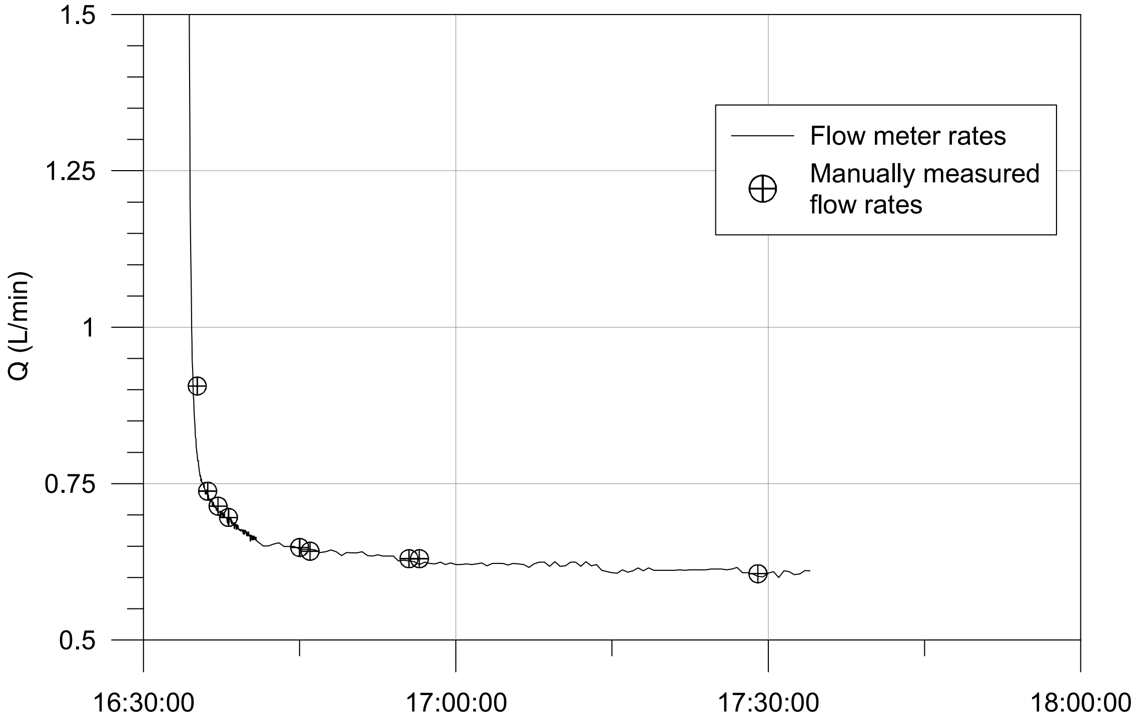


Figure 6-12. *Flow rate during draw down in KA3542G01:3.*

Comments to the test

Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

Interpreted flow regimes

0 – 0.2	minutes	Well Bore Storage (WBS)
0.2 – 1.5	minutes	Transition period
1.5 – 5	minutes	Radial flow period
5 –	minutes	Transition period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log and log-log diagrams according to the methods described in Section 5.4.1.

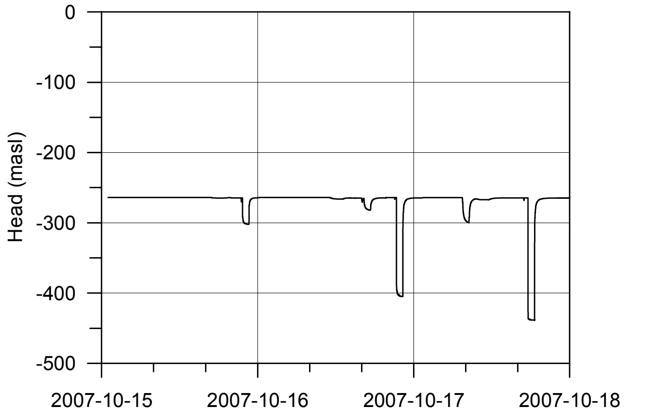
Selected representative parameters

The selected representative parameters from the test in the interval 18.60-20.30 m in KA3542G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

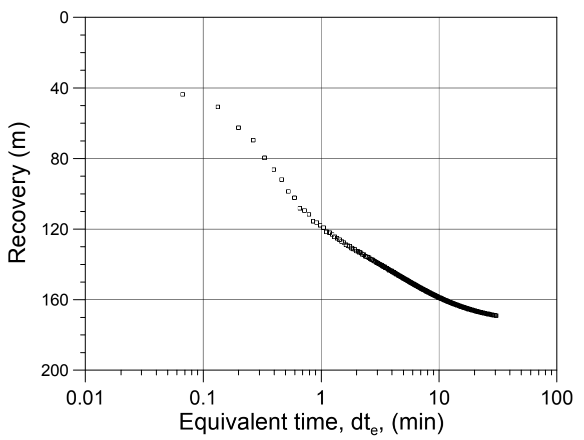
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:5c
Borehole ID:	KA3542G01	Test start:	2007-10-17 15:35
Test section (m):	18.60-20.30	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



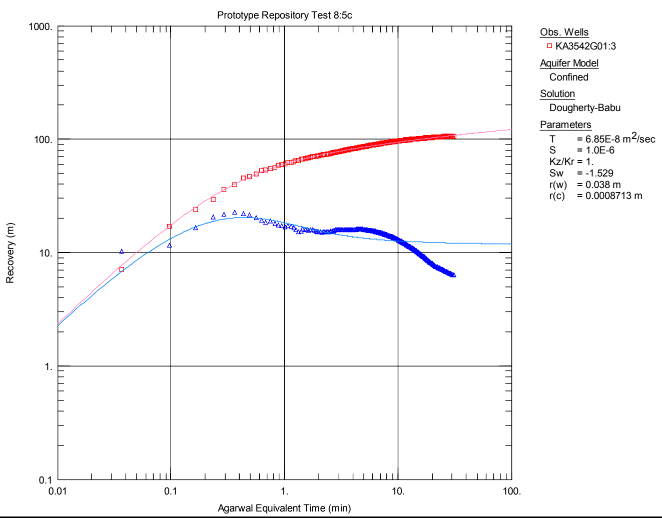
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1885.5		
p_i (kPa)			
p_p(kPa)	179.7	p_F (kPa)	1879.9
Q_p (m^3/s)	$1.01 \cdot 10^{-5}$		
tp (min)	60	t_F (min)	120
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$5.9 \cdot 10^{-8}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$3.9 \cdot 10^{-8}$	dt_{e1} (min)	1.5
Flow regime:		dt_{e2} (min)	5
dt_1 (min)		T (m^2/s)	$6.9 \cdot 10^{-8}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-2
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	1.5	C_D (-)	
dt_2 (min)	5	ξ (-)	-2
T_T (m^2/s)	$6.9 \cdot 10^{-8}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

6.1.13 KA3542G02:2 , test No 8:7a

General test data for the pressure build-up test in the interval 25.60-27.20 m of borehole KA3542G02 are presented in Table 6-13.

Table 6-13. General test data for the pressure build-up test in section 25.60-27.20 m of borehole KA3542G02.

General test data			
Borehole section	KA3542G02:2		
Test No	8:7a		
Field crew	A. Blom (SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approximate 100 m)		
	Nomen-clature	Unit	Value
Test section- secup	Secup	m	25.60
Test section- seclow	Seclow	m	27.20
Test section length	L_w	m	1.60
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071018 13:30:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071018 14:30:00
Stop of flow period		yymmdd hh:mm:ss	20071018 17:30:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071018 19:00:00
Total flow time	t_p	min	180
Total recovery time	t_F	min	90

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1653.2	
Absolute pressure in test section before stop of flow	p_p	kPa	952.5	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1551.6	
Maximal pressure change during flow period	dp_p	kPa	700.7	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$7.08 \cdot 10^{-8}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$8.04 \cdot 10^{-8}$
Total volume discharged during flow period	V_p	m^3	$8.68 \cdot 10^{-4}$

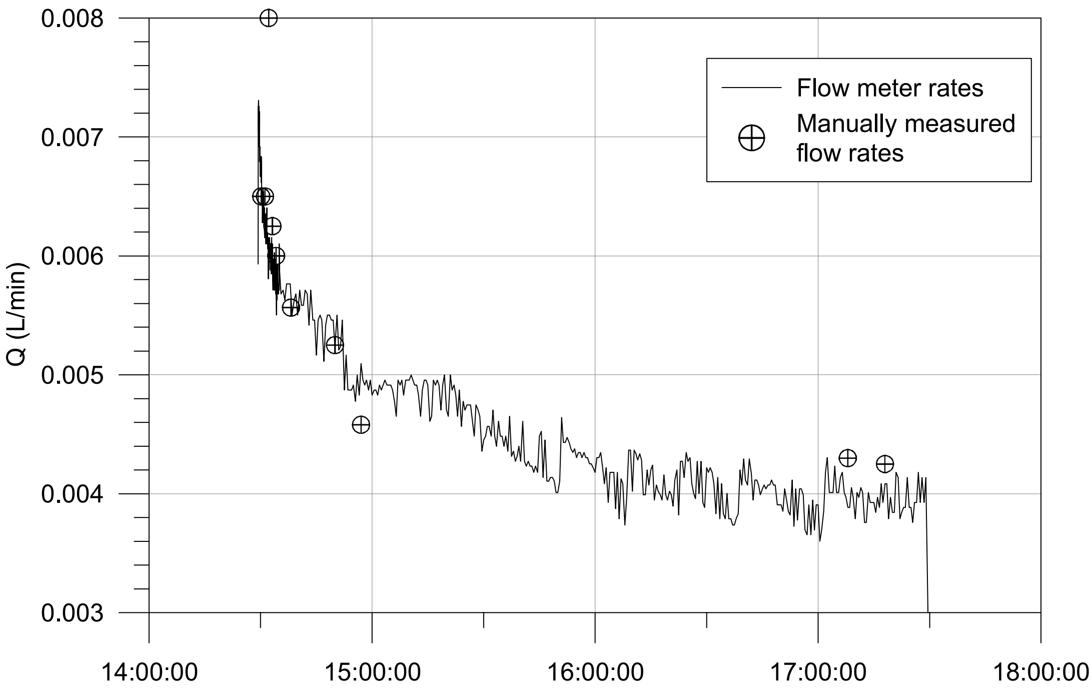


Figure 6-13. *Flow rate during draw down in KA3542G02:2.*

Comments to the test

Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

Interpreted flow regimes

0 – 0.5	minutes	Well Bore Storage (WBS)
0.5 – 6	minutes	Transition period
6 – 12	minutes	Radial flow
12 –	minutes	Transition period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

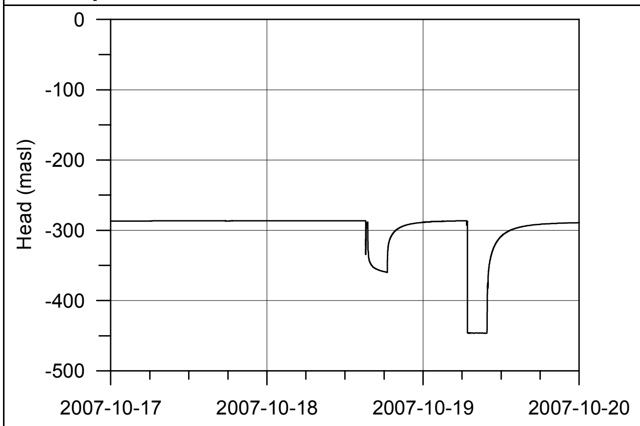
Selected representative parameters

The selected representative parameters from the test in the interval 25.60-27.20 m in KA3542G02 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

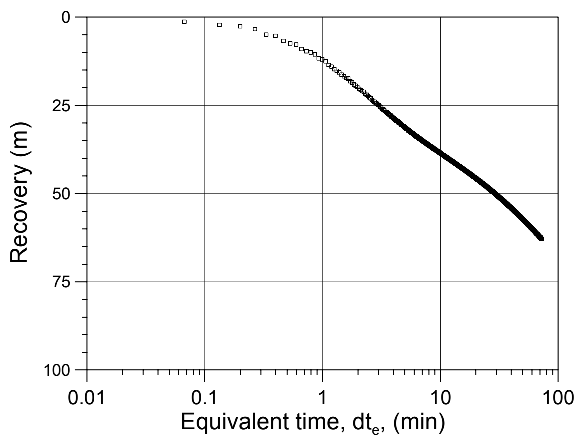
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:7a
Borehole ID:	KA3542G02	Test start:	2007-10-18 13:30
Test section (m):	25.60-27.20	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



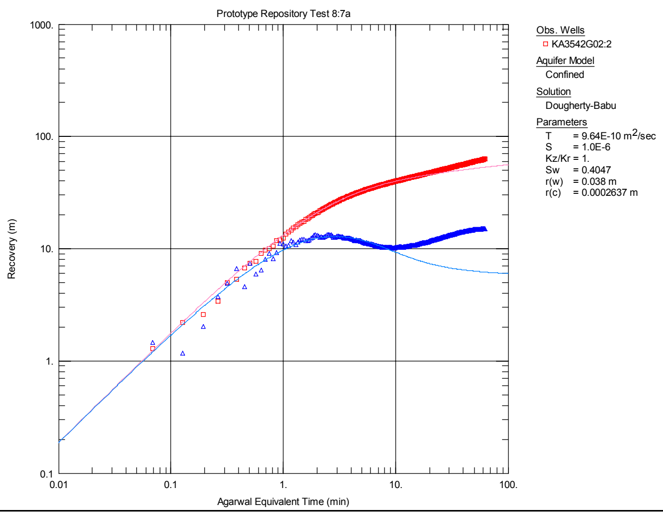
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1653.2		
p_i (kPa)			
p_p(kPa)	952.5	p_F (kPa)	1551.6
Q_p (m^3/s)	$7.08 \cdot 10^{-8}$		
tp (min)	180	t_F (min)	90
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$1.0 \cdot 10^{-9}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$6.5 \cdot 10^{-10}$	dt_{e1} (min)	6
Flow regime:		dt_{e2} (min)	12
dt_1 (min)		T (m^2/s)	$9.6 \cdot 10^{-10}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	0.4
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	6	C_D (-)	
dt_2 (min)	12	ξ (-)	0.4
T_T (m^2/s)	$9.6 \cdot 10^{-10}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

6.1.14 KA3542G02:2 , test No 8:7b

General test data for the pressure build-up test in the interval 25.60-27.20 m of borehole KA3542G02 are presented in Table 6-14.

Table 6-14. General test data for the pressure build-up test in section 25.60-27.20 m of borehole KA3542G02.

General test data			
Borehole section	KA3542G02:2		
Test No	8:7b		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = max)		
	Nomen-clature	Unit	Value
Test section- secup	Secup	m	25.60
Test section- seclow	Seclow	m	27.20
Test section length	L_w	m	1.60
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071019 04:50:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071019 05:50:00
Stop of flow period		yymmdd hh:mm:ss	20071019 08:50:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071019 10:20:00
Total flow time	t_p	min	180
Total recovery time	t_F	min	90

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1665.0	
Absolute pressure in test section before stop of flow	p_p	kPa	103.9	
Absolute pressure in test section at stop of recovery period	p_f	kPa	1380.0	
Maximal pressure change during flow period	dp_p	kPa	1561.1	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.55 \cdot 10^{-7}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$1.92 \cdot 10^{-7}$
Total volume discharged during flow period	V_p	m^3	$2.07 \cdot 10^{-3}$

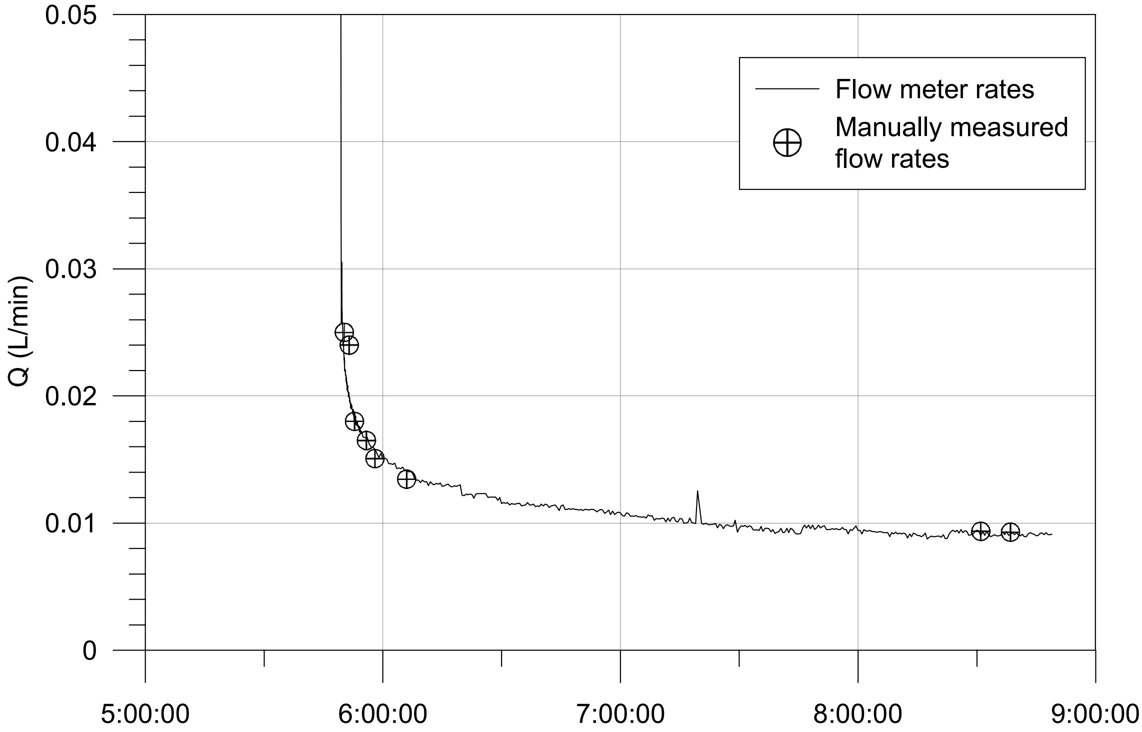


Figure 6-14. *Flow rate during draw down in KA3542G02:2.*

Comments to the test

The reason to the pressure disturbance during recovery is not known. Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

Interpreted flow regimes

0 – 1	minutes	Well Bore Storage (WBS)
1 – 6	minutes	Transition period
6 – 30	minutes	Radial flow
30 –	minutes	Transition period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

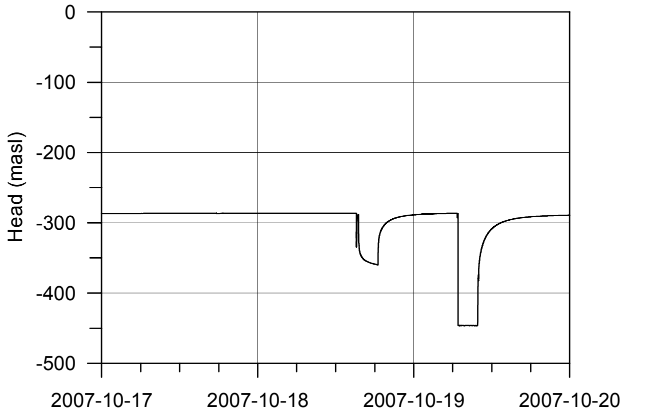
Selected representative parameters

The selected representative parameters from the test in the interval 25.60-27.20 m in KA3542G02 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

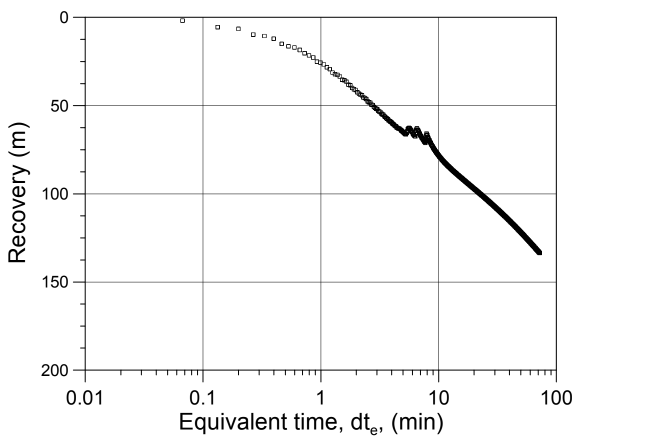
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:7b
Borehole ID:	KA3542G02	Test start:	2007-10-19 04:50
Test section (m):	25.60-27.20	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



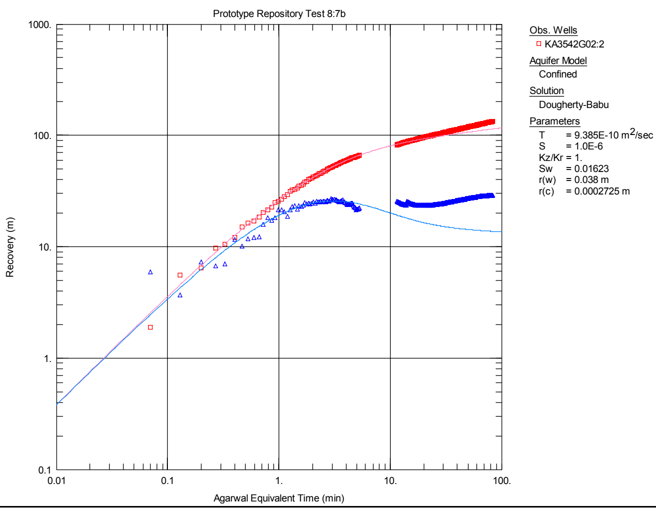
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1665.0		
p_i (kPa)			
p_p(kPa)	103.9	p_F (kPa)	1380.0
Q_p (m^3/s)	$1.55 \cdot 10^{-7}$		
tp (min)	180	t_F (min)	90
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$9.9 \cdot 10^{-10}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$6.4 \cdot 10^{-10}$	dt_{e1} (min)	6
Flow regime:		dt_{e2} (min)	30
dt_1 (min)		T (m^2/s)	$9.4 \cdot 10^{-10}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	0
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	6	C_D (-)	
dt_2 (min)	30	ξ (-)	0
T_T (m^2/s)	$9.4 \cdot 10^{-10}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: The reason to the pressure disturbance during recovery is not known. Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

6.1.15 KA3546G01:2 , test No 8:9

General test data for the pressure build-up test in the interval 6.75-8.30 m of borehole KA3546G01 are presented in Table 6-15.

Table 6-15. General test data for the pressure build-up test in section 6.75-8.30 m of borehole KA3546G01.

General test data			
Borehole section	KA3546G01:2		
Test No	8:9		
Field crew	A. Blom (SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = max)		
	Nomen-clature	Unit	Value
Test section- secup	Secup	m	6.75
Test section- seclow	Seclow	m	8.30
Test section length	L_w	m	1.55
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071017 10:35:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071017 11:35:00
Stop of flow period		yymmdd hh:mm:ss	20071017 14:35:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071017 16:05:00
Total flow time	t_p	min	180
Total recovery time	t_F	min	90

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	639.3	
Absolute pressure in test section before stop of flow	p_p	kPa	83.6	
Absolute pressure in test section at stop of recovery period	p_f	kPa	653.0	
Maximal pressure change during flow period	dp_p	kPa	555.7	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$2.92 \cdot 10^{-8}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	–
Total volume discharged during flow period	V_p	m^3	–

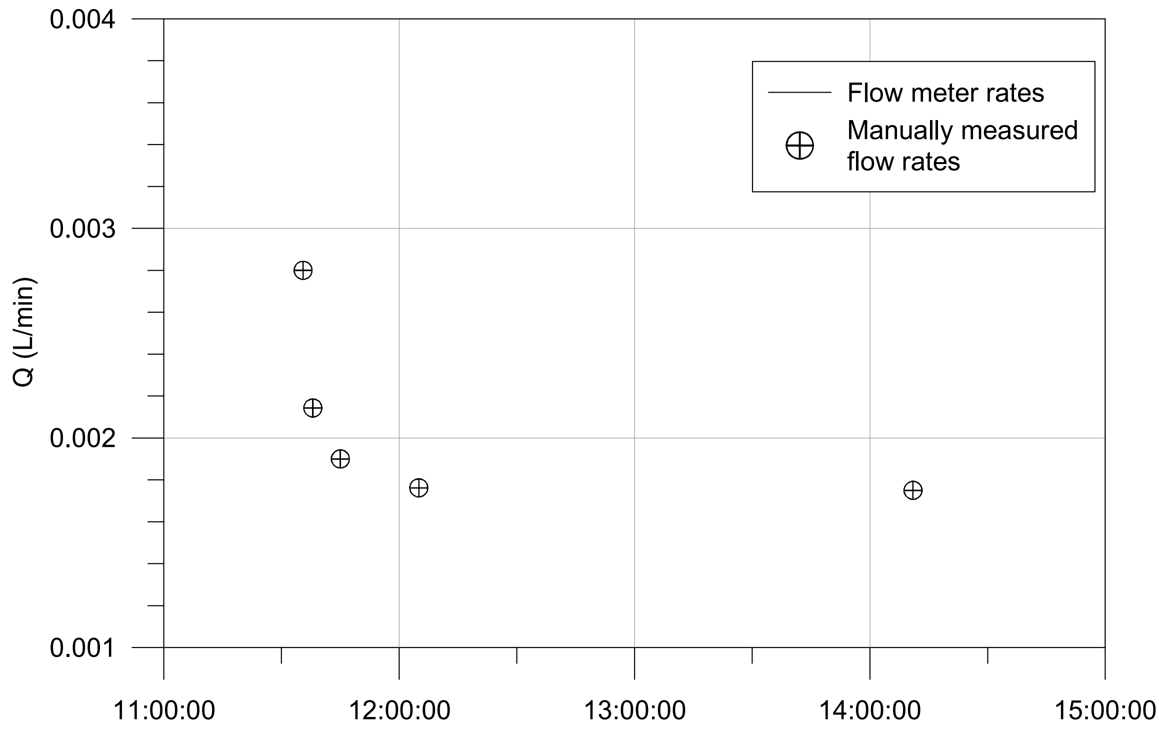


Figure 6-15. *Flow rate during draw down in KA3546G01:2. The flow in this section is very low. No flow meter readings are available.*

Comments to the test

A very low flow rate is established from this borehole. Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

Interpreted flow regimes

0 – 5	minutes	Well Bore Storage (WBS)
5 –	minutes	Transition period

No radial flow regime period is established.

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

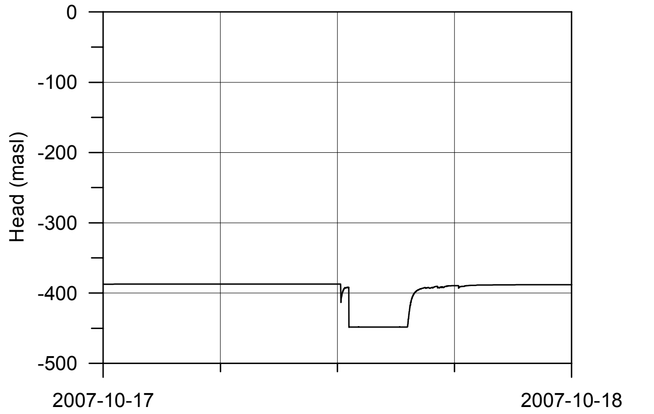
Selected representative parameters

The selected representative parameters from the test in the interval 6.75-8.30 m in KA3546G01 are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

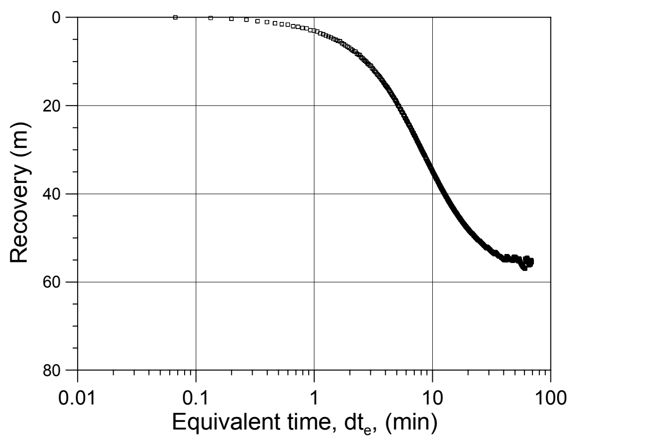
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:9
Borehole ID:	KA3546G01	Test start:	2007-10-17 10:35
Test section (m):	6.75-8.30	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



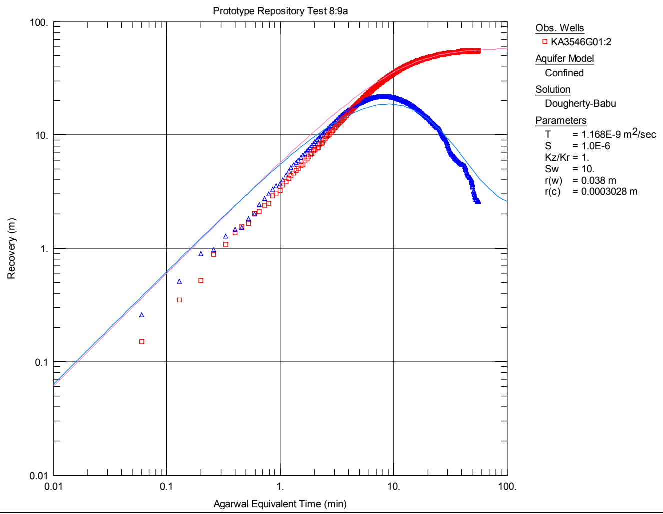
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	639.3		
p_i (kPa)			
p_p(kPa)	83.6	p_F (kPa)	653.0
Q_p (m^3/s)	$2.92 \cdot 10^{-8}$		
tp (min)	180	t_F (min)	90
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$5.3 \cdot 10^{-10}$	Flow regime:	-
T_{Moye}(m^2/s)	$3.4 \cdot 10^{-10}$	dt_{e1} (min)	-
Flow regime:		dt_{e2} (min)	-
dt_1 (min)		T (m^2/s)	$1.2 \cdot 10^{-9}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	10
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	-	C (m^3/Pa)	
dt_1 (min)	-	C_D (-)	
dt_2 (min)	-	ξ (-)	10
T_T (m^2/s)	$1.2 \cdot 10^{-9}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: No radial flow regime occurred during the test period. Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

6.1.16 KA3539G:2, test No 8:13a

General test data for the pressure build-up test in the interval 15.85-17.60 m of borehole KA3539G are presented in Table 6-16.

Table 6-16. General test data for the pressure build-up test in section 15.85-17.60 m of borehole KA3539G.

General test data			
Borehole section	KA3539G:2		
Test No	8:13a		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = approx. 100 m)		
	Nomenclature	Unit	Value
Test section- secup	Secup	m	15.85
Test section- seclow	Seclow	m	17.60
Test section length	L_w	m	1.75
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071015 17:40:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071015 18:40:00
Stop of flow period		yymmdd hh:mm:ss	20071015 19:40:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071015 20:40:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1016.3	
Absolute pressure in test section before stop of flow	p_p	kPa	554.9	
Absolute pressure in test section at stop of recovery period	p_f	kPa	931.5	
Maximal pressure change during flow period	dp_p	kPa	461.4	

Flow data

Flow data	**Nomenclature**	**Unit**	**Value**
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.14 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$1.40 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.0503

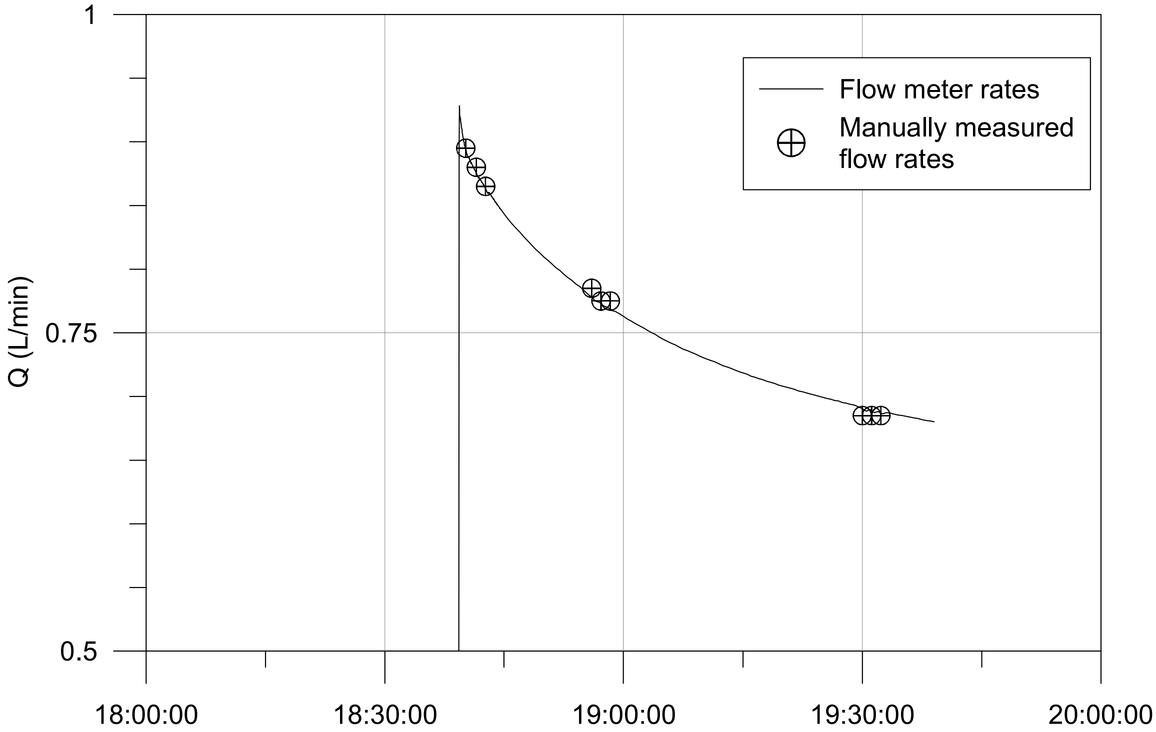


Figure 6-16. *Flow rate during draw down in KA3539G:2.*

Comments to the test

A linear channel flow period occurs during this test. Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

Interpreted flow regimes

0 – 0.05	minutes	Well Bore Storage (WBS)
0.05 – 0.25	minutes	Transition period
0.25 – 0.7	minutes	Radial flow period
0.7 – 10	minutes	Transition period
10 –	minutes	Possible linear channel flow period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

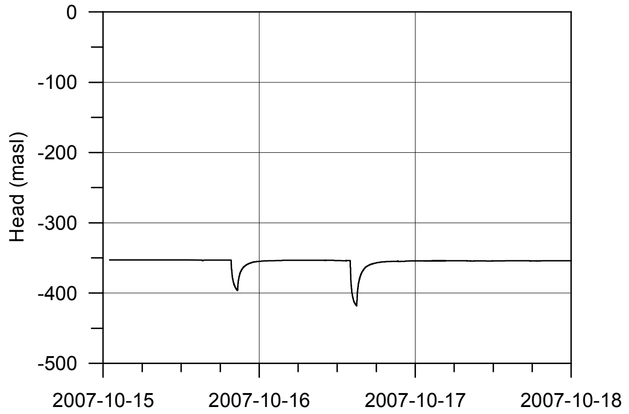
Selected representative parameters

The selected representative parameters from the test in the interval 15.85-17.60 m in KA3539G are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

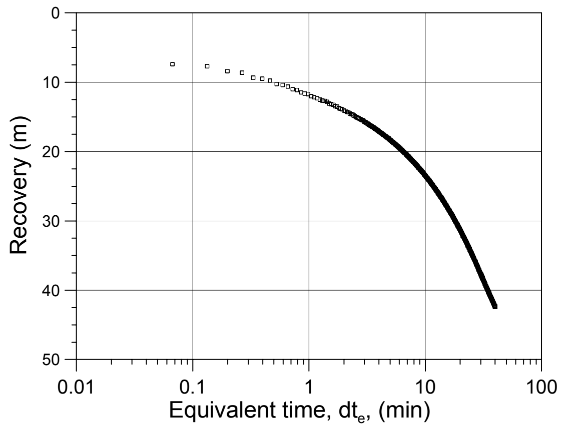
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:13a
Borehole ID:	KA3539G	Test start:	2007-10-15 17:40
Test section (m):	15.85-17.60	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



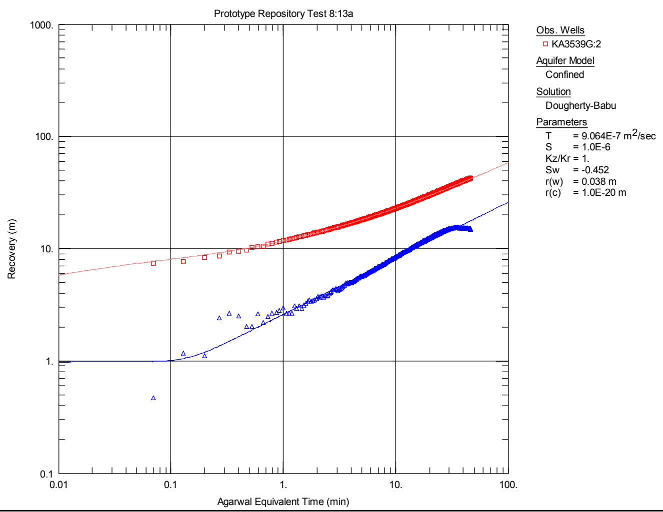
Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)	1016.3		
p_i (kPa)			
p_p(kPa)	554.9	p_F (kPa)	931.5
Q_p (m^3/s)	$1.14 \cdot 10^{-5}$		
tp (min)	60	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$2.5 \cdot 10^{-7}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$1.6 \cdot 10^{-7}$	dt_{e1} (min)	0.25
Flow regime:		dt_{e2} (min)	0.7
dt_1 (min)		T (m^2/s)	$9.1 \cdot 10^{-7}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-0.5
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	0.25	C_D (-)	
dt_2 (min)	0.7	ξ (-)	-0.5
T_T (m^2/s)	$9.1 \cdot 10^{-7}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: A channel flow regime is established during this test. Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

6.1.17 KA3539G:2, test No 8:13b

General test data for the pressure build-up test in the interval 15.85-17.60 m of borehole KA3539G are presented in Table 6-17.

Table 6-17. General test data for the pressure build-up test in section 15.85-17.60 m of borehole KA3539G.

General test data			
Borehole section	KA3539G:2		
Test No	8:13b		
Field crew	A. Blom(SWECO VIAK)		
Test equipment system	HMS		
General comment	Single hole test (dp_p = max)		
	Nomencl ature	Unit	Value
Test section- secup	Secup	m	15.85
Test section- seclow	Seclow	m	17.60
Test section length	L_w	m	1.75
Test section diameter	$2 \cdot r_w$	mm	76
Test start (start of pressure registration)		yymmdd hh:mm:ss	20071016 12:00:00
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	20071016 13:00:00
Stop of flow period		yymmdd hh:mm:ss	20071016 14:00:00
Test stop (stop of pressure registration)		yymmdd hh:mm:ss	20071016 15:00:00
Total flow time	t_p	min	60
Total recovery time	t_F	min	60

Pressure data

Pressure data	**Nomenclature**	**Unit**	**Value**	**Comment**
Absolute pressure in borehole before start of flow period	p_0	kPa	1010.4	
Absolute pressure in test section before stop of flow	p_p	kPa	315.8	
Absolute pressure in test section at stop of recovery period	p_f	kPa	885.3	
Maximal pressure change during flow period	dp_p	kPa	694.6	

Flow data

Flow data	Nomenclature	Unit	Value
Flow rate from test section just before stop of flowing	Q_p	m^3/s	$1.65 \cdot 10^{-5}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	$2.25 \cdot 10^{-5}$
Total volume discharged during flow period	V_p	m^3	0.081

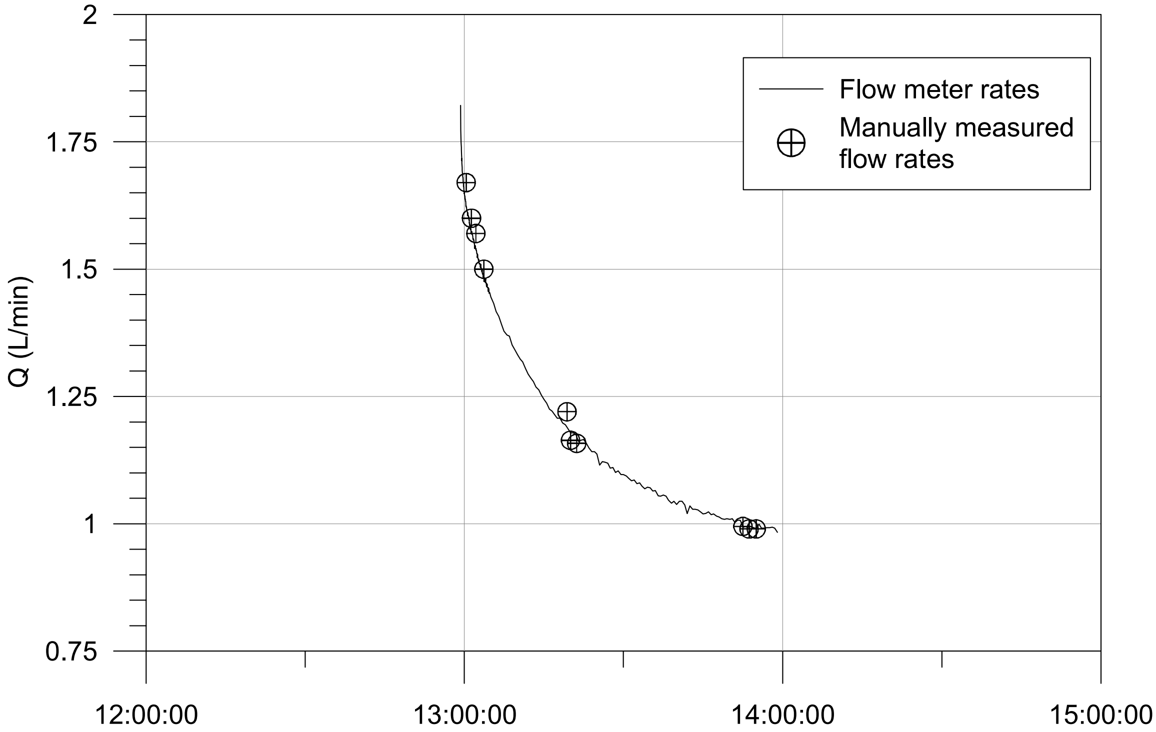


***Figure 6-17.** Flow rate during draw down in KA3539G:2.*

Comments to the test

A channel flow regime is established during this test. Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

Interpreted flow regimes

0 – 0.05	minutes	Well Bore Storage (WBS)
0.05 – 0.25	minutes	Transition period
0.25 – 0.7	minutes	Radial flow period
0.7 – 10	minutes	Transition period
10 –	minutes	Possible linear channel flow period

Calculated parameters

Quantitative analysis is made for recovery phases in lin-log- and log-log diagrams according to the methods described in Section 5.4.1.

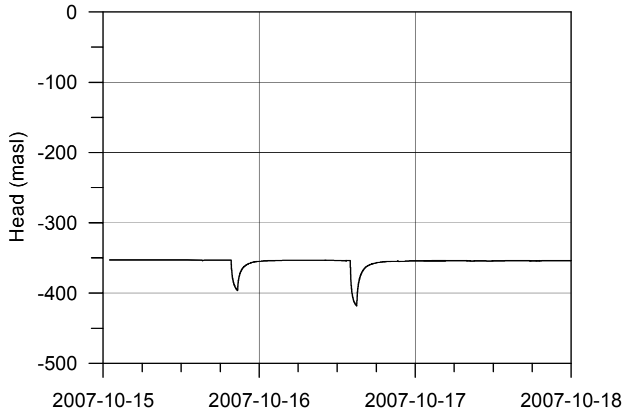
Selected representative parameters

The selected representative parameters from the test in the interval 15.85-17.60 m in KA3539G are presented in the Test Summary Sheet below. The selected parameters are derived from the recovery period.

Test Summary Sheet

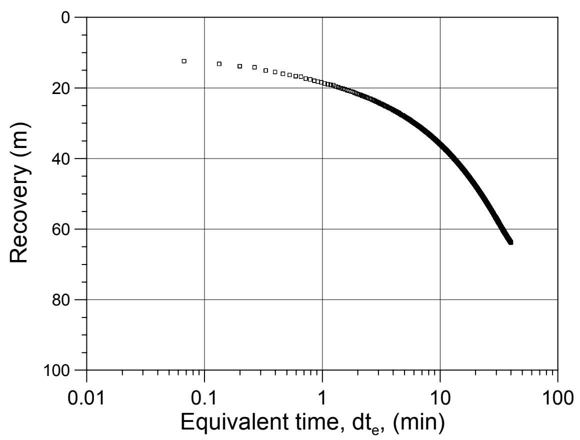
Project:	PROTOTYPE	Test type:	PBT
Area:	ÄSPÖ	Test no:	8:13b
Borehole ID:	KA3539G	Test start:	2007-10-16 12:00
Test section (m):	15.85-17.60	Responsible for test performance:	SWECO VIAK AB A. Blom
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	SWECO VIAK AB T. Forsmark

Linear plot Head



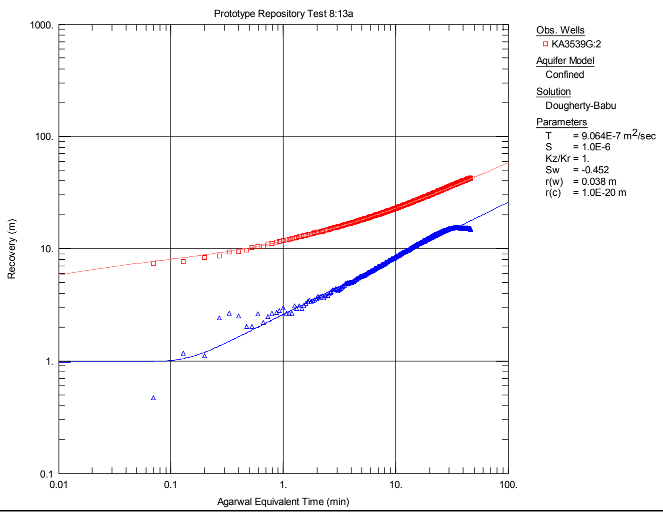
Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa)	1010.4		
p_i (kPa)			
p_p(kPa)	315.8	p_F (kPa)	885.3
Q_p (m^3/s)	$1.65 \cdot 10^{-5}$		
tp (min)	60	t_F (min)	60
S*		S*	$1 \cdot 10^{-6}$
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.		Derivative fact.	0.2

Lin-Log plot



Results		**Results**	
Q/s (m^2/s)	$2.4 \cdot 10^{-7}$	Flow regime:	Radial
T_{Moye}(m^2/s)	$1.6 \cdot 10^{-7}$	dt_{e1} (min)	0.25
Flow regime:		dt_{e2} (min)	0.7
dt_1 (min)		T (m^2/s)	$9.1 \cdot 10^{-7}$
dt_2 (min)		S (-)	
T (m^2/s)		K_s (m/s)	
S (-)		S_s (1/m)	
K_s (m/s)		C (m^3/Pa)	
S_s (1/m)		C_D (-)	
C (m^3/Pa)		ξ (-)	-0.5
C_D (-)			
ξ (-)			

Log-Log plot incl. derivative- recovery period



Interpreted formation and well parameters.

Flow regime:	Radial	C (m^3/Pa)	
dt_1 (min)	0.25	C_D (-)	
dt_2 (min)	0.7	ξ (-)	-0.5
T_T (m^2/s)	$9.1 \cdot 10^{-7}$		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: A channel flow regime is established during this test. Transmissivity and skinfactor evaluated by using AQTESOLV - with (Dougherty, Babu, 1984) method.

6.2 Deformation measurements

Deformation measurements started 2003-05-06. Evaluation of the deformations will be made in a separate report.

7 Conclusion

The results of some tests indicate increased transmissivity to the south side of the Prototype repository since earlier test-campigns. This may have been caused by the on-going investigation and construction work of a new tunnel from niche I. Some of the investigation boreholes in niche I have been leaking ground water into the tunnel system during several months. By doing that, fractures may have been cleansed of fracture minerals and the transmissivity of the rock mass may have increased at a local scale between the prototype repository and the proposed location of the new tunnel.

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