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Slug tests in groundwater monitoring wells in Forsmark in 2021

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Abstract

In summer 2021 single hole slug tests were performed in 27 groundwater monitoring wells in the Forsmark area. This report presents methodology, test responses and analyses in terms of evaluated hydraulic properties of regolith at screen depth at the locations of tested wells. The objective of the slug tests is to obtain hydraulic properties data for previously untested well locations (or recently installed wells). Slug test response data were mainly analysed using the Cooper-Bredehoeft-Papadopulos method and the Hvorslev method for observation wells installed with a filter under a confining layer (i.e. confined conditions), and the Bouwer and Rice method was used for observation wells installed in areas with unconfined conditions.

The principle of a slug test is to initiate an instantaneous displacement of the water level in a groundwater monitoring well and then observe the following recovery of the water level as a function of time. A slug test can be performed by causing a sudden rise of the water level (usually referred to as a falling-head test), or a sudden drop of the water level (usually referred to as a rising-head test). Both falling-head tests and rising-head tests were performed in the present study. The AQTESOLV 4.50 (Duffield 2007) software was used for slug test response analyses.

The values of hydraulic conductivities obtained from the analyses with the Cooper-Bredehoeft-Papadopulos method are between $1.01 \cdot 10^{-7}$ and $7.76 \cdot 10^{-5}$ m/s. Some results are outside of the upper or lower limits of slug tests, and are therefore not accounted for. The values of the hydraulic conductivity obtained from the analyses with the Hvorslev method are between $1.31 \cdot 10^{-7}$ and $4.4 \cdot 10^{-4}$ m/s. The Bouwer and Rice method was only used for evaluation of three slug tests, with values of evaluated hydraulic conductivity ranging between $3.04 \cdot 10^{-7}$ and $3.49 \cdot 10^{-5}$ m/s.

Sammanfattning

Sommaren 2021 utfördes enhålstester (slugtester) i 27 grundvattenrör i Forsmarksområdet. Denna rapport presenterar metodik, testresponser och analyser i termer av utvärderade hydrauliska egenskaper i jord vid filterdjup i lägena för de testade rören. Slugtesterna syftar till att erhålla data på hydrauliska egenskaper i tidigare otestade rörlägen (eller i lägen för nyligen installerade rör). Responsdata från slugtesterna utvärderades huvudsakligen med Cooper-Bredehoeft-Papadopulos-metoden och Hvorslev-metoden för rör installerade med intagsdelen i slutna akvifärförhållanden, samt Bouwer och Rice-metoden för rör installerade i områden med öppna akvifärförhållanden.

Principen för ett slugtest är att initiera en momentan förändring av vattennivån i ett grundvattenrör och observera den efterföljande återhämtningen av vattennivån som funktion av tiden. Ett slugtest kan utföras genom att orsaka en momentan höjning av vattennivån (vanligtvis benämnt ”falling-head-test”), eller genom en momentan sänkning av vattennivån (vanligtvis benämnt ”rising-head-test”). Vid de aktuella undersökningarna genomfördes båda typerna av tester. Mjukvaran AQTESOLV 4.50 användes för analys av slugtestresponser.

Värden på hydraulisk konduktivitet som erhållits från analyserna med Cooper-Bredehoeft-Papadopulos-metoden varierar mellan $1{,}01 \cdot 10^{-7}$ m/s och $7{,}76 \cdot 10^{-5}$ m/s. Vissa resultat är utanför den övre eller nedre gränsen för slugtester och har då inte medräknats. Värden på hydraulisk konduktivitet som erhållits från analyserna med Hvorslev-metoden varierar mellan $1{,}31 \cdot 10^{-7}$ m/s och $4{,}4 \cdot 10^{-4}$ m/s. Bouwer och Rice-metoden användes endast för utvärdering av tre slugtester, med värden för utvärderad hydraulisk konduktivitet mellan $3{,}04 \cdot 10^{-7}$ och $3{,}49 \cdot 10^{-5}$ m/s.

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1 Introduction

In Forsmark, SKB (Swedish Nuclear Fuel and Management Co) has installed more than 100 groundwater monitoring wells in regolith for groundwater level monitoring and groundwater sampling. The primary objective of the slug tests described in this report is to obtain data that can be used to estimate the hydraulic properties of regolith at previously untested locations, including recently installed wells. The report presents the performance and evaluation of slug tests of 27 groundwater monitoring wells at Forsmark. Objectives and scope are described below based on the SKB activity plan AP SFK-21-020* (Slugtester i grundvattenrör 2021).

The investigation includes sounding of vertical lengths from top of well casings to well bottoms, to find out the extent of sediment accumulation within the wells. The presence of sediment can cause turbidity during water sampling as well as indicate whether filter clogging can affect hydraulic response times and results from water sampling. However, for the slug tests presented in this study it was not possible to assess whether filter clogging may have affected results, since no previous tests had been conducted in them.

It should be pointed out that the type curve methods used here to analyse slug test responses do not consider skin effects, i.e. a relatively thin zone around well filters with a hydraulic conductivity that deviates from the properties of the surrounding geological material. In addition, tests were only carried out in a small selection of the groundwater monitoring wells installed in Forsmark (Figure 1-1). The slug tests have been evaluated for the determination of T (transmissivity) and K (hydraulic conductivity) according to the type curve methods that are described in SKB's method description for slug tests in open groundwater monitoring wells (Morosini and Hansson 2020). The main methods used here are those of Cooper et al. (1967) and Hvorslev (1951).

Most tested well screens are installed close to the contact zone between regolith and bedrock. According to the activity plan for the slug tests (Table 1-1), it was planned to perform slug tests in totally 39 previously untested groundwater monitoring wells (Figure 1-1). However, some of the wells could not be tested as they were temporarily dry or inaccessible during the field-work period, or because the stand pipe is too narrow for the equipment employed during the tests (Appendix 4). Moreover, one tested well (SFM0006) is close to a dry well and was therefore tested outside the scope of the activity plan (AP SFK-21-020*).

*Internal SKB document.

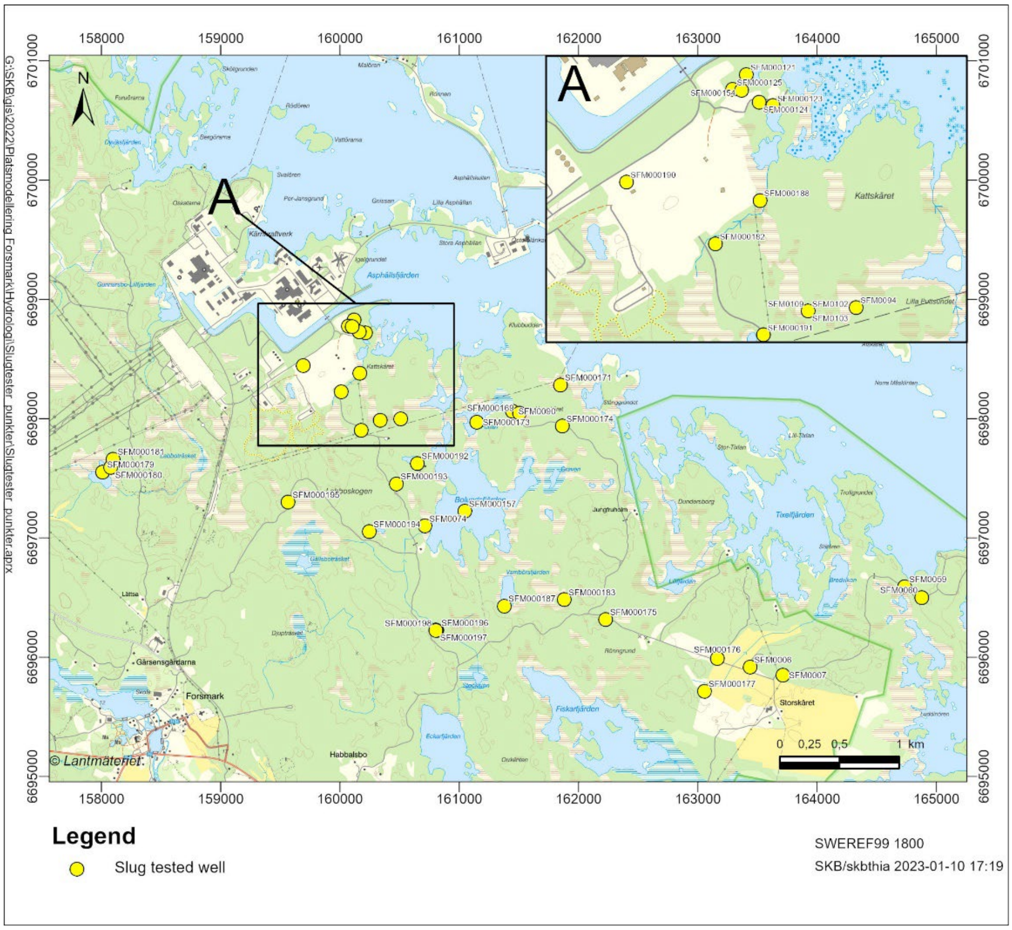

Figure 1-1 *Map showing the locations of the slug tested groundwater monitoring wells.*

Table *1-1* lists the controlling documents for the activity. Both activity plans and method descriptions and instructions are SKB's internal controlling documents (SKBdoc is SKB's internal document handling system).

Table 1-1 Controlling documents for the activity.

Activity plan		**SKBdoc id, version**
Slugtester i grundvattenrör 2021	AP SFK-21-020*	1935988, ver. 1.0
Method descriptions and instructions		
Metodbeskrivning för slugtester i öppna grundvattenrör	SKB MD 325.001	1230437, ver. 3.0
Instruktion för rengöring av borrhålsutrustning och viss markbaserad utrustning	SKB MD 600.004*	1191443, ver. 3.0

*Internal SKB document.

2 Scope

2.1 Tested wells

In Table 2-1 a list of 40 wells mentioned in this report are shown. Grey highlighted wells (totally 13) were not tested. 27 tested with slug (including the 5 test results are not analysed due to poor data results and highlighted in pipes are shown. According to the activity plan (AP SFK-21-020*) it was initially planned to test 39 wells. Of the 27 tested wells, slug test responses in 22 wells could be analysed; the responses in the remaining five wells could not be analysed because in some cases no response could be measured in both falling head and rising head tests and these erroneous responses can be an indication of poor well function (see Appendix 4). Table ***2-2*** presents technical data of the tested wells. Test times for falling-head and rising-head tests are presented in Table 2-3. Well drawings are presented in Appendix ***1.***

Table 2-1 List of slug tested groundwater monitoring wells. Untested wells are marked in grey and non-evaluated slug tests are marked in orange. Well coordinates and technical data are obtained from SKB's primary database (Sicada). Coordinates in the table are given in the coordinate systems SWEREF 99 18 00 (Northing, Easting) and RH 2000 (Elevation). ToC = top of casing, GSE = ground-surface elevation, Case ground = vertical distance from ground surface to ToC, WD = vertical well depth below ground surface.

Well id	ToC			GSE (m)	Case ground (m)	WD (m)
	N	E	Elevation			
SFM0006**	6695915.94	163437.50	6.47	5.96	0.51	4.21
SFM0007	6695848.23	163713.49	7.19	6.78	0.41	6.11
SFM0059	6696590.26	164735.77	4.72	4.22	0.50	6.15
SFM0060	6696500.78	164879.38	5.09	4.44	0.65	8.65
SFM0074	6697098.99	160712.07	1.00	0.70	0.30	12.7
SFM0090	6698060.51	161443.87	1.82	1.19	0.63	10.43
SFM0094	6697998.54	160510.58	1.55	0.75	0.80	10.3
SFM0102	6697985.95	160338.89	1.29	1.14	0.99	5.65
SFM0103	6697985.95	160338.89	1.29	1.14	0.76	5.65
SFM0109	6697985.95	160338.89	1.29	1.14	0.73	5.65
SFM000121	6698828.08	160119.37	2.87	1.44	1.43	6.50
SFM000123	6698717.19	160214.67	1.68	0.91	0.77	3.50
SFM000124	6698728.86	160163.99	2.37	1.51	0.86	3.50
SFM000125	6698774.54	160070.56	3.72	2.82	0.90	4.50
SFM000154	6698770.89	160101.86	4.22	3.62	0.60	2.40
SFM000157	6697223.10	161045.47	1.36	0.71	0.65	5.00
SFM000169	6698044.38	161506.48	2.33	1.73	0.6	4.00
SFM000171	6698281.13	161848.15	1.74	0.74	1.00	3.50
SFM000173	6697970.02	161145.48	1.88	0.68	1.20	5.00
SFM000174	6697935.95	161862.60	3.57	2.99	0.58	3.00
SFM000175	6696315.81	162226.80	4.33	3.03	1.30	6.00
SFM000176	6695987.41	163163.28	5.28	4.68	0.60	7.00
SFM000177	6695713.39	163054.58	4.82	3.82	1.00	6.00
SFM000179	6697552.49	158011.86	6.89	6.09	0.80	5.00
SFM000180	6697589.29	158078.43	6.95	6.25	0.70	6.00
SFM000181	6697660.35	158098.39	9.56	8.21	1.35	4.00
SFM000182	6698225.22	160009.51	2.66	1.66	1.00	5.00
SFM000183	6696481.17	161880.08	2.50	1.50	1.00	7.10
SFM000187	6696428.88	161376.14	2.14	1.04	1.10	4.00
SFM000188	6698379.64	160167.73	2.29	0.99	1.30	5.10
SFM000190	6698445.35	159691.78	5.62	4.70	0.92	7.00
SFM000191	6697900.44	160180.13	4.49	3.40	1.09	9.20
SFM000192	6697624.66	160647.63	3.44	2.41	1.03	9.00
SFM000193	6697452.73	160471.64	6.05	5.00	1.05	5.10
SFM000194	6697051.76	160244.69	4.30	3.40	0.90	4.00
SFM000195	6697298.64	159565.60	3.77	2.88	0.89	7.00
SFM000196	6696224.62	160813.50	3.25	2.05	1.20	11.00
SFM000197	6696226.86	160803.11	2.70	2.10	0.60	8.00
SFM000198	6696222.97	160805.12	3.16	2.13	1.03	7.00

**SFM0006 is not listed in the activity plan (AP SFK-21-020*).
*Internal SKB document.

Table 2-2 presents technical data of the tested wells. Test times for falling-head and rising-head tests are presented in Table 2-3. Well drawings are presented in Appendix 1.

Table 2-2 Technical data of the slug tested groundwater monitoring wells. Well depth (Sicada) is the well depth from ToC (Top of casing) measured in connection to well installation. Well depth (field) is well depth measured in connection to the 2021 slug tests.

Well id	Well depth (Sicada) (m)	Well depth (field) (m)	Inner diameter of stand pipe $Ø_i$ (mm)	Screen_Secup (m from ToC)	Screen_Seclow (m from ToC)	Measured water level (m from ToC)**
SFM0006	4.21	4.05	75	3.015	4.015	1.21
SFM0090	10.43	9.56*	101	2.625	5.125	1.12
SFM000109	5.65	5.07*	72	3.45	4.45	1.95
SFM000169	4.00	3.84	51	1.845	2.845	1.2
SFM000171	3.50	3.5	51	2.5	3.5	1.31
SFM000174	3.00	3.09	51	1.61	2.61	1.61
SFM000176	7.00	7.08	51	5.08	6.08	2.82
SFM000177	6.00	5.1*	51	3.5	4.5	2.5
SFM000179	5.00	5	51	3.99	4.99	0.96
SFM000180	6.00	4.84*	51	2.84	3.84	1.06
SFM000182	5.00	4.59	51	2.59	3.59	1.88
SFM000183	7.10	7.95*	51	5.1	6.1	1.81
SFM000187	4.00	4.09	51	2.07	3.07	1.07
SFM000188	5.10	3.63*	51	1.791	2.791	1.79
SFM000190	7.00	8.06*	51	6.06	7.06	2.82
SFM000191	9.20	8.56	51	8.255	9.255	3.26
SFM000192	9.00	9	51	7	8	1.55
SFM000193	5.10	5.06	51	3.055	4.055	1.95
SFM000194	4.00	3.86	51	1.82	2.82	1.52
SFM000195	7.00	6.82	51	3.765	4.765	1.87
SFM000197	8.00	8.54*	51	6.54	7.54	0.95
SFM000198	7.00	7.08	51	5.045	6.045	0.85

*Measured well depth differs more than 0.5 m from well-depth information in the Sicada database.
**Field data used to calculate the measured water level from ToC.

Table 2-3 Summary of the performed slug tests. FHT = falling-head test with test time (t1), RHT = rising-head test with test time (t2).

Well id	Test time (s)		Location	Regolith type, bold represents regolith type at screen depth (App. 1) *
	t1 (FHT)	t2 (RHT)		
SFM0006	3,595	9,927	Open farm land	Silt, Clay, **Sand,** Bedrock
SFM0090	1,573	1,924	Forest	**Till**, Bedrock
SFM000109	3,130	5,185	Forest	Silt, Clayey silt, **Sand**, Bedrock
SFM000169	3,416	1,080	Forest	**Till, Silty-sandy till**, Bedrock
SFM000171	1,029	820	Pond	Water, **Silty till, Bedrock**
SFM000174	3,572	5,039	Clear cut forest	**Silty-sandy till, Sandy till,** Bedrock
SFM000176	10,662	4,510	Open field	Friction soil, Silty-clayey till, **Clay, Till**, Bedrock
SFM000177	1,310	1,332	Open field	Friction soil, Clayey-silty till, **Clay**, Bedrock
SFM000179	9,63	853	Pond	Water, Clay, **Friction soil**, Bedrock
SFM000180	3,637	8,680	Wetland	Peat, **Till**, Bedrock
SFM000182	3,538	6,489	Forest	**Till, Silty-sandy till**, Bedrock
SFM000183	9,581	10,330	Wetland	Clay, S**ilty till, Boulder, Till**, Bedrock
SFM000187	3,804	1,596	Wetland	Peat, S**ilty till**, Bedrock
SFM000188	6,509	3,960	Forest	**Till, Silty till**, Bedrock
SFM000190	3,168	5,780	Clear cut forest	Till, Sandy till, **Silty-sandy till**, Bedrock
SFM000191	3,684	8,197	Forest	**Silty-sandy till, Bedrock**
SFM000192	3,691	3,403	Forest	**Silty-sandy till**, Bedrock
SFM000193	7,499	7,389	Forest	**Silty-sandy till, Bedrock**
SFM000194	4,035	8,833	Forest	Clay, **Friction soil, Bedrock**
SFM000195	6,091	5,671	Forest	Clay, **Friction soil, Till**
SFM000197	5,954	6,458	Wetland	Clay, **Till**, Bedrock
SFM000198	7,906	5,907	Wetland	**Clay**, Till, Bedrock

*Regolith layering is shown from ground surface to well bottom. Regolith types are determined in the field according to SKB-Metodbeskrivning för jordborrning (Larsson, 2020). Actual methods for regolith drilling and sampling depend on the depth and type of regolith, and is determined in each case according to the specific Activity Plan/on site by the geotechnician. Typically, auger drilling and/or flushing are used for drilling/sampling in till.

2.2 Parameters used in analyses

A list of parameters used for analyses of falling-head tests are shown in Table *2-4* and the parameters are applied in the analysis methods and associated equations presented in Chapter 4.

Parameters for rising-head tests are changed based on initial displacement and static water column height. The parameters for rising-head tests are not presented in this report.

Table 2-4 Parameters used for analysis of falling-head tests.

Well id	Static water column height in the well	Observed initial water-level displacement	Saturated thickness of aquifer	Depth of water to top of well screen	Length of well screen	Transducer depth below water	Inner radius of stand pipe	Inner radius of well	Outer radius of well skin
	H (m)	H0 (m)	b (m)	d (m)	L (m)	D (m)	r_c (m)	r_w (m)	r_{sk} (m)
SFM0006	2.835	0.2	2.5	1.8	1	2.8	0.09685	0.0375	0.0375
SFM0090	8.44	0.18	0.8	1.5	2.5	2.5	0.0505	0.0505	0.0505
SFM0109	3.125	0.19	2.7	1.5	1	2.5	0.09685	0.036	0.09685
SFM000169	2.645	0.467	1.64	0.65	1	1.6	0.0255	0.0255	0.0255
SFM000171	2.19	0.956	1.1	1.19	1	1.5	0.0255	0.0255	0.0255
SFM000174	1.485	0.23	0.48	0	1	1	0.0255	0.0255	0.0255
SFM000176	4.26	0.432	3.24	2.32	1	3.26	0.0255	0.0255	0.0255
SFM000177	2.6	0.31	1.6	1	1	1.5	0.0255	0.0255	0.0255
SFM000179	4.03	0.135	1	3.03	1	3.05	0.0255	0.0255	0.0255
SFM000180	3.78	0.46	3.4	1.78	1	2.7	0.0255	0.0255	0.0255
SFM000182	2.71	0.459	1.71	0.71	1	1.7	0.0255	0.0255	0.0255
SFM000183	6.14	0.316	2.8	4.14	1	0.92	0.0255	0.0255	0.0255
SFM000187	3.02	0.23	2	1	1	1.93	0.0255	0.0255	0.0255
SFM000188	1.84	0.36	0.85	0	1	1	0.0255	0.0255	0.0255
SFM000190	5.24	0.44	4.24	3.24	1	4.08	0.0255	0.0255	0.0255
SFM000191	5.31	0.43	6.875	6.565	1	5.31	0.0255	0.0255	0.0255
SFM000192	7.45	0.525	6.45	5.45	1	6.4	0.0255	0.0255	0.0255
SFM000193	3.11	0.42	1.9	1.1	1	1.5	0.0255	0.0255	0.0255
SFM000194	2.34	0.65	0.7	0.3	1	1	0.0255	0.0255	0.0255
SFM000195	4.96	0.425	3.8	1.9	1	2.9	0.0255	0.0255	0.0255
SFM000197	7.59	0.44	7.445	5.59	1	5.99	0.0255	0.0255	0.0255
SFM000198	6.235	0.445	5.235	4.2	1	5.15	0.0255	0.0255	0.0255

2.3 Equipment

For the slug tests, the following equipment was used:

1. Van Essen Instruments Diver® (Mini-Diver, model DI 501 see Figure 2-1) with built-in pressure transducer and temperature sensor, with connecting cable.
2. Laptop.
3. Slug and wire made of stainless steel. The diameter of the equipment lowered into each groundwater monitoring well was as follows: Outer diameter of signal cable: 4 mm. Outer diameter of wire: 5 mm. Outer diameter of slug: 40 mm.
4. Wire stopper (spanner wrench).
5. Folding rule.
6. Solinst 102 P10-level water meter, with light and sound indicator.

Basic sensor data of the Mini-Diver® are given in Table 2-5.

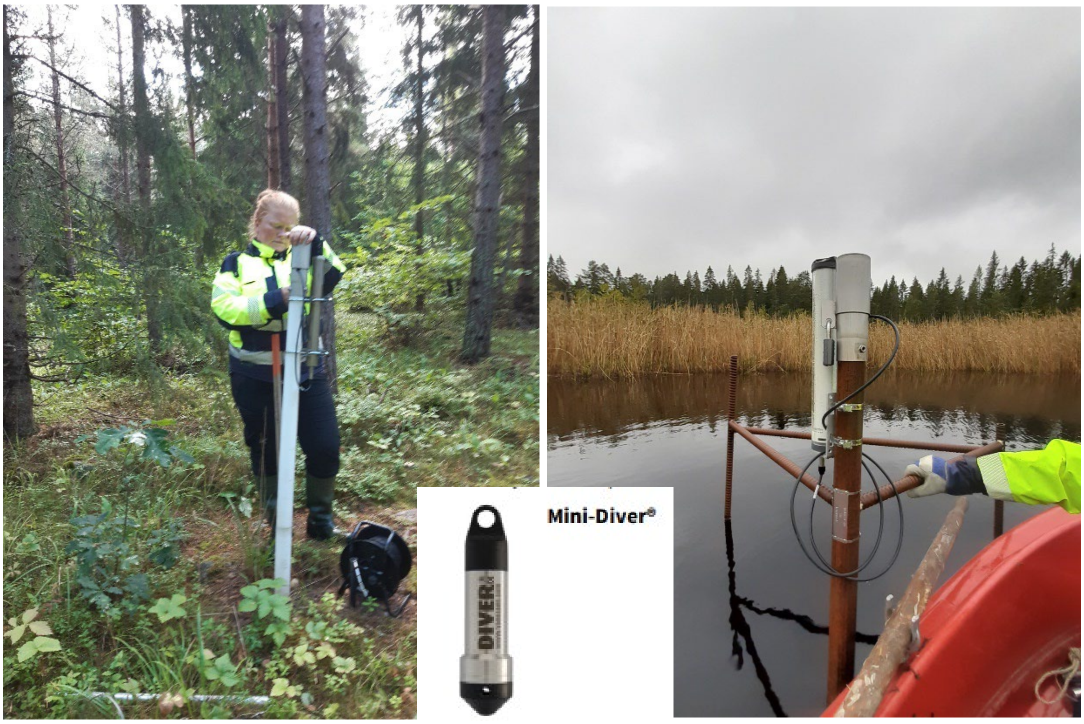

Figure 2-1 *Two types of locations of groundwater monitoring wells; SFM000181 installed in forest (left), and SFM000184 with the well screen installed in regolith the bottom of a pond (right). A Mini-Diver pressure transducer (insert) was used to record changes in the pressure head over time.*

Table 2-5 Sensor data for the Mini-Diver®.

Sensor parameter		Unit	Value/range
Pressure	Measurement range	Water column (cm)	0 to 1,000
	Resolution	Water column (cm)	0.2
	Accuracy	% of measurement range	± 0.5
Temperature	Measurement range	°C	-20 to +80
	Resolution	°C	0.01
	Accuracy	°C	±0.1

The Mini-Diver® has a built-in pressure transducer with a resistor bridge for absolute pressure measurements, and a semiconductor sensor for temperature measurements. The temperature is used to automatically compensate water depth (height of water column including atmosphere) measurements for temperature effects.

3 Performance of slug tests

The work was performed according to SKB’s method description and activity plan (see Table 1-1). Most tested wells are located on land, and wells located in ponds were tested from a boat (Figure 2-1).

3.1 Preparations

Before the tests, all clocks were synchronized to Swedish local time (GMT +1). The water level meter had previously been calibrated according to SKB standard. All equipment to be lowered into wells was cleaned before start of fieldwork and between tests. Pressure transducers were programmed with a measurement/saving interval of 1 second.

3.2 Test principle

The principle of a slug test is to initiate an instantaneous displacement of the water level in a well by inserting or removing a slug of known volume, and then observe the following recovery of the water level as a function of time. A slug test can be performed by causing a sudden rise of the water level (commonly referred to as a falling-head test), or a sudden fall of the water level (commonly referred to as a rising-head test). In all wells investigated as part of this study, both falling-head and rising-head tests were performed in sequence.

In order to obtain reliable values of transmissivity, it is necessary that the test lasts for a sufficiently long time. The concept of "sufficiently long time" means that a slug test must last until < 10 % of the level disturbance has recovered. In low-conductivity regolith this recovery cannot always be achieved from a practical perspective, which is why the measurement must continue until < 40 % of the level disturbance has recovered (Morosini and Hansson, 2020).

3.2.1 Falling-head test

A falling-head test is performed by first lowering the Mini-Diver® into the well. The Mini-Diver® causes a small displacement of the water level, so the test begins after the water level has recovered from the initial (small) disturbance. Water-level depths were measured manually using a Solinst 102 P10-level water meter. When the water level is fully recovered the slug is rapidly lowered into the well, causing a sudden rise of the water level. During the following recovery, the Mini-Diver® measures the absolute pressure every second. Once the water level is fully recovered, or when sufficient time has elapsed, the rising-head test commences.

3.2.2 Rising-head test

The performance of a rising-head test follows the same principle as a falling-head test. In this case, the slug is rapidly withdrawn from the well, causing a sudden drop of the water level. As the water level recovers, the Mini-Diver® measures the absolute pressure every second until the water level is fully recovered, or when sufficient time has elapsed.

3.3 Test procedure

The employed test procedure follows the method description (Table 1-1), and can be summarised as follows:

1. Measurement of groundwater level from ToC (top of casing).
2. Measurement of depth from ToC to well bottom.
3. Determination of placing depth of the Mini-Diver®, slug and wire lengths. The Diver is positioned such that it will be well below the bottom of the slug once it is inserted into the well.
4. Setting up the Mini-Diver® with 1 s measurement/saving interval.

5. Lowering the Mini-Diver® into the well. As the Mini-Diver® is constantly measuring, the air pressure (in m water column) before the test is logged, thereby the Diver depth from the undisturbed water level in the well was measured by deducting air pressure.
6. Lowering the slug quickly but smoothly, and then quickly make a manual measurement of the water level from ToC.
7. Waiting for at least 90 % water level recovery, measured using the manual water level meter.
8. When the recovery is satisfactory (i.e. > 90 % recovery), the slug is quickly but smoothly pulled out from the well, and then a manual measurement of water level from ToC is quickly performed.
9. Waiting for at least 90 % recovery, measured using the manual water-level meter.

3.4 Data handling

Raw data from the pressure transducer (*.csv; comma-separated format) were transferred optically to a portable PC using the software Diver-Office Version 1.507. Raw data were processed in Microsoft Excel® and saved in *.xlsx format. Data processing included the following:

1) If necessary, compensation for changes in pressure during the test by subtraction of air pressure from the Mini-Diver® readings in air before submerging it in water.
2) Identification of the exact start and end time, respectively, of each test phase (falling-head test, rising-head test). The timings are identified by plotting the data from the Mini-Diver®.
3) Normalising of pressure head data, met with a value of 1 representing maximum displacement and 0 representing the water level at the end of each recovery period.
4) Field notes of timing for different events during each test (Diver in, slug in, slug out and Diver out) were used to identify timings of pressure changes of relevance for the subsequent slug test response analyses.

4 Analyses of slug test responses

The Cooper-Bredehoeft-Papadopulos (Cooper et al. 1967) and Hvorslev (2002) methods were mainly used to analyse slug test responses. The Cooper-Bredehoeft-Papadopulos method was originally developed for fully penetrating wells in confined aquifers. By replacing the formation thickness by the effective screen length, the method may be applied also to partially penetrating wells. Hvorslev method is for fully or partially penetrating well in a confined or unconfined aquifer of an assumed infinite extent. Apart from these methods, wells with their screen installed in areas with unconfined aquifer conditions (SFM000174, SFM000187 and SFM000188) were also evaluated using the Bouwer and Rice method (Bouwer and Rice 1976). The Bouwer and Rice method is applicable for slug tests in fully or partially penetrating wells in an unconfined or leaky confined aquifer of apparently infinite extent. The Bouwer and Rice method (see Section 4.1.3) involves fitting a straight-line to a plot of the logarithm of the normalized displacement data versus time. This method of curve-fitting often involves a large degree of uncertainty. Therefore, the Bouwer and Rice method was applied only for evaluation of tests with the highest quality of data in order to reduce the uncertainty of the results. For the slug test response analyses, water level data were matched to type curves using both manual and automatic curve-fitting.

In some cases, the measured initial displacement for few datapoints are larger than the theoretical maximum initial displacement calculated from the volume of the slug. In other cases, there were few initial data (points) representing much higher initial displacement than the theoretical; such data (points) were ignored prior to data analysis. With slug tests, it is desirable to be able to determine the transmissivity (T) in the approximate range 10^{-7}–10^{-4} m^2/s (SKB MD 325.001).

4.1 Slug test response analysis methods

4.1.1 Cooper-Bredehoeft-Papadopulos

The Cooper-Bredehoeft-Papadopulos method is designed to estimate the transmissivity T (m^2/s) and the storativity S (m^3/m^3) of an aquifer (Cooper et al. 1967). The method was originally developed for fully penetrating wells in confined aquifers. By replacing the formation thickness by the effective screen length (the saturated part of the screen), the method may be applied also to partly penetrating wells. If a close match can be obtained with a type curve applying a physically plausible α (Todd 1980), the method can also be applied in unconfined aquifers (Butler 1998). The Cooper et al. method is recommended as “the first choice” method by Butler (1998).

In the method, a plot of the normalized displacement versus the logarithm of β, defined as

$$\boldsymbol{\beta = Tt/\,r_c^2} \qquad \textit{Equation 4-1}$$

where t (sec) and r_c (m) being time since start of the slug test and the inner radius of the stand pipe, respectively, forms a series of type curves for different values of the parameter α (Cooper et al. 1967), defined as

$$\boldsymbol{\alpha = \frac{r_w^2 S}{r_c^2}} \qquad \textit{Equation 4-2}$$

where r_w (m) is the well radius. The method involves manual fitting of a curve for a particular α ($\alpha = 10^{-1}$ to 10^{-5}) to the measured data. The theory of the method and practical recommendations for its application are given in Cooper et al. (1967). Evaluations of response data from all slug tests were performed using the AQTESOLV® ver. 4.5 software (Duffield 2007). A list of parameters used in analyses of falling-head tests are shown in Table *2-4*.

In the Cooper et al. method, the sensitivity of the evaluated transmissivity T to the curve-fitting procedure is relatively small compared to the corresponding sensitivity of evaluated S (Cooper et al. 1967). Hence, the values of S that are obtained by the Cooper et al. method are relatively uncertain, compared to obtained T values.

4.1.2 Hvorslev method

The Hvorslev method is designed to estimate the hydraulic conductivity of an aquifer (Hvorslev 1951). The method assumes a fully or partially penetrating well in a confined or unconfined aquifer of apparently infinite extent hence the storage is neglected. In the Hvorslev method, a straight-line is fitted to a plot of the logarithm of the normalized displacement data versus time. According to Hvorslev (1951), the flow rate q (m/s) at time t (sec) is related to the hydraulic conductivity K (m/s) and to the unrecovered pressure head difference H – h (m) at time t (H = reference pressure head, h = pressure head at time t) according to the following equation:

$$\boldsymbol{q(t) = \pi r^2 \frac{dh}{dt} = FK(H - h)} \qquad \textit{Equation 4-3}$$

In Equation 4-3, r (m) is the well radius and the shape parameter F (1/m) depends on the shape and dimensions of the well. As time t increases, the flow rate q will approach zero. The solution to Equation 4-3 is given as

$$\boldsymbol{H - h = (H - H_0)e^{-\frac{t}{T_0}}} \qquad \textit{Equation 4-4}$$

with the initial condition h = H_0 at t = 0 and in which the basic time lag T_0 is defined as

$$\boldsymbol{T_0 = \frac{\pi r^2}{FK}} \qquad \textit{Equation 4-5}$$

The natural logarithm of the normalized head recovery (H – h)/(H – H_0) versus time t will plot as a straight line. By assuming ideal measurement conditions in aquifer i.e. homogeneous, planar and cylinder-symmetric, the basic time lag T_0 can be defined from the plot being the time t, when ln (H – h)/(H – H0) = -1. The shape factor suggested by Hvorslev (1951) can be applied if L/R > 8 (L and R is the length and the inner radius, respectively, of the well screen). The shape factors in our cases are between 26 and 40 (in all the cases L/R > 8). The resulting equation for the hydraulic conductivity K then becomes

$$\boldsymbol{K = r^2 \frac{ln\frac{L}{R}}{2LT_0}} \qquad \textit{Equation 4-6}$$

4.1.3 Bouwer & Rice method

Similar to the Hvorslev method (Section 4.1.2), the Bouwer & Rice method (Bouwer and Rice 1976) is also designed to estimate the hydraulic conductivity K of an aquifer. The method assumes a fully or partially penetrating well in a confined or unconfined aquifer. The method implies that a straight-line plot of the logarithm of the ratio H/H_0 versus time t is fitted to the measured water level data. The theory of the Hvorslev method are given in Bouwer and Rice (1976) and in Butler (1998).

Bouwer and Rice (1976) developed an empirical relationship describing the water-level response in an unconfined aquifer due to the instantaneous injection or withdrawal of water from a well:

$$\boldsymbol{ln(H_0) - ln(H) = \frac{2K_r Lt}{r_{ce}^2\, ln\left({}^{R_e}/_{r_{we}}\right)}} \qquad \textit{Equation 4-7}$$

$$\boldsymbol{r_{ce} = \sqrt{(1 - n_e)r_c^2 + n_e r_w^2}} \qquad \textit{Equation 4-8}$$

$$\boldsymbol{r_{we} = r_w\sqrt{{}^{K_Z}/_{K_r}}} \qquad \textit{Equation 4-9}$$

where,

H is displacement (L) at time t

H_0 is initial displacement (L) at t = 0

K_r is radial (horizontal) hydraulic conductivity (L/T)

K_z is vertical hydraulic conductivity (L/T)

L is screen length (L)

n_e is effective porosity (specific yield) of the filter pack (-)

r_c is nominal casing radius (L)

r_w is well radius (L)

R_e is external or effective radius (L) of the test

t is elapsed time since initiation of the test

R_e/r_{we} in Equation 4-7 is an empirical quantity determined from the analogue model that accounts for well-aquifer geometry.

Note that r_w is typically taken as the borehole radius (i.e., extending to the outer radius of the filter pack) when the filter pack is expected to be more conductive than the aquifer. No correction to the casing radius is necessary when the screen is fully submerged below the water table or the aquifer is confined (Duffield 2007).

5 Results and discussion

5.1 Results

The results of the slug test response analyses are summarized in *Table 5-1*. The results of well depth measurements are presented in Table 2-2. Falling-head tests (FHT) were performed prior to rising-head tests (RHT). This implies less disturbed conditions for FHT, which therefore were chosen as "best choice" for data delivery to the Sicada database. Upper and lower limits of slug tests and aquifer conditions (confined/unconfined) are other criteria regarding "best choice" (for further details, see Appendix 2 and Appendix 3). Results from evaluations using the Bouwer and Rice method (*Table 5-2*) are not reported to Sicada.

Table 5-1 Summary of slug test response analyses. C-B-P = Cooper-Bredehoeft-Papadopulos method, H = Hvorslev method. T = transmissivity (m^2/s), K = hydraulic conductivity (m/s), S = storativity (-), FHT = falling-head test, RHT = rising-head test.

	K (calc. from T; C-B-P)	T, C-B-P		S from FHT (C-B-P)	K, H	
Well id	**FHT**	**FHT**	**RHT**		**FHT**	**RHT**
SFM0006	1.42E-05	1.42E-05	1.68E-05	2.21E-03	1.04E-05	1.28E-05
SFM0090	2.47E-06	6.18E-06	6.19E-05	6.50E-04	8.47E-06	2.56E-05
SFM0109	4.24E-04	4.24E-04*	4.24E-04*	1.00E-01	1.57E-04	1.57E-04
SFM000169	2.40E-05	2.40E-05	1.24E-04*	2.24E-06	1.46E-05	4.72E-05
SFM000171	1.17E-06	1.17E-06	1.33E-06	1.43E-03	2.13E-06	4.61E-06
SFM000174	7.55E-08	7.55E-08**	8.64E-07	1.00E-01	5.33E-07	4.03E-07
SFM000176	7.54E-06	7.54E-06	2.55E-05	3.16E-05	9.62E-06	1.29E-05
SFM000177	6.28E-07	6.28E-07	9.98E-06	3.73E-02	1.33E-06	3.94E-06
SFM000179	1.68E-05	1.68E-05	2.49E-04*	1.00E-01	3.00E-06	6.15E-05
SFM000180	3.22E-07	3.22E-07	3.89E-06	7.32E-07	1.58E-07	9.32E-07
SFM000182	4.19E-07	4.19E-07	3.58E-07	1.00E-10	1.57E-07	3.22E-07
SFM000183	8.14E-08	8.14E-08**	4.76E-07	1.59E-02	1.83E-07	2.12E-07
SFM000187	7.76E-05	7.76E-05	8.32E-05	1.00E-10	4.07E-05	3.31E-05
SFM000188	3.06E-05	3.06E-05	8.39E-05	1.72E-02	5.06E-05	6.67E-05
SFM000190	1.97E-07	1.97E-07	6.40E-06	1.91E-02	4.30E-07	1.34E-06
SFM000191	4.96E-07	4.96E-07	3.46E-06	6.16E-02	1.31E-06	3.09E-06
SFM000192	2.01E-06	2.01E-06	7.54E-06	1.17E-02	2.59E-06	2.43E-06
SFM000193	1.01E-07	1.01E-07	7.11E-07	1.00E-01	1.31E-07	1.70E-06
SFM000194	8.62E-04	8.62E-04*	6.74E-04*	1.00E-10	4.40E-04	5.06E-04
SFM000195	1.24E-06	1.24E-06	3.58E-06	1.89E-03	1.04E-06	1.20E-06
SFM000197	7.62E-07	7.62E-07	1.61E-06	4.37E-02	1.80E-06	2.36E-06
SFM000198	3.04E-07	3.04E-07	2.40E-06	6.65E-03	4.02E-07	6.91E-07

* Above upper limit for slug tests (1E-04).
** Below lower limit for slug tests (1E-07).

Table 5-2 Results from slug test responses analyses using the Bouwer and Rice method.

Well id	**K (Bouwer and Rice)**	
	FHT	**RHT**
SFM000174	3.04E-07	2.47E-07
SFM000187	3.49E-05	8.24E-05
SFM000188	7.27E-06	2.52E-05

5.2 Discussion

In summer 2021 slug tests were performed in 27 groundwater monitoring wells in Forsmark. Slug test responses could be analysed for 22 wells, whereas the responses in the remaining five wells (SFM000102, -103, -175, -181 and -196) were not possible to analyse since they gave erroneous responses. This may be an indication of poor well function, and the function of these wells hence need to be investigated further. Well depth deviations were observed in the field and these also need to be investigated further.

Hydraulic properties were evaluated using the methods of Cooper et al., Hvorslev and Bouwer and Rice. The evaluation software AQTESOLV was used for all analyses.

Sources of uncertainty varies from difficulty in predicting the thickness of the aquifer, possible screen clogging, well functions, difficulty in determining whether confined or unconfined conditions prevailed, the heterogeneity of the soil etc. One suggestion is to clean the mentioned five well screens (e.g. by flushing or pumping), and then redo slug tests in these wells.

Transmissivity (T) values obtained using the Cooper et al. method correspond to hydraulic conductivities (K) of $1 \cdot 10^{-7}$–$8 \cdot 10^{-5}$ m/s. Some results are above or below limits of slug tests and are therefore not accounted for.

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Appendix 1

Drawings of slug tested wells

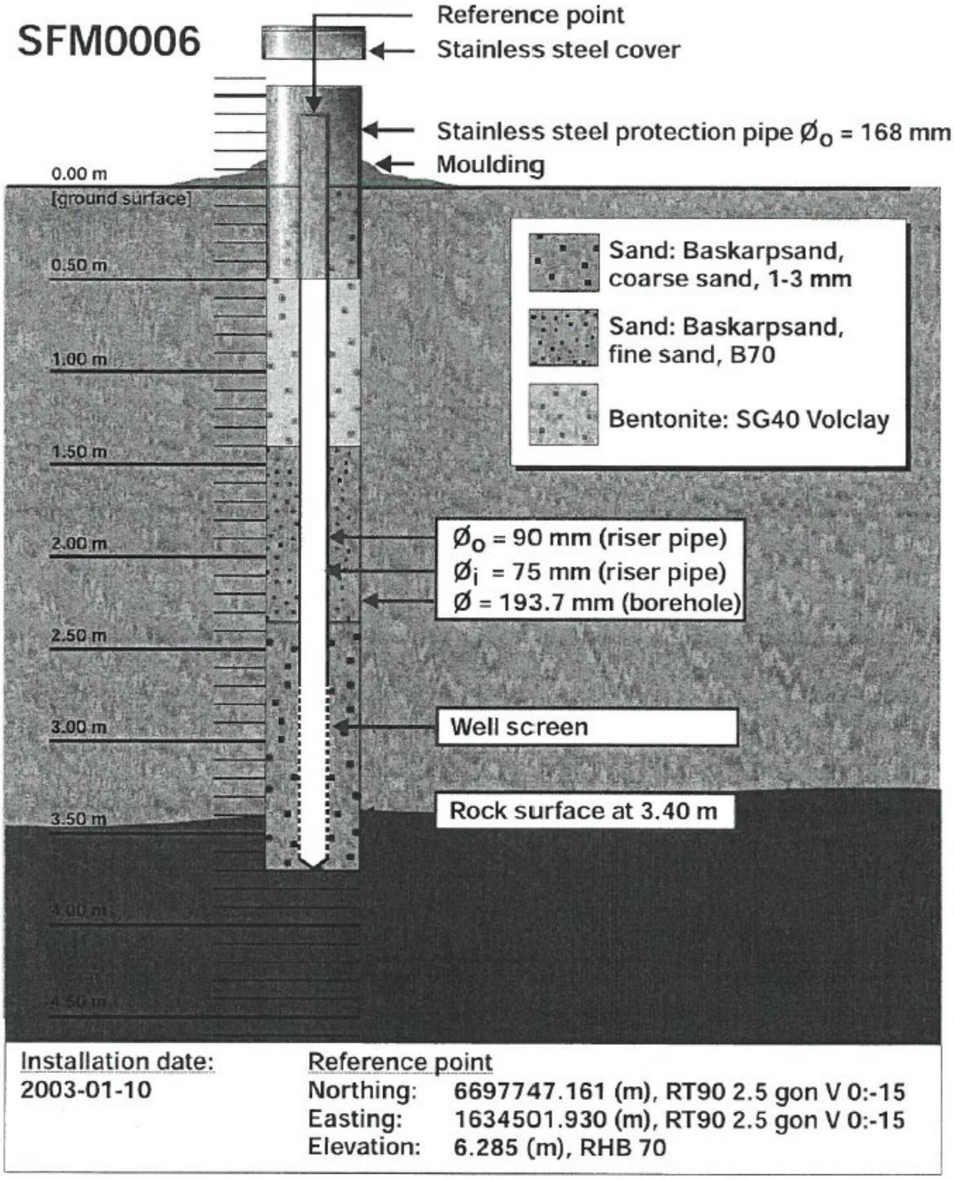


Figure A1-1 *Cross-section drawing of well SFM0006.*

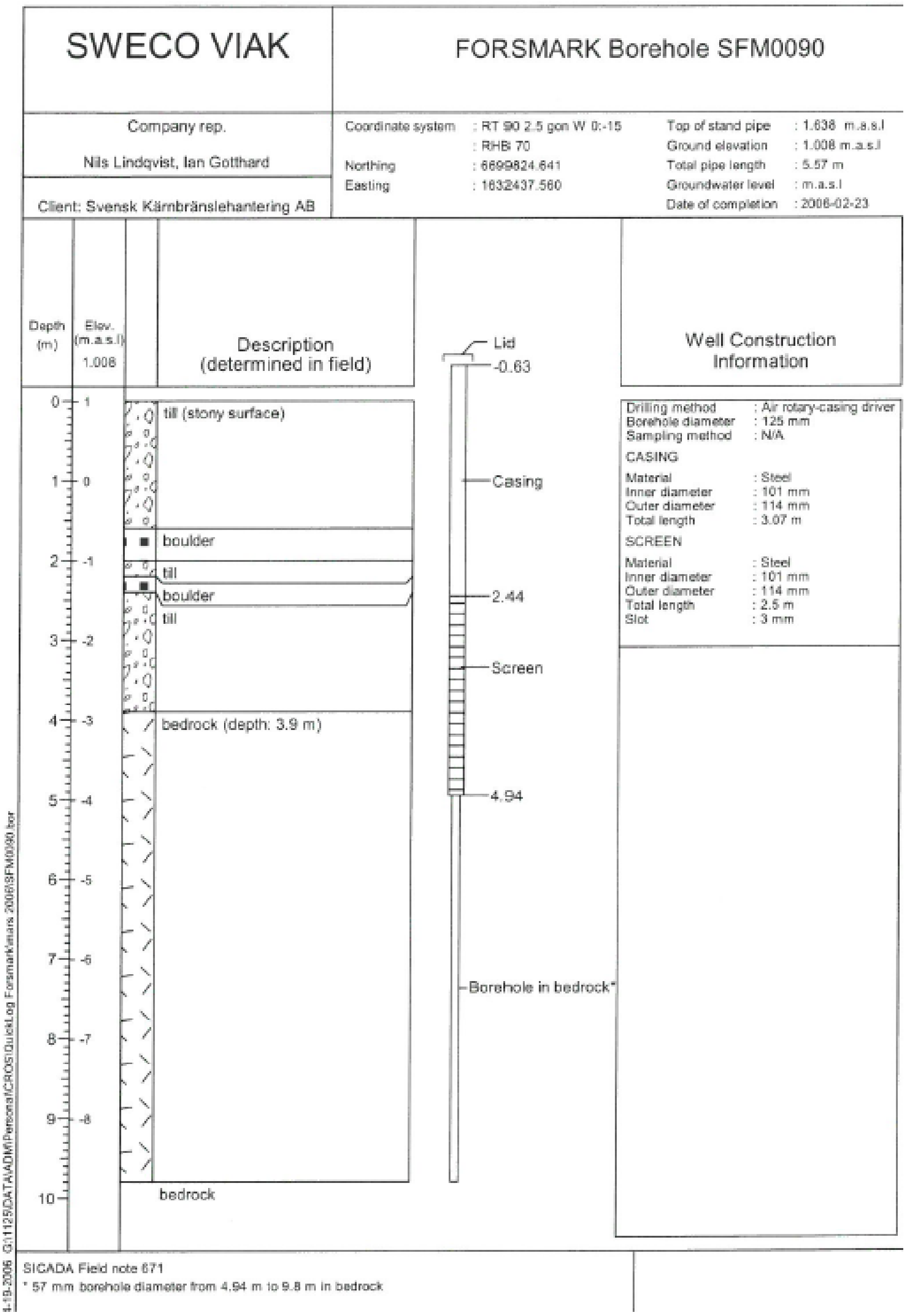


Figure A1-2 Cross-section drawing of well SFM0090.

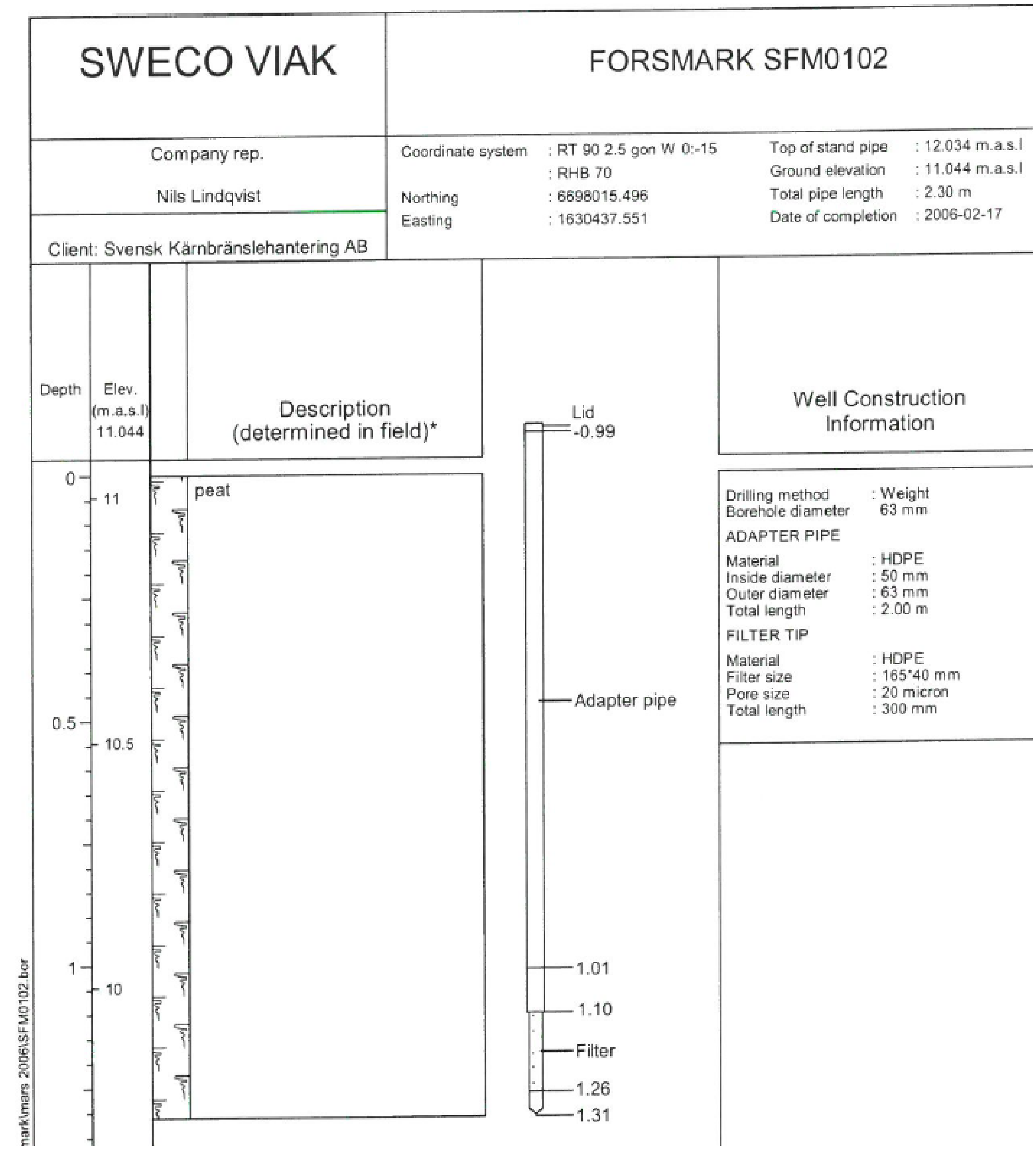


Figure A1-3 *Cross-section drawing of well SFM0102.*

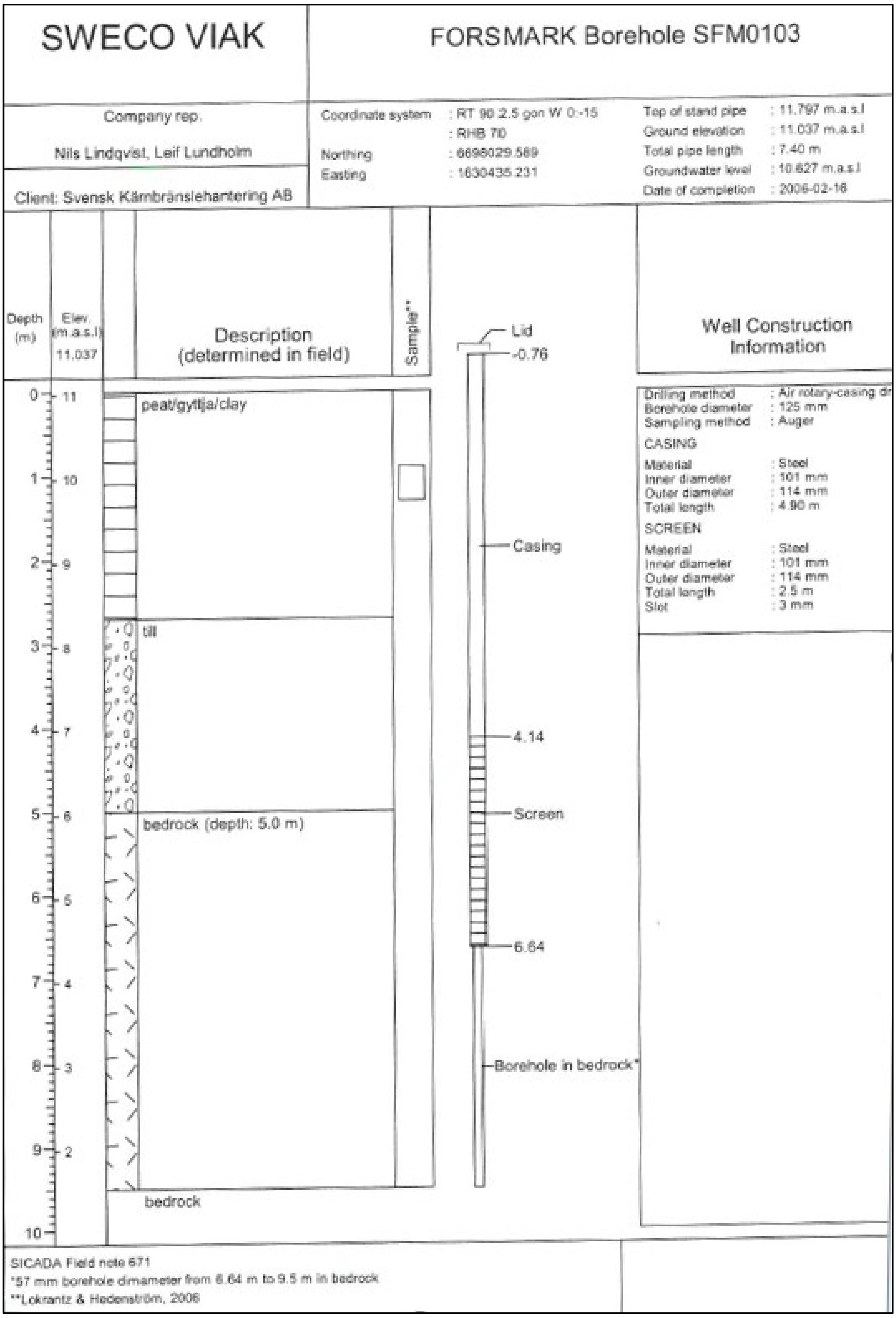


Figure A1-4 Cross-section drawing of well SFM0103.

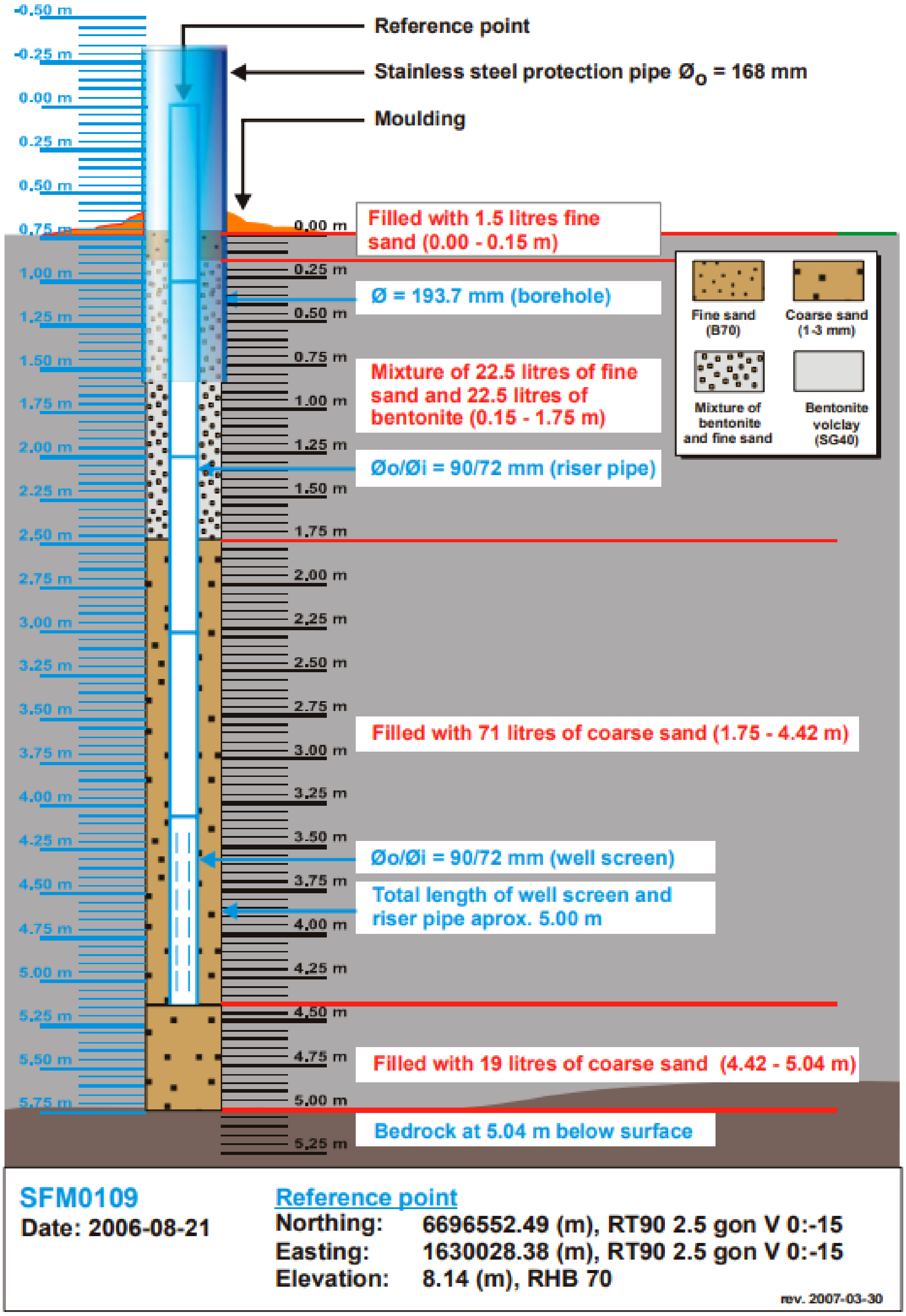


Figure A1-5 *Cross-section drawing of well SFM0109.*

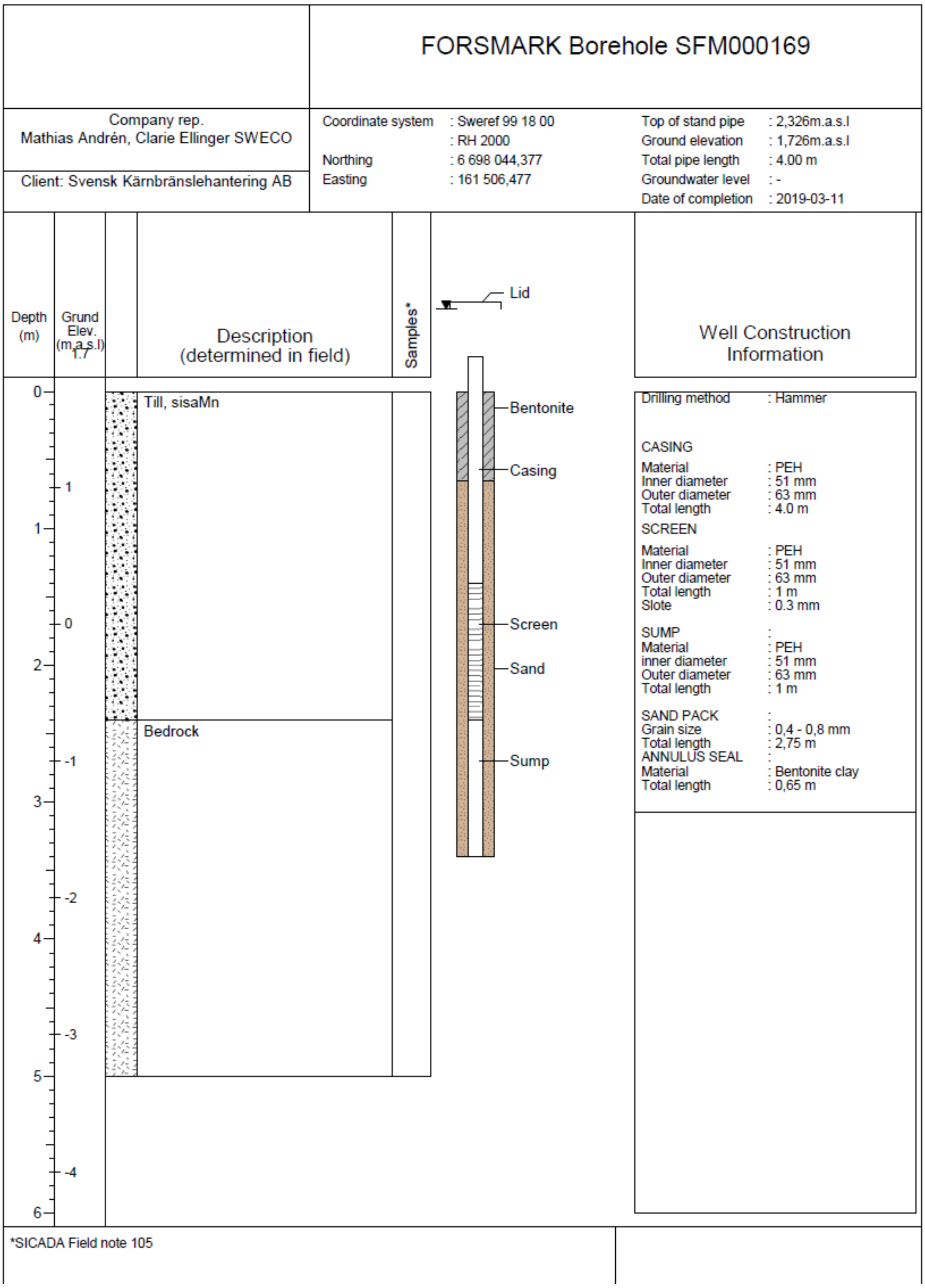


Figure A1-6 *Cross-section drawing of well SFM000169.*

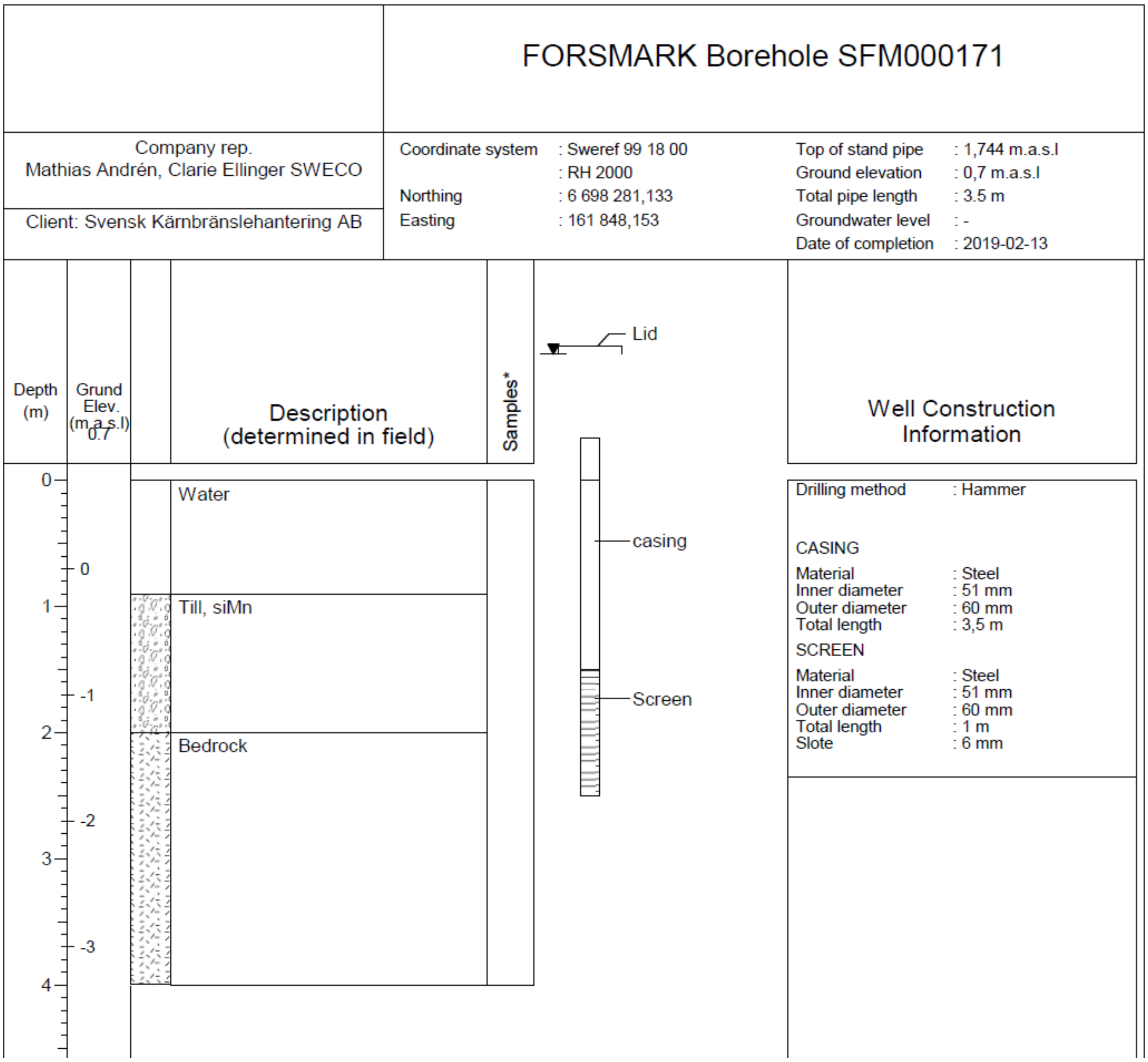


***Figure A1-7** Cross-section drawing of well SFM000171.*

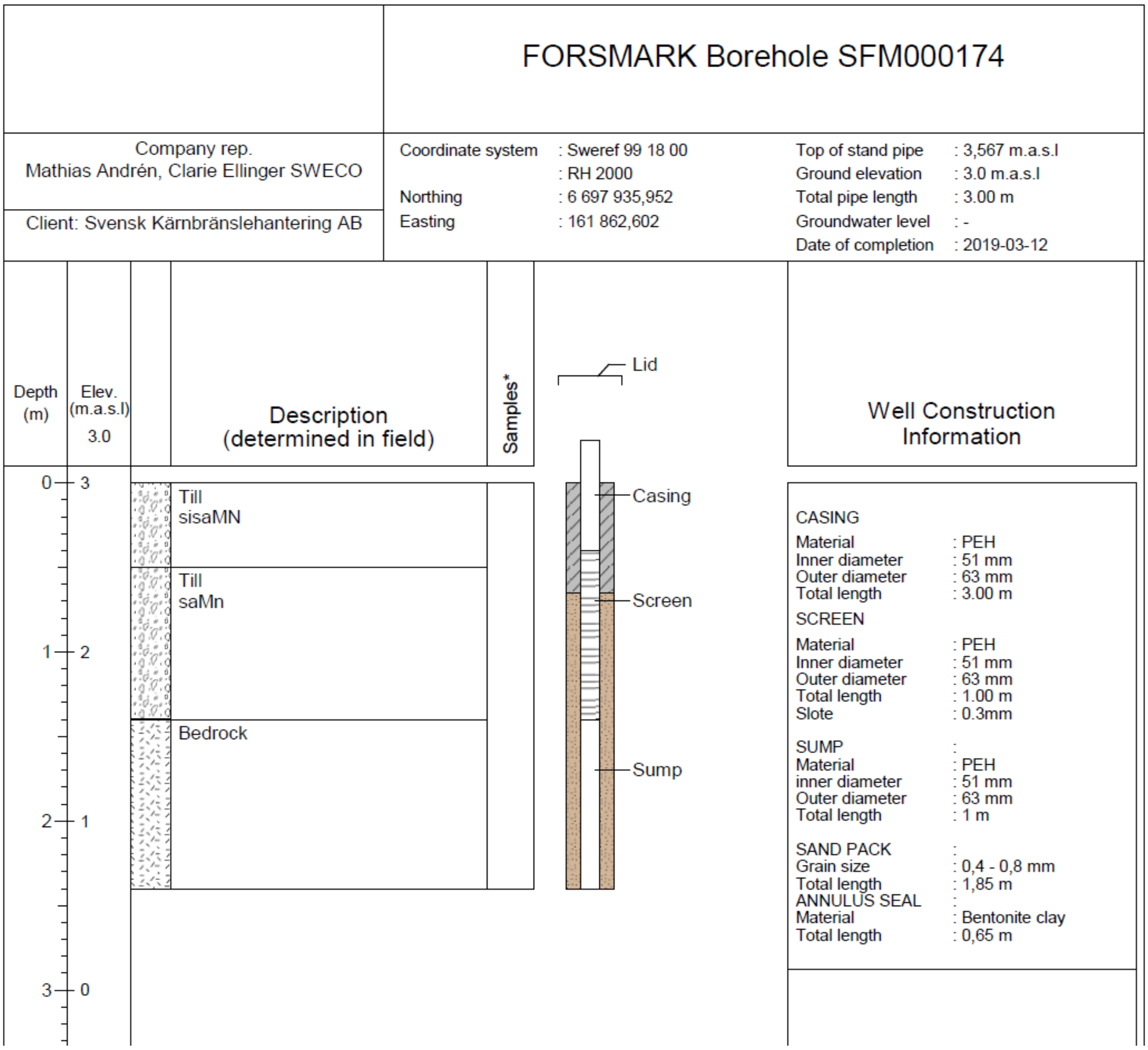


Figure A1-8 *Cross-section drawing of well SFM000174.*

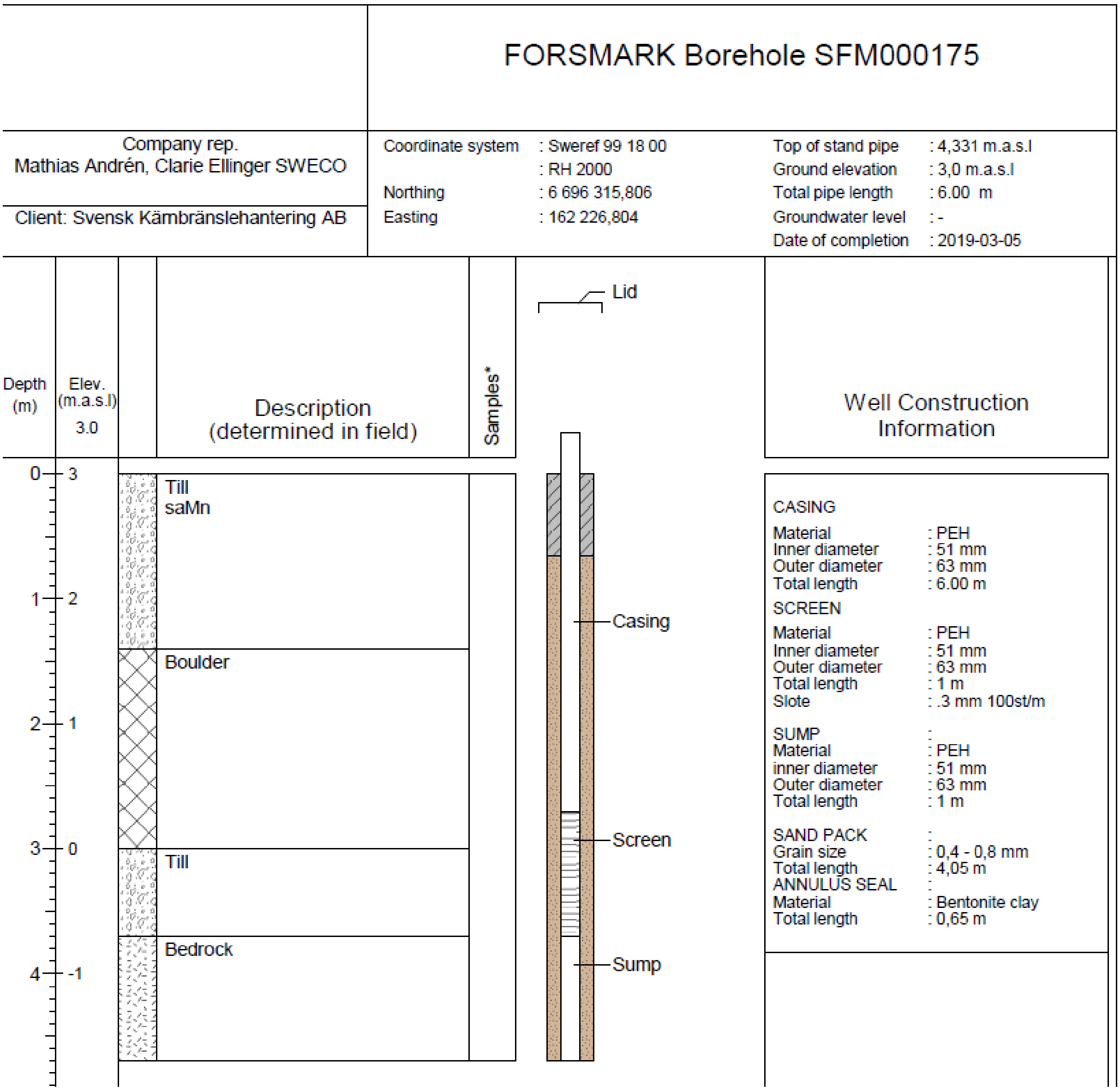


Figure A1-9 *Cross-section drawing of well SFM000175.*

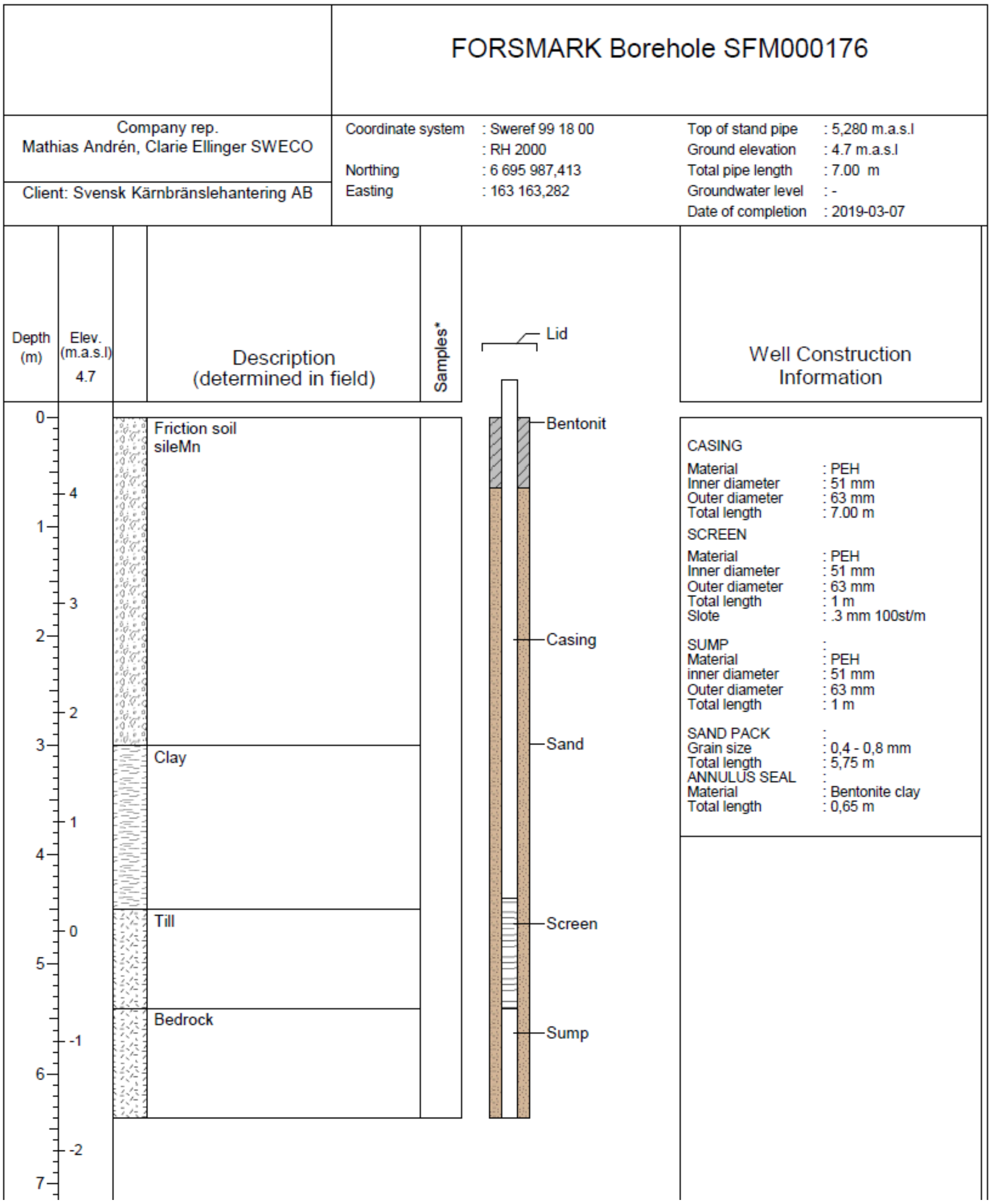


***Figure A1-10** Cross-section drawing of the well SFM000176.*

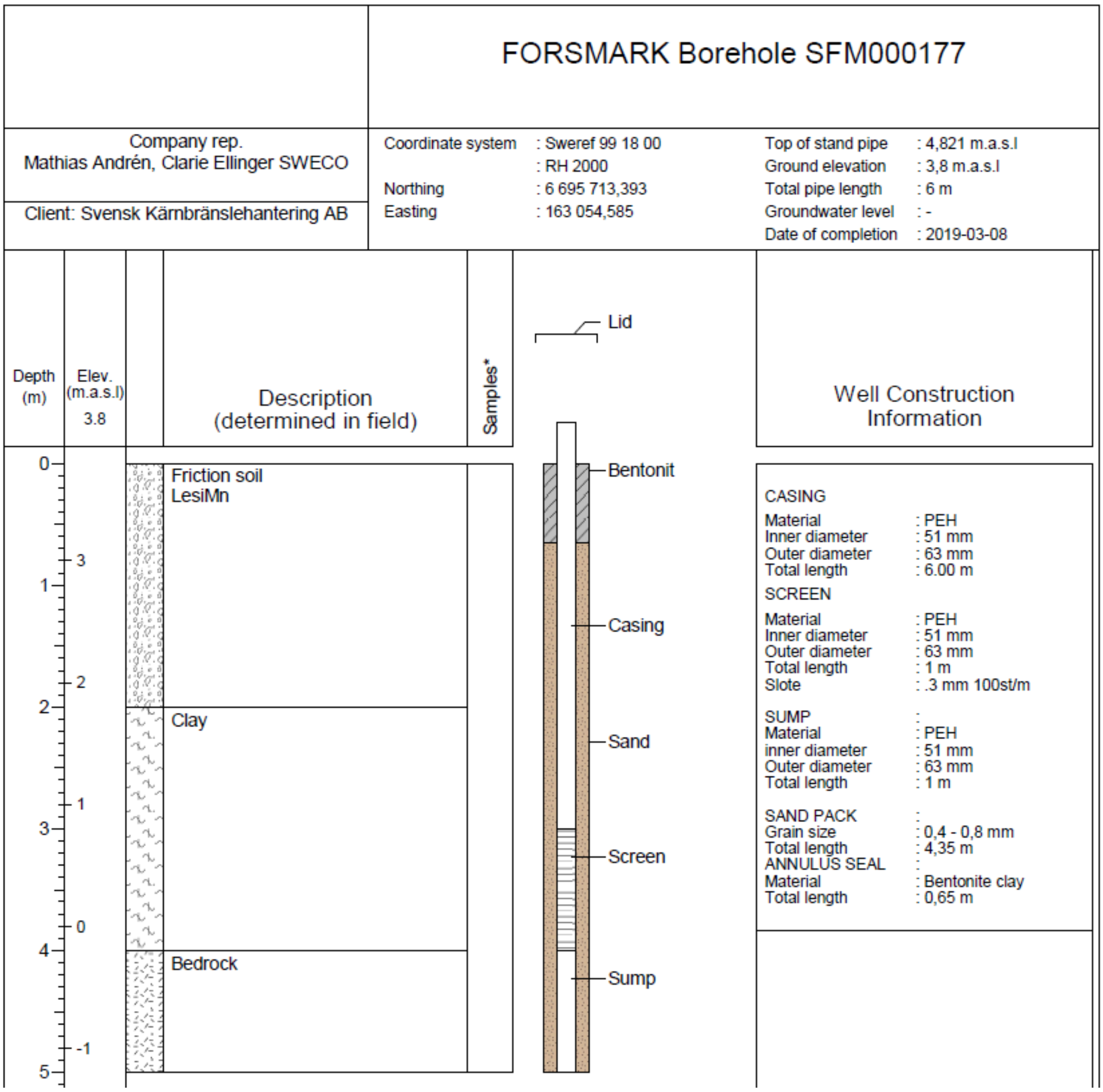


Figure A1-11 *Cross-section drawing of well SFM000177.*

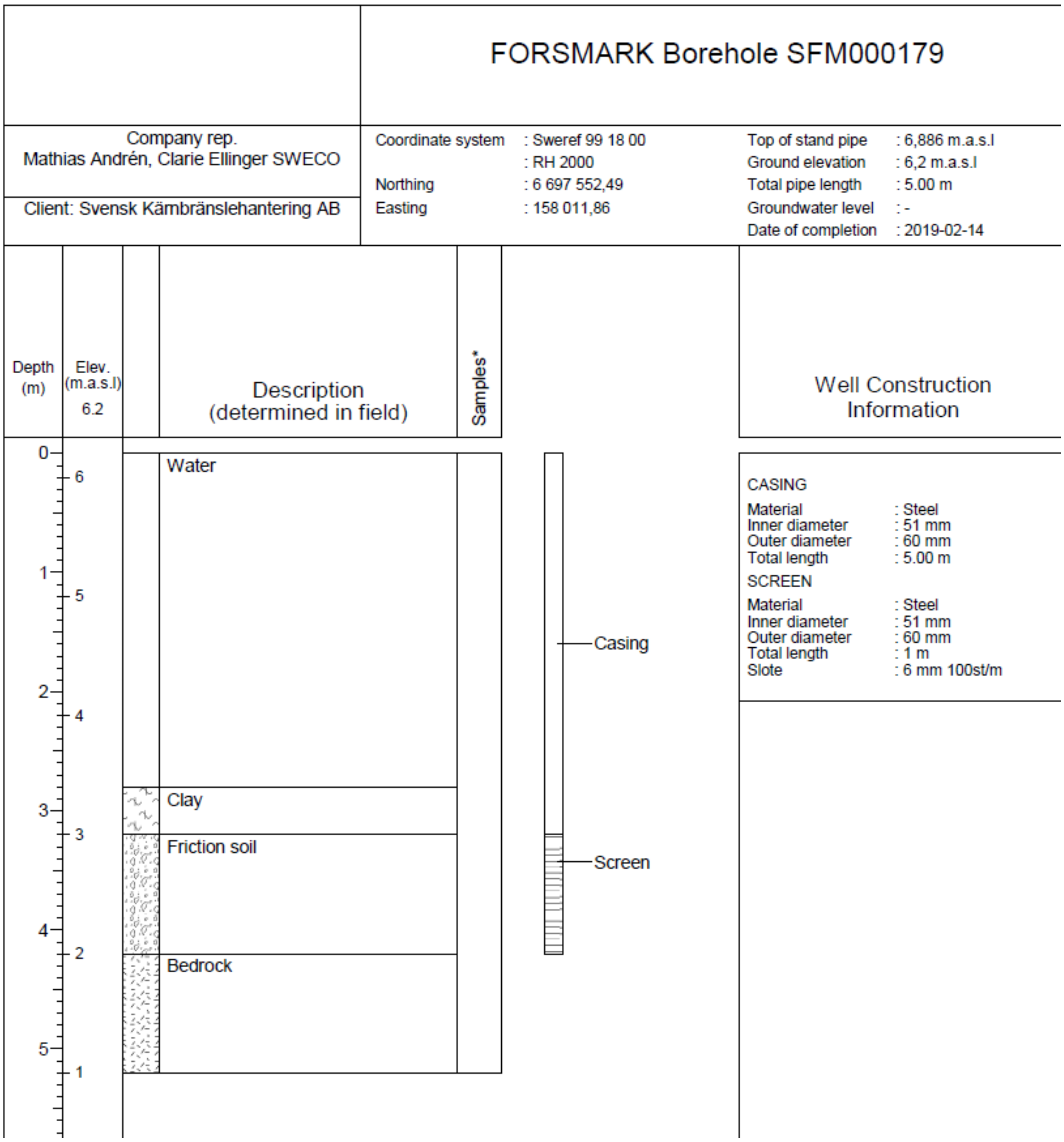


Figure A1-12 *Cross-section drawing of well SFM000179.*

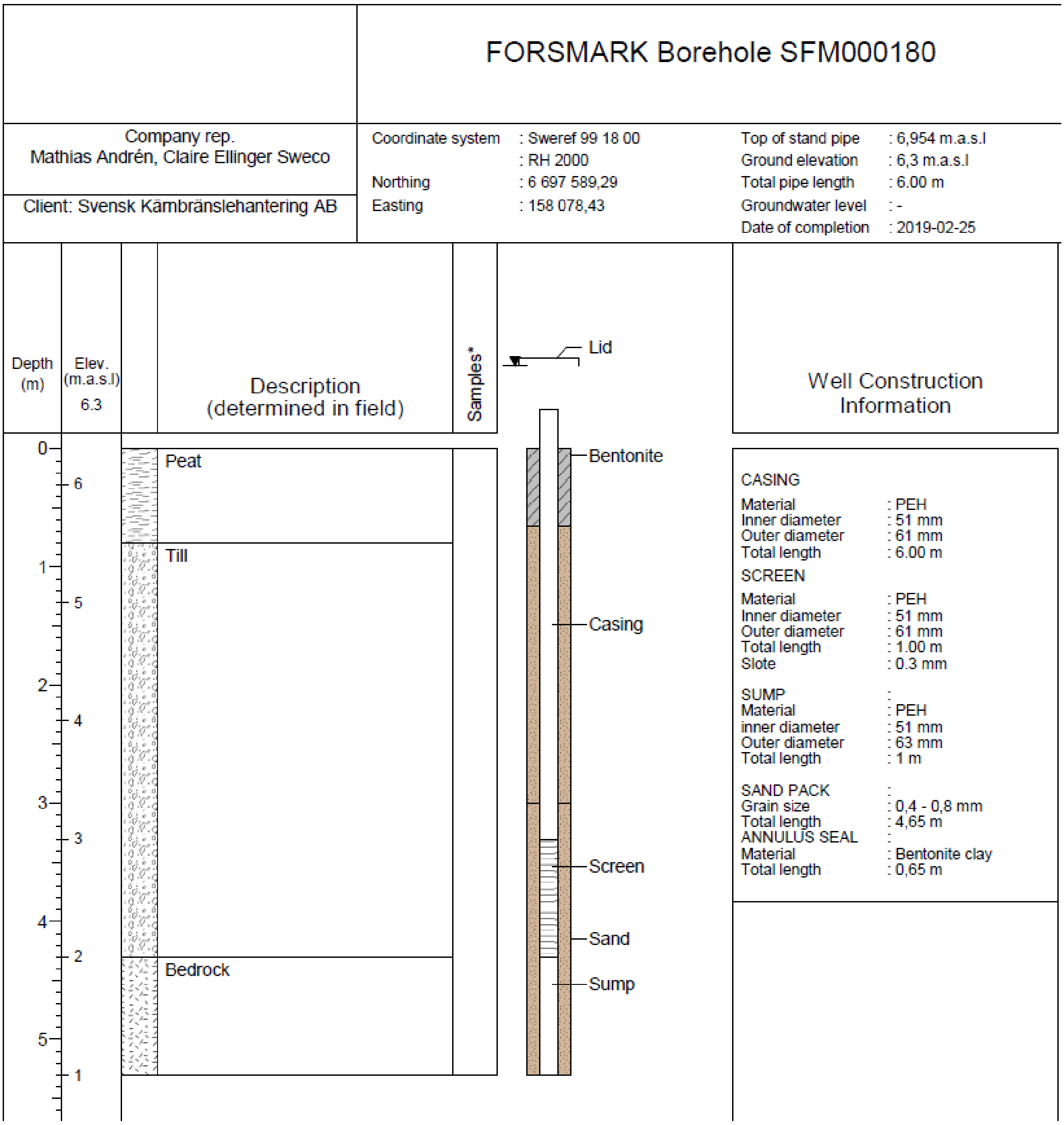


Figure A1-13 *Cross-section drawing of well SFM000180.*

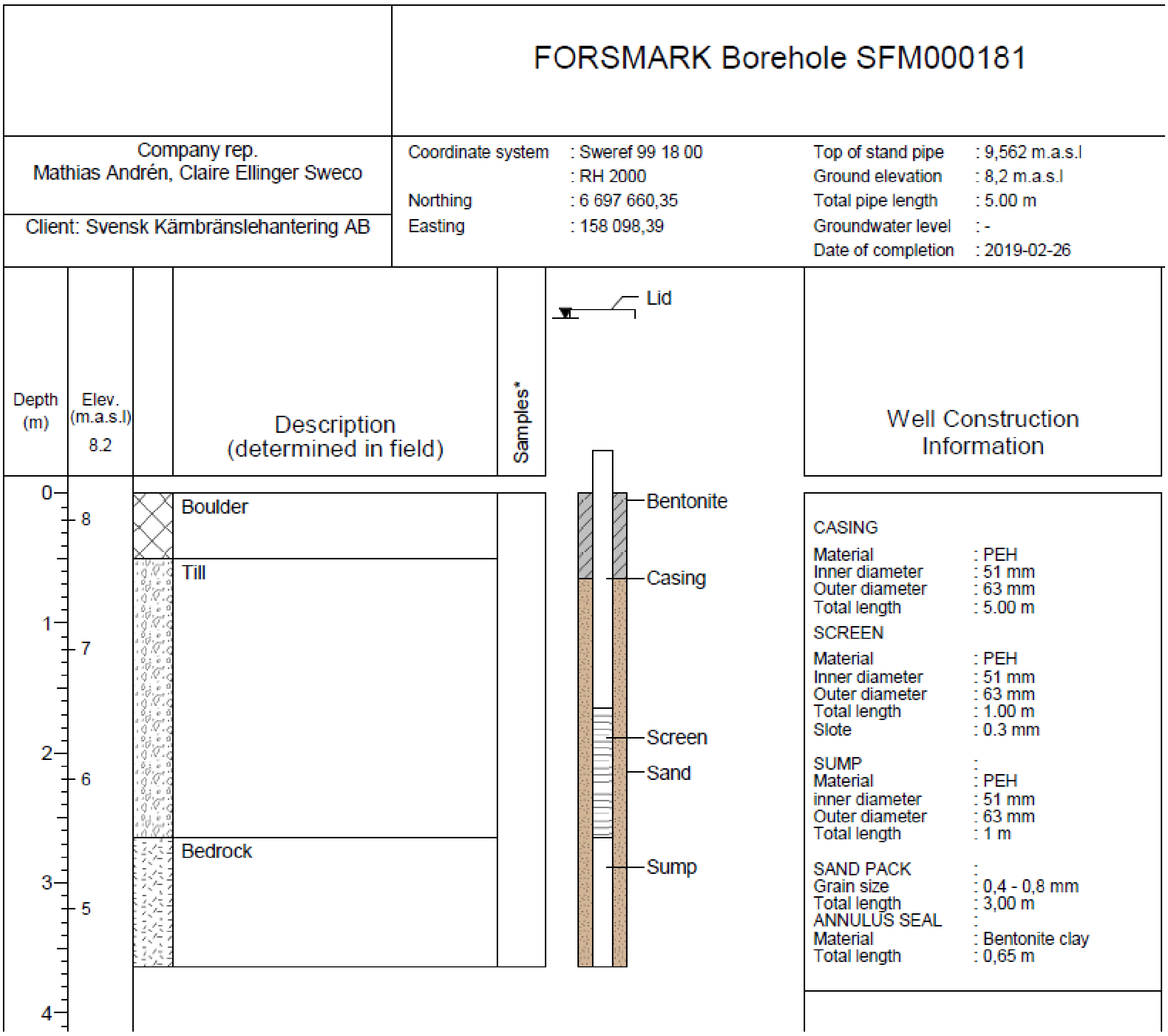


Figure A1-14 *Cross-section drawing of well SFM000181.*

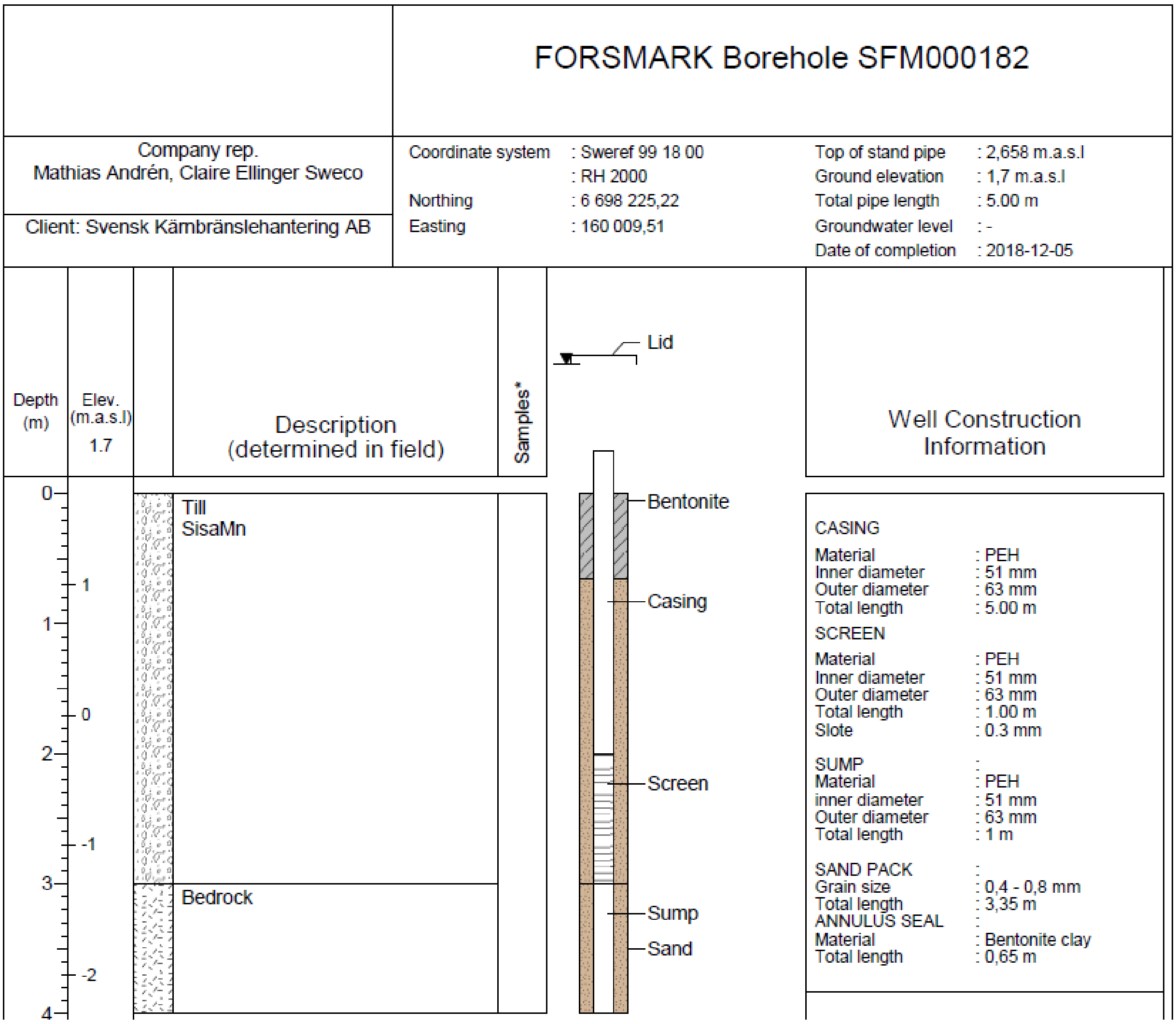


***Figure A1-15** Cross-section drawing of well SFM000182.*

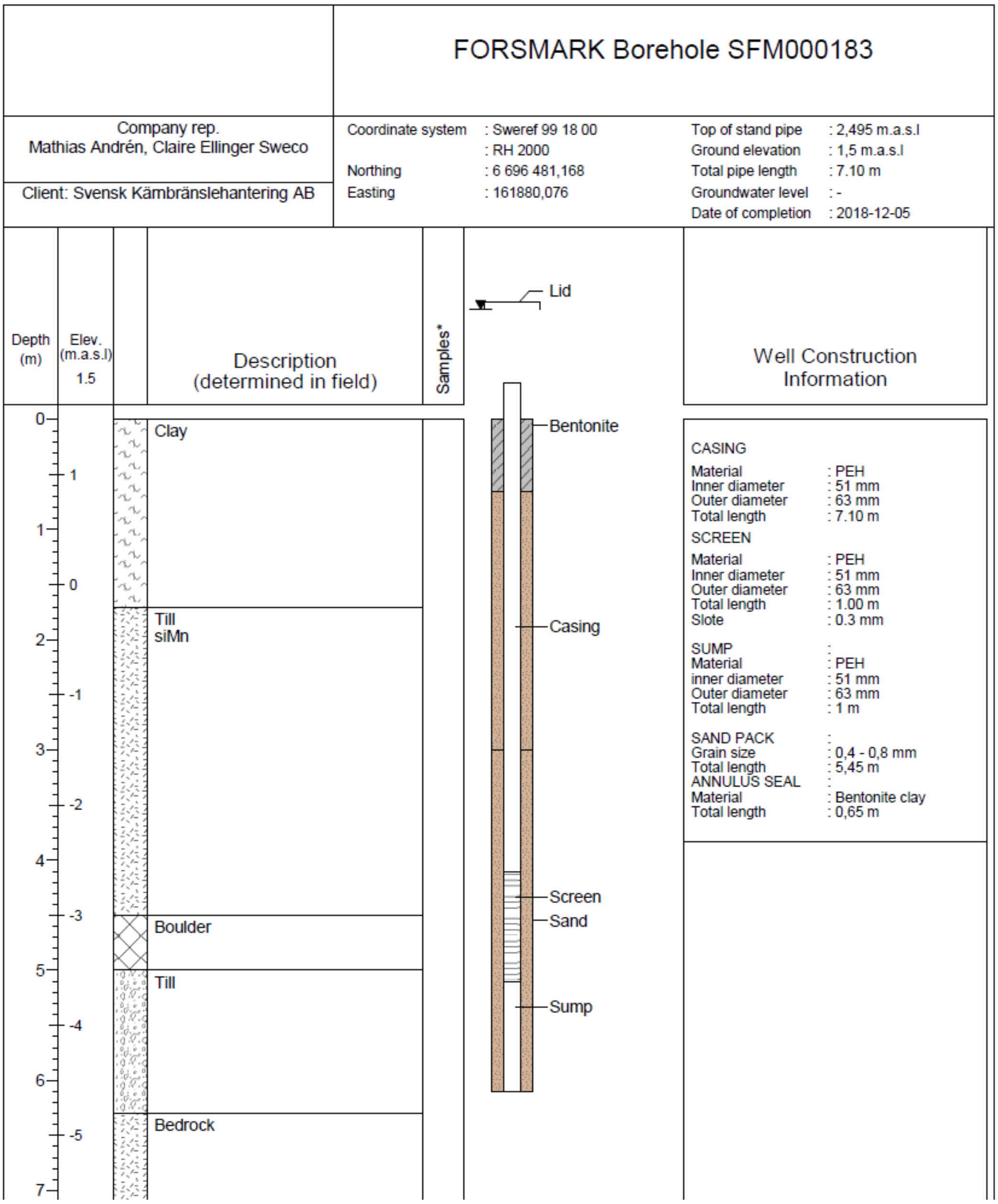


***Figure A1-16** Cross-section drawing of well SFM000183.*

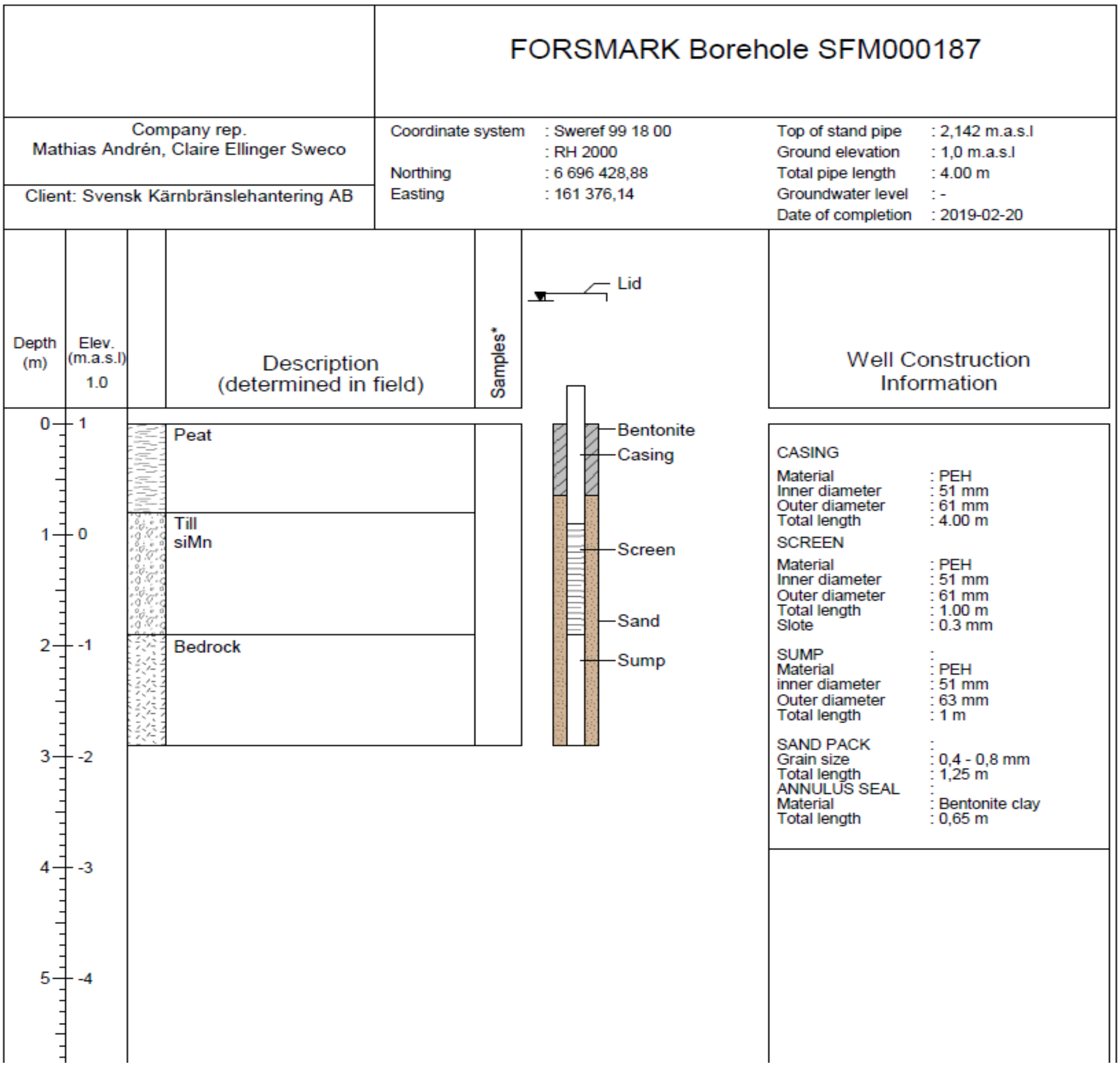


Figure A1-17 *Cross-section drawing of well SFM000187.*

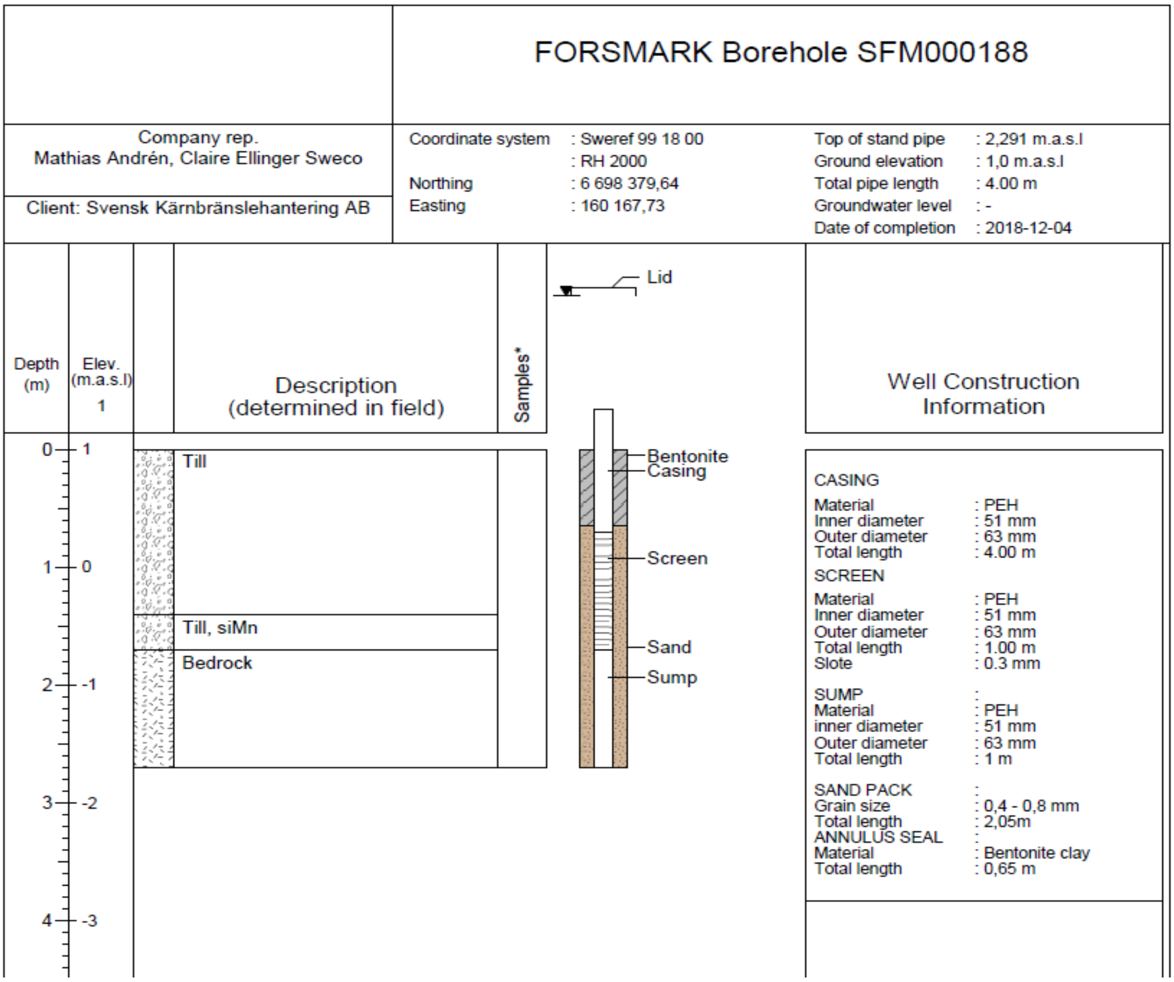


Figure A1-18 *Cross-section drawing of well SFM000188.*

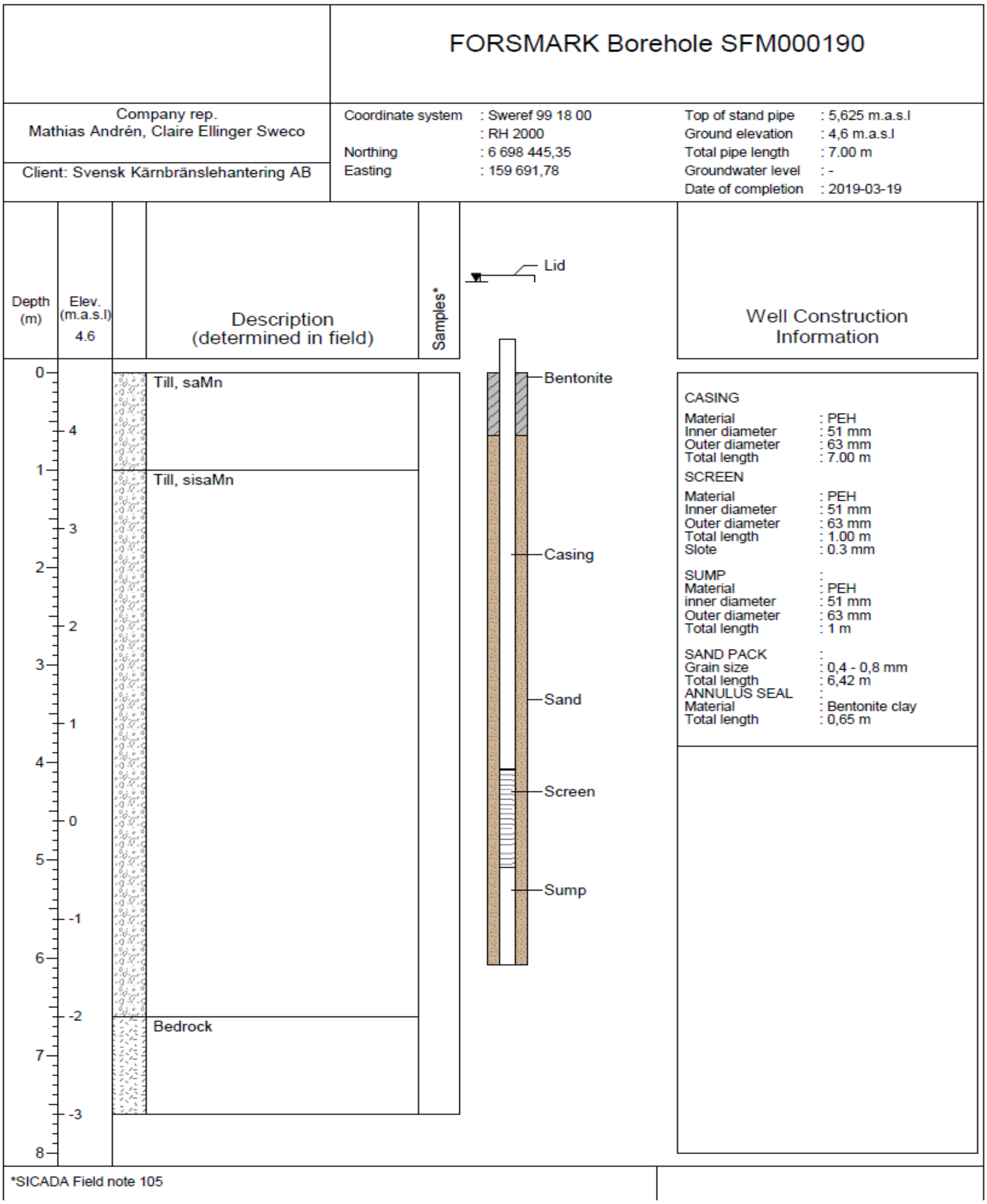


Figure A1-19 *Cross-section drawing of well SFM000190.*

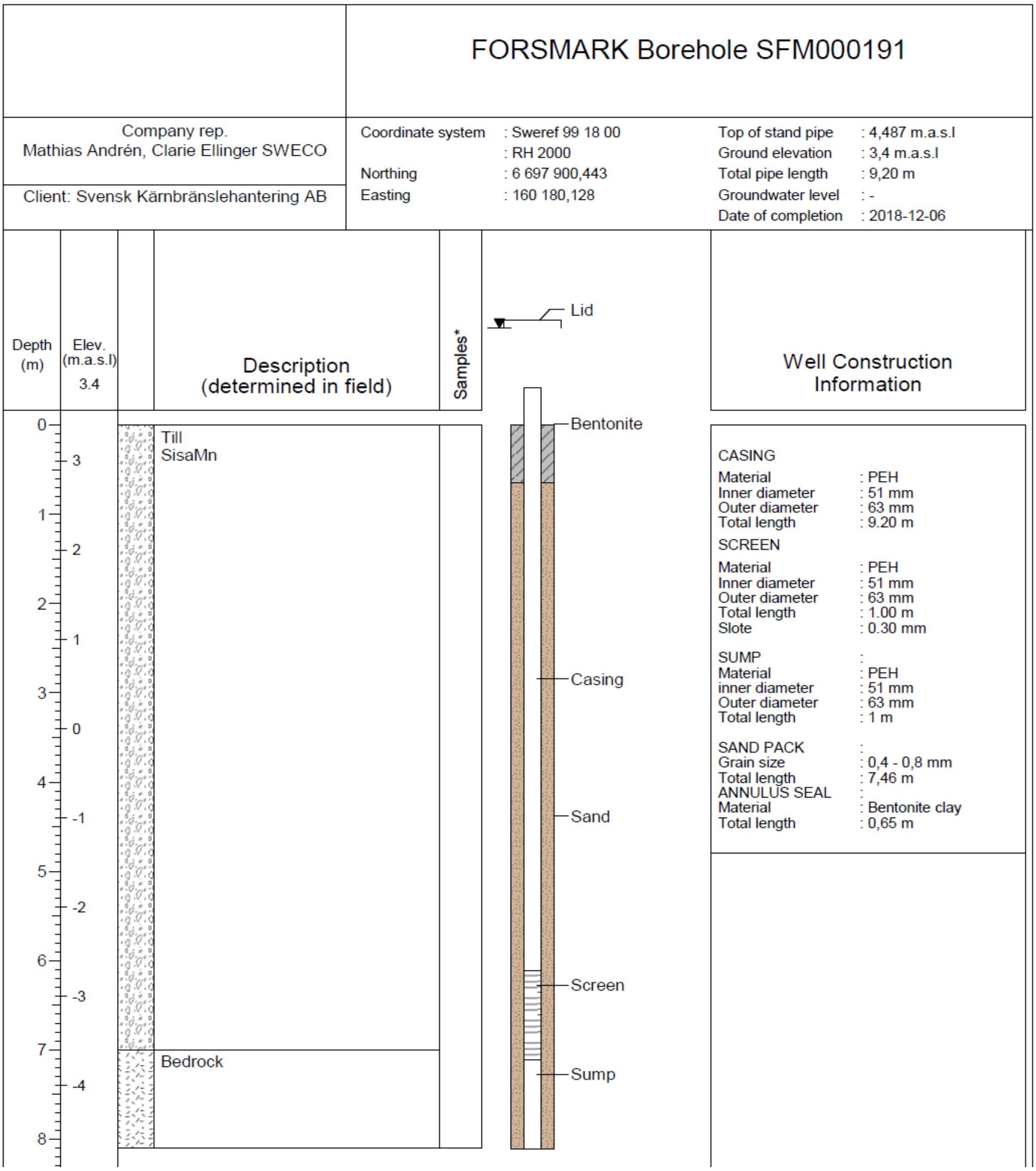


***Figure A1-20** Cross-section drawing of well SFM000191.*

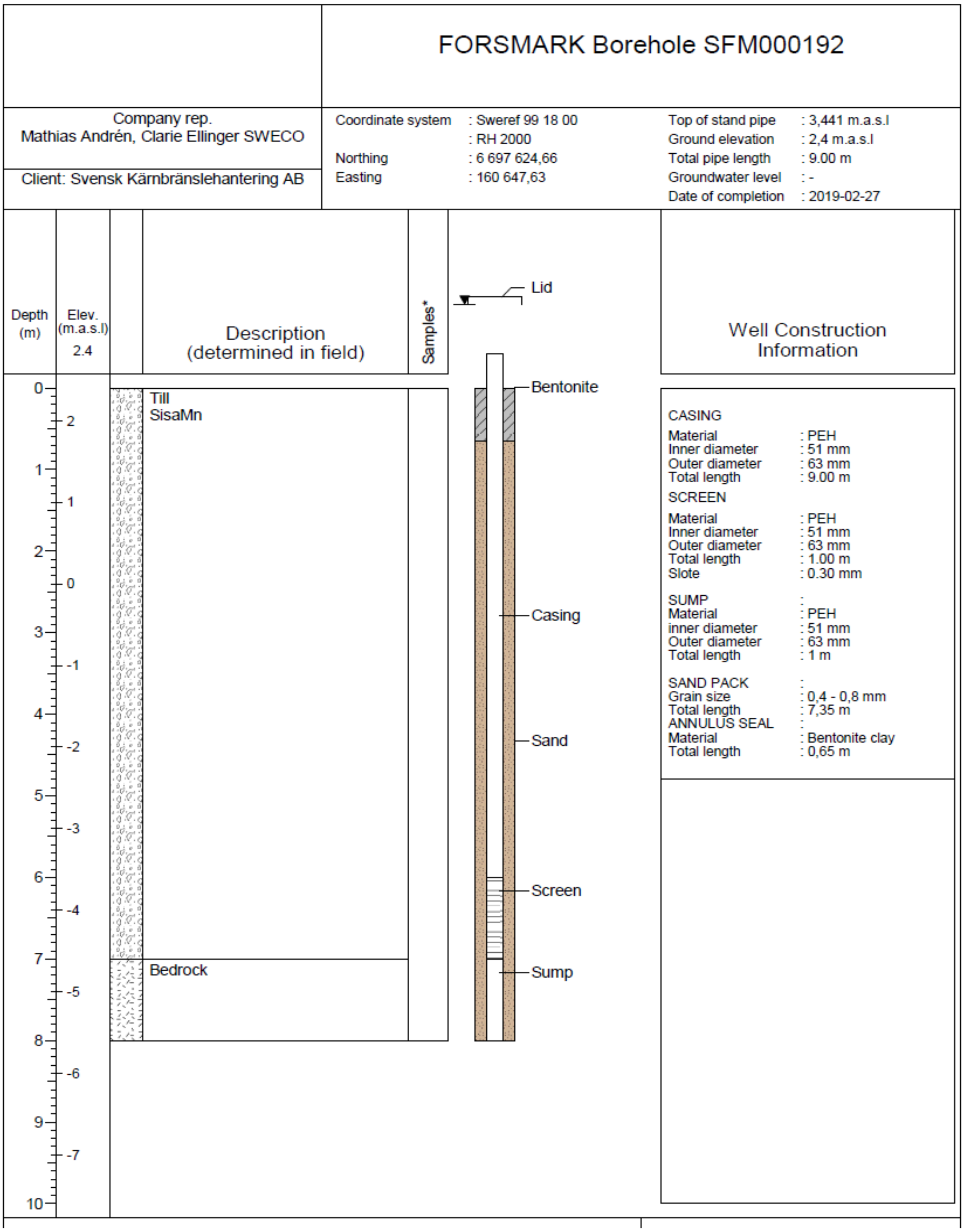


Figure A1-21 *Cross-section drawing of well SFM000192.*

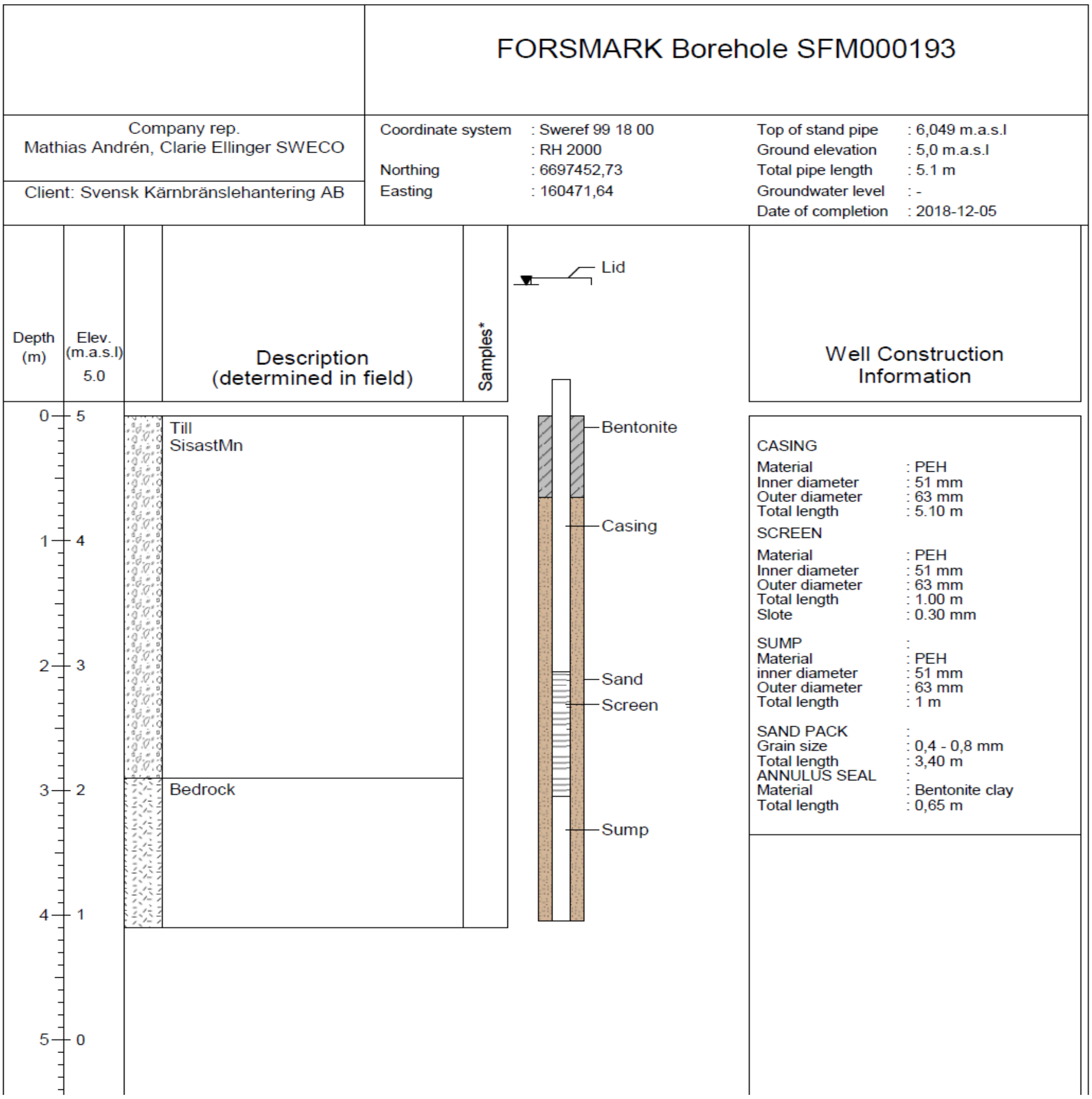


Figure A1-22 *Cross-section drawing of well SFM000193.*

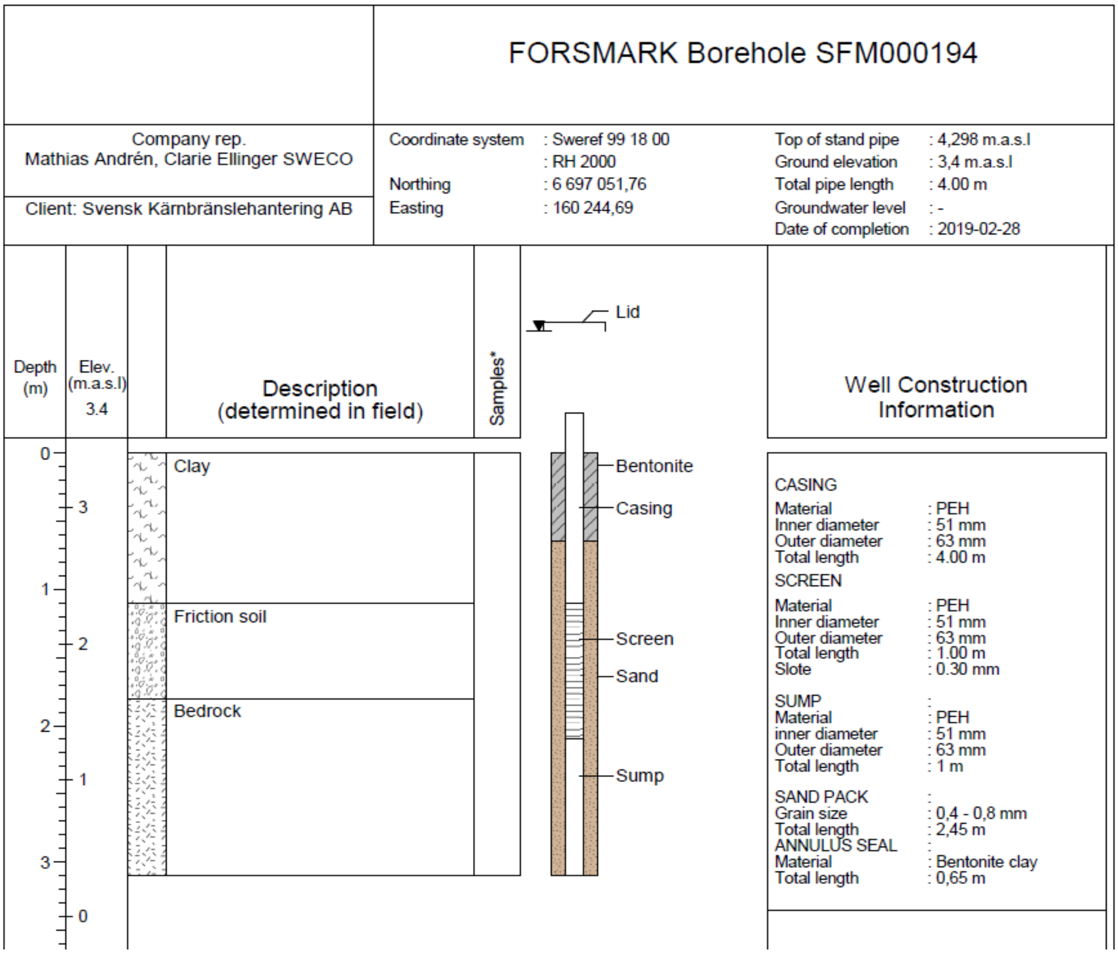


***Figure A1-23** Cross-section drawing of well SFM000194.*

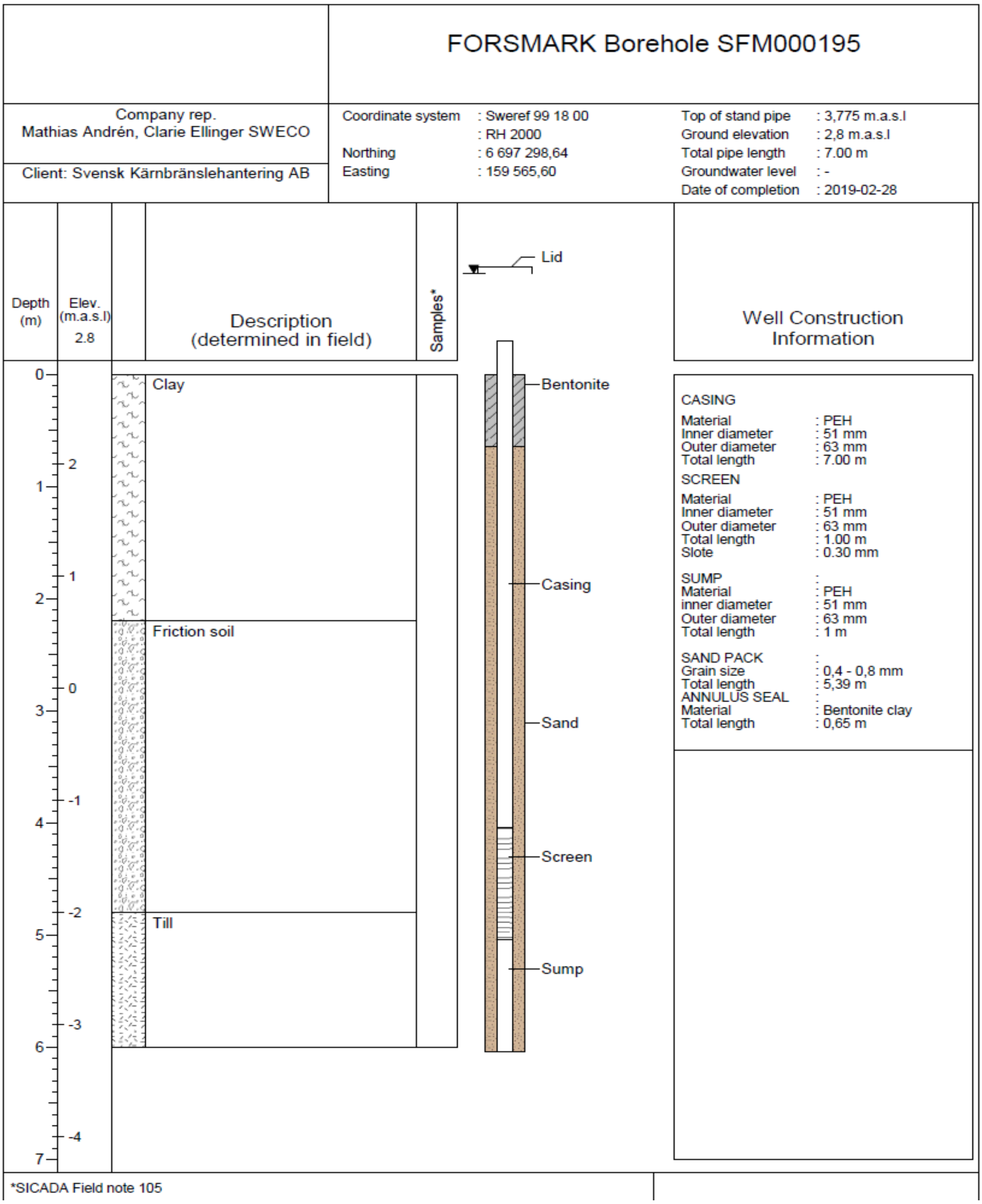


Figure A1-24 Cross-section drawing of well SFM000195.

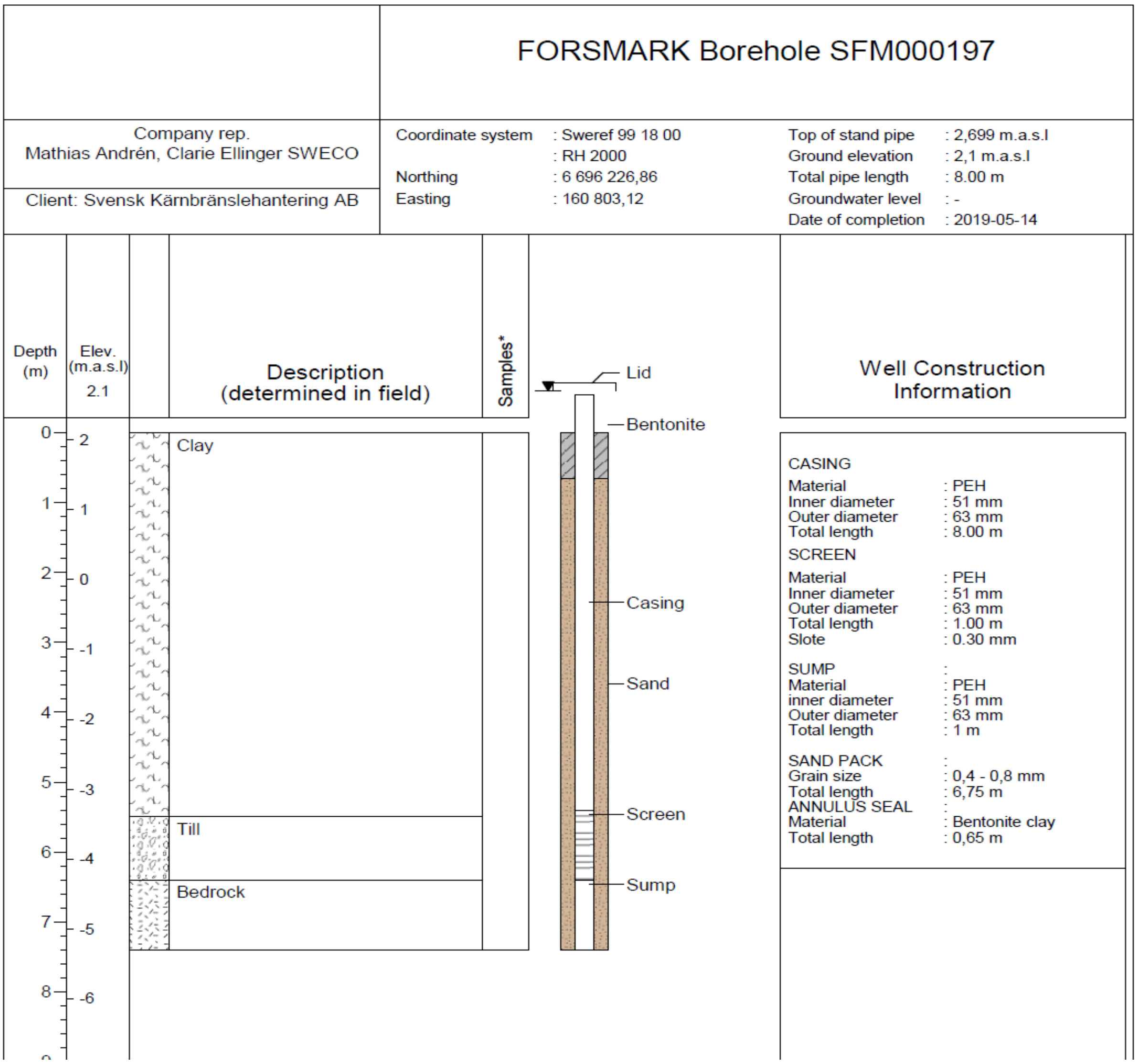


Figure A1-25 *Cross-section drawing of well SFM000197.*

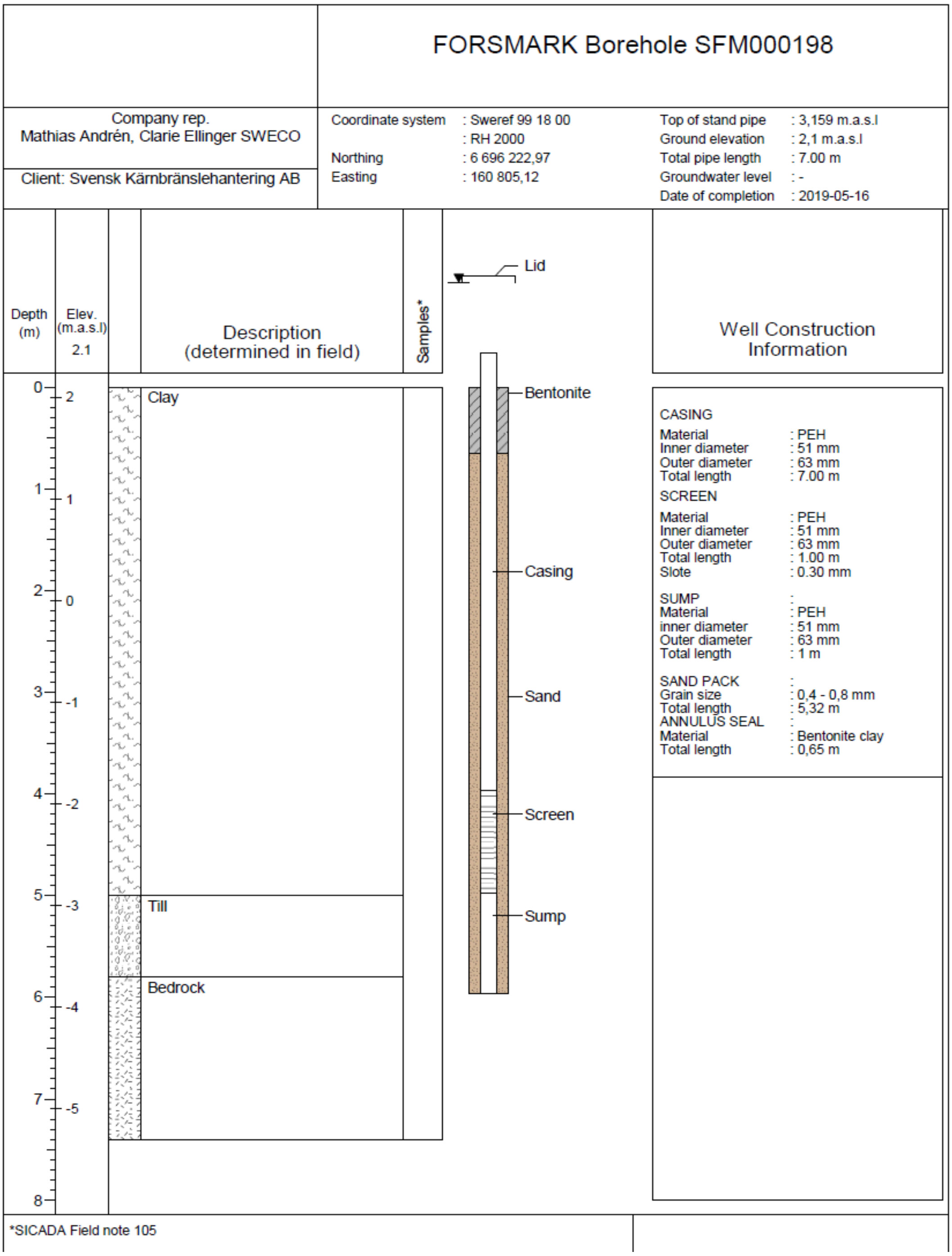
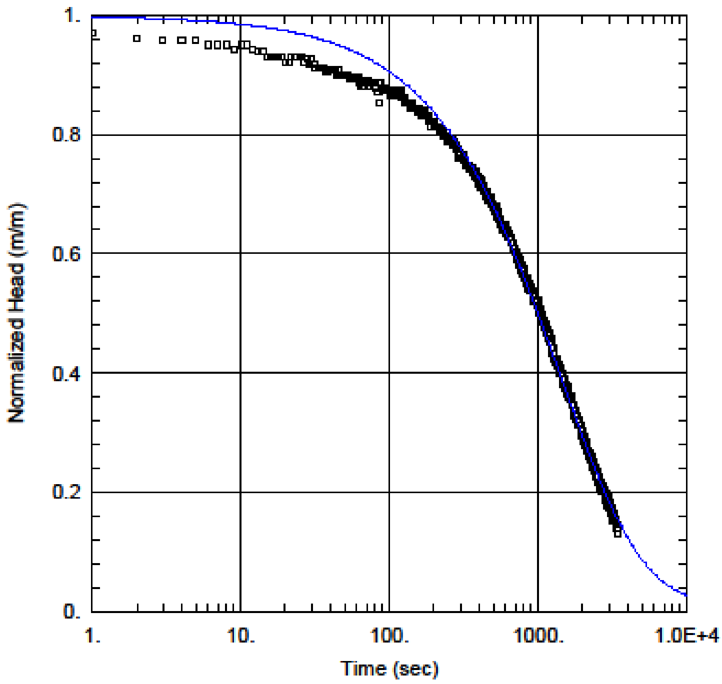


Figure A1-26 *Cross-section drawing of well SFM000198.*

Appendix 2

Displacement versus time and curve fitting plots using the Cooper-Bredehoeft-Papadopulos (C-B-P) or Bouwer-Rice (B-R) methods



SFM0006

Data Set: C:\temp\Aqtesolv_Results\SFM0006_FH.aqt
Date: 10/25/21
Time: 21:19:14

PROJECT INFORMATION

Company: SKB
Test Well: 0006

AQUIFER DATA

Saturated Thickness: 2.83 m
Anisotropy Ratio (Kz/Kr): 1.

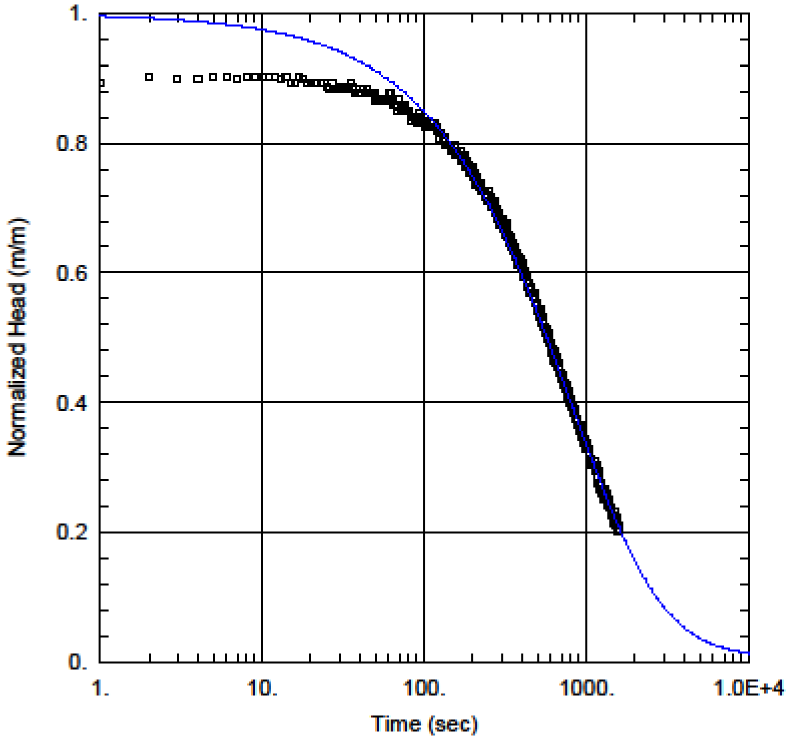
WELL DATA (SFM0006)

Initial Displacement: 0.2 m
Total Well Penetration Depth: 2.8 m
Casing Radius: 0.09685 m
Static Water Column Height: 2.835 m
Screen Length: 1. m
Well Radius: 0.0375 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 1.422E-5 m^2/sec
S = 0.002206

Figure A2-1. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM0006.*



SFM0090

Data Set: C:\temp\Aqtesolv_Results\SFM0090_FH.aqt
Date: 10/27/21 Time: 22:01:42

PROJECT INFORMATION

Company: SKB
Test Well: 0090

AQUIFER DATA

Saturated Thickness: 3. m Anisotropy Ratio (Kz/Kr): 1.

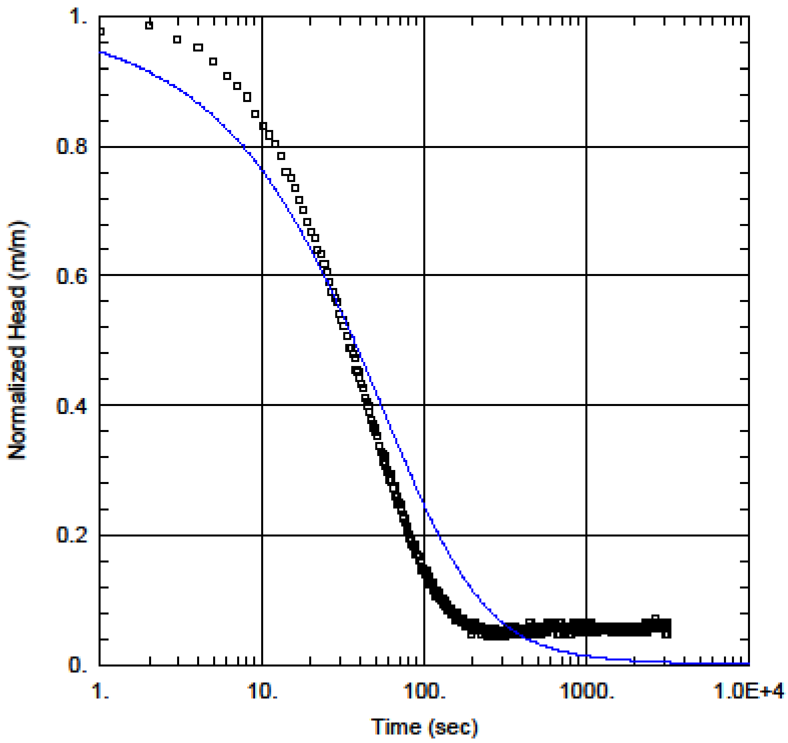
WELL DATA (SFM0090)

Initial Displacement: 0.18 m
Total Well Penetration Depth: 2.5 m
Casing Radius: 0.0505 m
Static Water Column Height: 8.44 m
Screen Length: 1. m
Well Radius: 0.0505 m

SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Bredehoeft-Papadopulos
T = 6.181E-6 m^2/sec S = 0.0006496

Figure A2-2. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM0090.*



SFM000109

Data Set: C:\temp\Aqtesolv_Results\SFM000109_FH.aqt
Date: 11/05/21 Time: 15:47:46

PROJECT INFORMATION

Company: SKB
Test Well: 109

AQUIFER DATA

Saturated Thickness: 2.7 m Anisotropy Ratio (Kz/Kr): 1.

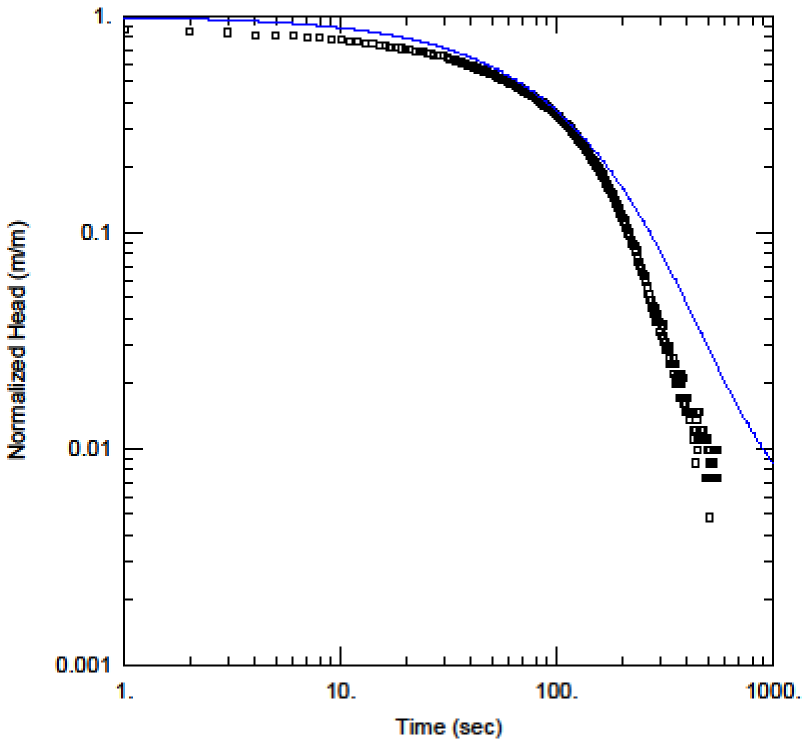
WELL DATA (SFM000109)

Initial Displacement: 0.19 m
Total Well Penetration Depth: 2.5 m
Casing Radius: 0.09685 m
Static Water Column Height: 3.125 m
Screen Length: 1. m
Well Radius: 0.036 m

SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Bredehoeft-Papadopulos
T = 0.0002011 m^2/sec S = 0.1

FigureA2-3. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM00109.*



SFM169_SLUG

Data Set: G:\...\SFM000169_FallingH_corrected.aqt
Date: 11/10/21
Time: 13:03:07

PROJECT INFORMATION

Company: SKB
Test Well: 000169

AQUIFER DATA

Saturated Thickness: 1.64 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SFM000169)

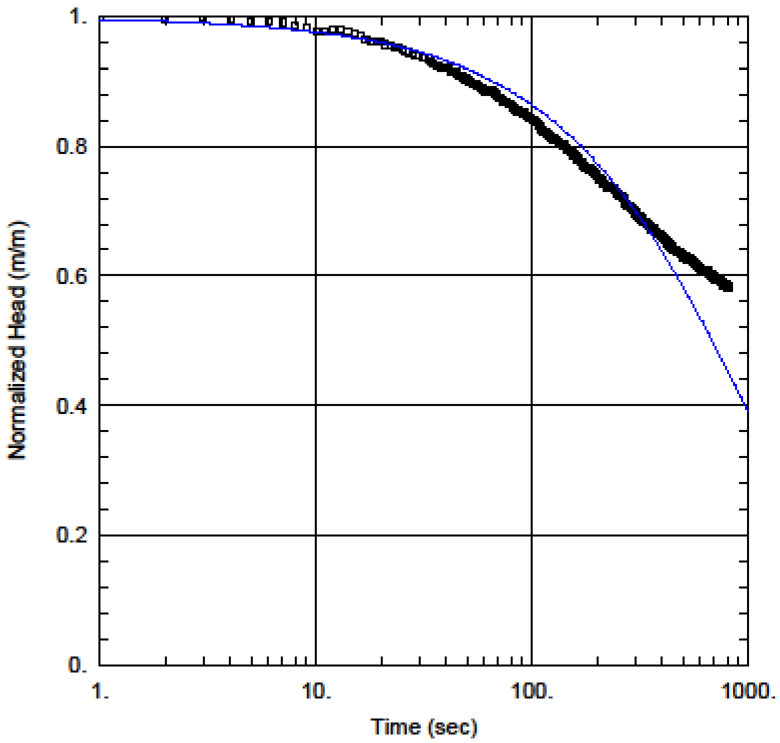
Initial Displacement: 0.467 m
Total Well Penetration Depth: 1.65 m
Casing Radius: 0.0255 m
Static Water Column Height: 2.645 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos

T = 2.4E-5 m^2/sec
S = 2.242E-6

Figure A2-4. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000169.*



SLUG171FH

Data Set: G:\...\SFM000171_FH.aqt
Date: 11/10/21 Time: 13:34:46

PROJECT INFORMATION

Company: SKB
Test Well: 000171

AQUIFER DATA

Saturated Thickness: 1.1 m Anisotropy Ratio (Kz/Kr): 1.

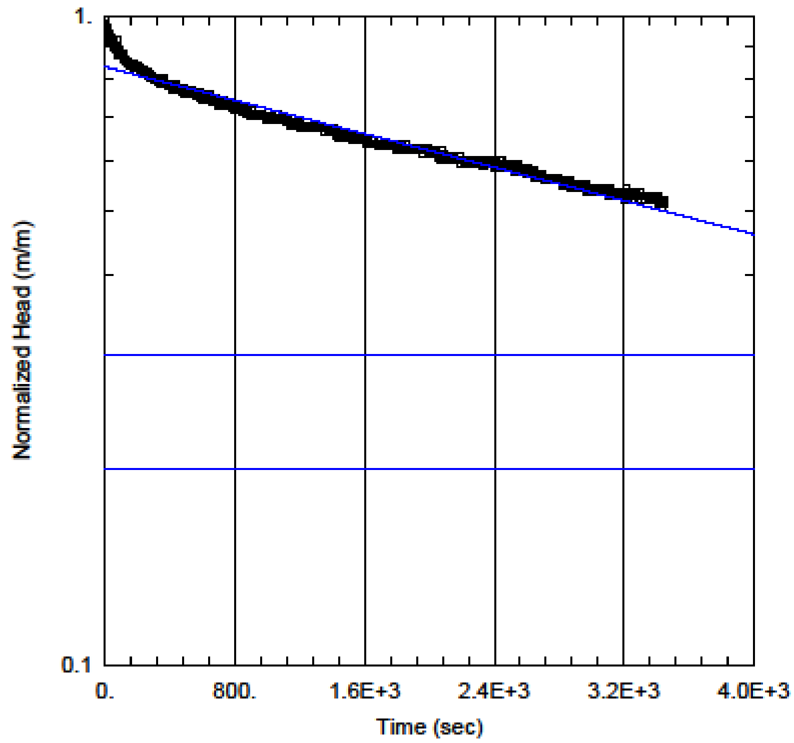
WELL DATA (SFM171)

Initial Displacement: 0.956 m
Total Well Penetration Depth: 1.69 m
Casing Radius: 0.0255 m
Static Water Column Height: 2.19 m
Screen Length: 0.5 m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 1.171E-6 m^2/sec
S = 0.001429

Figure A2-5. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000171.*



SFM000174

Data Set: G:\...\SFM000174_FH.aqt
Date: 10/25/21
Time: 11:36:58

PROJECT INFORMATION

Company: SKB
Test Well: 000174

AQUIFER DATA

Saturated Thickness: 0.4 m
Anisotropy Ratio (Kz/Kr): 1.

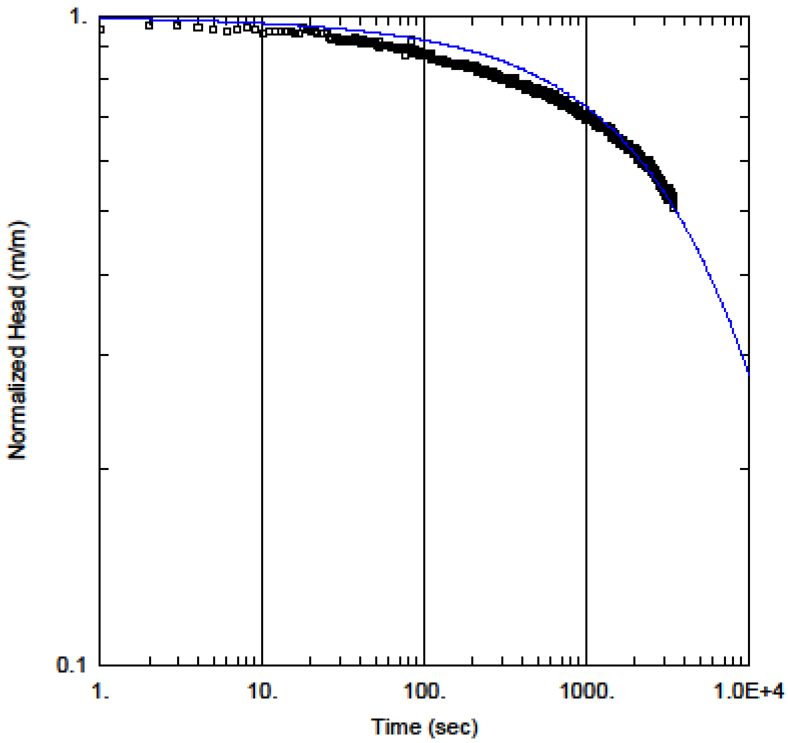
WELL DATA (SFM000174)

Initial Displacement: 0.23 m
Total Well Penetration Depth: 1. m
Casing Radius: 0.0255 m
Static Water Column Height: 1.485 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 3.044E-7 m/sec
y0 = 0.1924 m

Figure A2-6. *Semi-log plot of normalized displacement versus time and B-R curve fitting for the falling-head test in well SFM000174.*



SFM000174

Data Set: G:\...\SFM000174_FH.aqt
Date: 11/10/21 Time: 13:52:57

PROJECT INFORMATION

Company: SKB
Test Well: 000174

AQUIFER DATA

Saturated Thickness: 0.48 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SFM000174)

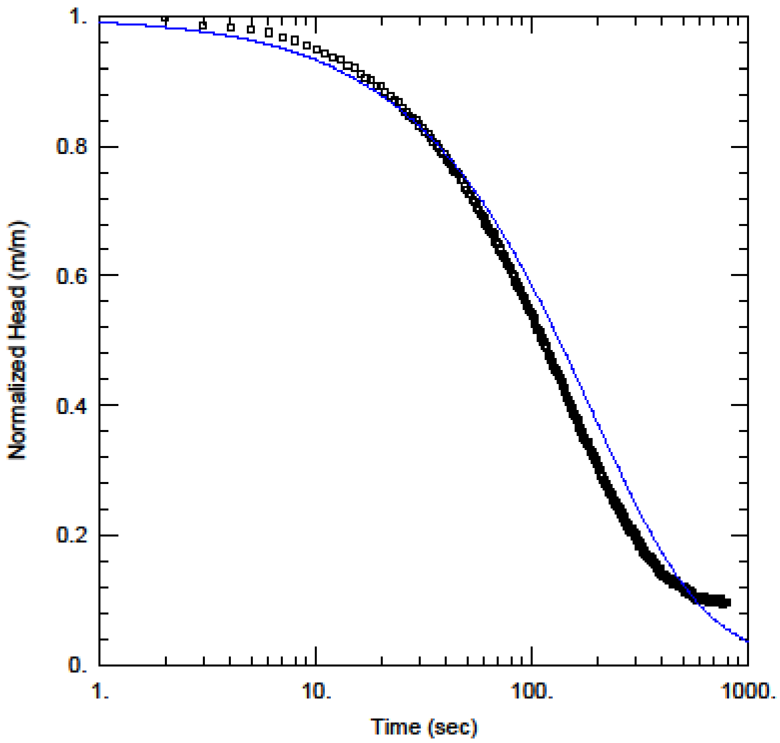
Initial Displacement: 0.23 m
Total Well Penetration Depth: 1. m
Casing Radius: 0.0255 m

Static Water Column Height: 1.485 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Bredehoeft-Papadopulos
T = 7.547E-8 m^2/sec S = 0.1

Figure A2-7. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000174.*



SLUG176FH

Data Set: G:\...\SFM000176_FH.aqt
Date: 11/11/21
Time: 09:54:51

PROJECT INFORMATION

Company: SKB
Test Well: SFM000176

AQUIFER DATA

Saturated Thickness: 0.9 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (176)

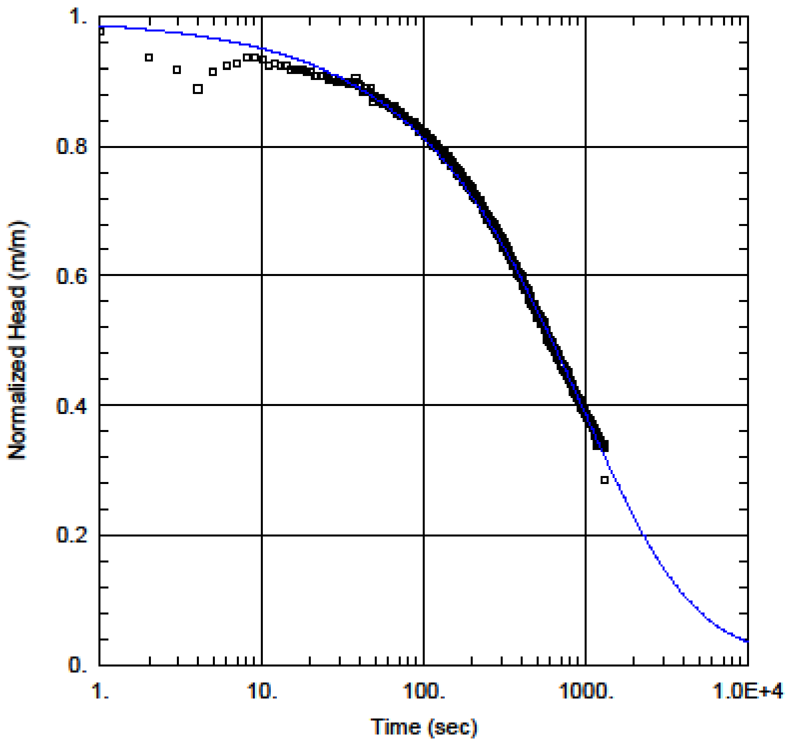
Initial Displacement: 0.432 m
Total Well Penetration Depth: 3.32 m
Casing Radius: 0.0255 m
Static Water Column Height: 4.32 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos

T = 9.491E-6 m^2/sec
S = 3.161E-5

Figure A2-8. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000176.*



SFM000177_FH

Data Set: C:\temp\Aqtesolv_Results\SFM000177_FH.aqt
Date: 10/24/21 Time: 21:49:36

PROJECT INFORMATION

Company: SKB
Test Well: 000177

AQUIFER DATA

Saturated Thickness: 1.6 m Anisotropy Ratio (Kz/Kr): 1.

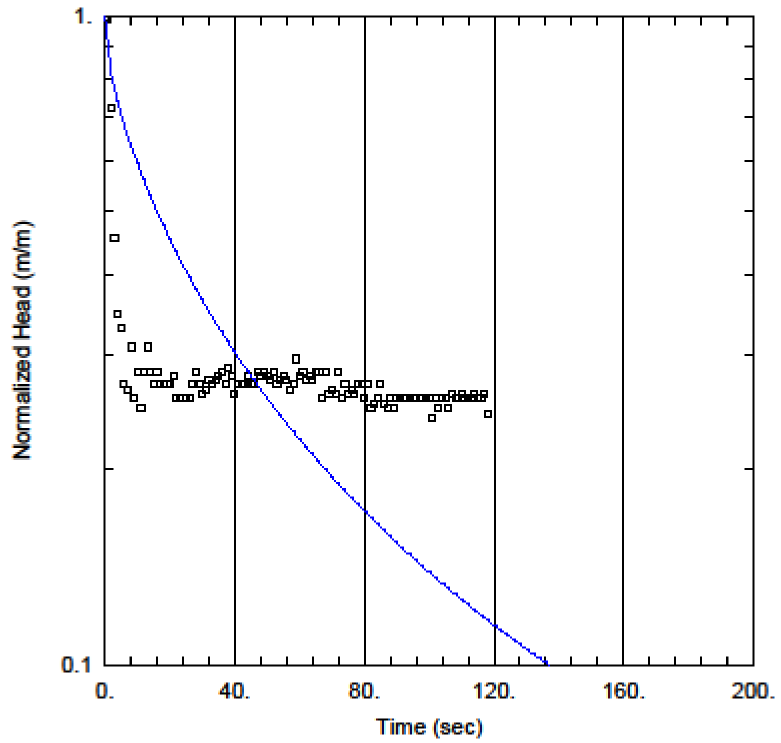
WELL DATA (177)

Initial Displacement: 0.31 m
Total Well Penetration Depth: 2. m
Casing Radius: 0.0255 m
Static Water Column Height: 2.6 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 6.278E-7 m^2/sec
S = 0.03734

Figure A2-9. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000177.*



SFM000179FH

Data Set:
Date: 11/05/21
Time: 10:04:47

PROJECT INFORMATION

Company: SKB
Test Well: 179

AQUIFER DATA

Saturated Thickness: 1. m
Anisotropy Ratio (Kz/Kr): 1.

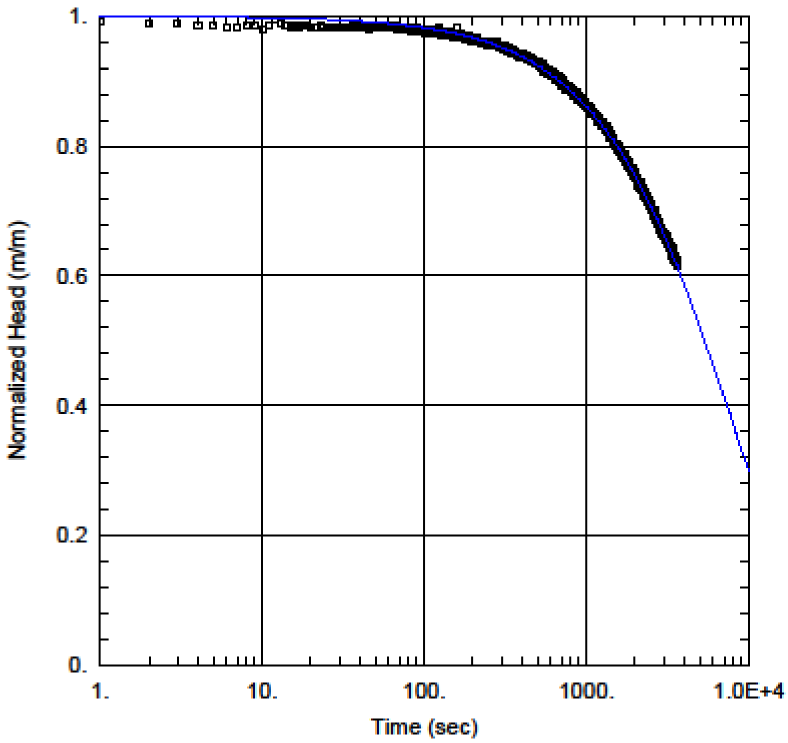
WELL DATA (SFM00179FH)

Initial Displacement: 0.135 m
Total Well Penetration Depth: 4.03 m
Casing Radius: 0.0255 m
Static Water Column Height: 4.03 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 1.684E-5 m^2/sec
S = 0.1

Figure A2-10. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000179.*



SFM000180FH

Data Set: C:\temp\Aqtesolv_Results\SFM000180_FH.aqt
Date: 11/05/21 Time: 11:39:48

PROJECT INFORMATION

Company: SKB
Test Well: 180

AQUIFER DATA

Saturated Thickness: 3.4 m Anisotropy Ratio (Kz/Kr): 1.

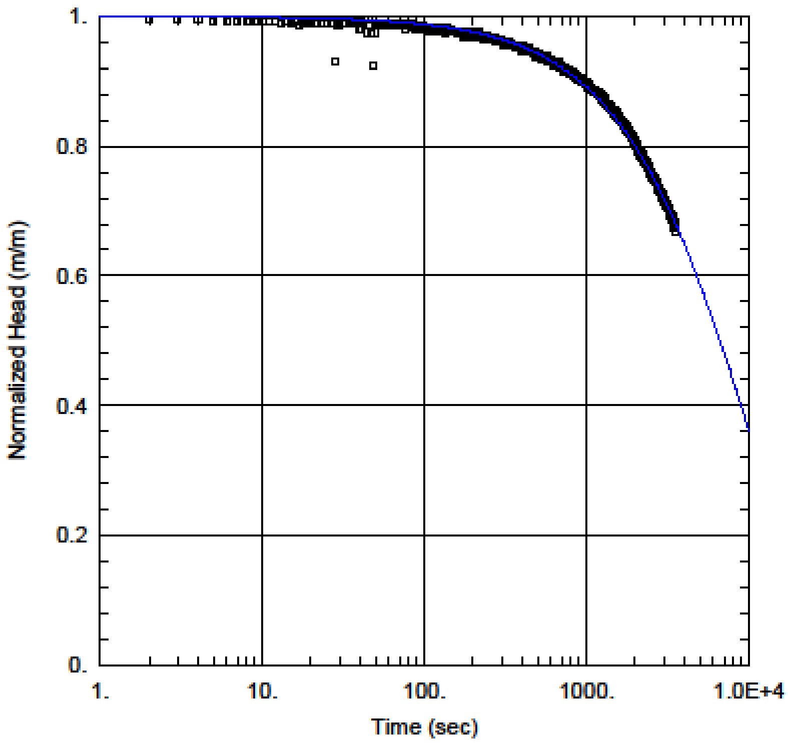
WELL DATA (SFM000180FH)

Initial Displacement: 0.46 m Static Water Column Height: 3.78 m
Total Well Penetration Depth: 2.78 m Screen Length: 1. m
Casing Radius: 0.0255 m Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Bredehoeft-Papadopulos
T = 3.224E-7 m^2/sec S = 7.323E-7

Figure A2-11. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000180.*



SFM000182FH

Data Set: C:\temp\Aqtesolv_Results\SFM000182_FH.aqt
Date: 11/05/21 Time: 12:25:43

PROJECT INFORMATION

Company: SKB
Test Well: 182

AQUIFER DATA

Saturated Thickness: 1.71 m Anisotropy Ratio (Kz/Kr): 1.

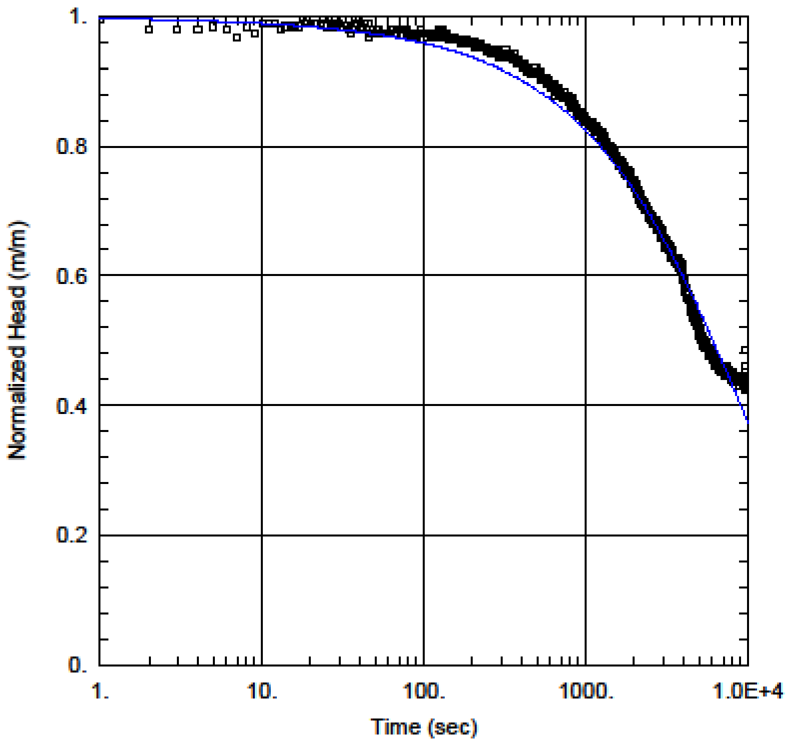
WELL DATA (SFM000182)

Initial Displacement: 0.459 m
Total Well Penetration Depth: 1.71 m
Casing Radius: 0.0255 m
Static Water Column Height: 2.71 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 4.19E-7 m^2/sec
S = 1.0E-10

Figure A2-12. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000182.*



SFM000183

Data Set: C:\temp\Aqtesolv_Results\SFM000183_FH.aqt
Date: 11/05/21 Time: 14:22:50

PROJECT INFORMATION

Company: SKB
Test Well: 183

AQUIFER DATA

Saturated Thickness: 2.8 m
Anisotropy Ratio (Kz/Kr): 1.

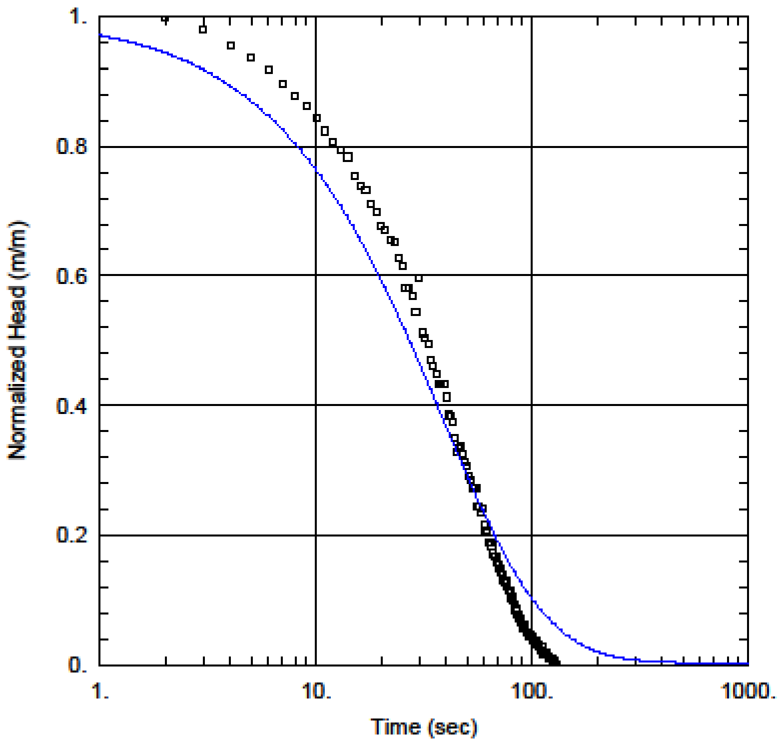
WELL DATA (SFM000183)

Initial Displacement: 0.316 m
Total Well Penetration Depth: 5.14 m
Casing Radius: 0.0255 m
Static Water Column Height: 6.14 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

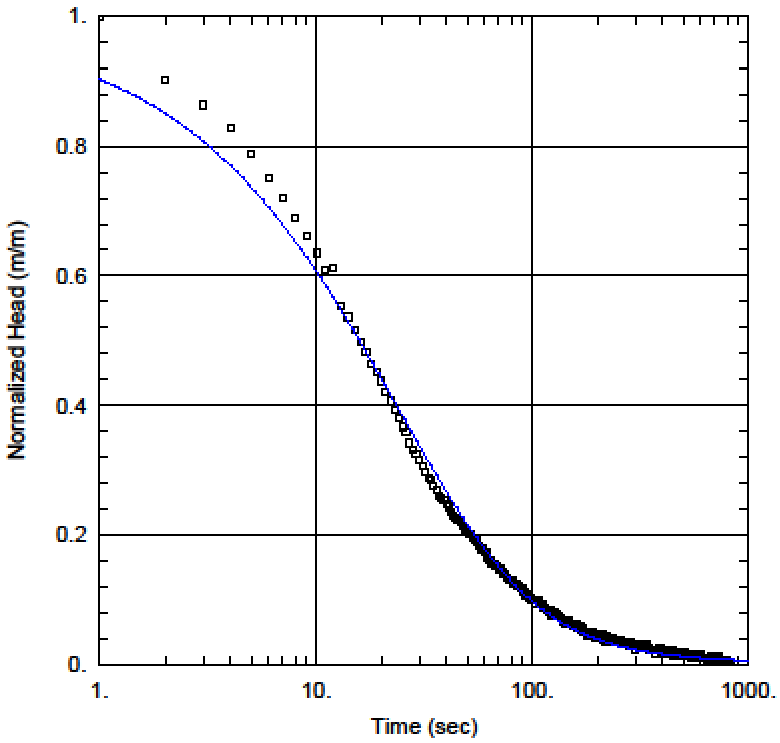
Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 8.139E-8 m^2/sec
S = 0.01593

Figure A2-13. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000183.*



SFM000187	
Data Set: C:\temp\Aqtesolv_Results\SFM000187_FH.aqt	
Date: 10/24/21	Time: 22:36:16
PROJECT INFORMATION	
Company: SKB	
Test Well: 000187	
AQUIFER DATA	
Saturated Thickness: 2. m	Anisotropy Ratio (Kz/Kr): 1.
WELL DATA (SFM000187)	
Initial Displacement: 0.23 m	Static Water Column Height: 3.02 m
Total Well Penetration Depth: 2. m	Screen Length: 1. m
Casing Radius: 0.0255 m	Well Radius: 0.0255 m
SOLUTION	
Aquifer Model: Confined	Solution Method: Cooper-Bredehoeft-Papadopulos
T = 0.0001023 m^2/sec	S = 1.0E-10

Figure A2-14. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000187.*



SFM000188

Data Set: C:\temp\Aqtesolv_Results\SFM000188_FH.aqt
Date: 10/24/21 Time: 23:08:33

PROJECT INFORMATION

Company: SKB
Test Well: 000188

AQUIFER DATA

Saturated Thickness: 0.85 m Anisotropy Ratio (Kz/Kr): 1.

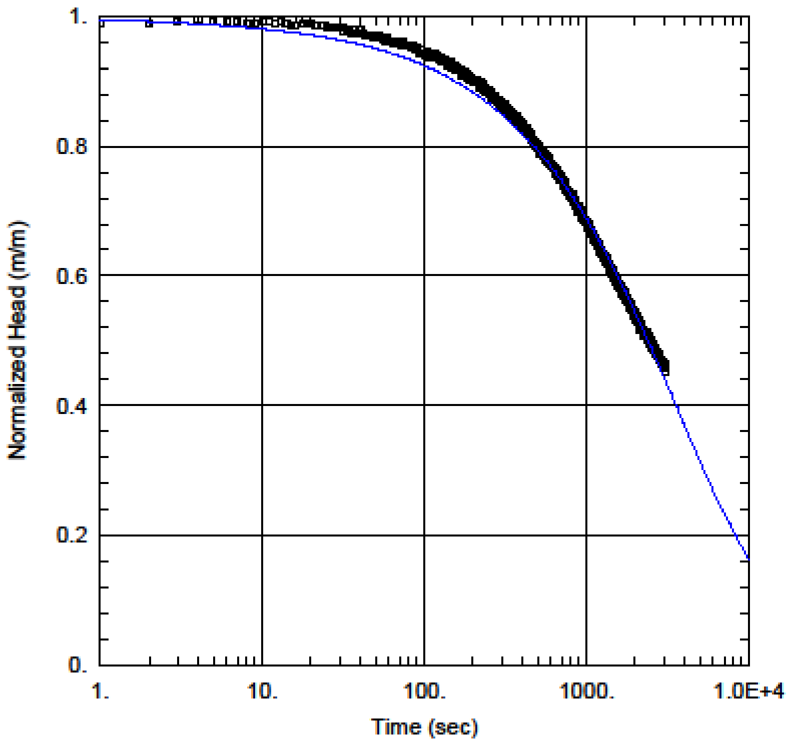
WELL DATA (SFM000188)

Initial Displacement: 0.36 m
Total Well Penetration Depth: 1. m
Casing Radius: 0.0255 m
Static Water Column Height: 1.84 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Bredehoeft-Papadopulos
T = 3.055E-5 m^2/sec S = 0.01722

Figure A2-15. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000188.*



SFM000190

Data Set: C:\temp\Aqtesolv_Results\SFM000190_FH.aqt
Date: 10/24/21 Time: 23:42:14

PROJECT INFORMATION

Company: SKB
Test Well: 000190

AQUIFER DATA

Saturated Thickness: 4.24 m Anisotropy Ratio (Kz/Kr): 1.

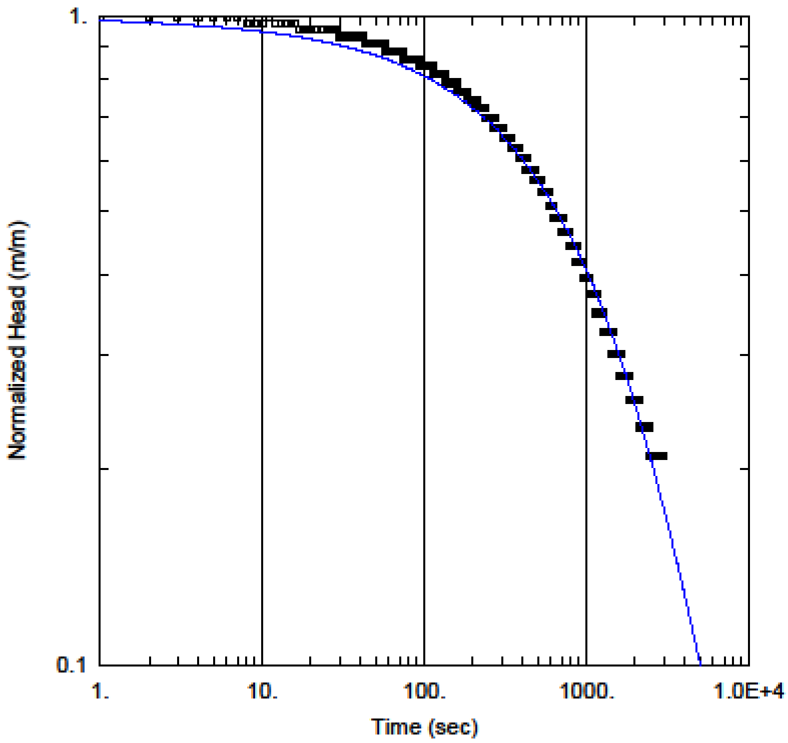
WELL DATA (SFM000190)

Initial Displacement: 0.44 m
Total Well Penetration Depth: 4.24 m
Casing Radius: 0.0255 m
Static Water Column Height: 5.24 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 1.97E-7 m^2/sec
S = 0.01914

Figure A2-16. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000190.*



SLUG_000191_F

Data Set: G:\...\SFM000191_Falling.aqt
Date: 03/14/22 Time: 10:57:48

PROJECT INFORMATION

Company: SKB
Test Well: 000191

AQUIFER DATA

Saturated Thickness: 5.875 m Anisotropy Ratio (Kz/Kr): 1.

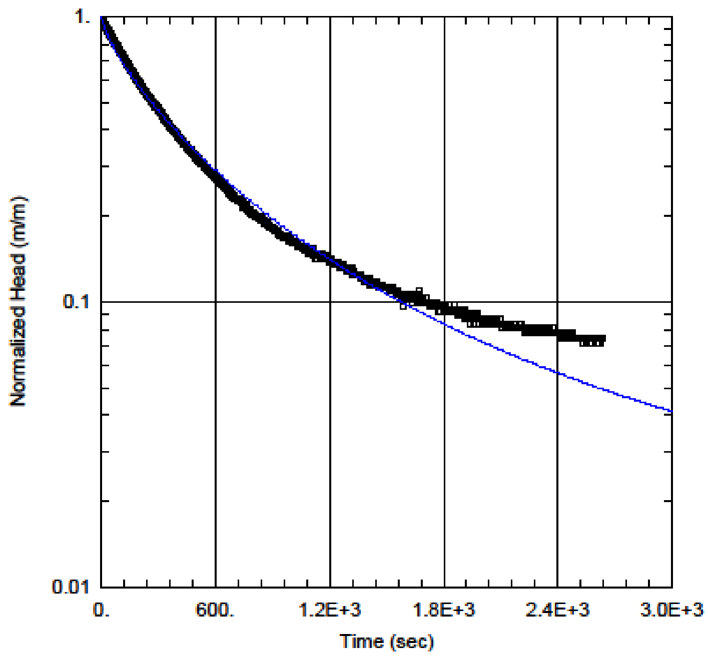
WELL DATA (SFM000191)

Initial Displacement: 0.43 m
Total Well Penetration Depth: 5.875 m
Casing Radius: 0.0255 m
Static Water Column Height: 5.31 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 4.963E-7 m^2/sec
S = 0.06163

Figure A2-17. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000191.*



SFM192_SLUG

Data Set: G:\...\192_FH.aqt
Date: 03/14/22
Time: 10:58:28

PROJECT INFORMATION

Company: SKB
Test Well: 000192

AQUIFER DATA

Saturated Thickness: 6.45 m
Anisotropy Ratio (Kz/Kr): 1.

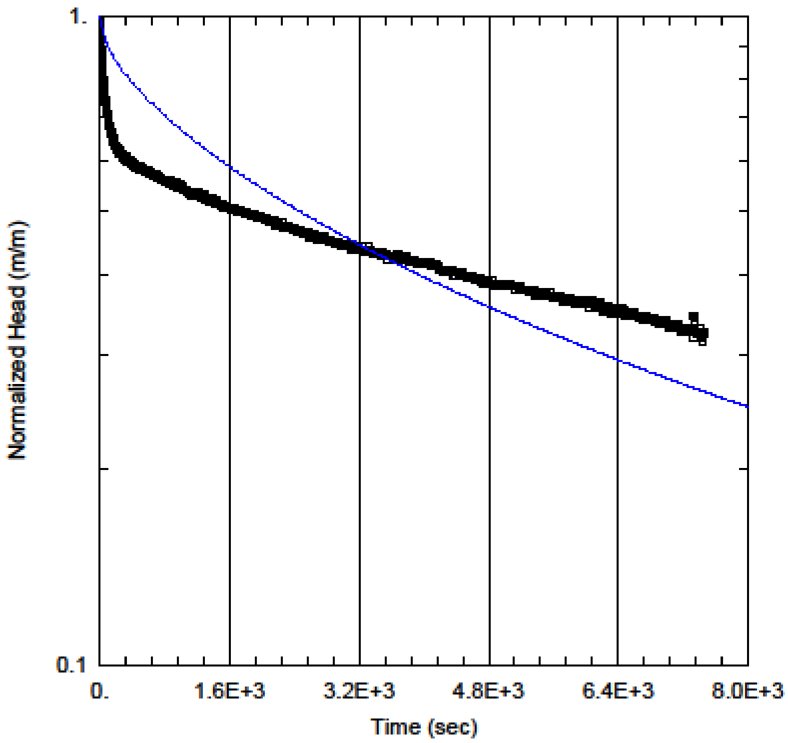
WELL DATA (SFM192)

Initial Displacement: 0.525 m
Total Well Penetration Depth: 6.45 m
Casing Radius: 0.0255 m
Static Water Column Height: 7.45 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 2.011E-6 m^2/sec
S = 0.01166

Figure A2-18. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000192.*



SFM000193

Data Set: C:\temp\Aqtesolv_Results\SFM000193_FH.aqt
Date: 10/25/21 Time: 00:08:37

PROJECT INFORMATION

Company: SKB
Test Well: 000193

AQUIFER DATA

Saturated Thickness: 1.9 m Anisotropy Ratio (Kz/Kr): 1.

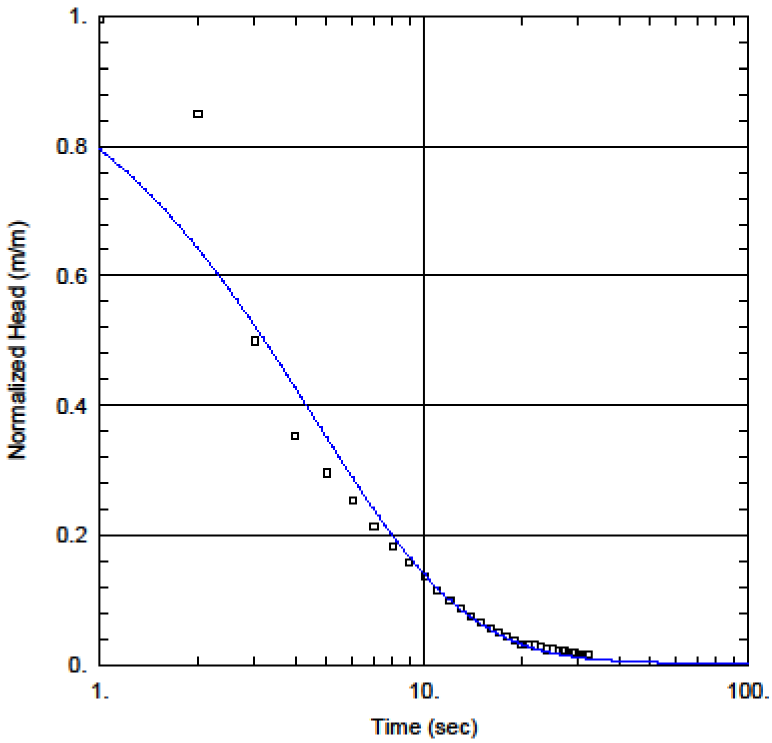
WELL DATA (SFM000193)

Initial Displacement: 0.42 m
Total Well Penetration Depth: 2.1 m
Casing Radius: 0.0255 m
Static Water Column Height: 3.11 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 1.099E-7 m^2/sec
S = 0.1

Figure A2-19. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000193.*



SFM000194

Data Set: G:\...\SFM000194_FH.aqt
Date: 10/25/21
Time: 13:03:19

PROJECT INFORMATION

Company: SKB
Test Well: 000194

AQUIFER DATA

Saturated Thickness: 0.7 m
Anisotropy Ratio (Kz/Kr): 1.

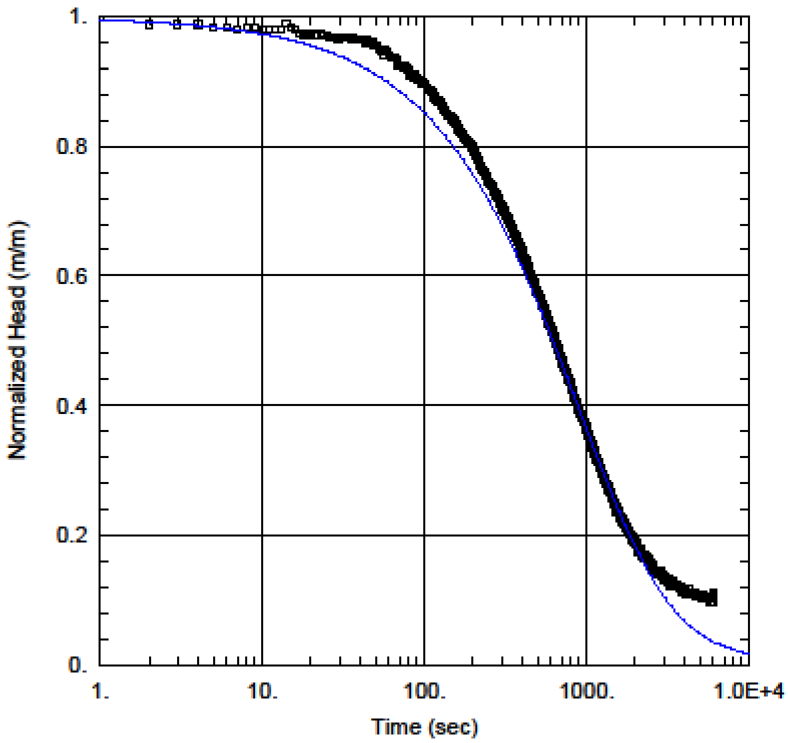
WELL DATA (SFM000194)

Initial Displacement: 0.65 m
Total Well Penetration Depth: 1.3 m
Casing Radius: 0.0255 m
Static Water Column Height: 2.34 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 0.0008622 m^2/sec
S = 1.0E-10

Figure A2-20. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000194.*



SFM195_FH

Data Set: G:\...\SFM000195_Falling.aqt
Date: 11/11/21 Time: 13:29:56

PROJECT INFORMATION

Company: SKB
Test Well: 000195

AQUIFER DATA

Saturated Thickness: 3.8 m Anisotropy Ratio (Kz/Kr): 1.

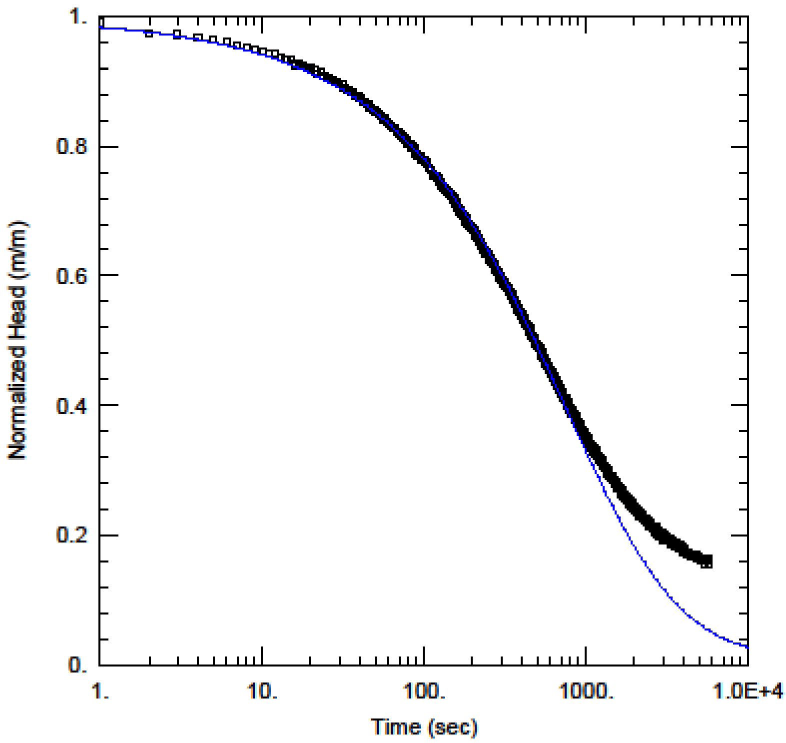
WELL DATA (SFM000195)

Initial Displacement: 0.425 m
Total Well Penetration Depth: 2.9 m
Casing Radius: 0.0255 m
Static Water Column Height: 4.96 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 1.236E-6 m^2/sec
S = 0.00189

Figure A2-21. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000195.*



WELL TEST ANALYSIS

Data Set: G:\...\SFM000197_FH.aqt
Date: 11/11/21 Time: 13:42:01

PROJECT INFORMATION

Company: SKB
Test Well: SFM000197

AQUIFER DATA

Saturated Thickness: 0.95 m Anisotropy Ratio (Kz/Kr): 1.

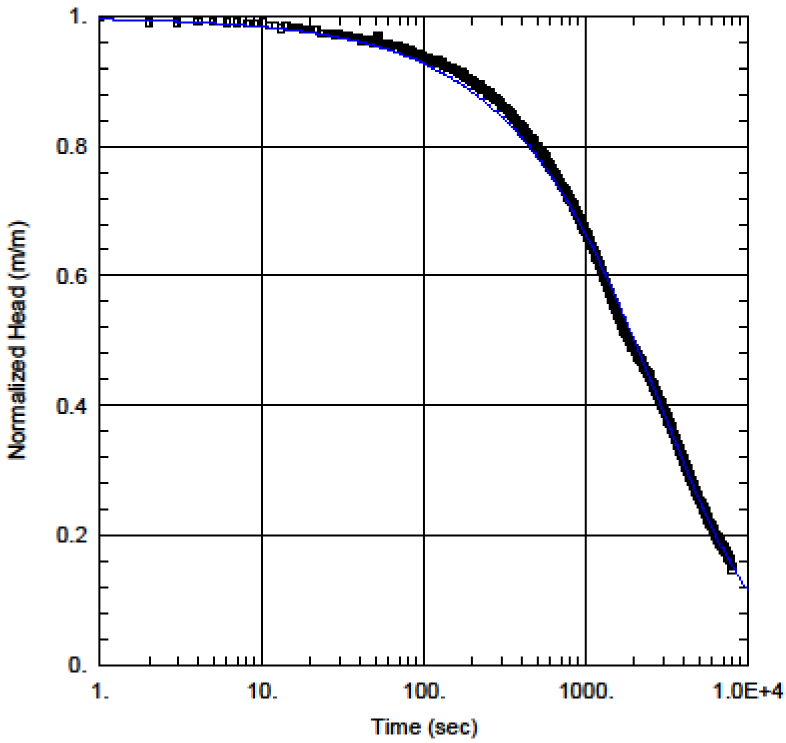
WELL DATA (197)

Initial Displacement: 0.44 m
Total Well Penetration Depth: 6.59 m
Casing Radius: 0.0255 m
Static Water Column Height: 7.59 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos
T = 7.617E-7 m^2/sec
S = 0.04365

Figure A2-22. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000197.*



SFM000198

Data Set: G:\..\SFM000198_FH.aqt
Date: 10/25/21 Time: 12:13:06

PROJECT INFORMATION

Company: SKB
Test Well: 000198

AQUIFER DATA

Saturated Thickness: 5.235 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SFM000198)

Initial Displacement: 0.445 m Static Water Column Height: 6.235 m
Total Well Penetration Depth: 5.2 m Screen Length: 1. m
Casing Radius: 0.0255 m Well Radius: 0.0255 m

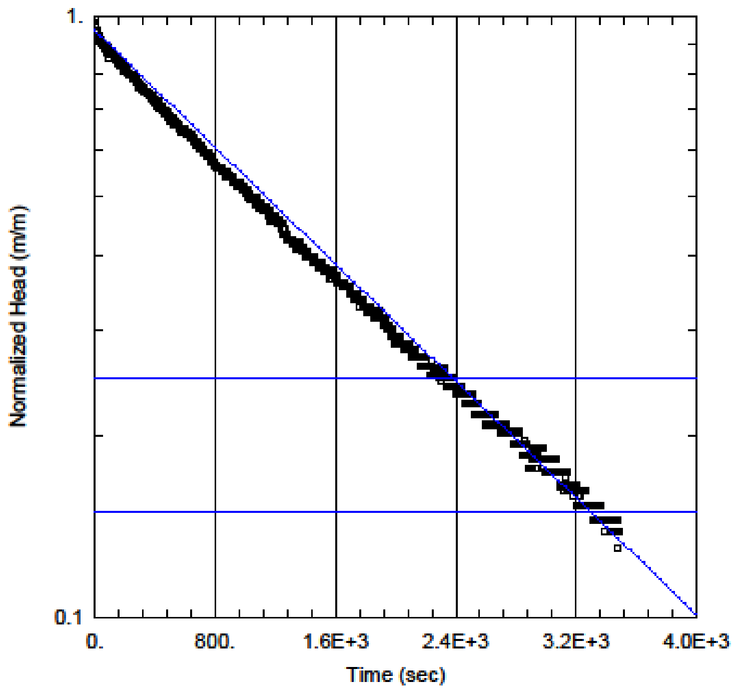
SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Bredehoeft-Papadopulos
T = 3.041E-7 m^2/sec S = 0.006651

Figure A2-23. *Semi-log plot of normalized displacement versus time and C-B-P curve fitting for the falling-head test in well SFM000198.*

Appendix 3

Displacement versus time and curve fitting plots using the Hvorslev (H) method



SFM0006

Data Set: G:\...\SFM0006_FH.aqt
Date: 11/10/21 Time: 09:23:42

PROJECT INFORMATION

Company: SKB
Test Well: 0006

AQUIFER DATA

Saturated Thickness: 2.5 m Anisotropy Ratio (Kz/Kr): 1.

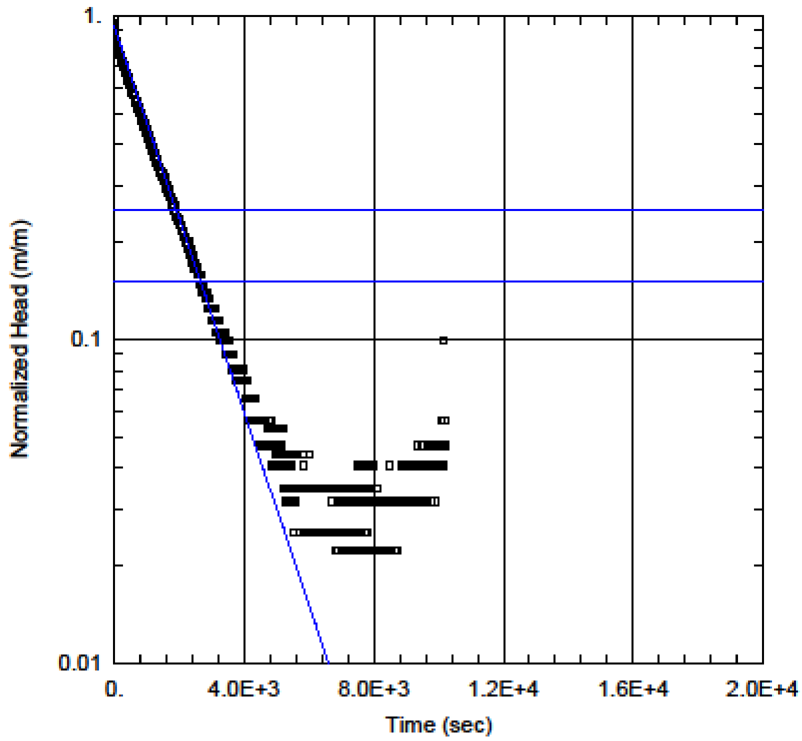
WELL DATA (SFM0006)

Initial Displacement: 0.2 m
Total Well Penetration Depth: 2.8 m
Casing Radius: 0.09685 m
Static Water Column Height: 2.835 m
Screen Length: 1. m
Well Radius: 0.0375 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 1.044E-5 m/sec y0 = 0.1898 m

Figure A3-1. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM0006.*



SFM0006

Data Set: G:\...\SFM0006_RH.aqt
Date: 11/10/21 Time: 09:33:04

PROJECT INFORMATION

Company: SKB
Test Well: 0006

AQUIFER DATA

Saturated Thickness: 2.5 m Anisotropy Ratio (Kz/Kr): 1.

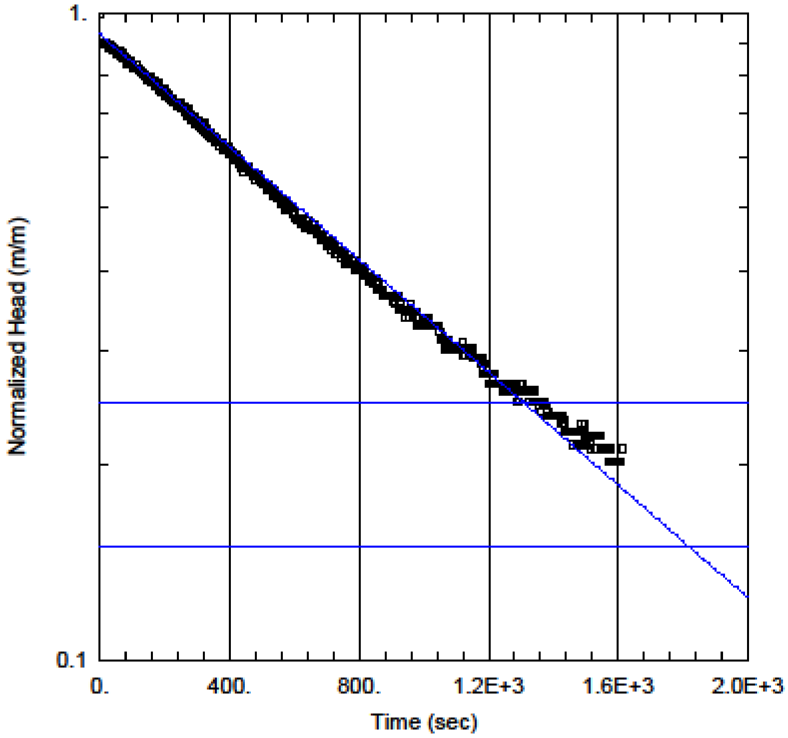
WELL DATA (SFM0006)

Initial Displacement: 0.19 m
Total Well Penetration Depth: 2.8 m
Casing Radius: 0.09685 m
Static Water Column Height: 2.835 m
Screen Length: 1. m
Well Radius: 0.0375 m

SOLUTION

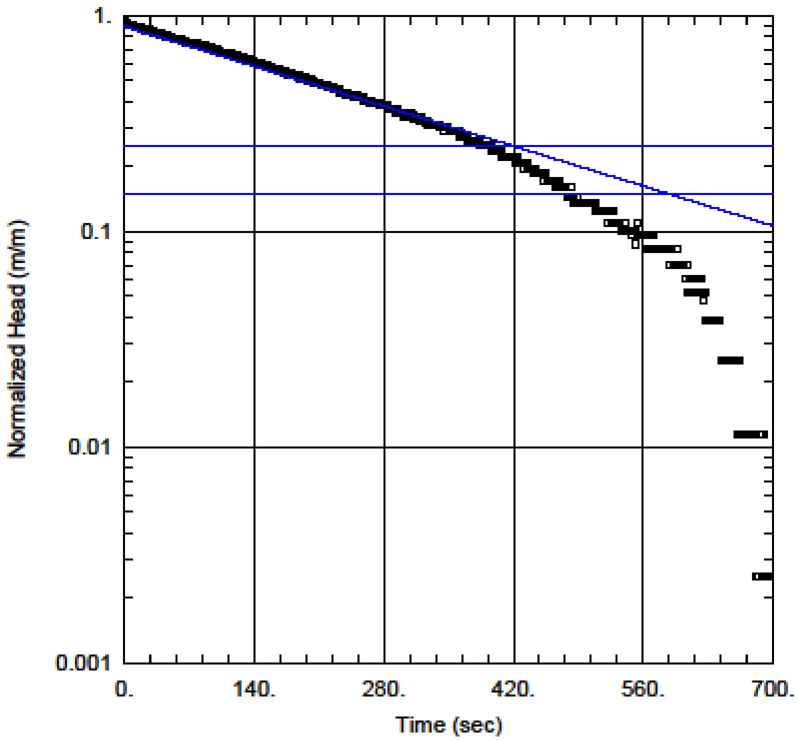
Aquifer Model: Confined Solution Method: Hvorslev
K = 1.279E-5 m/sec y0 = 0.1767 m

Figure A3-2. *Semi-log plot of normalized displacement versus time and H curve fitting for rising-head test in well SFM0006.*



SFM0090	
Data Set: G:\...\SFM0090_FH.aqt	
Date: 11/10/21	Time: 09:53:01
PROJECT INFORMATION	
Company: SKB	
Test Well: 0090	
AQUIFER DATA	
Saturated Thickness: 0.8 m	Anisotropy Ratio (Kz/Kr): 1.
WELL DATA (SFM0090)	
Initial Displacement: 0.18 m	Static Water Column Height: 8.44 m
Total Well Penetration Depth: 4. m	Screen Length: 2.5 m
Casing Radius: 0.0505 m	Well Radius: 0.0505 m
SOLUTION	
Aquifer Model: Confined	Solution Method: Hvorslev
K = 8.471E-6 m/sec	y0 = 0.1674 m

Figure A3-3. *Semi-log plots of normalized displacement versus time and H curve fitting for the falling-head test in well SFM0090.*



SFM0090

Data Set: G:\...\SFM0090_RH.aqt
Date: 11/10/21 Time: 11:56:51

PROJECT INFORMATION

Company: SKB
Test Well: 0090

AQUIFER DATA

Saturated Thickness: 0.8 m Anisotropy Ratio (Kz/Kr): 1.

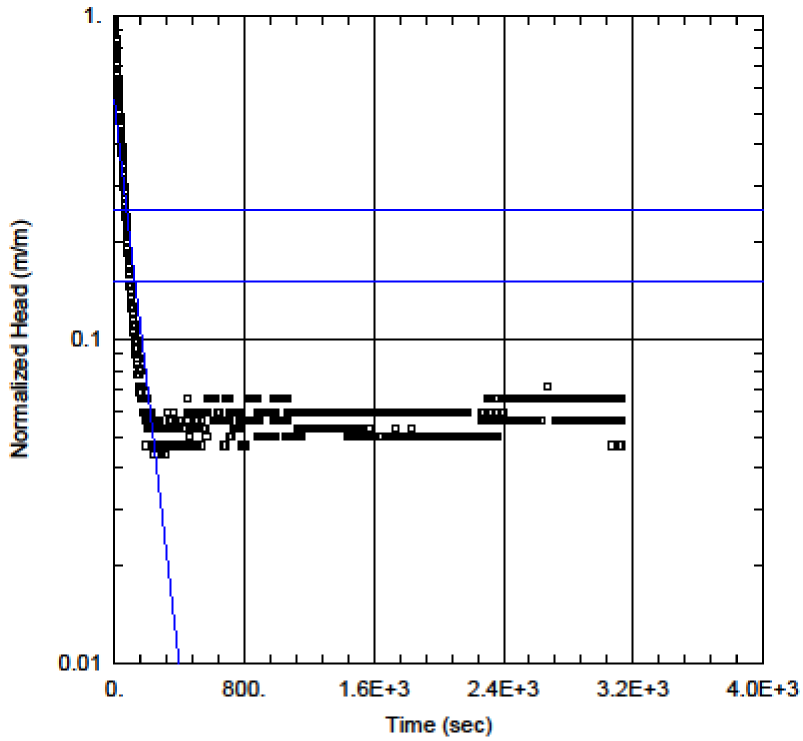
WELL DATA (SFM0090)

Initial Displacement: 0.13 m
Total Well Penetration Depth: 2.5 m
Casing Radius: 0.0505 m
Static Water Column Height: 8.44 m
Screen Length: 1. m
Well Radius: 0.0505 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev
K = 2.563E-5 m/sec
y0 = 0.1158 m

Figure A3-4. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM0090*



SFM000109

Data Set: G:\...\SFM000109_FH.aqt
Date: 11/10/21
Time: 12:31:22

PROJECT INFORMATION

Company: SKB
Test Well: 109

AQUIFER DATA

Saturated Thickness: 2.7 m
Anisotropy Ratio (Kz/Kr): 1.

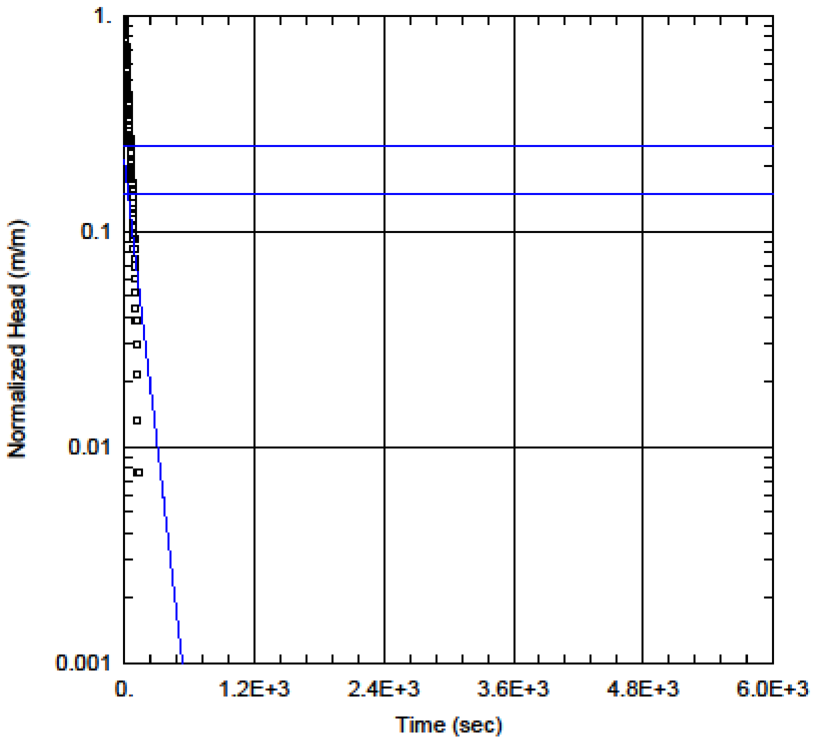
WELL DATA (SFM000109)

Initial Displacement: 0.19 m
Total Well Penetration Depth: 2.5 m
Casing Radius: 0.09685 m
Static Water Column Height: 3.125 m
Screen Length: 1. m
Well Radius: 0.036 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev
K = 0.0001568 m/sec
y0 = 0.1045 m

Figure A3-5. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000109.*



SFM000109

Data Set: G:\...\SFM000109_RH.aqt
Date: 11/10/21 Time: 12:37:22

PROJECT INFORMATION

Company: SKB
Test Well: 109

AQUIFER DATA

Saturated Thickness: 2.7 m Anisotropy Ratio (Kz/Kr): 1.

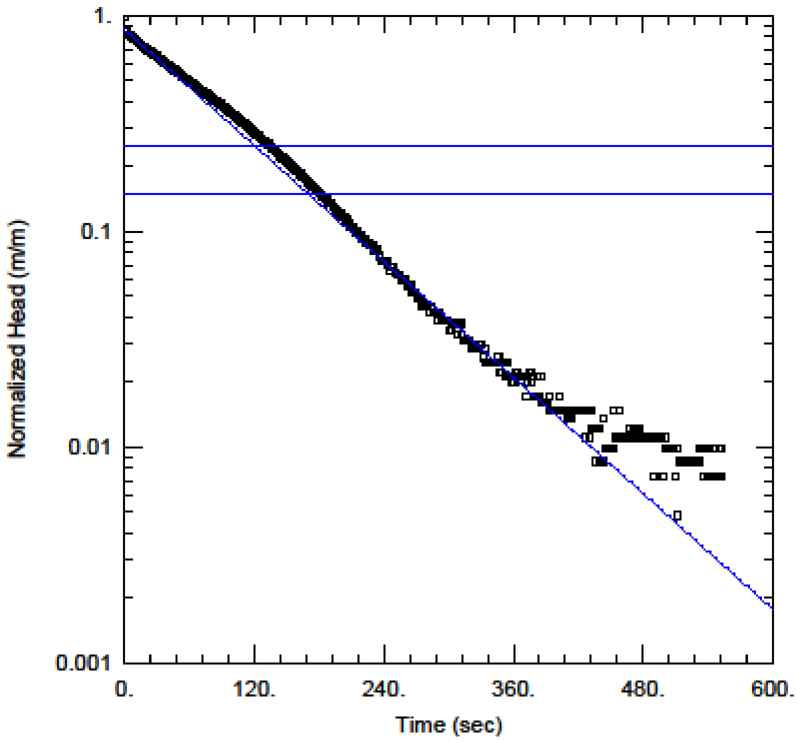
WELL DATA (SFM000109)

Initial Displacement: 0.2081 m Static Water Column Height: 3.125 m
Total Well Penetration Depth: 2.5 m Screen Length: 1. m
Casing Radius: 0.09685 m Well Radius: 0.036 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 0.0001568 m/sec y0 = 0.04515 m

Figure A3-6. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000109.*



SFM169_SLUG

Data Set: G:\...\SFM000169_FallingH_corrected.aqt
Date: 11/10/21 Time: 12:59:22

PROJECT INFORMATION

Company: SKB
Test Well: 000169

AQUIFER DATA

Saturated Thickness: 1.64 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SFM000169)

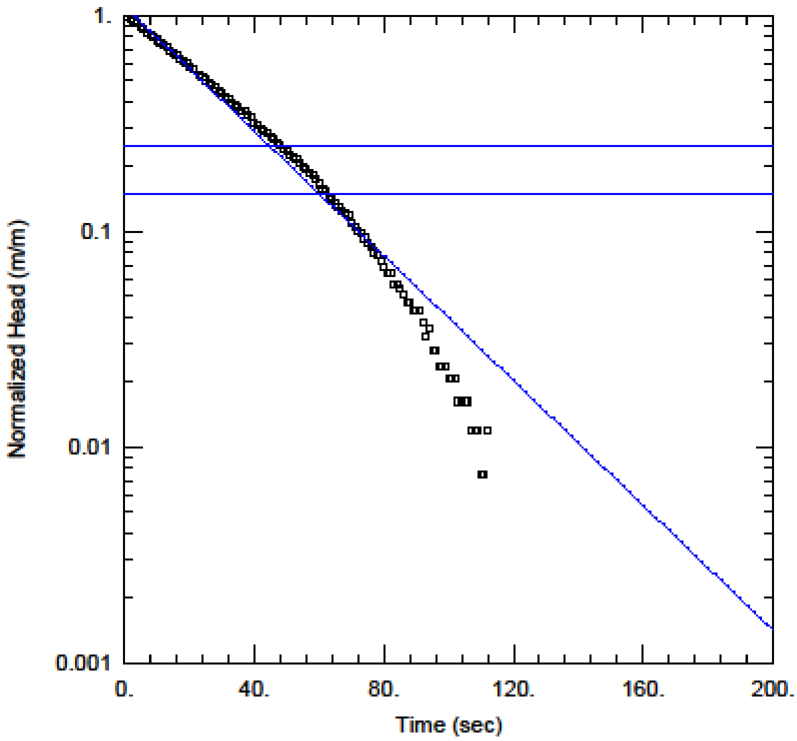
Initial Displacement: 0.467 m
Total Well Penetration Depth: 1.65 m
Casing Radius: 0.0255 m
Static Water Column Height: 2.645 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 1.464E-5 m/sec y0 = 0.406 m

Figure A3-7. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000169.*



SFM169_SLUG

Data Set: G:\...\SFM000169_RisingH_Corrected.aqt
Date: 11/10/21 Time: 13:07:22

PROJECT INFORMATION

Company: SKB
Test Well: 000169

AQUIFER DATA

Saturated Thickness: 1.65 m Anisotropy Ratio (Kz/Kr): 1.

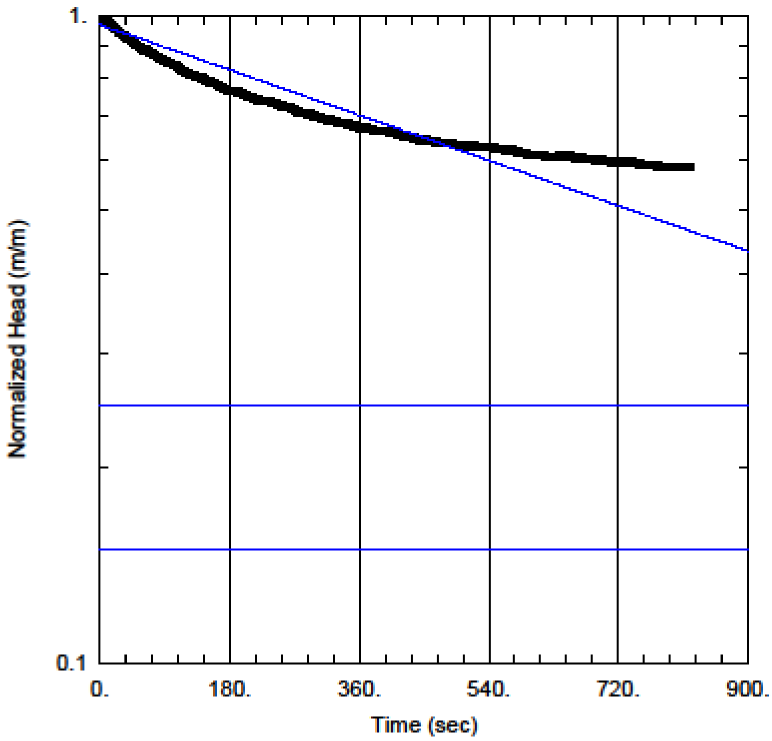
WELL DATA (SFM000169)

Initial Displacement: 0.4 m Static Water Column Height: 2.645 m
Total Well Penetration Depth: 1.65 m Screen Length: 1. m
Casing Radius: 0.0255 m Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 4.722E-5 m/sec y0 = 0.4452 m

Figure A3-8. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000169.*



SLUG171FH

Data Set: G:\...\SFM000171_FH.aqt
Date: 11/10/21 Time: 13:36:37

PROJECT INFORMATION

Company: SKB
Test Well: 000171

AQUIFER DATA

Saturated Thickness: 1.1 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SFM171)

Initial Displacement: 0.956 m
Total Well Penetration Depth: 1.69 m
Casing Radius: 0.0255 m

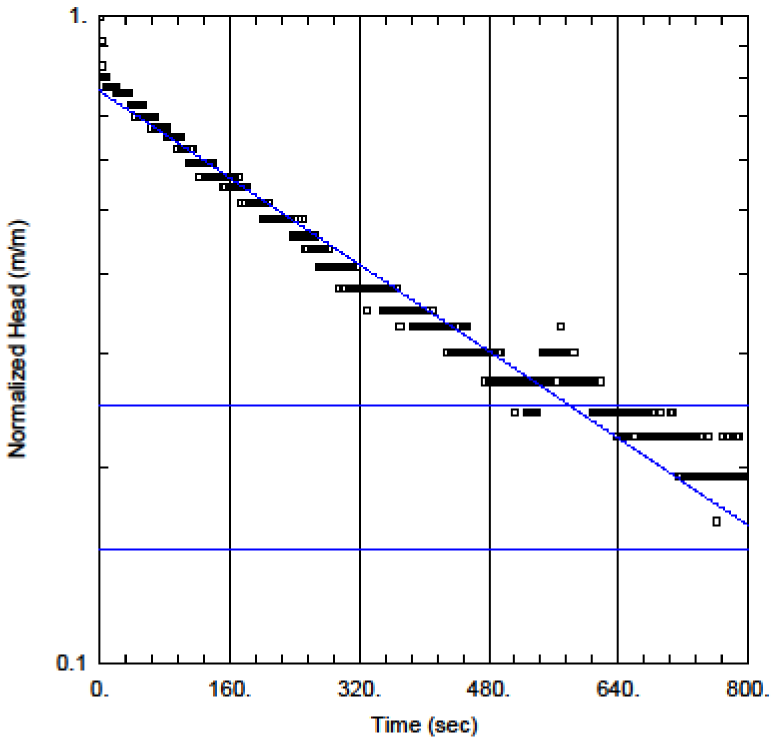
Static Water Column Height: 2.19 m
Screen Length: 0.5 m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 2.134E-6 m/sec y0 = 0.9265 m

Figure A3-9. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000171.*



SLUG171FH

Data Set: G:\...\SFM000171_RH.aqt
Date: 11/10/21 Time: 13:39:56

PROJECT INFORMATION

Company: SKB
Test Well: 000171

AQUIFER DATA

Saturated Thickness: 1.69 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SFM171)

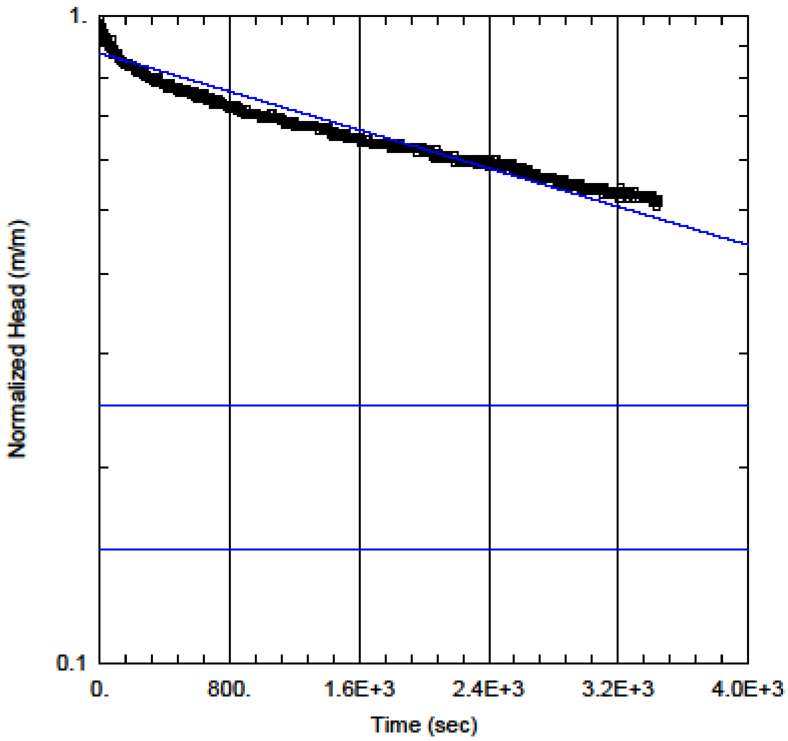
Initial Displacement: 0.06 m
Total Well Penetration Depth: 1.69 m
Casing Radius: 0.0255 m
Static Water Column Height: 2.19 m
Screen Length: 0.5 m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 4.609E-6 m/sec y0 = 0.04598 m

Figure A3-10. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000171.*



SFM000174

Data Set: G:\...\SFM000174_FH.aqt
Date: 11/10/21 Time: 13:45:24

PROJECT INFORMATION

Company: SKB
Test Well: 000174

AQUIFER DATA

Saturated Thickness: 0.4 m Anisotropy Ratio (Kz/Kr): 1.

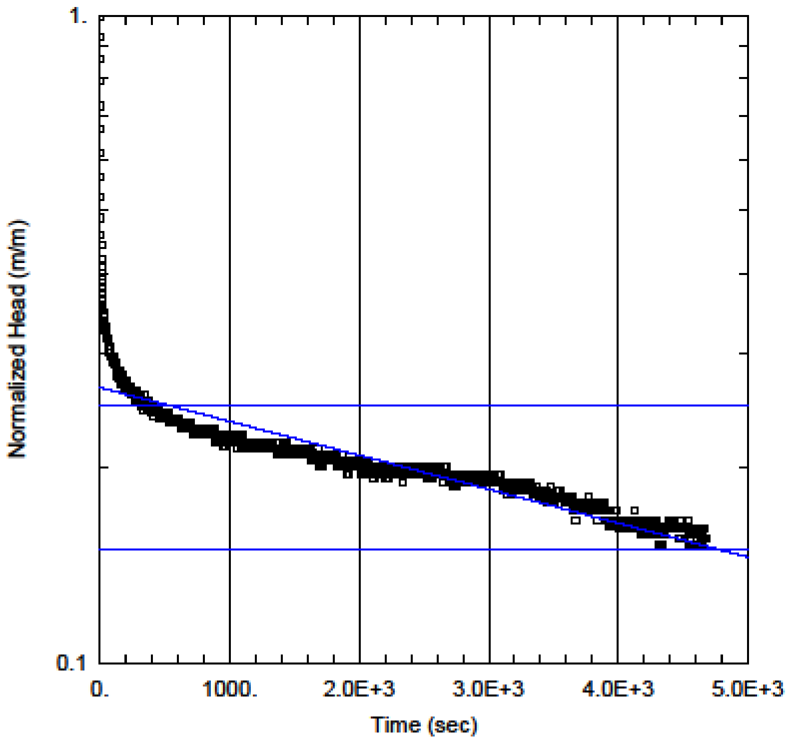
WELL DATA (SFM000174)

Initial Displacement: 0.23 m
Total Well Penetration Depth: 1. m
Casing Radius: 0.0255 m
Static Water Column Height: 1.485 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 7.348E-7 m/sec y0 = 0.2015 m

Figure A3-11. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000174.*



SFM000174

Data Set: G:\...\SFM000174_RH.aqt
Date: 11/11/21
Time: 09:45:30

PROJECT INFORMATION

Company: SKB
Test Well: 000174

AQUIFER DATA

Saturated Thickness: 0.48 m
Anisotropy Ratio (Kz/Kr): 1.

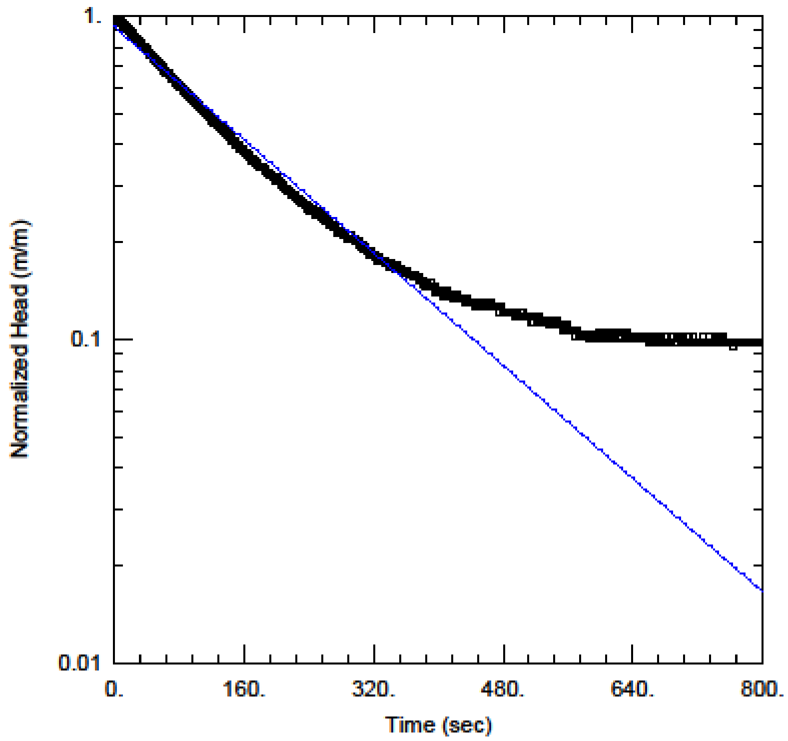
WELL DATA (SFM000174)

Initial Displacement: 0.34 m
Total Well Penetration Depth: 1. m
Casing Radius: 0.0255 m
Static Water Column Height: 1.485 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 4.328E-7 m/sec
y0 = 0.09055 m

Figure A3-12. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000174.*



SLUG176FH

Data Set: G:\...\SFM000176_FH.aqt
Date: 11/11/21
Time: 10:03:42

PROJECT INFORMATION

Company: SKB
Test Well: SFM000176

AQUIFER DATA

Saturated Thickness: 0.9 m
Anisotropy Ratio (Kz/Kr): 1.

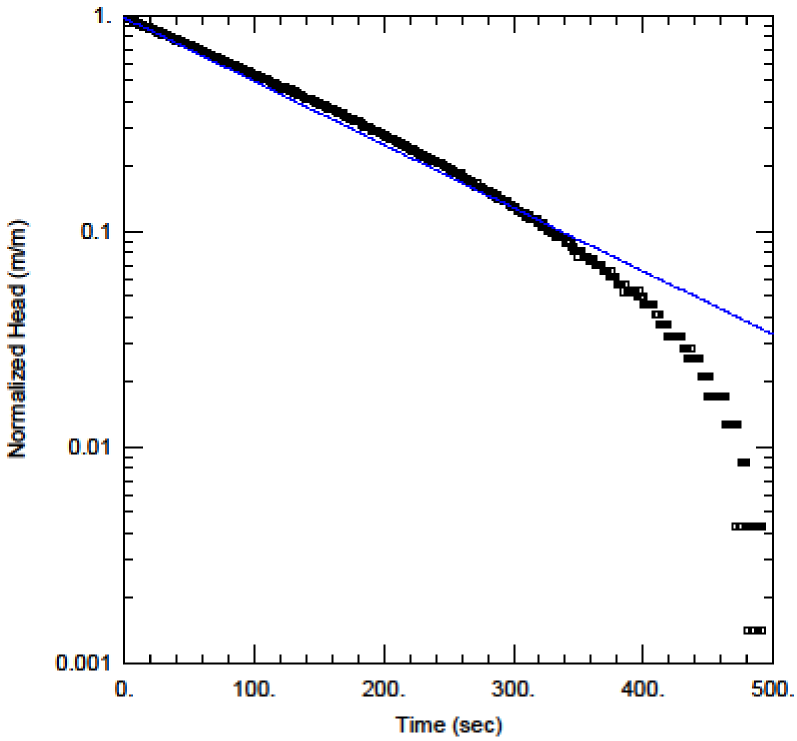
WELL DATA (176)

Initial Displacement: 0.432 m
Total Well Penetration Depth: 3.32 m
Casing Radius: 0.0255 m
Static Water Column Height: 4.32 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev
K = 9.617E-6 m/sec
y0 = 0.4013 m

Figure A3-13. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000176.*



SLUG176FH

Data Set: G:\...\176RH.aqt
Date: 11/11/21
Time: 10:24:15

PROJECT INFORMATION

Company: SKB
Test Well: SFM000176

AQUIFER DATA

Saturated Thickness: 0.9 m
Anisotropy Ratio (Kz/Kr): 1.

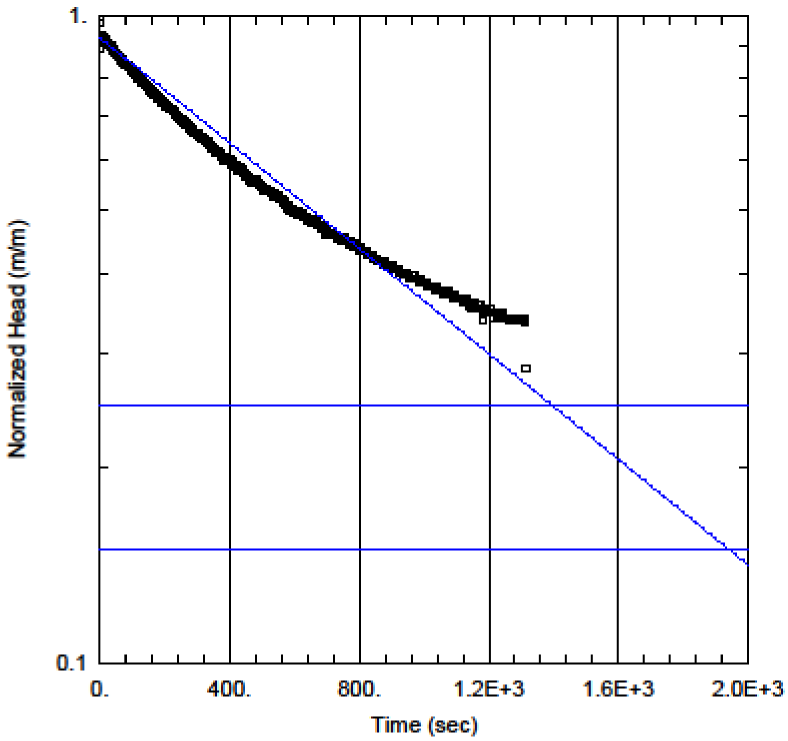
WELL DATA (176)

Initial Displacement: 0.41 m
Total Well Penetration Depth: 3.32 m
Casing Radius: 0.0255 m
Static Water Column Height: 4.26 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev
K = 1.293E-5 m/sec
y0 = 0.4013 m

Figure A3-14. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000176.*



SFM000177_FH

Data Set: G:\...\SFM000177_FH.aqt
Date: 11/11/21 Time: 10:21:59

PROJECT INFORMATION

Company: SKB
Test Well: 000177

AQUIFER DATA

Saturated Thickness: 1.6 m Anisotropy Ratio (Kz/Kr): 1.

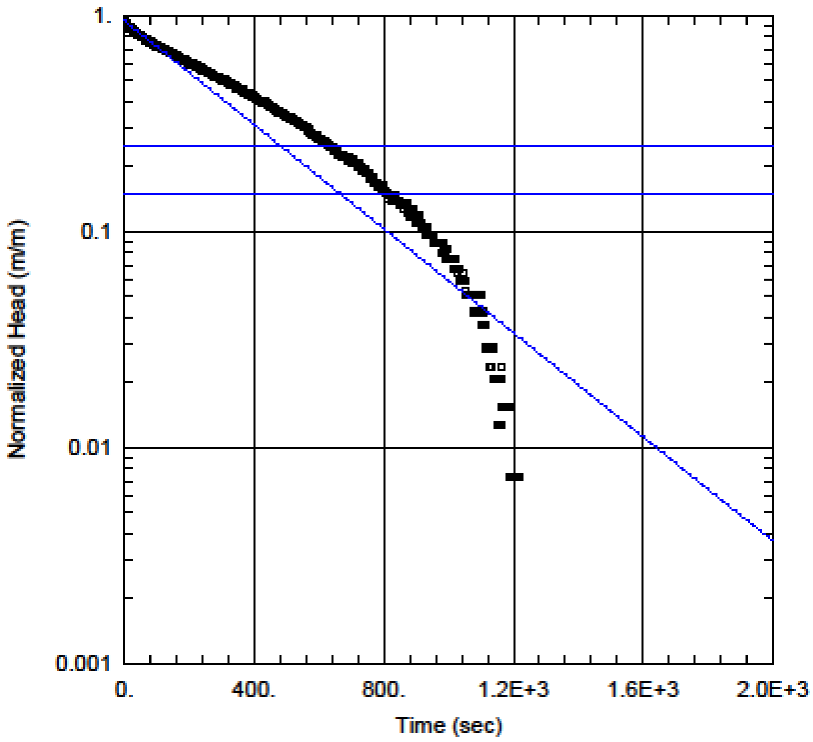
WELL DATA (177)

Initial Displacement: 0.31 m
Total Well Penetration Depth: 2. m
Casing Radius: 0.0255 m
Static Water Column Height: 2.6 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 1.331E-6 m/sec y0 = 0.2873 m

Figure A3-15. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000177.*



SFM000177_RH

Data Set: G:\...\SFM000177_RH.aqt
Date: 11/11/21 Time: 10:23:26

PROJECT INFORMATION

Company: SKB
Test Well: 000177

AQUIFER DATA

Saturated Thickness: 1.6 m Anisotropy Ratio (Kz/Kr): 1.

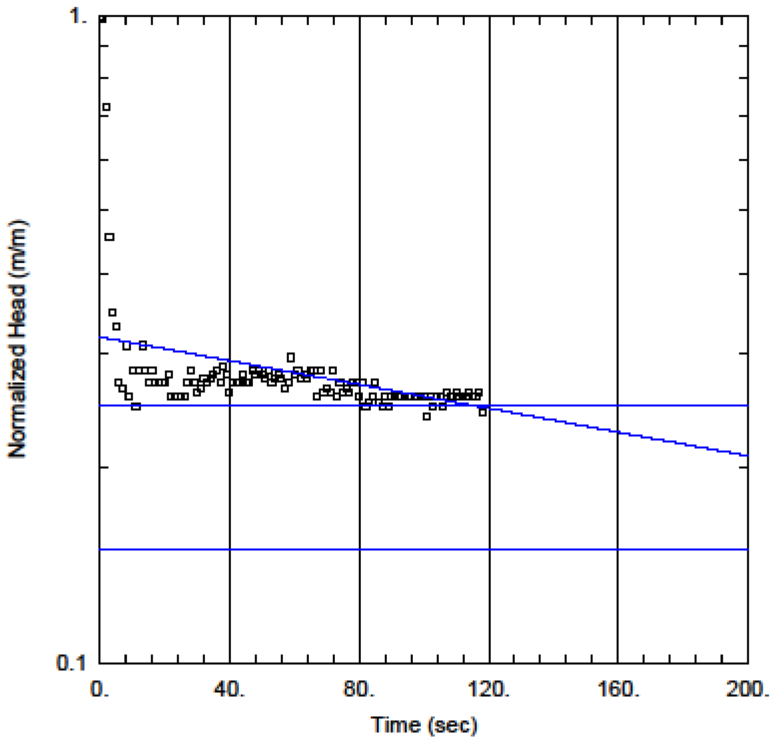
WELL DATA (177)

Initial Displacement: 0.216 m
Total Well Penetration Depth: 2. m
Casing Radius: 0.0255 m
Static Water Column Height: 2.6 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev
K = 3.935E-6 m/sec
y0 = 0.2059 m

Figure A3-16. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000177.*



SFM000179FH

Data Set: G:\...\SFM000179_FH.aqt
Date: 11/12/21
Time: 09:40:14

PROJECT INFORMATION

Company: SKB
Test Well: 179

AQUIFER DATA

Saturated Thickness: 1. m
Anisotropy Ratio (Kz/Kr): 1.

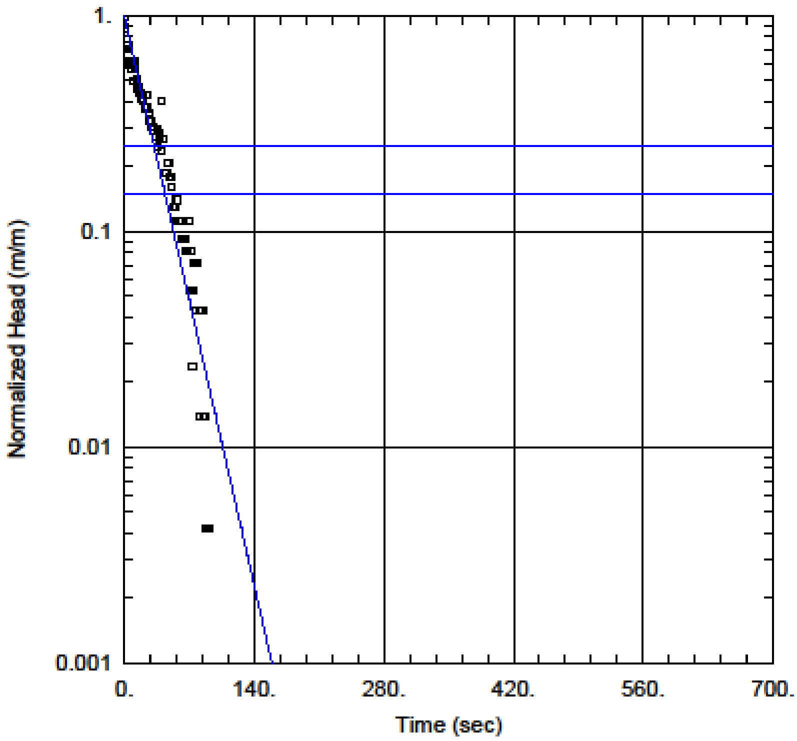
WELL DATA (SFM00179FH)

Initial Displacement: 0.135 m
Total Well Penetration Depth: 4.03 m
Casing Radius: 0.0255 m
Static Water Column Height: 4.03 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev
K = 3.002E-6 m/sec
y0 = 0.04303 m

Figure A3-17. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000179.*



SFM000179FH

Data Set: G:\...\SFM000179_RH.aqt
Date: 11/12/21
Time: 09:41:35

PROJECT INFORMATION

Company: SKB
Test Well: 179

AQUIFER DATA

Saturated Thickness: 1. m
Anisotropy Ratio (Kz/Kr): 1.

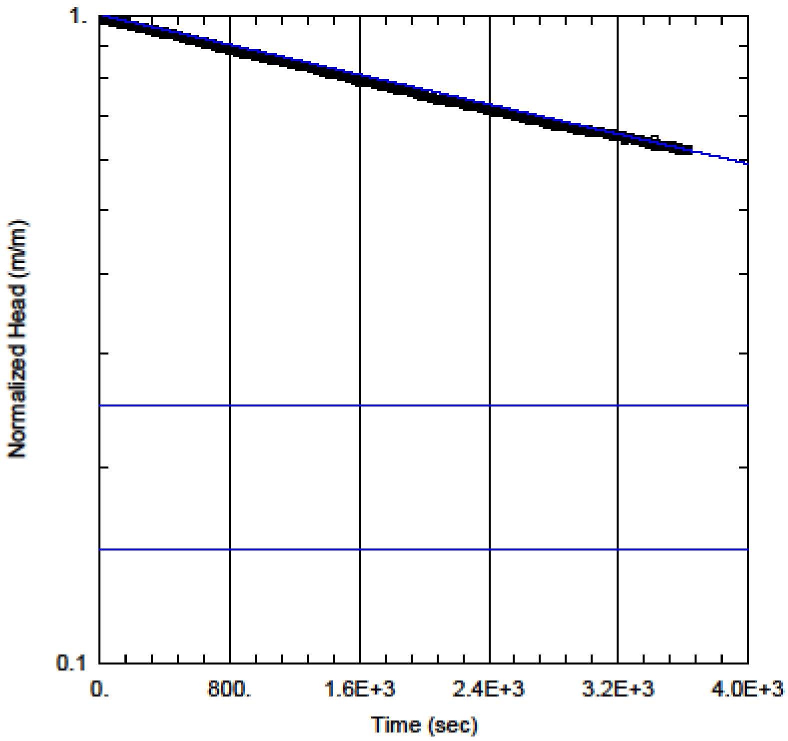
WELL DATA (SFM00179FH)

Initial Displacement: 0.06 m
Total Well Penetration Depth: 4.03 m
Casing Radius: 0.0255 m
Static Water Column Height: 4.03 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev
K = 6.148E-5 m/sec
y0 = 0.05984 m

Figure A3-18. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000179.*



SFM000180FH

Data Set: G:\...\SFM000180_FH.aqt
Date: 11/12/21 Time: 09:55:30

PROJECT INFORMATION

Company: SKB
Test Well: 180

AQUIFER DATA

Saturated Thickness: 3.4 m Anisotropy Ratio (Kz/Kr): 1.

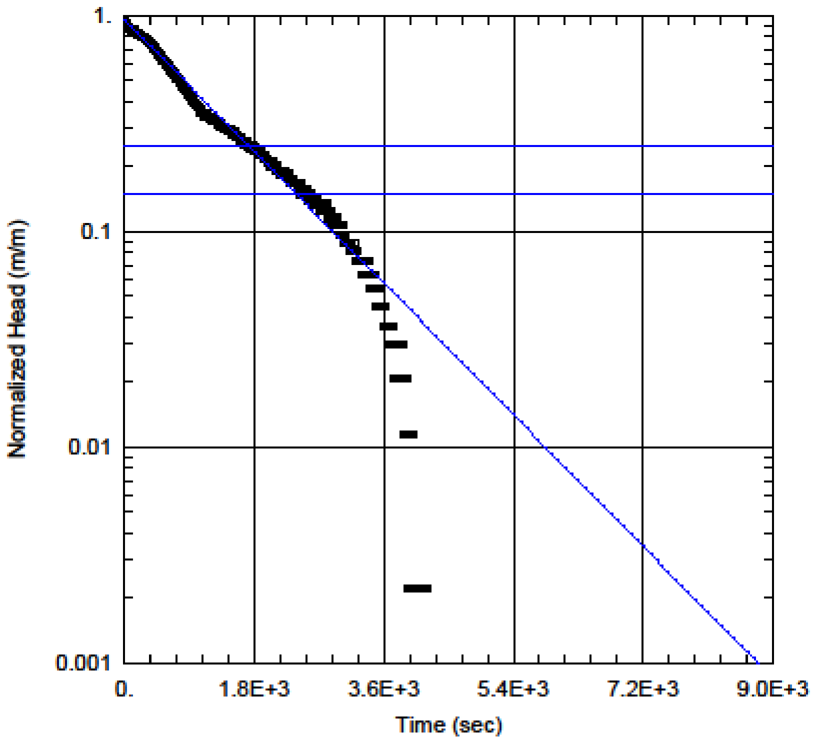
WELL DATA (SFM000180FH)

Initial Displacement: 0.46 m
Total Well Penetration Depth: 2.78 m
Casing Radius: 0.0255 m
Static Water Column Height: 3.78 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

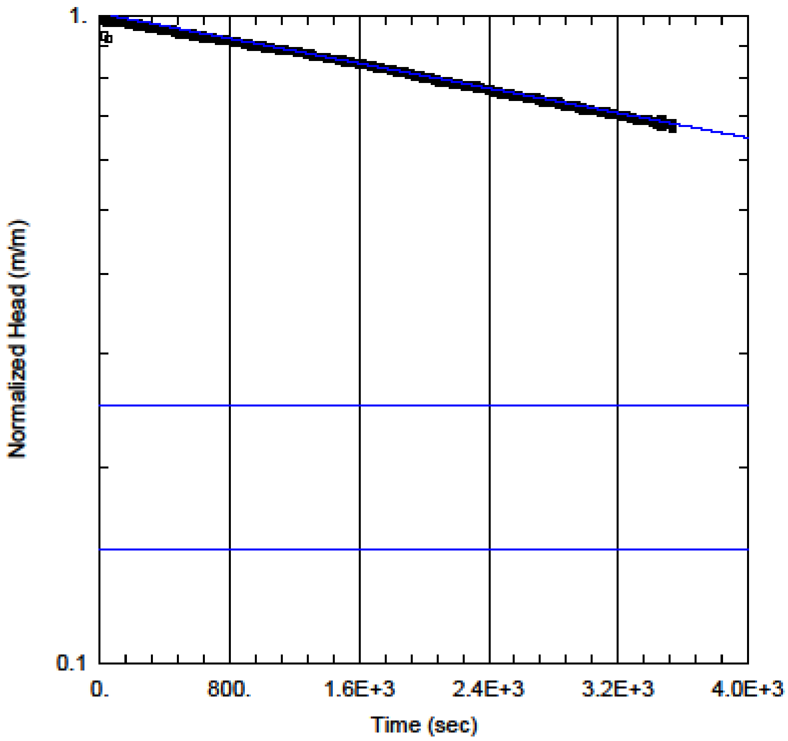
Aquifer Model: Confined Solution Method: Hvorslev
K = 1.578E-7 m/sec y0 = 0.4614 m

Figure A3-19. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000180.*



SFM000180FH	
Data Set: G:\...\SFM000180_RH.aqt	
Date: 11/12/21	Time: 09:59:38
PROJECT INFORMATION	
Company: SKB	
Test Well: 180	
AQUIFER DATA	
Saturated Thickness: 3.4 m	Anisotropy Ratio (Kz/Kr): 1.
WELL DATA (SFM000180FH)	
Initial Displacement: 0.19 m	Static Water Column Height: 3.78 m
Total Well Penetration Depth: 2.78 m	Screen Length: 1. m
Casing Radius: 0.0255 m	Well Radius: 0.0255 m
SOLUTION	
Aquifer Model: Confined	Solution Method: Hvorslev
K = 9.319E-7 m/sec	y0 = 0.1834 m

Figure A3-20. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000180.*



SFM000182FH

Data Set: G:\...\SFM000182_FH.aqt
Date: 11/12/21 Time: 10:08:03

PROJECT INFORMATION

Company: SKB
Test Well: 182

AQUIFER DATA

Saturated Thickness: 1.71 m Anisotropy Ratio (Kz/Kr): 1.

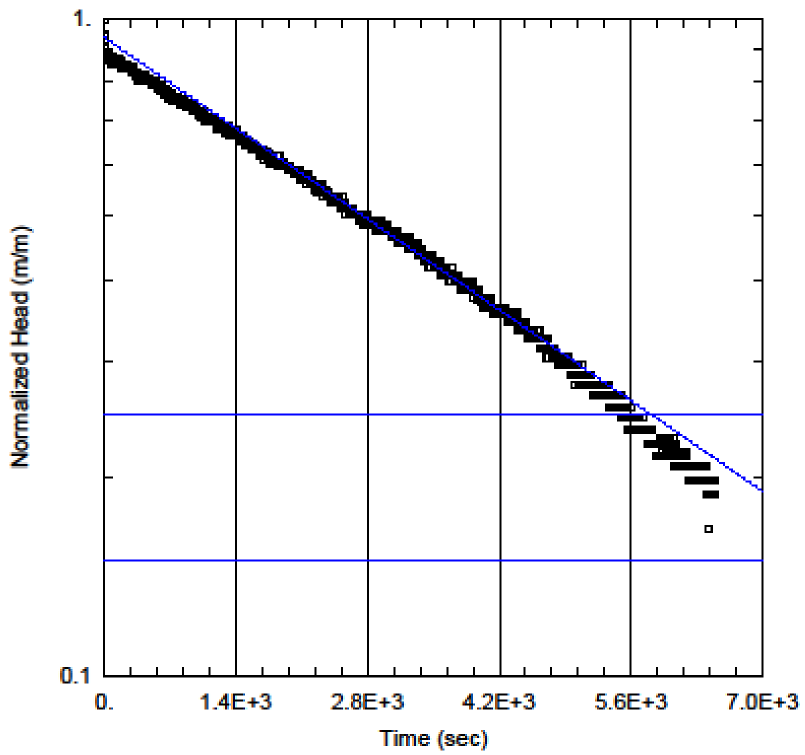
WELL DATA (SFM000182)

Initial Displacement: 0.459 m Static Water Column Height: 2.71 m
Total Well Penetration Depth: 1.71 m Screen Length: 1. m
Casing Radius: 0.0255 m Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 1.566E-7 m/sec y0 = 0.4625 m

Figure A3-21. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000182.*



SFM000182RH

Data Set: G:\...\SFM000182_RH.aqt
Date: 11/12/21 Time: 10:09:02

PROJECT INFORMATION

Company: SKB
Test Well: 182

AQUIFER DATA

Saturated Thickness: 1.71 m Anisotropy Ratio (Kz/Kr): 1.

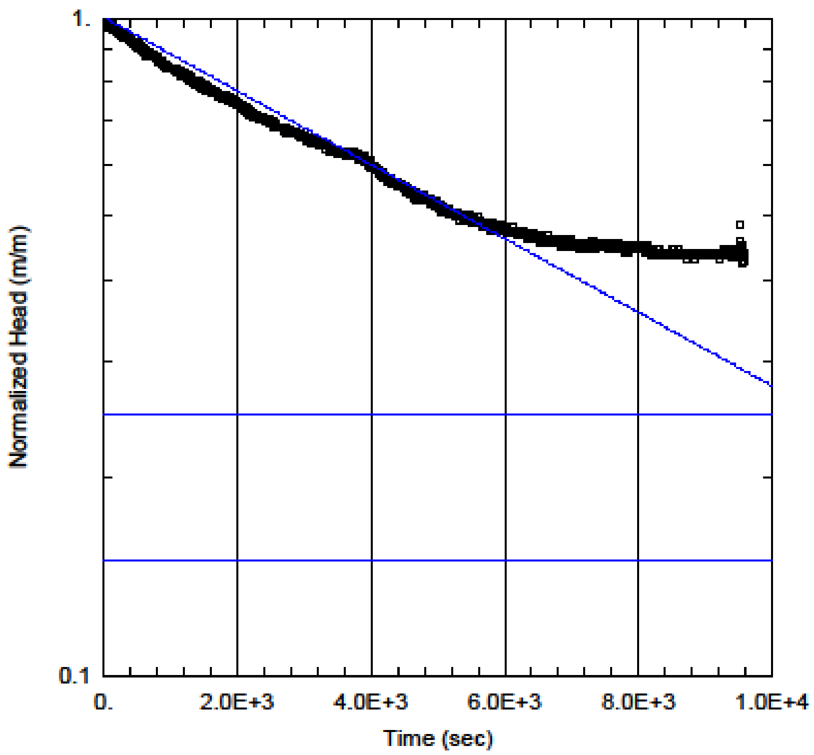
WELL DATA (SFM000182)

Initial Displacement: 0.17 m
Total Well Penetration Depth: 1.71 m
Casing Radius: 0.0255 m
Static Water Column Height: 2.71 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

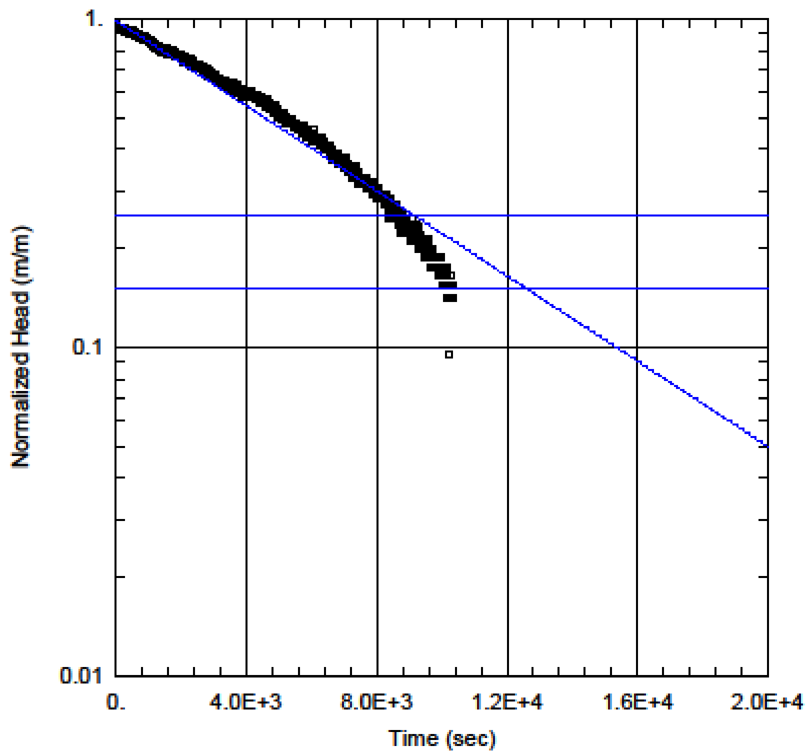
Aquifer Model: Confined Solution Method: Hvorslev
K = 3.223E-7 m/sec y0 = 0.1593 m

Figure A3-22. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000182.*



SFM000183	
Data Set: G:\...\SFM000183_FH.aqt	
Date: 11/12/21	Time: 10:12:38
PROJECT INFORMATION	
Company: SKB	
Test Well: 183	
AQUIFER DATA	
Saturated Thickness: 2.8 m	Anisotropy Ratio (Kz/Kr): 1.
WELL DATA (SFM000183)	
Initial Displacement: 0.316 m	Static Water Column Height: 6.14 m
Total Well Penetration Depth: 5.14 m	Screen Length: 1. m
Casing Radius: 0.0255 m	Well Radius: 0.0255 m
SOLUTION	
Aquifer Model: Confined	Solution Method: Hvorslev
K = 1.834E-7 m/sec	y0 = 0.3179 m

Figure A3-23. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000183.*



SFM000183

Data Set: G:\...\SFM000183_RH.aqt
Date: 11/12/21 Time: 10:14:30

PROJECT INFORMATION

Company: SKB
Test Well: 183

AQUIFER DATA

Saturated Thickness: 2.8 m Anisotropy Ratio (Kz/Kr): 1.

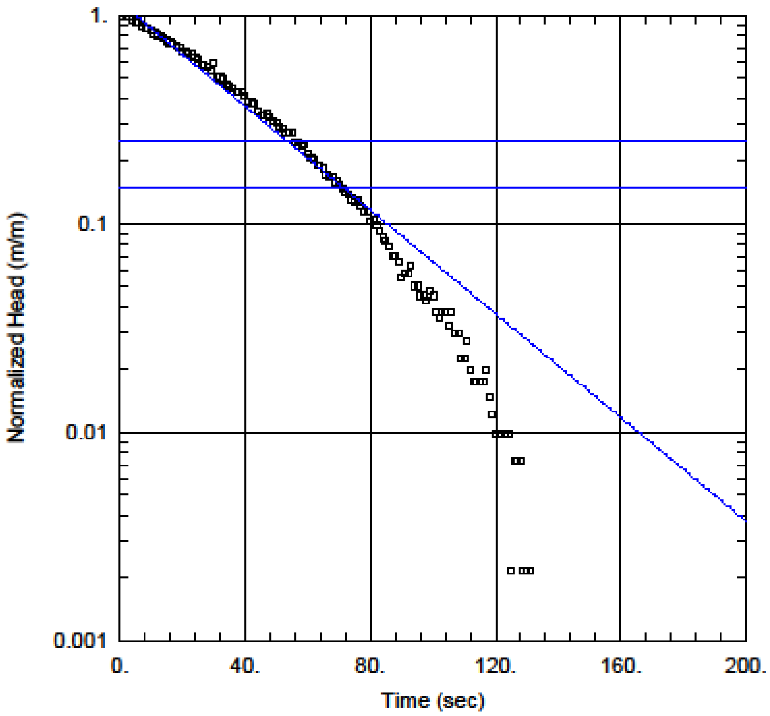
WELL DATA (SFM000183)

Initial Displacement: 0.14 m Static Water Column Height: 6.14 m
Total Well Penetration Depth: 5.14 m Screen Length: 1. m
Casing Radius: 0.0255 m Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 2.115E-7 m/sec y0 = 0.1383 m

Figure A3-24. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000183.*



SFM000187

Data Set: G:\...\SFM000187_FH.aqt
Date: 11/11/21
Time: 10:35:04

PROJECT INFORMATION

Company: SKB
Test Well: 000187

AQUIFER DATA

Saturated Thickness: 2. m
Anisotropy Ratio (Kz/Kr): 1.

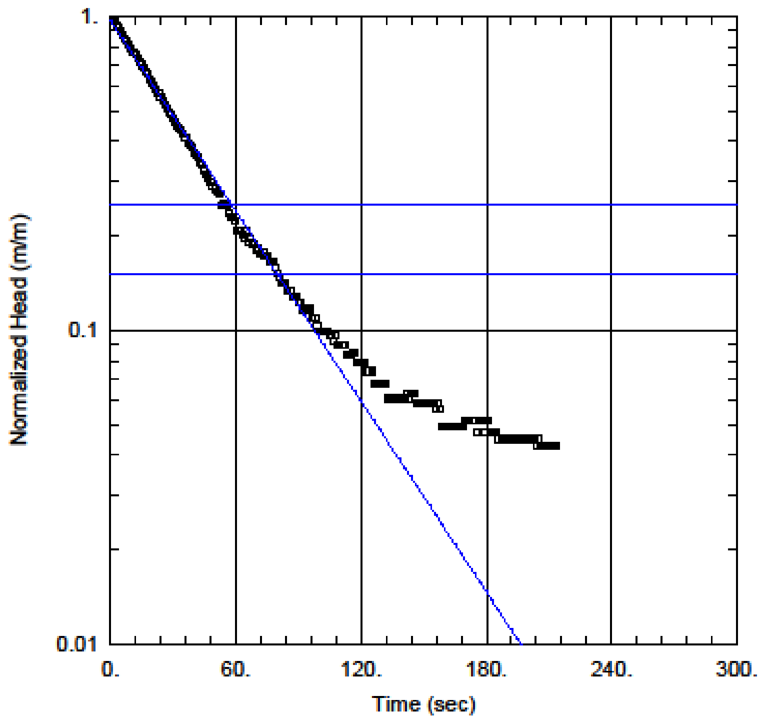
WELL DATA (SFM000187)

Initial Displacement: 0.23 m
Total Well Penetration Depth: 2. m
Casing Radius: 0.0255 m
Static Water Column Height: 3.02 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev
K = 4.065E-5 m/sec
y0 = 0.2672 m

Figure A3-25. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000187.*



SFM000187

Data Set: G:\...\SFM000187_RH.aqt
Date: 11/11/21 Time: 10:33:33

PROJECT INFORMATION

Company: SKB
Test Well: 000187

AQUIFER DATA

Saturated Thickness: 2. m Anisotropy Ratio (Kz/Kr): 1.

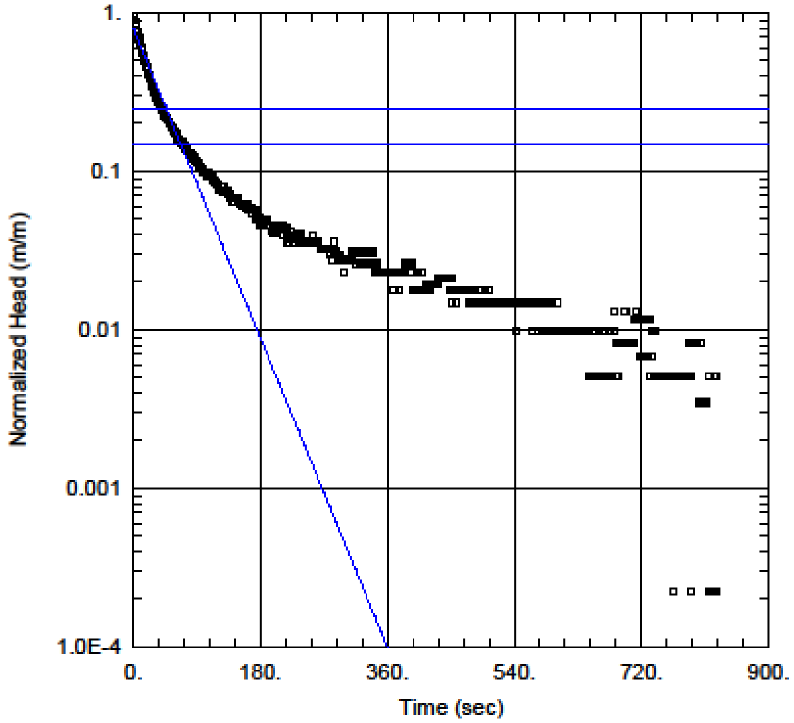
WELL DATA (SFM000187)

Initial Displacement: 0.261 m
Total Well Penetration Depth: 2. m
Casing Radius: 0.0255 m
Static Water Column Height: 3.02 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 3.305E-5 m/sec y0 = 0.2552 m

Figure A3-26. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000187.*



SFM000188

Data Set: G:\...\SFM000188_FH.aqt
Date: 11/11/21
Time: 10:43:26

PROJECT INFORMATION

Company: SKB
Test Well: 000188

AQUIFER DATA

Saturated Thickness: 0.85 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SFM000188)

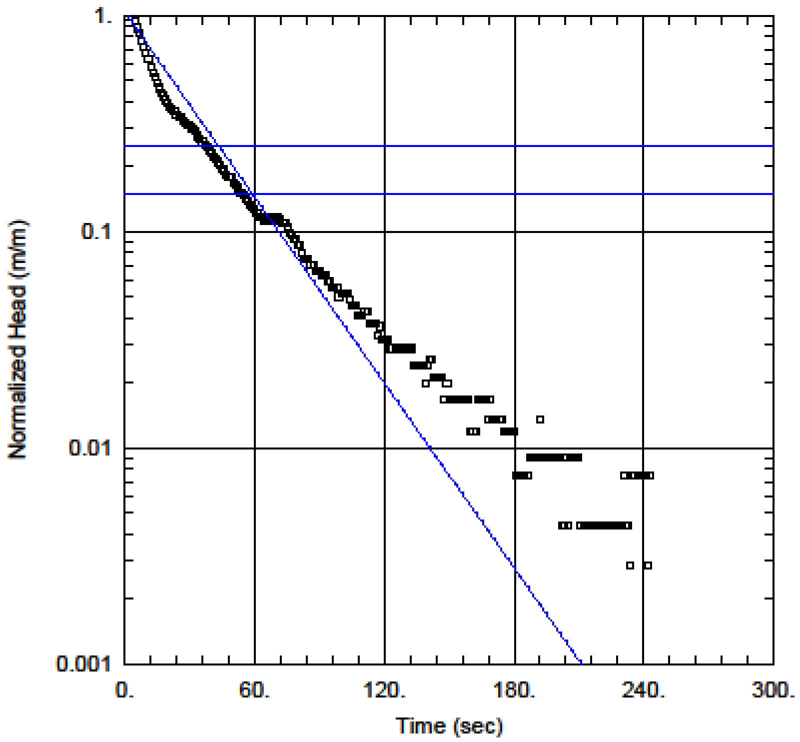
Initial Displacement: 0.36 m
Total Well Penetration Depth: 1. m
Casing Radius: 0.0255 m
Static Water Column Height: 1.84 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 5.06E-5 m/sec
y0 = 0.2902 m

Figure A3-27. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000188.*



SFM000188

Data Set: G:\...\SFM000188_RH.aqt
Date: 11/11/21
Time: 10:56:54

PROJECT INFORMATION

Company: SKB
Test Well: 000188

AQUIFER DATA

Saturated Thickness: 0.85 m
Anisotropy Ratio (Kz/Kr): 1.

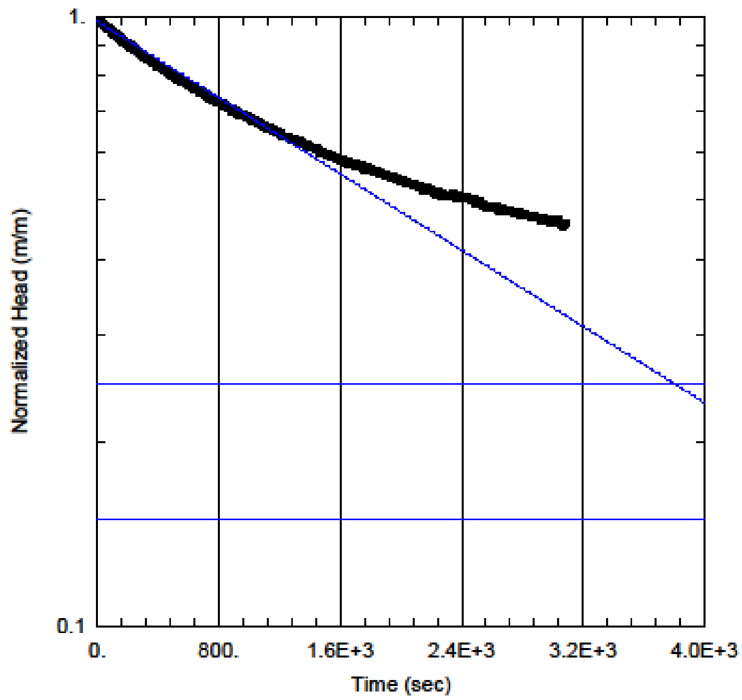
WELL DATA (SFM000188)

Initial Displacement: 0.38 m
Total Well Penetration Depth: 1. m
Casing Radius: 0.0255 m
Static Water Column Height: 1.84 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev
K = 6.668E-5 m/sec
y0 = 0.3987 m

Figure A3-28. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000188.*



SFM000190

Data Set: G:\...\SFM000190_FH.aqt
Date: 11/11/21
Time: 10:56:23

PROJECT INFORMATION

Company: SKB
Test Well: 000190

AQUIFER DATA

Saturated Thickness: 5.74 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SFM000190)

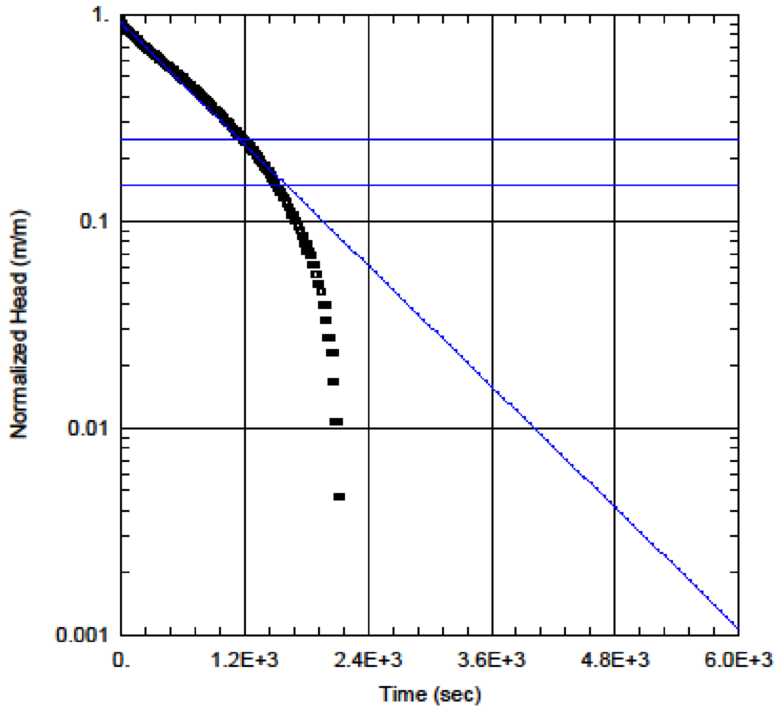
Initial Displacement: 0.44 m
Total Well Penetration Depth: 4.24 m
Casing Radius: 0.0255 m
Static Water Column Height: 5.24 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 4.3E-7 m/sec
y0 = 0.4332 m

Figure A3-29. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000190.*



SFM000190

Data Set: G:\...\SFM000190_RH.aqt
Date: 11/11/21 Time: 10:59:44

PROJECT INFORMATION

Company: SKB
Test Well: 000190

AQUIFER DATA

Saturated Thickness: 5.74 m Anisotropy Ratio (Kz/Kr): 1.

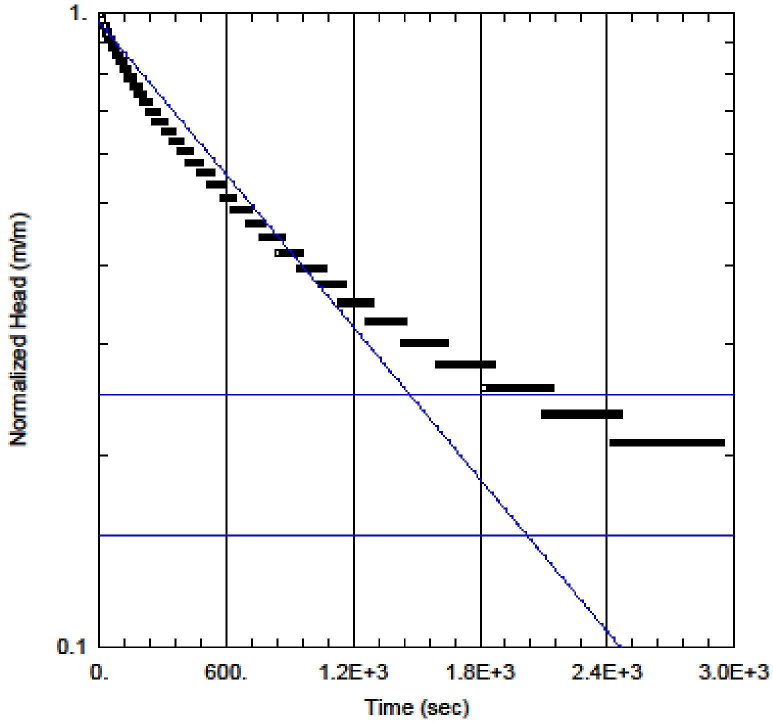
WELL DATA (SFM000190)

Initial Displacement: 0.285 m
Total Well Penetration Depth: 4.24 m
Casing Radius: 0.0255 m
Static Water Column Height: 5.24 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 1.34E-6 m/sec y0 = 0.26 m

Figure A3-30. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000190.*



SLUG_000191_F

Data Set: G:\...\SFM000191_Falling.aqt
Date: 11/11/21 Time: 11:09:54

PROJECT INFORMATION

Company: SKB
Test Well: 000191

AQUIFER DATA

Saturated Thickness: 5.875 m Anisotropy Ratio (Kz/Kr): 1.

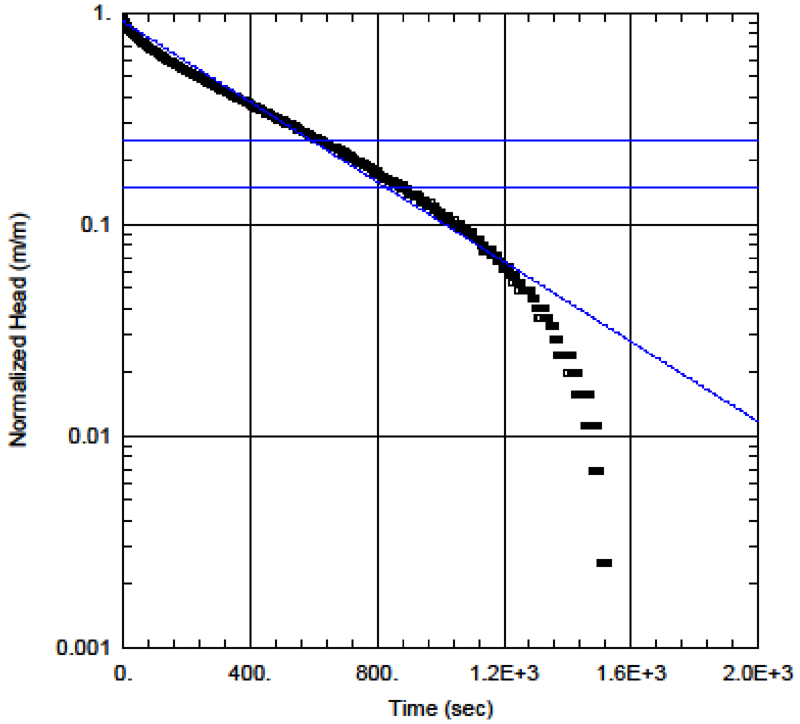
WELL DATA (SFM000191)

Initial Displacement: 0.43 m
Total Well Penetration Depth: 5.875 m
Casing Radius: 0.0255 m
Static Water Column Height: 5.31 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 1.308E-6 m/sec y0 = 0.4168 m

Figure A3-31. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000191.*



SLUG_000191_F

Data Set: G:\...\SFM000191_Rising.aqt
Date: 11/11/21 Time: 13:00:37

PROJECT INFORMATION

Company: SKB
Test Well: 000191

AQUIFER DATA

Saturated Thickness: 5.875 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SFM000191)

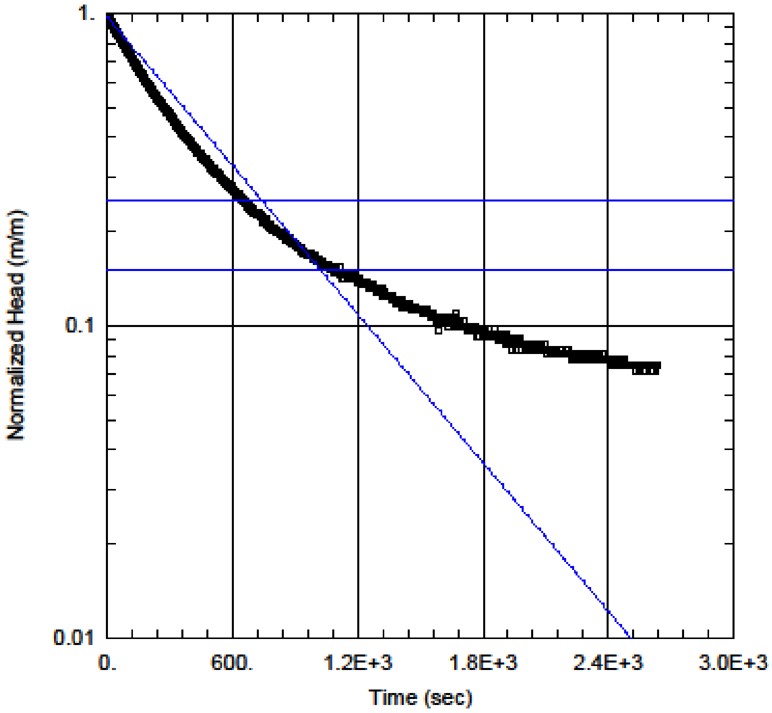
Initial Displacement: 0.4 m
Total Well Penetration Depth: 5.875 m
Casing Radius: 0.0255 m
Static Water Column Height: 5.31 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

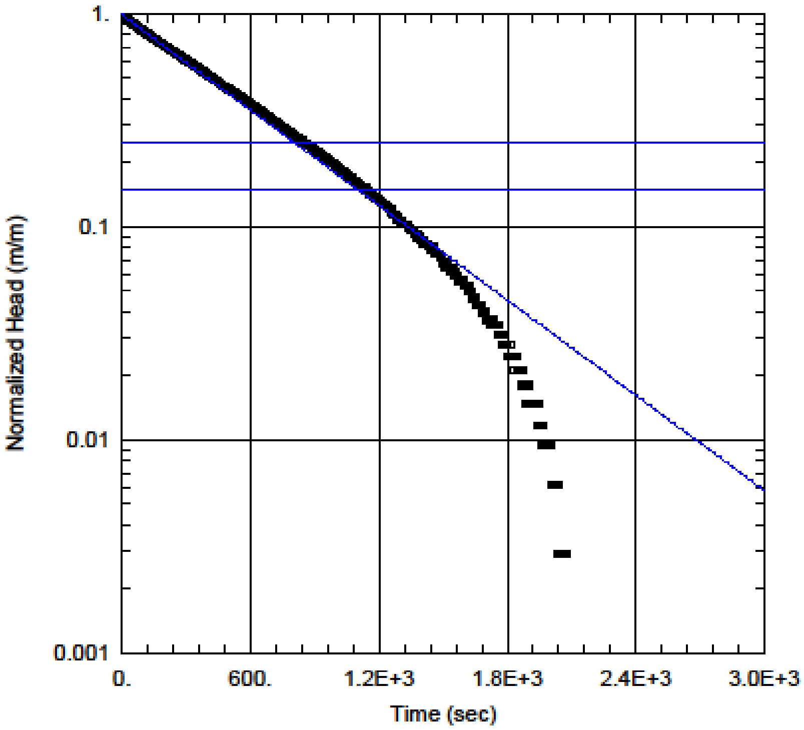
K = 3.087E-6 m/sec y0 = 0.3649 m

Figure A3-32. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000191.*



SFM192_SLUG	
Data Set: G:\...\192_FH.aqt	
Date: 11/11/21	Time: 12:58:44
PROJECT INFORMATION	
Company: SKB	
Test Well: 000192	
AQUIFER DATA	
Saturated Thickness: 6.45 m	Anisotropy Ratio (Kz/Kr): 1.
WELL DATA (SFM192)	
Initial Displacement: 0.525 m	Static Water Column Height: 7.45 m
Total Well Penetration Depth: 6.45 m	Screen Length: 1. m
Casing Radius: 0.0255 m	Well Radius: 0.0255 m
SOLUTION	
Aquifer Model: Confined	Solution Method: Hvorslev
K = 2.588E-6 m/sec	y0 = 0.5126 m

Figure A3-33. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000192.*



SFM192_SLUG

Data Set: G:\...\192_RH.aqt
Date: 11/11/21 Time: 13:01:46

PROJECT INFORMATION

Company: SKB
Test Well: 000192

AQUIFER DATA

Saturated Thickness: 6.45 m Anisotropy Ratio (Kz/Kr): 1.

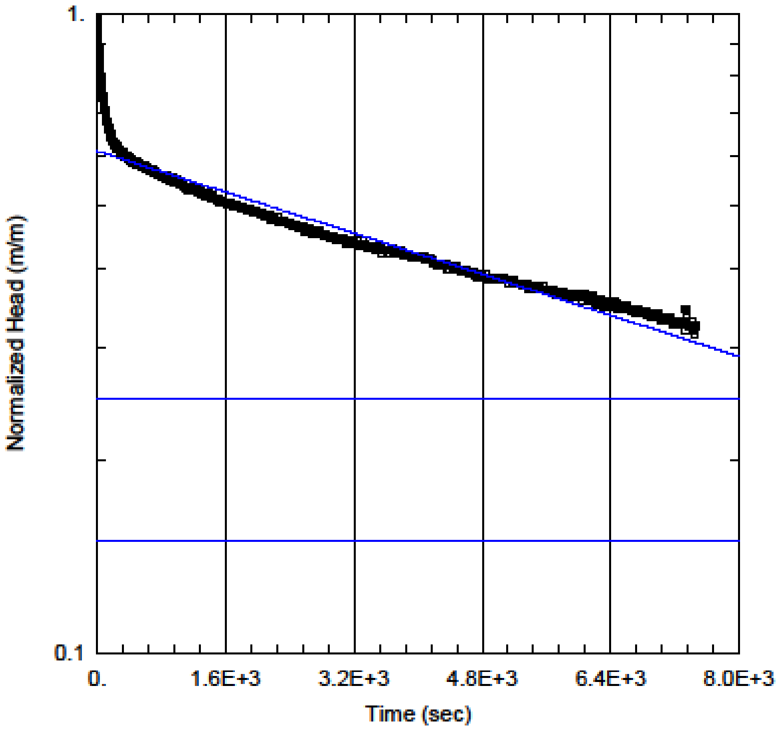
WELL DATA (SFM192)

Initial Displacement: 0.538 m
Total Well Penetration Depth: 6.45 m
Casing Radius: 0.0255 m
Static Water Column Height: 7.45 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 2.43E-6 m/sec y0 = 0.5346 m

Figure A3-34. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000192.*



SFM000193

Data Set: G:\...\SFM000193_FH.aqt
Date: 11/11/21
Time: 13:11:07

PROJECT INFORMATION

Company: SKB
Test Well: 000193

AQUIFER DATA

Saturated Thickness: 1.9 m
Anisotropy Ratio (Kz/Kr): 1.

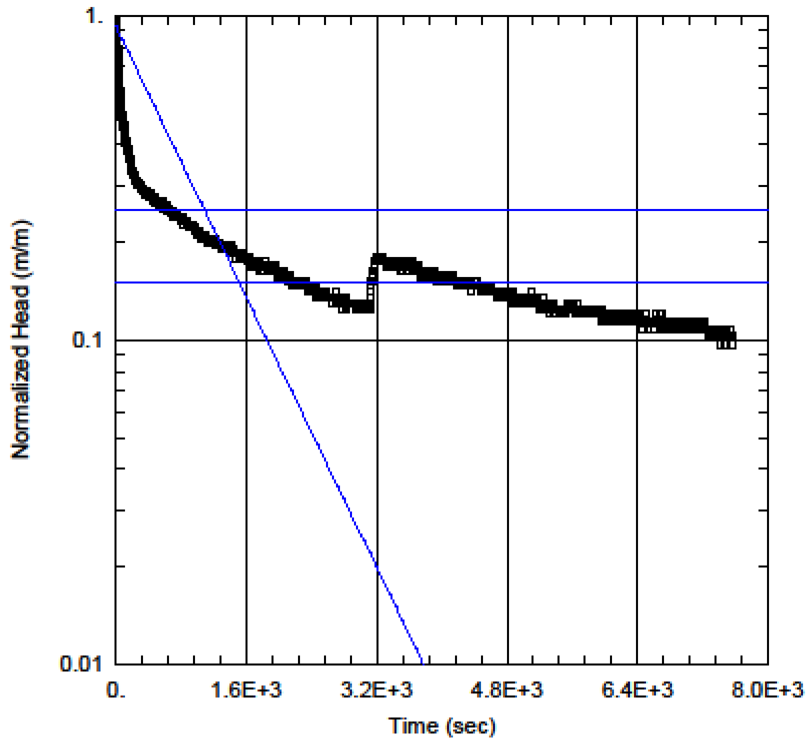
WELL DATA (SFM000193)

Initial Displacement: 0.42 m
Total Well Penetration Depth: 2.1 m
Casing Radius: 0.0255 m
Static Water Column Height: 3.11 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

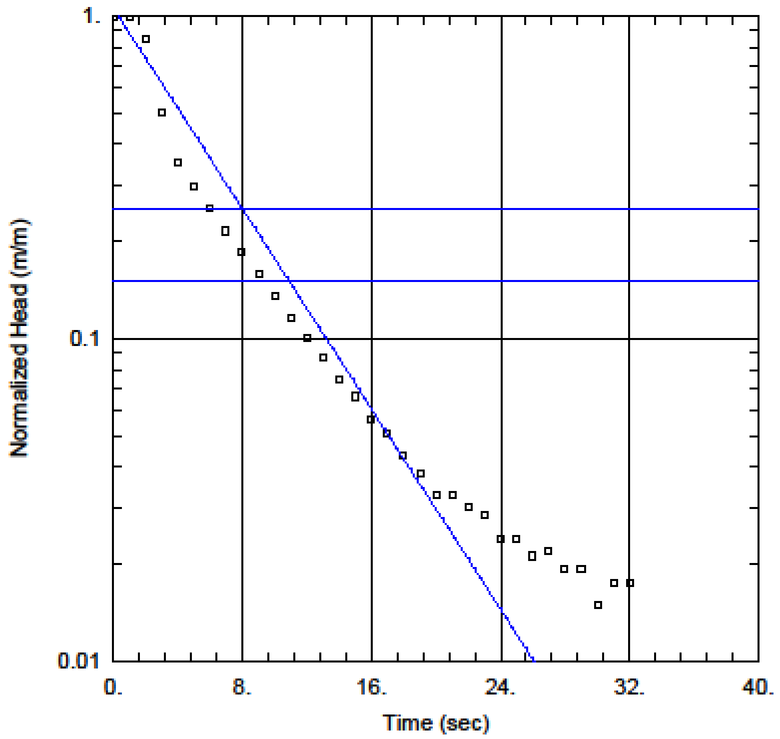
Aquifer Model: Confined
Solution Method: Hvorslev
K = 1.311E-7 m/sec
y0 = 0.2562 m

Figure A3-35. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000193.*



SFM000193	
Data Set: G:\...\SFM000193_RH.aqt	
Date: 11/11/21	Time: 13:12:57
PROJECT INFORMATION	
Company: SKB	
Test Well: 000193	
AQUIFER DATA	
Saturated Thickness: 1.9 m	Anisotropy Ratio (Kz/Kr): 1.
WELL DATA (SFM000193)	
Initial Displacement: 0.3 m	Static Water Column Height: 3.11 m
Total Well Penetration Depth: 2.1 m	Screen Length: 1. m
Casing Radius: 0.0255 m	Well Radius: 0.0255 m
SOLUTION	
Aquifer Model: Confined	Solution Method: Hvorslev
K = 1.703E-6 m/sec	y0 = 0.2797 m

Figure A3-36. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000193.*



SFM000194

Data Set: G:\...\SFM000194_FH.aqt
Date: 11/11/21 Time: 13:20:46

PROJECT INFORMATION

Company: SKB
Test Well: 000194

AQUIFER DATA

Saturated Thickness: 0.7 m Anisotropy Ratio (Kz/Kr): 1.

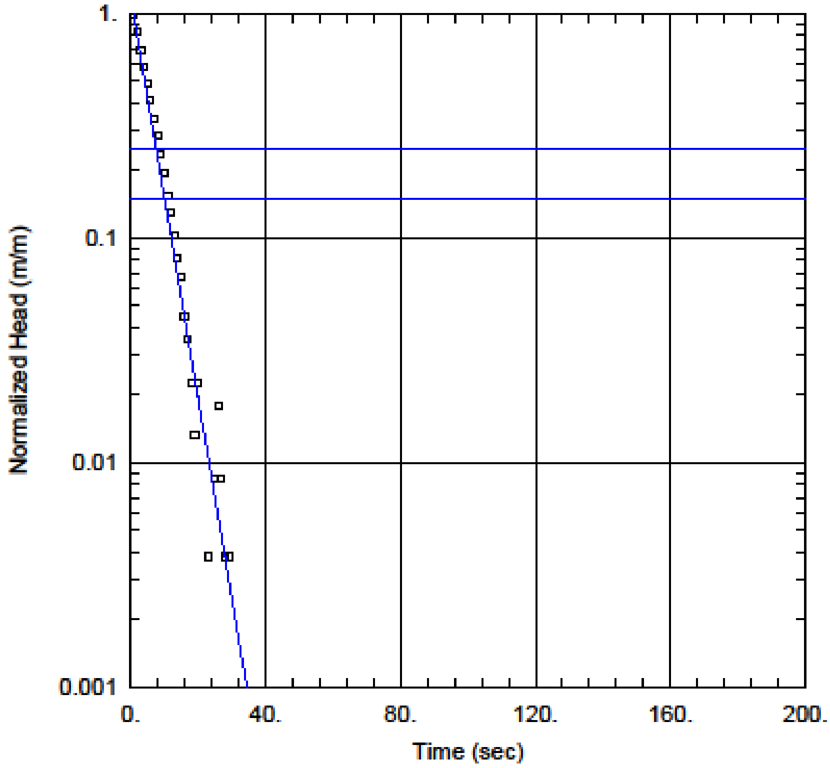
WELL DATA (SFM000194)

Initial Displacement: 0.65 m Static Water Column Height: 2.34 m
Total Well Penetration Depth: 1.3 m Screen Length: 1. m
Casing Radius: 0.0255 m Well Radius: 0.0255 m

SOLUTION

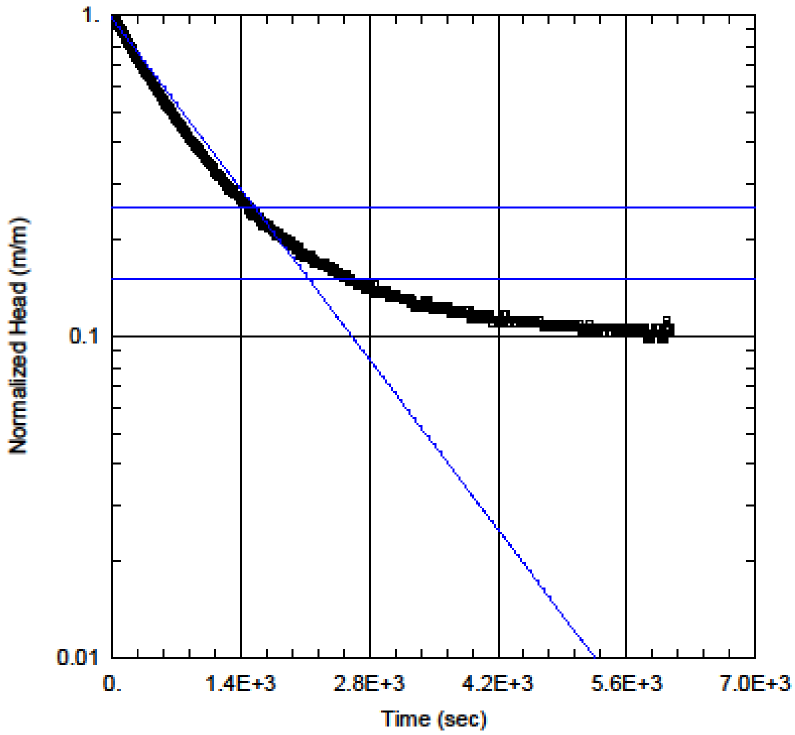
Aquifer Model: Confined Solution Method: Hvorslev
K = 0.0004398 m/sec y0 = 0.6909 m

Figure A3-37. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000194.*



SFM000194	
Data Set: G:\...\SFM000194_RH.aqt	
Date: 11/11/21	Time: 13:22:04
PROJECT INFORMATION	
Company: SKB	
Test Well: 000194	
AQUIFER DATA	
Saturated Thickness: 0.7 m	Anisotropy Ratio (Kz/Kr): 1.
WELL DATA (SFM000194)	
Initial Displacement: 0.372 m	Static Water Column Height: 2.34 m
Total Well Penetration Depth: 1.3 m	Screen Length: 1. m
Casing Radius: 0.0255 m	Well Radius: 0.0255 m
SOLUTION	
Aquifer Model: Confined	Solution Method: Hvorslev
K = 0.0005055 m/sec	y0 = 0.4495 m

Figure A3-38. *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000194.*



SFM195_FH

Data Set: G:\...\SFM000195_Falling.aqt
Date: 11/11/21 Time: 13:30:55

PROJECT INFORMATION

Company: SKB
Test Well: 000195

AQUIFER DATA

Saturated Thickness: 3.8 m Anisotropy Ratio (Kz/Kr): 1.

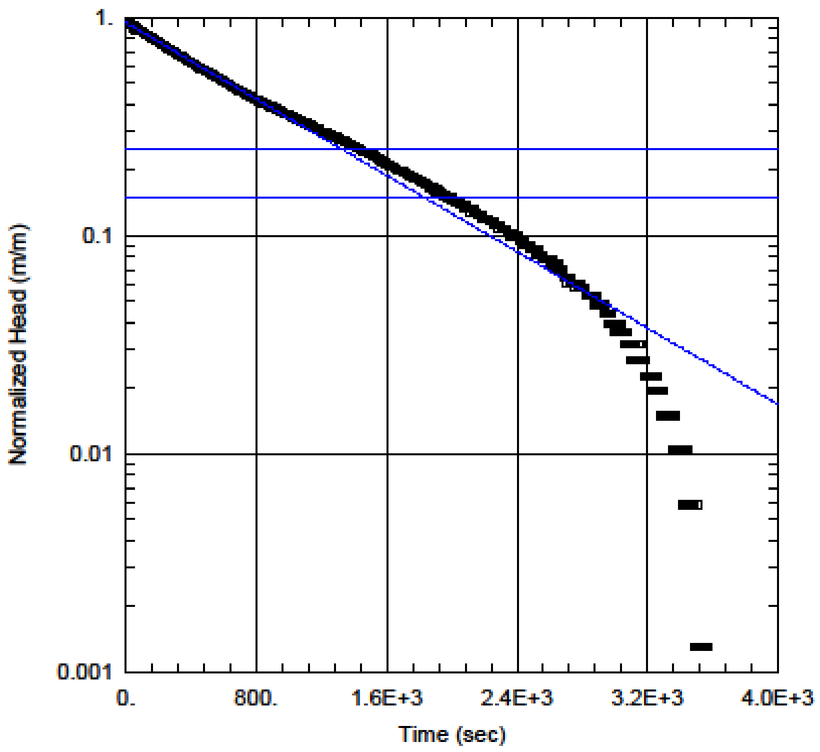
WELL DATA (SFM000195)

Initial Displacement: 0.425 m
Total Well Penetration Depth: 2.9 m
Casing Radius: 0.0255 m
Static Water Column Height: 4.96 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 1.04E-6 m/sec y0 = 0.416 m

Figure A3-39. *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000195.*



SFM195_FH

Data Set: G:\...\SFM000195_Rising.aqt
Date: 11/11/21 Time: 13:32:11

PROJECT INFORMATION

Company: SKB
Test Well: 000195

AQUIFER DATA

Saturated Thickness: 3.8 m Anisotropy Ratio (Kz/Kr): 1.

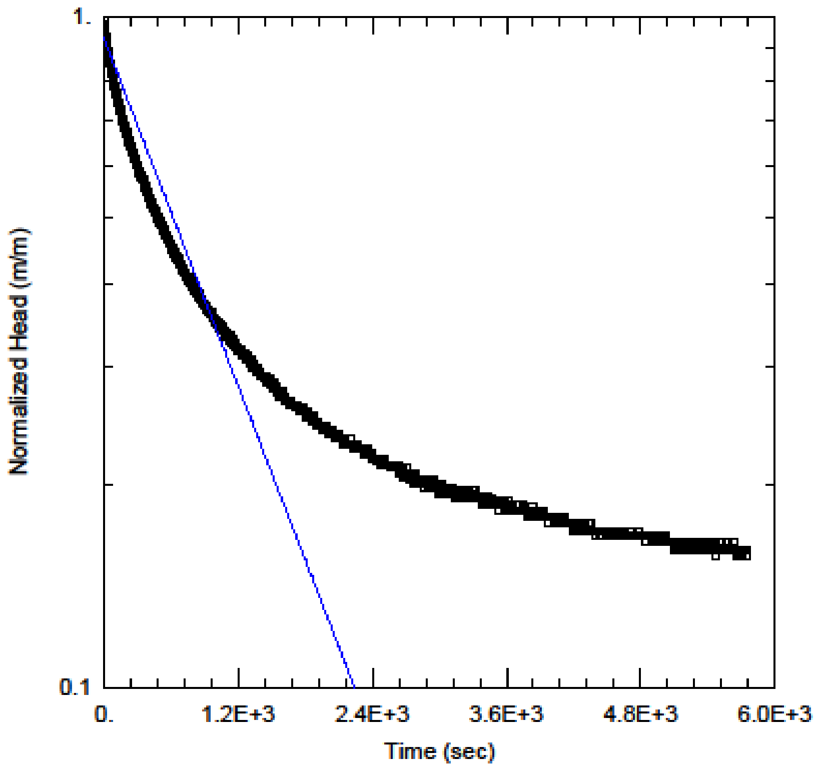
WELL DATA (SFM000195)

Initial Displacement: 0.385 m
Total Well Penetration Depth: 2.9 m
Casing Radius: 0.0255 m
Static Water Column Height: 4.96 m
Screen Length: 1. m
Well Radius: 0.0255 m

SOLUTION

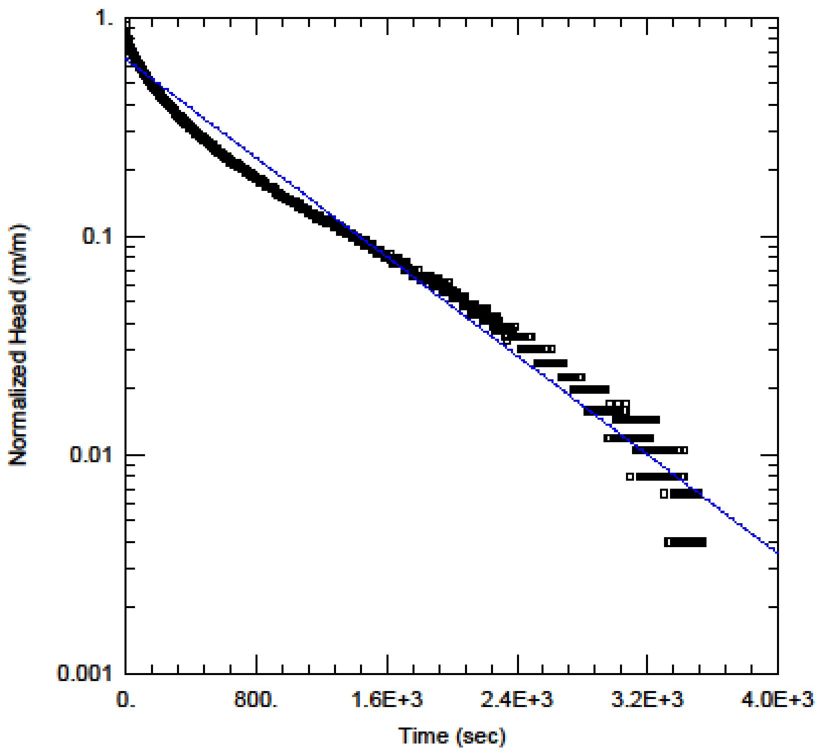
Aquifer Model: Confined Solution Method: Hvorslev
K = 1.202E-6 m/sec y0 = 0.3659 m

FigureA3-40 *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000195.*



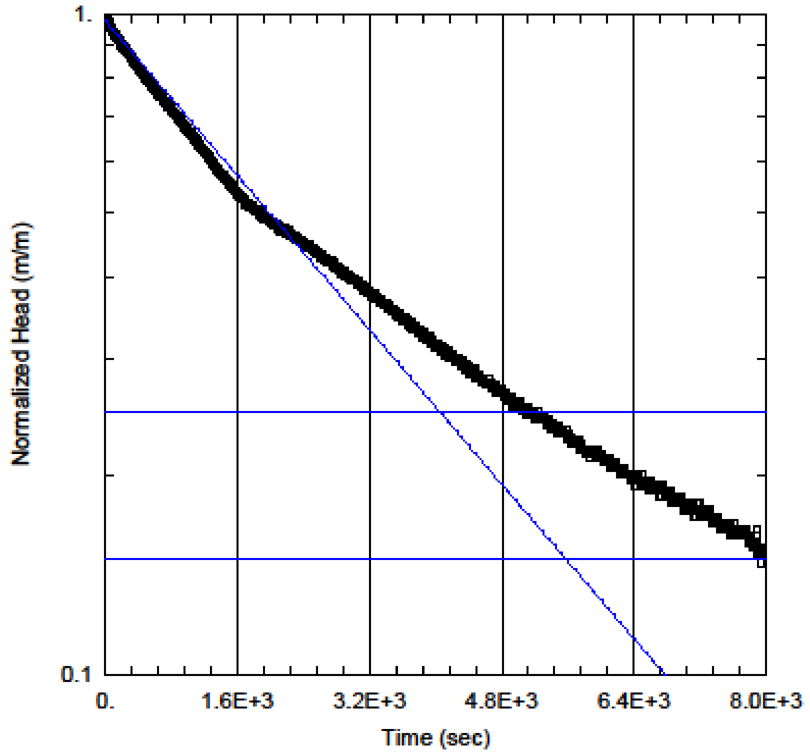
WELL TEST ANALYSIS	
Data Set: G:\...\SFM000197_FH.aqt	
Date: 11/11/21	Time: 13:43:50
PROJECT INFORMATION	
Company: SKB	
Test Well: SFM000197	
AQUIFER DATA	
Saturated Thickness: 0.95 m	Anisotropy Ratio (Kz/Kr): 1.
WELL DATA (197)	
Initial Displacement: 0.44 m	Static Water Column Height: 7.59 m
Total Well Penetration Depth: 6.59 m	Screen Length: 1. m
Casing Radius: 0.0255 m	Well Radius: 0.0255 m
SOLUTION	
Aquifer Model: Confined	Solution Method: Hvorslev
K = 1.803E-6 m/sec	y0 = 0.4091 m

FigureA3-41 *Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000197.*



WELL TEST ANALYSIS	
Data Set: G:\...\197RH.aqt	
Date: 11/11/21	Time: 13:49:16
PROJECT INFORMATION	
Company: SKB	
Test Well: SFM000197	
AQUIFER DATA	
Saturated Thickness: 0.95 m	Anisotropy Ratio (Kz/Kr): 1.
WELL DATA (197)	
Initial Displacement: 0.44 m	Static Water Column Height: 7.59 m
Total Well Penetration Depth: 6.59 m	Screen Length: 1. m
Casing Radius: 0.0255 m	Well Radius: 0.0255 m
SOLUTION	
Aquifer Model: Confined	Solution Method: Hvorslev
K = 2.362E-6 m/sec	y0 = 0.286 m

***FigureA3-42** Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000197.*



SFM000198

Data Set: G:\...\SFM000198_FH.aqt
Date: 11/12/21 Time: 09:28:37

PROJECT INFORMATION

Company: SKB
Test Well: 000198

AQUIFER DATA

Saturated Thickness: 5.235 m Anisotropy Ratio (Kz/Kr): 1.

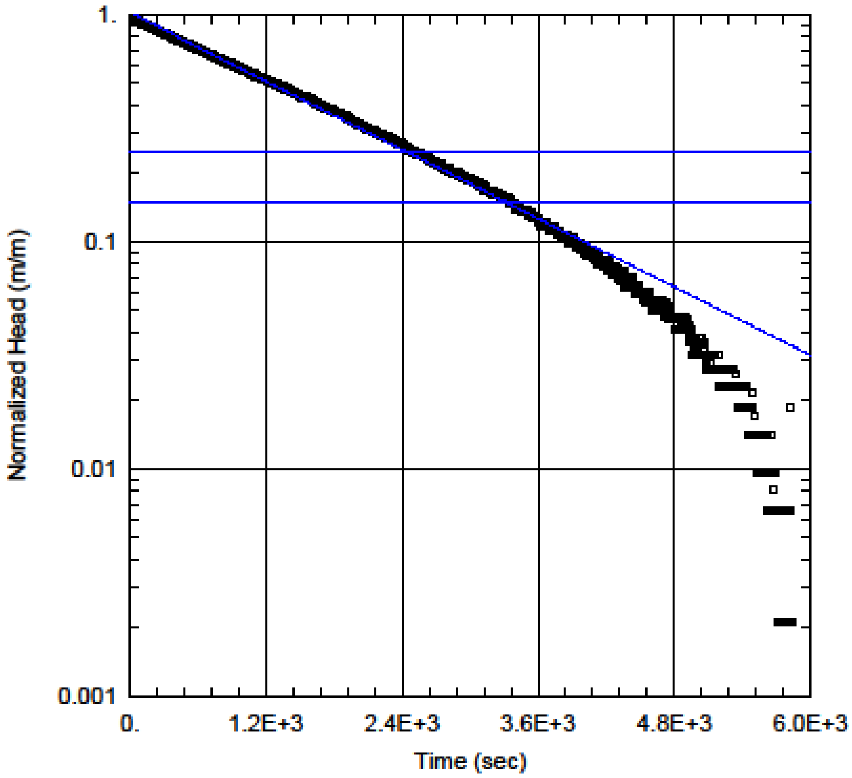
WELL DATA (SFM000198)

Initial Displacement: 0.445 m Static Water Column Height: 6.235 m
Total Well Penetration Depth: 5.2 m Screen Length: 1. m
Casing Radius: 0.0255 m Well Radius: 0.0255 m

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev
K = 4.016E-7 m/sec y0 = 0.4359 m

***FigureA3-43** Semi-log plot of normalized displacement versus time and H curve fitting for the falling-head test in well SFM000198.*



SFM000198	
Data Set: G:\...\SFM000198_RH.aqt	
Date: 11/12/21	Time: 09:35:05
PROJECT INFORMATION	
Company: SKB	
Test Well: 000198	
AQUIFER DATA	
Saturated Thickness: 5.235 m	Anisotropy Ratio (Kz/Kr): 1.
WELL DATA (SFM000198)	
Initial Displacement: 0.39 m	Static Water Column Height: 6.235 m
Total Well Penetration Depth: 5.2 m	Screen Length: 1. m
Casing Radius: 0.0255 m	Well Radius: 0.0255 m
SOLUTION	
Aquifer Model: Confined	Solution Method: Hvorslev
K = 6.914E-7 m/sec	y0 = 0.3997 m

FigureA3-44 *Semi-log plot of normalized displacement versus time and H curve fitting for the rising-head test in well SFM000198.*

Appendix 4

Non-evaluated slug test responses

Table A4-*1* shows a list untested wells and non-evaluated slug tests. Slug test responses for the non-evaluated slug tests are shown in Figure A4-1 to Figure A4-4.

Table A4-1 List of untested wells and non-evaluated slug tests.

Not slug tested wells	
SFM0007	Dry
SFM0059	Dry
SFM0060	Dry
SFM0074	Lid cannot be opened
SFM0094	Artesian
SFM000173	Erroneously marked
SFM000121	Stand pipe too narrow for slug
SFM000123	Stand pipe too narrow for slug
SFM000124	Stand pipe too narrow for slug
SFM000125	Stand pipe too narrow for slug
SFM000154	Dry
SFM000157	Not installed
SFM000184	Surface-water level gauge
Non-evaluated responses	
SFM0102	No well screen
SFM0103	Poor test response
SFM000175	Poor test response
SFM000181	Poor test response
SFM000196	Poor test response

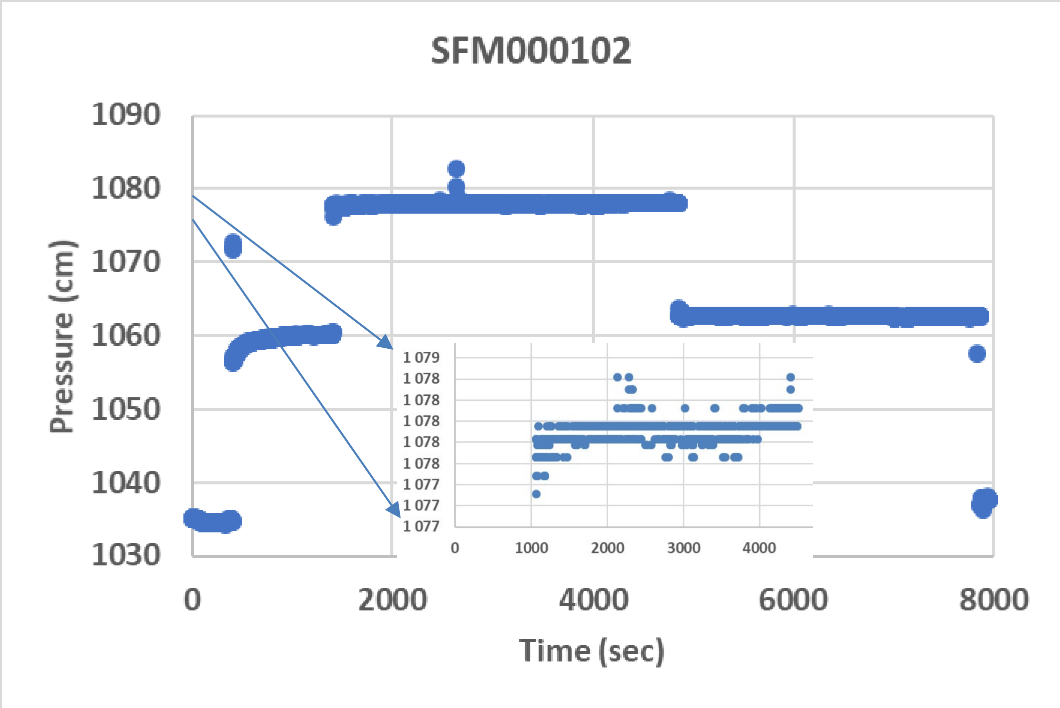


Figure A4-1 *Slug test responses for well SFM0102.*

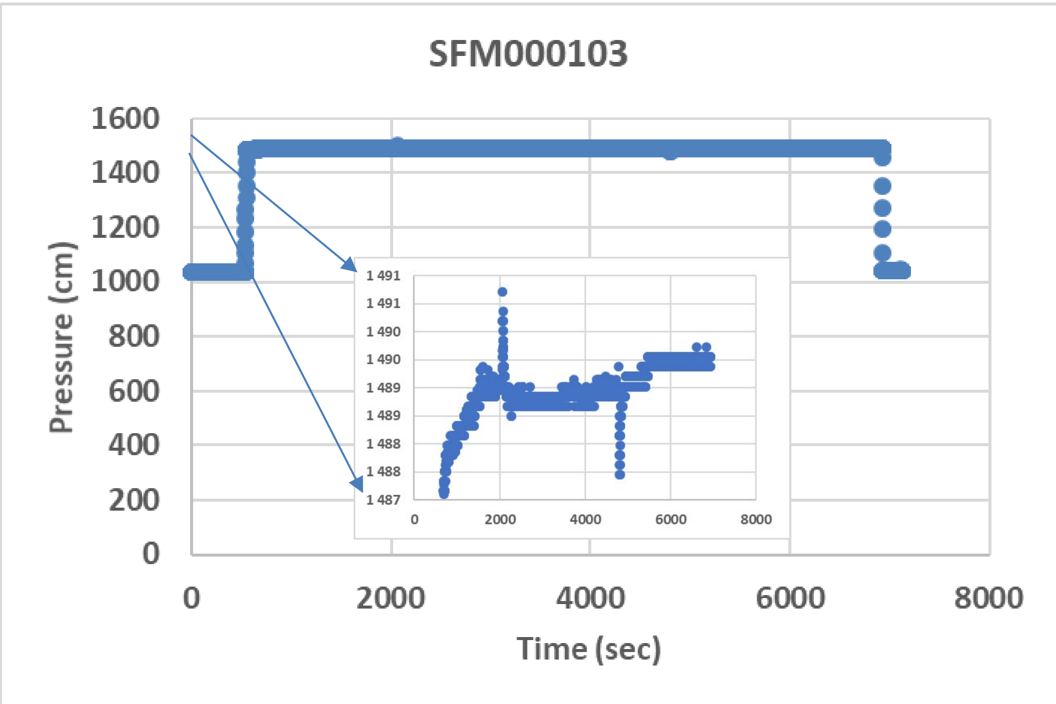


Figure A4-2 *Slug test responses for well SFM0103.*

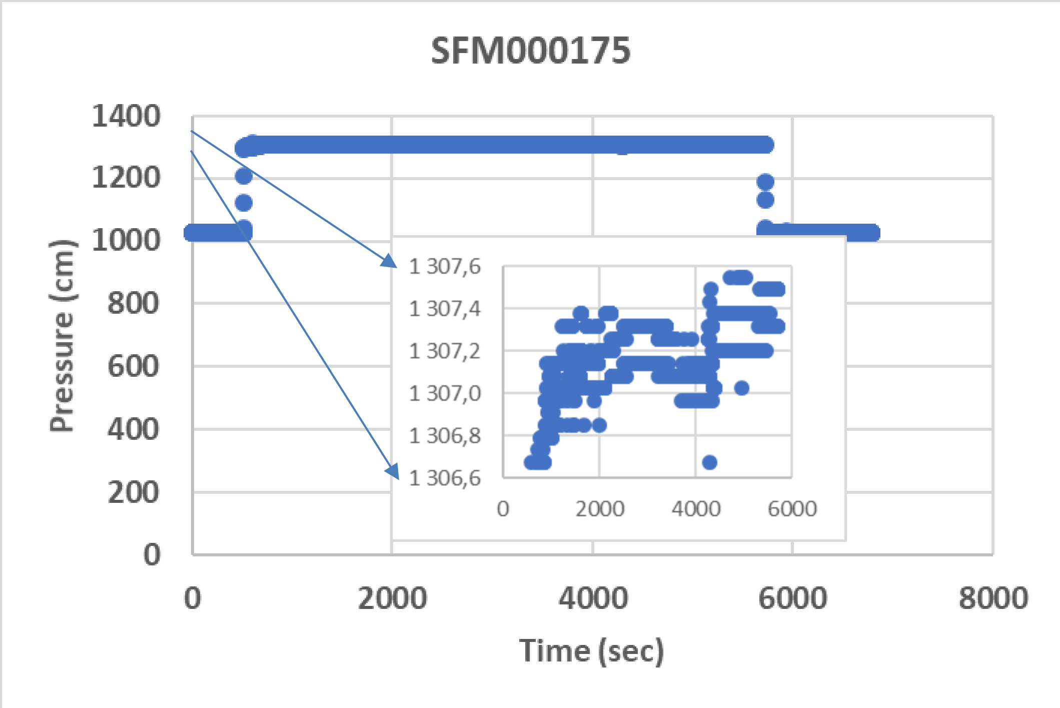


Figure A4-3 *Slug test responses for well SFM000175.*

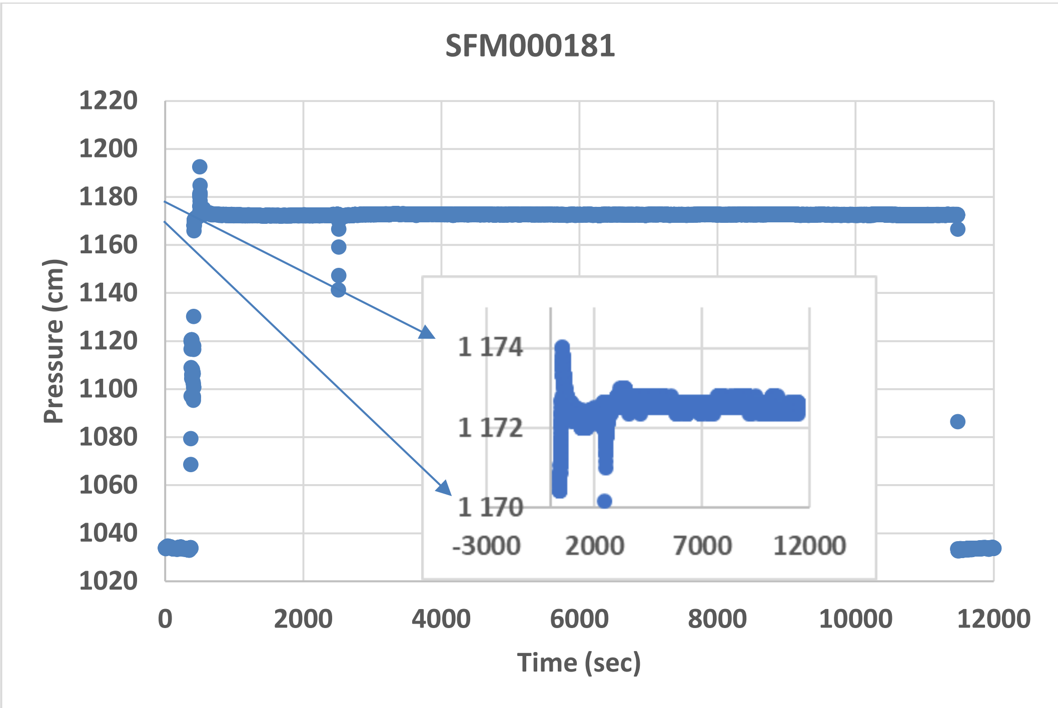


Figure A4-4 *Slug test responses for well SFM000181.*

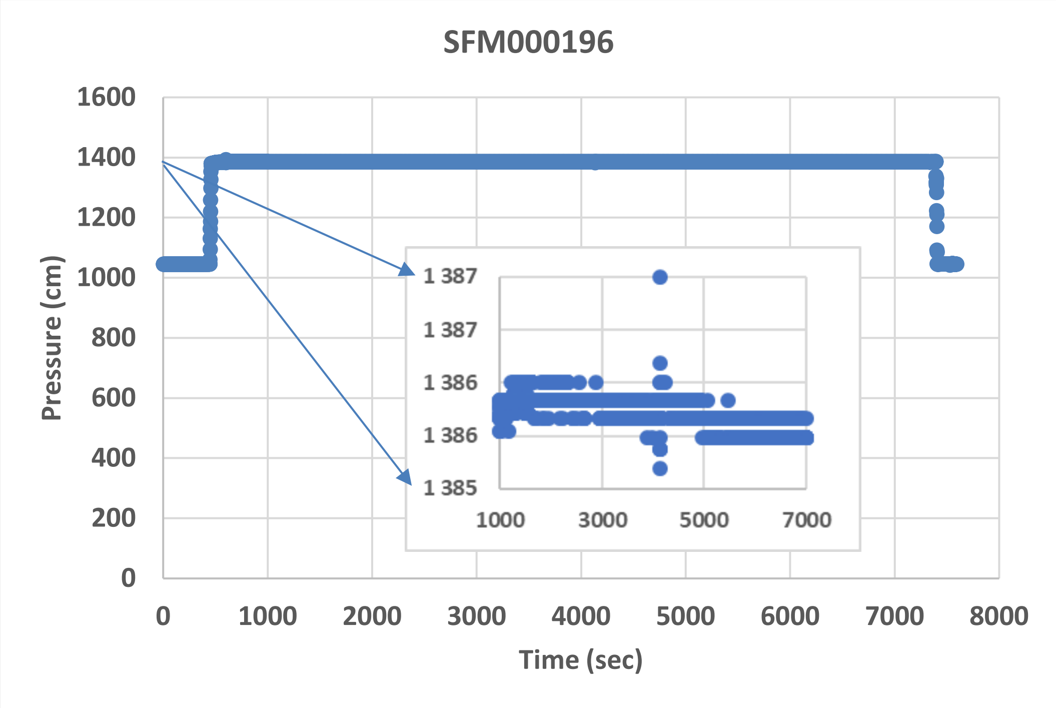


Figure A4-5 *Slug test responses for well SFM000196.*

Appendix 5

List of generated raw data files and primary data files

Table A5- 1 List of generated raw data files and primary data files. Column 2 is the raw data files. Column 3 is working Excel table with processing data. Column 4 and 5 are Aqtesolv files for FH (Falling head test) and RH (Rising head test).

Well id	Raw data files: Primary data files *.dat *.csv	Data processing files: *.xlsx	Aqtesolv_files (Falling head test) *.aqt	Aqtesolv_files (Rising head test) *.aqt
SFM0006	sfm6_210604135940_U7185	6	SFM00 6_FH	SFM00 6_RH
SFM0090	sfm90_210621175355_U7185	90	SFM00 90_FH	SFM00 90_RH
SFM0102	sfm102_210607133936_U7201	102	SFM00 102_FH	SFM00 102_RH
SFM0103	sfm103_210607132915_U7213	103	SFM00 103_FH	SFM00 103_RH
SFM0109	sfm109_210621141625_U7185	109	SFM00 109_FH	SFM00 109_RH
SFM000169	sfm169_210621175523_U7201	169	SFM00 169_FH	SFM00 169_RH
SFM000171	sfm171_210910151356_U7213	171	SFM00 171_FH	SFM00 171_RH
SFM000173	sfm173_210910151650_U7201	173	SFM00 173_FH	SFM00 173_RH
SFM000174	sfm174_210621173826_U7157	174	SFM00 174_FH	SFM00 174_RH
SFM000175	sfm175_210809150851_U7201	175	SFM00 175_FH	SFM00 175_RH
SFM000176	srfm176_210604150434_U7213	176	SFM00 176_FH	SFM00 176_RH
SFM000177	sfm177_210629144055_U7185	177	SFM00 177_FH	SFM00 177_RH
SFM000179	sfm179_210809102604_U7213	179	SFM00 179_FH	SFM00 179_RH
SFM000180	sfm180_210809143559_U7213	180	SFM00 180_FH	SFM00 180_RH
SFM000181	sfm181_210809143055_U7157	181	SFM00 181_FH	SFM00 181_RH
SFM000182	sfm182_210805124029_U7213	182	SFM00 182_FH	SFM00 182_RH
SFM000183	sfm183_210827152759_U7157	183	SFM00 183_FH	SFM00 183_RH
SFM000187	sfm187_210827155314_U7185	187	SFM00 187_FH	SFM00 187_RH
SFM000188	sfm188_210805144517_U7185	188	SFM00 188_FH	SFM00 188_RH
SFM000190	sfm190_210611153131_U7185	190	SFM00 190_FH	SFM00 190_RH
SFM000191	sfm191_210611135606_U7213	191	SFM00 191_FH	SFM00 191_RH
SFM000192	sfm000192_210527101250_U7183	192	SFM00 192_FH	SFM00 192_RH
SFM000193	sfm000193_210527153615_U7213	193	SFM00 193_FH	SFM00 193_RH
SFM000194	sfm194_210621172024_U7213	194	SFM00 194_FH	SFM00 194_RH
SFM000195	sfm195_210621143231_U7201	195	SFM00 195_FH	SFM00 195_RH
SFM000196	sfm196_210604152447_U7201	196	SFM00 196_FH	SFM00 196_RH
SFM000197	sfm197_210604091832_U7185	197	SFM00 197_FH	SFM00 197_RH
SFM000198	sfm198_210603152632_U7213	198	SFM00 198_FH	SFM00 198_RH