

Arbeitsbericht NAB 20-08

**TBO Bülach-1-1:
Data Report**

**Dossier I
Drilling**

March 2021

**National Cooperative
for the Disposal of
Radioactive Waste**

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5430 Wettingen
Switzerland
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**Dossier I
Drilling**

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Bülach-1-1, Bülach-1-1B, BUL1-1, BUL1-1B, Nördlich Lägern, TBO, deep drilling campaign, drilling report, rig site construction, casing scheme, drilling process, wireline coring, drilling tools, drilling fluids, cementation, borehole deviation

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Nagra Arbeitsberichte NAB ("Working Reports") present the results of work in progress that have not necessarily been subject to a comprehensive review. They are intended to provide rapid dissemination of current information.

This NAB aims at reporting drilling results at an early stage. Additional borehole-specific data will be published elsewhere.

In the event of inconsistencies between dossiers of this NAB, the dossier addressing the specific topic takes priority. In the event of discrepancies between Nagra reports, the chronologically later report is generally considered to be correct. Data sets and interpretations laid out in this NAB may be revised in subsequent reports. The reasoning leading to these revisions will be detailed there.

This Dossier was prepared by a project team consisting of:

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The Dossier has greatly benefitted from technical discussions with, and reviews by, external and internal experts. Their input and work are very much appreciated!

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Abbreviations

asl	Above sea level
ASLT	Array sonic logging tool
ATEX	EU directives describing the minimum safety requirements of the workplace and equipment used in explosive atmosphere (appareils destinés à être utilisés en ATmosphères EXplosives)
AWEL	Office of Waste, Water, Energy and Air (WWEA, Amt für Abfall, Wasser, Energie und Luft)
BHA	Bottom hole assembly
BOP	Blow out preventer
BTC	Buttress connection
CCL	Casing collar locator
CBL	Cement bond log
CHH	Casing head housing
DEW	Döring/Ellert/Wilkens Wartungs und Reparatur GmbH
DLS	Dog leg severity
DMT	Deutsche Montan Technologie GmbH & Co KG
DP	Drill pipe
FIT	Formation integrity test
FOEN	Federal Office for the Environment
GPIT	General purpose inclinometer tool
GTS	General Tubular Services GmbH
HiVis	High viscosity
HMR	High magnesium-resistant cement
HPU	Hydraulic power unit
HSE	Health safety environment
HWDP	Heavyweight drill pipe
IADC	International Association of Drilling Contractors
ID	Inner diameter
KOP	Kick-off point
LIH	Left in hole
MBT	Test to determine the amount of clay-like materials in a water-based drilling fluid based on the amount of methylene blue dye absorbed by the sample
MD	Measured depth
MHF	Microhydraulic fracturing
MSIP	Modular sonic imaging platform

NOV	National Oilwell Varco
NPT	Non-productive time
NSG	Application for exploration permits (Nagra Sondiergesuch)
OD	Outer diameter
PDC	Polycrystalline diamond compact bit
POOH	Pull out of hole
RIH	Run in hole
ROP	Rate of penetration
RPM	Revolutions per minute
SG	Specific gravity
SGT	Sectoral Plan for Deep Geological Repositories
SHO	Staged hole opener
SLB	Schlumberger N. V.
SPP	Standpipe pressure
TBO	Tiefbohrung
TD	Target depth of section or hole
TOC	Top of cement
TRS	Tubular running service
TT	Transit time
TVD	True vertical depth
UBI	Ultrasonic borehole imager
VDL	Variable density log
VS	Vertical section
VSP	Vertical seismic profile
WEP	Well Engineering Partners BV
WL	Wireline
WOB	Weight on bit

1 Introduction

1.1 Context

To provide input for site selection and the safety case for deep geological repositories for radioactive waste, Nagra has drilled a series of deep boreholes in Northern Switzerland. The aim of the drilling campaign is to characterise the deep underground of the three remaining siting regions located at the edge of the Northern Alpine Molasse Basin (Fig. 1-1).

In this report, we present the results from the Bülach-1-1 borehole.

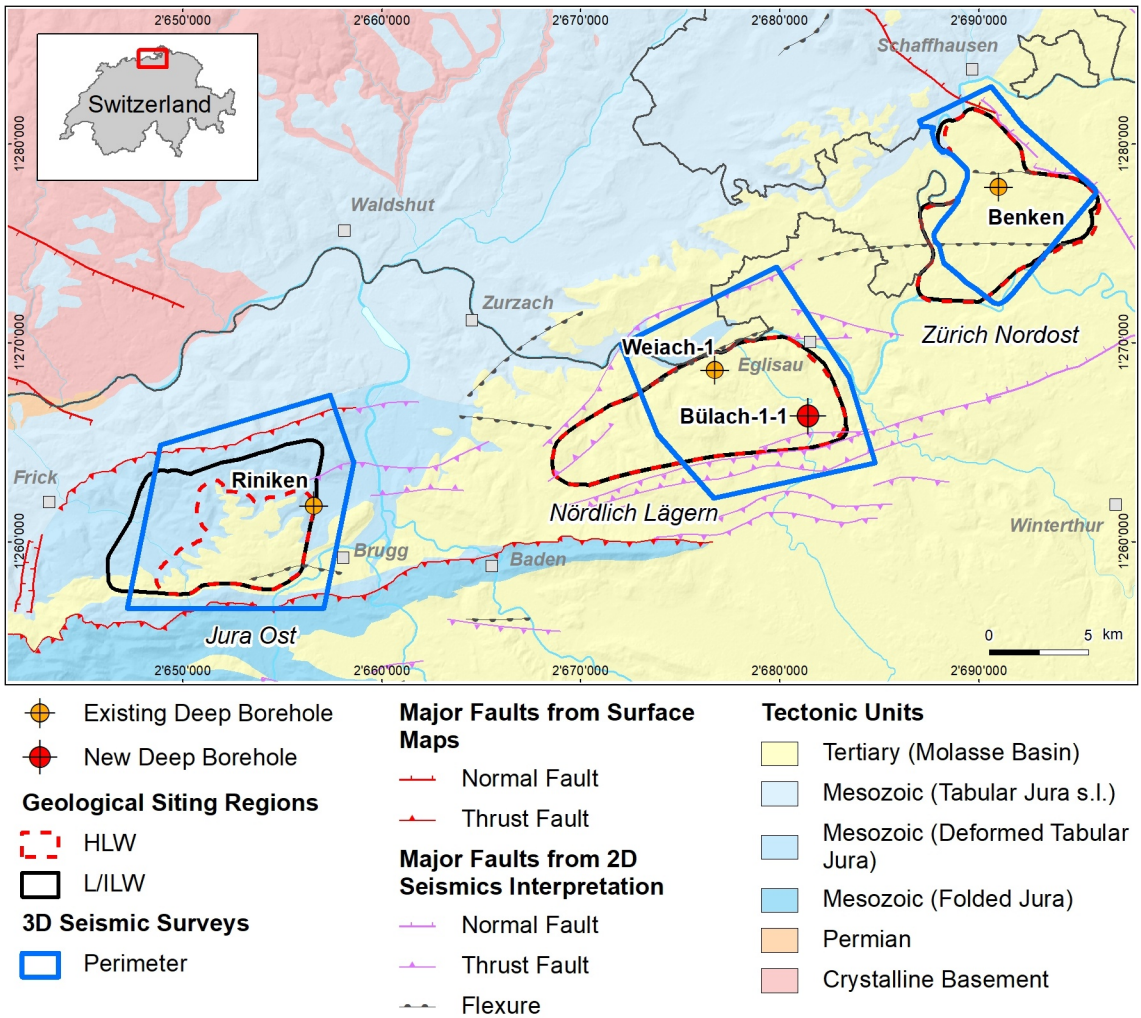


Fig. 1-1: Tectonic overview map with the three siting regions under investigation

1.2 Location and specifications of the borehole

The Bülach-1-1 (BUL1-1) exploratory borehole is the first deep borehole drilled within the framework of the TBO project. BUL1-1 is a vertical borehole. The drill site is located in the south-eastern part of the Nördlich Lägern siting region (Fig. 1-2). The borehole specifications are provided in Tab. 1-1. The lithostratigraphic profile and the casing scheme are shown in Fig. 1-3. Due to instabilities, the borehole was plugged back from 1'043.00 m to 918.70 m (*cf.* Dossier I). Resuming coring operations, a sidetrack was initiated with a kickoff point at 995.85 m. This sidetrack was labelled Bülach-1-1B (BUL1-1B). BUL1-1B reached the final depth of 1'370.19 m (measured depth MD core depth)¹. For easier communication and labelling, the name BUL1-1 is generally used for the complete vertical borehole unless stated otherwise. Fig. 1-3 shows the combined lithostratigraphic profile of BUL1-1.

Tab. 1-1: General information about the BUL1-1 borehole

Location	Bülach (Canton Zurich / ZH), Switzerland
Siting region	Nördlich Lägern
Coordinates	2'681'446.028 / 1'266'298.472
Elevation	389.62 m asl (top of rig cellar)
Borehole depth	1'370.19 m MD core depth
Drilling period	15 April 2019 – 27 November 2019 (spud – rig release)
Drilling company	Daldrup & Söhne AG
Drilling rig	Wirth B 152t
Drilling fluid	Water-based mud with varying amounts of Pure-Bore®, Pure-Bore® ULV, soda ash, sodium bicarbonate, xanthan gum

¹ *Measured depth (MD)* below top rig cellar along borehole trajectory. In all dossiers, depth refers to MD unless stated otherwise.

MD core depth refers to the depth marked on the cores. Note that petrophysical logs have not been shifted to core depth, hence MD log depth differs from MD core depth. The depth shift between core depth and log depth is documented in Dossier V, Appendix E-1.

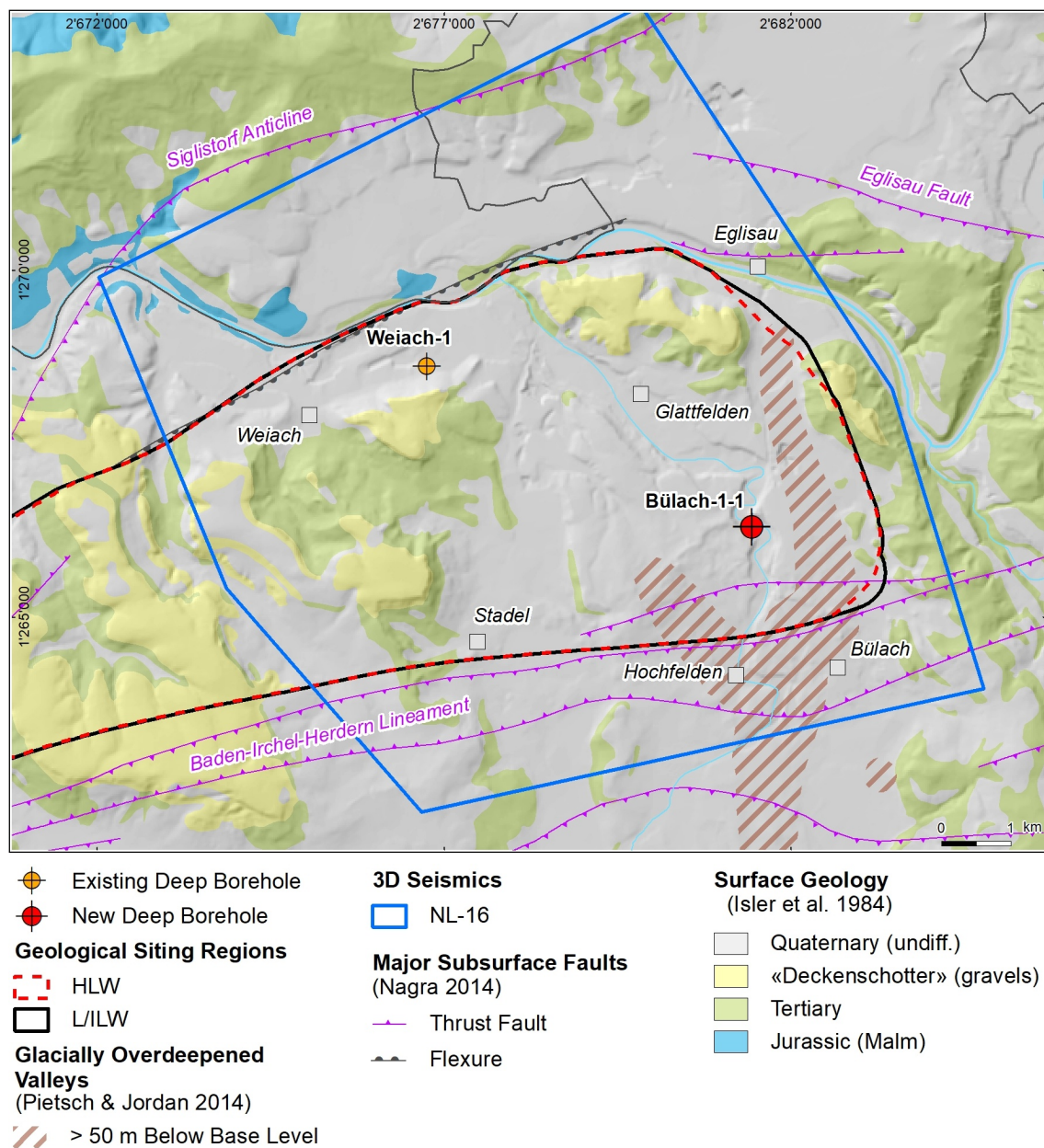


Fig. 1-2: Overview map of the investigation area in the Nördlich Lägern siting region with the location of the BUL1-1 borehole and the existing Weiach-1 borehole

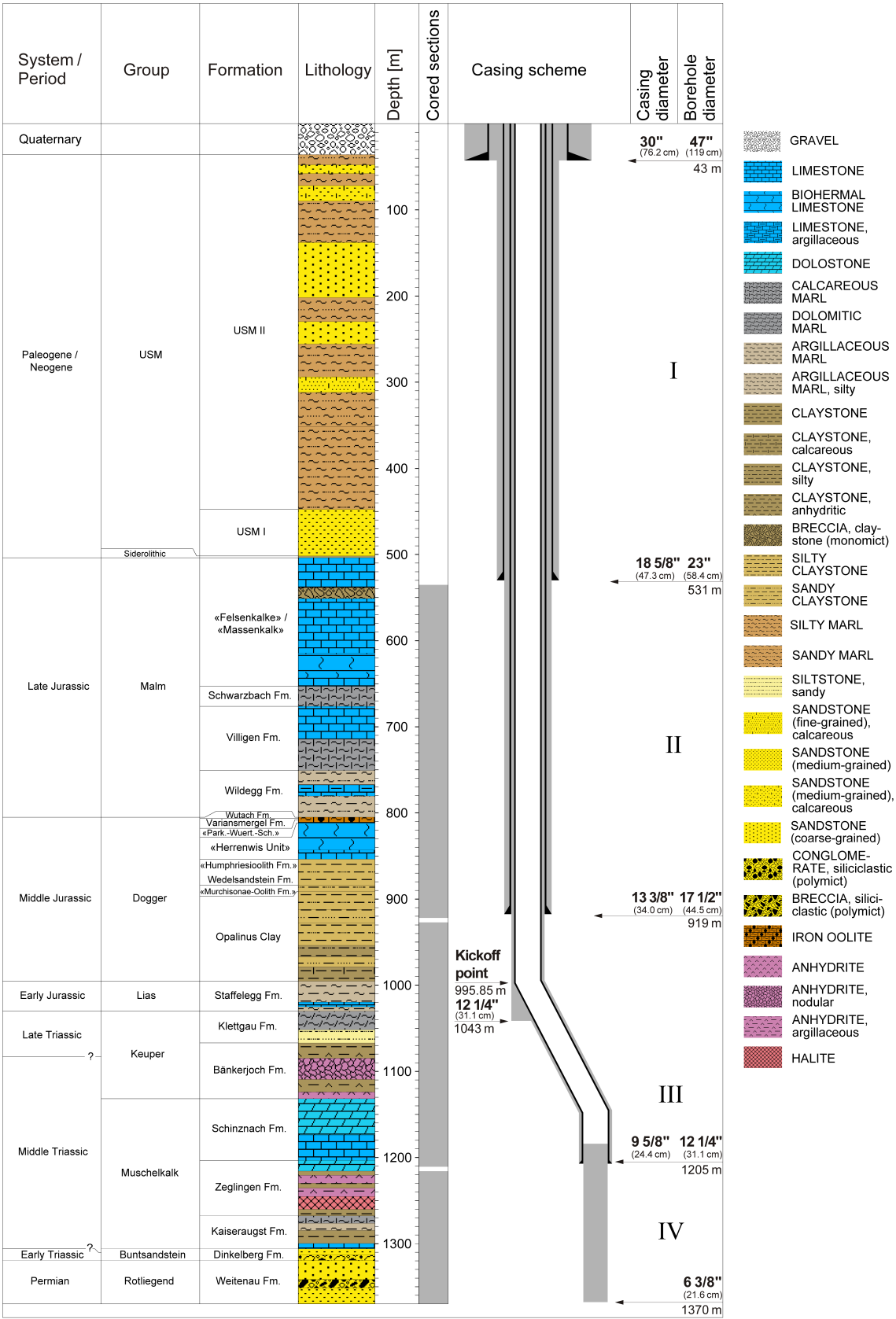


Fig. 1-3: Lithostratigraphic profile and casing scheme for the BUL1-1 borehole

1.3 Documentation structure for the BUL1-1 borehole

NAB 20-08 documents the majority of the investigations carried out in the BUL1-1 borehole, including laboratory investigations on core material. The NAB comprises a series of stand-alone dossiers addressing individual topics and a final dossier with a summary composite plot (Tab. 1-2).

This borehole documentation aims at early publication of the data collected in the BUL1-1 borehole. It includes the majority of the data available approximately one year after completion of the borehole. Some analyses are still ongoing (e.g. diffusion experiments, analysis of veins, hydrochemical interpretation of water samples) and will be published in separate reports.

The current borehole report will provide an important basis for the integration of datasets from different boreholes. The integration and interpretation of the results in the wider geological context will be documented later in separate geoscientific reports.

Tab. 1-2: List of dossiers included in NAB 20-08

Black marks the dossier at hand.

Dossier	Title	Authors
I	TBO Bülach-1-1: Drilling	M. Ammen & P.-J. Palten
II	TBO Bülach-1-1: Core Photography	D. Kaehr & M. Gysi
III	TBO Bülach-1-1: Lithostratigraphy	P. Jordan, H. Naef, P. Schürch, M. Schwarz, T. Ibele, R. Felber & M. Gysi
IV	TBO Bülach-1-1: Microfacies, Bio- and Chemostratigraphic Analysis	S. Wohlwend, H.R. Bläsi, S. Feist-Burkhardt, B. Hostettler, U. Menkveld-Gfeller, V. Dietze & G. Deplazes
V	TBO Bülach-1-1: Structural Geology	A. Ebert, L. Gregorczyk, E. Hägerstedt & M. Gysi
VI	TBO Bülach-1-1: Wireline Logging and Microhydraulic Fracturing	R. Garrard, J. Gonus, J. Desroches & E. Bailey
VII	TBO Bülach-1-1: Hydraulic Packer Testing	R. Schwarz, L. Schlickenrieder & T. Vogt
VIII	TBO Bülach-1-1: Rock Properties, Porewater Characterisation and Natural Tracer Profiles	M. Mazurek, L. Aschwanden, L. Camesi, T. Gimmi, A. Jenni, M. Kiczka, U. Mäder, D. Rufer, H.N. Waber, P. Wanner, P. Wersin & D. Traber
IX	TBO Bülach-1-1: Rock-mechanical and Geomechanical Laboratory Testing	E. Crisci, L. Laloui & S. Giger
X	TBO Bülach-1-1: Petrophysical Log Analysis	S. Marnat & J.K. Becker
	TBO Bülach-1-1: Summary Plot	Nagra

1.4 Scope and objectives of this dossier

The objective of this report is to provide a summary of the drilling operations including drill site construction, casing tallies, cement bond quality, coring parameters and recovery.

The report is structured as follows:

- Chapter 1 presents the general overview of the drilling campaign and the vertical borehole BUL1-1.
- Chapter 2 describes the construction phase (prior to spud).
- Chapter 3 is dedicated to drilling technology.
- Chapter 4 describes drilling operations and their chronology.
- Chapter 5 describes further drilling-related topics.
- Chapter 6 discusses the health, safety and environmental topic.
- Finally, this report includes a set of appendices, which present relevant general project information and further investigation details.

1.5 Involved companies

The following companies were involved in the drilling activities of the BUL1-1 borehole:

- Nagra:
 - drilling manager: project management, coordination and organisation of the drilling of the borehole, definition of test aims, quality control, technical supervision of all the drilling, coring, casing running, cementing, logging and testing operations performed in the borehole
 - drilling engineer: technical supervision of all drilling, coring, casing running, cementing, logging and testing operations performed in the borehole
 - health safety environment (HSE) manager
- Daldrup & Söhne AG: drilling contractor
- GEO-data GmbH: mud logging
- Sirius-ES Deutschland: mud engineering
- Fangmann Energy Services: cementing service
- General Tubular Services GmbH (GTS): casing running / float equipment
- Döring/Ellert/Wilkens (DEW) / National Oilwell Varco (NOV): liner hanger / packer systems (liner was planned but not used)
- Schlumberger (SLB) and SEMM Logging: wireline logging and testing
- Solexperts: Hydraulic testing
- Well Engineering Partners BV (WEP): night and day drilling supervisors and HSE specialist

2 Drill site construction and conductor pipe

Start of execution

The construction of the drill site started on 08.10.2018 (Landolt + Co. AG construction company, Kleinandelfingen). Prior to the work preparation, a technical investigation was carried out for the drill site because of an entry in the cadastre of contaminated sites. Site investigations were carried out simultaneously with the technical investigation. Due to poor stability, the soil had to be reinforced with micropiles. In accordance with the authorities, the building permit was released in two stages: stage one involved earthworks and stage two the in situ concrete drilling cellar.

Work preparation

The layout of the drill site was planned and prepared by Nagra with the assistance of the mandated civil engineering company swrplus AG, Dietikon. Because contaminated soil was encountered and the drilling company was not known at the beginning of the planning, a number of issues had to be adjusted during construction.

Construction of site and standpipe

The drill site primarily consists of a drill cellar containing the standpipe, a surrounding area with an asphalt pavement and other gravel areas which were used to accommodate the test and office containers (*cf.* Fig. 2-1).

After the upper soil layers were removed and deposited laterally, the foundation work could start. Unfortunately, contaminated material was found during the groundwork and had to be disposed of. In addition, the soil was unstable in some places, therefore the soil was stabilised with micropiles.

A subcontractor (STRABAG AG, Schlieren) was hired to drill and install the 30" conductor pipe (Fig. 2-2). The 43 m were drilled and cased from 03.12.2018 to 12.12.2018. Unconsolidated sediments were excavated using a gripper whereas consolidated sediments were rammed with a large-scale chisel and then removed using a smaller gripper.

For the infrastructure of the construction site and firefighting water supply, a new freshwater pipeline was installed from the Herrenwis pumping station beneath the river Glatt to the drill site. In agreement with the cantonal authorities of the Canton of Zürich, AWEL (Office of Waste, Water, Energy and Air), the rainwater collected on the drill site could be discharged into the river Glatt. The sewage water was collected and brought to the nearby wastewater treatment plant by lorry.

During the commissioning of the power supply, a power blackout occurred in the community of Bülach due to a false operation. As a result, three minor claims from companies in Bülach had to be settled.

For the protection of amphibians, the construction company built a special ladder. Amphibians that fell into the cellar could use the ladder to climb back to the surface.

The following significant adjustments to the drill site were implemented during construction:

- the area of the drill site was enlarged by adding a strip of approximately 4 m
- the ground was reinforced after the installation of a new surface for the front support of the drilling rig
- a cellar was built to collect washing fluid for cleaning the cores
- planum and access route were built for visitor containers
- installation of connections to all additional media was necessary
- various smaller installations were necessary for the protection of amphibians



Fig. 2-1: Drill site after rig up of the Daldrup drilling rig



Fig. 2-2: Run in hole (RIH) 30" standpipe (welding)

Further pictures and a site plan are shown in Appendix C1 and Appendix C2, respectively.

3 Drilling technology

The drilling operation combined wireline coring operations with rotary drilling operations.

The wireline coring process was driven rotary from the surface by the topdrive. To pull the core to surface, the drill string was kept in the hole and the inner core tube was brought to surface with a catcher retracted on a slickline. Compared with conventional coring, this is much faster and the hole experiences less stress. With this method, short core sections (3 m) can be obtained in better quality without losing much time. Also, the handling of the cores is easier in terms of weight and time required at the surface. In difficult sections of the borehole, individual core runs of less than one metre were drilled to increase the core gain and core quality.

A topdrive guided on the drilling mast was used on the drilling rig. For ecological reasons, this system was operated electrically by providing a separate electro-hydraulic main drive unit. The mud pumps were also operated by drives of which the electric frequency could be adjusted.

3.1 Technical data of the drilling rig

The drilling rig of the contractor Daldrup & Söhne AG was a Wirth B 152t (152 t operational hook load with 10 lines) semi-trailer with movable mast. The draw works had a power of 300 kW. The topdrive was a B152 with 255 kW drive system power (1'520 kN torque dynamic capacity); mud pumps were two triplex pumps IDECO T-1000 with a 750 kW power rating for each pump. Three shakers were used. One centrifuge and one flocculation unit were provided by the mud service company. An overview of the general drilling rig data can be found in Tab. 3-1 and a detailed description of the equipment in Appendix D. The nominal pulling force of the system was 175 t.

The topdrive has been in operation since 1981 and was purchased by the drilling contractor in 2003. Records showed that the unit had completed a total of 79'655 m of drilling by 2016.

The entire load of the semi-trailer was transferred to four supports. The maximum vertical load on each support in the rig cellar supporting the mast was 950 kN. At the shaft end of the trailer the load on each support was 150 kN.

A schematic overview of the rig and ancillary equipment installed at Bülach-1-1 is presented in Fig. 3-1.

Tab. 3-1: General drilling rig data

Drilling rig manufacturer	Wirth Maschinen- und Bohrgeräte GmbH, Erkelenz
Type of drilling rig	Universal rig
Construction	Semi-trailer with movable mast
Type	B 152t
Original	B 12 SH 30000 / DS 05
Construction year	1980, modified 2007
Total height above ground level	21.3 m
Height of rotary table	2.83 m
Rig floor area	24 m ²
Rig floor load capacity	1'500 kg/m ²
Hook load dynamic (10 lines)	1'520 kN
Hook load static (10 lines)	1'750 kN
Crown block load	2'000 kN
Maximum torque	50 kNm
Continuous torque	12.5 kNm
Maximum rotational speed	390 RPM
Drill pipe handling	Single drill pipe handling
Drive	Electro-hydraulic
Drive power	2 × 174 kW
Lifting drive	Hydrostatic
Lifting – input power	300 kW
Rotary system	Topdrive
Maximum allowable wind velocity (operation)	80 km/h
Total trailer weight	54'000 kg
Maximum shaft load	12'000 kg
Maximum width	2'750 mm
Trailer length	17.89 m
Transport height	3.45 m

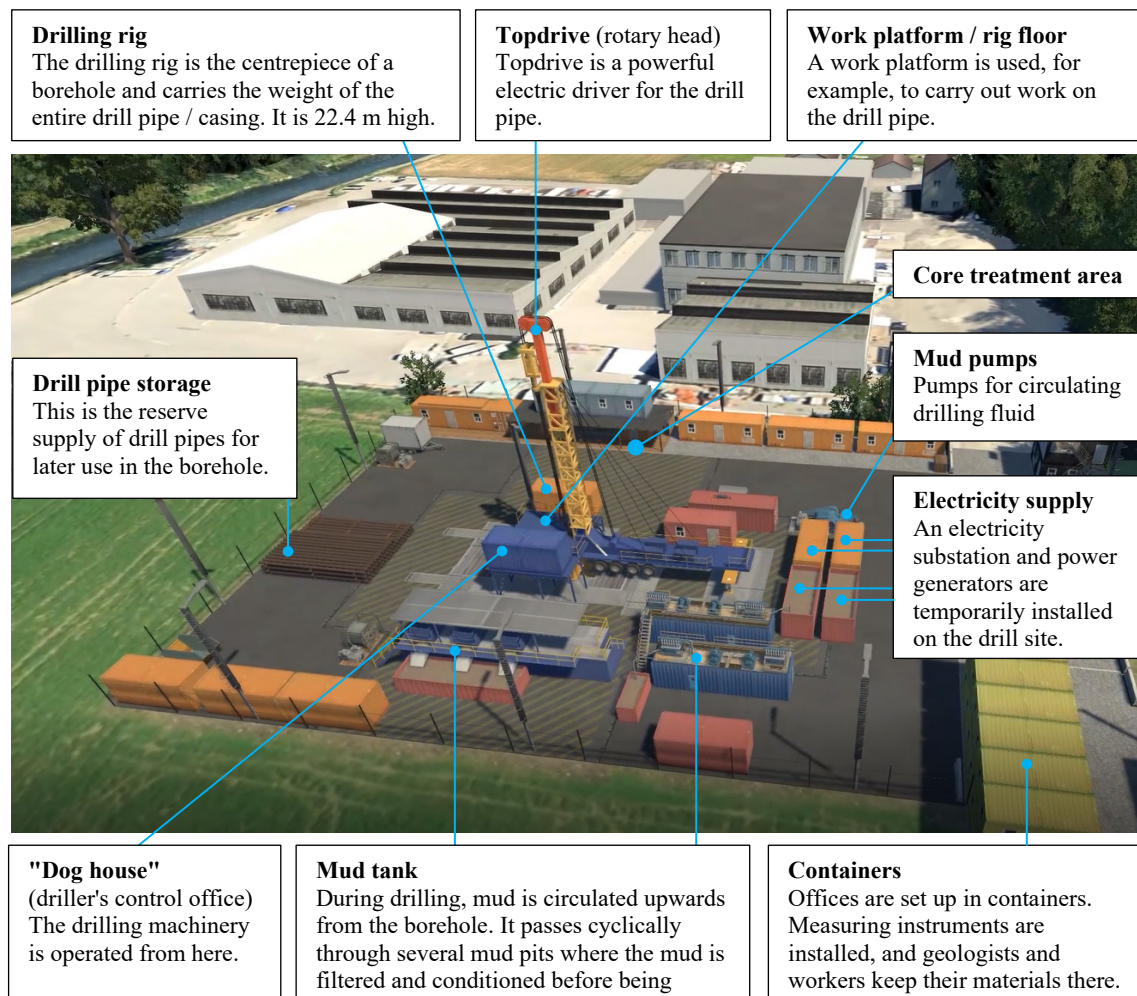


Fig. 3-1: Drilling rig

3.2 Drilling tools

3.2.1 Drill string and wireline coring string

Two different drill strings were used for the BUL1-1 borehole. A 5 ½" wireline coring string (SK 5 ½" B, N80) from the manufacturer MICON-Drilling GmbH (MICON-Drilling 2016) was mainly used for coring operations (see Appendix H) and a 5" drill string (S135, #19.5) was mainly used for destructive drilling, hole opening and drilling out cement and float equipment.

Wireline core barrels were used to ensure complete recovery of the cores without pulling out the drill string. This technique speeds up core retrieval, reduces time-consuming drill rod handling and helps to maximise coring efficiency. The catching assembly is attached to a wireline winch system and lowered into the wireline drill string. The overshot securely interlocks with the latching head. Subsequently, the core-filled inner tube system can be hoisted out through the wireline drill string.

The wireline coring system used for the BUL1-1 borehole consisted of a core bit, inner and outer core barrel, core catcher, core pipes, stabilisers as well as crossovers and other spare parts and consumables. The drilling diameter was 6 $\frac{3}{8}$ " (161.9 mm) resulting in a core diameter of 95 mm. All cores were drilled with plastic liners for protection and higher quality of the cores. These plastic liners allowed simplified handling of the cores, eliminating mechanical impacts such as hammering or pumping out the core from the inner core barrel. It enabled transport of the cores to the core handling table in one piece. The core was then removed from the plastic liner by pushing it out by hand or cutting the liner along the longitudinal axis. Core lengths up to 6 m could be reached with the wireline coring system, but to decrease the exposure time of the core in the drilling fluid and during sampling, the core length was set to 3 m.

Compared to conventional drill pipes, the wireline coring pipes with an average length of 9 m have slick tool joints, which means that the outer diameter of the pipe body and the tool joint are identical. Tool joints have no shoulders and the diameter of 5 $\frac{1}{2}$ " is the same along the entire drill string. This prevents flow restrictions and improves hole cleaning during coring within the small annulus between the formation and the coring string.

For drilling operations other than coring, conventional 5" drill pipes were used as they have standard connections which makes assembling the BHA much easier compared to the coring string, which has non-standard connections. The outer diameter of the tool joint is larger (168 mm) than the body of the 5" drill pipe to accommodate the threads. Furthermore, these shoulders provide stiffness to prevent bending and breaking. Due to the large diameter at the tool joint, the 5" drill pipes with an average length of 9.6 m did not fit into the 6 $\frac{3}{8}$ " borehole.

3.2.2 Coring bits

The 5 $\frac{1}{2}$ " wireline coring string allows to use 6 $\frac{3}{8}$ " (161.9 mm) core bits; the core barrel OD (outer diameter) is 152.4 mm with a core diameter of 95 mm. Two different types of core bits (see Fig. 3-2) were used in the BUL1-1 borehole:

- Thermally stable diamond (TSD) core bit, also called "Synset":

This type of core bit is designed for medium hard to hard and medium abrasive formations. TSD cutters consist of multiple layers of synthetic diamond fragments. This feature gives TSD cutters a self-sharpening property.
- Diamond-impregnated matrix core bit:

This type of core bit is designed for medium hard to extremely hard formations, but also for less abrasive to very abrasive rocks. Multiple layers of synthetic diamond fragments are sintered into a hard metal matrix. This compound has self-sharpening properties during progressive abrasion. Worn diamonds are released and replaced by new ones until the matrix compound is completely eroded. This core bit is available with different types of matrix.



Fig. 3-2: Synset core bit (left) and impregnated core bit (right)

Pictures including comments of selected bits after POOH are available in Appendix H

3.2.3 Tricone bits

The tricone bit is by far the most common bit type used in rotary drilling operations. They are available with a large variety of tooth designs, bearing types and nozzle designs. They have three roller cutter cones with a series of teeth that crush the rock on the rock face as they roll across their face. Because of the bearings used for every cone the revolutions for such a bit are limited. There are different types available with either longer or shorter teeth, and wider or closer placement of teeth for different levels of hardness of the drilled formation. Furthermore, the teeth can have milled teeth for softer formations or tungsten carbide insert teeth for harder formations. The teeth are cleaned by hydraulic nozzles.

The 23" section of BUL1-1 was drilled with two tricone bits.

The hard formations drilled in the upper hole section of BUL1-1 required short teeth, which needed sufficient weight to crush the rock. Because of the short drill string length below the rotary table, the weight exerted onto the drill bit by the drill collar was limited. In the beginning the drilling ROP (rate of penetration) was thus restricted by the available WOB (weight on bit).

The first bit had to be pulled at 380 m because of low ROP after 290 h with 820'000 bit revolutions. The lifetime of the bearings had already been reached and the bit was pulled because of bit revolutions. Back at the surface, all outer teeth and more than half of the inner teeth of the bit were found to be lost and the bit was graded with 5-8-LT-M-E-I-CD-PR (see Appendix J: IADC bit dull grading).

The second 23" bit managed to drill to the end of the section at 631.5 m and was pulled without any wear with 1-1-NO-A-E-I-NO-TD.

After cementing the different casings (18⁵/₈", 13³/₈" and 9⁵/₈"), the float valve and cement in the casing had to be drilled out. This was done with 17¹/₂", 12¹/₄" and 8¹/₂" tricone bits.

To enlarge the hole from 6³/₈" coring diameter to a size suitable to run the casing, the borehole was opened with hole openers guided by tricone bits to prevent a new wellbore path being cut when running the hole opener.

3.2.4 Hole opening tools

Staged hole openers (SHO) were used to enlarge the existing borehole to the required diameter for casing running and cementing, mostly in steps from 6³/₈" to 8¹/₂" and from 8¹/₂" to 12¹/₄". By relieving stress from the formation with this intermediate stage, larger-hole drilling can be done at a more aggressive ROP. These SHO run with a bull nose or a pilot bit of the same size as the existing borehole at the bottom, which serves as guidance for the enlarged hole. The pilot section of the SHO itself (lower part of the SHO) consists of one or two rows of cuttings structures to recondition the pilot hole and remove any swelling clays or loose material. Gauge pads provide initial stabilisation as the SHO begins the staged reaming process to reduce stick / slip, whirling, or off-centre tendencies. The lower cutters of the SHO are designed to minimise work rates on each cutter position for maximum durability. This part of the SHO recentralises the SHO on the given vertical borehole trajectory. The main body of the SHO completes the final hole diameter. With the formation is already stress-relieved, the reaming section remains aggressive even in more competent formations. Gauge trimmers and spiralled gauge pads ensure good hole quality. For examples of staged hole openers see Appendix H-3.

Besides the drilling and hole opening bits, a well-stocked supply of various stabilisers, drill collars, heavy weight drill pipes and other BHA (bottom hole assembly) components were kept on-site to be able to arrange suitable BHA setups for the planned work steps. Appropriate BHA designs are of great importance in drilling operations to effectively load and control the drill bit.

Tab. 3-2: Table with bit runs

depth in	run description	bit no.	run no.	bit type	total runs	date in	date out	depth out	bit dia.	tfa	run type	Dull Grading										drill hour s
[m]								[m]	[in]	[in ²]												[h]
BUL-1-1																						
33.50	ZM 23" Ser.Nr. RG 7868 XR+VEJ3C	1	1	TRICONE	1	15 Apr 2019	30 Apr 2019	380.00	23.000	2.0709	DRILLING	5	8	LT	M	E	I	CD	PR			290
380.00	ZM 23" Ser.Nr. RG 4485 XR+VEJ3C	2	1	TRICONE	1	30 Apr 2019	8 May 2019	531.50	23.000	1.8208	DRILLING	1	1	NO	A	E	I	NO	TD			135.8
531.50	ZM 17 1/2" Ser.Nr. RJ4564	3	1	TRICONE	1	13 May 2019	14 May 2019	535.00	17.500	1.1689	DRILLING	0	0	NO		N	X	NO	HR			3.75
535.00	CB 6 3/8" Ser.Nr.67434 Synset	4	1	COREBIT	1	16 May 2019	18 May 2019	545.00	6.375	0.0000	CORING	0	0	OC		N	X	NO	HR			8.5
545.00	CB 6 3/8" Ser.Nr.67434 Synset	4	2	COREBIT	2	21 May 2019	25 May 2019	578.80	6.375	0.0000	CORING	0	0	NO		N	X	NO	HR			61.25
578.80	CB 6 3/8" Ser.Nr.67436 Synset	5	1	COREBIT	1	25 May 2019	26 May 2019	580.40	6.375		CORING	0	0	NO		N	X	NO	HR			7.5
580.40	CB 6 3/8" Ser.Nr.691916 Impreg	6	1	COREBIT	1	26 May 2019	9 Jun 2019	868.00	6.375	0.0000	CORING	0	0	NO		N	X	NO	HR			181.3
868.00	CB 6 3/8" Ser.Nr.67450 PDC	7	1	COREBIT	1	10 Jun 2019	11 Jun 2019	869.00	6.375	0.0000	CORING	0	0	NO		N	X	NO	HR			2
869.00	CB 6 3/8" Ser.Nr.67450 PDC	7	2	COREBIT	2	26 Jun 2019	26 Jun 2019	886.50	6.375	11.0447	CORING	0	0	NO		N	X	NO	HR			23.25
886.50	CB 6 3/8" Ser.Nr.67457 PDC	8	1	COREBIT	1	29 Jun 2019	5 Jul 2019	952.00	6.375	11.0447	CORING	0	0	NO		N	X	NO	TD			110.3
952.00	Bull Nose 5 7/8" + 8 1/2" Hole Opener	9	2	REAMER	2	18 Jul 2019	18 Jul 2019	952.00	8.500	0.7547	REAMING	0	0	NO		N	X	NO	HR			65.8
952.00	RM 8 1/2" + 12 1/4" Hole Opener	11	1	PDC	1	23 Jul 2019	23 Jul 2019	952.00	12.250	1.5309	REAMING	0	0	NO		N	X	NO	HR			
952.00	Bull Nose 5 7/8" + 8 1/2" Hole Opener Impr�gnier Bit	10	1	REAMER	1	16 Jul 2019	18 Jul 2019	952.00	8.500	0.1963	REAMING	0	0	NO		N	X	NO	BHA			30.5
952.00	CB 6 3/8" Ser.Nr.67457 PDC	8	3	COREBIT	3	9 Jul 2019	12 Jul 2019	952.00	6.375	11.0447	REAMING	0	0	NO		N	X	NO	CM			
952.00	RM 12 1/4 + 17 1/2" Hole Opener	12	1	REAMER	1	29 Jul 2019	3 Aug 2019		17.500	1.9451	REAMING	0	0	LC		N	X	NO	HR			
952.00	RM 12 1/4	12	2	OTHER	2	11 Aug 2019	11 Aug 2019		12.250	1.4849	REAMING	0	0	NO		N	X	NO	HR			
952.00	CB 6 3/8" Ser.Nr.67685 PDC	14	1	COREBIT	1	16 Aug 2019	18 Aug 2019	958.00	6.375	11.0447	CORING	0	0	NO		N	X	NO	HP			
952.00	CB 6 3/8" Ser.Nr.67457 PDC	8	2	COREBIT	2	7 Jul 2019	8 Jul 2019	952.00	6.375	11.0447	REAMING	0	0	NO		N	X	NO	TD			
952.00	RM 3 3/4 + CB PDC 6 3/8"	13	1	TRICONE	1	14 Aug 2019	14 Aug 2019	952.00	3.750	0.3889	REAMING	0	0	NO		N	X	NO	BHA			11.9
952.00	Bull Nose 5 7/8" + 8 1/2" Hole Opener	9	1	REAMER	1	15 Jul 2019	16 Jul 2019	952.00	8.500	0.7547	REAMING	0	0	NO		N	X	NO	BHA			12.5
952.00	RM 6 3/8" + 17 1/2" Hole Opener	13	1	REAMER	1	3 Aug 2019	3 Aug 2019		17.500	1.9451	REAMING	0	0	NO		N	X	NO	HR			
958.00	CB 6 3/8" Ser.Nr.691922 PDC	15	1	COREBIT	1	19 Aug 2019	22 Aug 2019	979.00	6.375	11.0447	CORING	0	0	NO		N	X	NO	BHA			
958.00	RM 3 3/4 + CB PDC 6 3/8"	13	2	TRICONE	2	18 Aug 2019	19 Aug 2019	958.00	3.750	0.3889	REAMING	0	0	NO		N	X	NO	BHA			
979.00	RM 12 1/4	12	3	TRICONE	3	30 Aug 2019	30 Aug 2019	979.00	12.250	1.4849	REAMING	0	0	NO		N	X	NO	HR			
979.00	Bull Nose 5 7/8" + 8 1/2" Hole Opener	9	3	REAMER	3	23 Aug 2019	23 Aug 2019	979.00	8.500	0.7547	REAMING	0	0	NO		N	X	NO	HR			
979.00	CB 6 3/8" Ser.Nr.67442 PDC	18	1	COREBIT	1	5 Sep 2019	8 Sep 2019	1006.00	6.375	11.0447	CORING	0	0	NO		N	X	NO	HR			22.7
979.00	8 1/2" RM Ser.Nr. GAY-R54	17	1	TRICONE	1	31 Aug 2019	31 Aug 2019	979.00	8.500	0.4694	REAMING	0	0	NO		N	X	NO	HR			
979.00	RM 8 1/2"	16	1	TRICONE	1	30 Aug 2019	30 Aug 2019	979.00	8.500		DRILLING	0	0	NO		N	X	NO	HR			
979.00	RM 8 1/2 + 12 1/4" Hole Opener	11	2	REAMER	2	25 Aug 2019	25 Aug 2019	979.00	12.250	1.9451	REAMING	0	0	NO		N	X	NO	HR			
1006.00	CB 6 3/8" Ser.Nr.67444 Synset	19	1	COREBIT	1	8 Sep 2019	11 Sep 2019	1043.00	6.375	11.0447	CORING	0	0	NO		N	X	NO	HR			28.5
1043.00	RM 12 1/4" Ser.Nr. RG5317	12	4	TRICONE	4	17 Sep 2019	20 Sep 2019	1043.00	12.250	1.4849	REAMING	0	0	NO		N	X	NO	HR			
1043.00	CB 6 3/8" Ser. Nr.67444 Impreg	20	1	COREBIT	1	24 Sep 2019	24 Sep 2019	996.00	6.375		CORING	0	0	NO		N	X	NO	HR			
1043.00	8 1/2" RM Ser.Nr. GAY-R54	17	3	TRICONE	3	23 Sep 2019	23 Sep 2019	1043.00	8.500	0.4694	REAMING	0	0	NO		N	X	NO	HR			
1043.00	8 1/2" RM Ser.Nr. GAY-R54	17	2	TRICONE	2	14 Sep 2019	17 Sep 2019	1043.00	8.500	0.4694	REAMING	0	0	NO		N	X	NO	HR			27.8
BUL-1-1B																						
923.00	RM 8 1/2 Ser. Nr. GAY-R54 + 12 1/4" Hole Opener Ser. Nr. JW 1369	6	1	REAMER	4	30 Oct 2019	3 Oct 2019	1211.00	12.250	0.4694	REAMING	0	0	NO		N	X	NO	TD			57
923.00	5 7/8" Bull Nose Ser. Nr. 52416E + 8 1/2" Hole Opener Ser. Nr. JP6423	6	1	REAMER	3	28 Oct 2019	30 Oct 2019	1208.00	8.500	0.8314	REAMING	0	0	NO		N	X	NO	HR			
996.00	CB 6 3/8" Ser. Nr.67444 Impreg	1	2	COREBIT	2	28 Sep 2019	2 Sep 2019	1074.00	6.375		CORING	0	0	NO		N	X	NO	LOG			80.7
1074.00	CB 6 3/8" Ser. Nr.67446 Impreg	2	1	COREBIT	1	7 Oct 2019	8 Oct 2019	1090.00	6.375	11.0447	CORING	0	0	NO		N	X	NO	BHA			12.5
1090.00	CB 6 3/8" Ser. Nr.67441 Synset	3	1	COREBIT	1	8 Oct 2019	13 Oct 2019	1137.00	6.375	11.0447	CORING	0	0	NO		N	X	NO	BHA			46.5
1137.00	CB 6 3/8" Ser. Nr.67446 Impreg	4	2	COREBIT	2	13 Oct 2019	16 Oct 2019	1210.00	6.375	11.0447	CORING	0	0	NO		N	X	NO	HR			
1210.00	CB 6 3/8" Ser. Nr.67446 Impreg	5	3	COREBIT	3	18 Oct 2019	19 Oct 2019	1211.00	6.375	11.0447	CORING	0	0	NO		N	X	NO	HR			
1211.00	8 1/2" WM Ser.Nr. 6057026	18	1	TRICONE	1	9 Nov 2019	11 Nov 2019	1216.00	8.500	0.6934	DRILLING	0	0	NO		N	X	NO	HR			6.75
1211.00	RM 12 1/4" Ser.Nr. RG5317	12	5	TRICONE	5	3 Nov 2019	5 Nov 2019	1211.00	12.250	1.4849	REAMING	0	0	NO		N	X	NO	LOG			
1211.00	8 1/2" RM Ser.Nr. GAY-R54	17	4	TRICONE	4	8 Nov 2019	9 Nov 2019	1211.00	8.500	0.4694	REAMING	0	0	NO		N	X	NO	HR			
1216.00	CB 6 3/8" Ser. Nr.67442 Impreg	19	1	COREBIT	1	11 Nov 2019	11 Nov 2019	1370.00	6.375	11.0447	CORING	0	0	NO		N	X	NO	HR			80.25

4 Drilling operations

4.1 Overview

After a long installation phase, drilling began on 15.04.2019 and continued until 27.11.2019. With a final depth of 1'370.19 m, the borehole passed through 1'319.60 m of Cenozoic and Mesozoic sediments and 50.6 m into siliciclastic Pre-Mesozoic sediments. Opalinus Clay was found from 892 m to 996 m (105 m in thickness).

The borehole was drilled with two tricone bits (tooth bits) for the uppermost 531.50 m; the remaining three sections were continuously cored using wireline coring.

For the cored sections, triple core barrels with synthetic liners were used and core recovery was 99%. The main diameter of the borehole drilled with a core bit and the diameter of the final borehole section was 6 $\frac{3}{8}$ " (161.9 mm). The cores have a diameter of 95 mm.

Borehole instabilities occurred in the Opalinus Clay. Therefore, four cement plugs were placed from 852 m to 911 m, from 993 m to 1'043 m, from 926 m to 993 m and from 915 m to 926 m. While coring through the cement plug at 996 m, the retrieved core consisted of 100% formation instead of cement, therefore the sidetrack BUL1-1B was kicked-off. The initial borehole BUL1-1 was drilled to 1'043 m and the KOP (kick-off point) for the borehole BUL1-1B was at 996 m.

In addition to the conductor, three permanent casings were installed in the borehole. The 18 $\frac{5}{8}$ " (anchor casing) and 9 $\frac{5}{8}$ " casings were cemented up to ground level. The top of the cement behind the 13 $\frac{3}{8}$ " casing was found at 64 m.

The upper section of the borehole down to the base of the Upper and Middle Muschelkalk were drilled using a water-based polymer drilling fluid (Pure-Bore® mud system). The bottom section was drilled with a saturated brine for drilling through the salt horizon in the Muschelkalk.

Once the final depth of 1'370.19 m was reached and the borehole investigations were completed, the borehole was backfilled into the last casing with cement (casing shoe at 1'205 m).

Work was completed in 226 working days (continuous 24 h operation) after spud-in, followed by 15 d of rig down (see final time-depth diagram, Appendix B). Scientific investigations in the borehole add up to 17% and the drilling activities including casing runs and cementation add up to 83% of the total time. The difference between the planned and actual time equals 55 d. Down to 952 m, where instabilities in the Opalinus Clay occurred, the actual time required was close to the planned time although drilling started later than planned.

The total NPT (non-productive time) recorded for Bülach-1-1 and Bülach-1-1B were 320.75 h. A total of 56.25 h was required for logging and testing and 264.5 h for all drilling operations. In relation to the total time of 5'442.75 h needed for all the work done, the total NPT amounts to 5.9%.

While drilling the borehole, dynamic losses of 2 m³/h to 6 m³/h occurred at 1'153 m and 0.3 m³/h to 0.8 m³/h from 1'156 m to 1'162 m, respectively, making up losses of 5 m³ in total. Cavings in the Opalinus Clay were reported (see Dossier VI). During the wiper-trip from 869 m upwards a total gas content of 38.4% was detected, mainly composed of methane. The gas was most likely generated by germs in the mud because the gas was detected after no circulation had been induced for a longer period of time during a hydraulic test.

Weekly chronology

The weekly chronology is represented in Tab. 4-1. For details on tests, see Dossier VI: Wireline Logging and Microhydraulic Fracturing and Dossier VII: Hydraulic Packer Testing.

Tab. 4-1: Weekly chronology of all working steps of the BUL1-1 and BUL1-1B borehole

Week 10 – 14 04.03.2019 – 07.04.2019	Rig up and installation of drilling rig and all peripheral facilities
Week 15 08.04.2019 – 14.04.2019	Laying out drill string, run in hole (RIH) 23" drill string
Week 16 15.04.2019 – 21.04.2019	Drilled 23" from 43 m to 168 m, carried out the first two single shot measurement at 96.5 m and 150 m (deviations: ~ 0.25°)
Week 17 22.04.2019 – 28.04.2019	Drilled 23" from 168 m to 175 m, repaired topdrive (changed two hydraulic motors), check trip up to 30" casing shoe at 43 m (ok), drilled 23" from 175 m to 355 m, carried out four single shot measurements at 196 m, 245 m, 304 m and 352 m (deviations: 0° to ~ 0.25°)
Week 18 29.04.2019 – 05.05.2019	Drilled 23" from 355 m to 380 m, round trip, 23"; bit change, drilled 23" from 380 m to 510 m, no dynamic losses, carried out three single shot measurements at 401 m, 447 m and 497 m (deviations: 0°)
Week 19 06.05.2019 – 12.05.2019	Drilled 23" from 510 m to 531.5 m, POOH, petrophysical logging, RIH 18 ⁵ / ₈ " casing: K55, 96.5 lbs/ft, shoe depth 530 m, cementation, float valve test performed (result positive), casing cut to the correct height and 30" diverter removed, rig up 21 ¹ / ₄ " diverter
Week 20 13.05.2019 – 19.05.2019	Changed diverter line, pressure test of the annular preventer and the welding on the casing flange against the cement plug; held at 44 bar for 20 min, shoe track of the 18 ⁵ / ₈ " casing drilled out and into the formation to 535 m, FIT (formation integrity test) performed with a head pressure of 20 bar, logging: cement bond log, casing collar log, RIH 7 ⁵ / ₈ " auxiliary casing, BTC (buttress connection) to 534.8 m; every connection spot welded, repaired hydraulic motor on topdrive, RIH core string, cored to 545 m, hydraulic tests (including assembly and disassembly)
Week 21 20.05.2019 – 26.05.2019	RIH, cored from 545 m to 578.8 m, POOH (pull out of hole) core string, core bit changed; bit heavily worn and burned, RIH, cored to 580.4 m, POOH core string due to a low ROP of 20 cm/h, changed core bit, RIH to 530 m, single shot measurement (depth 554 m) with deviation less than 0.5°
Week 22 27.05.2019 – 02.06.2019	Cored from 580.4 m to 736 m, single shot measurement, deviation less than 0.5°
Week 23 03.06.2019 – 09.06.2019	Cored from 736 m to 869 m, single shot measurement every 50 m, deviation less than 0.5°

Tab. 4-1: (continued)

Week 24 10.06.2019 – 16.06.2019	Cored from 868 m to 869 m, single shot measurement every 50 m, deviation less than 0.5°, technical logging, hydraulic tests in intervals 814 m to 846.7 m and 608.8 m to 641.5 m, pump test in interval 608.8 m to 641.5 m
Week 25 17.06.2019 – 23.06.2019	Continued pump test in interval 608.8 m to 641.5 m, packer release and POOH the 2 $\frac{7}{8}$ " tubing and the test string, wiper trip at 700 m and a rise in gas was observed (methane, max. 38.3% [trip gas]); borehole circulated clean by gas and mud conditioning; POOH and core string racked back, technical logging in interval 869 m to 525 m, hydraulic test including assembly and disassembly
Week 26 24.06.2019 – 30.06.2019	Hydraulic packer test in interval 848.2 m to 869.0 m, cored from 869.0 m to 911.5 m
Week 27 01.07.2019 – 07.07.2019	Cored from 886.5 m to 952 m, POOH core string, petrophysical logging (four runs, including assembly and disassembly)
Week 28 08.07.2019 – 14.07.2019	MHF (microhydraulic fracturing; first run), wiper trip, MHF (second run), standby (wiper trip, mud conditioning, etc.), logging: UBI (ultrasonic borehole imager), MHF (7 to 8 tests), logging after MHF
Week 29 15.07.2019 – 21.07.2019	RIH 8 $\frac{1}{2}$ " hole opener to 535 m, drilled with three runs from 535 m to 920 m. First run PDC (polycrystalline diamond compact bit), second run impregnated hole opener because of cherts, ROP < 0.6 m/h resulted in third run
Week 30 22.07.2019 – 28.07.2019	Technical logging failed deeper than 535 m, several attempts without success, RIH 7 $\frac{5}{8}$ " auxiliary casing, another attempt to log, again tools could not be run deeper than 535 m, logging and testing cancelled, POOH 7 $\frac{5}{8}$ " auxiliary casing, RIH 12 $\frac{1}{4}$ " hole opener with 8 $\frac{1}{2}$ " bit until 535 m, 5 t resistance, drilled out the bridge; no cement was found on the shakers, drilled from 535 m to 920 m, POOH 12 $\frac{1}{4}$ " drill string, pick up 17 $\frac{1}{2}$ " hole opener
Week 31 29.07.2019 – 04.08.2019	RIH 17 $\frac{1}{2}$ " hole opener, drilled from 530 m to 920 m, POOH and RIH gravel string, several attempts to enter the old 6 $\frac{3}{8}$ " borehole (depth: 922 m) were without success; impossible to fill up the borehole with sand, technical logging
Week 32 05.08.2019 – 11.08.2019	RIH 13 $\frac{3}{8}$ " casing, BTC down to shoe depth of 919 m, cementation, diverter line dismantled, casing cut, diverter 18 $\frac{5}{8}$ " casing head removed, 13 $\frac{3}{8}$ " 3K casing head housing rigged up, 13 $\frac{3}{8}$ " BOP (blow out preventer) stack rigged up, flare and flare line installed, pressured BOP and remaining safety equipment up in eight steps with a pressure of 500 psi (34 bar) for 5 min and 3000 psi (207 bar) for 10 min, result positive, RIH to drill out the 13 $\frac{3}{8}$ " casing shoe, casing integrity test with pressure of 40 bar for 20 min above shoe, FIT

Tab. 4-1: (continued)

Week 33 12.08.2019 – 18.08.2019	Technical logging (cement bond log [CBL]) – TOC (top of cement) at 64 m, VSP (vertical seismic profile), bottom of shuttle at depth 910 m, RIH of 97 joints 7 $\frac{5}{8}$ " auxiliary casing to 922.8 m, RIH coring string with 3 $\frac{3}{4}$ " multidrill system bit to 915 m, mud weight increased to 1.15 SG (specific gravity) with calcium carbonate, 6 $\frac{3}{8}$ " core section was cleaned from 924 m to 952 m with a flowrate of 400 l/min to 500 l/min, POOH core string, RIH core string to 952 m, reamed core section several times with high torque and high pressures from 948 m to 952 m (bottom hole), drill-off test, cored from 952 m to 958 m, POOH core string, RIH core string with 3 $\frac{3}{4}$ " multidrill system bit with circulation and rotation from a depth of 924 m down to 958 m (bottom hole); performed check trip several times in open hole section
Week 34 19.08.2019 – 25.08.2019	POOH core string with 3 $\frac{3}{4}$ " multidrill system bit, RIH core string with 3 $\frac{3}{4}$ " multidrill system bit and new coring head until 958 m, cored from 958 m to 979 m, borehole filled with gravel from 979 m to 952 m, POOH coring BHA and auxiliary casing; measured weight of the auxiliary casing was 15 t, should have been 38 t; it was not possible to pull the casing out of the hole; circulated with a low pump rate, the string was released with 58 t, RIH 8 $\frac{1}{2}$ " BHA to 850 m; tried to circulate but no returns, string plugged; POOH; gravel found at the top of the first heavy weight drill pipe (HWDP), cleaned 8 $\frac{1}{2}$ " drill string and RIH to 800 m, interrupted circulation every 100 m; from 800 m to 921 m RIH with circulation of 1'000 l/min and 20 bar SPP (standpipe pressure); drilled from 921 m to 952 m
Week 35 26.08.2019 – 01.09.2019	Drilled with 12 $\frac{1}{4}$ " hole opener from 924 m to 952 m, technical logging (washouts with a volume of 7 m ³), preparation for cement plug, RIH cement stinger to 952 m, cement plug inserted from 952 m to 910 m, POOH cement stinger, BOP test carried out, RIH 12 $\frac{1}{4}$ " drill string, drilled from 911 m to 916 m, 8 $\frac{1}{2}$ " pilot hole drilled from 916 m to 919 m, drilled out cement plug from 919 m to 952 m, borehole circulated clean, POOH drill string, RIH 7 $\frac{5}{8}$ " auxiliary casing
Week 36 02.09.2019 – 08.09.2019	RIH 7 $\frac{5}{8}$ " auxiliary casing, RIH BHA, HiVis (high viscosity) pills pumped to improve the discharge of the gravel, BHA pulled into the auxiliary casing and the inner coring tube was pulled with the drill bit, inner tube installed with plastic liner, pump tests with pump pressure always above 50 bar, POOH BHA, deposits were found in the core crown which made circulation impossible, repair of topdrive, RIH coring BHA, tried to circulate, pressure immediately increased again; BHA was POOH, no contamination found in inner or outer tube or the crown, mud conditioned and pumped through cyclone system, entire pit system cleaned, RIH with BHA and tried to circulate with the inner tube, no free flow, pump test with 450 l/min and 3.6 bar SPP, RIH to 955 m with 3 t slack off, then RIH with circulation and rotation to 979 m, coring from 979 m to 1'009 m, the slickline for pulling the cores to the surface was torn off and the BHA had to be POOH to make a new connection with clamps, drill bit exchanged, single shot measurement at 1'000 m (deviation less than 0.5°)

Tab. 4-1: (continued)

Week 37 09.09.2019 – 15.09.2019	Cored from 1'009 m to 1'043 m, no indication that the inner tube landed; pulled inner tube, stuck at 170 m; inner tube was pulled with catcher and laid down, POOH coring BHA, drill pipes (DP) were cleaned and singled out, petrophysical logging, stand up occurred at 985 m; logging run cancelled, RIH with roller cone bit rotary BHA to 958 m, circulated every 200 m with 300 l/min and 10 bar SPP, reamed section several times, topdrive motor broke, pulled back BHA into the auxiliary casing at 940 m; changed topdrive motor; RIH to 958 m, reamed down to 964 m; at 967 m again no progress, up to 3 t WOB, 450 l/min, 30 bar SPP, 50 RPM; POOH to surface, exchanged topdrive for 7 $\frac{5}{8}$ " casing and relocated the coring DP, repaired topdrive gear box hydraulic motor, POOH 7 $\frac{5}{8}$ " auxiliary casing; prepared hole opening BHA, RIH 8 $\frac{1}{2}$ " hole opened BHA to 915 m, RIH with circulation from 915 m to 955 m with 1'000 l/min, 18 bar; opened the 6 $\frac{3}{8}$ " core section to 8 $\frac{1}{2}$ " from 955 m to 1'040 m; parameters: 60 RPM, 1'900 l/min, 73 bar, 0.5 t to 2 t WOB
Week 38 16.09.2019 – 22.09.2019	Opening of the 6 $\frac{3}{8}$ " core section to 8 $\frac{1}{2}$ " from 916 m to 1'043 m, reamed problematic section from 977 m to 985 m several times, technical logging: not possible to run to bottom because a hang up occurred in 976 m to 982 m; opened the 8 $\frac{1}{2}$ " hole to 12 $\frac{1}{4}$ " from 916 m to 1'043 m, RIH stinger on 5" DP to 1'043 m, first cement plug set from 1'043 m to 933 m; pumped 6 m ³ of water spacer, 5.2 m ³ of cement (1.7 SG), 0.3 m ³ of water spacer and 8.7 m ³ of mud (1.15 SG), second cement plug set from 933 m to 926 m; pumped 6 m ³ of water spacer, 10.4 m ³ of cement (1.7 SG), 0.1 m ³ of water spacer, 8.6 m ³ of mud (1.15 SG), last cement plug set from 926 m to 915 m; pumped 3 m ³ of water spacer, 1.6 m ³ of cement (1.7 SG), 0.3 m ³ of water spacer, 7 m ³ of mud (1.15 SG), last cement plug tagged at 916.5 m, POOH and BOP test
Week 39 23.09.2019 – 29.09.2019	RIH 8 $\frac{1}{2}$ " drilled BHA to top cement (916.5 m) and drilled cement to 922 m, POOH, installed 7 $\frac{5}{8}$ " auxiliary casing to 920.5 m, RIH coring BHA to 922 m and cored to 995.85 m, below 995.85 m 100% formation was cored down to 1'054 m, the borehole was sidetracked at 995.85 m (100% formation cored instead of cement), multi-shot showed an inclination of 0.5°, name change to BUL1-1B
Week 40 30.09.2019 – 06.10.2019	Cored to 1'074 m, hydraulic tests, petrophysical logging, RIH coring BHA
Week 41 07.10.2019 – 13.10.2019	Cored from 1'074 m to 1'137 m, core bit changed twice
Week 42 14.10.2019 – 20.10.2019	Cored from 1'137 m to 1'210 m, petrophysical logging, RIH coring BHA to core 1 m core to 1'211 m and POOH; RIH hydraulic test equipment
Week 43 21.10.2019 – 27.10.2019	Hydraulic test, packer was stuck but released after several attempts; POOH test string, technical logging, MHF (three tests) and petrophysical logging

Tab. 4-1: (continued)

Week 44 28.10.2019 – 03.11.2019	Opening the core section in two steps from 922 m to 1'211 m, from 6 $\frac{3}{8}$ " to 8 $\frac{1}{2}$ ", from 8 $\frac{1}{2}$ " to 12 $\frac{1}{4}$ ", technical logging; complete logging impossible, logging cancelled after several attempts; wiper trip
Week 45 04.11.2019 – 10.11.2019	Technical logging, 9 $\frac{5}{8}$ " casing to 1'205 m, two stages of cementation of the 9 $\frac{5}{8}$ " casing, RIH drilling BHA, drilled out first stage and reamed several times, casing test with 50 bar for 10 min (ok), rathole drilled out and reamed several times, pit system was cleaned and mud disposed of, exchanged mud: pumped 14 m ³ of spacer and 44 m ³ of new mud, spacer to surface; 4 m ³ of mixing zone sheared, 8 $\frac{1}{2}$ " borehole drilled with roller cone bit from 1'211.3 m to 1'216 m, circulated borehole; technical logging, POOH 8 $\frac{1}{2}$ " BHA, BOP function and pressure test
Week 46 11.11.2019 – 17.11.2019	Petrophysical logging, RIH 6 $\frac{3}{8}$ ", coring BHA to 1'216 m, cored from 1'216 m to 1'333 m
Week 47 18.11.2019 – 24.11.2019	Cored from 1'333 m to 1'370 m, petrophysical logging, MHF (eight tests), technical logging, VSP, cemented back to 1'184 m, WOC (waiting for cement)
Week 48 25.11.2019 – 01.12.2019	WOC, top of cement tagged at 1'184 m, mud replaced with completion fluid (55 m ³ water inhibitor), rigged down topdrive, substructure rig floor, trip tank and flowline, BOP removed and blind flange installed, rig release: 27.11.2019, 03:30 p.m., rig down
Week 49 02.12.2019 – 08.12.2019	Rig down and demobilisation
Week 50 09.12.2019 – 15.12.2019	Demobilisation

4.2 Casings and sectional overview

Fig. 1-3 shows the final casing scheme and formation tops, the figure in Appendix E shows the planned formation tops and casing scheme. In Tab. 4-2 a sectional overview of the drilling operations is given.

The casing diameters, grades of the steel, weight per foot (lbs/ft), types of connection and depths along hole are:

0 m to 43 m	30" conductor pipe, S355, --, structural steel, welded
0 m to 530.5 m	18 $\frac{5}{8}$ " surface casing, K55, 96.5 lbs/ft, Big Omega
0 m to 918.7 m	13 $\frac{3}{8}$ " intermediate casing, J55, 68 lbs/ft, BTC
0 m to 1'205 m	9 $\frac{5}{8}$ " intermediate casing, J55, 40 lbs/ft, BTC

The 7 $\frac{5}{8}$ " liner was planned as a contingency but was not run in hole.

Tab. 4-2: Drilling operations by sections

	Section	Casing	From	To	Diameter	Drilling technology
BUL1-1	Conductor section	30"	0 m	30 m	59"	Excavator borehole
			30 m	43 m	47"	Excavator borehole
	Section I	18 ⁵ / ₈ "	43 m	531.5 m	23"	Rotary BHA
	Section II	13 ³ / ₈ "	531.5 m	535 m	17½"	Rotary BHA for FIT
			535 m	952 m	6 ³ / ₈ "	Coring
			535 m	919 m	8½"	Hole opening
			535 m	919 m	12¼"	Hole opening
			535 m	919 m	17½"	Hole opening
	Section III	9 ⁵ / ₈ "	920 m	923.5 m	1 ¼"	Rotary BHA for FIT
			923.5 m	952 m	6 ³ / ₈ "	Drilling out rathole
			952 m	979 m	6 ³ / ₈ "	Coring
			923.5 m	952 m	8½"	Hole opening
			923.5 m	952 m	12¼"	Hole opening
BUL1-1B	Section III		911 m	916 m	12¼"	Drilling out cement plug
			916 m	952 m	½"	Drilling out cement plug
			979 m	1'043 m	6 ³ / ₈ "	Coring
			952 m	1'043 m	8½"	Hole opening
			918 m	1'043 m	12¼"	Hole opening
		916.5 m	922 m	8 ½"	Drilling out cement plug	
		922 m	1'211 m	6 ³ / ₈ "	Core cement plug to 996 m and coring	
		922 m	1'211 m	8½"	Hole opening	
		922 m	1'211 m	12¼"	Hole opening	
		1'211 m	1'216 m	8½"	Rotary BHA for FIT	
Section IV	Cement plug	1'205 m	1'370 m	6 ³ / ₈ "	Coring	

4.3 Drilling by sections

4.3.1 Conductor section: 30" standpipe to 43m

A subcontractor (STRABAG AG, Schlieren) was hired to drill and install the 30" conductor pipe. The first 43 m were drilled and cased from 03.12.2019 to 12.12.2019. Unconsolidated sediments were excavated using a gripper whereas consolidated sediments were first rammed with a large-scale chisel and then removed using a smaller gripper. Details regarding the drilling of the conductor pipe including the casing are not part of this report.

4.3.2 Section I: 43 m to 531.5 m (18 $\frac{5}{8}$ " anchor casing)

Before drilling started, a 30" diverter and a connecting line to a 40 m³ tank were installed.

The 23" hole was drilled from 15.04.2019 to 07.05.2019 with bottom hole assembly using a roller cone tooth bit from 45 m to 380 m. At 380 m the rate of penetration dropped, and a new roller cone tooth bit was installed to drill down to 531.50 m.

The topdrive on the Daldrup rig has two gears. The first gear can be run with up to 60 rpm (revolutions per minute; with higher torque) and the second gear with a maximum of 120 rpm and half the available torque of the first gear. The 23" section could only be run in first gear because the torque was too high for the second gear.

All drilling activities in all sections were permanently recorded by the mud logging service using real-time monitoring. The following parameters were recorded:

- suction pit levels
- mixing pit levels
- trip tank level
- desilting pit level
- sand trap level
- topdrive torque
- make-up torque
- RPM of bit and string
- flowrate OUT
- strokes per minute (SPM) of the two mud pumps
- standpipe pressure
- hook load
- annular pressure
- hook height
- mud weight (MW) IN/OUT
- mud temperature IN/OUT
- wind speed and direction – anemometer
- gas detection: total hydrocarbons (C1 to iC5), lower explosive limit (LEL), H₂S, CO₂

The average drilling parameters of the first bit were as follows:

- ROP: 1.2 m/h
- WOB: 8.4 t
- string revolutions: 56 rpm
- torque: 1'988 daNm
- flowrate: 2'800 l/min
- SPP: 18.9 bar

The second bit achieved the following average parameters:

- ROP: 1.1 m/h
- WOB: 9.1 t
- string revolutions: 40 rpm
- torque: 1'891 daNm
- flowrate: 3'090 l/min
- SPP: 37.0 bar

The mud system used was a Pure-Bore® water-based mud with a density between 1.05 kg/l and 1.10 kg/l. The inclination was measured every 50 m with single shots; all inclination measurements were below 1°.

The gas content at the upper drilling section was low. The maximum gas readings while drilling with a 23" drill bit are summarised in Tab. 4-3.

Tab. 4-3: Gas content in section 33.5 m to 531.5 m

From	To	Total gas	C1	C2	C3	iC4	nC4	iC5	nC5
[m]	[m]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
33.5	531.5	0.6	0.031	0.029	0.001	0.000	0.001	0.003	0.003

Casing

The 18⁵/₈" casing (96.5 lbs/ft, inner diameter [ID] of 17.655", grade K55, Big Omega connection) was RIH without problems. The last joint was run to 530 m with a circulation of 600 l/min.

Cementation

The casing was cemented through a stinger with 66.8 m³ lead cement (1.7 kg/l) and 9 m³ tail cement. The cement seen at the surface had a density of 1.88 kg/l. A volume of 20 m³ of mixing zone was sheared out.

The 18⁵/₈" casing was cemented to surface on 11.05.2019. Lead cement volume was 66.8 m³ with a density of 1.7 SG. The tail cement volume was 9 m³ with a density of 1.88 SG.

The cementing chart and programme can be found in Appendix K.

A cement bond log (CBL) was acquired in the Bülach-1-1 borehole to evaluate the integrity of the cement and control the casing collar locations. The transit time (TT) log, picked from the first arrivals of the variable density log (VDL), was relatively straight indicating a good tool centralisation. Average TT values were within the range of the theoretical casing travel time for an 18 $\frac{5}{8}$ " – 96.5 lbs/ft casing ($\sim 496 \mu\text{s}$) indicating that the data are suitable for CBL interpretation. CBL amplitudes acquired were unusually high (higher than the theoretical free pipe signal) making the quantitative assessment of cement integrity impractical.

The casing collar locator (CCL) tool could not locate the casing collars, most likely due to the large casing diameter. The casing collars were, however, clearly identifiable in the TT, CBL and VDL.

The cement bond was classified as medium to good across the interval from 43 m to 531.5 m (above 43 m the signal was attenuated by the second casing), characterised by strong formation arrivals and a medium to low CBL amplitude. Cement zone descriptions are shown in Appendix K. In preparation for section II, a 20 $\frac{3}{4}$ " diverter and the casing head housing were installed.

4.3.3 Section II: wireline coring from 535 m to 952 m (13 $\frac{3}{8}$ " casing)

After drilling out the shoe track at 530.5 m MD on 14.05.2019, the borehole was deepened to 535.0 m with a 17 $\frac{1}{2}$ " roller cone tooth bit, followed by coring down to 952.0 m using a 6 $\frac{3}{8}$ " core bit assembly. The borehole was circulated to an equivalent mud weight of 1.47 kg/l (mud density of 1.09 kg/l and additional pressure at the surface of 20 bar) before the formation integrity test was performed. The auxiliary 7 $\frac{7}{8}$ " casing (29.7 lbs/ft, grade J55, connection BTC, special clearance) was RIH until 534.80 m to enable coring. It was set into the wellhead with a tubing hanger.

The 5 $\frac{1}{2}$ " coring string (SK 5 $\frac{1}{2}$ " B) was tested (make-up test with dope). Core length were set to a maximum of 3 m before pulling the liner out again, using a plastic liner only. Coring was performed with a ballaset core head until 545 m before the BHA was pulled out of hole and the test string was run on 2 $\frac{7}{8}$ " tubings.

After finishing the hydraulic tests, coring continued to 578.80 m with the same ballaset core head. Because the ROP was very slow, the BHA was POOH. The ballaset crown was worn out from too high temperatures and had to be replaced, unfortunately without a better progress. BHA was POOH at 580.4 m and the crown had the same wear and tear as the previous one at the surface. Therefore, an impregnated core bit was RIH and cored from 580.4 m to 869 m. When coring resumed, the ROP rose to a normal level of 1.5 m/h on average. Every 50 m a single shot was performed; all measured inclinations were below 1°. At this depth hydraulic testing was performed again (842.2 m to 869 m).

After testing, a polycrystalline diamond compact (PDC) core bit was RIH and used to core from 869 m to 889 m with low ROP. The PDC cutters could not penetrate the formation with their specific design. The cutting depth and therefore ROP were low. A PDC bit with a different design was RIH and the groove of the inner core barrel was modified. The following drill-off test did not show an improvement in ROP, but coring continued from 889 m to 952 m. A single shot was performed every 50 m (all measured inclinations were below 1°). The target depth (TD) of this section was changed several times due to customs problems of the logging company.

Unfortunately, some logging measuring devices had malfunctions. Furthermore, the packer elements needed for the MHF tests had failed. After several attempts it was decided not to carry out the MHF tests. The coring BHA was POOH and several WL (wireline) measurements were performed. Then the 7 $\frac{5}{8}$ " auxiliary casing was POOH and a hole opener BHA with a bull nose was RIH and opened the hole from 535 m to 920 m (rathole 32 m). Because many chert nodules with large diameters were detected in the cores in the section between 576 m to 614 m, this section was opened with an impregnated hole opener (see Fig. 4-1).

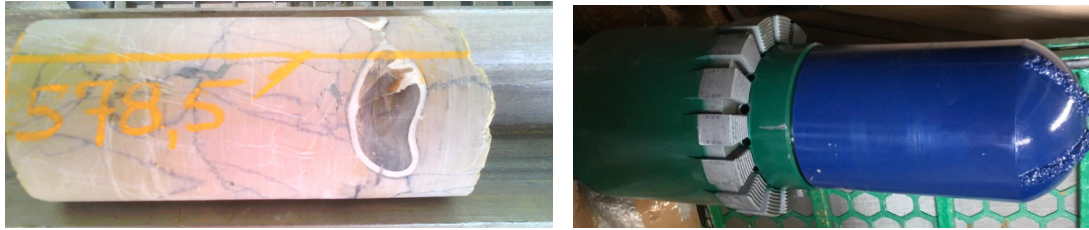


Fig. 4-1: Core picture (left) and impregnated hole opener (right)

During a logging attempt, the tools could not pass the hole at 535 m where the hole diameter changed from 17 $\frac{1}{2}$ " to 8 $\frac{1}{2}$ ". Nagra decided to run the 7 $\frac{5}{8}$ " auxiliary casing to help the WL tool string pass 535 m. Because the WL tools still did not pass, the auxiliary casing was POOH and a hole opener BHA with a 8 $\frac{1}{2}$ " bull nose was run from 535 m to 920 m (rathole 32 m), which opened the hole from 8 $\frac{1}{2}$ " to 12 $\frac{1}{4}$ ". The next BHA was run with a 12 $\frac{1}{4}$ " bull nose and opened the hole to 17 $\frac{1}{2}$ " from 535 m to 920 m. Afterwards a drill string was run to fill up the rathole with gravel. Unfortunately, this string could not pass 922 m even with circulation. Nagra decided not to fill up the rathole and the drill string was POOH.

The logging truck was rigged up and performed WL measurements.

The 6 $\frac{3}{8}$ " core bit assemblies provided the following parameters (all parameters on average) along the section:

- ROP: 1.1 m/h
- WOB: 3.9 t
- string revolutions: 152 rpm
- torque: 438 daNm
- flowrate: 384 l/min
- SPP: 17.4 bar

The gas readings increased significantly in the Opalinus Clay below 870 m. The maximum gas readings while drilling with a 6 $\frac{3}{8}$ " drill bit are summarised in Tab. 4-4.

Tab. 4-4: Gas content in section 531.5 m to 952 m

From	To	Total gas	C1	C2	C3	iC4	nC4	iC5	nC5
[m]	[m]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
531.5	952	1.9	0.849	0.002	0.003	0.001	0.000	0.000	0.000

Casing

The tubular running service (TRS) was rigged up to run the 13 $\frac{3}{8}$ " casing, ID 12.415", 68 lbs/ft, J55 steel, CS 918.7 m, to 912 m. From 912 m to 918.7 m the casing was run with circulation.

Cementing

The stinger cement job was performed as planned, but the backflow through the flowline dropped after pumping 63 m³ of lead cement. After pumping 65 m³ there was no return visible at all. Even with a reduced pump rate there was no backflow and the cement job was completed at a rate of 300 l/min. The last density value measured from backflow was 1.13 kg/l. In total, 89 m³ of lead cement with a density of 1.7 kg/l and 11.4 m³ of tail cement with a density of 1.88 kg/l were pumped. The stinger was POOH and the rig waited on cement. Top of cement in the annulus was found at 63 m. Cementing chart and programme can be found in Appendix K.

A CBL was acquired in section 2 of the Bülach-1-1 borehole to evaluate the integrity of the cement and identify the locations of the TOC and the lead-tail interface. CBL readings in the free pipe were consistent with the theoretical free pipe amplitude for a 13 $\frac{3}{8}$ " – 68 lbs/ft casing (43 mV), indicating that the tool was properly calibrated. The TOC was identified at a depth of 64 m. The lead-tail interface was estimated at a depth of 741 m.

The cement bond was classified as medium to good across the interval from 64 m to 515 m and characterised by moderately visible casing arrivals, medium formation arrivals and a low CBL amplitude. From 515 m to 918 m casing arrivals were weak and formation arrivals were strong, indicating a good bond between the casing, cement and formation.

Cement zone descriptions are shown in Appendix L.

In preparation of section III, the diverter and the 13 $\frac{3}{8}$ " casing head housing (CHH) with a 13 $\frac{3}{8}$ " BOP (double ram and annular) were installed and tested successfully.

4.3.4 Section III: wireline coring from 952 m to 1'211 m (9 $\frac{5}{8}$ " casing)

The third section was drilled from 17.08.2019 to 11.09.2019 and characterised by difficulties. The choice of drill bits in the clay-rich formations, the conditioning of the drilling fluid as well as the timely mobilisation of the testing companies were challenging. Instabilities in the Opalinus Clay and the necessary safety measures led to the fact that the hole was cemented back several times; the last time from 1'043.00 m to 918.7 m. The subsequent core drilling resulted in a sidetrack at 995.85 m. This sidetrack was named BUL1-1B.

First, the float collar was drilled out with a 12 $\frac{1}{4}$ " tooth bit. The casing was pressure-tested at 40 bar for 20 min. Then the float shoe and cement (including 4 m formation) were drilled down to 924 m. Conditioning the mud and attempting the planned FIT were without success. The pressure drop during the FIT was most likely caused by the rathole in the Opalinus Clay. The FIT was cancelled and the petrophysical logging including VSP measurements started. The 7 $\frac{7}{8}$ " auxiliary casing was installed down to 923 m and the BHA was RIH down to 915 m with wireline core barrel SK 5 $\frac{1}{2}$ " B and a multidrill system with a roller cone bit. The mud weight (Pure-Bore® 1.09 kg/l) was increased by adding up to 1.15 kg/l of chalk (CaCO₃) to protect the Opalinus Clay.

After drilling out the rathole, the multidrill bit was pulled and coring was performed from 952 m to 958 m. The core was partly brittle, and the pressure increased during coring. Nagra decided to POOH and to drill ahead until no more cuttings appeared on the shakers.

Coring continued from 958 m to 961 m, including a drill-off test. There were problems retrieving the core. Deposits in the core barrel caused problems when pumping out the inner tube. The Opalinus Clay was cored from 961 m to 979 m with difficulties. Due to continuous caving from the Opalinus Clay, clay fill was observed on the top of the cores and the decision was made to plug back the open hole with sand up to 951.70 m. After opening the hole from 921 m to 952 m with a stage hole opener in two steps, washouts in the Opalinus Clay were detected again and the borehole was cemented back to 911 m.

After drilling out the cement with an 8½" tooth bit, the 7⅝" auxiliary casing was RIH down to 951.50 m. It was possible to core down to a depth of 1'006 m where the borehole repeatedly had to be cleaned from cavings. Coring operations were stopped at 1'043 m followed by a caliper measurement. Unfortunately, tools could not run deeper than 985 m and the measurement showed a 18" diameter between 985 m to 952 m. The following reaming was not successful, and it was decided to cement back and stabilise the borehole.

Cementing was done in three stages and top of cement was at 916.50 m. After drilling out the cement to 922 m, coring operations started again. At 995.85 m a kick-off point was seen in the core, changing from cement to 100% formation (sidetrack Bülach-1-1B).

The coring operations were interrupted at 1'074 m to conduct logging and a hydraulic test before coring to the final section depth of 1'211 m. During coring, losses of approximately 5 m³ occurred because the Muschelkalk had already been reached at 1'153 m. Petrophysical logging and hydraulic tests were conducted before the hole was opened to 12¼" from 917 m to 1'211 m in two stages.

The 6⅜" core bit assemblies drilled ahead across the section with the following average drilling parameters:

- ROP: 1.2 m/h
- WOB: 2.6 t
- string revolutions: 176 rpm
- torque: 523 daNm
- flowrate: 322 l/min
- SPP: 22.9 bar

To prevent cavings in this section, the drilling mud was conditioned from 1.12 kg/l to 1.15 kg/l.

Coring the sidetrack BUL1-1B, ROP was slightly faster with the following parameters:

- ROP: 1.4 m/h
- WOB: 4 t
- string revolutions: 185 rpm
- torque: 992 daNm
- flowrate: 340 l/min
- SPP: 27 bar

While drilling the marlstones of the Lias (Staffelegg Formation), elevated hydrocarbon readings were observed. The maximum gas readings while drilling with the 6⅜" drill bit are summarised in Tab. 4-5.

Tab. 4-5: Gas content in BUL1-1 from 952 m to 1'043 m and in sidetrack BUL1-1B from 995.85 m to 1'211 m

From	To	Total gas	C1	C2	C3	iC4	nC4	iC5	nC5
[m]	[m]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
952	1'043	0.4	0.025	0.006	0.006	0.003	0.003	0.003	0.002
995.85	1'211	1.7	0.341	0.042	0.024	0.002	0.005	0.002	0.003

Casing

RIH the 9 $\frac{5}{8}$ " casing down to 870 m with a stage tool was performed on 6.11.2019. The 9 $\frac{5}{8}$ " casing was set into the wellhead with a tubing hanger; CS at 1205 m. The cementation was carried out via the side outlets of the wellhead in two stages.

Cementation

The 9 $\frac{5}{8}$ " casing was cemented from 06.11.2019 to 07.11.2019 in two stages:

- first stage: 19.1 m³ of cement (HMR+), MW 1.89 kg/l (stage tool at 870 m)
- second stage: 28.8 m³ of cement (HMR+), MW 1.88 kg/l, cement at surface.

The cement in the shoe was very soft. ROP was up to 11 m/h with low WOB (0 t to 0.2 t). Cementing chart and programme can be found in Appendix K.

A CBL was acquired in section III (including sidetrack) of the Bülach borehole to evaluate the integrity of the cement and identify the TOC. The logs show a good tool centralisation and a cementation to surface.

The cement bond was classified as medium across most of the logged interval, characterised in the VDL by moderate / weak casing arrivals and medium / strong formation arrivals and a medium / low CBL amplitude.

Three zones of poor cementation were identified (1'063 m to 1'079 m, 1'136 m to 1'147 m and 1'194 m to 1'204 m). In these intervals the VDL showed strong casing and formation arrivals suggesting a poor bond to the casing and a good bond to the formation.

4.3.5 Section IV: wireline coring from 1'216 m to 1'370 m (plug cementation)

The coring operations were performed from 12.11.2019 to 19.11.2019. After drilling out the 9 $\frac{5}{8}$ " stage tool, the shoe track and the cement down to 1'211.30 m, the polymer mud was exchanged for NaCl brine (including pure bore). The borehole was then drilled down to 1'216.00 m with an 8 $\frac{1}{2}$ " roller bit assembly. The last metres of the cored section (below 1'363 m) were drilled with a low average ROP of around 1.0 m/h to 1.5 m/h. The coring BHA was POOH without any problems; no overpulls occurred. After petrophysical logging runs the NaCl brine was exchanged for protection liquid / inhibitor with a density of 1.0 kg/l. During coring no gains or losses were observed. Due to the completion of the core drilling phase, the liners of the mud pumps were replaced from 5 $\frac{1}{2}$ " to 7".

The 6 $\frac{3}{8}$ " core bit assembly was operated along this section with the following average drilling parameters:

- ROP: 1.8 m/h
- WOB: 3.1 t
- string revolutions: 178 rpm
- torque: 585 daNm
- flowrate: 335 l/min
- SPP: 15 bar

The gas readings increased in the «Wellenmergel» of the Kaiseraugst Formation at the top of the Muschelkalk. The maximum gas readings while drilling with a 6 $\frac{3}{8}$ " drill bit are summarised in Tab. 4-6.

Tab. 4-6: Gas content in section 1'211.00 m to 1'370.19 m

From	To	Total gas	C1	C2	C3	iC4	nC4	iC5	nC5
[m]	[m]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1'211.00	1'370.19	0.3	0.042	0.011	0.010	0.002	0.002	0.003	0.003

Casing

No casing was installed in this section.

Cementing

Upon completion of the logging runs, the borehole was cemented back to the 9 $\frac{5}{8}$ " casing on 24.11.2019 as follows:

- first stage: 2.5 m³ of water spacer
- second stage: 7.1 m³ of cement, MW 1.88 kg/l, then 0.6 m³ of spacer and 8.8 m³ of mud were pumped; top of cement at 1'184.0 m MD

The cementing chart and programme can be found in Appendix K.

4.4 Time analysis

Work was completed in 226 working days (continuous 24 h operation) after spud-in, followed by 15 d of rig down (see final time-depth diagram, Appendix B). Before starting the drilling phase, 42 d were spent on installing the rig, beginning on 04.03.2019. This was done in 12 h dayshifts until the drilling permission was given, because it was still part of the construction phase.

Scientific investigations in the borehole add up to 16.9% (hydraulic tests: 8.2%, logging operations: 8.7%) of the total time. Drilling activities including casing runs and cementation add up to 32.2%; hole opening operations took 16% and coring works added up to 34.9% of the total time.

The difference between the planned and actual time equals 55 d. Down to 952 m, where instabilities in the Opalinus Clay occurred, the actual time required was close to the planned time although drilling started later than planned.

NPT adds up to 20 d including equipment repairs, unplanned cement plugs and double coring of the unstable cemented sections.

The total NPT recorded for Bülach-1-1 and Bülach-1-1B adds up to 320.75 h. A total of 56.25 h was required for logging and testing and 264.5 h for all drilling operations. In relation to the total time of 5'442.75 h needed for all the work done, the NPT amounts to 5.9%. Most of the NPT was caused by problems with the topdrive (84 h). A total of 53.4 h resulted from waiting for deliveries and 42.75 h were caused by problems with the mud system.

5 Drilling related topics

5.1 Borehole deviation

The borehole is almost vertical. The maximum inclination measured is 1.33° at 1'080 m. The maximum dog leg severity (DLS) is $2.97^\circ/30$ m at 340 m caused by a big turn of the sagging WL tool.

The final survey report was created by combining different survey sections from general purpose inclinometer tool (GPIT) measurements and from gyro runs. Plan view (Fig. 5-1) and section view (Fig. 5-2) show a deviation from the origin with a maximum of approximately 8.44 m to the west and approximately 1 m to the south.

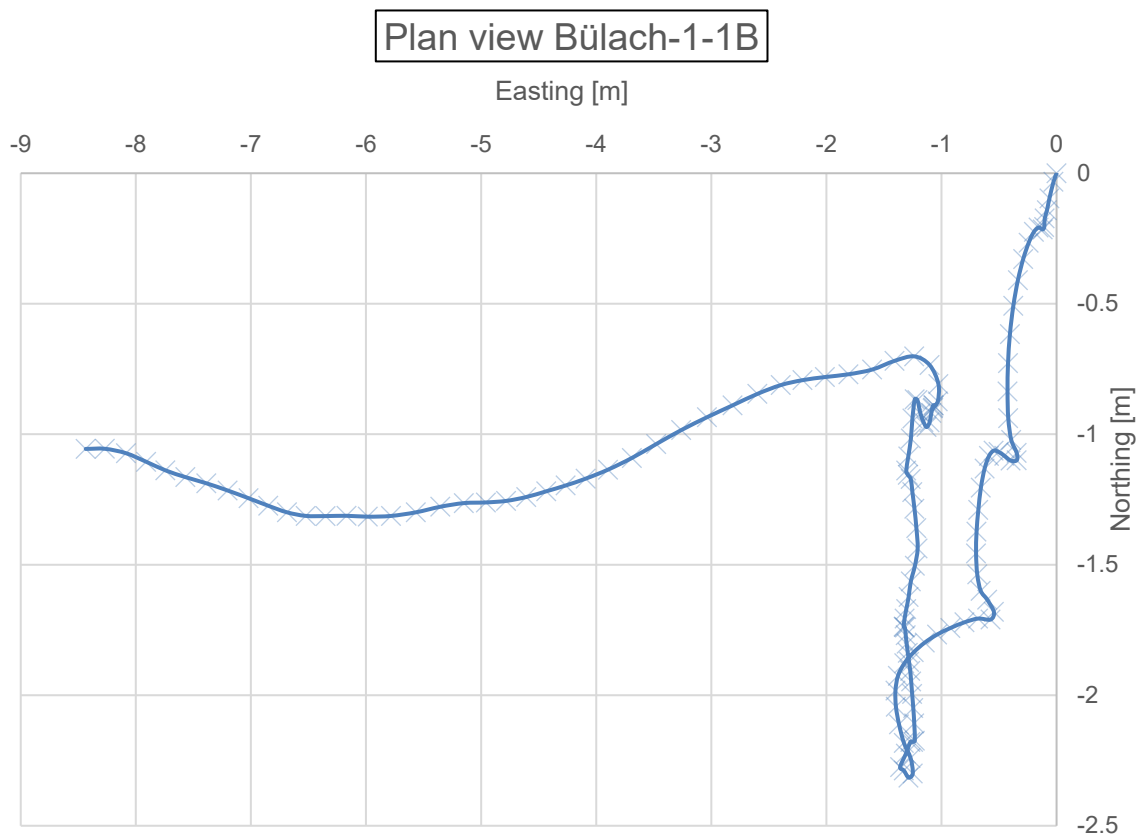


Fig. 5-1: Plan view of Bülach-1-1B

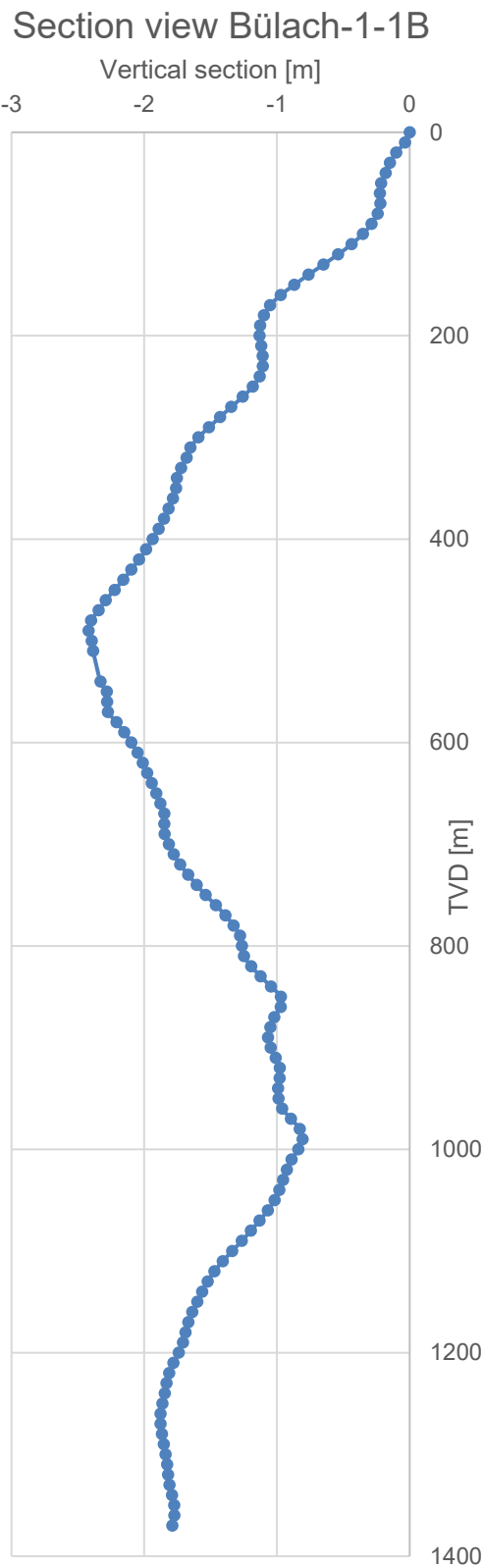


Fig. 5-2: Section view of Bülach-1-1B

5.2 Drilling fluids

In sections I to III, the drilling fluid Pure Bore® was used. Pure-Bore® is a CEFAS (UK Centre for Environment, Fisheries and Aquaculture Science) registered and Water Supply Regulations approved natural, biodegradable drilling fluid, which can be used in a wide variety of drilling applications. It is a dry, free flowing polymer that provides exceptional borehole stability and removal of cuttings in a wide range of ground conditions. Due to the surface activity of this polymer, it can interact with shale / clay material. It creates a network structure by cross-linking at the surface and forming a gel layer that limits pressure transmission and fluid loss into the formation. The choice of mud and mud treatment was under the contractual control of the drilling company. The mud engineering sub-contractor had excellent experience with Pure-Bore® in clay-rich formations. The mud had additionally been tested in Mont Terri where it also showed a satisfactory inhibiting behaviour for several weeks and a good repeatability for tests determining hydraulic parameters, when compared to water and silicate muds. Due to this fact, Pure-Bore® was approved for BUL1-1. In section IV, the mud system was changed to a fully saturated NaCl brine in the lower part of the Muschelkalk to gain good quality cores while coring through the salt layers.

Tab. 5-1: Drilling fluid parameters – sections I to IV – Pure-Bore®
alap: as low as possible

Parameters	Unit	Section	Min	Max	Planned
Flowline temperature	°C	I	15	45	-
		II	17	42	-
		III	24	47	-
		IV	26	30	-
Density	SG	I	1.05	1.10	1.01 – 1.10
		II	1.06	1.10	1.01 – 1.10
		III	1.09	1.16	1.10 – 1.20
		IV	1.17	1.21	1.15
Plastic viscosity	cP	I	9	15	alap
		II	9	21	alap
		III	9	22	alap
		IV	11	17	alap
Yield point	lb/100 ft ²	I	16	21	20 – 30
		II	11	23	5 – 20
		III	17	25	5 – 20
		IV	17	21	15 – 20
pH	-	I	8.6	10.8	9 – 10
		II	8.9	9.8	9 – 10
		III	8.8	11.1	9 – 10
		IV	8.9	11	9 – 10
Sand content	vol.-%	I	0	0.5	< 1.0%
		II	0.1	0.25	< 1.0%
		III	0.1	0.2	< 1.0%
		IV	0.0	0.1	< 1.0%
MBT (methylene blue test)	kg/m ³	I	-	43	< 36
		II	14.3	28.6	< 36
		III	14.3	14.3	< 36
		IV	n	n	< 36

Tab. 5-2: Drilling fluid materials – sections I to IV

Product	Section I	Section II	Section III	Section IV
Pure Bore®	1'775 kg	2'175 kg	2'375 kg	1'475 kg
Pure Bore® ULV	1'600 kg	3'650 kg	3'700 kg	400 kg
Sodium carbonate (soda ash)	1'000 kg	2'500 kg	2'225 kg	1'300 kg
Sodium bicarbonate		450 kg	1'000 kg	
Calcium carbonate fine			28'000 kg	
Floc cationic	675 kg	175 kg		
Xanthan gum (viscosifier)		800 kg	750 kg	
DefoStab 220 (biostabiliser)	1'000 l	200 l	2'000 l	
Citric acid		50 kg	950 kg	
Grotan OX (biocide)		260 l	610 l	
DefoameX (defoaming agent)	800 l		800 l	
NaCl				72'300 kg

5.3 Mud treatment

The pit level system consisted of eight pits (suction pit chambers 1 to 3, mixing pit 1 to 3, desilting pit and sand trap), each of which was monitored by an ultrasonic pit level sensor.

Especially in sections II and III, the conditioning of the mud was difficult. The mud engineers had difficulties preparing the mud and thus creating good conditions for an ideal drilling environment. The shaker system as well as the cyclone system did not work properly in some cases and needed maintenance several times. As a result, components that were not separated, unintentionally flowed back into the active system.

6 Health, safety and environment (HSE)

6.1 Health and safety

The health and safety of employees, contractors and subcontractors of Nagra is of vital importance. Therefore, several measures were taken during the planning and operation of the drilling campaign to reduce hazards to a minimum and to create safe working conditions.

The drill site was fenced to protect workers from external influences and to define a clear boundary for people and animals which are not allowed to access the drill site. Additionally, the drill site was permanently guarded by a security service during the entire drilling phase. The security guards were also responsible for performing detailed access controls.

To respect the different ATEX zones around the drilling rig, the drill site was divided into a restricted area and a non-restricted area. Access to the restricted area was only allowed with the correct personal protective equipment (PPE), which consisted of:

- overall / jacket
 - anti-flammable
 - anti-static
 - high visibility
- safety shoes
 - S3
 - mid height
- safety helmet
- safety glasses
- safety gloves

Within the restricted area, it was not permitted to carry any non-explosion-proof electrical devices to prevent hazardous sparks within the ATEX zone.

A firefighting and rescue plan with specific procedures for emergency situations was in place for the drill site. Furthermore, the drill site was equipped with emergency exits, muster points, fire-extinguishers, first aid kits and alarm signals. Evacuation drills and trainings were carried out with the personnel on-site on a weekly basis to practice correct behaviour in emergency situations.

Daily changes of shifts always started with pre-job safety meetings to make the rig crew aware of potential hazards on location. Special jobs such as cementing required additional safety meetings together with subcontractors to address all planned work steps and further safety instructions.

Life-saving rules were implemented which everyone who was visiting or working at the drill site had to follow. These rules set the minimum requirements for controlling the risk of serious injury from common activities.

The drilling contractor had a STOP card system in place that allowed all persons on-site to address positive and / or negative observations at the drill site related to HSE. These STOP cards were collected and analysed to pinpoint problems that needed to be addressed and improved for the future. Good cards served as feedback and motivation on excellent performance.

Throughout the drilling phase of BUL1-1 one first-aid case was reported. The first-aid case was related to a falling object: while manually lifting an elevator, a crew member lost their grip and the elevator landed on their foot.

6.2 Environment

6.2.1 Environmental supervision and monitoring

Due to official regulations, the entire project had to be accompanied by an environmental supervisor. This supervisor was responsible for advising and informing Nagra on environmental aspects and for consulting external experts if necessary.

The tasks of the environmental supervisor during the drilling phase were:

- the communication of transport routes
- verifying whether environmental requirements and protective measures were respected for transporting and drilling activities
- to check if the drainage concept was respected and working correctly
- to check if the lighting concept was respected and whether further measures were necessary
- to check the machinery list and particle filters of all vehicles and machines
- to check the storage of hazardous substances
- to check the emergency power generator and its leakage detection system
- the conduction of leakage tests of wastewater and sewage pipes
- to check the storage, separation and disposal of waste at the drill site
- to check if legal noise limits were complied with

The drill site was inspected on a regular basis. No major findings were identified, and all official regulations were fulfilled.

6.2.2 Pedological site support

The drill site was constructed in a previously contaminated area. Several official regulations thus had to be fulfilled during the construction and drilling phase. The project was accompanied by a pedological site support and a soil protection concept was developed to define the work steps.

The soil removed during the construction phase was stored in different categories. Contaminated soil was disposed of. Remaining soil was temporarily stored to be reused for the decommissioning phase.

The pedological site support was responsible for maintaining and checking the quality of the soil on a regular basis. All regulations relevant to soil were fulfilled.

6.2.3 Noise measurements

During the entire drilling phase, the legal limits of the Noise Abatement Ordinance had to be complied with at the nearest residential properties to the drill site. Because drilling operations were carried out without any interruptions, it was important to stay within the legal limits during the day and at night. The limits were 60 dB(A) during the daytime 50 dB(A) during the night. For the BUL1-1 borehole, several noise measurements were performed by a specialised company at the nearest house to evaluate the average noise emissions of the work carried out. Noise measurements showed localised noise disturbances, therefore additional countermeasures were put in place.

At the beginning of the drilling, noise protection walls were erected according to the calculations. Measurements showed that the measures taken were not sufficient. Further measures were successively implemented: a newly installed noise reduction on the topdrive (water-cooling system, two metal sheets welded at an angle of 90°) with additional foam material and two noise reduction mats in front of the hydraulic power unit (HPU). The installation of five additional sound protection elements of 10 m in height led to the desired noise protection of the closest property.



Fig. 6-1: Noise reduction wall

6.2.4 Lighting

Besides noise emissions light emissions were also relevant for the drill site, especially during the night. Proper lighting at the workspace is essential in terms of crew safety but must not affect the surrounding environment. Therefore, warm-white LED lamps were installed at the site to reduce the content of harmful blue light in the emitted spectrum, making the light more environmentally friendly for wildlife and people.

6.2.5 Waste management

Waste material from the drilling process was categorised and disposed of according to the regulations of the Federal Office for the Environment (FOEN).

In every section of the borehole, a detailed analysis of the cuttings and drilling fluid was performed at a specified laboratory to classify the waste materials. For each analysis, two samples were taken: a first sample to determine the texture and mechanical modularity and a second sample for eluate investigations.

6.2.6 Mud losses

At the BUL1-1 borehole no significant mud quantities were lost into the formations. A total of 5 m³ of Pure-Bore® mud were lost in the Schinznach Formation without affecting the drilling operations or the environment.

7 References

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Appendix C1: Drill site pictures



Fig. C-1: Site construction / construction of standpipe



Fig. C-2: Drill cellar with standpipe



Fig. C-3: Site, ready for installations of drilling equipment



Fig. C-4: Rig and noise reduction walls



Fig. C-5: Geology container with core table



Fig. C-6: Site overview

Appendix D: Technical data of the rig

Tab. D-1: Derrick / mast, substructure, draw works and associated equipment

A 1 Derrick / mast

Manufacturer		Wirth GmbH
Type		B 152t
Year of construction		1980
Free height	m	21.40
Min. nominal gross capacity (with 8 lines)	kN	1'750
Nominal hook load (with 8 lines)	kN	1'520
Crown block		
Gross capacity	kN	2'000
Nominal capacity	kN	2'000
Racking capacity		
5" string incl. DC	m	3'000 (horizontal system)
3½" string incl. DC	m	5'000 (horizontal system)
Casing stabbing board	Yes / no	No
Derrickman windbreaks height	m	Not applicable
Derrick camera system	Yes / no	Not applicable

A 2 Substructure

Manufacturer		Daldrup & Söhne AG
Type		Frame type
Year of construction		2004
Width	m	24.00 (doghouse extra)
Clear height below rotary table beams up to	m	2.60
Setback capacity up to	kN	n.a.
Casing / rotary capacity	kN	n.a.
Setback capacity at max. rotary capacity BOP installation equipment	kN	n.a.

A 2.1 Drill floor

Size	m ²	15.5
Drill floor windbreaks height	m	Not applicable / not available
Drainage system		Slip resistant grates
Kelly hole	Yes / no	No
Mouse hole	Yes / no	No

A 3 Draw works

Manufacturer		Wirth
Type		Wirth
Year of construction		1980
Number of electric motors		
Drive system power	kW	300
Max. cable tension, second layer	kN	193 (first gear)
Auxiliary brake		Eddy current brake
Automatic feed system		
Manufacturer		Lebus
Type		B 12 – 512 mm

A 4 Drilling and coring lines**A 4.1 Drilling line**

Diameter		26 mm
Type		Diepa PZ 371
Minimum breaking load	kN	632

A 4.2 Coring wireline

Diameter		9 mm (can be adjusted)
Length	m	3'000

A 5 Dead line anchor

Manufacturer		National Oilwell Varco
Type		G

A 6 Crown block and hook**A 6.1 Crown block**

Manufacturer		Wirth
Type		Wirth B 152
Year of construction		1980
Capacity	kN	1'750
Crown block safety device		Electronic

A 6.2 Hook

Manufacturer		Wirth
Type		Wirth
Year of construction		1980
Capacity	kN	1'750

A 7 Swivel

Manufacturer		Wirth
Type		Wirth
Year of construction		1980
Static capacity	kN	N/a, integral part of the power swivel
Pressure rating	bar	210

A 8 Auxiliary winches

Number		1
Type		Lebus
Maximum cable load, first layer	kN	30

B 1 Rotary table

Manufacturer		
Type		
Maximum opening		Not applicable / not available
Static capacity	kN	
Number of electric motors		
Drive system power	kW	
Maximum rotary speed	min ⁻¹	

B 2 Topdrive

(Electric / hydraulic)

Manufacturer		Wirth
Model		B 152
Drive system power	kW	255
Static capacity	kN	1'750
Dynamic capacity	kN	1'520
Maximum torque	Nm	50'000
Continuous torque	Nm	12'500
Maximum rotary speed	min ⁻¹	390
Rotary speed at continuous torque	min ⁻¹	240

C 1 Mud pumps

Number		2
Manufacturer		IDECO
Model		T-1000
Drive system (electric)		AC
Power rating	kW	750
Maximum pressure	psi / bar	5'000 / 350
with liner		
size	in	4¼
Maximum flowrate	l/min	2'960 × 2
with liner		
size	in	7

C 2 Standpipe(s)

Number		1
ID	in	4
Working pressure	psi / bar	5'000 / 350

C 3 Rotary hose

Number		1
ID	in	3
Working pressure	psi / bar	5'000 / 350

C 4 Circulation head

Are to be provided matching the string(s)

C 5	Wash lines		
	ID	in	4 to 7 (depending on piston size)
	Connection type		Plugged and screwed
	Working pressure	psi / bar	3'000 / 210
D 1	Active tanks		
	Total capacity	m ³	135
D 1.1	Shaker tank		
	Capacity	m ³	9
	Number of chambers	1	
	Sand trap	m ³	5
	Agitators		
	Number		Not applicable
	Power	kW	
	Mud guns		
	Number		1
D 1.2	Intermediate tank		
	Number		1
	Capacity	m ³	37
	Number of chambers		3 (22 m ³ , 2 × 15 m ³)
	Agitators		
	Number		2
	Power	kW	3.2 each
	Mud guns		
	Number		1

D 1.3 Suction tank

Number		1
Capacity	m ³	44.5
Number of chambers		3 (14.5 m ³ , 15 m ³ , 15 m ³)

Agitators

Number		3
Power	kW	3.2 each

Mud guns

Number		3
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D 2 Mixing system**D 2.1 Mix tank**

Capacity	m ³	45
Pill tank capacity	m ³	17.5

Agitators

Number		3
Power	kW	3.2 each

D 2.2 Mix funnels

Number		2
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D 2.3 Mix pumps

Number		2
Manufacturer		NOV Mission
Type		Magnum 6 × 5 × 14
Power rating	kW	45

D 3 Chemical mixing tank

Capacity	m ³	1 (if required)
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D 4 Mud treatment equipment**D 4.1 Shale shakers**

Number		3
Manufacturer		Brandt
Type		King Cobra "minicobra-3-panel"
Drive system		Linear, direct drive
Power rating	kW	1.2
Screen area	m ²	50

D 4.2 Desander

Number		1
Manufacturer		Brandt
Type		Hydrocyclone King Cobra
Number of cyclones		2
Diameter of cyclones	in	12
Cyclone capacity	l/min	3'500

Feed pump

Number		1
Manufacturer		NOV
Type		Mission Magnum 6 × 5 × 14
Drive system (electric)		Electric driven
Power rating	kW	45
Rotary speed control	Yes / no	Yes

D 4.3 Desilter

Number		1
Manufacturer		Brandt
Type		Hydrocyclone King Cobra
Number of cyclones		16
Diameter of cyclones	in	4
Cyclone capacity	l/min	3'500
Feed pump		
Number		1
Manufacturer		NOV
Type		Mission Magnum 6 × 5 × 14
Drive system (electric)		Electric driven
Power rating	kW	45
Rotary speed control	Yes / no	Yes

D 4.4 (Vacuum) degasser

Number		1/atm
Manufacturer		J.D. Apparatebau GmbH
Type		Poor Boy
Capacity	l/m	2'600

D 4.5 Flowline magnets

Number		8
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D 5 Additional tanks and silos**D 5.1 Reserve tanks**

Number		1
Type		Bulk tank
Total capacity	m ³	45
Agitators		
Number		2
Power	kW	3.2 each

D 5.2 Drinking water tanks

Number		1
Total capacity	m ³	1.5

D 5.3 Drill water tanks

Number		1 (or as needed) max. 3
Total capacity	m ³	45

D 5.4 Dry material silos

Number		As needed for operations
Total capacity	m ³	20 each

E 1 Drive system (electric)

Hydraulic electric driven

E 1.1 Power requirement

kVA	2'000
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E 1.2 Diesel engines

Number		Not applicable, see E5
Manufacturer		
Type		
Power rating	kW	
At revs	min ⁻¹	

E 1.3 Torque converter

(only for diesel-mechanical rigs)

Number		Not applicable
Power rating	kW	

E 1.4 Generators

(only for diesel-electric rigs)

Number		2
Manufacturer		MTU 12V4000 G63
Power rating	kVA	1'650 each

E 1.5 SCR system

(only for diesel-electric rigs)

Manufacturer		Assistec
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E 2	Auxiliary power supply (400 V / 50 Hz)		
	Number		1
	Manufacturer		Bemax alternatively Atlas Copco
	Power rating	kVA	700
E 3	Fuel tanks		
	Number		1
	Capacity	m ³	30 respectively 5
	With EX-protection	Yes / no	Yes
E 4	Rig service air system		
	Number		1
	Volume	m ³ /min	3
	Working pressure	bar	10
	Storage capacity	l	1'000
	Air dryer unit		Yes
F 1	Diverter system		
	Manufacturer		NOV or Axxon or comparable
	Type		Hydril MSP
	Size	in	30 respectively 21¼
	Side outlets quantity		2
	Side outlets size	in	13½
	H ₂ S rating	Yes / no	No
	Diverter lines		
	Length		20 m (can be adjusted as needed)
	Nominal ID	In	13½
	Manual valves		
	Number		2
	Working pressure	psi / bar	580 / 40
	Hydraulic actuated valves		
	Number		1
	Working pressure	psi / bar	Max. 1'000 / 70

F 2 Annular preventer

Number		1
Manufacturer		NOV, T3, Axxon or comparable
Type		Hydril
Size	in	20 ³ / ₄ to 13 ⁵ / ₈
Pressure rating	psi	3'000 / 5'000
H ₂ S-rating	Yes / no	20 ³ / ₄ " no 13 ⁵ / ₈ " yes

F 3 Ram type preventer

Number		1
Manufacturer		NOV, T3 Axxon or comparable
Type		Shaffer
Size	in	20 ³ / ₄ to 13 ⁵ / ₈
Pressure rating	psi	3'000 / 10'000
H ₂ S rating	Yes / no	20 ³ / ₄ " no 13 ⁵ / ₈ " yes
Side outlets quantity		2
Side outlets size	in	4 ¹ / ₁₆

F 4 Ram types**F 4.1 Pipe rams**

Number	sets	1 (kit per size)
Size	in	6 ¹ / ₄ – 5 – 3 ¹ / ₂ (variable)

F 4.2 Blind / shear rams

sets	1 (kit) each
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F 4.3 Variable bore rams

Number	sets	2 (depending on the well control programme)
Size (from-to)	in	2 ⁷ / ₈ to 6 ¹ / ₄ 4 to 9 ⁵ / ₈

F 5 Drilling spools

Side outlets quantity		2
Side outlets size	in	4 $\frac{1}{16}$

F 6 BOP control system

Manufacturer		T3 and NOV
Total capacity	l	1'135.5
Bottle working pressure	psi / bar	3'000 / 210
Annular pressure control valve	Yes / no	Yes

Electric pumps

Number		1
Capacity	l/min	240

Air pumps

Number		1
Capacity	l/min	240

Remote control panels

Number		2
Locations	(driller / toolpusher etc.)	driller and toolpusher

F 7 Choke / kill lines

H ₂ S rating	Yes / no	Yes
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F 7.1 Choke manifold

Nominal ID	in	4 $\frac{1}{16}$
Working pressure inlet	psi / bar	5'000 / 350
Working pressure outlet	psi / bar	5'000 / 350
Flanges with wear plugs	Yes / no	Yes

Manual choke

Number		1
Nominal ID	in	4 $\frac{1}{16}$

Remote choke

Number		1
Nominal ID	in	4 $\frac{1}{16}$
Automatic control	Yes / no	Yes

F 7.2 Choke lines

Number		1
Type		Steel
Nominal ID	in	3
Length	m	On demand
Working pressure	psi	5'000

Manual valves

Number		2
Working pressure	psi / bar	5'000 / 350

Hydraulically actuated valves

Number		1
Working pressure	psi / bar	5'000 / 350

F 7.3 Kill lines

Number		1
Type		Coflexip hose
Nominal ID	in	4 ¹ / ₁₆
Length	m	On demand, min. 4 m
Working pressure check valve	psi / bar	5'000 / 350

Manual valves

Number		1
Working pressure	psi / bar	5'000 / 350

Hydraulic actuated valves

Number		1
Working pressure	psi / bar	5'000 / 350

F 7.4 Poor boy degasser / mud gas separator

Capacity	m ³ /min	3
Volume	l	1'250

F 7.5 Flare line

Length	m	On demand/as needed
Nominal ID	in	5
Working pressure	psi / bar	725 / 50

F 7.6	Flare		
	Height	m	8 to 12 (variable)
	OD	in	9 $\frac{5}{8}$
	Ignition system		Propane
F 8	BOP test equipment		
F 8.1	Test unit / test pump		
	Working pressure	psi / bar	High pressure pump 10'000 / 700
	Pressure recorder	Yes / no	Yes
F 8.2	Cup type tester		
	As per casing programme	Yes / no	Yes
F 9	Kelly cocks		
	Number		1
	Connection type		Drill pipe fitted
	Working pressure	psi / bar	5'000 / 350
	H ₂ S rating	Yes / no	Yes
F 10	Drop-in valves		
	Number		1
	OD	in	Depending on drill pipe size
	ID	in	See above
	Working pressure	psi / bar	5'000 / 350
	Landing nipple		
	OD	in	Depending on drill pipe size
	ID	in	See above
	Connection type		Depending on drill pipe connection

F 11 IBOP / gray valve

Number		1
Connection type		Connected to the topdrive
Working pressure	psi / bar	5'000 / 350

G 1 Drill string

OD	in	5 to 3½
Total length	m	3'000
Nominal weight	lbs/ft	19.5 / 15.5 and / or 13.3
Range		R 2
Grade		S 135
Class		Premium
Connection type		NC 50 / NC 38
Tool joint OD	in	6½ to 5 IEU
Tool joint ID	in	3 to 2⅛
Hard facing	Yes / no / type	Yes
Internal coating	Yes / no / type	No (IPC-207 available on request)

G 1.1 Coring string

OD	in	5⅝
Inner barrel OD	in	4⅝
Total length	m	1'500
Nominal weight	lbs/ft	13.5
Joint length	m	9
Grade		
Class		N/P
Connection type		CSK/NSK
Tool joint OD	in	5½
Tool joint ID	in	4⅞
Hard facing	Yes / no / type	No
Internal coating	Yes / no / type	No

G 2 Pup joints

Number / length	m	3 × 1 m
Number / length	m	3 × 2 m
Number / length	m	3 × 3 m
		Other lengths available on request

G 3 HW drill pipe

Number		10
OD	in	5
Nominal weight	lbs/ft	57.93
Range		R2
Grade class		E75/X95 P
Connection type		NC 50
Tool joint OD	in	6½
Tool joint ID	in	3
Hard facing	Yes / no / type	Yes / TCS
Internal coating	Yes / no / type	No (IPC-207 available on request)

G 4 Drill collars

Number		As needed
OD	in	9½ – 8¼ – 6¾
ID	in	3 – 3 – 2½
Nominal weight	lbs/ft	217 – 157 – 96
Range		R2
Connection type		7⅝" reg, 6⅝" reg/NC-50
Spiral	Yes / no	Yes
Handling/slip reces	Yes / no	As needed

G 5 Bit and string stabilisers

As required for the drilling programme

G 6 Drilling jar

As required for the drilling programme

G 7 Drilling accelerator

As required for the drilling programme

G 8	Bumber sub	As required for the drilling programme	
G 9	Crossovers	As required for the drilling programme	
G 10	Bits	Drilling: as required for the drilling programme Coring: as required for the drilling programme	
H	Handling tools		
	Elevator links	In sufficient quantities to perform the work scope for all strings (DP, casing, stinger, etc.)	
	Elevators		
	Rotary tongs		
	Slips		
	DC safety clamps		
	Drill pipe wipers		
	Bit breakers		
	Automatic slips	Yes / no	Yes, hydraulically operated
I 1	Catheads		
	Number	Yes / no	All functions by power swivel
I 2	Ezy torque (or similar)	Yes / no	All functions by power swivel
I 3	Spinning wrench (or similar)	Yes / no	All functions by power swivel
I 4	Torque wrench (or similar)	Yes / no	All functions by power swivel
I 5	Iron roughneck (or similar)	Yes / no	No

I 6	Kelly spinner		
	Drive	Yes / no Hydraulic/ pneumatic	Not applicable
J	Fishing equipment		
	Over shots	In sufficient quantities to handle all strings in the work	
	Scope		
	Junk basket		
	Overshot		
K 1	Drilling control console with		
	Weight indicator	Yes / no	Martin Decker
	Hook position	Yes / no	Yes
	Standpipe pressure gauges	Yes / no	Yes
	Choke manifold pressure gauges	Yes / no	Yes
	Rotary speed tachometer	Yes / no	Yes
	Rotary torque indicator	Yes / no	Yes
	Pump pressure indicators	Yes / no	Yes
	Pump stroke counters	Yes / no	Yes
	Flow rate	Yes / no	Yes
	Pit volume	Yes / no	Yes
	Trip tank level	Yes / no	Yes
K 2	Drilling recorder		
	Manufacturer		GeoData
	Type		GeoData brand
	Recording all parameters as shown at drilling console as minimum	Yes / no	No
K 3	Pit volume totaliser		
	Number of sensors		2
	Loss / gain indicators and alarm	Yes / no	Yes
K 4	Trip tank		
	Capacity	m ³	1

K 5 Tong torque / line pull indicators

Line pull range (maximum)	kN	Not applicable
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K 6 General measuring equipment

Ring gauges	In adequate quantities for contractor's string and drilling programme
DP / DC drifts	
Casing drifts	
Bit calipers / gauges	
Internal / external calipers	
Derrick tapes (steel)	

K 7 Pressure gauges

Standpupe manifold	Number	3
Choke manifold	Number	3

K 8 Flowline gas sensor

Total gas	Yes / no	Yes
H ₂ S sensor	Yes / no	Yes
Measurement range (C1 – Cx)		
Alarm	Yes / no	Yes

K 9 Soft torque drilling system

Yes / no	No
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K 10 Internal telephone system

Yes / no	Yes
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K 11 Mud laboratory

Fully equipped mud laboratory as required to keep mud within programme parameters

K 12 Direction measuring system

Totco / Gyro available	Totco / Gyro on request
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L 1 General personnel safety equipment

Fire fighting equipment	In adequate quantities
Personal protective equipment	In adequate quantities
First aid equipment	In adequate quantities
Eye washing stations	In adequate quantities
Emergency lights	In adequate quantities

L 2	Derrick safety equipment		
	Derrick escape line		In adequate quantities
	Manufacturer		
	Type		
	Derrick safety belts		In adequate quantities
	Derrick safety devices		In adequate quantities
	Derrick climbing assistant		In adequate quantities
L 3	Gas / fire / smoke detection		
	H ₂ S monitoring system	Yes / no	Yes, on request
	H ₂ S / CO ₂ detectors (portable)	Yes / no	Yes, on request
	Explosimeters	Yes / no	Yes, on request
N 1	Phone and internet connection	Yes / no	Yes
N 2	Pipe racks		
	Capacity	m	3'000
N 3	Cutting and welding equipment		
		Yes / no	Yes
N 4	High pressure cleaner		
		Yes / no	
N 5	Cellar pump		
	Manufacturer		KSB
	Type		ATEX
	Power	kW	1.5
N 6	Forklift		
	Capacity	kN	35

Appendix E: Planned formation tops and casing schemes

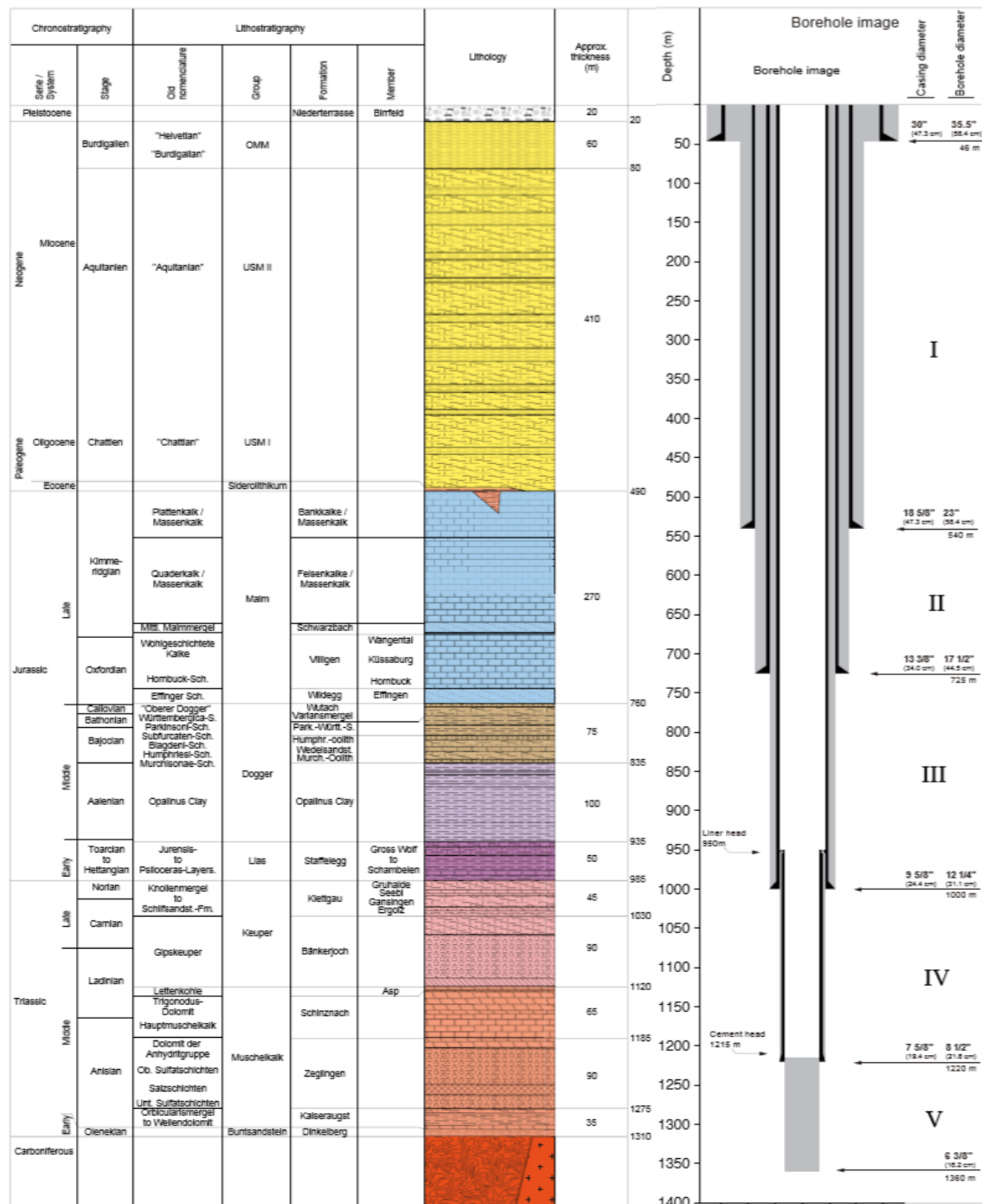


Fig. E-1: Planned formation tops and casing schemes

The 7 5/8" liner was not run in the actual borehole – it was planned as a contingency for drilling the salt section.

Appendix F: Survey report

The borehole is almost vertical. Maximum inclination measured is 1.33° at 1'080 m. Maximum DLS is 2.97°/30 m at 340 m caused by a big turn of the sagging WL tool.

Tab. F-1: Borehole deviation

MD [m]	Inclination [°]	Azimuth [°]	TVD [m]	Easting [m]	Northing [m]	VS [m]	DLS [°/30 m]
0	0	0	0	0	0	0	0
10	0.48	218.92	10.00	-0.03	-0.03	-0.03	1.44
20	0.37	196.7	20.00	-0.06	-0.10	-0.10	0.59
30	0.22	219.29	30.00	-0.08	-0.14	-0.15	0.56
40	0.2	203.38	40.00	-0.10	-0.17	-0.18	0.18
50	0.2	172.39	50.00	-0.11	-0.21	-0.21	0.32
60	0.2	297.86	60.00	-0.12	-0.22	-0.22	1.07
70	0.23	266.8	70.00	-0.16	-0.21	-0.22	0.36
80	0.3	233.94	80.00	-0.20	-0.22	-0.24	0.49
90	0.41	222.51	90.00	-0.24	-0.27	-0.29	0.39
100	0.49	213.38	100.00	-0.29	-0.33	-0.35	0.32
110	0.58	206.37	110.00	-0.34	-0.41	-0.44	0.33
120	0.64	198.08	120.00	-0.38	-0.51	-0.54	0.32
130	0.65	192.45	130.00	-0.41	-0.62	-0.65	0.19
140	0.64	184.35	140.00	-0.42	-0.73	-0.76	0.27
150	0.6	180.09	150.00	-0.43	-0.84	-0.87	0.18
160	0.58	172.75	160.00	-0.42	-0.94	-0.97	0.23
170	0.44	149.31	169.99	-0.39	-1.02	-1.05	0.75
180	0.37	121.31	179.99	-0.35	-1.07	-1.10	0.62
190	0.34	246.58	189.99	-0.35	-1.10	-1.13	1.89
200	0.32	293.32	199.99	-0.40	-1.10	-1.13	0.79
210	0.34	283.6	209.99	-0.45	-1.08	-1.12	0.18
220	0.26	290.05	219.99	-0.50	-1.07	-1.11	0.26
230	0.25	262.86	229.99	-0.55	-1.06	-1.11	0.36
240	0.29	225.65	239.99	-0.59	-1.08	-1.13	0.53
250	0.42	213.88	249.99	-0.62	-1.13	-1.18	0.45
260	0.51	195.68	259.99	-0.66	-1.20	-1.26	0.52
270	0.5	193.47	269.99	-0.68	-1.29	-1.34	0.07
280	0.47	187.47	279.99	-0.70	-1.37	-1.43	0.18

Tab. F-1: (continued)

MD [m]	Inclination [°]	Azimuth [°]	TVD [m]	Easting [m]	Northing [m]	VS [m]	DLS [°/30 m]
290	0.49	178.69	289.99	-0.70	-1.46	-1.51	0.23
300	0.45	166.15	299.99	-0.69	-1.54	-1.59	0.33
310	0.37	139.7	309.99	-0.66	-1.60	-1.65	0.61
320	0.42	104.73	319.99	-0.60	-1.63	-1.68	0.73
330	0.5	148.99	329.99	-0.54	-1.68	-1.72	1.06
340	0.59	279.02	339.99	-0.57	-1.71	-1.75	2.97
350	0.66	265.71	349.99	-0.68	-1.71	-1.76	0.48
360	0.71	260.71	359.99	-0.80	-1.72	-1.78	0.23
370	0.71	258.97	369.99	-0.92	-1.74	-1.82	0.06
380	0.65	256.56	379.99	-1.04	-1.77	-1.85	0.20
390	0.63	251.31	389.99	-1.14	-1.80	-1.89	0.19
400	0.55	246.1	399.99	-1.24	-1.84	-1.94	0.29
410	0.5	238.57	409.99	-1.32	-1.88	-1.99	0.26
420	0.36	215.82	419.99	-1.38	-1.93	-2.04	0.65
430	0.36	186.94	429.99	-1.40	-1.98	-2.10	0.54
440	0.36	165.39	439.99	-1.40	-2.04	-2.16	0.40
450	0.48	152.8	449.99	-1.37	-2.11	-2.22	0.45
460	0.47	145.41	459.99	-1.33	-2.18	-2.29	0.19
470	0.49	125.29	469.99	-1.27	-2.24	-2.34	0.51
480	0.43	205.8	479.98	-1.25	-2.30	-2.40	1.79
490	0.31	311.12	489.98	-1.29	-2.32	-2.42	1.78
500	0.25	295.48	499.98	-1.33	-2.29	-2.40	0.29
510	0.16	285.66	509.98	-1.36	-2.28	-2.39	0.29
540	0.38	66.17	539.98	-1.31	-2.22	-2.33	0.51
550	0.37	14.81	549.98	-1.27	-2.18	-2.28	0.98
560	0.4	152.33	559.98	-1.25	-2.18	-2.28	2.15
570	0.41	356.92	569.98	-1.23	-2.17	-2.27	2.37
580	0.35	353.89	579.98	-1.24	-2.11	-2.21	0.19
590	0.33	349.8	589.98	-1.24	-2.05	-2.15	0.09
600	0.3	349.58	599.98	-1.25	-2.00	-2.10	0.09
610	0.26	350.17	609.98	-1.26	-1.95	-2.05	0.12
620	0.21	346.74	619.98	-1.27	-1.91	-2.01	0.16
630	0.2	340.02	629.98	-1.28	-1.87	-1.98	0.08

Tab. F-1: (continued)

MD [m]	Inclination [°]	Azimuth [°]	TVD [m]	Easting [m]	Northing [m]	VS [m]	DLS [°/30 m]
640	0.22	344.31	639.98	-1.29	-1.84	-1.94	0.08
650	0.2	345.48	649.98	-1.30	-1.80	-1.91	0.06
660	0.18	345.26	659.98	-1.31	-1.77	-1.88	0.06
670	0.17	348.43	669.98	-1.32	-1.74	-1.85	0.04
680	0.16	202.75	679.98	-1.33	-1.74	-1.85	0.95
690	0.17	10.19	689.98	-1.33	-1.74	-1.85	0.98
700	0.2	19.11	699.98	-1.32	-1.71	-1.81	0.12
710	0.25	24.98	709.98	-1.31	-1.67	-1.78	0.16
720	0.33	22.43	719.98	-1.29	-1.62	-1.73	0.24
730	0.39	14.06	729.98	-1.27	-1.56	-1.67	0.24
740	0.44	45.05	739.98	-1.23	-1.50	-1.61	0.68
750	0.45	354.96	749.98	-1.21	-1.44	-1.54	1.13
760	0.45	349.14	759.98	-1.22	-1.36	-1.46	0.14
770	0.42	345.07	769.98	-1.23	-1.29	-1.39	0.13
780	0.34	343.23	779.98	-1.25	-1.22	-1.33	0.24
790	0.26	344.94	789.98	-1.27	-1.17	-1.28	0.24
800	0.23	252.4	799.98	-1.29	-1.16	-1.26	1.06
810	0.27	13.18	809.98	-1.31	-1.14	-1.25	1.31
820	0.38	21.71	819.98	-1.29	-1.09	-1.19	0.36
830	0.45	15.37	829.98	-1.27	-1.02	-1.12	0.25
840	0.45	4.03	839.98	-1.25	-0.94	-1.04	0.27
850	0.44	27.3	849.98	-1.23	-0.87	-0.97	0.54
860	0.43	171.91	859.98	-1.21	-0.87	-0.97	2.49
870	0.29	123.88	869.98	-1.18	-0.92	-1.02	0.96
880	0.22	163.01	879.98	-1.16	-0.95	-1.05	0.55
890	0.24	93.07	889.98	-1.13	-0.97	-1.07	0.79
900	0.23	16.65	899.98	-1.10	-0.95	-1.05	0.87
910	0.22	28.07	909.98	-1.09	-0.92	-1.01	0.14
920	0.17	33.35	919.98	-1.07	-0.89	-0.98	0.16
930	0.16	191.92	929.98	-1.07	-0.89	-0.98	0.97
940	0.09	287.59	939.98	-1.08	-0.90	-0.99	0.57
950	0.15	84.58	949.98	-1.07	-0.90	-0.99	0.71
960	0.39	48.59	959.98	-1.03	-0.87	-0.96	0.85

Tab. F-1: (continued)

MD [m]	Inclination [°]	Azimuth [°]	TVD [m]	Easting [m]	Northing [m]	VS [m]	DLS [°/30 m]
970	0.55	335.46	969.98	-1.03	-0.81	-0.89	1.72
980	0.73	297.38	979.98	-1.10	-0.73	-0.83	1.35
990	0.88	272.87	989.98	-1.24	-0.70	-0.81	1.12
1'000	1.11	257.46	999.98	-1.41	-0.72	-0.84	1.05
1'010	1.16	262.97	1'009.97	-1.60	-0.75	-0.89	0.36
1'020	1.2	266.92	1'019.97	-1.81	-0.77	-0.92	0.27
1'030	1.15	267.13	1'029.97	-2.01	-0.78	-0.95	0.15
1'040	1.08	265.86	1'039.97	-2.21	-0.79	-0.98	0.22
1'050	1.1	262.73	1'049.97	-2.40	-0.81	-1.02	0.19
1'060	1.26	258.71	1'059.96	-2.60	-0.85	-1.07	0.54
1'070	1.27	258.28	1'069.96	-2.82	-0.89	-1.13	0.04
1'080	1.33	258.56	1'079.96	-3.04	-0.93	-1.20	0.18
1'090	1.29	256.59	1'089.96	-3.26	-0.98	-1.26	0.18
1'100	1.28	255.74	1'099.95	-3.48	-1.04	-1.34	0.06
1'110	1.22	256	1'109.95	-3.69	-1.09	-1.41	0.18
1'120	1.21	259.67	1'119.95	-3.90	-1.14	-1.47	0.24
1'130	1.05	260.23	1'129.95	-4.09	-1.17	-1.52	0.48
1'140	0.96	262.72	1'139.95	-4.26	-1.20	-1.56	0.30
1'150	0.99	262.2	1'149.94	-4.43	-1.22	-1.60	0.09
1'160	1.02	263.43	1'159.94	-4.61	-1.24	-1.64	0.11
1'170	0.99	266.87	1'169.94	-4.78	-1.26	-1.67	0.20
1'180	1.03	269.26	1'179.94	-4.96	-1.26	-1.69	0.17
1'190	1.16	269.22	1'189.94	-5.15	-1.26	-1.71	0.39
1'200	1.2	263.07	1'199.94	-5.35	-1.28	-1.74	0.40
1'210	1.24	265.43	1'209.93	-5.57	-1.30	-1.78	0.19
1'220	1.25	267.24	1'219.93	-5.78	-1.31	-1.81	0.12
1'230	1.06	271.49	1'229.93	-5.98	-1.32	-1.83	0.62
1'240	1.06	270.63	1'239.93	-6.17	-1.31	-1.85	0.05
1'250	1.02	268.6	1'249.93	-6.35	-1.31	-1.86	0.16
1'260	0.96	271.98	1'259.92	-6.52	-1.31	-1.88	0.25
1'270	0.92	277.76	1'269.92	-6.69	-1.30	-1.88	0.31
1'280	0.96	279.78	1'279.92	-6.85	-1.27	-1.87	0.16
1'290	1.03	279.35	1'289.92	-7.02	-1.25	-1.85	0.21

Tab. F-1: (continued)

MD [m]	Inclination [°]	Azimuth [°]	TVD [m]	Easting [m]	Northing [m]	VS [m]	DLS [°/30 m]
1'300	1.08	279.17	1'299.92	-7.20	-1.22	-1.84	0.15
1'310	1.07	277.8	1'309.92	-7.39	-1.19	-1.83	0.08
1'320	1.04	277.02	1'319.91	-7.57	-1.16	-1.82	0.10
1'330	0.96	280.02	1'329.91	-7.74	-1.14	-1.81	0.29
1'340	0.99	282.25	1'339.91	-7.91	-1.11	-1.79	0.15
1'350	1.06	279	1'349.91	-8.09	-1.07	-1.77	0.27
1'360	1.05	271.55	1'359.91	-8.27	-1.06	-1.77	0.41
1'370	0.87	267.78	1'369.91	-8.44	-1.06	-1.79	0.57

Appendix G: Casing / liner tally lists

Tab. G-1: 18⁵/₈" tally list

Rohrliste										
Rohrliste		Ohne Gewinde gem.		Rohr-Ø: 18 5/8"		Bohrung:		NAGRA BÜL1-1		
Contr.: Daldrup		RS-Teufe:	530,00 m	Einbaudatum:		09.05.2019		Spüldungsdichte: kg/l		1,09
RohrNr	Einzellänge (m)	Gesamtlänge	Teufe Rückwärts OK Rohr	Gütegrad	Nenngewicht lbs/ft Wd.	Gewinde	Centralizer	Bemerkung	Stranggewicht in Spülung (t)	
CS	0,52	0,52	529,48	K55	96,50	Big Omega				
1	11,96	12,48	517,52	K55	96,50	Big Omega	x			
Foat	0,70	13,18	516,82	K55	96,50	Big Omega				
2	11,96	25,14	504,86	K55	96,50	Big Omega				
3	11,95	37,09	492,91	K55	96,50	Big Omega	x			
4	11,97	49,06	480,94	K55	96,50	Big Omega				
5	11,96	61,02	468,98	K55	96,50	Big Omega				
6	11,97	72,99	457,01	K55	96,50	Big Omega				
7	11,96	84,95	445,05	K55	96,50	Big Omega	x			
8	11,98	96,93	433,07	K55	96,50	Big Omega				
9	11,96	108,89	421,11	K55	96,50	Big Omega				
10	11,96	120,85	409,15	K55	96,50	Big Omega				
11	11,97	132,82	397,18	K55	96,50	Big Omega				
12	11,96	144,78	385,22	K55	96,50	Big Omega	x			
13	11,95	156,73	373,27	K55	96,50	Big Omega				
14	11,96	168,69	361,31	K55	96,50	Big Omega				
15	11,96	180,65	349,35	K55	96,50	Big Omega				
16	11,76	192,41	337,59	K55	96,50	Big Omega	x			
17	11,96	204,37	325,63	K55	96,50	Big Omega				
18	11,96	216,33	313,67	K55	96,50	Big Omega				
19	11,96	228,29	301,71	K55	96,50	Big Omega				
20	11,96	240,25	289,75	K55	96,50	Big Omega	x			
21	11,95	252,20	277,80	K55	96,50	Big Omega				
22	11,95	264,15	265,85	K55	96,50	Big Omega				
23	11,96	276,11	253,89	K55	96,50	Big Omega				
24	11,95	288,06	241,94	K55	96,50	Big Omega	x			
25	11,74	299,80	230,20	K55	96,50	Big Omega				
26	11,74	311,54	218,46	K55	96,50	Big Omega				
27	11,57	323,11	206,89	K55	96,50	Big Omega				
28	11,82	334,93	195,07	K55	96,50	Big Omega				
29	11,80	346,73	183,27	K55	96,50	Big Omega				
30	11,58	358,31	171,69	K55	96,50	Big Omega	x			
31	11,85	370,16	159,84	K55	96,50	Big Omega				
32	11,96	382,12	147,88	K55	96,50	Big Omega				
33	11,96	394,08	135,92	K55	96,50	Big Omega				
34	11,97	406,05	123,95	K55	96,50	Big Omega	x			
35	11,96	418,01	111,99	K55	96,50	Big Omega				
36	11,96	429,97	100,03	K55	96,50	Big Omega				
37	11,97	441,94	88,06	K55	96,50	Big Omega				
38	11,96	453,90	76,10	K55	96,50	Big Omega				
39	11,97	465,87	64,13	K55	96,50	Big Omega	x			
40	11,96	477,83	52,17	K55	96,50	Big Omega				
41	11,96	489,79	40,21	K55	96,50	Big Omega				
42	11,97	501,76	28,24	K55	96,50	Big Omega				
43	11,97	513,73	16,27	K55	96,50	Big Omega	x			
44	11,96	525,69	4,31	K55	96,50	Big Omega				
45	11,97	537,66	-7,66	K55	96,50	Big Omega				
46	11,96	549,62	-19,62	K55	96,50	Big Omega		Reserve		
47	11,98	561,60	-31,60	K55	96,50	Big Omega		Reserve		
48										
49										
50			Überstand von RT 4,80 m							
51										
52										
53										
54										

Tab. G-2: 13 3/8" tally list

Rohrliste		Ohne Gewinde gem.		Rohr-Ø: 13 3/8"		Bohrung:		NAGRA BÜL1-1	
Contr.: Daldrup		RS-Teufe:	918,70 m	Einbaudatum:		Spülungsdichte: kg/l		1,09	
RohrNr	Einzellänge (m)	Gesamtlänge	Teufe Rückwärts OK Rohr	Gütegrad	Nenngewicht lbs/ft Wd.	Gewinde	Centralizer	Bemerkung	Stranggewicht in Spülung (t)
CS	0,56	0,52	918,18	J55	68#	BTC			
1	11,79	12,31	906,39	J55	68#	BTC	x		
Float	0,58	12,89	905,81	J55	68#	BTC			
2	11,78	24,67	894,03	J55	68#	BTC	x		
3	11,74	36,41	882,29	J55	68#	BTC	x		
4	11,05	47,46	871,24	J55	68#	BTC	x		
5	11,8	59,26	859,44	J55	68#	BTC			
6	11,8	71,06	847,64	J55	68#	BTC			
7	11,71	82,77	835,93	J55	68#	BTC	x		
8	11,79	94,56	824,14	J55	68#	BTC			
9	11,75	106,31	812,39	J55	68#	BTC			
10	11,75	118,06	800,64	J55	68#	BTC	x		
11	11,74	129,80	788,90	J55	68#	BTC			
12	11,73	141,53	777,17	J55	68#	BTC			
13	11,79	153,32	765,38	J55	68#	BTC	x		
14	11,81	165,13	753,57	J55	68#	BTC			
15	11,69	176,82	741,88	J55	68#	BTC			
16	11,78	188,60	730,10	J55	68#	BTC	x		
17	11,78	200,38	718,32	J55	68#	BTC			
18	11,74	212,12	706,58	J55	68#	BTC			
19	11,79	223,91	694,79	J55	68#	BTC	x		
20	11,77	235,68	683,02	J55	68#	BTC			
21	11,78	247,46	671,24	J55	68#	BTC			
22	11,56	259,02	659,68	J55	68#	BTC	x		
23	11,82	270,84	647,86	J55	68#	BTC			
24	11,73	282,57	636,13	J55	68#	BTC			
25	11,82	294,39	624,31	J55	68#	BTC	x		
26	11,49	305,88	612,82	J55	68#	BTC			
27	11,79	317,67	601,03	J55	68#	BTC			
28	11,8	329,47	589,23	J55	68#	BTC	x		
29	11,75	341,22	577,48	J55	68#	BTC			
30	11,76	352,98	565,72	J55	68#	BTC			
31	11,12	364,10	554,60	J55	68#	BTC	x		
32	11,81	375,91	542,79	J55	68#	BTC			
33	11,82	387,73	530,97	J55	68#	BTC			
34	11,81	399,54	519,16	J55	68#	BTC	x		
35	11,8	411,34	507,36	J55	68#	BTC			
36	11,73	423,07	495,63	J55	68#	BTC			
37	11,8	434,87	483,83	J55	68#	BTC	x		
38	11,77	446,64	472,06	J55	68#	BTC			
39	11,67	458,31	460,39	J55	68#	BTC			
40	11,77	470,08	448,62	J55	68#	BTC	x		
41	11,83	481,91	436,79	J55	68#	BTC			
42	11,75	493,66	425,04	J55	68#	BTC			
43	11,81	505,47	413,23	J55	68#	BTC	x		
44	11,75	517,22	401,48	J55	68#	BTC			
45	11,81	529,03	389,67	J55	68#	BTC			
46	11,79	540,82	377,88	J55	68#	BTC	x		
47	11,15	551,97	366,73	J55	68#	BTC			
48	11,19	563,16	355,54	J55	68#	BTC			
49	11,79	574,95	343,75	J55	68#	BTC	x		
50	11,6	586,55	332,15	J55	68#	BTC			
51	11,78	598,33	320,37	J55	68#	BTC			
52	11,75	610,08	308,62	J55	68#	BTC			
53	11,73	621,81	296,89	J55	68#	BTC			
54	11,75	633,56	285,14	J55	68#	BTC			

Tab. G-2: (continued)

Tab. G-3: 9 5/8" tally list

Rohrliste		Mit Gewinde gem.		Rohr-Ø:	9 5/8"	Bohrung:		NAGRA BÜL1-1	
Contr.: Daldrup		RS-Teufe:	1204,93 m	Einbaudatum:		Spülungsdichte: kg/l		1,16	
RohrNr	Einzellänge mit Gewinde (m)	Gesamtlänge abz. Gewinde	Teufe Rückwärts OK Rohr	Gütegrad	Nenngewicht lbs/ft Wd.	Gewinde	Centralizer	Bemerkung	Stranggewicht in Spülung (l)
GOK bis HOP	2,00	2,00							
Shoe	0,54	2,54	1202,39	J55	40,00	BTC		11408383	
1	11,97	14,39	1190,54	J55	40,00	BTC	x	9680687	
Float	0,75	15,02	1189,91	J55	40,00	BTC			
2	12,01	26,91	1178,02	J55	40,00	BTC	x	9680686	
3	11,66	38,45	1166,48	J55	40,00	BTC		9680688	
4	12,03	50,36	1154,57	J55	40,00	BTC	x	9680690	
5	11,96	62,20	1142,73	J55	40,00	BTC		9680689	
6	11,71	73,80	1131,14	J55	40,00	BTC	x	9680692	
7	11,72	85,39	1119,54	J55	40,00	BTC		9680694	
8	12,05	97,32	1107,61	J55	40,00	BTC	x	9680693	
9	12,23	109,44	1095,50	J55	40,00	BTC		9680695	
10	12,07	121,38	1083,55	J55	40,00	BTC	x	9680683	
11	11,71	132,97	1071,96	J55	40,00	BTC		9680685	
12	12,02	144,87	1060,06	J55	40,00	BTC		9680684	
13	11,86	156,61	1048,33	J55	40,00	BTC		9680680	
14	12,13	168,61	1036,32	J55	40,00	BTC		9680682	
15	12,02	180,51	1024,42	J55	40,00	BTC	x	9680681	
16	11,97	192,37	1012,56	J55	40,00	BTC		9680670	
17	11,90	204,14	1000,79	J55	40,00	BTC		9680673	
18	12,05	216,08	988,85	J55	40,00	BTC		9680671	
19	12,00	227,96	976,97	J55	40,00	BTC		9680679	
20	12,02	239,85	965,08	J55	40,00	BTC	x	9680678	
21	12,01	251,74	953,19	J55	40,00	BTC		9680677	
22	12,05	263,67	941,26	J55	40,00	BTC		9680675	
23	12,09	275,64	929,29	J55	40,00	BTC		9680674	
24	11,96	287,48	917,45	J55	40,00	BTC		9680676	
25	12,06	299,42	905,51	J55	40,00	BTC	x	9680649	
26	11,80	311,10	893,83	J55	40,00	BTC		9680648	
27	12,00	322,98	881,95	J55	40,00	BTC		9680647	
28	11,93	334,78	870,15	J55	40,00	BTC		9680641	
Stufe	0,84	335,50	869,43	J55	40,00	BTC		9680705	
29	12,09	347,47	857,46	J55	40,00	BTC	x	9680643	
30	11,99	359,34	845,59	J55	40,00	BTC		9680642	
31	11,63	370,85	834,08	J55	40,00	BTC	x	9680665	
32	11,82	382,55	822,38	J55	40,00	BTC		9680667	
33	12,04	394,47	810,46	J55	40,00	BTC	x	9680666	
34	11,94	406,30	798,63	J55	40,00	BTC		9680659	
35	11,97	418,15	786,78	J55	40,00	BTC	x	9680661	
36	11,89	429,92	775,01	J55	40,00	BTC		9680660	
37	11,48	441,27	763,66	J55	40,00	BTC	x	9680668	
38	11,96	453,11	751,82	J55	40,00	BTC		9680669	
39	12,06	465,05	739,88	J55	40,00	BTC	x	9680645	
40	11,89	476,82	728,11	J55	40,00	BTC		9680644	
41	11,48	488,18	716,75	J55	40,00	BTC	x	9680646	

Tab. G-3: (continued)

Rohrliste		Mit Gewinde gem.		Rohr-Ø: 9 5/8"		Bohrung:		NAGRA BÜL1-1	
Contr.:	Daldrup	RS-Teufe:	1204,93 m	Einbaudatum:			Spülungsdichte: kg/l		1,16
RohrNr	Einzellänge mit Gewinde (m)	Gesamtlänge abz. Gewinde	Teufe Rückwärts OK Rohr	Gütegrad	Nenngewicht lbs/ft Wd.	Gewinde	Centra-lizer	Bemerkung	Stranggewicht in Spülung (t)
42	11,75	499,81	705,12	J55	40,00	BTC		9680650	
43	11,95	511,64	693,29	J55	40,00	BTC	x	9680652	
44	11,95	523,47	681,47	J55	40,00	BTC		9680651	
45	11,89	535,24	669,70	J55	40,00	BTC	x	9680654	
46	11,62	546,73	658,20	J55	40,00	BTC		9680653	
47	11,93	558,55	646,38	J55	40,00	BTC	x	9680665	
48	11,78	570,21	634,73	J55	40,00	BTC		9680664	
49	11,89	581,98	622,95	J55	40,00	BTC	x	9680663	
50	11,76	593,61	611,32	J55	40,00	BTC		9680662	
51	11,95	605,45	599,48	J55	40,00	BTC	x	9680658	
52	11,85	617,18	587,75	J55	40,00	BTC		9680657	
53	11,95	629,01	575,92	J55	40,00	BTC	x	9680656	
54	12,08	640,97	563,96	J55	40,00	BTC		9680710	
55	11,83	652,68	552,25	J55	40,00	BTC	x	9680712	
56	12,01	664,57	540,36	J55	40,00	BTC		9680711	
57	12,08	676,53	528,40	J55	40,00	BTC	x	9680719	
58	11,55	687,96	516,97	J55	40,00	BTC		9680721	
59	12,12	699,96	504,97	J55	40,00	BTC	x	9680720	
60	11,63	711,47	493,46	J55	40,00	BTC		9680803	
61	12,06	723,41	481,52	J55	40,00	BTC	x	9680805	
62	11,86	735,15	469,78	J55	40,00	BTC		9680804	
63	11,64	746,67	458,26	J55	40,00	BTC	x	9680714	
64	11,90	758,45	446,48	J55	40,00	BTC		9680713	
65	12,03	770,36	434,57	J55	40,00	BTC	x	9680716	
66	11,83	782,07	422,86	J55	40,00	BTC		9680816	
67	11,85	793,80	411,13	J55	40,00	BTC	x	9680815	
68	11,89	805,57	399,36	J55	40,00	BTC		9680708	
69	11,84	817,29	387,64	J55	40,00	BTC	x	9680707	
70	11,81	828,98	375,95	J55	40,00	BTC		9680709	
71	11,75	840,61	364,32	J55	40,00	BTC	x	9680704	
72	11,60	852,09	352,84	J55	40,00	BTC		9680706	
73	11,96	863,93	341,00	J55	40,00	BTC	x		
74	11,82	875,63	329,30	J55	40,00	BTC		9680716	
75	11,56	887,07	317,86	J55	40,00	BTC	x	9680718	
76	11,93	898,88	306,05	J55	40,00	BTC		9680717	
77	11,98	910,74	294,19	J55	40,00	BTC		9680701	
78	12,03	922,65	282,28	J55	40,00	BTC	x	9680703	
79	12,06	934,59	270,34	J55	40,00	BTC		9680702	
80	11,81	946,28	1204,93	J55	40,00	BTC		9680696	
81	11,96	958,12	246,81	J55	40,00	BTC		9680700	
82	12,04	970,04	234,89	J55	40,00	BTC	x	9680699	
83	12,06	981,98	222,95	J55	40,00	BTC		9680807	
84	11,89	993,75	211,18	J55	40,00	BTC		9680806	
85	11,59	1005,22	199,71	J55	40,00	BTC		9680808	
86	11,98	1017,08	187,85	J55	40,00	BTC	x	9680799	
87	11,83	1028,79	176,14	J55	40,00	BTC		9680798	

Tab. G-3: (continued)

NAGRA BÜL1-1									
Rohrliste		Mit Gewinde gem.	Rohr-Ø:	9 5/8"	Bohrung:		NAGRA BÜL1-1		
Contr.: Daldrup		RS-Teufe:	1204,93 m	Einbaudatum:		Spülungsdichte: kg/l			1,16
RohrNr	Einzellänge mit Gewinde (m)	Gesamtlänge abzgl. Gewinde	Teufe Rückwärts OK Rohr	Gütegrad	Nenngewicht lbs/ft Wd.	Gewinde	Centralizer	Bemerkung	Stranggewicht in Spülung (t)
88	12,02	1040,69	164,24	J55	40,00	BTC		9681341	
89	11,90	1052,47	152,46	J55	40,00	BTC		9680797	
90	11,71	1064,06	140,87	J55	40,00	BTC	x	9680796	
91	11,59	1075,53	129,40	J55	40,00	BTC		9680795	
92	11,75	1087,16	117,77	J55	40,00	BTC		9680794	
93	11,92	1098,96	105,97	J55	40,00	BTC		9680791	
94	11,99	1110,83	94,10	J55	40,00	BTC	x	9680793	
95	11,92	1122,63	82,30	J55	40,00	BTC		9680792	
96	11,85	1134,36	70,57	J55	40,00	BTC		9680800	
97	11,95	1146,19	58,74	J55	40,00	BTC	x	9680802	
98	11,84	1157,91	47,02	J55	40,00	BTC		9680801	
99	11,77	1169,56	35,37	J55	40,00	BTC		9680785	
100	11,67	1181,11	23,82	J55	40,00	BTC		9680787	
101	11,98	1192,97	11,96	J55	40,00	BTC	x	9680786	
102	12,08	1204,93	0,00	J55	40,00	BTC		9680789	
Hänger + Landing joint	6,02	1210,83	-6,02			BTC	Wird wieder ausgebaut, nach absetzen im CHH ca. 2 m unter GOK.		
RS der 9 5/8" ist auf 1205 m von GOK.									

Appendix H1: MICON slickline core drilling system

The 5½" coring drill pipe SK 5½" B owned by Nagra is part of the coring equipment ordered from MICON Drilling in Celle. With this system, a core diameter of 95 mm is drilled with 6¾" (161.9 mm) core bits. The information shown in this appendix was taken from the MICON brochure (see MICON-Drilling 2016).

Tab. H-1: Coring drill pipe technical data

Technical data	
Hole size	161.9 mm
Core diameter without liner	101.4 mm
Core diameter with liner	95.0 mm
Outer tube	
Outside diameter	152.4 mm
Inside diameter	124.0 mm
Inner tube	
Outside diameter	115.0 mm
Inside diameter	107.0 mm
Drill pipe	
Outside diameter	141.0 mm
Inside diameter	124.0 mm
Weight	29 kg/m
Operational limits	
Torque to yield	185.4 kNm
Tension to yield	2'200 kN
Make-up torque (new tool joints)	11.0 kNm
Depth range (safety factor 2)	3'000 m

Wireline core barrels (double / triple tube core barrels with wireline connection) were used for a reliable, complete recovery of the core without pulling out the drill string. This technique speeds up core retrieval, reduces time-consuming drill rod handling and helps to maximise coring efficiency.

Core recovery (Fig. H-1): the catching assembly (A) is attached to a wireline winch system and lowered into the wireline drill string (B). The overshot securely interlocks with the latching head (C). Subsequently, the core-filled inner tube system can be hoisted out (D) through the wireline drill string.

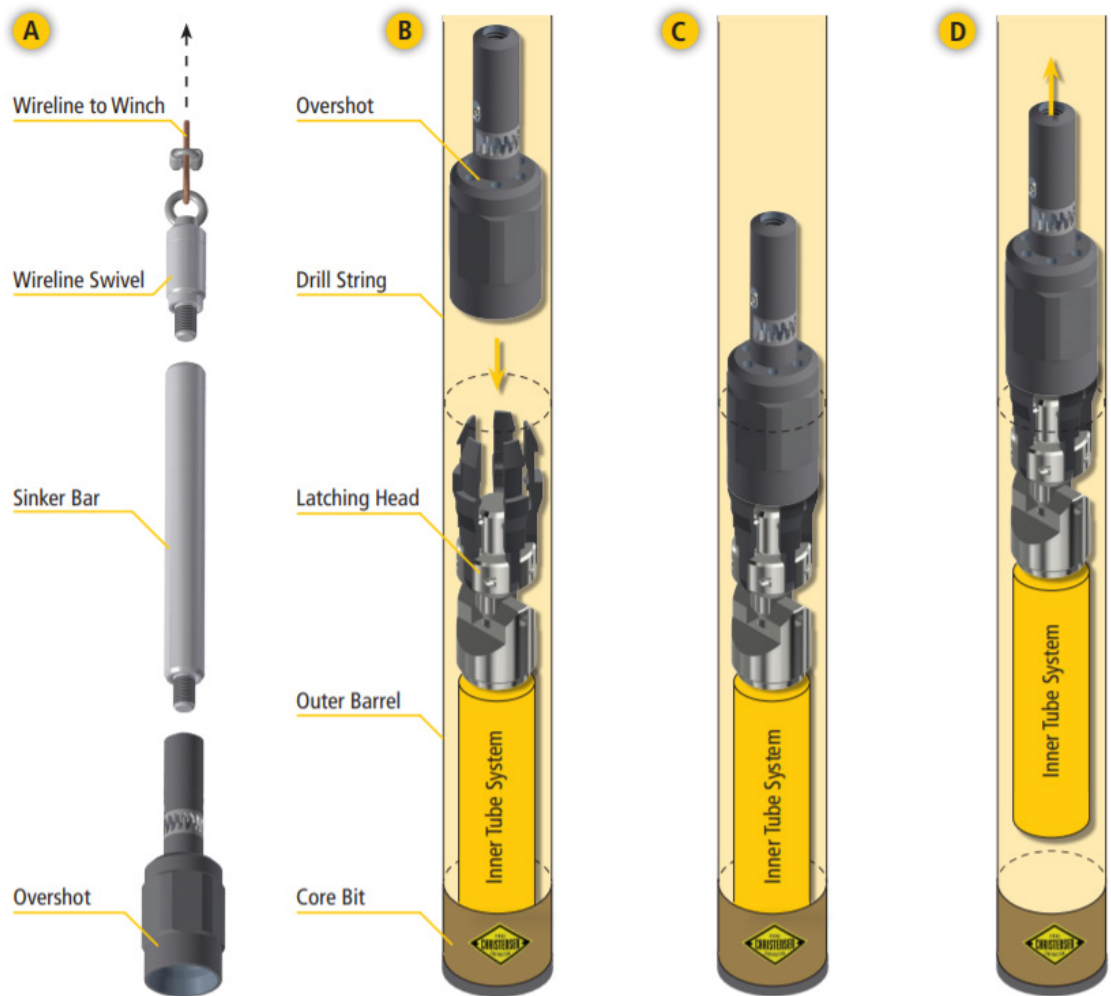


Fig. H-1: Core retrieval

Latching head

All wireline core barrels are equipped with the unique latching head (Fig. H-2) providing more latching surface than any other wireline system. The robust Christensen latching system minimises the number of moving parts to achieve a new level of dependable performance and long service life. The design ensures reliable latching for trouble-free operation while coring and during core retrieval.

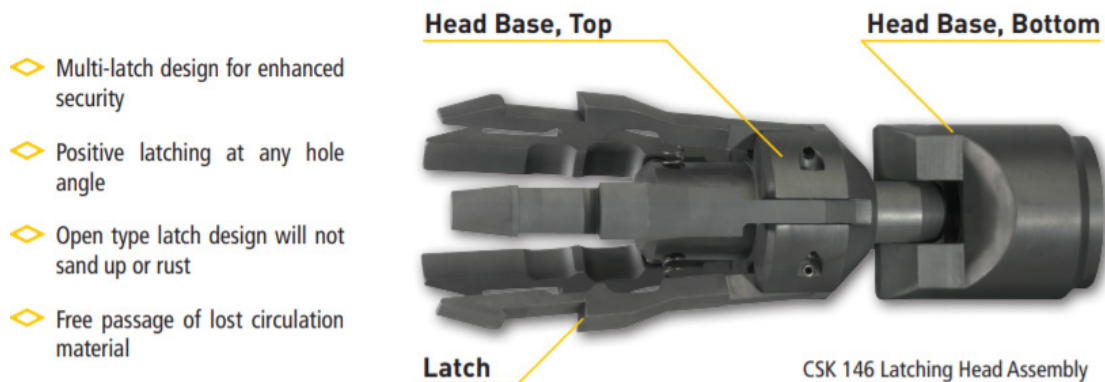


Fig. H-2: Latching head

Overshot

Complementing the reliable operation of the core barrel, the Christensen overshoot (Fig. H-3) works without external triggering hardware. Using a step ratch spring release mechanism, the overshoot is activated by repeated short raising and lowering of the wireline cable. After a pre-determined number of steps, the latching head is unblocked. This safety design prevents premature release of the inner tube. Inner tube retrieval is simply handled by pre-setting the step ratch spring before the overshoot is lowered to pick-up the inner tube.

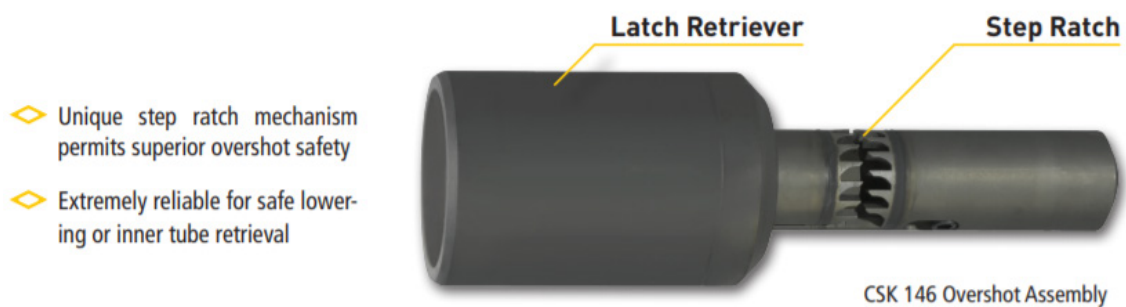


Fig. H-3: Overshot

Appendix H2: Pictures of selected bits

6 $\frac{3}{8}$ " core bit 67434 Synset Ballas – depth: 531.50 m, 535.0 m – 545.0 m

Tab. H-2: Core bit 67434

Hersteller	Artikelbez.	Form	Größe	Serien Nr.	Typen Nr.	Dia-Qualität	Karat	Steingöße	Matrize	Laufzeit		Laufstrecke		Verschleißbild / Bemerkung
			mm				ct			h	m	von	bis	
Christensen SK 5 1/2" B TSD Core Bit	Synset Ballas - Krone,	128 Ballas large triangle, Matrix halbrund	161,9mm x 95mm	67434	23-691922			large triangle	Medium Hart - Hart	79	44	534,8m	578,8m	70 von 128 Zähnen ausgebrochen. OD & ID ok. Matrize verschlissen.



Fig. H-4: Core bit 67434

6 $\frac{3}{8}$ " core bit 67436 Synset Ballas – depth: 578.80 m – 580.40 m

Tab. H-3: Core bit 67436

Hersteller	Artikelbez.	Form	Größe	Serien Nr.	Typen Nr.	Dia-Qualität	Karat	Steingöße	Matrize	Laufzeit		Laufstrecke		Verschleißbild / Bemerkung
			mm				ct			h	m	von	bis	
Christensen SK 5 1/2" B TSD Core Bit	Synset Ballas - Krone,	128 Ballas large triangle, Matrix halbrund	161,9mm x 95mm	67436	23-691922			large triangle	Medium Hart - Hart	9	1,6	578,8m	580,4m	61 von 128 Zähnen ausgebrochen. OD & ID ok. Matrize Blaufärbung & verschlissen.



Fig. H-5: Core bit 67436

6³/₈" core bit 67450 PDC – depth: 868.0 m – 869.0 m, 869.0 m – 886.50 m

Tab. H-4: Core bit 67450

Hersteller	Artikelbez	Form	Größe	Serien Nr	Typen Nr	Dia-Qualität	Karat	Steingöße	Matrize	Laufzeit		Laufstrecke		Verschleißbild / Bemerkung
			mm							h	m	von	bis	
Christensen	SK 5 1/2" B PDC Krone	24 PDC	161,9mm x 95mm	67450	28-691918				medium hart - extrem hart	42	21	868m	889m	Kein Verschleiß an den Cuttern zu Erkennen Kein Verschleiß an der Matrix zu Erkennen



Fig. H-6: Core bit 67450

6³/₈" core bit 67442 PDC, depth: 979.0 m – 979.0 m

Tab. H-5: Core bit 67442

Hersteller	Artikelbez	Form	Größe	Serien Nr	Typen Nr	Dia-Qualität	Karat	Steingöße	Matrize	Laufzeit		Laufstrecke		Verschleißbild / Bemerkung	Formation
			mm							h	m	von	bis		
Christensen	Synset Ballas - Krone, TSD Core Bit	128 Ballas large triangle, Matrix halbrund	161,9mm x 95mm	67442	23-691922			large triangle	Medium Hart - Hart	58,25	48	958m	1006m	Zähne außen abgenutzt, bzw. rund. Nachgebohrt	Opalinuston Lias



Fig. H-7: Core bit 67442

6³/₈" core bit 67438 Synset Ballas, 1'006.0 m – 1'043.0 m

Tab. H-6: Core bit 67438

Hersteller	Artikelbez.	Form	Größe	Serien Nr.	Typen Nr.	Dia-Qualität	Karat	Steingöße	Matrize	Laufzeit		Laufstrecke		Verschleißbild / Bemerkung	Formation
			mm							h	m	von	bis		
Christensen SK 5 12" B TSD Core Bit	Synset Ballas - Krone,	128 Ballas large triangle, Matrix halbrund	161,9mm x 96mm	67438	23-691922		ct	large triangle	Medium Hart - Hart	29	30	1006	1043		Opalinuston Lias



Fig. H-8: Core bit 67438

63/8" core bit 67444 impreg, depth: 1'043.0 m – 1'043.0 m, BUL1-1B 996.0 m – 1'074.0 m

Tab. H-7: Core bit 67444

Hersteller	Artikelbez	Form	Größe	Serien Nr	Typen Nr	Dia- Qualität	Karat	Steingöße	Matrize	Laufzeit		Laufstrecke		Verschleißbild / Bemerkung	Formation
			mm				ct			h	m	von	bis		
Christensen SK 5 1/2" B TSD Core Bit	Gold Red 1		161.9mm x 95mm	67444	28- 691916			large triangle	Medium Hart - Hart	96	45	895m	1074m	Zement Nachgebohrt	Zement



Fig. H-9: Core bit 67444

6³/₈" core bit 67441 Synset, BUL1-1B 1'090.0 m – 1'137.0 m

Tab. H-8: Core bit 67441

Hersteller	Artikelbez	Form	Größe	Serien Nr	Typen Nr	Dia- Qualität	Karat	Steingröße	Matrize	Laufzeit		Laufstrecke		Verschleißbild / Bemerkung	Formation
			mm				ct			h	m	von	bis		
Christensen SK 5 1/2" B TSD Core Bit	Synset Ballas - Krone, Matrix halbrund	128 Ballas large triangle, Matrix halbrund	161,9mm x 95mm	67441	23- 691922			large triangle	Medium Hart - Hart	50	47	1090	1137	Zähne stark abgenutzt, bzw. rund. Teilweise ausgebrochen.	Anhydrit, Tonstein, Muschelkalk



Fig. H-10: Core bit 67441

6 3/8" core bit 67442 Synset, BUL1-1B, depth: 1'216.0 m – 1'370.0 m

Tab. H-9: Core bit 67442

Hersteller	Artikelbez	Form	Größe	Serien Nr	Typen Nr	Dia- Qualität	Karat	Steingöße	Matrize	Laufzeit		Laufstrecke		Verschleißbild / Bemerkung	Formation
			mm				ct			h	m	von	bis		
Christensen SK 5 1/2" B TSD Core Bit	Synset Ballas - Krone, Matrix halbrund	128 Ballas large triangle, Matrix halbrund	161,9mm x 95mm	67442	23- 691922			large triangle	Medium Hart - Hart	58,25	48	958m	1006m	Zähne außen abgenutzt, bzw. rund. Nachgebohrt	Opalinuston Lias



Fig. H-11: Core bit 674442

Appendix H3: Staged hole opener

Figs. H-1 andH-2 show examples for staged hole openers. Because the diameter of the coring head is 6⅜", the hole has to be opened for casing runs up to 17½" for the 13⅜" casing.

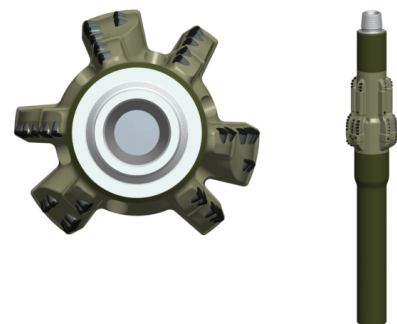
Staged Hole Opener (SHO)

12 1/4 in SHOSI616

SMITH BITS

A Schlumberger Company

(311mm) ID: 65271A0302



Concentric Staged Hole Openers (SHO) from Smith Bits have been developed from a tradition of application knowledge and technical excellence gained from the success of QUAD-D reaming products. SHO tools incorporate scientifically designed cutting structures to ensure fast, smoothly drilled and high quality hole opening under a wide range of application conditions. SHO tools are run successfully on rotary and rotary steerable assemblies in both straight and deviated holes.

FEATURES

- Bit design and performance have been certified through the validation process prescribed by IDEAS simulation technology.
- SHARC high-abrasion-resistance cutting structure provides two rows of cutters for superior stability and durability, and allows the bit to drill at maximum ROP for longer periods of time.
- The PX feature extends PDC bit life by reinforcing its gauge areas with diamond-enhanced inserts (DEI) set in highly wear-resistant tungsten carbide.



Specifications

Total Cutters	63
Cutter Size	16 mm (5/8 in)
Face Cutters	(38) 16mm
Gauge Cutters	(12) 16mm
Blade Count	6
Nozzles	6 Standard Series 60N
Lower Connection	4-1/2 IF PIN
Junk Slot Area, in2	41.5
Upper Connection	4-1/2 IF BOX
Gauge	Length: 2 in Protection: Options Available
Length	Make-Up: 72.304 in Overall: 76.742 in
Fishing Neck	Diameter: 7.01 in Length: 42.728 in

Operating Parameters

Bit Rotary Speed (RPM)	Suitable for Rotary & PDM
Weight-on-Bit	6,000 to 36,000 (lbf) 2,727 to 16,362 (daN) 3 to 6 (Tonnes)
Max Flow Rate	50 to 150
Hydraulic Horsepower	1 to 6

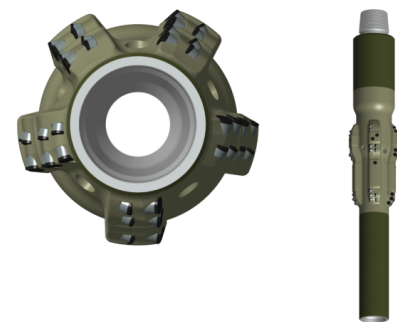
Fig. H-12: 12¼" staged hole opener profiles

Staged Hole Opener (SHO)

8 1/2 in SHOS516

SMITH BITS
A Schlumberger Company

(216mm) ID: 67553A0001 ER: 27419



FEATURES

- SHARC high-abrasion-resistance cutting structure provides two rows of cutters for superior stability and durability, and allows the bit to drill at maximum ROP for longer periods of time.
- The PX feature extends PDC bit life by reinforcing its gauge areas with diamond-enhanced inserts (DEI) set in highly wear-resistant tungsten carbide.



Concentric Staged Hole Openers (SHO) from Smith Bits have been developed from a tradition of application knowledge and technical excellence gained from the success of QUAD-D reaming products. SHO tools incorporate scientifically designed cutting structures to ensure fast, smoothly drilled and high quality hole opening under a wide range of application conditions. SHO tools are run successfully on rotary and rotary steerable assemblies in both straight and deviated holes.

Specifications

Total Cutters	45
Cutter Size	16 mm (5/8 in)
Face Cutters	(16) 16mm
Gauge Cutters	(9) 16mm
Blade Count	5
Nozzles	5 Standard Series 50N
Lower Connection	3-1/2 IF BOX
Junk Slot Area, in2	19.462
Upper Connection	4-1/2 IF PIN
Gauge	Length: 2 in Protection: Options Available
Length	Make-Up: 49.431 in Overall: 53.869 in
Fishing Neck	Diameter: 7.01 in Length: 11.986 in

Operating Parameters

Bit Rotary Speed (RPM)	Suitable for Rotary Steerable & PDM
Weight-on-Bit	4,000 To 35,000 (lbf) 1,779 To 15,569 (daN) 2 To 16 (Tonnes)
Max Flow Rate	300 to 800
Hydraulic Horsepower	1 to 6

Fig. H-13: 8½" staged hole opener profiles

Appendix I: Core section listing

The core recovery was 99% for the Bülach-1-1 and Bülach-1-1B boreholes.

Tab. I-1: Core section listing

CS-Nr.	Ø core	depth MD		depth MD core'		core section			date	time RIH			time POOH			drilling duration				RpM	WoB	pump		dens.	mudloss	
		from	to	from	to	target	actual	rcy		from	to	Δ	from	to	Δ	from	to	Δ	ROP			p	Flow in		vol	v
		[mm]	[m]	[m]	[m]	[m]	[m]	[%]								[m/h]	[min-1]	[t]	[bar]			[l/min]	[g/cm3]		[m3]	[l/min]
1 & 2	95	535.0	536.2	534.94	536.20	1.2	1.26	105	17/05/2019	07:30	08:00	00:30	12:00	12:25	00:25	08:05	11:54	03:49	1.0	160	2.0	5.0	300	1.07	-	-
3	95	536.2	539.2	536.20	539.20	3.0	3.00	100	17/05/2019	12:50	13:15	00:25	15:00	15:23	00:23	13:15	14:57	01:42	1.7	160	2.0	8.0	300	1.07	-	-
4	95	539.2	542.0	539.20	542.00	2.8	2.80	100	17/05/2019	16:16	17:00	00:44	19:06	19:30	00:24	17:04	19:03	01:59	1.5	160	2.0	5.0	300	1.07	-	-
5	95	542.0	545.0	542.00	545.00	3.0	3.00	100	17/05/2019	19:50	20:33	00:43	00:52	01:23	00:31	20:41	00:49	04:08	0.9	160	2.0	5.0	300	1.07	-	-
6	95	545.0	548.0	545.00	548.00	3.0	3.00	100	21/05/2019	16:20	16:33	00:13	19:38	20:09	00:31	16:33	19:38	03:05	0.8	157	2.0	3.0	294	1.07	-	-
7	95	548.0	551.0	548.00	551.00	3.0	3.00	100	21/05/2019	20:26	20:44	00:18	00:57	01:20	00:23	20:44	00:49	04:05	0.8	159	2.0	6.0	291	1.07	-	-
8	95	551.0	554.0	551.00	554.00	3.0	3.00	100	22/05/2019	01:41	01:59	00:18	07:10	07:50	00:40	01:58	07:10	05:12	0.6	160	2.0	3.0	300	1.07	-	-
9	95	554.0	557.0	554.00	557.00	3.0	3.00	100	22/05/2019	08:15	09:30	01:15	15:20	16:50	01:30	09:30	15:20	05:50	0.5	160	2.0	5.0	300	1.07	-	-
10	95	557.0	560.0	557.00	560.08	3.0	3.08	103	22/05/2019	16:30	17:00	00:30	00:20	00:40	00:20	17:00	00:20	07:20	0.5	160	3.0	5.0	300	1.07	-	-
11	95	560.0	563.0	560.08	563.00	3.0	2.92	97	23/05/2019	01:00	01:20	00:20	07:15	07:35	00:20	01:20	07:00	05:40	0.5	160	4.0	6.0	300	1.07	-	-
12	95	563.0	566.0	563.00	566.07	3.0	3.07	102	23/05/2019	07:45	08:17	00:32	13:05	13:35	00:30	08:17	13:00	04:43	0.6	190	3.0	6.0	300	1.08	-	-
13	95	566.0	569.0	566.07	569.07	3.0	3.00	100	23/05/2019	13:50	14:03	00:13	19:00	19:30	00:30	14:03	19:00	04:57	0.6	194	3.0	6.6	254	1.08	-	-
14	95	569.0	571.0	569.07	571.10	2.0	2.03	101	24/05/2019	19:30	20:00	00:30	03:30	04:00	00:30	20:00	03:30	06:17	0.3	161	3.0	5.0	254	1.08	-	-
15	95	571.0	574.0	571.10	574.00	3.0	2.90	97	24/05/2019	04:00	04:30	00:30	12:00	12:30	00:30	04:30	12:00	07:30	0.4	160	3.0	7.0	300	1.08	-	-
16	95	574.0	577.0	573.90	576.94	3.0	3.04	101	24/05/2019	12:52	13:17	00:25	19:45	20:15	00:30	13:17	19:45	06:28	0.3	162	3.0	6.0	293	1.07	-	-
17	95	577.0	578.5	577.00	578.50	1.5	1.50	100	25/05/2019	22:15	22:35	00:20	05:30	05:45	00:15	22:35	05:45	07:10	0.2	162	3.0	5.0	300	1.07	-	-
18	95	578.5	578.8	578.50	578.80	0.3	0.30	100	25/05/2019	06:05	06:20	00:15	08:15	08:45	00:30	06:20	08:10	01:50	0.2	160	4.0	11.0	300	1.07	-	-
19	95	578.8	579.4	578.80	579.40	0.6	0.60	100	26/05/2019	17:00	23:45	06:45	04:20	04:50	00:30	23:45	04:20	04:35	0.1	185	4.0	4.0	295	1.07	-	-
20	95	579.4	580.4	579.40	580.37	1.0	0.97	97	26/05/2019	05:25	05:45	00:20	09:48	10:22	00:34	05:45	09:48	04:03	0.3	160	3.0	5.0	300	1.07	-	-
21	95	580.4	583.0	580.40	583.05	2.6	2.65	102	27/05/2019	17:36	07:00	13:24	08:40	09:25	00:45	07:00	08:40	01:40	1.6	160	2.0	3.0	300	1.06	-	-
22	95	583.0	586.0	583.05	586.00	3.0	2.95	98	27/05/2019	09:40	09:54	00:14	11:30	12:00	00:30	09:54	11:30	01:36	1.8	160	3.0	3.0	300	1.06	-	-
23	95	586.0	589.0	586.00	589.00	3.0	3.00	100	27/05/2019	12:23	12:38	00:15	14:03	14:33	00:30	12:38	14:03	01:25	2.1	160	3.0	7.0	300	1.06	-	-
24	95	589.0	592.0	589.00	592.00	3.0	3.00	100	27/05/2019	14:52	15:18	00:26	16:53	17:25	00:32	15:18	16:53	01:35	1.7	160	3.0	6.0	300	1.06	-	-
25	95	592.0	595.0	592.00	595.00	3.0	3.00	100	27/05/2019	17:41	17:55	00:14	19:40	20:00	00:20	17:55	19:40	01:45	1.7	160	3.0	4.0	295	1.07	-	-
26	95	595.0	598.0	595.00	598.00	3.0	3.00	100	27/05/2019	20:40	21:00	00:20	23:00	23:30	00:30	21:00	23:00	02:00	1.5	160	3.0	5.0	300	1.07	-	-
27	95	598.0	601.0	598.00	601.00	3.0	3.00	100	27/05/2019	23:45	00:15	00:30	02:15	02:50	00:35	00:15	02:15	02:00	1.5	160	3.0	6-8	300	1.07	-	-
28	95	601.0	604.0	601.00	603.94	3.0	2.94	98	28/05/2019	03:30	04:00	00:30	06:47	07:15	00:28	04:00	06:47	02:47	1.1	160	3.3	8.0	300	1.07	-	-
29	95	604.0	607.0	604.00	607.00	3.0	3.00	100	28/05/2019	07:30	07:44	00:14	10:13	10:45	00:32	07:44	10:13	02:29	1.2	160	4.0	8.0	300	1.07	-	-
30	95	607.0	610.0	607.00	610.00	3.0	3.00	100	28/05/2019	11:03	14:43	03:40	17:37	18:05	00:28	14:43	17:37	02:54	1.1	160	4.0	7.0	300	1.07	-	-
31	95	610.0	613.0	610.00	613.00	3.0	3.00	100	28/05/2019	18:15	18:40	00:25	20:50	21:20	00:30	18:40	20:50	02:10	1.4	159	4.0	7.0	290	1.07	-	-
32	95	613.0	616.0	613.00	616.00	3.0	3.00	100	28/05/2019	21:20	21:55	00:35	23:40	00:15	00:00	21:55	23:40	01:45	1.7	160	4.0	7.5	295	1.07	-	-
33	95	616.0	619.0	616.00	619.00	3.0	3.00	100	29/05/2019	03:30	04:07	00:37	05:57	06:32	00:35	04:07	05:57	01:50	1.7	157	4.0	7.0	300	1.07	-	-
34	95	619.0	622.0	619.00	622.00	3.0	3.00	100	29/05/2019	06:51	07:06	00:15	09:03	09:32	00:29	07:06	09:03	01:57	1.5	160	4.0	7.0	300	1.07	-	-
35	95	622.0	625.0	622.00	625.00	3.0	3.00	100	29/05/2019	09:47	10:04	00:17	11:59	12:28	00:29	10:04	11:59	01:55	1.6	160	4.0	8.0	300	1.07	-	-
36	95	625.0	628.0	625.00	628.00	3.0	3.00	100	29/05/2019	12:43	13:13	00:30	14:26	14:58	00:32	13:13	14:26	01:13	2.5	160	4.0	8.0	300	1.07	-	-
37	95	628.0	631.0	628.00	630.95	3.0	2.95	98	29/05/2019	15:16	15:32	00:16	16:56	17:30	00:34	15:32	16:56	01:24	2.1	160	4.0	8.0	300	1.07	-	-
38	95	631.0	634.0	630.95	634.00	3.0	3.05	102	29/05/2019	18:02	18:35	00:33	20:05	20:48	00:43	18:35	20:05	01:30	2.1	160	4.0	8.0	300	1.07	-	-
39	95	634.0	637.0	634.00	637.00	3.0	3.00	100	29/05/2019	21:01	21:25	00:24	23:00	23:33	00:33	21:25	23:00	01:35	1.9	160	4.0	8.0	300	1.07	-	-
40	95	637.0	640.0	637.00	640.00	3.0	3.00	100	30/05/2019	23:46	00:04	00:18	02:00	02:34	00:34	00:04	02:00	01:56	1.6	160	4.0	9.0	300	1.07	-	-
41	95	640.0	643.0	640.00	643.09	3.0	3.09	103	30/05/2019	02:45	03:13	00:28	04:52	05:30	00:38	03:13	04:48	01:35	1.9	160	4.0	9.0	300	1.07	-	-
42	95	643.0	646.0	643.09	646.00	3.0	2.91	97	30/05/2019	05:30	06:05	00:35	07:25	08:10	00:45	06:05	07:25	01:20	2.2	159	4.0	7.5	295	1.07	-	-
43	95	646.0	649.0	646.00	649.00	3.0	3.00	100	30/05/2019	08:10	08:34	00:24	10:16	10:46	00:30	08:34	10:16	01:42	1.8	159	4.0	8.0	290	1.07	-	-
44	95	649.0	652.0	649.00	652.00	3.0	3.00	100	30/05/2019	10:46	11:20	00:34	13:36	14:10	00:34	11:20	13:36	02:16	1.3	160	4.0	9.0	285	1.07	-	-
45	95	652.0	655.0	652.00	655.00	3.0	3.00	100	30/05/2019	14																

CS-Nr.	Ø core	depth MD		depth MD core*		core section			date	time RIH			time POOH			drilling duration				RpM	WoB	pump		dens.	mudloss	
		from	to	from	to	target	actual	rcy		from	to	Δ	from	to	Δ	from	to	Δ	ROP			p	Flow in		vol	v
		[mm]	[m]	[m]	[m]	[m]	[m]	[%]											[m/h]			[min-1]	[t]		[bar]	[l/min]
51	95	670.0	673.0	670.00	673.00	3.0	3.00	100	31/05/2019	12:00	12:40	00:40	14:51	15:30	00:39	12:40	14:51	02:11	1.4	161	4.0	12.0	293	1.07	-	-
52	95	673.0	676.0	673.00	675.93	3.0	2.93	98	31/05/2019	15:30	16:00	00:30	18:20	18:56	00:36	16:00	18:20	02:20	1.3	161	4.0	12.0	300	1.07	-	-
53	95	676.0	679.0	676.00	679.00	3.0	3.00	100	31/05/2019	19:08	20:02	00:54	21:30	22:10	00:40	20:02	21:30	01:28	2.1	160	4.0	13.0	300	1.07	-	-
54	95	679.0	682.0	679.00	682.02	3.0	3.02	101	31/05/2019	22:20	22:40	00:20	00:20	00:45	00:25	22:40	00:20	01:30	2.0	160	4.0	13.0	300	1.07	-	-
55	95	682.0	685.0	682.02	685.00	3.0	2.98	99	01/06/2019	01:25	01:45	00:20	03:30	04:05	00:35	01:45	03:30	01:45	1.7	160	4.0	13.0	300	1.07	-	-
56	95	685.0	688.0	685.00	688.00	3.0	3.00	100	01/06/2019	04:20	04:39	00:19	06:07	06:50	00:43	04:39	06:07	01:28	2.0	160	4.0	13.0	300	1.07	-	-
57	95	688.0	691.0	688.00	691.00	3.0	3.00	100	01/06/2019	06:50	07:30	00:40	08:57	09:35	00:38	07:30	08:57	01:27	2.1	159	4.0	15.0	295	1.07	-	-
58	95	691.0	694.0	691.00	694.00	3.0	3.00	100	01/06/2019	09:35	10:13	00:38	11:33	12:12	00:39	10:13	11:33	01:20	2.3	159	4.0	14.0	300	1.07	-	-
59	95	694.0	697.0	694.00	697.00	3.0	3.00	100	01/06/2019	12:12	12:50	00:38	13:57	14:37	00:40	12:50	13:57	01:07	2.7	159	4.0	15.0	300	1.07	-	-
60	95	697.0	700.0	697.00	700.00	3.0	3.00	100	01/06/2019	14:37	15:25	00:48	16:50	17:32	00:42	15:25	16:50	01:25	2.1	157	4.0	11.0	290	1.07	-	-
61	95	700.0	703.0	700.00	703.00	3.0	3.00	100	01/06/2019	18:55	20:00	01:05	21:18	21:57	00:39	20:00	21:18	01:18	2.3	160	4.0	10.0	300	1.07	-	-
62	95	703.0	706.0	703.00	706.00	3.0	3.00	100	01/06/2019	22:01	22:25	00:24	00:07	00:40	00:33	22:25	00:04	01:39	2.0	160	4.0	13.0	300	1.07	-	-
63	95	706.0	709.0	706.00	709.00	3.0	3.00	100	02/06/2019	00:53	01:19	00:26	03:01	03:40	00:39	01:19	03:01	01:42	1.8	160	4.0	10.5	300	1.07	-	-
64	95	709.0	712.0	709.00	712.00	3.0	3.00	100	02/06/2019	03:50	04:09	00:19	05:49	06:23	00:34	04:09	05:49	01:40	1.8	160	4.0	11.0	300	1.07	-	-
65	95	712.0	715.0	712.00	715.00	3.0	3.00	100	02/06/2019	06:23	06:56	00:33	08:42	09:18	00:36	06:56	08:42	01:46	1.7	160	4.0	13.0	290	1.08	-	-
66	95	715.0	718.0	715.00	718.00	3.0	3.00	100	02/06/2019	09:18	10:00	00:42	11:41	12:22	00:41	10:00	11:41	01:41	1.7	160	4.0	13.0	290	1.08	-	-
67	95	718.0	721.0	718.00	721.00	3.0	3.00	100	02/06/2019	12:22	12:56	00:34	14:30	15:12	00:42	12:56	14:30	01:34	1.7	159	4.0	15.0	290	1.08	-	-
68	95	721.0	724.0	721.00	724.00	3.0	3.00	100	02/06/2019	15:12	16:06	00:54	17:50	18:30	00:40	16:06	17:50	01:44	1.7	159	4.0	14.0	290	1.08	-	-
69	95	724.0	727.0	724.00	727.00	3.0	3.00	100	02/06/2019	18:49	19:07	00:18	21:07	21:47	00:40	19:07	21:07	02:00	1.5	160	4.0	14.0	300	1.08	-	-
70	95	727.0	730.0	727.00	730.00	3.0	3.00	100	02/06/2019	21:56	22:15	00:19	23:54	00:27	00:33	22:15	23:54	01:39	1.8	160	4.0	14.0	300	1.08	-	-
71	95	730.0	733.0	730.00	733.00	3.0	3.00	100	03/06/2019	00:36	00:57	00:21	02:39	03:20	00:41	00:57	02:39	01:42	1.8	160	4.0	10.5	300	1.08	-	-
72	95	733.0	736.0	733.00	736.00	3.0	3.00	100	03/06/2019	03:28	03:58	00:30	06:57	07:40	00:43	03:58	06:57	02:59	1.1	160	4.0	15.0	270	1.08	-	-
73	95	736.0	739.0	736.00	739.00	3.0	3.00	100	03/06/2019	08:23	08:50	00:27	10:42	11:20	00:38	08:50	10:42	01:52	1.6	160	4.0	19.0	280	1.08	-	-
74	95	739.0	742.0	739.00	742.00	3.0	3.00	100	03/06/2019	11:20	11:55	00:35	13:30	14:14	00:44	11:55	13:30	01:35	1.9	160	4.0	17.0	300	1.08	-	-
75	95	742.0	745.0	742.00	745.00	3.0	3.00	100	03/06/2019	14:14	15:00	00:46	17:19	17:53	00:34	15:00	17:19	02:19	1.3	160	4.0	11.0	315	1.08	-	-
76	95	745.0	748.0	745.00	748.00	3.0	3.00	100	03/06/2019	18:06	18:27	00:21	20:37	21:18	00:41	18:27	20:37	02:10	1.4	160	4.0	18.0	300	1.08	-	-
77	95	748.0	751.0	748.00	751.00	3.0	3.00	100	03/06/2019	21:28	21:53	00:25	00:16	00:57	00:41	21:53	00:16	02:23	1.3	160	4.0	18.5	300	1.08	-	-
78	95	751.0	754.0	751.00	754.00	3.0	3.00	100	04/06/2019	01:10	01:38	00:28	04:17	04:55	00:38	01:38	04:17	02:39	1.1	160	4.0	17.0	300	1.08	-	-
79	95	754.0	757.0	754.00	757.00	3.0	3.00	100	04/06/2019	05:45	06:10	00:25	08:38	09:14	00:36	06:10	08:38	02:28	1.2	160	4.0	16.0	304	1.08	-	-
80	95	757.0	760.0	757.00	760.00	3.0	3.00	100	04/06/2019	09:14	09:50	00:36	12:15	12:47	00:32	09:50	12:15	02:25	1.2	163	4.0	18.0	290	1.08	-	-
81	95	760.0	763.0	760.00	763.00	3.0	3.00	100	04/06/2019	12:47	13:32	00:45	12:47	13:32	00:45	13:32	15:57	02:25	1.2	180	4.0	23.0	360	1.08	-	-
82	95	763.0	766.0	763.00	766.00	3.0	3.00	100	04/06/2019	16:42	17:16	00:34	19:29	20:10	00:41	17:16	19:29	02:13	1.4	192	4.0	21.8	370	1.08	-	-
83	95	766.0	769.0	766.00	769.00	3.0	3.00	100	04/06/2019	20:12	20:32	00:20	23:08	23:44	00:36	20:32	23:08	02:36	1.2	192	4.5	24.0	380	1.08	-	-
84	95	769.0	772.0	769.00	772.00	3.0	3.00	100	05/06/2019	23:57	00:25	00:28	02:42	03:17	00:35	00:25	02:42	02:17	1.3	182	4.5	20.0	385	1.08	-	-
85	95	772.0	775.0	772.00	775.00	3.0	3.00	100	05/06/2019	03:30	03:50	00:20	06:03	06:37	00:34	03:50	06:03	02:13	1.4	193	4.5	20.0	375	1.08	-	-
86	95	775.0	778.0	775.00	778.00	3.0	3.00	100	05/06/2019	06:37	07:17	00:40	08:48	09:30	00:42	07:17	09:30	02:13	1.4	194	4.1	20.0	370	1.08	-	-
87	95	778.0	781.0	778.00	781.00	3.0	3.00	100	05/06/2019	10:20	11:02	00:42	13:08	13:48	00:40	11:02	13:08	02:06	1.3	183	4.6	21.0	330	1.08	-	-
88	95	781.0	784.0	781.00	783.92	3.0	2.92	97	05/06/2019	13:48	14:22	00:34	16:23	17:02	00:39	14:22	16:23	02:01	1.5	185	4.3	20.0	350	1.08	-	-
89	95	784.0	787.0	783.92	787.00	3.0	3.08	103	05/06/2019	17:02	17:40	00:38	19:35	20:05	00:30	17:40	19:35	01:55	1.5	189	4.4	22.0	355	1.08	-	-
90	95	787.0	790.0	787.00	790.00	3.0	3.00	100	05/06/2019	20:05	20:43	00:38	23:26	00:10	00:44	20:43	23:26	02:43	1.1	190	4.2	22.0	397	1.08	-	-
91	95	790.0	793.0	790.00	793.00	3.0	3.00	100	06/06/2019	00:10	00:52	00:42	04:05	04:40	00:35	00:52	04:05	03:13	1.0	186	4.7	21.0	387	1.08	-	-
92	95	793.0	796.0	793.00	796.00	3.0	3.00	100	06/06/2019	04:40	05:11	00:31	08:08	09:00	00:52	05:11	08:08	02								

CS-Nr.	Ø core	depth MD		depth MD core		core section			date	time RIH			time POOH			drilling duration				RpM	WoB	pump		dens.	mudloss	
		from	to	from	to	target	actual	rcy		from	to	Δ	from	to	Δ	from	to	Δ	ROP			p	Flow in		vol	v
		[mm]	[m]	[m]	[m]	[m]	[m]	[%]											[m/h]			[min-1]	[t]		[bar]	[l/min]
101	95	820,0	823,0	820,00	823,00	3,0	3,00	100	07/06/2019	11:26	11:52	00:26	13:22	14:10	00:48	11:52	13:22	01:30	2,0	163	5,5	19,4	340	1,09	-	-
102	95	823,0	826,0	823,00	826,00	3,0	3,00	100	07/06/2019	14:30	15:06	00:36	16:30	17:00	00:30	15:06	16:30	01:24	2,2	164	5,3	18,0	330	1,09	-	-
103	95	826,0	829,0	826,00	829,00	3,0	3,00	100	08/06/2019	03:00	03:39	00:39	05:42	06:18	00:36	03:39	05:42	02:03	1,5	164	5,2	19,0	350	1,09	-	-
104	95	829,0	832,0	829,00	832,00	3,0	3,00	100	08/06/2019	06:34	07:00	00:26	09:02	09:42	00:40	07:00	09:02	02:02	1,5	173	5,3	21,0	344	1,09	-	-
105	95	832,0	835,0	832,00	835,00	3,0	3,00	100	08/06/2019	09:55	10:28	00:33	12:02	12:45	00:43	10:28	12:02	01:34	1,7	171	5,2	18,0	315	1,09	-	-
106	95	835,0	838,0	835,00	838,00	3,0	3,00	100	08/06/2019	13:00	13:39	00:39	15:25	16:06	00:41	13:39	15:25	01:46	1,7	173	5,2	18,0	280	1,09	-	-
107	95	838,0	841,0	838,00	841,00	3,0	3,00	100	08/06/2019	16:25	16:53	00:28	18:24	19:13	00:49	16:53	18:24	01:31	2,0	172	4,8	20,0	320	1,09	-	-
108	95	841,0	844,0	841,00	844,00	3,0	3,00	100	08/06/2019	19:13	19:51	00:38	21:56	22:31	00:35	19:51	21:56	02:05	1,5	168	5,0	19,0	347	1,09	-	-
109	95	844,0	847,0	844,00	847,00	3,0	3,00	100	09/06/2019	22:31	23:05	00:34	01:02	01:37	00:35	23:05	01:02	01:57	1,5	169	5,0	20,0	357	1,09	-	-
110	95	847,0	850,0	847,00	850,00	3,0	3,00	100	09/06/2019	01:37	02:07	00:30	04:00	04:36	00:36	02:07	04:00	01:53	1,8	161	5,2	20,0	355	1,09	-	-
111	95	850,0	853,0	850,00	853,00	3,0	3,00	100	09/06/2019	04:36	05:16	00:40	07:29	08:10	00:41	05:16	07:29	01:53	1,4	165	5,3	23,0	348	1,09	-	-
112	95	853,0	856,0	853,00	856,07	3,0	3,07	102	09/06/2019	09:12	09:35	00:23	11:43	12:23	00:40	09:35	11:43	01:53	1,4	168	5,3	19,0	310	1,09	-	-
113	95	856,0	859,0	856,07	859,00	3,0	2,93	98	09/06/2019	12:34	13:19	00:45	15:14	15:57	00:43	13:19	15:12	01:53	1,6	169	4,9	20,0	300	1,09	-	-
114	95	859,0	862,0	859,00	862,00	3,0	3,00	100	09/06/2019	16:10	16:41	00:31	19:03	19:51	00:48	16:41	19:03	02:22	1,3	177	4,9	16,0	295	1,09	-	-
115	95	862,0	865,0	862,00	864,74	3,0	2,74	91	09/06/2019	19:51	20:15	00:24	23:03	23:41	00:38	20:15	23:03	02:48	1,1	172	5,0	17,0	305	1,09	-	-
116	95	865,0	868,0	864,74	867,61	3,0	2,87	96	10/06/2019	23:41	00:26	00:45	04:02	04:55	00:53	00:26	04:02	03:36	0,8	172	4,9	20,0	341	1,09	-	-
117	95	868,0	869,0	868,00	869,00	1,0	1,00	100	11/06/2019	16:45	01:15	08:30	03:39	04:30	00:51	01:15	03:39	02:24	0,4	172	3,8	26,0	307	1,09	-	-
118	95	869,0	869,4	869,00	869,34	0,4	0,34	85	26/06/2019	06:00	18:58	12:58	20:30	21:20	00:50	18:58	20:30	01:32	0,4	90	2,8	27,0	220	1,07	-	-
119	95	869,4	872,0	869,34	872,00	2,6	2,66	102	26/06/2019	22:02	22:32	00:30	01:23	02:09	00:46	22:32	01:23	02:51	0,9	82	4,1	29,0	260	1,07	-	-
120	95	872,0	875,0	872,00	874,95	3,0	2,95	98	27/06/2019	02:23	02:45	00:22	06:20	06:58	00:38	02:45	06:20	03:35	0,9	100	4,5	30,0	300	1,08	-	-
121	95	875,0	877,0	874,95	877,13	2,0	2,18	109	27/06/2019	07:03	07:42	00:39	10:14	10:50	00:36	07:40	10:14	02:34	0,8	109	4,5	36,0	265	1,08	-	-
122	95	877,0	880,0	877,13	880,00	3,0	2,87	96	27/06/2019	10:50	11:43	00:53	16:03	16:35	00:32	11:43	15:56	04:13	0,6	100	4,5	41,0	230	1,08	-	-
123	95	880,0	883,0	880,00	882,88	3,0	2,88	96	27/06/2019	16:40	17:15	00:35	22:22	22:55	00:33	17:15	22:22	05:07	0,6	110	4,4	36,0	280	1,08	-	-
124	95	883,0	886,0	883,00	886,15	3,0	3,15	105	28/06/2019	23:14	23:39	00:25	02:13	03:05	00:52	23:39	02:13	02:34	1,2	109	4,1	33,0	250	1,08	-	-
125	95	886,0	886,5	886,15	886,40	0,5	0,25	50	28/06/2019	03:20	03:39	00:19	04:13	05:00	00:47	03:39	04:13	00:34	0,9	108	4,4	37,0	225	1,08	-	-
126	95	886,5	889,0	886,50	889,00	2,5	2,50	100	29/06/2019	18:00	01:00	07:00	06:35	07:15	00:40	01:00	06:31	05:31	0,7	104	4,5	33,0	230	1,08	-	-
127	95	889,0	890,5	889,00	890,50	1,5	1,50	100	29/06/2019	07:27	07:50	00:23	10:35	11:05	00:30	07:50	10:31	02:41	0,6	105	4,6	33,0	235	1,08	-	-
128	95	890,5	892,0	890,50	892,05	1,5	1,55	103	29/06/2019	11:20	11:58	00:38	13:40	14:15	00:35	12:00	13:54	01:54	1,0	105	3,5	38,0	200	1,08	-	-
129	95	892,0	895,0	892,05	895,00	3,0	2,95	98	29/06/2019	14:28	14:57	00:29	18:28	19:11	00:43	14:57	18:28	03:31	0,9	110	4,7	36,0	240	1,09	-	-
130	95	895,0	898,0	895,00	898,10	3,0	3,10	103	29/06/2019	19:33	20:08	00:35	00:25	01:08	00:43	20:08	00:26	04:18	0,7	110	4,8	36,0	260	1,09	-	-
131	95	898,0	901,0	898,10	901,00	3,0	2,90	97	30/06/2019	01:19	01:48	00:29	06:12	06:55	00:43	01:48	06:12	04:24	0,7	109	4,7	38,0	270	1,09	-	-
132	95	901,0	904,0	901,00	903,84	3,0	2,84	95	30/06/2019	07:00	07:39	00:39	12:36	13:15	00:39	07:40	12:24	04:44	0,6	110	4,8	42,0	235	1,09	-	-
133	95	904,0	907,0	903,84	907,14	3,0	3,30	110	30/06/2019	13:20	14:05	00:45	19:48	20:31	00:43	14:05	19:48	05:43	0,5	106	4,2	40,0	250	1,09	-	-
134	95	907,0	910,0	907,14	910,00	3,0	2,86	95	30/06/2019	21:30	21:54	00:24	02:13	03:03	00:50	21:54	02:13	04:17	0,7	165	4,9	38,0	320	1,09	-	-
135	95	910,0	913,0	910,00	912,96	3,0	2,96	99	01/07/2019	03:07	03:33	00:26	10:33	11:04	00:31	03:33	10:23	06:50	0,6	137	4,9	40,0	280	1,08	-	-
136	95	913,0	916,0	912,96	916,10	3,0	3,14	105	01/07/2019	11:05	11:41	00:36	16:30	17:04	00:34	11:43	16:25	04:42	0,6	117	5,0	45,0	230	1,08	-	-
137	95	916,0	919,0	916,10	919,00	3,0	2,90	97	01/07/2019	17:10	17:48	00:38	21:28	22:07	00:39	17:48	21:28	03:40	0,8	115	4,6	42,0	220	1,08	-	-
138	95	919,0	922,0	919,00	922,07	3,0	3,07	102	01/07/2019	22:20	22:46	00:26	02:45	03:25	00:40	22:46	02:45	03:59	0,8	118	4,8	41,0	200	1,08	-	-
139	95	922,0	925,0	922,07	925,00	3,0	2,93	98	02/07/2019	03:45	04:11	00:26	08:18	08:58	00:40	04:11	08:12	04:01	0,8	107	4,9	41,0	210	1,08	-	-
140	95	925,0	928,0	925,00	928,02	3,0	3,02	101	02/07/2019	09:05	09:32	00:27	14:03	14:40	00:37	09:39	14:00	04:21	0,7	110	4,9	43,0	280	1,08	-	-
141	95	928,0	931,0	928,02	931,00	3,0	2,98	99	02/07/2019	14:46	15:16	00:30	21:00	21:42	00:42	15:16	21:00	05:44	0,5	113	4,9	41,0	300	1,08	-	-
142	95	931,0	934,0	931,00	933,95	3,0	2,95	98	02/07/2019	21:57	22:28	00:31	04:43	05:23	00:4											

CS-Nr.	Ø core	depth MD		depth MD core		core section			date	time RIH			time POOH			drilling duration				RpM	WoB	pump		dens.	mudloss	
		from	to	from	to	target	actual	rcy		from	to	Δ	from	to	Δ	from	to	Δ	ROP			p	Flow in		vol	v
		[mm]	[m]	[m]	[m]	[m]	[m]	[%]										[m/h]	[min-1]			[t]	[bar]		[l/min]	[g/cm3]
151	95	958.0	961.0	958.00	961.00	3.0	3.00	100	20/08/2019	03:50	04:18	00:28	05:42	09:45	04:03	04:18	05:42	01:24	2.1	200	2.5	19.0	340	1.15	-	-
152	95	961.0	964.0	961.00	963.88	3.0	2.88	96	20/08/2019	09:45	15:10	05:25	16:50	17:30	00:40	15:10	16:50	01:40	1.8	180	2.8	29.0	330	1.15	-	-
153	95	964.0	967.0	963.88	966.88	3.0	3.00	100	20/08/2019	17:30	18:15	00:45	19:43	20:35	00:52	18:15	19:43	01:28	2.1	193	2.5	31.0	330	1.15	-	-
154	95	967.0	970.0	966.88	969.93	3.0	3.05	102	20/08/2019	20:35	21:42	01:07	23:02	23:52	00:50	21:42	23:02	01:20	2.3	180	2.0	27.0	327	1.15	-	-
155	95	970.0	973.0	969.93	972.80	3.0	2.87	96	20/08/2019	23:52	00:36	00:44	02:00	02:51	00:51	00:36	02:00	01:24	2.1	175	2.0	30.0	285	1.16	-	-
156	95	973.0	976.0	972.80	976.00	3.0	3.20	107	21/08/2019	02:51	03:40	00:49	05:18	06:00	00:42	03:40	05:18	01:38	1.8	175	2.4	30.0	280	1.16	-	-
157	95	976.0	979.0	976.00	979.07	3.0	3.07	102	21/08/2019	06:37	07:06	00:29	08:51	09:40	00:49	07:06	08:51	01:45	1.7	185	2.9	30.0	300	1.16	-	-
158	95	979.0	980.0	979.38	980.27	1.0	0.89	89	06/09/2019	12:50	13:13	00:23	14:23	15:00	00:37	13:13	14:23	01:10	0.6	170	2.0	30.0	210	1.15	-	-
159	95	980.0	982.0	980.27	982.00	2.0	1.73	87	06/09/2019	15:25	15:50	00:25	18:10	18:50	00:40	16:10	18:10	02:00	1.0	183	2.0	26.0	300	1.15	-	-
160	95	982.0	985.0	982.00	985.12	3.0	3.12	104	06/09/2019	18:50	20:15	01:25	23:23	00:05	00:42	20:15	23:23	03:08	1.0	180	2.5	23.0	325	1.15	-	-
161	95	985.0	988.0	985.12	988.02	3.0	2.90	97	07/09/2019	00:05	01:00	00:55	03:30	04:20	00:50	01:00	03:30	02:30	1.2	172	3.0	23.0	350	1.15	-	-
162	95	988.0	991.0	988.02	991.04	3.0	3.02	101	07/09/2019	04:20	05:00	00:40	07:42	08:20	00:38	05:00	07:42	02:42	1.1	175	2.5	22.0	340	1.15	-	-
163	95	991.0	994.0	991.06	994.16	3.0	3.10	103	07/09/2019	08:20	09:08	00:48	11:03	11:40	00:37	09:08	11:03	01:55	1.2	175	2.7	22.9	321	1.15	-	-
164	95	994.0	997.0	994.16	997.05	3.0	2.89	96	07/09/2019	11:40	12:25	00:45	14:06	14:45	00:39	12:25	14:06	01:41	1.8	174	2.6	25.6	296	1.15	-	-
165	95	997.0	1000.0	997.05	1000.14	3.0	3.09	103	07/09/2019	14:45	15:25	00:40	17:44	18:26	00:42	15:25	17:44	02:19	1.3	179	2.9	20.0	360	1.15	-	-
166	95	1000.0	1003.0	1000.14	1003.25	3.0	3.11	104	07/09/2019	18:26	19:05	00:39	21:56	22:43	00:47	19:05	21:56	02:51	1.1	180	2.5	23.0	290	1.15	-	-
167	95	1003.0	1006.0	1003.25	1003.89	3.0	0.64	21	07/09/2019	22:43	23:26	00:43	01:53	09:25	07:32	23:26	01:53	02:27	1.2	180	2.5	20.0	315	1.15	-	-
168	95	1006.0	1009.0	1006.00	1008.95	3.0	2.95	98	09/09/2019	09:25	03:19	17:54	04:44	05:28	00:44	03:19	04:44	01:25	2.1	178	2.5	20.0	355	1.15	-	-
169	95	1009.0	1012.0	1008.95	1012.03	3.0	3.08	103	09/09/2019	05:28	07:06	01:38	08:08	08:46	00:38	07:08	08:08	01:00	2.8	180	2.3	21.8	326	1.15	-	-
170	95	1012.0	1015.0	1012.03	1014.92	3.0	2.89	96	09/09/2019	08:46	09:28	00:42	10:31	11:14	00:43	09:28	10:31	01:03	2.9	184	2.8	26.4	308	1.15	-	-
171	95	1015.0	1018.0	1014.92	1017.93	3.0	3.01	100	09/09/2019	11:14	11:49	00:35	13:05	13:45	00:40	11:49	13:05	01:16	2.7	182	2.7	25.7	289	1.15	-	-
172	95	1018.0	1021.0	1017.93	1021.11	3.0	3.18	106	09/09/2019	13:45	14:23	00:38	15:44	16:28	00:44	14:23	15:44	01:21	2.0	180	2.3	19.2	402	1.15	-	-
173	95	1021.0	1024.0	1021.11	1024.02	3.0	2.91	97	09/09/2019	16:28	17:16	00:48	18:56	19:42	00:46	17:16	18:56	01:40	1.8	179	2.7	27.0	300	1.15	-	-
174	95	1024.0	1027.0	1024.02	1026.97	3.0	2.95	98	09/09/2019	19:42	20:27	00:45	22:19	22:59	00:40	20:27	22:19	01:52	1.6	180	2.5	20.0	315	1.15	-	-
175	95	1027.0	1030.0	1026.97	1030.06	3.0	3.09	103	09/09/2019	22:59	23:40	00:41	03:09	03:53	00:44	23:40	03:09	03:29	0.9	184	3.0	20.0	280	1.15	-	-
176	95	1030.0	1033.0	1030.06	1032.99	3.0	2.93	98	10/09/2019	03:53	04:33	00:40	07:20	08:08	00:48	04:33	07:20	02:47	1.1	183	2.7	18.0	340	1.15	-	-
177	95	1033.0	1036.0	1032.99	1035.99	3.0	3.00	100	10/09/2019	08:08	08:54	00:46	11:32	12:12	00:40	08:54	11:32	02:38	1.1	183	3.0	23.4	314	1.15	-	-
178	95	1036.0	1039.0	1035.99	1039.10	3.0	3.11	104	10/09/2019	12:12	12:53	00:41	16:06	16:45	00:39	12:53	16:06	03:13	1.0	186	2.8	24.1	285	1.15	-	-
179	95	1039.0	1043.0	1039.10	1040.26	4.0	1.16	29	10/09/2019	16:45	20:38	03:53	03:22	07:40	04:18	20:38	07:40	12:58	0.3	180	3.0	20.0	335	1.15	-	-
1B	95	994.0	1000.0	994.00	999.38	6.0	5.38	90	26/09/2019	20:18	20:56	00:38	01:10	01:58	00:48	20:56	01:10	04:14	1.3	185	3.6	23.4	360	1.15	-	-
2B	95	1000.0	1003.0	999.38	1003.00	3.0	3.62	121	27/09/2019	01:58	02:34	00:36	05:50	06:38	00:48	03:12	05:50	02:38	1.1	181	4.0	23.8	327	1.15	-	-
3B	95	1003.0	1006.0	1003.00	1005.00	3.0	2.00	67	27/09/2019	09:50	10:24	00:34	12:39	13:25	00:46	10:24	12:39	02:15	1.6	180	3.0	27.0	290	1.15	-	-
4B	95	1006.0	1009.0	1005.00	1008.92	3.0	3.92	131	27/09/2019	13:30	14:45	01:15	16:41	17:35	00:54	14:45	16:41	01:56	1.6	180	4.0	28.5	430	1.15	-	-
5B	95	1009.0	1012.0	1008.92	1012.03	3.0	3.11	104	27/09/2019	21:15	21:22	00:07	22:55	23:32	00:37	21:22	22:55	01:33	2.0	186	4.3	24.0	369	1.15	-	-
6B	95	1012.0	1015.0	1012.03	1014.94	3.0	2.91	97	28/09/2019	23:32	00:15	00:43	02:02	02:43	00:41	00:15	02:02	01:47	1.7	185	3.8	23.5	345	1.15	-	-
7B	95	1015.0	1018.0	1014.94	1017.94	3.0	3.00	100	28/09/2019	02:43	03:22	00:39	05:15	05:58	00:43	03:22	05:15	01:53	1.7	185	3.8	23.7	360	1.15	-	-
8B	95	1018.0	1021.0	1017.94	1021.04	3.0	3.10	103	28/09/2019	05:58	06:35	00:37	08:25	09:10	00:45	06:35	08:25	01:50	1.6	180	4.0	27.0	370	1.15	-	-
9B	95	1021.0	1024.0	1021.04	1023.91	3.0	2.87	96	28/09/2019	09:10	10:05	00:55	12:13	13:05	00:52	10:05	12:13	02:08	1.4	180	4.0	28.0	325	1.15	-	-
10B	95	1024.0	1027.0	1023.91	1026.97	3.0	3.06	102	28/09/2019	13:20	14:37	01:17	16:26	17:14	00:48	15:09	16:26	01:17	1.5	180	3.0	28.0	337	1.15	-	-
11B	95	1027.0	1030.0	1026.97	1030.10	3.0	3.13	104	28/09/2019	17:14	18:24	01:10	22:29	23:06	00:37	18:24	22:29	04:05	0.9	181	3.5	27.6	334	1.15	-	-
12B	95																									

CS-Nr.	Ø core	depth MD		depth MD core		core section			date	time RIH			time POOH			drilling duration				RpM	WoB	pump		dens.	mudloss	
		from	to	from	to	target	actual	rcy		from	to	Δ	from	to	Δ	from	to	Δ	ROP			p	Flow in		vol	v
		[mm]	[m]	[m]	[m]	[m]	[m]	[%]								[m/h]	[min-1]	[t]	[bar]			[l/min]	[g/cm3]		[m3]	[l/min]
31B	95	1084,0	1087,0	1084,05	1087,04	3,0	2,99	100	08/10/2019	03:25	04:13	00:48	06:45	07:30	00:45	04:13	06:45	02:32	1,3	186	4,7	26,8	316	1,15		
32B	95	1087,0	1090,0	1087,04	1090,00	3,0	2,96	99	08/10/2019	07:30	08:21	00:51	10:39	11:23	00:44	08:21	10:39	02:18	1,3	200	4,1	27,0	276	1,15		
33B	95	1090,0	1093,0	1090,00	1093,09	3,0	3,09	103	08/10/2019	19:30	04:05	08:35	05:50	06:39	00:49	04:05	05:50	01:45	1,7	184	2,0	21,0	312	1,15		
34B	95	1093,0	1096,0	1093,09	1096,00	3,0	2,91	97	09/10/2019	06:39	20:53	14:14	22:35	23:21	00:46	20:53	22:35	01:42	1,8	183	2,3	24,0	300	1,15		
35B	95	1096,0	1099,0	1096,00	1098,97	3,0	2,97	99	10/10/2019	23:29	00:05	00:36	02:09	02:54	00:45	00:05	02:09	02:04	1,5	178	2,1	22,0	325	1,15		
36B	95	1099,0	1102,0	1098,97	1102,07	3,0	3,10	103	10/10/2019	02:54	03:44	00:50	05:34	06:20	00:46	03:44	05:34	01:50	1,6	178	2,3	23,0	320	1,15		
37B	95	1102,0	1105,0	1102,07	1104,95	3,0	2,88	96	10/10/2019	06:20	07:10	00:50	09:17	10:01	00:44	07:10	09:17	02:07	1,4	179	2,5	25,0	314	1,15		
38B	95	1105,0	1108,0	1104,95	1108,02	3,0	3,07	102	10/10/2019	10:01	10:45	00:44	13:24	14:12	00:48	10:45	13:24	02:39	1,1	205	2,5	25,0	300	1,15		
39B	95	1108,0	1111,0	1108,02	1111,10	3,0	3,08	103	10/10/2019	14:12	15:00	00:48	18:00	18:53	00:53	15:00	18:00	03:00	1,0	200	3,0	33,0	300	1,15		
40B	95	1111,0	1114,0	1111,10	1114,10	3,0	3,00	100	10/10/2019	18:53	20:00	01:07	23:41	00:30	00:49	20:00	23:41	03:41	0,8	170	3,0	23,0	320	1,15		
41B	95	1114,0	1117,0	1114,10	1117,20	3,0	3,10	103	11/10/2019	00:30	01:20	00:50	06:00	06:46	00:46	01:20	06:00	04:40	0,6	180	2,3	24,0	310	1,15		
42B	95	1117,0	1120,0	1117,20	1120,12	3,0	2,92	97	11/10/2019	06:46	08:12	01:26	10:53	11:43	00:50	08:12	10:53	02:41	1,1	188	3,5	26,0	325	1,15		
43B	95	1120,0	1123,0	1120,12	1123,08	3,0	2,96	99	11/10/2019	11:43	12:55	01:12	14:57	15:47	00:50	12:55	14:57	02:02	1,5	180	3,8	25,0	353	1,15		
44B	95	1123,0	1126,0	1123,08	1126,20	3,0	3,12	104	11/10/2019	15:47	17:36	01:49	21:03	21:47	00:44	17:36	21:03	03:27	0,9	190	3,7	26,0	365	1,15		
45B	95	1126,0	1129,0	1126,20	1129,20	3,0	3,00	100	11/10/2019	21:47	22:34	00:47	01:55	02:36	00:41	22:34	01:55	03:21	0,9	200	4,0	26,0	360	1,15		
46B	95	1129,0	1132,0	1129,20	1132,13	3,0	2,93	98	12/10/2019	02:36	03:24	00:48	06:40	07:34	00:54	03:24	06:40	03:16	0,9	190	4,5	26,0	360	1,15		
47B	95	1132,0	1135,0	1132,13	1135,12	3,0	2,99	100	12/10/2019	07:34	09:15	01:41	13:01	13:47	00:46	09:15	13:01	03:46	0,8	192	4,0	29,0	370	1,15		
48B	95	1135,0	1138,0	1135,12	1137,12	2,0	2,00	100	12/10/2019	13:47	14:55	01:08	19:12	19:58	00:46	14:55	19:12	04:17	0,7	196	4,2	31,0	405	1,15		
49B	95	1137,0	1141,0	1137,12	1141,16	4,0	4,04	101	13/10/2019	03:30	12:15	08:45	15:08	16:10	01:02	12:15	15:08	02:53	1,4	190	5,0	29,0	400	1,15		
50B	95	1141,0	1144,0	1141,16	1144,13	3,0	2,97	99	13/10/2019	16:10	17:02	00:52	18:43	19:35	00:52	17:02	18:43	01:41	1,8	218	5,0	25,0	392	1,15		
51B	95	1144,0	1147,0	1144,13	1147,24	3,0	3,11	104	13/10/2019	19:35	20:32	00:57	21:46	22:35	00:49	20:32	21:46	01:14	2,4	215	4,8	27,0	404	1,15		
52B	95	1147,0	1150,0	1147,24	1150,24	3,0	3,00	100	13/10/2019	22:35	23:20	00:45	00:45	01:35	00:50	23:20	00:45	01:25	2,1	200	4,2	26,0	395	1,15		
53B	95	1150,0	1153,0	1150,24	1153,28	3,0	3,04	101	14/10/2019	01:35	02:20	00:45	03:53	04:38	00:45	02:20	03:53	01:33	1,9	193	4,5	26,0	364	1,15		
54B	95	1153,0	1156,0	1153,28	1156,32	3,0	3,04	101	14/10/2019	04:38	05:24	00:46	06:40	07:45	01:05	05:24	06:40	01:16	2,4	198	4,5	27,0	380	1,15	5	21
55B	95	1156,0	1159,0	1156,32	1159,13	3,0	2,81	94	14/10/2019	07:45	08:45	01:00	10:04	10:56	00:52	08:45	10:04	01:19	2,3	177	5,3	27,5	316	1,15	2,5	5-13
56B	95	1159,0	1162,0	1159,13	1162,23	3,0	3,10	103	14/10/2019	10:56	11:49	00:53	13:09	13:53	00:44	11:49	13:09	01:20	2,3	179	5,0	25,7	297	1,15	2,5	5-13
57B	95	1162,0	1165,0	1162,23	1165,23	3,0	3,00	100	14/10/2019	13:53	15:00	01:07	16:34	17:22	00:48	15:00	16:34	01:34	1,9	176	5,5	28,2	313	1,15		
58B	95	1165,0	1168,0	1165,23	1168,35	3,0	3,12	104	14/10/2019	17:22	18:33	01:11	20:06	20:51	00:45	18:33	20:06	01:33	1,9	179	5,0	27,0	340	1,15		
59B	95	1168,0	1171,0	1168,35	1171,30	3,0	2,95	98	14/10/2019	20:51	21:37	00:46	23:15	00:05	00:50	21:37	23:15	01:38	1,8	178	5,0	27,0	335	1,15		
60B	95	1171,0	1174,0	1171,30	1174,33	3,0	3,03	101	15/10/2019	00:05	00:44	00:39	02:02	02:52	00:50	00:44	02:02	01:18	2,3	178	4,8	27,0	330	1,15		
61B	95	1174,0	1177,0	1174,33	1177,39	3,0	3,06	102	15/10/2019	02:46	03:40	00:54	05:23	06:11	00:48	03:40	05:23	01:43	1,7	180	4,9	30,0	380	1,15		
62B	95	1177,0	1180,0	1177,39	1180,41	3,0	3,02	101	15/10/2019	06:11	08:04	01:53	09:40	10:51	01:11	08:04	09:40	01:36	1,9	177	5,0	27,0	320	1,15		
63B	95	1180,0	1180,0	1180,41	1183,29	3,0	2,88	96	15/10/2019	10:51	11:50	00:59	13:20	14:16	00:56	11:50	13:20	01:30	2,0	180	5,0	29,0	310	1,15		
64B	95	1183,0	1186,0	1183,29	1186,35	3,0	3,06	102	15/10/2019	14:16	15:16	01:00	16:43	17:25	00:42	15:16	16:43	01:27	2,1	171	4,5	30,0	350	1,15		
65B	95	1186,0	1189,0	1186,35	1189,35	3,0	3,00	100	15/10/2019	17:25	18:15	00:50	19:48	20:44	00:56	18:15	19:48	01:33	1,9	178	4,8	28,0	335	1,15		
66B	95	1189,0	1192,0	1189,35	1192,40	3,0	3,05	102	15/10/2019	20:44	21:45	01:01	23:25	00:13	00:48	21:45	23:25	01:40	1,8	178	4,6	30,0	350	1,15		
67B	95	1192,0	1195,0	1192,40	1195,46	3,0	3,06	102	16/10/2019	00:13	01:11	00:58	03:02	03:53	00:51	01:11	03:02	01:51	1,6	180	4,6	27,0	360	1,15		
68B	95	1195,0	1198,0	1195,46	1198,48	3,0	3,02	101	16/10/2019	03:53	04:55	01:02	06:26	07:22	00:56	04:55	06:26	01:31	2,0	180	4,2	31,0	370	1,15		
69B	95	1198,0	1201,0	1198,48	1201,48	3,0	3,00	100	16/10/2019	07:22	08:08	00:46	09:12	09:57	00:45	08:08	09:12	01:04	2,8	177	5,0	29,0	325	1,15		
70B	95	1201,0	1204,0	1201,48	1204,42	3,0	2,94	98	16/10/2019	09:57	10:45	00:48	11:52	12:38	00:46	10:45	11:52	01:07	2,7	177	5,0	29,5	370	1,15		
71B	95	1204,0	1207,0	1204,42	1207,34	3,0	2,92	97	16/10/2019	12:38	13:25	00:47	14:40	15:27	00:47	13:25	14:40	01:15	2,4	177	4,8	29,5	307	1,15		
72B	95	1207,0	1210,0	1207,34	12120																					

CS-Nr.	Ø core	depth MD		depth MD core		core section			date	time RIH			time POOH			drilling duration			RPM	WoB	pump		dens.	mudloss	
		from	to	from	to	target	actual	rcy		from	to	Δ	from	to	Δ	from	to	Δ			p	Flow in		vol	v
		[mm]	[m]	[m]	[m]	[m]	[m]	[%]													[bar]	[l/min]		[m3]	[l/min]
81B	95	1237,0	1240,0	1236,87	1239,79	3,0	2,92	97	13/11/2019	19:29	20:17	00:48	22:03	23:00	00:57	20:17	22:03	01:46	1,7	180	4,0	16,0	260	1,2	
82B	95	1240,0	1243,0	1239,79	1242,79	3,0	3,00	100	14/11/2019	23:00	23:40	00:40	01:20	02:15	00:55	23:40	01:20	01:40	1,8	180	4,0	13,0	300	1,2	
83B	95	1243,0	1246,0	1242,79	1245,84	3,0	3,05	102	14/11/2019	02:15	02:58	00:43	04:23	05:07	00:44	02:58	04:23	01:25	2,1	180	4,0	13,0	330	1,2	
84B	95	1246,0	1249,0	1245,84	1248,94	3,0	3,10	103	14/11/2019	05:07	05:55	00:48	06:45	07:32	00:47	05:55	06:45	00:50	3,6	183	5,0	11,0	320	1,2	
85B	95	1249,0	1252,0	1248,94	1251,96	3,0	3,02	101	14/11/2019	07:32	08:30	00:58	09:20	10:07	00:47	08:30	09:20	00:50	3,6	175	4,9	10,0	320	1,2	
86B	95	1252,0	1255,0	1251,96	1254,97	3,0	3,01	100	14/11/2019	10:07	11:00	00:53	11:55	12:37	00:42	11:00	11:55	00:55	3,3	183	4,5	11,0	320	1,2	
87B	95	1255,0	1258,0	1254,97	1257,98	3,0	3,01	100	14/11/2019	12:37	13:26	00:49	14:14	15:39	01:25	13:26	14:15	00:49	3,8	185	4,5	11,0	310	1,2	
88B	95	1258,0	1261,0	1257,98	1261,00	3,0	3,02	101	14/11/2019	15:39	16:23	00:44	17:21	18:10	00:49	16:23	17:21	00:58	3,1	180	4,3	11,0	300	1,2	
89B	95	1261,0	1264,0	1261,00	1264,00	3,0	3,00	100	14/11/2019	18:10	18:55	00:45	20:33	21:26	00:53	18:55	20:33	01:38	1,8	185	4,0	16,0	260	1,2	
90B	95	1264,0	1267,0	1264,00	1267,00	3,0	3,00	100	15/11/2019	21:26	00:00	02:34	01:28	02:19	00:51	00:00	01:28	01:28	2,0	186	3,6	12,0	290	1,2	
91B	95	1267,0	1270,0	1267,00	1269,95	3,0	2,95	98	15/11/2019	02:19	03:03	00:44	04:10	05:02	00:52	03:03	04:10	01:07	2,7	190	4,0	13,0	300	1,2	
92B	95	1270,0	1273,0	1269,95	1273,02	3,0	3,07	102	15/11/2019	05:02	05:53	00:51	07:14	08:00	00:46	05:53	07:14	01:21	2,2	190	4,2	14,0	320	1,2	
93B	95	1273,0	1276,0	1273,02	1275,95	3,0	2,93	98	15/11/2019	08:00	08:47	00:47	10:02	10:53	00:51	08:47	10:02	01:15	2,4	188	4,8	17,0	350	1,2	
94B	95	1276,0	1279,0	1275,95	1279,06	3,0	3,11	104	15/11/2019	10:53	13:00	02:07	14:43	15:31	00:48	13:00	14:43	01:43	1,7	188	4,5	15,0	320	1,2	
95B	95	1279,0	1282,0	1279,06	1282,00	3,0	2,94	98	15/11/2019	15:31	16:16	00:45	18:43	19:31	00:48	16:16	18:43	02:27	1,2	190	3,5	15,0	350	1,2	
96B	95	1282,0	1285,0	1282,00	1284,97	3,0	2,97	99	15/11/2019	19:31	20:20	00:49	22:36	23:36	01:00	20:20	22:36	02:16	1,3	180	4,5	12,0	320	1,2	
97B	89-95	1285,0	1288,0	1284,97	1288,07	3,0	3,10	103	16/11/2019	23:36	00:37	01:01	02:54	03:52	00:58	00:37	02:54	02:17	1,3	175	3,0	18,0	300	1,2	
98B	89-95	1288,0	1291,0	1288,07	1291,05	3,0	2,98	99	16/11/2019	03:52	05:30	01:38	07:58	08:43	00:45	05:30	07:58	02:28	1,2	173	4,3	17,0	340	1,2	
99B	89-95	1291,0	1294,0	1291,05	1294,11	3,0	3,06	102	16/11/2019	08:43	09:30	00:47	12:00	12:46	00:46	09:30	12:00	02:30	1,3	187	4,2	15,0	300	1,2	
100B	89-95	1294,0	1297,0	1294,11	1297,09	3,0	2,98	99	16/11/2019	12:46	13:32	00:46	16:09	17:00	00:51	13:32	16:09	02:37	1,1	184	4,1	15,0	300	1,2	
101B	89-95	1297,0	1300,0	1297,09	1300,17	3,0	3,08	103	16/11/2019	17:00	17:47	00:47	21:00	21:46	00:46	17:47	21:00	03:13	0,9	180	4,2	15,0	276	1,2	
102B	95	1300,0	1303,0	1300,17	1303,08	3,0	2,91	97	17/11/2019	21:46	22:35	00:49	00:53	01:47	00:54	22:35	00:53	02:18	1,3	180	3,9	13,0	295	1,2	
103B	95	1303,0	1306,0	1303,08	1306,13	3,0	3,05	102	17/11/2019	01:47	02:31	00:44	04:06	05:02	00:56	02:31	04:06	01:35	1,9	180	3,0	19,0	280	1,2	
104B	95	1306,0	1309,0	1306,13	1309,19	3,0	3,06	102	17/11/2019	05:02	05:46	00:44	06:45	07:32	00:47	05:46	06:45	00:59	3,1	180	3,0	14,0	310	1,2	
105B	95	1309,0	1312,0	1309,19	1312,22	3,0	3,03	101	17/11/2019	07:32	08:21	00:49	09:21	10:14	00:53	08:21	09:21	01:00	3,0	188	2,3	15,0	300	1,2	
106B	95	1312,0	1315,0	1312,22	1315,35	3,0	3,13	104	17/11/2019	10:14	10:58	00:44	11:47	12:35	00:48	10:58	11:47	00:49	3,7	180	2,0	16,0	390	1,2	
107B	95	1315,0	1318,0	1315,35	1318,40	3,0	3,05	102	17/11/2019	12:35	13:18	00:43	14:20	15:10	00:50	13:18	14:20	01:02	2,9	180	2,4	14,0	300	1,2	
108B	95	1318,0	1321,0	1318,40	1321,35	3,0	2,95	98	17/11/2019	15:10	16:10	01:00	17:07	17:55	00:48	16:10	17:07	00:57	3,2	180	2,0	16,0	290	1,2	
109B	95	1321,0	1324,0	1321,35	1324,35	3,0	3,00	100	17/11/2019	17:55	18:45	00:50	20:27	21:25	00:58	18:45	20:27	01:42	1,8	182	3,0	17,0	240	1,2	
110B	95	1324,0	1327,0	1324,35	1327,31	3,0	2,96	99	18/11/2019	21:25	22:07	00:42	23:25	00:23	00:58	22:07	23:35	01:28	2,1	183	3,0	17,0	305	1,2	
111B	95	1327,0	1330,0	1327,31	1330,38	3,0	3,07	102	18/11/2019	00:23	01:12	00:49	02:22	03:20	00:58	01:12	02:22	01:10	2,5	180	2,5	15,0	270	1,2	
112B	95	1330,0	1333,0	1330,38	1333,46	3,0	3,08	103	18/11/2019	03:20	04:05	00:45	05:25	06:20	00:55	04:05	05:25	01:20	2,3	188	3,0	17,0	280	1,2	
113B	95	1333,0	1336,0	1333,46	1336,42	3,0	2,96	99	18/11/2019	06:20	07:01	00:41	07:52	08:42	00:50	07:01	07:52	00:51	3,5	179	2,2	17,0	310	1,2	
114B	95	1336,0	1339,0	1336,42	1339,43	3,0	3,01	100	18/11/2019	08:42	09:29	00:47	10:13	11:10	00:57	09:29	10:13	00:44	4,1	185	2,6	17,0	300	1,2	
115B	95	1339,0	1342,0	1339,43	1342,42	3,0	2,99	100	18/11/2019	11:10	11:57	00:47	12:47	13:50	01:03	11:57	12:47	00:50	3,6	185	2,6	18,0	300	1,2	
116B	95	1342,0	1345,0	1342,42	1345,44	3,0	3,02	101	18/11/2019	13:50	14:32	00:42	15:25	16:21	00:56	14:32	15:25	00:53	3,4	182	2,3	18,0	310	1,2	
117B	95	1345,0	1348,0	1345,44	1348,47	3,0	3,03	101	18/11/2019	16:21	17:20	00:59	18:15	19:14	00:59	17:20	18:15	00:55	3,4	183	2,0	15,0	350	1,2	
118B	95	1348,0	1351,0	1348,47	1351,49	3,0	3,02	101	18/11/2019	19:14	20:00	00:46	20:54	21:50	00:56	20:00	20:54	00:54	3,3	185	1,6	16,0	245	1,2	
119B	95	1351,0	1354,0	1351,49	1354,14	3,0	2,65	88	19/11/2019	21:50	22:30	00:40	23:24	00:10	00:46	22:30	23:24	00:54	3,3	185	1,5	16,0	338	1,2	
120B	95	1354,0	1357,0	1354,14	1357,17	3,0	3,03	101	19/11/2019	00:10	01:06	00:56	02:16	03:10	00:54	01:06	02:16	01:10	2,6	180	1,7	20,0	283	1,2	
121B	95	1357,0	1360,0	1357,17	1360,19	3,0	3,02	101	19/11/2019	03:10	03:53	00:43	04:54	05:54	01:00	03:53	04:54	01:01	3,0	180	2,0	15,0	300	1,2	
122B	95	1360,0	1363,0	1360,19	1363,24	3,0	3,05	102	19/11/2019	05:54	06:59	01:05	08:41	09:35	00:54	06:59	08:41	01:42	1,8	183	3,0	20,0	240	1,2	
123B	95	1363,0	1366,0	1363,24	1366,19	3,0	2,95	98	19/11/2019	09:35	10:25	00:50	13:02	14:00	00:58	10:25	13:02	02:37	1,1	183	3,6	22,0	300	1,2	
124B	95	1366,0	1370,0	1366,19	1370,19	4,0	4,00	100	19/11/2019	14:00	15:53	01:53	17:18	18:30	01:12	15:53	17:18	01:25	2,1	183	2,2	19,0	320	1,2	

Appendix J: IADC bit dull grading

An eight-point dull grading system has been established by the IADC to enable drillers and bit manufacturers to evaluate the performance of a drill bit. This eight-point system is described below and is used on tricones, fixed cutter and impregnated bits.

Tab. J-1: IADC dull grading system

Cutting structure							
Inner rows	Outer rows	Dull grading characteristics	Location	Bearings / seals	Gauge $\frac{1}{16}$ "	Other dull	Reason pulled
1.	2.	3.	4.	5.	6.	7.	8.

1. Inner cutting structure

Used to report the condition of the cutting elements not touching the wall of the hole. Inner cutting structure wear is classified by a number ranging from 0 to 8 with 0 being no wear and 8 being total wear.

2. Outer cutting structure

Used to report the condition of the cutting elements that touch the wall of the hole. Outer cuttings structure wear is classified by a number ranging from 0 to 8 with 0 being no wear and 8 being total wear. Do not include heel elements.

Steel tooth bits

Steel tool bits are a measure of lost tooth height due to abrasion and / or damage.

0 – no loss of tooth height

8 – total loss of tooth height

Insert bits

Insert bits are a measure of the total reduction of the cutting structure due to lost, worn and / or broken inserts.

0 – no lost, worn and / or broken inserts

8 – all inserts lost, worn and / or broken

Fixed cutter bits

Fixed cutter bits are a measure of the total reduction of the cutting structure due a to lost, worn and / or broken cutting structure.

0 – no lost, worn and / or broken cutting structure

8 – all cutting structures lost, worn and / or broken

Cutting structure wear

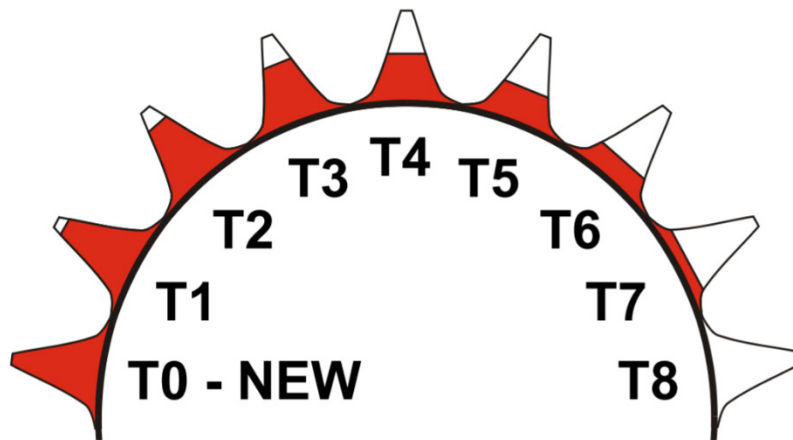


Fig. J-1: Cutting structure wear

3. Dull grading characteristics

Dull characteristics enable the bit salesperson or driller to determine the overall, distinctive aspect of the dulled drill bit according to IADC standards as follows:

BC	broken cone	
BF	bond failure	not used for roller cone bits
BT	broken teeth / cutters	
BU	balled up	
CC	cracked cone	show cone # or #'s under location 4
CD	cone dragged	show cone # or #'s under location 4
CI	cone interference	
CR	cored	
CT	chipped teeth / cutters	
ER	erosion	
FC	flat crested wear	
HC	heat checking	
JD	junk damage	
LC	lost cone	show cone # or #'s under location 4
LN	lost nozzle	
LT	lost teeth / cutters	
NO	no dull characteristics	
NR	not re-runnable	
OC	off centre wear	
PB	pinched bit	
PN	plugged nozzle / flow passage	
RG	rounded gauge	
RO	ring out	show cone # or #'s under location 4
RR	re-runnable	
SD	shirttail damage	
SS	self-sharpening wear	
TR	tracking	
WO	washout	
WT	worn teeth / cutters	

4. Location

Location describes where the damage is on the cone:

N	nose row
M	middle row
G	gauge row
A	all rows

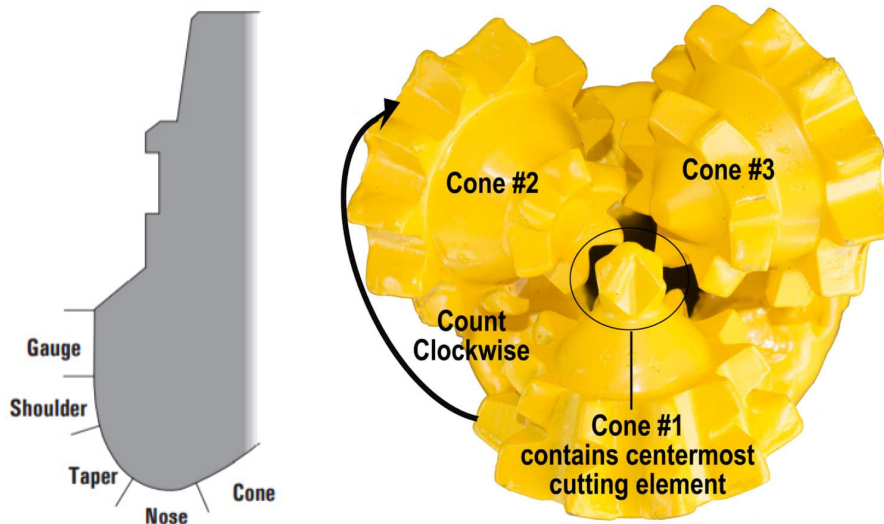


Fig. J-2: Location

Cone #1, as in Fig. J-2, contains the centremost cutting component. Cones #2 and #3 follow in a clockwise manner. The nose row is the centremost cutting structure, the gauge row is the outer most cutting structure.

5. Bearings / seals

For open or roller bearing bits, the bearing life is estimated on a scale of 0 to 8.

Non-sealed bearings

0	no life used
8	all life used, i.e. no bearing life remaining

Sealed bearings

E	seals effective
F	seals failed
N	not able to grade
"X"	indicates fixed cutter

Items to check when determining seal / bearing effectiveness:

- ability to rotate cone
- cone springback
- seal squeak
- internal sounds
- weeping grease
- shale burn
- shale packing
- gaps – backface or throat
- bearing letdown – inner or outer

6. Gauge

Gauge measures the amount of gauge wear a drill bit has suffered:

I	in gauge
1	$\frac{1}{16}$ " out of gauge
2	$\frac{1}{8}$ " out of gauge
4	$\frac{1}{4}$ " out of gauge

Round the gauge to nearest $\frac{1}{16}$ ".

- bits with bearing / seal failures: can measure amount out of gauge as long as cones do not have any axial or radial movement
- measurement should be made on either gauge or heel elements, whichever is closer to gauge
- applies to cutting structure elements only
- ensure that a nominal ring gauge is used; if nominal ring gauges are not available, true gauge condition cannot be determined

7. Other dull characteristics

Any other dull grading characteristics should be noted here using the codes from #3.

8. Reason pulled

The following codes are used to indicate the reason why a bit was pulled from the hole:

BHA	change bottom hole assembly
CM	condition mud
CP	core point
DMF	downhole motor failure
DP	drill plug
DSF	drill string failure
DST	drill stem test
DTF	downhole tool failure
FM	formation change
HP	hole problems
HR	hours on bit
LIH	left in hole
LOG	run logs
PP	pump pressure
PR	penetration rate
RIG	rig repair
TD	total depth / casing depth
TQ	torque
TW	twist off
WC	weather conditions
WO	washout – drill string

Appendix K: Cementing

Tab K-1: Cementation

From	To	Amount	Specification
0 m	43 m	15 m ³	CEM III 32.5HRS
0 m	530 m	66.8 m ³ 9 m ³	Lead: CEM III/B 32.5 N-LH/HS/NA Tail: high magnesium resistance (HMR)+ blend
64 m	920 m	89 m ³ 11.4 m ³	Lead: CEM III B 32.5 N-LH/HS/NA Tail: HMR+ blend
911 m	952 m	12 m ³	Cement plug: CEM III/B 32.5 N-LH/HS/NA
993 m	1'043 m	5.2 m ³	Cement plug: CEM III/B 32.5 N-LH/HS/NA
926 m	993 m	10.4 m ³	Cement plug: CEM III/B 32.5 N-LH/HS/NA
915 m	926 m	1.6 m ³	Cement plug: CEM III/B 32.5 N-LH/HS/NA
896 m	1'211 m	19.1 m ³	First stage: HMR+ blend
0 m	869 m	28.8 m ³	Second stage: HMR+ blend
1'184 m	1'370 m	7.1 m ³	Cement plug: HMR+ blend

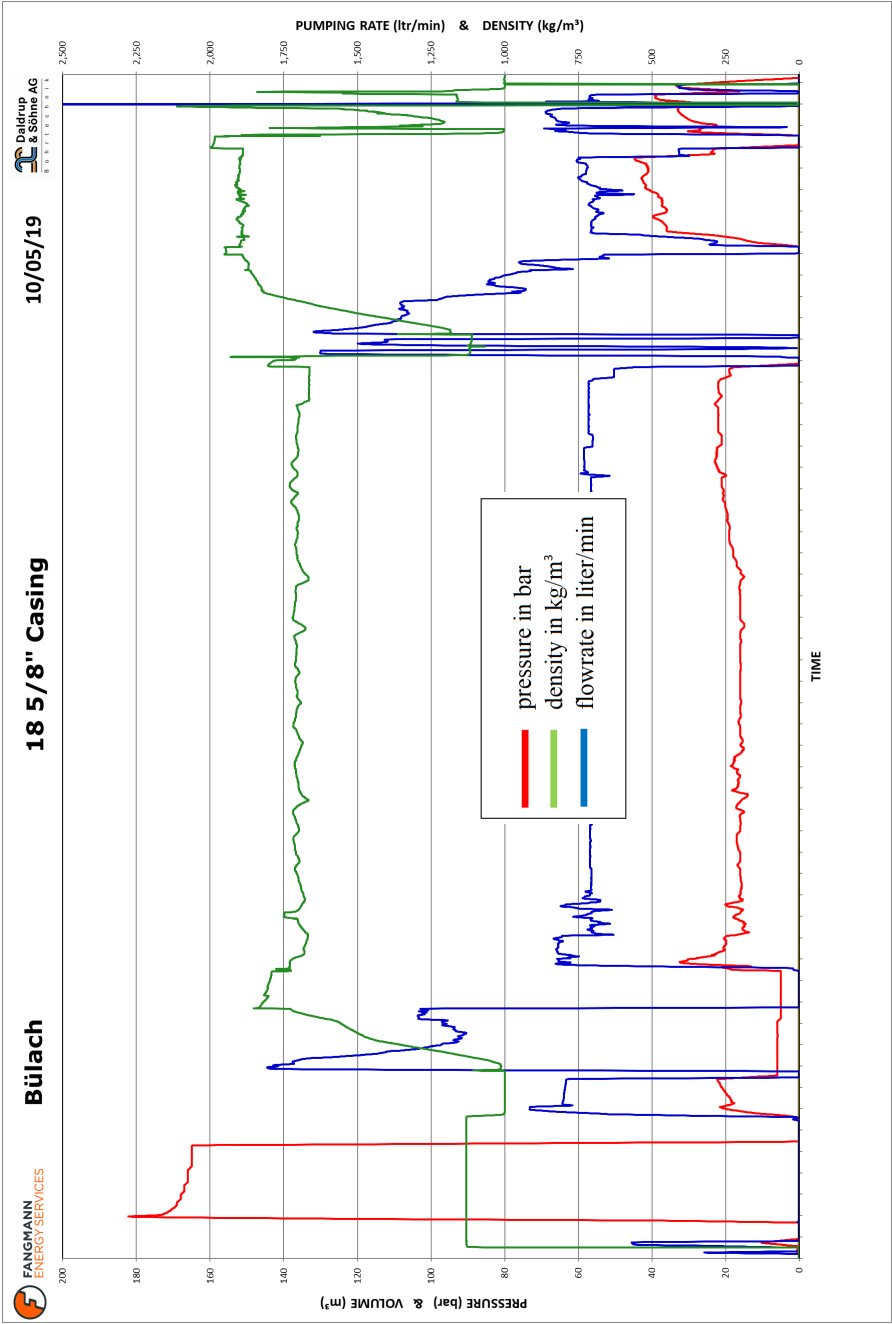
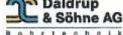
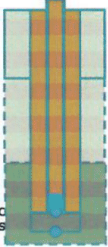


Fig. K-1: 18 5/8" cementing chart

	Kunde: Daldrup & Söhne AG Bohrung: Bülach Zementation: 18 5/8" Casing	MD 531.5 m TVD 531.5 m Max. Neigung 0°	TG 3.0°/100m BHST 31°C Test Temp. 24°C	
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Volumenberechnung									
	-9m	0m	OD	Beschreibung	Länge	Kapazität	Kommentar	Volumen	
			30 "	161.4 ppf	45m	426.10l/m	Gesamt-Kap.	+ 19.17 m³	
			23 "	3% OH XS	487m	268.20l/m	OH ohne XS	+ 130.48 m³	
		45m	23.34 "	9% Ringraum XS	100.38l/m im Ringraum	OH XS	+ 3.91 m³		
			18 5/8 "	94.5 ppf	530m	158.19l/m	Verdrängung	Gesamt-Verdr.	
						175.87l/m	- 93.21 m³		
	482m			24m		Shoetrack	+ 3.8 m³		
				5 "	19.5 ppf	515m	9.03l/m	Zementvolumen	64.20m³
							Gesamt-Kap.	4.65m³	
							Nachpumpvolumen	4.65m³	
				Enddruck	30 bar	Casing Lift	-14 To	CSP	38 bar

Fluid Design								
Lead	1.70kg/l	Totvol. 0.0 m³	55.1m³		Tail	1.88kg/l	Totvol. 0.3 m³	9.4m³
Frischwasser	lt	pro 1000 kg Zmt.	pro m³	gesamt	Frischwasser	lt	pro 1000 kg Zmt.	pro m³
CMT-003	mt	608.3	643.7	35467.31	BLN-014	kg	579.8	490.9
		1.0	1.1	58.31	CSL-944	mt	127.2	107.7
							1.5	1.3
Ergiebigkeit	lt	945.0			Ergiebigkeit	lt	1181.0	

Logistik							
Personal	1	Ausrüstung	1x	Material	Menge	Kommentar	
Supervisor:	Pumpe	Pumpwagen inkl. Datenaufzeichnung	1x	CMT-003	58.31 mt	135 mt. vor Ort bereitgestellt	
Operator:	Mischtrank	7 m³ Mischtrank inkl. Antrieb	1x	BLN-014	12.06 mt	27 mt. vor Ort bereitgestellt	
Operator:	Bulk	27 t Zementsilo inkl. Kompressor	5x	CSL-944	1012.43 kg	6 mt vor Ort bereitgestellt	
Operator:		30 m³ Vertikaltank	1x				
		27 t Silowagen inkl. Kompressor	1x				
		Von Kunde:		Von Kunde:			
		Saugwagen (Entsorgung Restfluide)	1x	Frischwasser für Spacer	5.60 m³		
				Frischwasser für Zement	40.10 m³		

Pumpprogramm						
Uhrzeit	Schritt	Bemerk.	Volumen	Dichte	Pumptrate	Dauer
			m³	kg/ltr	ltr/min	min
	BL-Zirkulation min. 2 Umläufe / Jobsicherheitsanalyse (JSA)					
	Leitungen entlüften		0.30		300	1
	Leitungstest		200 bar			10
	Verpumpen von Frischwasser-Spacer		45 m	4.50	1.00	900
	Vormischen erste 7 m³ Lead-Zement					20
	Mischen & pumpen von Lead-Zement		55.10	1.70	800	69
	wenn Lead zutage, umstellen auf Tail					
	Mischen & pumpen von Tail-Zement		50 m	9.10	1.88	800
	Verpumpen von Frischwasser-Spacer		0.50	1.00	800	1
	Verpumpen von Spülung		3.85	1.09	800	5
	Verpumpen von Frischwasser (Leitungen zutage)		0.30	1.00	300	1
	Flow Check, Ausstingen, DP sauber zirkulieren, WOC (Check auch mit Probe zutage)					15
	Pumpzeit:					122min

Empfehlungen / Kommentare - Nachpumpmenge noch zu bestätigen - Casing mit Ketten befestigen um ein Aufschwimmen während der Verpumpens zu verhindern	Dokument Info Erstellt von: T. Precup Kunde: Daldrup & Söhne AG Version #: 6 Status: Field Version Datum: 08.05.2019
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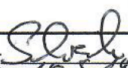
Dieses Programm basiert auf den bis zum heutigen Zeitpunkt bekannten Angaben vom AG. Erstellt von FES und kontrolliert von AG. Alle Schritte wurden mitgeteilt und vor dem Job genehmigt.		FES Supervisor:  Datum: 10.5.19	AG: _____ Datum: _____
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Fig. K-2: 18 5/8" cementing programme

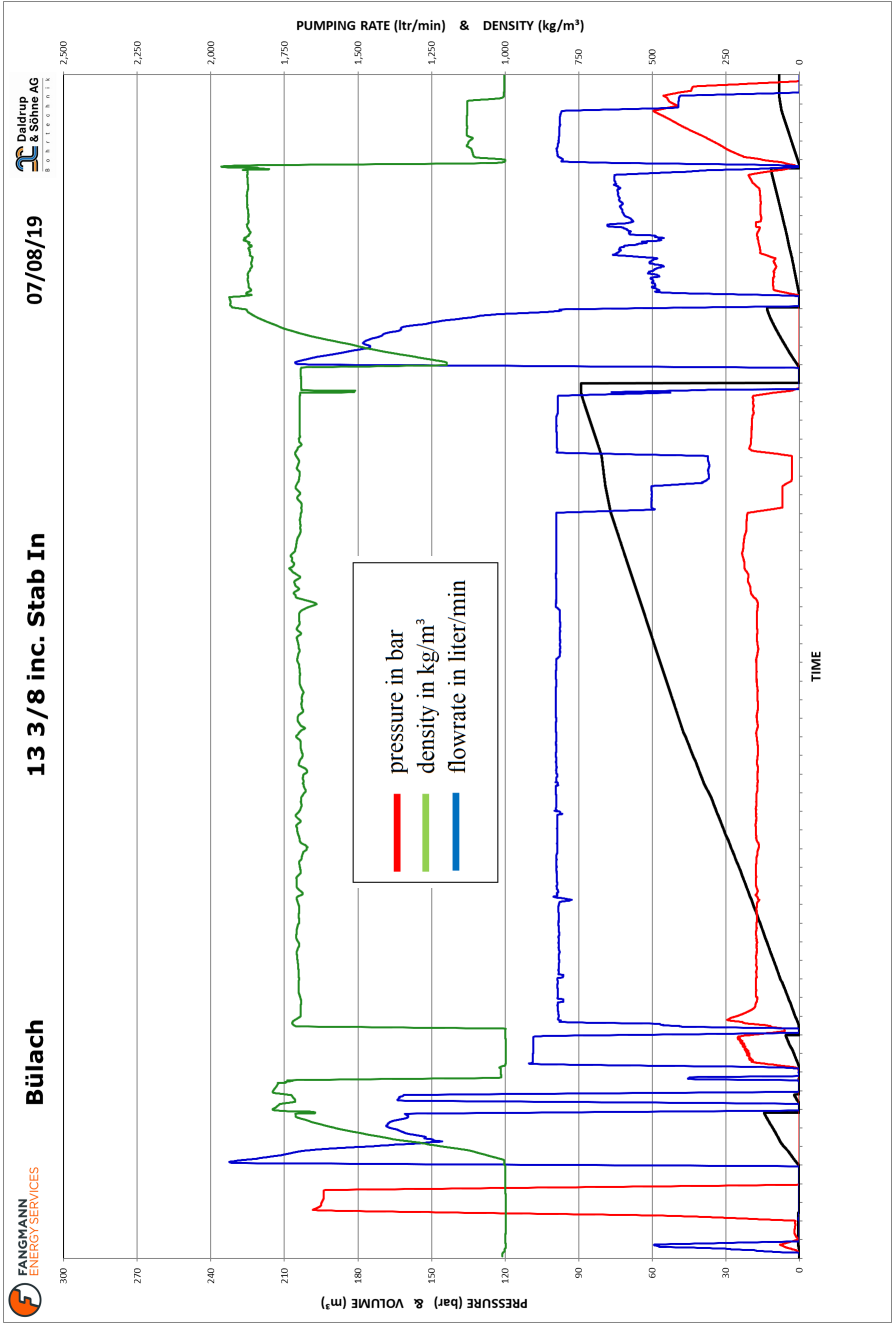


Fig. K-3: 13³/₈" cement chart

		Kunde: Daldrup & Söhne AG Bohrung: Bülach Zementation: 13 3/8" Rohrtour		MD 922 m TVD 922 m Max. Neigung 0°		TG 3,0°/100m BHST 43°C Test Temp. 24°C			
Volumenberechnung									
	ZK		OD	Beschreibung	Länge	Kapazität		Kommentar	Volumen
			Voriges Rohr	18 5/8 " 94,5 ppf	530m	158,19l/m		Gesamt-Kap.	+ 83,84 m³
			Offenes Loch	17 1/2 " 41% OH XS 20,81 " 100% Ringraum XS	392m	155,27l/m		OH ohne XS	+ 60,87 m³
						128,85l/m im Ringraum		OH XS	+ 25,2 m³
			Casing zum zementieren	13 3/8 " 68,0 ppf	919m	77,98l/m	90,70l/m	Gesamt-Verdr.	- 83,35m³
					0m	0,00l/m	0,00l/m		- 0,00m³
					0m	0,00l/m	0,00l/m		- 0,00m³
					12m			Shoetrack	+ 0,93 m³
								Zementvolumen	87,50m³
			Drill Pipe	5 " 19,5 ppf	916m	9,03l/m		Gesamt-Kap.	8,27m³
				0m	0,00l/m			0,00m³	
								0,00m³	
							Nachpumpvolumen	8,27m³	
			Enddruck	54 bar		Casing Lift	-31 To	CSP	88 bar

Fluid Design									
Lead		1,70kg/l	Totvol. 0,0 m³	79,9m³	Tail		1,88kg/l	Totvol. 0,3 m³	7,9m³
Frischwasser	lt	pro 1000 kg Zmt.	pro m³	gesamt	Frischwasser	lt	pro 1000 kg Zmt.	pro m³	gesamt
CMT-003	mt	608,3	643,7	51430,82	CSL-944	kg	579,6	490,8	3877,42
		1,0	1,1	84,55	BLN-014	mt	127,1	107,6	850,28
							1,5	1,3	10,14
Ergiebigkeit	lt		945,0		Ergiebigkeit	lt		1180,9	

Logistik									
Personal		Ausrüstung		Material		Menge	Kommentar		
Supervisor:	1	Pumpwagen inkl. Datenaufzeichnung	1x	CMT-003	CEM III B (Hochofenzement)	84,55 mt	104 mt. vor Ort bereitgestellt		
Operator:	Pumpe	7 m³ Mischtank inkl. Antrieb	1x	BLN-014	HMR+ Blend	10,14 mt	15 mt. vor Ort bereitgestellt		
Operator:	Mischtank	27 t Zementsilo inkl. Kompressor	5x	CSL-944	Salz NaCl	850,28 kg	5 mt. vor Ort bereitgestellt		
Operator:	Bulk	30 m³ Vertikaltank	1x						
Von Kunde:				Von Kunde:					
Saugwagen (Entsorgung Restfluide)		1x		Frischwasser für Spacer		7,10 m³			
				Frischwasser für Zement		55,40 m³			

Pumpprogramm						
Uhrzeit	Schritt	Bemerk.	Volumen	Dichte	Pumprate	Dauer
			m³	kg/ltr	ltr/min	min
	BL-Zirkulation min. 2 Umläufe / Jobsicherheitsanalyse (JSA)					
	Leitungen entlüften		0,30		300	1
	Leitungstest	200 bar				10
	Verpumpen von Frischwasser-Spacer	47 m	6,00	1,00	900	7
	Vormischen erste 7 m³ Lead-Zement					20
	Mischen & pumpen von Lead-Zement		79,90	1,70	800	100
	wenn Lead zutage, umstellen auf Tail					
	Mischen & pumpen von Tail-Zement	50 m	7,60	1,88	800	10
	Verpumpen von Frischwasser-Spacer		0,50	1,00	800	1
	Verpumpen von Spülung		7,47	1,10	800	9
	Verpumpen von Frischwasser (Leitungen zutage)		0,30	1,00	300	1
	Flow Check, Ausstingen, DP sauber zirkulieren, WOC (Check mit Probe zutage)					15
					Pumpzeit:	162min

Empfehlungen / Kommentare					Dokument Info	
- OH XS & Rohrkapazitäten noch zu bestätigen					Erstellt von:	T. Precup
					Kunde:	Daldrup & Söhne AG
					Version #:	4
					Status:	Field Version
					Datum:	05.08.2019

Dieses Programm basiert auf den bis zum heutigen Zeitpunkt bekannten Angaben vom AG.
Erstellt von FES und kontrolliert von AG.
Alle Schritte wurden mitgeteilt und vor dem Job genehmigt.

FES Supervisor _____
Datum _____

AG _____
Datum _____

Fig. K-4: 13 3/8" cement programme

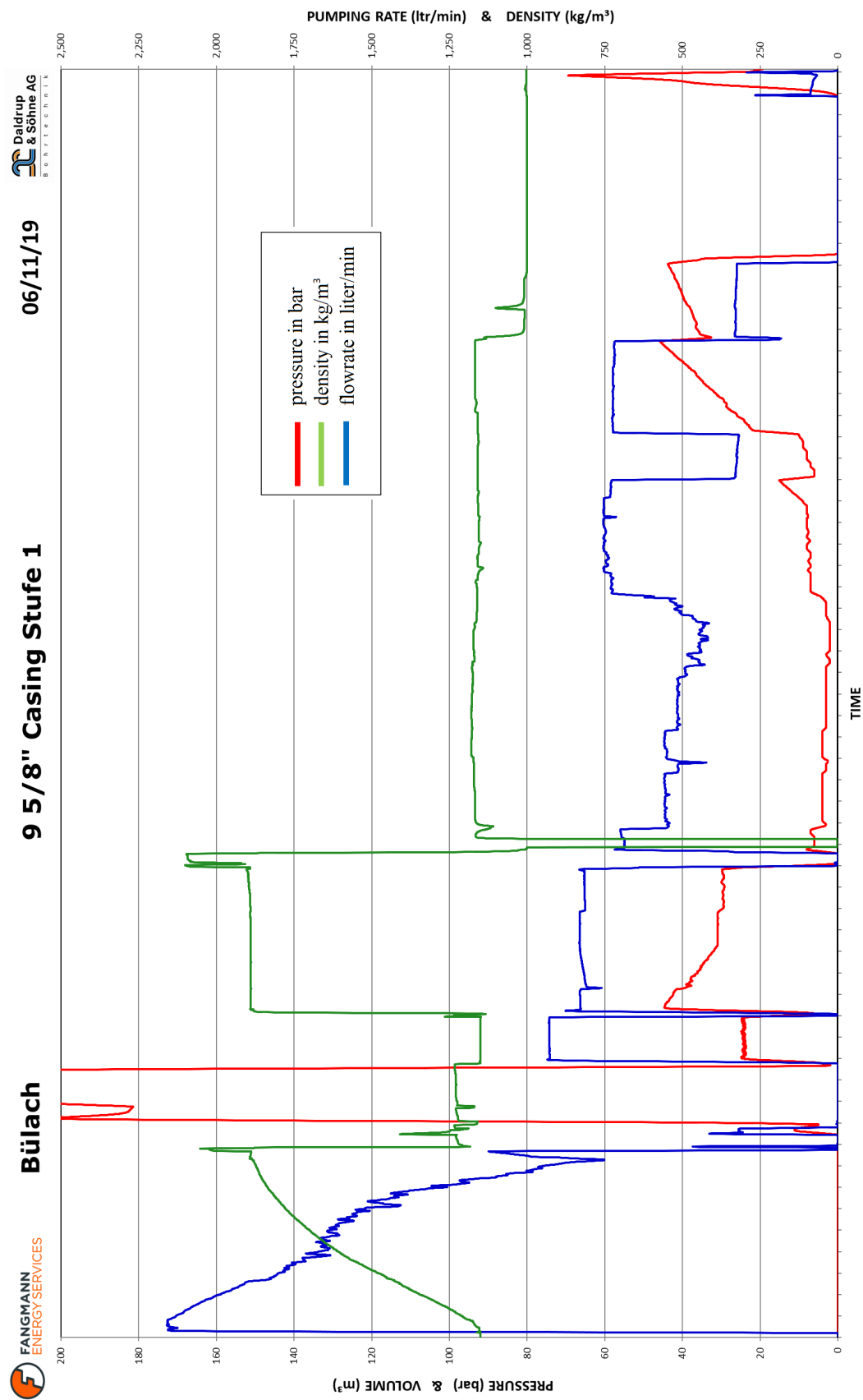


Fig. K-5: 9 5/8" cement chart stage one

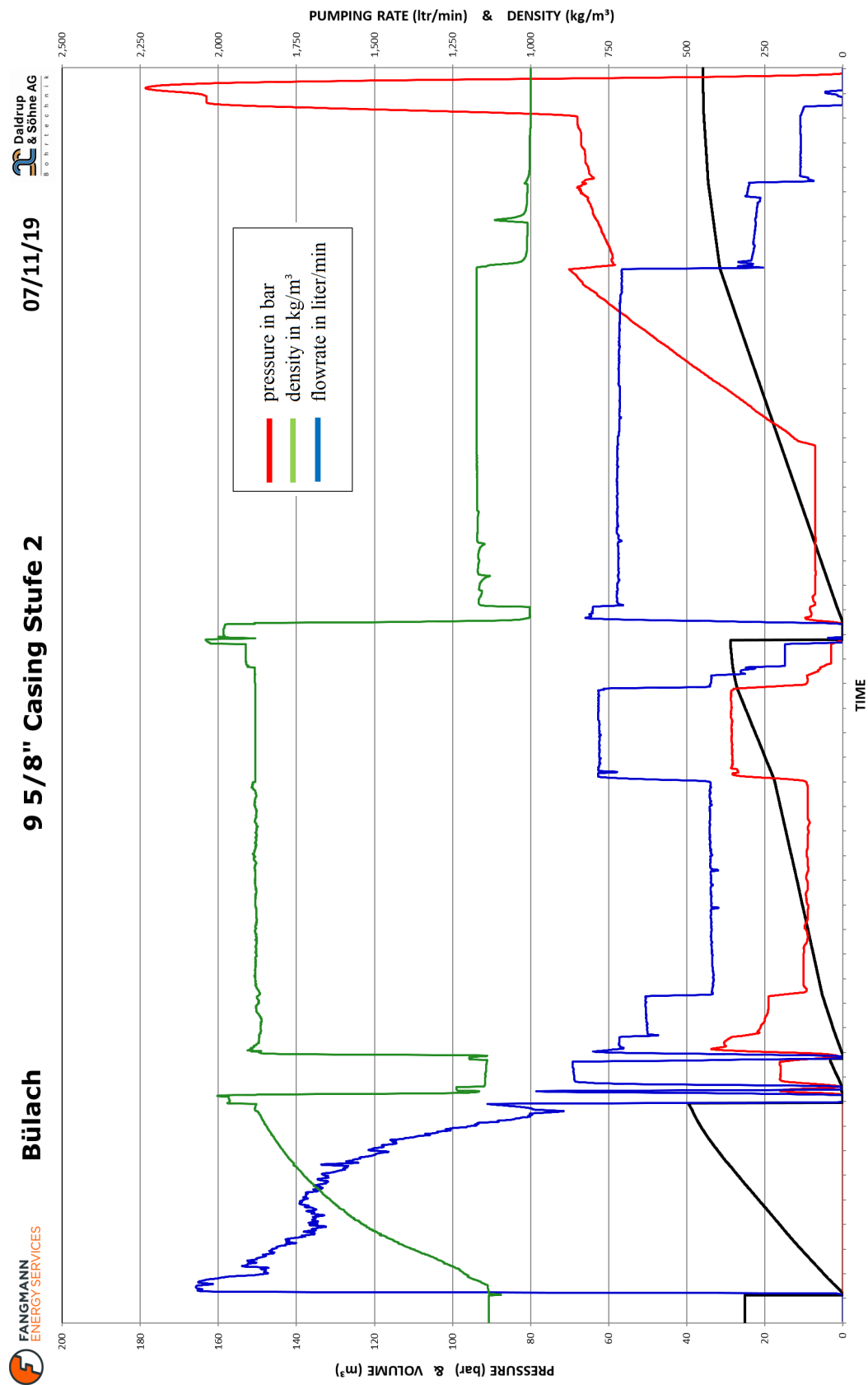


Fig. K-6: 9 5/8" cement chart stage two

FANGMANN ENERGY SERVICES	Kunde: Daldrup & Söhne Bohrung: Bülach (Schweiz) Zementation: 9 5/8" Casing	MD 1205.0 m TVD 1205.0 m Max. Neigung 0° TG 3.05°/100m BHST 52°C Test Temp. 42°C	 Daldrup & Söhne AG BURGERMANN
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Volumenberechnung

ZK

Stufe

13 3/8" FS

9 5/8" FC

9 5/8" FS

TD

-9m

0m

869m

918.7m

1193m

1205m

1209m

	OD	Beschreibung	Länge	Kapazität	Kommentar	Volumen
Voriges Rohr	13 3/8"	68.0 ppf	918.7m	77.981/m	Gesamt-Kap.	+ 71.64 m³
Offenes Loch nach Kaliber	13 1/2"	15% OH XS 30% Ringraum XS	286m	92.541/m	OH ohne XS OH XS	+ 26.49 m³ + 3.97 m³
Casing zum zementieren	9 5/8"	40.0 ppf	1205m	39.491/m	Gesamt-Verdr.	- 56.60m³
			12m		Shoetrack	+ 0.47 m³
Casing zum zementieren	9 5/8"	40.0 ppf	1202m	39.491/m	Zementvolumen	46.00m³
					Gesamt-Kap.	47.46m³
					Nachpumpvolumen	47.46m³

Enddruck: 43 bar Casing Lift: -21 To CSP: 129 bar

Fluid Design

Zement Step 1				Zement Step 2			
	1.88kg/l	Totvol. 0.5 m³	19.6m³		1.88kg/l	Totvol. 0.5 m³	27.4m³
Frischwasser	lt	559.4	477.1	Frischwasser	lt	557.9	13073.17
CAF-902	lt	1.5	1.3	CAF-902	lt	1.5	35.15
CSL-944	kq	122.7	104.8	CSL-944	kq	122.4	2867.47
CDI-213	kq	2.0	1.7	CDI-213	kq	3.0	70.30
CRE-120	kq	2.5	2.1	BLN-014	mt	1.5	35.50
BLN-014	mt	1.5	1.3				
Ergiebigkeit	lt	1171.1		Ergiebigkeit	lt	1169.3	

Logistik

Personal	Ausrüstung	Materiel	Menge	Kommentar
Supervisor:	Pumpwagen inkl. Datenaufzeichnung	BLN-014	60.86 mt	
Operator:	20 m³ Mischtank inkl. Antrieb	CAF-902	60.25 lt	
Operator:	27 t Silowagen inkl. Kompressor	CSL-944	6985.17 kq	
Operator:	9 5/8" 2-Stöpsel Zementierkopf	CRE-120	41.84 kq	
Operator:	inkl. BTC-Übergang	CDI-213	103.77 kq	
	27 t Zementstilo inkl. Kompressor	SGL-312	51.00 kq	
	30 m³ Vertikaltank			
	9 5/8" Stufe mit Plug Set			
	Von Kunde:			
	Saugwagen (Entsorgung Restfluide)	Frischwasser für Spacer	19.80 m³	
		Frischwasser für Zement	22.50 m³	

Pumpprogramm

Uhrzeit	Schritt	Bemerk.	Volumen m³	Dichte kg/ltr	Pumprate ltr/min	Dauer min
	BL-Zirkulation min. 2 Umläufe / Jobsicherheitsanalyse (JSA)					
	Leitungen entlüften		0.30		300	1
	Leitungstest	200 bar				10
	Vormischen erste 7 m³ Zement					20
	Verpumpen von Spacer	118 m	7.00	1.15	900	8
	Mischen & pumpen von Zement		19.10	1.88	800	24
	Latch Down Plug lösen					5
	Verpumpen von Frischwasser-Spacer		1.50	1.00	800	2
	Verpumpen von Spülung		42.96	1.15	700	61
	Verpumpen von Frischwasser (Leitungen zutage)		3.00	1.00	300	10
	Flow Check, Opening Dart lösen, Stufe öffnen, extra Zement auszirkulieren					
	WOC 24 Std., gleichzeitig zirkulieren 400 LPM					90
	BL-Zirkulation min. 2 Umläufe / Jobsicherheitsanalyse (JSA)					
	Leitungen entlüften		0.30		300	1
	Leitungstest	200 bar				10
	Vormischen erste 7 m³ Zement					20
	Verpumpen von Spacer	103 m	3.20	1.15	900	4
	Mischen & pumpen von Zement		26.90	1.88	800	34
	Closing Displacement Plug lösen					
	Verpumpen von Frischwasser-Spacer		1.50	1.00	800	2
	Verpumpen von Spülung		30.17	1.15	700	43

Fig. K-7: 9⁵/₈" cement programme

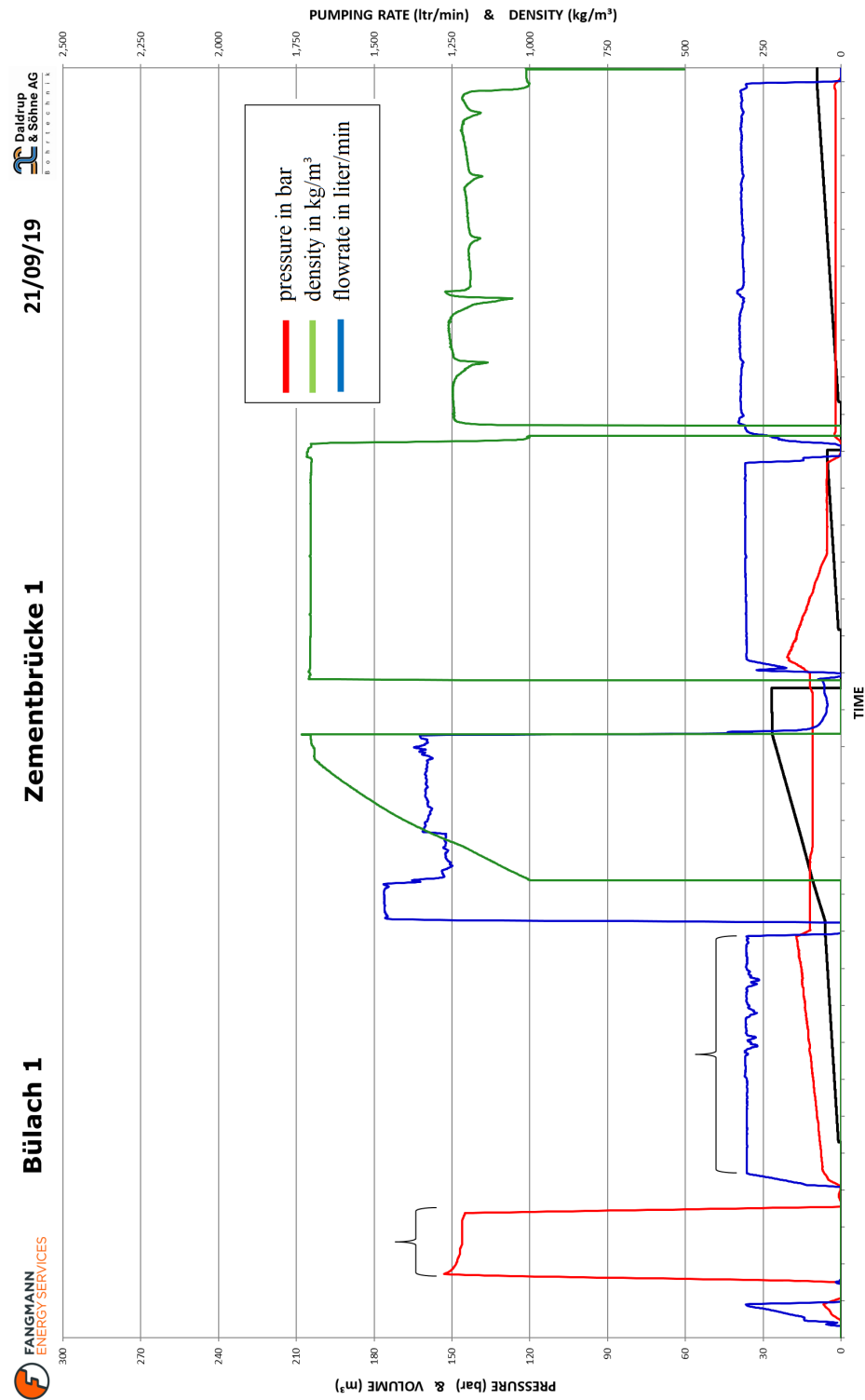


Fig. K-8: Cement plug below 9 $\frac{5}{8}$ " casing; cementing chart plug No. 1

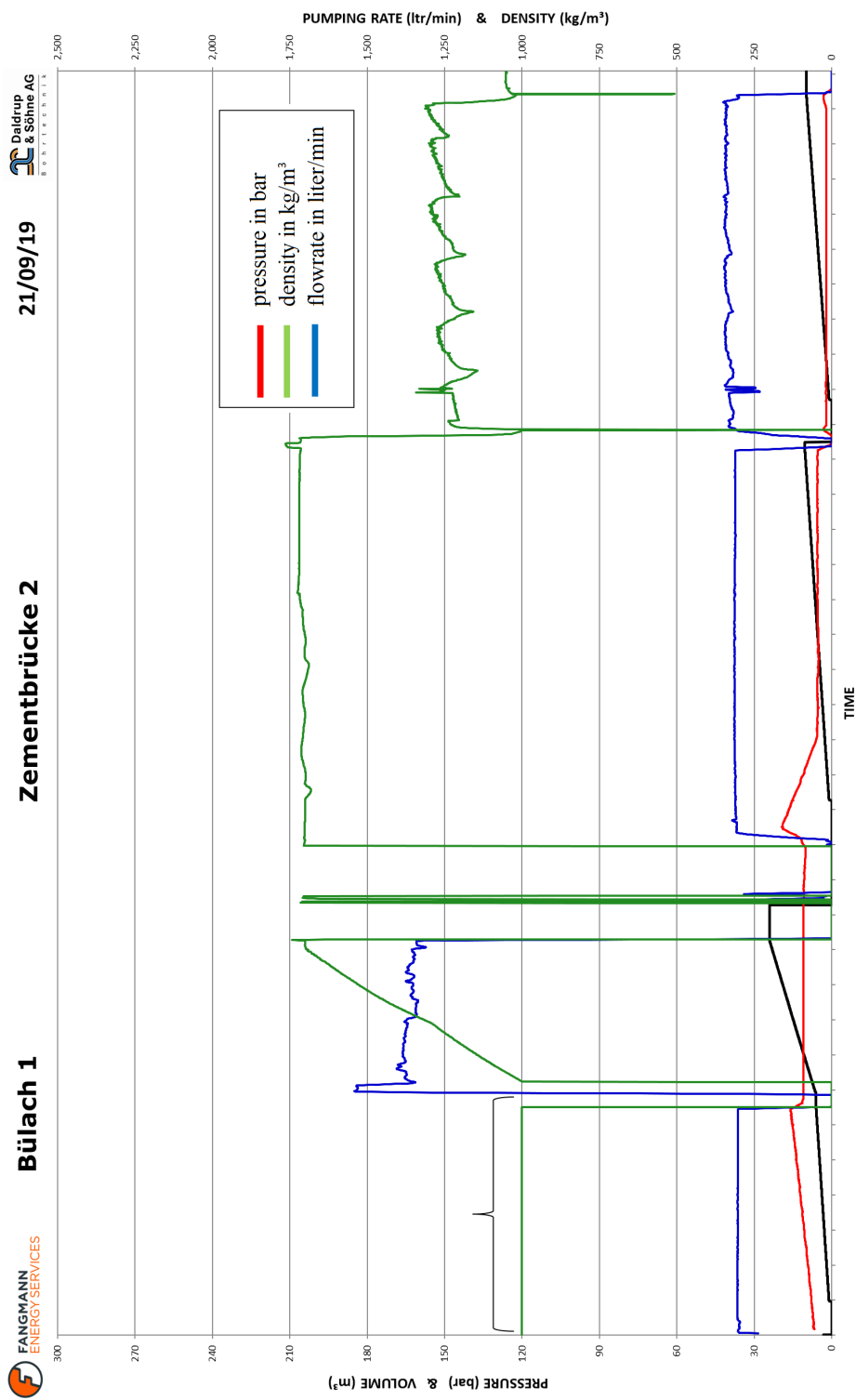
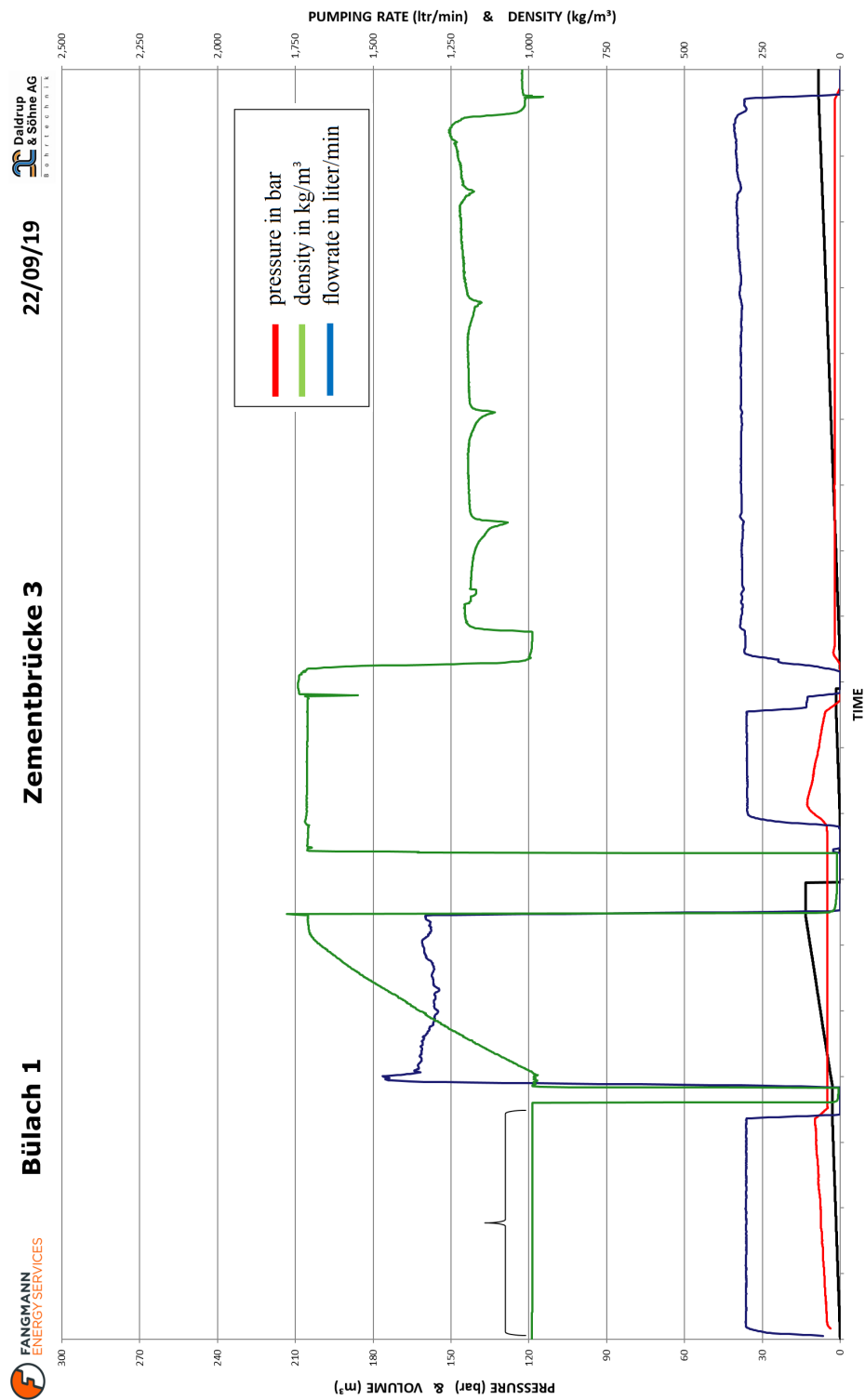


Fig. K-9: Cement plug below 9 5/8" casing; cementing chart plug No. 2



Appendix L: Cement bond log

Tab. L-1: Cement zone description for 18 $\frac{5}{8}$ " casing

* Zone descriptions for this phase are based primarily on the VDL because the acquired CBL amplitudes were unusually high for most parts of the borehole section. Therefore, they can only be used in a qualitative manner. Overall, this is a poor-quality log because the tool was designed for use in boreholes less than 12" in diameter, i.e. much smaller than the 18 $\frac{5}{8}$ " casing (18.14" ID).

From	To	Lithostratigraphic units	Zone description*
[m MD]			
0	46	USM II	Unable to evaluate because VDL readings were strongly attenuated
46	71	USM II	Low CBL amplitude, weak casing and formation arrivals; suggests good bond to casing, but poor accoustic coupling to the formation – medium bond
71	113	USM II	Medium to low CBL amplitude, weak casing arrivals and medium formation arrivals – good bond
113	221	USM II	Medium to high CBL amplitude, strong casing and medium formation arrivals; strong casing arrivals could be the result of a micro-annulus – medium bond
221	376	USM II	High CBL, strong casing arrivals and weak formation arrivals – poor bond
376	487	USM II USM I	Intermittent medium to high CBL, medium casing and formation arrivals – medium bond
487	524	USM I «Felsenkalke» / «Masssenkalk»	Low CBL, weak casing and medium to strong formation arrivals – good bond
524	528	«Felsenkalke» / «Masssenkalk»	Low CBL, weak casing and formation arrivals; suggests good bond to casing, but poor accoustic coupling to the formation – medium bond

Tab. L-2: Cement zone descriptions for 13 $\frac{3}{8}$ " casing

From	To	Lithostratigraphic units	Zone description
[m MD]			
0	14		Unable to evaluate because VDL readings were attenuated
14	63	USM II	Free pipe – strong casing arrivals, no formation arrivals; losses were observed during cementing
63	85	USM II	Medium to low CBL amplitude, weak casing arrivals and strong formation arrivals – good bond
85	103	USM II	Medium CBL, strong casing and medium formation arrivals; likely due to a micro-annulus or channel – medium bond

Tab. L-2: (continued)

From	To	Lithostratigraphic units	Zone description
[m MD]			
103	340	USM II	Low CBL, weak casing arrivals and medium to strong formation arrivals – good bond
340	399	USM II	Low CBL (values not reliable), strong casing arrivals, weak formation arrivals – poor bond
399	487	USM II USM I	Intermittent zones of weak to medium casing and formation arrivals – medium bond
487	515	USM I «Felsenkalke» / «Masssenkalk»	Low CBL, medium casing and formation arrivals; perhaps due to micro-annulus or channel – medium bond
515	551	«Felsenkalke» / «Masssenkalk»	Zones of washout under the casing shoe which attenuated the formation arrivals, no casing arrivals – good bond
551	653	«Felsenkalke» / «Masssenkalk»	Intermittent zones of fast formation with no casing arrivals and strong formation arrivals – good bond
653	676	Schwarzbach Fm.	Low CBL, no casing arrivals and strong formation arrivals – good bond
676	704	Villigen Fm.	Formation signals arrive before casing signals, indicates fast formation; increased CBL amplitude– good bond
704	751	Villigen Fm.	Low CBL, weak casing arrivals and medium to strong formation arrivals – good bond
751	806	Wildegge Fm. Wutach Fm.	Low CBL, no casing arrivals, medium to strong formation arrivals – good bond
806	812	Variansmergel Fm. «Parkinsoni- Württembergica- Schichten»	Low CBL, no casing or formation arrivals; suggests good bond to casing and perhaps poorer bond to formation; however, there were washouts in this zone, which attenuated the readings – good bond
812	821	«Herrenwis Unit»	Low CBL, no casing arrivals and strong formation arrivals which arrive before the casing arrivals; indicates fast formation – good bond
821	845	«Herrenwis Unit»	Low CBL, no casing arrivals and strong formation arrivals – good bond
845	853	«Herrenwis Unit»	Low CBL, no casing arrivals and strong formation arrivals which arrive before the casing arrivals; indicates fast formation – good bond
853	918	«Humphriesoolith Fm.» Wedelsandstein Fm. «Murchisonae-Oolith Fm.» Opalinus Clay	Very low CBL, no casing arrivals, intermittent weak to medium formation arrivals; suggests good bond to casing and perhaps poorer bond to formation; however, there were a lot of washouts in this zone, which attenuated the readings – good bond

Tab. L-3: Cement zone descriptions for 9⁵/₈" casing

* Zone descriptions from 0 m to 1'106.0 m are based solely on the logs using the ASLT (array sonic logging tool) tool. From 1'106.0 m to TD zone descriptions were primarily based on logs acquired using the MSIP tool, because logs acquired using the ASLT tool were of worse quality.

From	To	Lithostratigraphic units	Zone description*
[m MD]			
0	40	USM II	Unable to evaluate because VDL readings were attenuated
40	242	USM II	Medium CBL readings (20 mV to 27 mV); medium casing and formation arrivals on the VDL – medium bond
242	820	USM II USM I «Felsenkalke» / «Masssenkalk» Schwarzbach Fm. Villigen Fm. Wildegg Fm. Wutach Fm. Variansmergel Fm. «Parkinsoni- Württembergica- Schichten» «Herrenwis Unit»	Low CBL (4 mV to 8 mV); weaker casing arrivals and strong formation arrivals (in particular below 530 m outsideof the second casing) – good bond
820	828	«Herrenwis Unit»	Medium to low CBL, medium casing and formation arrivals – medium bond
828	862	«Herrenwis Unit» «Humphriesioolith Fm.» Wedelsandstein Fm.	Low CBL (4 mV to 8 mV); weak casing arrivals and strong formation arrivals (in particular below the 530 m when outside of the second casing) – good bond
862	1'063	«Murchisonae-Oolith Fm.» Opalinus Clay Staffelegg Fm. Klettgau Fm.	Medium to high CBL (17 mV to 40 mV); VDL shows intermittent zones of medium to strong casing arrivals with visible formation arrivals – medium bond
1'063	1'079	Klettgau Fm. Bänkerjoch Fm.	High CBL amplitude, reaching free pipe signal; strong casing and formation arrivals; suggests significant micro-annulus or channel – low bond
1'079	1'117	Bänkerjoch Fm.	Medium to low CBL, weak casing and formation arrivals; suggests good bond to casing, but less strong coupling to formation – medium bond
1'117	1'126	Bänkerjoch Fm.	Medium to high CBL, strong casing and formation arrivals in the VDL; suggests micro-annulus or channel – medium bond
1'126	1'136	Bänkerjoch Fm. Schinznach Fm.	Low CBL, weak casing and strong formation arrivals – good bond

Tab. L-3: (continued)

From	To	Lithostratigraphic units	Zone description
[m MD]			
1'136	1'147	Schinznach Fm.	High CBL amplitude, reaching free pipe signal; strong casing arrivals and medium formation arrivals; suggests significant micro-annulus or channel – low bond
1'147	1'170	Schinznach Fm.	Low CBL amplitude; weak casing arrivals and strong formation arrivals in VDL – good bond
1'170	1'173	Schinznach Fm.	Medium to high CBL; strong casing arrivals with medium formation arrivals – medium bond
1'173	1'194	Schinznach Fm.	Fast formation; i.e. formation arrivals show before casing arrivals in VDL; indicates good cement bond to casing and formation – good bond
1'194	1'204	Schinznach Fm.	High CBL amplitude, reaching free pipe signal; strong casing arrivals and formation arrivals; suggests significant micro-annulus or channel – low bond
1'204	1'240	Zeglingen Fm.	Out of casing; strong formation arrivals