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Äspö Hard Rock Laboratory

Prototype Repository

Hydraulic tests in exploratory holes
Interference tests B after drilling campaign 3

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Geosigma

November 1999

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Foreword

This technical document is one of several reports describing the hydrogeological field characterisation work within the project ”Prototype Repository ” at the Äspö Hard Rock Laboratory. Up to now the field investigations have been performed in seven test campaigns between November 1997 and August 1999. Each campaign is described in a field report. The field work includes borehole flow logging with double packer system, pressure build up tests, interference tests, pressure measurements and injection tests.

Gentzschein, B. 1997: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Pilot Holes. Drill campaign 1. SKB International Progress Report IPR 99-27, December 1997.

Gentzschein, B. 1998: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Exploratory Holes. Drill campaign 2. SKB International Progress Report IPR 99-28, May 1998.

Gentzschein, B. 1999: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Exploratory Holes. Drill campaign 3a. SKB International Progress Report IPR 99-29, June 1999.

Gentzschein, B. 1999: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Exploratory Holes. Drill campaign 3b. SKB International Progress Report IPR 99-30, June 1999.

Gentzschein, B. 1999: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Exploratory Holes. Injection Tests. SKB International Progress Report IPR 99-31 , May 1999.

Gentzschein, B. 1999: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Exploratory Holes. Interference Tests A after drill campaign 3. SKB International Progress Report IPR 99-32, May 1999.

Gentzschein, B. 1999: Äspö Hard Rock Laboratory. Prototype Repository. Hydraulic Tests in Exploratory Holes. Interference Tests B after drill campaign 3. SKB International Progress Report IPR 99-33, November 1999.

The reports include technical specifications and description of the equipment used, measurement procedures, results of the flow and pressure measurements, relevant test data and all the background data necessary for interpretation and evaluation of field data.

Each test produces a great number of diagrams showing responses in test sections or observation boreholes caused by pressure draw-downs. Each report comprises between 120 and 600 diagrams sorted in appendices after the describing text. Due to the great number, the diagrams are not included in the printed versions of the reports. But the reports, including the diagrams are also stored as Word documents on a CD-R. In addition each diagram is stored as a file (GIF – format). The Word-documents, converted to PDF-format, as well as the diagram-files are available at the Äspö Hard Rock Laboratory.

ABSTRACT

The Prototype Repository in the Äspö Hard Rock Laboratory aims at simulating conditions in the future Deep Repository as realistically as possible. Some of many tasks are to observe the water saturation and homogenisation of the bentonite buffer and the backfill, and their interaction with the rock as well as to compare developed codes and material models with the observations. These tasks among other things need information on the hydraulic properties of the rock. The geohydraulic characterisation of the rock around the Prototype Repository is made in three stages. Each stage is intended to contribute to more details useful for determination of the localisation of the deposition holes and the boundary and rock conditions needed for the interpretation of the experimental data. The three stages are focused on

1. Mapping of the tunnel
2. Pilot and exploratory holes
3. Deposition holes

This International Progress Report is report number 7 out of seven in a series which presents the results from stage 2, i e hydrogeological characterisation in pilot and exploratory holes, which have been obtained during seven test campaigns between November 1997 and August 1999. More precisely the present International Progress Report presents the results from the second batch of interference tests, which were performed in seven of the deep exploratory holes (approximately 30 to 50 m deep). (The first four reports concerned in-flow and pressure build-up studies in the 33 exploratory drillholes in the Prototype Repository rock volume, supplemented with interference tests in hole sections with high in-flows. The fifth report concerned injection tests in the first 1.75 m of 13 of the altogether 33 exploratory holes, and the sixth report the first batch of interference tests in four of the 30 m deep holes.)

Packers were installed in the seven holes so that eight sections varying from approximately 5 to 15 m in length were obtained. Packers, one to five per hole, were also installed in all other exploratory holes (29 holes) in the Prototype Repository rock volume. All of these bore hole sections were connected to the Hydro Monitoring System, HMS, 63 during one period and 62 during another. Flowing of each of the eight sections was made in accordance to prepared plans and the data were processed, stored and plotted by the HMS. Two parameters were later processed: groundwater pressure and hydraulic head.

SAMMANFATTNING

Prototypförvaret i Äspölaboratoriet byggs för att simulera förhållandena så naturnära som möjligt i det framtida djupförvaret. Några av många uppgifter är att observera bentonitbuffertens och återfyllens vattenmättnad och homogenisering liksom den interaktion mellan materialen och berget som sker. samt att jämföra utvecklade koder och materialmodeller med de gjorda observationerna. För dessa uppgifter behöver bl a bergets hydrauliska egenskaper kunna beskrivas. Denna geohydrauliska karakteriseringen av berget omkring Prototypförvaret görs i tre steg. Varje steg ska bidra med mer användbar detaljinformation om lokalisering av deponeringshål samt randvillkor och bergegenskaper som behövs för tolkning av framtida observationer. De tre stegen inriktas på:

1. Kartering av tunneln
2. Pilot-och undersökningshål
3. Deponeringshål

Denna International Progress Report utgör rapport nummer 7 av sju i en serie som presenterar resultaten från Steg 2, dvs de hydrogeologiska karakteriseringar i pilot-och undersökningshål som gjorts i sju testkampanjer mellan november 1997 och augusti 1999. Mer precist redovisar föreliggande International Progress Report resultaten från den andrafasen av interferenstester, vilka utfördes i 7 av de djupa undersökningshålen (ca 30-50 m djupa). (Den fyra första rapporterna redovisade resultaten från inflödes-och tryckuppbyggnadstester i de 33 undersökningshålen i prototypförvarsområdet kompletterade med interferenstester i borrhålssektioner med stort inflöde. Den femte rapporten redovisade resultaten av injektionstester i de första 1,75 m i 13 av de totalt 33 undersökningshålen i prototypförvarsområdet, och den sjätte de första interferenstesterna i fyra av de ca 30 m djupa undersökningshålen)

Manschetter installerades i de sju hålen så att åtta sektioner med en längd på mellan ca 5 och 15 m bildades. En till fem manschetter installerades också i alla de andra undersökningshålen (29 st hål) i prototypförvaret. Nästan alla de avskilda sektionerna (63 under en period och 62 under en annan) anslöts till Äspölaboratoriets hydromoniteringssytem, HMS. Flödning av all de åtta testsektionerna gjordes enligt förberedda planer, och data processades, lagrades och plottades upp av HMS. Två parametrar processades senare: grundvattentrycket och hydrauliska trycket.

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1. BACKGROUND

Within the scope of the SKB program for R&D 1995, SKB has decided to carry out a project named ”Prototype Repository” at the Äspö Hard Rock Laboratory. The aim of the project is to test important components in SKB’s deep repository system in full scale and in a realistic environment.

The Prototype Repository is focused on testing and demonstrating the function of SKB’s 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.

The characterisation of the test site, located in the TBM-drilled part of the Äspö HRL-tunnel, will be made in three stages. Each stage is intended to contribute to more details useful for the determination of the localisation of the deposition holes and also the boundary and rock conditions needed for the interpretation of the experimental data. The three stages are focused on:

1. Mapping of the tunnel
2. Pilot and exploratory holes
3. Deposition holes

Stage 1 is completed and stage 2 has been divided into three drilling campaigns:

1. Drilling of pilot holes
2. Drilling of exploratory holes-short boreholes
3. Drilling of exploratory holes-long boreholes

Ten pilot holes were drilled between October 14th and October 20th 1997. in the tunnel interval 3/539 m - 3/593 m. Ten of the short exploratory boreholes were drilled in the tunnel interval 3/544 m - 3/588 m between March 16th and March 24th 1998. Hydraulic tests were performed in these boreholes in November 1997 and in April 1998.

Two short exploratory holes were drilled on April 25th and 26th 1998. Nine long exploratory (30 m) boreholes were drilled June 3rd - June 28th. Further more four of the older boreholes were extended to 30 m depth during May. In July and August two c 50 m long exploratory boreholes where drilled from the G-tunnel towards and above the prototype tunnel. During the summer and autumn 1998 flow measurements and hydraulic tests; pressure build-up (PBT) and interference tests were performed in the long exploratory holes. The last tests were completed in December 1998. In January 1999 constant pressure injection tests were carried out in 13 exploratory boreholes in the prototype tunnel.

A first campaign of interference tests were carried out in 4 exploratory boreholes in February and April 1999. This report describes objectives, performance and results of the second campaign of interference tests performed in seven of the exploratory holes on June 17th (test #7) and between August 16th and 22nd (tests #8 - #14).

2. OBJECTIVES

2.1 General objectives

The Prototype Repository should simulate a real Repository in as many aspects as possible, 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 of the Prototype Repository are:

- To demonstrate the integrated function of a full-scale prototype of the Repository system.
- To provide a full-scale reference for testing/scrutinization of models, experiments and assumptions.
- To develop, test and demonstrate appropriate engineering standards and quality assurance systems.
- To demonstrate technology for monitoring of the Repository system.

The objectives for the characterisation program are:

- To provide a basis for determination of localisation of the deposition holes.
- To provide data on boundary and rock conditions to enable interpretation of the experimental data.

2.2 Objectives of the hydraulic tests – interference tests

The objectives of the interference tests in the exploratory bore holes are to obtain data for the geological and hydrogeological models.

The objectives of the hydraulic tests in the exploratory bore holes are:

- The hydraulic tests in the exploratory holes shall provide hydrogeological data useful for setting up a hydrogeological model of the rock volume around the TBM tunnel. Identification of the positions and properties of larger conductive features are the main objectives.

3. SCOPE

Interference tests were performed in eight borehole sections in seven of the long exploratory holes of the Prototype Repository tunnel. The tested intervals and basic test data are listed in Table 3-1. Test number 7 in KG0048A01 was carried out in June 1999. The remaining 7 tests were performed during August 1999. The tests are numbered from 7 since 6 tests were performed in the interference test campaign A.

Table 3-1 A list of interference tests conducted in seven of the long exploratory boreholes. Prototype Repository, June and August 1999 (test campaign B)

Borehole: Section	Section Limits (m)	Date of test	Test No	Start of Test (hh:mm)	V. 0pen (hh:mm)	V Close (hh:mm)	End of Test (hh:mm)
KG0048A01:1	49.00-54.69	990617	7	09:00	08:00.00	09:25.00	14:20
KA3554G01:1	22.30-30.01	990818	8	08:00	10:00.03	16:04.05	08:55 (990819)
KA3554G02:2	10.30-21.30	990816	9	09:00	11:02.07	17:06.05	09:20 (990817)
KA3542G01:2	8.80 – 24.80	990817	10	09:00	11:00.03	17:05.03	09.55 (990818)
KA3542G02:4	1.30- 7.80	990819	11	07:00	09:00.01	15:01.01	07:55 (990820)
KA3539G:2	9.80–18.30	990822	12	07:00	08:00.07	09:11.05	18:00
KG0021A01:1	42.50-48.82	990821	13	07:00	09:00.05	15:02.10	07:55 (990822)
KG0021A01:3	25.00-34.00	990820	14	06:00	08:00.05	14:00.07	08:55 (990821)

Start/End of test = Start/end of data fetch

Packers were installed in all boreholes in the Prototype Repository (including KG0048A01) prior to interference test campaign A in February 1999 or earlier. In borehole KG0021A01 five packers were installed shortly before test # 7 in KG0048A01. In some of the boreholes only one mechanical single packer was installed, in others up to four inflatable polyurethane packers were installed, dividing the boreholes in 2 – 4 measurement intervals. Prior to the seven tests in August the packers were reconfigured. Two or more inflatable packers were installed in boreholes, earlier equipped with only one mechanical packer and vice versa. The number of measurement sections in the majority of the boreholes was therefore changed. All borehole sections in the Prototype Repository tunnel were connected to the Hydro Monitoring System (HMS) of the Äspö HRL. Altogether 63 sections were connected during test # 7, while 62 sections were connected during the tests in August.

After the packer installation the ground-water pressure of the borehole sections was stabilised.

4. EQUIPMENT USED

Two types of packers were used to confine the borehole measurement sections.

1. PUR 72
   Inflatable Polyurethane packers. The sealing length of each packer is 1.0 m. The packers are inflated using water pressurised by nitrogen, cf. Lindström (1997)
   The packer pressure was maintained by means of six pressure vessels, five of them located next to borehole KA3510A and one located in the G-tunnel.

2. Mechanical, 0.28 m (Mech 0.28)
   A new type of mechanical packer, with no packer pipe outside the borehole. The total packer length is 0.28 m. The sealing length is 0.135 m.

The groundwater pressure of the measurement sections in the Prototype Repository tunnel were monitored using the Hydro Monitoring System (HMS) of Äspö HRL (Nyberg et al 1997, Manual för HMS 1994). Via polyamide hoses each section was connected to a pressure transducer mounted on control boards in the I-tunnel and in the G-tunnel respectively. The pressure transducers used were of type Druck PTX 520. The pressure range was 50 bar. The distance between the control board and the boreholes in the TBM-drift varied between c. 10 m and c. 100 m. In the G-tunnel the control board was mounted on the south tunnel wall c. 5 m from borehole KG0021A01. The level of each pressure transducer above the tunnel floor is listed in Tables 4-1 and 4-2

The technical specifications of the pressure transducers are:

Supply voltage:	9 - 30 VDC
Output current:	4 - 20 mA
Linearity, hysteresis and Repeatability :	± 0.3 % of full scale (typically 0.15 % F.S)
Best straight line definition:	±0.2 % F.S. (typically ±0.1 % F.S)
Temperature error :	± 1 % F.S. over -10 ^{o}C to +50 ^{o}C (typically 0.7 % F.S)

Table 4-1 Bore hole section limits and level of pressure transducers above the tunnel floor during test # 7. Prototype Repository. Interference tests B after drill campaign 3, June 1999.

Idcode	Secup	Seclow	z-coordinate	Level above floor (m)
KA3510A:1	122.02	150.00	-447.960	0.81
KA3510A:2	114.02	121.02	-447.960	0.81
KA3510A:3	4.52	113.02	-447.960	0.81
KA3539G:1	0.30	30.01	-448.250	0.52
KA3542G01:1	0.30	30.04	-448.250	0.52
KA3542G02:1	0.30	30.01	-448.250	0.52
KA3544G1:1	0,30	12,00	-448,250	0.52
KA3546G1:1	0,30	12,00	-448,250	0.52
KA3548A01:1	15.00	30.00	-448.250	0.52
KA3548A01:2	10.00	14.00	-448.250	0.52
KA3548G01:1	0.3	12.01	-448.250	0.52
KA3550G01.1	0.30	12.03	-448.250	0.52
KA3552G01:1	0.30	12.01	-448.250	0.52
KA3554G01:1	0.30	30.01	-448.250	0.52
KA3554G02:1	0.30	30.01	-448.250	0.52
KA3557G:1	0.30	30.04	-448.250	0.52
KA3563G01:1	9.30	30.00	-447.540	1.23
KA3563G01:2	3.80	8.30	-447.540	1.23
KA3563G01:3	1.30	2.80	-447.540	1.23
KA3566G01:1	20.80	30.01	-447.540	0.52
KA3566G01:2	12.30	19.80	-447.540	1.23
KA3566G01:3	7.30	11.30	-447.540	1.23
KA3566G01:4	1.30	6.30	-447.540	1.23
KA3566G02:1	19.30	30.01	-447.540	1.23
KA3566G02:2	12.30	18.30	-447.540	1.23
KA3566G02:3	7.80	11.30	-447.540	1.23
KA3566G02:4	1.30	6.80	-447.900	0.87
KA3572G01:1	6.30	12.00	-447.900	0.87
KA3572G01:2	1.30	5.30	-447.900	0.87
KA3573A:1	18.00	40.07	-448.250	0.52
KA3573A:2	4.50	17.00	-448.250	0.52
KA3574G01:1	8.80	12.00	-447.900	0.87
KA3574G01:2	5.30	7.80	-447.900	0.87
KA3574G01:3	1.30	4.30	-447.900	0.87
KA3576G01:1	8.80	12.01	-447.900	0.87
KA3576G01:2	3.80	7.80	-447.900	0.87
KA3576G01:3	1.30	2.80	-447.900	0.87
KA3578G01:1	6.80	12.58	-447.900	0.87
KA3578G01:2	1.30	5.80	-447.900	0.87
KA3579G01:1	9.30	22.65	-447.900	0.87
KA3579G01:2	5.30	8.30	-447.900	0.87
KA3579G01:3	1.30	4.30	-447.900	0.87
KA3584G01:1	0.30	12.00	-448.250	0.52
KA3590G01:1	17.30	30.06	-447.900	0.87
KA3590G01:2	7.80	16.30	-447.900	0.87

Idcode	Secup	Seclow	z-coordinate	Level above floor (m)
KA3590G01:3	1.30	6.80	-447.900	0.87
KA3590G02:1	23.30	30.05	-447.900	0.87
KA3590G02:2	17.30	22.30	-447.900	0.87
KA3590G02:3	8.30	16.30	-447.900	0.87
KA3590G02:4	1.20	7.20	-447.900	0.87
KA3593G01:1	8.30	30.02	-447.900	0.87
KA3593G01:2	1.30	7.30	-448.250	0.52
KA3600F:1	22.00	50.10	-448.250	0.52
KA3600F:2	4.50	21.00	-448.250	0.52
KG0021A01:1	42.50	48.82	-446.78	0.98
KG0021A01:2	35.00	41.50	-446.78	0.98
KG0021A01:3	25.00	34.00	-446.78	0.98
KG0021A01:4	17.00	24.00	-446.78	0.98
KG0021A01:5	4.00	16.00	-446.78	0.98
KG0048A01:1	49.00	54.69	-446.78	0.98
KG0048A01:2	41.00	48.00	-446.78	0.98
KG0048A01:3	30.00	40.00	-447.03	0.73
KG0048A01:4	4.00	29.00	-447.03	0.73

The section limits in the two tables are recorded as the length along the borehole. The reference level (0 level) is the highest point of the intersection between the borehole and the tunnel wall (-floor).

Table 4-2 Bore hole section limits and level of pressure transducers above the tunnel floor during tests # 8 - #14. Prototype Repository. Interference tests B after drill campaign 3, August 1999

Idcode	Secup	Seclow	z-coordinate	Level above floor (m)
KA3510A:1	122.02	150.00	-447.960	0.81
KA3510A:2	114.02	121.02	-447.960	0.81
KA3510A:3	4.52	113.02	-447.960	0.81
KA3539G:1	19.30	30.01	-447.54	1.23
KA3539G:2	9.80	18.30	-447.54	1.23
KA3539G:3	1.30	8.80	-447.54	1.23
KA3542G01:1	25.8	30.04	-447.90	0.87
KA3542G01:2	8.80	24.80	-447.90	0.87
KA3542G01:3	1.30	7.80	-447.90	0.87
KA3542G02:1	2230	30.01	-447.90	0.87
KA3542G02:2	13.80	21.30	-447.90	0.87
KA3542G02:3	8.80	12.80	-447.90	0.87
KA3542G02:4	1.30	7.80	-447.90	0.87
KA3544G01:1	6.30	12.00	-447.90	0.87
KA3544G01:2	1.30	5.30	-447.90	0.87
KA3546G01:1	6.80	12.00	-447.90	0.87
KA3546G01:2	1.30	5.80	-447.90	0.87
KA3548A01:1	15.00	30.00	-448.250	0.52
KA3548A01:2	10.00	14.00	-448.250	0.52

Idcode	Secup	Seclow	z-coordinate	Level above floor (m)
KA3548G01:1	0.3	12.01	-448.250	0.52
KA3550G01:1	6.30	12.03	-447.90	0.87
KA3550G01:2	1.30	5.30	-448.25	0.52
KA3552G01:1	8.80	12.01	-447.90	0.87
KA3552G01:2	4.05	7.80	-447.90	0.87
KA3552G01:3	1.30	3.05	-447.90	0.87
KA3554G01:1	22.30	30.01	-447.90	0.87
KA3554G01:2	12.30	21.30	-447.90	0.87
KA3554G01:3	1.30	11.30	-447.90	0.87
KA3554G02:1	22.30	30.01	-447.90	0.87
KA3554G02:2	10.30	21.01	-447.90	0.87
KA3554G02:3	1.30	9.30	-447.90	0.87
KA3557G:1	0.30	30.04	-448.250	0.52
KA3563G01:1	0.30	30.00	-448.25	0.52
KA3566G01:1	20.80	30.01	-447.540	1.23
KA3566G01:2	12.30	19.80	-447.540	1.23
KA3566G01:3	7.30	11.30	-447.540	1.23
KA3566G01:4	1.30	6.30	-447.540	1.23
KA3566G02:1	19.30	30.01	-447.540	1.23
KA3566G02:2	12.30	18.30	-447.540	1.23
KA3566G02:3	7.80	11.30	-447.540	1.23
KA3566G02:4	1.30	6.80	-447.900	0.87
KA3572G01:1	0.30	12.00	-448.25	0.52
KA3573A:1	18.00	40.07	-448.250	0.52
KA3573A:2	4.50	17.00	-448.250	0.52
KA3574G01:1	0.30	12.00	-448.25	0.52
KA3576G01:1	0.30	12.01	-448.25	0.52
KA3578G01:1	0.30	12.58	-448.25	0.52
KA3579G01:1	0.30	22.65	-447.900	0.87
KA3590G01:1	0.30	30.06	-448.25	0.52
KA3590G02:1	0.30	30.05	-448.25	0.52
KA3593G01:1	0.30	30.02	-448.25	0.52
KA3600F:1	22.00	50.10	-448.250	0.52
KA3600F:2	4.50	21.00	-448.250	0.52
KG0021A01:1	42.50	48.82	-446.78	0.98
KG0021A01:2	35.00	41.50	-446.78	0.98
KG0021A01:3	25.00	34.00	-446.78	0.98
KG0021A01:4	17.00	24.00	-446.78	0.98
KG0021A01:5	4.00	16.00	-446.78	0.98
KG0048A01:1	49.00	54.69	-446.78	0.98
KG0048A01:2	41.00	48.00	-446.78	0.98
KG0048A01:3	30.00	40.00	-447.03	0.73
KG0048A01:4	4.00	29.00	-447.03	0.73

Water flow rates were measured using a stopwatch and graduated cylinders of different sizes. The test section water was discharged through one (test #7) or two (tests #8 - #14) Tecalan pipes. The outflow level of the boreholes respectively varied between 0.2 m and 1.1 m, see Table 4-3.

Table 4-3 Outflow level above the floor. Tests in exploratory holes, June 1999-August 1999. Prototype Repository, Interference tests B

Borehole: Section	Date Of test	Test No	Start of Test (hh:mm)	Outflow level above floor (m)
KG0048A01:1	990617	7	09:00	1.1
KA3554G01:1	990818	8	08:00	0.2-0.5
KA3554G02:2	990816	9	09:00	0.2-0.5
KA3542G01:2	990817	10	09:00	0.3-0.6
KA3542G02:4	990819	11	07:00	0.3-0.6
KA3539G:2	990822	12	07:00	0.3-0.5
KG0021A01:1	990821	13	07:00	1.1
KG0021A01:3	990820	14	06:00	1.1

Six of the boreholes are supplied with a borehole casing. The lengths are listed in Table 4-4.

Table 4-4 Casing lengths in boreholes of the Prototype Repository

Borehole	Length of casing in borehole (m)
KA3510A	<2.48
KA3548A01	2.20
KA3573A	2.31
KA3600F	2.27
KG0021A01	2.20
KG0048A01	2.42

Any notation of the exact length of the casing in borehole KA3510A does not exist, but the drilling record indicates that the length is less than and probably not far from 2.48 m.

5. PERFORMANCE

5.1 Packer installations and HMS-connection prior to test #7

During test # 7 the existing packer installation and HMS-configuration, completed in February 1999, was utilized. The only exception was KG0021A01 in which new observation sections were established and connected to HMS on June 16th 1999, see Table 4-1.

5.2 Packer installations and HMS-connection prior to tests #8 - #14

Prior to interference test #8 the packers were reconfigured in a majority of the boreholes in the Prototype tunnel. The installation field work started on July 27th and was completed on August 5th, see Tables 4-2 and 5-1.

In ten boreholes the already established packer configuration was used.
These bore holes were:

KA3510A	KA3566G02
KA3548A01	KA3573A
KA2548G01	KA3584G01
KA3557G	KA3600F
KA3566G01	KG0048A01

In nine boreholes the mechanical packer (Mech.0.28 m, see section 4) was replaced by one or more polyurethane packers. These boreholes were:

KA3539G	KA3550G01
KA3542G01	KA3552G01
KA3542G02	KA3554G01
KA3544G01	KA3554G02
KA3546G01	

In eight boreholes the number of measurement interval was reduced by replacing the PUR 72-packers by one mechanical packer:

KA3563G	KA3579G01
KA3572G01	KA3590G01
KA3574G01	KA3590G02
KA3578G01	KA3593G

The packer installation failed in borehole KA3576G01. The packer got stuck and the hole was left opened. However, the borehole yielded no water and was impossible to fill up. Possibly it was drained by the adjacent deposition hole.

The reinstalled packers were expanded or inflated the 4th or 5th of August. The evacuation of air in the Tecalan pipes between the boreholes and the pressure transducers

was performed in the afternoon August 5th. This was done by loosening the fittings connecting the Tecalan pipes from the boreholes to the transducers.

Table 5-1 illustrates packer type and the last packer inflation date of each borehole.

Since borehole KA3576G01 did not have a working packer the ground water pressure was not measured during the tests #8 - #14.

Table 5-1 Packer type and packer inflation date prior to test #8. Interference tests B after drill campaign 3. Prototype Repository, August 1999

Borehole	Packer type	Last date/time of packer inflation	Comments
KA3510A	PUR 72	981123	
KA3539G	PUR 72	99-08-04/ 16:20	
KA3542G01	PUR 72	99-08-04/ 16:20	
KA3542G02	PUR 72	99-08-04/ 16:20	
KA3544G01	PUR 72	99-08-04/ 16:20	
KA3546G01	PUR 72	99-08-04/ 16:20	
KA3548A01	PUR 72	99-02-17 10:20	
KA3548G01	Mech. 0.28	Before 99-02-03	
KA3550G01	PUR 72	99-08-04/ 16:20	
KA3552G01	PUR 72	99-08-04/ 16:20	Almost no water in the section KA3552G01:1
KA3554G01	PUR 72	99-08-04/ 16:20	Small amounts of water in section KA3554G01:3
KA3554G02	PUR 72	99-08-04/ 16:20	Small amounts of water in sections KA3554G02:1,3
KA3557G	Mech. 0.28	Before 99-02-03	
KA3563G	Mech. 0.28	99-08-05/ 16:00	
KA3566G01	PUR 72	99-02-17 10:30	
KA3566G02	PUR 72	99-02-17 10:30	
KA3572G01	PUR 72	99-08-05/ 16:00	
KA3573A	PUR 72	99-02-15 19:50	
KA3574G01	PUR 72	99-08-05/ 16:00	No water in the Tecalan pipe, closed 5/8 16:20
KA3576G01	Mech. 0.28		Packer installation failed
KA3578G01	Mech. 0.28	99-08-05/ 16:00	No water in the Tecalan pipe, closed 5/8 16:20
KA3579G01	Mech. 0.28	99-08-05/ 16:00	No water in the Tecalan pipe, closed 5/8 16:20
KA3584G01	Mech. 0.28	99-02-02	
KA3590G01	Mech. 0.28	99-08-05/ 16:00	
KA3590G02	Mech. 0.28	99-08-05/ 16:00	
KA3593G01	Mech. 0.28	99-08-05/ 16:00	
KA3600F	PUR 72	99-02-16	
KG0021A01	PUR 72	99-06-16/ 11:15	
KG0048A01	PUR 72	99-02-16	

Later a leakage was found in a fitting in KA3539G. The leakage connected the two borehole sections KA3539G:1 and KA3539G:2.

5.3 Interference Tests.

Prior to the tests, the boreholes were left undisturbed in order to enable the pressures of the borehole sections to stabilise.

The tests were performed according to the following standard cycle:

- The undisturbed pressure was monitored in all boreholes for at least 1 hour before the start of the flowing period, sampling interval 3 minutes.
- The sampling interval was changed to 2 seconds.
- As soon as possible the valve of the flowing section was opened and the flow was measured 3 times during the first c. 5 minutes. The flow measurements were repeated 4 more times during the first hour.
- 5 minutes or more after the flow start the pressure sampling interval was changed to 30 seconds and after further 60 minutes to 3 minutes.
- The flowing section was left open for 1.5 --6 –7 hours.
- Shortly before the valve was closed the flow was measured 3 times after which the pressure sampling interval again was changed to 2 seconds.
- The test valve was closed and the recovery period started.
- 5 minutes or more after the flow stop the pressure sampling interval was changed to 30 seconds and after further 60 minutes to 3 minutes. The length of the recovery period was 3 hours or 17 hours .

In practice, the duration of the flowing period and the recovery period varied, see Table 3-1.

The change of the sampling interval of the HMS-system at flow start was usually operated by personnel at the GEOSIGMA office in Uppsala, after call from the field crew.

For practical reasons and due to equipment problems the tests in August were not performed in numerical order. The test succession was as follows:

Test #7	(test start June 17th)
Test #9	(test start August 16th)
Test #10	(test start August 17th)
Test #8	(test start August 18th)
Test #11	(test start August 19th)
Test #14	(test start August 20th)
Test #13	(test start August 21st)
Test #12	(test start August 22nd)

Between test #7 and test #9 four of the six planned deposition boreholes were drilled in the Prototype Repository tunnel. The center of the holes were positioned at 3587 m, 3581 m, 3575 m and 3569 m tunnel length respectively. They were drilled vertically to the depth of 8-9 m with a diameter of 1.75 m. The submersible pumps did not work, why the deposition holes were more or less filled up during the August test period.

Between August 17^{h} and August 20th preparations were made for Acoustic emission measurements in the Prototype Repository tunnel. The work entailed opening of some holes in the TBM drilled tunnel. The boreholes opened were:

KA3551G04	opened 99-08-17 at c. 10.00
KA3553G01	opened 99-08-18 at c. 10.20
KA3548G02	opened 99-08-18 at c. 10.40
KA3545G03	opened 99-08-18 at c. 10.55
KA3543G01	opened 99-08-18 at c. 11.30
KA3548G01	opened 99-08-18 at c. 12.30

The opening of the boreholes influenced the groundwater pressure of some of the nearby observation holes and as a result the monitoring of borehole KA3548G01 had to be stopped.

5.4 Data Processing

Data from the HMS-monitored borehole sections were processed, stored and plotted by the HMS-system, see Nyberg et al, 1997 and Manual för HMS 1994. Two parameters were processed, ground-water pressure (including the barometric pressure) and hydraulic head. The hydraulic head (HH, m.a.s.l.) was determined according to:

$$HH = K1 + K2 \times MV$$

MV = Measured Value (kPa)

$$K1 = (\rho_s \times g \times (Z_{tr} - Z_{mid}) - P_0) / (\rho_0 \times g) + Z_{mid}$$

ρ_s = Density in tube between Pressure Gauge and section midpoint (kg/m^3)
g = 9.81 = Acceleration of Gravity (m/s^2)
Z_{tr} = Level of Pressure Gauge (m.a.s.l.)
Z_{mid} = Level of section midpoint (m.a.s.l.)
P_0 = 101325 = Normal Barometric Pressure at Ground Surface (Pa)
ρ_0 = Density of "fresh water" (kg/m^3)
$K2 = 1000 / (\rho_0 \times g)$

ρ_s was estimated by calculating the values from measured or estimated electric conductivity data. The formula used is:

$$\text{Density (kg/m}^3\text{)} = 997.3 + 0.00467 \times \text{Electrical conductivity (mS/m)}$$

See also Ingvar Rhén et. al, 1993, (Appendix 1:5) and Nyberg et al, 1997 (p 27). ρ_0 was taken from Ingvar Rhén et. al 1993, (Appendix 1:5).

In the hydraulic head calculations for the Prototype Repository boreholes an electrical conductivity of 1000 mS/m was used resulting in a density of 1002 kg/m^3.

6. RESULTS

6.1 Interference Tests.

Appendices 2- 9 contain the diagrams for each test respectively. Linear plots of the ground-water pressure and the hydraulic head are included. The plotted intervals are:

Test #7:	99-06-16 07:00 - 99-06-17 14:00 and
	99-06-17 06:00 - 99-06-17 14:00
Test #8:	99-08-18 08:00 - 99-08-19 08:55
Test: #9:	99-08-16 09:00 - 99-08-17 09:20 and
	99-08-13 12:00 - 99-08-17 09:20
Test #10:	99-08-17 09:00 - 99-08-18 09:55
Test #11:	99-08-19 07:00 - 99-08-20 07:55
Test #12:	99-08-22 07:00 - 99-08-22 18:00
Test #13:	99-08-21 07:00 - 99-08-22 07:55
Test #14:	99-08-20 06:00 - 99-08-21 08:55

Data files (MIO-format) corresponding to the eight test periods were created and saved. Data files and diagrams containing the hydraulic head of the borehole sections for the corresponding time periods have also been created, see appendices.

Appendix 10 comprises diagrams of the ground water pressure of the period 990813 – 990822, covering pressure data of the tests #8 - #14.

Details and important test data for each test are described in sections 6.1.1 – 6.1.8. The abbreviations used are:

- P_0 = Initial pressure before opening of the valve
- P_p = Pressure just before closing the valve
- P_f = Pressure at the end of the pressure build-up period
- Q_p = Flow rate at the end of the flowing period (average of the three last measurements)
- V_{tot} = The integral of the flow rate during the entire flowing period
- Q_{ave} = Average flow rate, calculated according to:

$$Q_{ave} = \frac{V_{tot}}{tp}$$, where tp = length of the flowing period.

- Recovery (%) = $$\frac{(Pf - Pp) \cdot 100}{Po - Pp}$$

6.1.1 Borehole KG0048A01, section 49.00 m –54.69 m, test # 7

Date: 99-06-17 Field Crew: A. Bern, J. Olausson
Borehole length: 54.69 m Borehole diameter: 76 mm
Flowing borehole: KG0048A01, section #1: 49.00 – 54.69 m

Valve opened: 990617 08:00.00 Valve closed: 990617 09:25.00
End of Test: 990617 14:00
Total flowing time : 85 min Tot. Pr. Build-up time: 275 min.

The test was performed as an interference test. Pressure responses were monitored in 63 borehole sections.

Pressure data

Table 6-1 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KG0048A01, section 49.00 – 54.69 m. Prototype Repository, June 1999

Borehole section	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KA3510A:1	4124.2	4122.3	4123.6	1.9	1.3	68.4
KA3510A:2	4110.9	4109.2	4109.9	1.7	0.7	41.2
KA3510A:3	3863	3803.4	3863.6	59.6	60.2	101.0
KA3539G:1	3076.5	3062.6	3075.1	13.9	12.5	89.9
KA3542G01:1	3747.7	3697	3748.1	50.7	51.1	100.8
KA3542G02:1	3211.6	3199.1	3211.4	12.5	12.3	98.4
KA3544G01:1	2950.2	2938.4	2949.2	11.8	10.8	91.5
KA3546G01:1	436.6	436	437.4	0.6	1.4	233.3
KA3548A01:1	3860.9	3791.8	3861.1	69.1	69.3	100.3
KA3548A01:2	3764.5	3713.2	3765	51.3	51.8	101.0
KA3548G01:1	147.6	147.6	147.4	0	-0.2	<0
KA3550G01:1	97.3	96.9	97.1	0.4	0.2	50.0
KA3552G01:1	263.5	262.9	263.3	0.6	0.4	66.7
KA3554G01:1	3688.5	3628.2	3688.9	60.3	60.7	100.7
KA3554G02:1	3269.8	3257.7	3269.4	12.1	11.7	96.7
KA3557G:1	133.9	133.7	133.7	0.2	0	0
KA3563G01:1	1394	1389.1	1393.8	4.9	4.7	95.9
KA3563G01:2	1394.6	1389.7	1394.4	4.9	4.7	95.9
KA3563G01:3	241.4	240.8	241.2	0.6	0.4	66.7
KA3566G01:1	2560.1	2524.7	2559.8	35.4	35.1	99.2
KA3566G01:2	1977.3	1957.7	1977.1	19.6	19.4	99.0
KA3566G01:3	3201.9	3201.9	3206.1	0	4.2	-
KA3566G01:4	2773.8	2769.3	2776.4	4.5	7.1	157.8

Borehole section	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KA3566G02:1	3323.8	3316.5	3327.7	7.3	11.2	153.4
KA3566G02:2	3467.3	3458.9	3470	8.4	11.1	132.1
KA3566G02:3	2686	2691.9	2705.4	-5.9	13.5	-
KA3566G02:4	337.2	336.4	337.2	0.8	0.8	100.0
KA3572G01:1	1849.2	1850.2	1851.4	-1	1.2	-
KA3572G01:2	369.9	370.1	370.1	-0.2	0	0
KA3573A:1	4014.5	3993.4	4014.7	21.1	21.3	100.9
KA3573A:2	3873.3	3794.1	3873.6	79.2	79.5	100.4
KA3574G01:1	1026.7	1025.7	1026.5	1	0.8	80.0
KA3574G01:2	944.6	943.2	942.8	1.4	-0.4	<0
KA3574G01:3	190.5	190.7	190.3	-0.2	-0.4	-
KA3576G01:1	1171.7	1170.7	1171.5	1	0.8	80.0
KA3576G01:2	168.4	168.6	169	-0.2	0.4	-
KA3576G01:3	395.2	394.8	395.6	0.4	0.8	200.0
KA3578G01:1	1273	1272.1	1272.8	0.9	0.7	77.8
KA3578G01:2	161.9	162.1	161.9	-0.2	-0.2	-
KA3579G01:1	1966.6	1967.2	1968.6	-0.6	1.4	-
KA3579G01:2	507.1	507.1	507.3	0	0.2	-
KA3579G01:3	334.6	334.2	334.4	0.4	0.2	50.0
KA3584G01:1	113	113.2	113	-0.2	-0.2	-
KA3590G01:1	3928.6	3890.7	3928.8	37.9	38.1	100.5
KA3590G01:2	3864.5	3786.9	3864.9	77.6	78	100.5
KA3590G01:3	1589.3	1573.2	1589.3	16.1	16.1	100.0
KA3590G02:1	3602.6	3591.1	3604.4	11.5	13.3	115.7
KA3590G02:2	3261.4	3254.6	3265.2	6.8	10.6	155.9
KA3590G02:3	2686.6	2682.9	2687.2	3.7	4.3	116.2
KA3590G02:4	917	915.2	913.3	1.8	-1.9	<0
KA3593G01:1	2052.1	2034.3	2052.3	17.8	18	101.1
KA3593G01:2	1994.7	1994.5	1997.6	0.2	3.1	1550.0
KA3600F:1	4079.9	4078.2	4079.7	1.7	1.5	88.2
KA3600F:2	4057.4	4052.6	4057.4	4.8	4.8	100.0
KG0021A01:1	3479.8	3471.4	3481.3	8.4	9.9	117.9
KG0021A01:2	3486.9	3479.1	3488.1	7.8	9	115.4
KG0021A01:3	3487.3	3480.9	3488.5	6.4	7.6	118.7
KG0021A01:4	3277.1	3277.3	3289.8	-0.2	12.5	-
KG0021A01:5	2304.4	2303.4	2306.7	1	3.3	330.0
KG0048A01:1	**3856.7**	**-**	**3856.7**			**100**

Borehole section	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KG0048A01:2	3635	3588.2	3633.6	46.8	45.4	97.0
KG0048A01:3	3700.3	3668.8	3701.2	31.5	32.4	102.9
KG0048A01:4	2248.2	2245.2	2250.3	3	5.1	170.0

" – " in the Recovery column means that there has been no drawdown
" <0 " in the Recovery column means that there has been no recovery

Flow data
Manually measured flow rates of KG0048A01, section 49.00– 54.69 m are presented in the table below, see also Appendix 2a.

The height of the water flow outlet was c. 1.1 m above the tunnel floor.

Table 6-2 Manually measured flow rates during interference test in KG0048A01, section 49.00 – 54.69 m (test #7) of Prototype Repository, June 1999

Time	Flow rate (l/min)
08:00.45	2.500
08:02:30	2.500
08:04:30	2.430
08:06.30	2.410
08:10:30	2.400
08:15:30	2.370
08:25:30	2.350
08:30:30	2.290
08:35.30	2.320
08:40.30	2.490
08:48.30	2.410
08:50.30	2.410
09:00.30	2.410
09:05.30	2.400
09:12.30	2.420
09:15.30	2.440
09:20.30	2.410
09:22:30	2.410

Calculated flow data

Flow rate at the end of the flowing period (Q_p, l/min): 2.42
Average flow rate during the flowing period (Q_{ave}, l/min): 2.40
Total flow volume during the flowing period (V_{tot}, litres): 204.0

Comments on the diagrams

As mentioned in section 5.1 new packers were installed in Borehole KG0021A01 prior to test #7, causing pressure draw-down in almost all prototype boreholes. KG0021A01 was opened June15th at 11:47. The outermost packer was inflated June 16th at 09.40 while the four remaining packers were inflated between 10:02 and 10:15 the same day.

There was only one Tecalan pipe (the pressure line to the transducer) out from the flowing section during this test. Because of this the test performance differed somewhat compared to the other 7 tests.

- at about 07:05 the valve to the flowing section was closed. The Tecalan pipe on the “transducer side” was removed from the valve connection and the pipe end was plugged.
- At 08:00 the valve was opened and the flowing period started.
- At 09:25 the valve to the flowing section was closed and the recovery period started.
- Immediately after the valve was closed the pressure line was connected to the valve. The valve was opened and the monitoring of the section pressure started again.

As a consequence of the test performance no data of the section pressure during the flowing phase was monitored. Neither was a value of the pressure Po just before the flow stop achieved. But considering the measured flow rate, the length and the diameter of the Tecalan pipe the friction losses at the end of the flow period could be estimated to approximately 1880 kPa (according to nomographic chart by GEOTEC). The corresponding section pressure should then be equal to c. 1980 kPa (the barometric pressure is added).

During the flow period a pressure increase was measured in the shut-in Tecalan pipe. This could be an effect of the heat caused by the asphalt covering of the floor that was going on in the J-tunnel at the same time.

The recovery period had to be interrupted since some heavy drilling equipment was dropped on the pressure lines to three of the Prototype boreholes. This occurred shortly after 2 ó clock p.m.

6.1.2 Borehole KA3554G02, section 10.30 m –21.80 m, test #9

Date: 99-08-16 Field Crew: Bengt Gentzschein
Borehole length: 30.01 m Borehole diameter: 76 mm
Flowing borehole: KA3554G02, section #2: 10.30 – 21.30 m

Valve opened: 990816 11:02.07 Valve closed: 990816 17:06.05
End of Test: 990817 09:20
Total flowing time : 364 min Tot. Pr. Build-up time 974 min.

The test was performed as an interference test. Pressure responses were monitored in 62 borehole sections.

Pressure data

Table 6-3 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KA3554G02, section 10.30 – 21.30 m. Prototype Repository, August 1999

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KA3510A:1	4130.1	4129.9	4130.5	0.2	0.6	300.0
KA3510A:2	4101.1	4100.7	4102.1	0.4	1.4	350.0
KA3510A:3	3866.7	3861.7	3864	5	2.3	46.0
KA3539G:1	2987.4	2928.7	2975.1	58.7	46.4	79.0
KA3539G:2	2987.1	2928.7	2975.1	58.4	46.4	79.5
KA3539G:3	2837.7	2782.1	2825.6	55.6	43.5	78.2
KA3542G01:1	3853	3848.1	3850.2	4.9	2.1	42.9
KA3542G01:2	3750.8	3742.5	3747.8	8.3	5.3	63.9
KA3542G01:3	1241.7	1234	1240.9	7.7	6.9	89.6
KA3542G02:1	3004.4	2924.8	3002.3	79.6	77.5	97.4
KA3542G02:2	3145.4	2724	3156.8	421.4	432.8	102.7
KA3542G02:3	3145.3	2653.1	3140.8	492.2	487.7	99.1
KA3542G02:4	3115.1	3055	3105.3	60.1	50.3	83.7
KA3544G01:1	2874,2	2810	2854,4	64,2	44,4	69,2
KA3544G01:2	2799	2136,7	2165,5	662,3	28,8	4,3
KA3546G01:1	350.1	344.4	348.4	5.7	4	70.2
KA3546G01:2	568.4	549.8	556.1	18.6	6.3	33.9
KA3548A01:1	3866	3861.5	3863.3	4.5	1.8	40.0
KA3548A01:2	3779.3	3771.7	3776.4	7.6	4.7	61.8
KA3548G01:1	166.3	165	167.1	1.3	2.1	161.5
KA3550G01:1	147.5	146.1	148.5	1.4	2.4	171.4
KA3550G01:2	210.1	209.7	211.5	0.4	1.8	450.0
KA3552G01:1	667.9	668.9	672	-1	3.1	-

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KA3552G01:2	240.1	240.5	241.6	-0.4	1.1	-
KA3552G01:3	231.8	231.6	232	0.2	0.4	200.0
KA3554G01:1	3848.7	3843.8	3845.7	4.9	1.9	38.8
KA3554G01:2	3829.4	3824.3	3826.3	5.1	2	39.2
KA3554G01:3	1076.2	1074.5	1075.9	1.7	1.4	82.4
KA3554G02:1	3380.2	3270.2	3384.5	110	114.3	103.9
KA3554G02:2	**3154**	**119.2**	**3148.5**	**3034.8**	**3029.3**	**99.8**
KA3554G02:3	3323.8	3286.6	3341.4	37.2	54.8	147.3
KA3557G01:1	134.5	134.9	135.9	-0.4	1	-
KA3563G01:1	281.7	281.7	281	0	-0.7	-
KA3566G01:1	2595.4	2592.6	2593	2.8	0.4	14.3
KA3566G01:2	1903.3	1902	1905.1	1.3	3.1	238.5
KA3566G01:3	3200.6	3201.9	3208.2	-1.3	6.3	-
KA3566G01:4	2750.1	2748.7	2751.3	1.4	2.6	185.7
KA3566G02:1	3311.3	3171.1	3305	140.2	133.9	95.5
KA3566G02:2	3474.7	3445.6	3472.6	29.1	27	92.8
KA3566G02:3	2735.5	2728.9	2734.1	6.6	5.2	78.8
KA3566G02:4	337.8	337.4	338.6	0.4	1.2	300.0
KA3572G01:1	316.5	316.7	318.5	-0.2	1.8	-
KA3573A:1	4007.7	4006.3	4007.9	1.4	1.6	114.3
KA3573A:2	3875.2	3870.7	3872.7	4.5	2	44.4
KA3574G01:1	101	101	101	0	0	-
KA3578G01:1	93.4	92.2	92.4	1.2	0.2	16.7
KA3579G01:1	330.5	341.3	372.2	-10.8	30.9	-
KA3584G01:1	106.7	106.9	107.5	-0.2	0.6	-
KA3590G01:1	747.3	746.9	746.3	0.4	-0.6	<0
KA3590G02:1	3563.5	3538.5	3561.6	25	23.1	92.4
KA3593G01:1	1391	1389.9	1394.2	1.1	4.3	390.9
KA3600F:1	4070.1	4069.6	4070.9	0.5	1.3	260.0
KA3600F:2	4048.6	4047.7	4049.6	0.9	1.9	211.1
KG0021A01:1	3490.5	3463.1	3487.4	27.4	24.3	88.7
KG0021A01:2	3489.5	3458.8	3486.7	30.7	27.9	90.9
KG0021A01:3	3489.5	3456.3	3486.8	33.2	30.5	91.9
KG0021A01:4	3292.9	3250.5	3290.6	42.4	40.1	94.6
KG0021A01:5	2267.3	2257.5	2266.3	9.8	8.8	89.8
KG0048A01:1	3859.4	3854.9	3857.2	4.5	2.3	51.1
KG0048A01:2	3612.1	3606.8	3610.9	5.3	4.1	77.4

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KG0048A01:3	3692.5	3681.9	3691.3	10.6	9.4	88.7
KG0048A01:4	2199.9	2190.7	2199.3	9.2	8.6	93.5

" – " in the Recovery column means that there has been no drawdown
" <0 " in the Recovery column means that there has been no recovery

Flow data

Manually measured flow rates of KA3554G02, section 10.30 – 21.30 m are presented in the table below, see also Appendix 3a.

The height of the water flow outlet was 0.2 – 0.5 m above the tunnel floor.

Table 6-4 Manually measured flow rates during interference test in KA3554G02, section 10.30 – 21.30 m (test #9) of Prototype Repository, August 1999

Time	Flow rate (l/min)
11:02.37	0.652
11:04.07	0.549
11:07.37	0.528
11:15	0.519
11:30	0.509
11:45	0.501
12:05	0.499
16:52	0.482
16:57	0.484
17:03	0.482

Calculated flow data

Flow rate at the end of the flowing period (Q_p, l/min): 0.483
Average flow rate during the flowing period (Q_{ave}, l/min): 0.494
Total flow volume during the flowing period (V_{tot}, litres): 179.8

Comments on the diagrams

Test #9 was the first test performed after the reconfiguration of the prototype borehole packers. The planned start of test #8 was inhibited since the Tecalan pipes to the test section #8 (KA3554G01, 22.3-30.0 m) was found to be plugged by borehole debris on the morning August 16th. Some attempts were made to clean the pipes, which only resulted in instant pressure changes in the measurement sections of borehole KA3554G01.

The major event preceding the interference test in August was the drilling of borehole KI0025F03, which started August 5th. After the end of the drilling, Maxibor measurements were carried out in the borehole. KI0025F03 was shut in at c. five o'clock August 13th. The pressure recovery after these activities can be seen on many of the diagrams.

In borehole KA3554G02 a sudden pressure response occurred in the sections above and beneath the flowing section when the test valve was opened and closed respectively. The explanation could be that the instant pressure change in the flowing section causes volume changes in the Polyurethane packers or /and in the Tecalan pipes. The magnitude of this response should be permeability-dependent and higher in low permeable sections. This phenomenon was observed during all of the seven August tests.

In the borehole section KA3544G01:2 the pressure decreases from c. 2800 kPa to about 2150 kPa. The pressure decrease is probably not an effect of the draw down in KA3554G02 since it occurs 2.5 hours after test start. The section pressure does not recover after the closing of the test vale, on the contrary the pressure continues at the lower level the rest of the test period and even longer. Smaller pressure drops in section #1 of the same borehole as well as pressure changes in other boreholes, i.e. KA3539G and KA3546G01, are probably responses of the decrease in KA3544G01:2. The explanation of the pressure drop is not easy to find, possibly it is due to malfunction of the packer.

About one hour after midnight the 17th of August there is a pressure disturbance in almost every borehole section according to the diagrams. At the same time the major earthquake in Turkey occurred.

By mistake the measurement interval was 3 minutes and not 2 or 30 seconds, as stipulated in section 5.3, in a number of boreholes during the beginning of the recovery phase.

The pressure of borehole KA3590G01 (0.3 – 30.0 m) is much lower than the pressure of any of the three intervals of KA3590G01 that were shut in and monitored during test #7.

The two bottom sections of KA3539G show almost exactly the same pressures during this test and during the following six tests. This was a consequence of a leakage between the two measurement sections.

6.1.3 Borehole KA3542G01, section 8.80 m –24.80 m, test # 10

Date: 99-08- 17 Field Crew: Bengt Gentzschein
Borehole length: 30.04 m Borehole diameter: 76 mm
Flowing borehole: KA3542G01, section #2: 8.80 – 24.80 m

Valve opened: 990817 11:00.03 Valve closed: 990817 17:05.03
End of Test: 990818 09:55
Total flowing time : 365 min Tot. Pr. Build-up time 1010 min.

The test was performed as an interference test. Pressure responses were monitored in 62 borehole sections.

Pressure data

Table 6-5 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KA3542G01, section 8.80– 24.80m. Prototype Repository, August 1999

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KA3510A:1	4130.5	4127	4130.5	3.5	3.5	100.0
KA3510A:2	4102.3	4098.8	4102.9	3.5	4.1	117.1
KA3510A:3	3861.5	3749.9	3861.5	111.6	111.6	100.0
KA3539G:1	2975.3	2924.4	2970.2	50.9	45.8	90.0
KA3539G:2	2975.3	2924.4	2970.2	50.9	45.8	90.0
KA3539G:3	2825.6	2778	2822	47.6	44	92.4
KA3542G01:1	3848.1	3774.5	3847.5	73.6	73	99.2
KA3542G01:2	**3745.1**	**374.2**	**3743.9**	**3370.9**	**3369.7**	**100.0**
KA3542G01:3	1240.5	1173.9	1241.5	66.6	67.6	101.5
KA3542G02:1	3002.7	2979.4	3001.9	23.3	22.5	96.6
KA3542G02:2	3157.3	3118.6	3155.8	38.7	37.2	96.1
KA3542G02:3	3141	3102.8	3138.6	38.2	35.8	93.7
KA3542G02:4	3105.7	3059.9	3101.8	45.8	41.9	91.5
KA3544G01:1	2854,6	2805,9	2849,1	48,7	43,2	88,7
KA3544G01:2	2164,9	2131	2160,8	33,9	29,8	87,9
KA3546G01:1	344.6	336.4	344.8	8.2	8.4	102.4
KA3546G01:2	555.1	545.1	552.4	10	7.3	73.0
KA3548A01:1	3861.5	3796.3	3860.7	65.2	64.4	98.8
KA3548A01:2	3774	3278.2	3774.4	495.8	496.2	100.1
KA3548G01:1	160.7	159.5	161.3	1.2	1.8	150
KA3550G01:1	137.5	137.7	138.7	-0.2	1	-
KA3550G01:2	212.2	210.9	206.9	1.3	-4	<0

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KA3552G01:1	672	671.2	671	0.8	-0.2	<0
KA3552G01:2	239.7	219.7	240.5	20	20.8	104.0
KA3552G01:3	232	224.3	230.8	7.7	6.5	84.4
KA3554G01:1	3846.5	3773.8	3845.7	72.7	71.9	98.9
KA3554G01:2	3829.4	3733.9	3828	95.5	94.1	98.5
KA3554G01:3	1075.7	786.8	1082.3	288.9	295.5	102.3
KA3554G02:1	3385.1	3330	3383.3	55.1	53.3	96.7
KA3554G02:2	3148.9	3110.4	3146.7	38.5	36.3	94.3
KA3554G02:3	3341.8	3309.3	3337.5	32.5	28.2	86.8
KA3557G01:1	136.3	134.9	137.2	1.4	2.3	164.3
KA3563G01:1	280.4	233.4	282.1	47	48.7	103.6
KA3566G01:1	2591.4	2551.3	2591.6	40.1	40.3	100.5
KA3566G01:2	1904.1	1875.4	1906.7	28.7	31.3	109.1
KA3566G01:3	3208.4	3202.3	3209.8	6.1	7.5	123.0
KA3566G01:4	2751.5	2701.4	2747.7	50.1	46.3	92.4
KA3566G02:1	3305.4	3265.1	3303.9	40.3	38.8	96.3
KA3566G02:2	3472.8	3444.6	3472.2	28.2	27.6	97.9
KA3566G02:3	2734.3	2725.5	2733.5	8.8	8	90.9
KA3566G02:4	338.2	324.3	339.1	13.9	14.8	106.5
KA3572G01:1	318.5	318.7	320.1	-0.2	1.4	-
KA3573A:1	4007.3	3988.9	4007.9	18.4	19	103.3
KA3573A:2	3871.1	3811.5	3870.7	59.6	59.2	99.3
KA3574G01:1	101.2	100.8	101.2	0.4	0.4	100.0
KA3578G01:1	92.4	92.4	92.2	0	-0.2	-
KA3579G01:1	374.8	385	413.9	-10.2	28.9	-
KA3584G01:1	107.5	107.5	107.5	0	0	-
KA3590G01:1	745.9	738.3	747.1	7.6	8.8	115.8
KA3590G02:1	3561.6	3535.6	3561.6	26	26	100.0
KA3593G01:1	1394.2	1385.2	1395.4	9	10.2	113.3
KA3600F:1	4071.1	4067.4	4071.5	3.7	4.1	110.8
KA3600F:2	4049.6	4043.5	4050.2	6.1	6.7	109.8
KG0021A01:1	3486.8	3367.3	3491.3	119.5	124	103.8
KG0021A01:2	3486.2	3423.2	3487.7	63	64.5	102.4
KG0021A01:3	3486.8	3454.9	3486.8	31.9	31.9	100.0
KG0021A01:4	3291	3268.1	3290.8	22.9	22.7	99.1
KG0021A01:5	2266.7	2254.2	2265.4	12.5	11.2	89.6
KG0048A01:1	3855.5	3796.9	3855.1	58.6	58.2	99.3

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KG0048A01:2	3609.5	3567.7	3609.5	41.8	41.8	100.0
KG0048A01:3	3690.5	3655.3	3690.5	35.2	35.2	100.0
KG0048A01:4	2199.5	2187.6	2198.5	11.9	10.9	91.6

" – " in the Recovery column means that there has been no drawdown
" <0 " in the Recovery column means that there has been no recovery

Flow data

Manually measured flow rates of KA3542G01, section 8.80 m –24.80 m, are presented in the table below, see also Appendix 5a.

The height of the water flow outlet was 0.3 – 0.6 m above the tunnel floor.

Table 6-6 Manually measured flow rates during interference test in KA3542G01, section 8.80 m –24.80 m (test #10) of Prototype Repository, August 1999

Time	Flow rate (l/min)
11:00.33	5.35
11:03.33	3.078
11:06.03	2.942
11:15	2.796
11:30	2.70
11:45	2.682
12:00	2.66
16:52	2.556
16:57	2.557
17:03	2.556

Calculated flow data

Flow rate at the end of the flowing period (Q_p, l/min): 2.56
Average flow rate during the flowing period (Q_{ave}, l/min): 2.64
Total flow volume during the flowing period (V_{tot}, litres): 965

Comments on the diagrams

Some of the comments on the preceding tests concerning pressure levels and instant pressure changes in the sections above and beneath the flowing section are valid for this test as well.

Shortly before the start of the test #10 the drilling debris (or whatever it was) that was stuck in the Tecalan pipes to section KA3554G01:1 was removed. The pipes were cleared by flushing, using water from a pressure vessel. The operation was carried out between c.

09:25 and 10:25 and caused pressure responses in a number of borehole sections. In some boreholes (KA3573A and KA3548A01) the pressure does not recover completely before the start of the flowing period. In three boreholes (KA3548G01, KA3550G01 and KA3552G01) the correlation between pressure drops and the flushing operation is not obvious. In KA3552G01 sudden pressure changes occur at flow start and flow stop in a similar way that was the case in KA3542G01.

6.1.4 Borehole KA3554G01, section 22.30 m –30.01 m, test # 8

Date: 99-08-18 Field Crew: Bengt Gentzschein
Borehole length: 30.01 m Borehole diameter: 76 mm
Flowing borehole: KA3554G01, section #1: 22.3 – 30.01 m

Valve opened: 990818 10:00.03 Valve closed: 990818 16:04.05
End of Test: 990819 08:50
Total flowing time : 364 min Tot. Pr. Build-up time 1011 min.

The test was performed as an interference test. Pressure responses were monitored in 62 borehole sections.

Pressure data

Table 6-7 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KA3554G01, section 22.30 – 30.01 m. Prototype Repository, August 1999

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf - Pp	Recovery %
KA3510A:1	4130.5	4125.8	4130.1	4.7	4.3	91.5
KA3510A:2	4102.9	4096.8	4102.7	6.1	5.9	96.7
KA3510A:3	3861.3	3702.8	3858.7	158.5	155.9	98.4
KA3539G:1	2970	2928.3	2966.7	41.7	38.4	92.1
KA3539G:2	2970	2928.3	2966.7	41.7	38.4	92.1
KA3539G:3	2822	2781.5	2817.9	40.5	36.4	89.9
KA3542G01:1	3847.3	3692.9	3844.4	154.4	151.5	98.1
KA3542G01:2	3743.9	3610.7	3741.6	133.2	130.9	98.3
KA3542G01:3	1241.5	1215.2	1220.9	26.3	5.7	21.7
KA3542G02:1	3001.9	2978.4	3000.3	23.5	21.9	93.2
KA3542G02:2	3156	3117.8	3154.4	38.2	36.6	95.8
KA3542G02:3	3138.6	3100.8	3136.3	37.8	35.5	93.9
KA3542G02:4	3101.6	3061.1	3097.5	40.5	36.4	89.9
KA3544G01:1	2849,3	2807,6	2844,2	41,7	36,6	87,8
KA3544G01:2	2161	2119,1	2154,3	41,9	35,2	84,0
KA3546G01:1	344.6	282	281.8	62.6	-0.2	<0
KA3546G01:2	552.4	527.1	516.9	25.3	-10.2	<0
KA3548A01:1	3860.7	3723.2	3858	137.5	134.8	98.0
KA3548A01:2	3774.6	3640.8	3771.7	133.8	130.9	97.8
KA3548G01:1	161.3	-	-	-	-	-
KA3550G01:1	138.7	51.4	51.2	87.3	-0.21	<0
KA3550G01:2	206.9	203	178.4	3.9	-24.6	<0

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf - Pp	Recovery %
KA3552G01:1	671.2	668.7	666.1	2.5	-2.6	<0
KA3552G01:2	240.3	209.7	210.7	30.6	1	3.3
KA3552G01:3	230.8	228	221.8	2.8	-6.2	<0
KA3554G01:1	**3845.7**	**1234.4**	**3841.2**	**2611.3**	**2606.8**	**99.8**
KA3554G01:2	3828	3639.7	3826.9	188.3	187.2	99.4
KA3554G01:3	1082.1	1049.4	1080.4	32.7	31	94.8
KA3554G02:1	3383.5	3331.9	3381.2	51.6	49.3	95.5
KA3554G02:2	3146.9	3108.8	3144.6	38.1	35.8	94.0
KA3554G02:3	3337.7	3302.1	3335.6	35.6	33.5	94.1
KA3557G01:1	137.2	137.4	136.3	-0.2	-1.1	-
KA3563G01:1	282.1	280.2	286.6	1.9	6.4	336.8
KA3566G01:1	2591.6	2492.1	2589.7	99.5	97.6	98.1
KA3566G01:2	1906.5	1823.3	1906.5	83.2	83.2	100.0
KA3566G01:3	3209.8	3194.5	3207.6	15.3	13.1	85.6
KA3566G01:4	2747.7	2709.6	2747.2	38.1	37.6	98.7
KA3566G02:1	3304	3265.3	3302.5	38.7	37.2	96.1
KA3566G02:2	3472.2	3438.7	3471.6	33.5	32.9	98.2
KA3566G02:3	2733.2	2721.4	2731.4	11.8	10	84.7
KA3566G02:4	339	333.9	335.8	5.1	1.9	37.3
KA3572G01:1	320.1	320.1	321.2	0	1.1	-
KA3573A:1	4008.1	3969.2	4006.7	38.9	37.5	96.4
KA3573A:2	3870.7	3745.8	3868.2	124.9	122.4	98.0
KA3574G01:1	101.2	101.2	101	0	-0.2	-
KA3578G01:1	92	92.2	92.2	-0.2	0	-
KA3579G01:1	414.1	428.8	455.8	-14.7	27	-
KA3584G01:1	107.5	107.9	107.1	-0.4	-0.8	-
KA3590G01:1	747.1	724.4	750.6	22.7	26.2	115.4
KA3590G02:1	3561.6	3529.1	3561.4	32.5	32.3	99.4
KA3593G01:1	1395.4	1371.6	1396.4	23.8	24.8	104.2
KA3600F:1	4071.5	4065.3	4071.3	6.2	6	96.8
KA3600F:2	4048	4038.3	4049.6	9.7	11.3	116.5
KG0021A01:1	3491.3	3440.1	3490.9	51.2	50.8	99.2
KG0021A01:2	3487.7	3448.1	3487.9	39.6	39.8	100.5
KG0021A01:3	3486.6	3455.1	3488.1	31.5	33	104.8
KG0021A01:4	3290.8	3266.1	3290	24.7	23.9	96.8
KG0021A01:5	2265.6	2252.2	2264.8	13.4	12.6	94.0
KG0048A01:1	3855.1	3731.8	3852.6	123.3	120.8	98.0

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf - Pp	Recovery %
KG0048A01:2	3609.3	3524.6	3607.4	84.7	82.8	97.8
KG0048A01:3	3690.5	3626.2	3689.5	64.3	63.3	98.4
KG0048A01:4	2198.5	2185.8	2197.5	12.7	11.7	92.1

" – " in the Recovery column means that there has been no drawdown
" <0 " in the Recovery column means that there has been no recovery

Flow data

Manually measured flow rates of KA3554G01, section 22.30 – 30.01 m are presented in the table below, see also Appendix 3a.

The height of the water flow outlet was 0.2 – 0.5 m above the tunnel floor.

Table 6-8 Manually measured flow rates during interference test in KA3554G01, section, 22.30 – 30.01 m (test #8) of Prototype Repository, August 1999

Time	Flow rate (l/min)
10:00.33	6.15
10:02.33	5.84
10:06.03	4.94
10:18	4.80
10:30	4.79
10:45	4.54
11:01	4.51
15:51	4.47
15:56	4.455
16:02:30	4.47

Calculated flow data

Flow rate at the end of the flowing period (Q_p, l/min): 4.465
Average flow rate during the flowing period (Q_{ave}, l/min): 4.54
Total flow volume during the flowing period (V_{tot}, litres): 1 652

Comments on the diagrams
Some of the comments on the preceding tests concerning pressure trends and instant pressure changes in the sections above and beneath the flowing section are valid for this test as well.

As mentioned in section 5.2 preparations were made for Acoustic Emission measurements in the section 3/543m – 3/553m of the TBM-tunnel. During test #8 five boreholes were opened:

KA3535G01	opened 99-08-18 at c. 10.20
KA3548G02	opened 99-08-18 at c. 10.40
KA3545G03	opened 99-08-18 at c. 10.55
KA3543G01	opened 99-08-18 at c. 11.30
KA3548G01	opened 99-08-18 at c. 12.30

These openings and other activities related to the preparation works are probably the reason why the pressure in the boreholes KA3544G01, KA3546G01, KA3548G01, KA3550G01, KA3552G01 decreases (and/or temporarily increases). Since the packer of KA3548G01 was removed the monitoring of this borehole was stopped.

The pressure of borehole KA3590G01 increases a little more than 5 kPa c. 4.5 hours after the start of the recovery. The reason why is unknown.

6.1.5 Borehole KA3542G02, section 1.30 m – 7.80 m, test # 11

Date: 99-08-19 Field Crew: Bengt Gentzschein
Borehole length: 30.04 m Borehole diameter: 76 mm
Flowing borehole: KA3542G02, section #4: 1.30 – 7.80m

Valve opened: 990819 09:00.01 Valve closed: 990819 15:01.01
End of Test: 990820 07:55
Total flowing time : 361 min Tot. Pr. Build-up time 1 014 min.

The test was performed as an interference test. Pressure responses were monitored in 61 borehole sections.

Pressure data

Table 6-9 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KA3542G02, section 1.30– 7.80 m Prototype Repository, August 1999

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KA3510A:1	4130.1	4129.5	4130.3	0.6	0.8	133.3
KA3510A:2	4102.7	4100.9	4102.9	1.8	2	111.1
KA3510A:3	3858.7	3826.8	3855.2	31.9	28.4	89.0
KA3539G:1	2966.7	2287.8	2976.5	678.9	688.7	101.4
KA3539G:2	2966.7	2287.8	2976.5	678.9	688.7	101.4
KA3539G:3	2817.9	2158.4	2826.9	659.5	668.5	101.4
KA3542G01:1	3844.4	3815.8	3841	28.6	25.2	88.1
KA3542G01:2	3741.4	3681.9	3737.5	59.5	55.6	93.4
KA3542G01:3	1221.3	1142	1233.9	79.3	91.9	115.9
KA3542G02:1	3000.5	2866.8	2994.6	133.7	127.8	95.6
KA3542G02:2	3154.4	2845.5	3154.8	308.9	309.3	100.1
KA3542G02:3	3136.5	2805.1	3136.3	331.4	331.2	99.9
KA3542G02:4	**3097.3**	**312.5**	**3110**	**2784.8**	**2797.5**	**100.5**
KA3544G01:1	2844.2	2187.6	2857.7	656.6	670.1	102.1
KA3544G01:2	2153.9	1611.5	2167.8	542.4	556.3	102.6
KA3546G01:1	281.6	235.4	311.4	46.2	76	164.5
KA3546G01:2	516.9	408.3	523	108.6	114.7	105.6
KA3548A01:1	3858	3831.1	3855	26.9	23.9	88.8
KA3548A01:2	3771.7	3719.7	3767.8	52	48.1	92.5
KA3550G01:1	51.4	45.9	50.8	5.5	4.9	89.1
KA3550G01:2	178.6	171.3	161.9	7.3	-9.4	<0
KA3552G01:1	666.1	663.8	666.7	2.3	2.9	126.1

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KA3552G01:2	210.5	205.2	236.4	5.3	31.2	588.7
KA3552G01:3	221.8	219.2	224.1	2.6	4.9	188.5
KA3554G01:1	3841.2	3812.9	3838.1	28.3	25.2	89.0
KA3554G01:2	3826.9	3797.7	3823.5	29.2	25.8	88.4
KA3554G01:3	1080.4	1059.4	1080	21	20.6	98.1
KA3554G02:1	3381.2	3161.8	3377.7	219.4	215.9	98.4
KA3554G02:2	3144.6	2742.9	3151.4	401.7	408.5	101.7
KA3554G02:3	3335.4	3104.9	3332	230.5	227.1	98.5
KA3557G01:1	136.1	135.9	137.6	0.2	1.7	850.0
KA3563G01:1	286.6	282.7	287.8	3.9	5.1	130.8
KA3566G01:1	2589.9	2573.3	2587.9	16.6	14.6	88.0
KA3566G01:2	1906.5	1894.5	1904.1	12	9.6	80.0
KA3566G01:3	3207.6	3204.5	3211.7	3.1	7.2	232.3
KA3566G01:4	2747.2	2735	2747	12.2	12	98.4
KA3566G02:1	3202.8	2951.6	3298.5	251.2	346.9	138.1
KA3566G02:2	3471.8	3311	3469.8	160.8	158.8	98.8
KA3566G02:3	2731.6	2694.4	2725.1	37.2	30.7	82.5
KA3566G02:4	335.8	330.5	337.6	5.3	7.1	134.0
KA3572G01:1	321.2	321.2	322.2	0	1	-
KA3573A:1	4006.7	3997.3	4006.1	9.4	8.8	93.6
KA3573A:2	3862.2	3842.2	3865.4	20	23.2	116.0
KA3574G01:1	101.2	101	101.4	0.2	0.4	200.0
KA3578G01:1	92.2	92.2	92.4	0	0.2	-
KA3579G01:1	455.8	471.1	439	-15.3	-32.1	-
KA3584G01:1	107.1	106.9	107.3	0.2	0.4	200.0
KA3590G01:1	750.4	746.3	749.2	4.1	2.9	70.7
KA3590G02:1	3561.6	3434.2	3556.3	127.4	122.1	95.8
KA3593G01:1	1396.4	1384.9	1396.2	11.5	11.3	98.3
KA3600F:1	4071.3	4068.2	4071.3	3.1	3.1	100.0
KA3600F:2	4049.4	4045.1	4049.6	4.3	4.5	104.7
KG0021A01:1	3490.7	3303.2	3481.7	187.5	178.5	95.2
KG0021A01:2	3488.1	3281.6	3479.9	206.5	198.3	96.0
KG0021A01:3	3488.1	3270.6	3479.7	217.5	209.1	96.1
KG0021A01:4	3290	3156.9	3284.3	133.1	127.4	95.7
KG0021A01:5	2264.6	2202.4	2263.2	62.2	60.8	97.7
KG0048A01:1	3852.6	3826.6	3849.8	26	23.2	89.2
KG0048A01:2	3607.2	3574.5	3605	32.7	30.5	93.3

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KG0048A01:3	3689.5	3624.6	3686.2	64.9	61.6	94.9
KG0048A01:4	2197.2	2139.6	2196	57.6	56.4	97.9

" – " in the Recovery column means that there has been no drawdown
" <0 " in the Recovery column means that there has been no recovery

Flow data

Manually measured flow rates of KA3542G02, section 1.30– 7.80 m are presented in the table below, see also Appendix 6a.

The height of the water flow outlet was 0.3 – 0.6 m above the tunnel floor.

Table 6-10 Manually measured flow rates during interference test in KA3542G02, section 1.30 – 7.80 m (test #11) of Prototype Repository, August 1999

Time	Flow rate (l/min)
09:00.31	4.37
09:03.01	3.88
09:06.11	3.82
09:15	3.70
09:30	3.595
09:45	3.525
10:00	3.51
14:51	3.36
14:55	3.37
14:58	3.37

Calculated flow data

Flow rate at the end of the flowing period (Q_p, l/min) : 3.37
Average flow rate during the flowing period (Q_{ave}, l/min): 3.47
Total flow volume during the flowing period (V_{tot}, litres): 1252

Comments on the diagrams

The instant pressure changes in the sections above and beneath the flowing section that was noted during the preceding tests cannot be observed during test #11.

In section KA3552G01:2 there is a pressure increase around 8 o'clock p.m., several hours after flow stop!

In borehole KA3579G01 the pressure starts to decrease around 7 o'clock p.m. interrupting an increasing trend that lasted several days.

6.1.6 Borehole KG0021A01, section 25.00 m –34.00 m, test #14

Date: 99-08-20 Field Crew: Bengt Gentzschein
Borehole length: 48.82 m Borehole diameter: 76 mm
Flowing borehole: KG0021A01, section #3: 25.00 – 34.00 m

Valve opened: 990820 08:00.05 Valve closed: 990820 14:00.07
End of Test: 990821 08:55
Total flowing time : 360 min Tot. Pr. Build-up time 1135 min.

The test was performed as an interference test. Pressure responses were monitored in 61 borehole sections.

Pressure data

Table 6-11 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KG0021A01, section 25.00 – 34.00 m. Prototype Repository, August 1999

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf - Pp	Recovery %
KA3510A:1	4130.3	4128.7	4130.7	1.6	2	125.0
KA3510A:2	4102.9	4098.6	4103.1	4.3	4.5	104.7
KA3510A:3	3855.4	3801.8	3851.9	53.6	50.1	93.5
KA3539G:1	2976.5	2523	2975.5	453.5	452.5	99.8
KA3539G:2	2976.5	2523	2975.5	453.5	452.5	99.8
KA3539G:3	2826.9	2386.6	2807.8	440.3	421.2	95.7
KA3542G01:1	3840.8	3788.6	3837.3	52.2	48.7	93.3
KA3542G01:2	3737.3	3648.5	3735.9	88.8	87.4	98.4
KA3542G01:3	1233	1136.5	1235.4	96.5	98.9	102.5
KA3542G02:1	2994.6	2701.8	3033.6	292.8	331.8	113.3
KA3542G02:2	3154.6	2657.8	3168.9	496.8	511.1	102.9
KA3542G02:3	3136.1	2596.5	3168.6	539.6	572.1	106.0
KA3542G02:4	3110.2	2550.1	3104.5	560.1	554.4	99.0
KA3544G01:1	2857,9	2114,4	2856	743,5	741,6	99,7
KA3544G01:2	2167,6	1809,8	2168,8	357,8	359	100,3
KA3546G01:1	311.6	277.3	312.9	34.3	35.6	103.8
KA3546G01:2	523	447.4	524.4	75.6	77	101.9
KA3548A01:1	3855	3803.9	3851.7	51.1	47.8	93.5
KA3548A01:2	3767.8	3686.2	3765.9	81.6	79.7	97.7
KA3550G01:1	50.8	48.6	54.1	2.2	5.5	250.0
KA3550G01:2	161.9	157.6	152.5	4.3	-5.1	<0
KA3552G01:1	666.9	664.2	667.3	2.7	3.1	114.8

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf - Pp	Recovery %
KA3552G01:2	236.2	229.2	237.5	7	8.3	118.6
KA3552G01:3	224.1	221.8	225.5	2.3	3.7	160.9
KA3554G01:1	3837.9	3785.7	3834.4	52.2	48.7	93.3
KA3554G01:2	3823.5	3770.3	3819.8	53.2	49.5	93.0
KA3554G01:3	1080	1049.6	1080.2	30.4	30.6	100.7
KA3554G02:1	3377.9	3119.2	3382.9	258.7	263.7	101.9
KA3554G02:2	3151.6	2593.4	3177	558.2	583.6	104.6
KA3554G02:3	3331.8	2963.7	3331.8	368.1	368.1	100.0
KA3557G01:1	137.8	137.8	139.8	0	2	-
KA3563G01:1	287.6	282.7	289.4	4.9	6.7	136.7
KA3566G01:1	2587.9	2554.9	2586.2	33	31.3	94.8
KA3566G01:2	1903.9	1879.9	1901.8	24	21.9	91.2
KA3566G01:3	3211.7	3199.4	3211.9	12.3	12.5	101.6
KA3566G01:4	2747	2713.9	2746	33.1	32.1	97.0
KA3566G02:1	3298.5	2846.7	3304.8	451.8	458.1	101.4
KA3566G02:2	3469.6	3112	3471.4	357.6	359.4	100.5
KA3566G02:3	2725.1	2623.1	2723	102	99.9	97.9
KA3566G02:4	337.4	326.6	338.4	10.8	11.8	109.3
KA3572G01:1	322.4	320.7	324.2	1.7	3.5	205.9
KA3573A:1	4006.1	3985.8	4005.3	20.3	19.5	96.1
KA3573A:2	3865.1	3813.8	3862.3	51.3	48.5	94.5
KA3574G01:1	101.4	101.4	101.6	0	0.2	-
KA3578G01:1	92.2	92.4	92.4	-0.2	0	-
KA3579G01:1	438.8	438.6	448.2	0.2	9.6	4800.0
KA3584G01:1	107.1	107.5	108.3	-0.4	0.8	-
KA3590G01:1	749.2	741.8	747.9	7.4	6.1	82.4
KA3590G02:1	3556.3	3176.8	3555.9	379.5	379.1	99.9
KA3593G01:1	1396	1361.6	1395.4	34.4	33.8	98.3
KA3600F:1	4071.3	4062.9	4071.1	8.4	8.2	97.6
KA3600F:2	4049.4	4038.7	4049.2	10.7	10.5	98.1
KG0021A01:1	3481.7	2918.7	3478.6	563	559.9	99.4
KG0021A01:2	3480.1	2791.3	3479.1	688.8	687.8	99.9
KG0021A01:3	**3479.7**	**2625**	**3479.9**	**854.7**	**854.9**	**100.0**
KG0021A01:4	3284.3	2877.2	3299.2	407.1	422	103.7
KG0021A01:5	2263	2079	2269.5	184	190.5	103.5
KG0048A01:1	3849.8	3798.2	3846.9	51.6	48.7	94.4
KG0048A01:2	3605	3519.9	3605.2	85.1	85.3	100.2

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf - Pp	Recovery %
KG0048A01:3	3886.4	3485.1	3685.4	401.3	200.3	49.9
KG0048A01:4	2195.8	2024.1	2202.2	171.7	178.1	103.7

" – " in the Recovery column means that there has been no drawdown
" <0 " in the Recovery column means that there has been no recovery

Flow data

Manually measured flow rates of KG0021A01 section 25.00 – 34.00 m are presented in the table below, see also Appendix 9a.

The height of the water flow outlet was 1.1 m above the tunnel floor.

Table 6-12 Manually measured flow rates during interference test in KG0021A01, section 25.00 – 34.00 m (test #14) of Prototype Repository, August 1999

Time	Flow rate (l/min)
08:00.35	8.30
08:03.35	8.10
08:06.05	7.95
08:15	7.70
08:31	7.51
08:45	7.45
09:00	7.42
13:50	7.28
13:54	7.28
13:58	7.29

Calculated flow data

Flow rate at the end of the flowing period (Q_p, l/min): 7.28
Average flow rate during the flowing period (Q_{ave}, l/min): 7.39
Total flow volume during the flowing period (V_{tot}, litres): 2 661

Comments on the diagrams

The instant pressure changes in the sections above and beneath the flowing section that was noted during some of the preceding tests cannot be observed during test #14.

The pressure of KA3552G01 dropped rapidly after the closing of the test valve. Then it increased 10-15 minutes whereupon a more gentle decrease begins. After flow stop the pressure variation is reversed. The pressure curves of the borehole sections KA3554G01:3 and KA3566G02:4 show a similar pattern. The pressure of KA3579G starts to increase again at the end of the recovery phase.

6.1.7 Borehole KG0021A01, section 42.50 m – 48.82 m, test #13

Date: 99-08-21 Field Crew: Bengt Gentzschein
Borehole length: 48.82 m Borehole diameter: 76 mm
Flowing borehole: KG0021A01, section #1: 42.50 – 48.82 m

Valve opened: 990821 09:00.05 Valve closed: 990821 15:02.10
End of Test: 990822 07:55
Total flowing time : 362 min Tot. Pr. Build-up time 1013 min.

The test was performed as an interference test. Pressure responses were monitored in 61 borehole sections.

Pressure data

Table 6-13 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KG0021A01, section 42.50– 48.82 m. Prototype Repository, August 1999

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf - Pp	Recovery %
KA3510A:1	4130.7	4130.9	4131.1	-0.2	0.2	-
KA3510A:2	4103.1	4103.9	4104.1	-0.8	0.2	-
KA3510A:3	3851.9	3848	3850.9	3.9	2.9	74.4
KA3539G:1	2975.5	2959.6	2976.5	15.9	16.9	106.3
KA3539G:2	2975.7	2959.3	2976.5	16.4	17.2	104.9
KA3539G:3	2807.8	2791.9	2809.5	15.9	17.6	110.7
KA3542G01:1	3837.5	3833.6	3835.9	3.9	2.3	59.0
KA3542G01:2	3735.9	3719.7	3735.3	16.2	15.6	96.3
KA3542G01:3	1235.4	1221.1	1234.8	14.3	13.7	95.8
KA3542G02:1	3033.6	3024.8	3036.3	8.8	11.5	130.7
KA3542G02:2	3168.7	3151.9	3169.7	16.8	17.8	106.0
KA3542G02:3	3168.8	3151.7	3169.4	17.1	17.7	103.5
KA3542G02:4	3104.5	3085.7	3104.3	18.8	18.6	98.9
KA3544G01:1	2855,8	2840,1	2855,8	15,7	15,7	100,0
KA3544G01:2	2168,8	2156,9	2170,7	11,9	13,8	116,0
KA3546G01:1	312.9	311	314.1	1.9	3.1	163.2
KA3546G01:2	524.4	522	526.7	2.4	4.7	195.8
KA3548A01:1	3851.7	3848.4	3850.9	3.3	2.5	75.8
KA3548A01:2	3765.8	3751.2	3765	14.6	13.8	94.5
KA3550G01:1	54.1	55.9	62.3	-1.8	6.4	-
KA3550G01:2	152.5	151.3	149.4	1.2	-1.9	<0
KA3552G01:1	667.1	666.7	668.5	0.4	1.8	450.0
KA3552G01:2	237.5	236.7	237.9	0.8	1.2	150.0

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf - Pp	Recovery %
KA3552G01:3	225.7	225.7	226.7	0	1	-
KA3554G01:1	3834.6	3830.9	3833.5	3.7	2.6	70.3
KA3554G01:2	3819.8	3815.7	3818.4	4.1	2.7	65.9
KA3554G01:3	1080.2	1073.5	1079.4	6.7	5.9	88.1
KA3554G02:1	3383.1	3375.1	3386.3	8	11.2	140.0
KA3554G02:2	3177.2	3159.5	3178	17.7	18.5	104.5
KA3554G02:3	3331.8	3319.7	3332.4	12.1	12.7	105.0
KA3557G01:1	139.8	140	141.5	-0.2	1.5	-
KA3563G01:1	289.4	288.8	289.8	0.6	1	166.7
KA3566G01:1	2586.2	2584.4	2586	1.8	1.6	88.9
KA3566G01:2	1901.6	1901.2	1903.5	0.4	2.3	575.0
KA3566G01:3	3212.1	3213.3	3216	-1.2	2.7	-
KA3566G01:4	2745.8	2745.2	2748.1	0.6	2.9	483.3
KA3566G02:1	3304.8	3291.3	3308.3	13.5	17	125.9
KA3566G02:2	3471.4	3459.5	3473.2	11.9	13.7	115.1
KA3566G02:3	2722.8	2724.6	2731.6	-1.8	7	-
KA3566G02:4	338.4	338	338.6	0.4	0.6	150.0
KA3572G01:1	324	324.6	325.7	-0.6	1.1	-
KA3573A:1	4005.1	4004.6	4005.7	0.5	1.1	220.0
KA3573A:2	3862.3	2859.2	3861.3	1003.1	1002.1	99.9
KA3574G01:1	101.4	101.6	101.6	-0.2	0	-
KA3578G01:1	92.4	92.4	92.6	0	0.2	-
KA3579G01:1	448.2	459.7	474	-11.5	14.3	-
KA3584G01:1	108.3	108.1	108.5	0.2	0.4	200.0
KA3590G01:1	748	747.1	746.5	0.9	-0.6	<0
KA3590G02:1	3556.1	3543.4	3557.9	12.7	14.5	114.2
KA3593G01:1	1395.6	1395.6	1398.1	0	2.5	-
KA3600F:1	4071.1	4071.9	4071.7	-0.8	-0.2	-
KA3600F:2	4049.1	4049.6	4050.2	-0.5	0.6	-
KG0021A01:1	**3478.8**	**227.7**	**3477.6**	**3251.1**	**3249.9**	**100.0**
KG0021A01:2	3479.1	3342.4	3480.3	136.7	137.9	100.9
KG0021A01:3	3479.9	3455.7	3481.7	24.2	26	107.4
KG0021A01:4	3299	3286.7	3302.9	12.3	16.2	131.7
KG0021A01:5	2265.9	2263	2268.7	2.9	5.7	196.6
KG0048A01:1	3846.9	3843.8	3846.1	3.1	2.3	74.2
KG0048A01:2	3605	3601.1	3605	3.9	3.9	100.0
KG0048A01:3	3685.6	3677.2	3686	8.4	8.8	104.8

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf - Pp	Recovery %
KG0048A01:4	2202.2	2196.5	2202	5.7	5.5	96.5

" – " in the Recovery column means that there has been no draw down
" <0 " in the Recovery column means that there has been no recovery

Flow data

Manually measured flow rates of KG0021A01 section 42.50 – 48.82 m are presented in the table below, see also Appendix 8a.

The height of the water flow outlet was 1.1 m above the tunnel floor.

Table 6-14 Manually measured flow rates during interference test in KG0021A01, section 42.50 – 48.82 m (test #13) of Prototype Repository, August 1999

Time	Flow rate (l/min)
09:00.35	2.179
09:02.35	0.647
09:05.35	0.628
09:15	0.620
09:30	0.620
09:45	0.612
10:00	0.606
14:51.30	0.380
14:54.30	0.379
15:00.30	0.380

Calculated flow data

Flow rate at the end of the flowing period (Q_p, l/min): 0.380
Average flow rate during the flowing period (Q_{ave}, l/min): 0.519
Total flow volume during the flowing period (V_{tot}, litres): 187.9

Comments on the diagrams

The instant pressure changes in the sections above and beneath the flowing section that was noted during some of the preceding tests was observed also during test #13.

Borehole KG0021A01 is directed upwards. During the flow phase air entered the test section, which entailed a slow start of the pressure build up after closing the test valve.

6.1.8 Borehole KA3539G, section 9.80 m –18.30 m, test #12

Date: 99-08-22 Field Crew: Bengt Gentzschein
Borehole length: 30.01 m Borehole diameter: 76 mm
Flowing borehole: KA3539G, section #2: 9.80 – 18.30 m

Valve opened: 990822 08:00.07 Valve closed: 990822 09:11.05
End of Test: 990822 18:00
Total flowing time : 61 min Tot. Pr. Build-up time 529 min.

The test was performed as an interference test. Pressure responses were monitored in 61 borehole sections.

Pressure data

Table 6-15 Key pressure data , draw-down and recovery respectively of each borehole section. Interference test in KA3539G, section 9.80 – 18.30 m. Prototype Repository, August 1999

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KA3510A:1	4131.1	4130.1	4131.3	1	1.2	120.0
KA3510A:2	4103.9	4103.3	4104.7	0.6	1.4	233.3
KA3510A:3	3850.9	3826.8	3849.7	24.1	22.9	95.0
KA3539G:1	2976.5	1160.5	2979.2	1816	1818.7	100.1
KA3539G:2	**2976.5**	**1160.7**	**2979.2**	**1815.8**	**1818.5**	**100.1**
KA3539G:3	2809.5	1896.9	2782.7	912.6	885.8	97.1
KA3542G01:1	3835.9	3815.4	3834.6	20.5	19.2	93.7
KA3542G01:2	3735.5	3691.7	3733	43.8	41.3	94.3
KA3542G01:3	1235	1198.4	1234.4	36.6	36	98.4
KA3542G02:1	3036.3	3012.3	3032.4	24	20.1	83.7
KA3542G02:2	3169.5	2970.3	3184.2	199.2	213.9	107.4
KA3542G02:3	3169.4	2913.2	3170.3	256.2	257.1	100.4
KA3542G02:4	3104.3	2343.7	3109.4	760.6	765.7	100.7
KA3544G01:1	2855,6	1907,2	2875,1	948,4	967,9	102,1
KA3544G01:2	2170,9	1673,1	2178,8	497,8	505,7	101,6
KA3546G01:1	314.3	265	315.1	49.3	50.1	101.6
KA3546G01:2	526.7	477.2	528.9	49.5	51.7	104.4
KA3548A01:1	3850.9	3831.7	3849.6	19.2	17.9	93.2
KA3548A01:2	3765	3726.5	3762.9	38.5	36.4	94.5
KA3550G01:1	62.2	59.4	65.7	2.8	6.3	225.0
KA3550G01:2	149.2	148.8	148.4	0.4	-0.4	<0
KA3552G01:1	668.5	667.5	668.5	1	1	100.0

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KA3552G01:2	237.9	234.8	237.9	3.1	3.1	100.0
KA3552G01:3	226.5	225.1	227.1	1.4	2	142.9
KA3554G01:1	3833.2	3812.9	3832.2	20.3	19.3	95.1
KA3554G01:2	3818.1	3798.3	3816.7	19.8	18.4	92.9
KA3554G01:3	1079.6	1071.2	1078.2	8.4	7	83.3
KA3554G02:1	3386.3	3281.9	3380.8	104.4	98.9	94.7
KA3554G02:2	3177.8	2798.8	3185.1	379	386.3	101.9
KA3554G02:3	3332.4	3153.1	3332.2	179.3	179.1	99.9
KA3557G01:1	141.5	141.5	141.9	0	0.4	-
KA3563G01:1	290	288.6	289.6	1.4	1	71.4
KA3566G01:1	2586	2577.4	2585.8	8.6	8.4	97.7
KA3566G01:2	1903.5	1898.6	1903.7	4.9	5.1	104.1
KA3566G01:3	3216	3214.9	3216.8	1.1	1.9	172.7
KA3566G01:4	2748.1	2745.6	2747.2	2.5	1.6	64.0
KA3566G02:1	3308.3	3060.1	3304.4	248.2	244.3	98.4
KA3566G02:2	3473.2	3364.4	3471.6	108.8	107.2	98.5
KA3566G02:3	2731.6	2731	2727.1	0.6	-3.9	<0
KA3566G02:4	338.6	335	338.9	3.6	3.9	108.3
KA3572G01:1	326.1	325.9	326.5	0.2	0.6	300.0
KA3573A:1	4005.7	3999.9	4005.7	5.8	5.8	100.0
KA3573A:2	3861.5	3843.3	3860.5	18.2	17.2	94.5
KA3574G01:1	101.6	101.4	101.6	0.2	0.2	100.0
KA3578G01:1	92.6	92.6	92.6	0	0	-
KA3579G01:1	474.2	475.6	478.1	-1.4	2.5	-
KA3584G01:1	108.7	108.5	108.7	0.2	0.2	100.0
KA3590G01:1	746.5	744.1	745.1	2.4	1	41.7
KA3590G02:1	3557.7	3474.5	3556.1	83.2	81.6	98.1
KA3593G01:1	1397.9	1396.2	1399.9	1.7	3.7	217.6
KA3600F:1	4071.7	4070.9	4072.7	0.8	1.8	225.0
KA3600F:2	4050	4048.1	4050.6	1.9	2.5	131.6
KG0021A01:1	3477.6	3324.9	3476.8	152.7	151.9	99.5
KG0021A01:2	3480.5	3314.2	3478.9	166.3	164.7	99.0
KG0021A01:3	3481.7	3308.5	3480.1	173.2	171.6	99.1
KG0021A01:4	3303.1	3263.8	3300.5	39.3	36.7	93.4
KG0021A01:5	2268.7	2235.5	2268.9	33.2	33.4	100.6
KG0048A01:1	3846.1	3827.9	3845.1	18.2	17.2	94.5
KG0048A01:2	3605	3582.1	3603.5	22.9	21.4	93.4

Idcode	Po (kPa)	Pp (kPa)	Pf (kPa)	Po - Pp	Pf – Pp	Recovery %
KG0048A01:3	3686	3640.1	3685.2	45.9	45.1	98.3
KG0048A01:4	2201.8	2173.5	2201.8	28.3	28.3	100.0

" – " in the Recovery column means that there has been no drawdown
" <0 " in the Recovery column means that there has been no recovery

Flow data

Manually measured flow rates of KA3539G, section 9.80 – 18.30 m are presented in the table below, see also Appendix 7a.

The height of the water flow outlet was 0.3 – 0.6 m above the tunnel floor.

Table 6-16 Manually measured flow rates during interference test in KA3539G, section 9.80 – 18.30 m (test #12) of Prototype Repository, August 1999

Time	Flow rate (l/min)
08:00.37	5.28
08:03.37	5.26
08:06.37	5.095
08:16	4.73
08:30	4.462
08:40	4.37
08:50	4.348
09:01	4.32
09:04	4.285
09:10	4.278

Calculated flow data

Flow rate at the end of the flowing period (Q_p, l/min): 4.29
Average flow rate during the flowing period (Q_{ave}, l/min): 4.55
Total flow volume during the flowing period (V_{tot}, litres): 75.6

Comments on the diagrams

Test #12 was the last of the eight tests performed in the "Interference Test B campaign". The planned test interval was 9.8 m – 18.3 m in KA3539G. However, in practice the test interval was a double interval, 9.8m –18.3m + 19.3m-30.01m, since there was a leakage between the two borehole sections KA3539G:2 and KA3539G:1, see section 5.

6.1.9 Compilation of results

In Table 6-17 important flow- and pressure data are summarized.

Table 6-17 Summary of the results. Interference tests B after drilling campaign 3. Prototype Repository , August 1999

Borehole: Section	Test No	P_0 (kPa)	P_p (kPa)	P_f (kPa)	Q_p (l/min)	Q_{ave} (l/min)	V_{tot} (l)
KG0048A01:1	7	3856.7		3856.7	2.42	2.40	204
KA3554G01:1	8	3845.7	1234.4	3841.2	4.465	4.54	1 652
KA3554G02:2	9	3154	119.2	3148.5	0.483	0.494	179.8
KA3542G01:2	10	3745.1	374.2	3743.9	2.56	2.64	965
KA3542G02:3	11	3097.3	312.5	3110	3.37	3.47	1252
KA3539G02:2	12	2976.5	1160.7	2979.2	4.29	4.55	75.6
KG0021A01:1	13	3478.8	227.7	3477.6	0.380	0.519	187.9
KG0021A01:3	14	3479.7	2625	3479.9	7.28	7.39	2661

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APPENDICES

Appendices 2a - 10 are not included as hard copies in the report, but stored on CD-Rom which is available at Äspö Hard Rock Laboratory.

APPENDIX 1: Data files.

APPENDIX 2a: Flow rate of borehole KG0048A01, section 49.00 – 54.69 m
and groundwater pressure of 63 borehole sections during test # 7
Prototype Repository, interference Tests B after drill campaign 3.

APPENDIX 2b: Hydraulic head of 63 borehole sections during test # 7
Prototype Repository, interference Tests B after drill campaign 3.

APPENDIX 3a: Flow rate of borehole KA3554G01, section 22.30 – 30.01 m
and groundwater pressure of 62 borehole sections during test # 8.
Prototype Repository, interference Tests B after drill campaign 3**.**

APPENDIX 3b: Hydraulic head of 62 borehole sections during test # 8.
Prototype Repository, interference Tests B after drill campaign 3.

APPENDIX 4a: Flow rate of borehole KA3554G02, section 10.30 – 21.30 m
and groundwater pressure of 62 borehole sections during test # 9.
Prototype Repository, interference Tests B after drill campaign 3**.**

APPENDIX 4b: Hydraulic head of 62 borehole sections during test # 9.
Prototype Repository, interference Tests B after drill campaign 3**.**

APPENDIX 5a: Flow rate of borehole KA3542G01, section 8.80 – 24.80m
and groundwater pressure of 62 borehole sections during test # 10.
Prototype Repository, interference Tests B after drill campaign 3.

APPENDIX 5b: Hydraulic head of 62 borehole sections during test # 10.
Prototype Repository, Interference Tests B after drill campaign 3.

APPENDIX 6a: Flow rate of borehole KA3542G02, section 1.30 – 7.80 m
and groundwater pressure of 61 borehole sections during test # 11.
Prototype Repository, interference Tests B after drill campaign 3.

APPENDIX 6b: Hydraulic head of 61 borehole sections during test # 11.
Prot otype Repository, interference Tests B after drill campaign 3.

APPENDIX 7a: Flow rate of borehole KA3539G, section 9.80 – 18.30 m
and groundwater pressure of 61 borehole sections during test #12.
Prototype Repository, interference Tests B after drill campaign 3.

APPENDIX 7b: Hydraulic head of 61 borehole sections during test # 12. Prototype Repository, interference Tests B after drill campaign 3.

APPENDIX 8a: **Flow rate of borehole KG0021A01, section 42.50 – 48.82 m** and groundwater pressure of 61 bore hole hole sections during test #13. Prototype Repository, interference Tests B after drill campaign 3.

APPENDIX 8b: Hydraulic head of 61 borehole sections during test # 13. Prototype Repository, interference Tests B after drill campaign 3.

APPENDIX 9a: **Flow rate of borehole KG0021A01, section 25.00 – 34.00 m** and groundwater pressure of 61 borehole sections during test #14. Prototype Repository, interference Tests B after drill campaign 3.

APPENDIX 9b: Hydraulic head of 61 borehole sections during test # 14. Prototype Repository, interference Tests B after drill campaign 3.

APPENDIX 10: Diagrams of the ground water pressure between August 13th and August 22nd in 62 borehole sections of the Prototype Repository site, covering tests #8 - #14. Interference Tests B after drill campaign 3

APPENDIX 1

DATA FILES

All pressure data of tests #7 - #14 were registered and stored by the Hydro Monitoring System (HMS) at Äspö Hard Rock Laboratory. Manually measured flow data were stored in data files according to the table below.

Table: A list of data files in the containing flow rate data from tests #7 - #14 Prototype Repository. Interference tests B after drill campaign 3, June and August 1999

Test No	Borehole:	Test section (and observation section) (m)	Start of Test (kl.)	End of test	Data files
7	KG0048A01:1	49.00 – 54.69	990716 07:00	990716 0800	07fd048a.txt
8	KA3554G01:1	22.30 – 30.01	990818 08:00	990819 08:00	08fd3554.txt
9	KA3554G02:2	10.30 – 21.30	990816 09:00	990817 08:00	09d3554.txt
10	KA3542G01:2	8.80 – 24.80	990817 09:00	990818 07:30	10fd3542.txt
11	KA3542G02:4	1.30 - 7.80	990819 07:00	990820 08:33	11d3542.txt
12	KA3539G	9.80 – 18.30	990822 07:00	990822 08:00	12fd3539.txt
13	KG0021A01:1	42.50 – 48.82	990821 07:00	990822 08:00	13fd021a.txt
14	KG0021A01:3	25.00 – 34.00	990820 06:00	990821 06:30	14fd021a.txt