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13

V.O.F. Geothermie De Lier

End of Well Report LIR-GT-01

V.O.F. Geothermie de Lier

Prepared by	**Well Engineering Partners**
Version	**1**
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Reviewed	**Bertjan Koers**
Approved	**Maarten Middelburg**
Agreed	**Henny Cornelissen**

CONTENTS

APPENDICES

1. GENERAL PROJECT DATA

Field	de Lier
Well Number:	LIR-GT-01
Well Name	Geothermal Well LIR-GT-01
Well Type	Geothermal Well Producer
Start rig mobilisation	08-05-2014; 08:00 hr
Spud date	20-05-2014; 11:00 hr
End Date	07-07-2014; 08:00 hr
Days Operational	48
Operator	V.O.F. Geothermie de Lier

Surface Location

Latitude & Longitude	Geographical
51°58'39.975"N 4°16'57.311"E	X: 79087,73 Y: 443732,32

Grid Coordinate System	Rijksdriehoeksmeting / Netherlands New
Drilling Contractor	KCA Deutag
Drilling Rig	T-49, Pyramid 270 mt
Depth reference	Rotary Table (RT), unless otherwise stated

Project Management:

Operations Director	Paul van Steekelenburg	08/05/2017 / 07-07-2014
Project Manager	Aad de Bruijn	08-05-2014 / 07-07-2014
Drilling Advisor	Henny Cornelissen	08-05-2014 / 07-07-2014
Drilling Manager	Maarten Middelburg	08-05-2014 / 07-07-2014
Lead ops Engineer	Bertjan Koers	08-05-2014 / 07-07-2014
HSE Manager	Guus Wiering	08-05-2014 / 07-07-2014

Drilling Supervisors on 2 week rotational scheme:

Drilling Supervisor	Jan Bender	08-05-2014 / 12-05-2014
Drilling Supervisor	Karl Gollob	13-05-2014 / 19-05-2014
		03-06-2014 / 17-06-2014
		01-07-2014 / 07-07-2014
Drilling Supervisor	Peter Nutters	20-05-2014 / 02-06-2014

		17-06-2014/30-06-2014
Night Drilling Supervisor	Claudio Virgilio	19-05-2014 / 28-05-2014 11-06-2014/19-06-2014
Night Drilling Supervisor	Bertjan Koers	01-06-2014 / 11-06-2014 19-06-2014 / 26-06-2014
Night Drilling Supervisor	Dirk Brinkgreve	26-06-2014 / 28-02-2014

Project Engineering:

Drilling Engineer	Shantie Kapoerchan	08-05-2014 / 07-07-2014
Well Site Geologist	Julien Smeulders	08-05-2014 / 07-07-2014

2. WELL SUMMARY

Primary Objective Delft Sandstone

LIR-GT-01

Primary Objective Depth		2876 m MD	2558 m TVD
Total Depth		2897 m MD	2575 m TVD
Elevation	RT – GL	6.91 m	
	GL – NAP	- 1.90 m	
	NAP – RT	5.01 m	

Table 1: LIR-GT-01 well summary

Item	m MD	m TVD	Comments
Conductor	140	140	24" Conductor driven to 140 m MD and cemented in place prior to the rig arriving on location. Moved the rig to location, rig up and commissioned from 08-05-2014 until 19-05-2014 at 18:00 hrs. Spud in on 20-05-2014 at 12:00 hrs (bit on bottom of conductor, start to drill)
17 ½" Hole TD	1080	1078	This section was drilled with 2 BHA's. Rotary drilled from 140m to 182m MD with low parameters to avoid washing out the conductor shoe. At this depth the well was kicked-off and nudged 4° towards approximately 350° azimuth. At 845 m the BHA was pulled out of hole for rig repair and bit change. The section was drilled to 1080m where section TD was called in Texel Marlstone Member. The hole volume was calculated as 3.4% overgauge (average diameter of 17.871") circulating a high-viscosity pill.
13 ⅜" Casing	1028	1027	13 3/8" casing was run to 1030 m MD but unable to run deeper. The shoe was spaced out to 1028 m and the casing cemented to surface. The casing was pressure tested on grey cement on 50 bar / 20 min.
12 ¼" Hole TD	2565	2321.5	This section was drilled using the Autotrak rotary steerable system of Baker Hughes. The section was drilled in one run without major problems. The build-up was initiated in this section to a maximum inclination of ca. 40° from where it was kept tangent to section TD at 2565m in the base of the Rodenrijs claystone. At TD the hole was circulated clean and a hi-vis pumped. The hole volume was calculated to be 12.5". The BHA was pulled out of hole while circulating. Tight spots were seen during pull out, but were treated before pulling out to run liner. Tight spots were reamed only if necessary.
9 ⅝" Liner	2313	2553	1st attempt liner run: RIH to 1140m. Stood up at 1140m with 15 ton drag. Attempted to rotate string; no success. POOH liner to ream. Reaming run 1: While reaming had to use jar several times to get free. At tight spots had to work string with pumps and string rotation. Reaming run 2: Performed dedicated reamer trip with a DEI reamer to open hole. 2nd attempt liner run: Liner was set at 2313m TVD / 2553m MD with TOL at 924.9m. Plug didn't bump after final displacement of the cement job. Therefor the casing was pressure tested on green cement 50 bar / 20 min.

8 ½" Hole TD	2575	2897	Drilled 8 1/2" section from 2313m TVD / 2553m MD to 2575m TDV / 2897m MD. Performed FIT at 2568m MD with 1.23s.g mud to 1.38 s.g. EMW. Displaced well from 1.23sg mud to 1.08sg drill in fluid. Drilled ahead 8 1/2" hole section to final TD (at 2897m MD).
6 ⅝"Liner	2275-2563	2499-2881	Screen assembly with inner wash string was washed down on 5" DP to 2881m. Set liner hanger packer and successfully pressure tested liner hanger. Retrieved running tool and 3-1/2" DP wash string. RIH kill string and monitored well while waiting on well test equipment and USIT logging over 9 ⅝" and 13 ⅜" casing. Screen interval from 2353m TVD / 2606m MD to 2553m TVD / 2868m MD.

2.1 DIRECTIONAL PLOTS

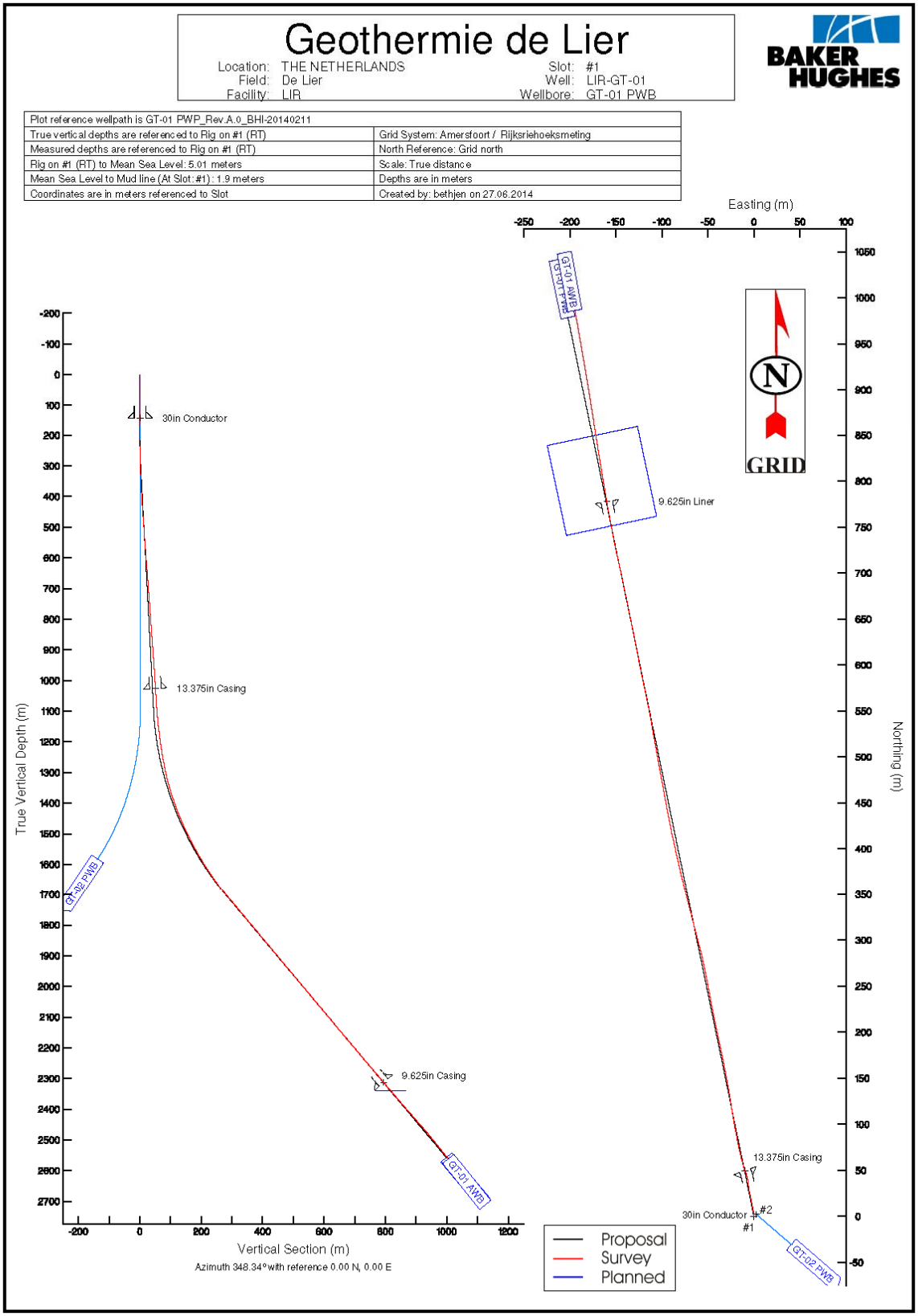

Figure 1: LIR-GT-01 Vertical Section plot and plan view plot- drilled vs. planned

2.2 TECHNICAL SUMMARY

2.2.1 Casing

Table 2: LIR-GT-01 tubular summary

Item	Top m MD	Bottom m MD	Weight	Grade	Connection
24" Conductor	8.21	140	125.7 ppf	X65	welded
13 ⅜" Casing	7.57	1028	68 ppf	L80	VAM TOP
9 ⅝" Liner	925	2553	47 ppf	L80	GT-Premium
6 ⅝" Liner	2499	2881	24 ppf 7" WWS*	L80	Polseal

*Screen interval from 2606 m – 2868 m

2.2.2 Cement

Table 3: LIR-GT-01 cement summary

Item	TOC (MD)	Lead Slurry Volume (m^3)	Lead Slurry Weight (s.g.)	Tail Slurry Volume (m^3)	Tail Slurry Weight (s.g.)	Type
13 ⅜" Casing	Surface	122.08	1.58	14.08	1.67	Pozzo Cemoil
9 ⅝" Liner	1380*	95	1.70	n/a	n/a	Pozzo Cemoil

*Based on USIT log

3. DRILLING FLUID SUMMARY

Per section the following drilling fluid types have been used:

Table 4: LIR-GT-01 drilling fluid summary

Section	Type	Density Min – Max
17-1/2”	KCl-Glycol Polymer (AMC Glycodrill)	1.07 – 1.18 s.g.
12 ¼”	KCl-Glycol Polymer (AMC Glycodrill)	1.15 – 1.23 s.g.
8 ½”	Drill-in Fluid	1.08 – 1.09

The figure below shows the mud weight versus depth during drilling operations.

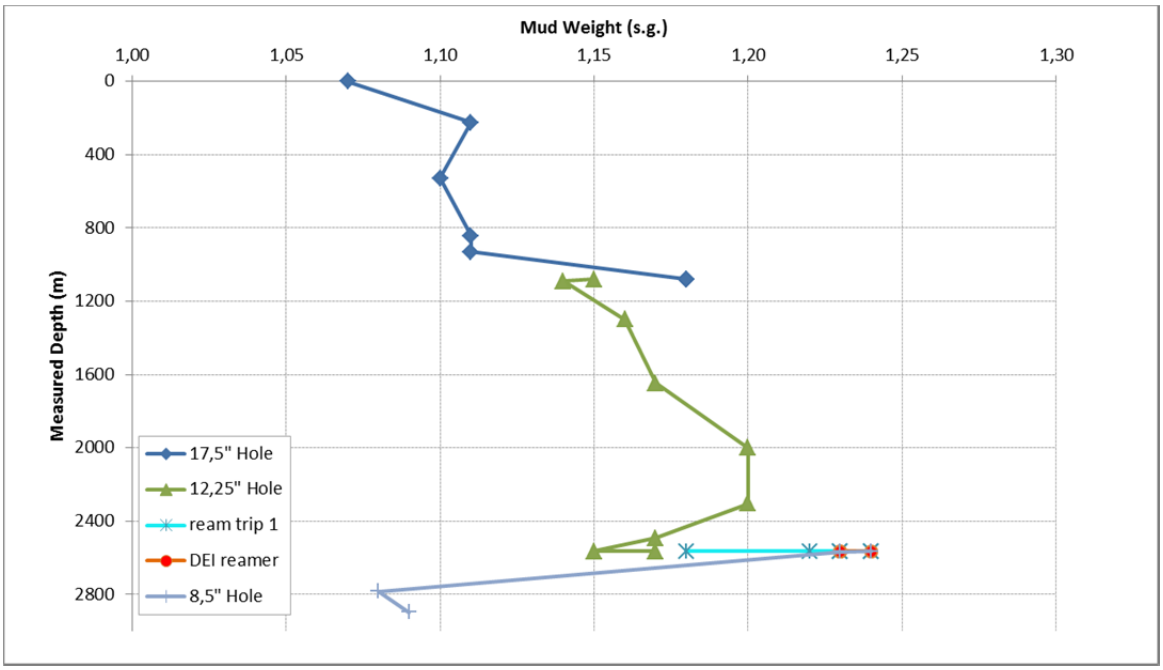

Figure 2: LIR-GT-01 mud weight vs. depth

4. GEOLOGY

Below the geological column with vertical and along hole depths below RT.

Table 5: LIR-GT-01 Cenozoic and Mesozoic geological summary

1	07-07-2014	Lithostratigraphic Column	Julien Smeulders				LIR-GT-01		Section TD
Era	Group	Period	Formation	Epoch (Age)	Member	Lithology	TV-RT Depth (m)	AH-RT Depth (m)	
Cenozoicum	Upper North Sea NU	Quaternary	"Diverse"	Holocene-Pleistocene		Diverse continental deposits, mostly fluvial sands and silts intercalated by some thin layers of grey or greenish-grey, silty clays.	7	7	24"
			Maassluis NUMS	Early Pleistocene		Deposits of coastal sands, very fine to medium coarse, calcareous, shell bearing, mica rich. Silty to sandy, grey to dark grey clay containing shells and mica.	-	-	
		Tertiary	Oosterhout NUOT	Pliocene		Deposits of shallow marine greenish clays, sandy clays, silts and coastal sands.	250	250	
			Breda NUBA	Miocene		Sequence of marine, glauconitic sands, silty to sandy clays and clayey silts. In many places a glauconite-rich layer occurs at the base.	387	387	
	Middle North Sea NM		Rupel NMRF	Oligocene/Eocene Rupelian to Chattian	Rupel Clay NMRFC	Marine clays that become more silty towards base and top. It is rich in pyrite, contains hardly any glauconite & CaCO3 tends to be concentrated in the septaria layers.	432	432	
	Lower North Sea NL		Dongen NLFF	Middle to Late Eocene Lutetian to Bartonian	Asse NLFFB	Marine dark greenish-grey and blue-grey, plastic clays. The unit locally shows indications of bioturbation, and may be glauconitic and micaceous.	452	452	
				Early to Middle Eocene Ypresian to Lutetian	Brussels Sand NLFFS	Succession of green-grey, glauconitic, very fine-grained sand.	486	486	
				Early Eocene Ypresian	Ieper NLFFI	Soft, tough and sticky to hardened and friable clay.	505	505	
					Basal Dongen Tuffite NLFFT	Tuffaceous clays, blue to violet-grey in colour, alternating with dark-grey and red-brown clays.	666	667	
			Landen NLLF	Late Paleocene Thanetian	Landen Clay NLLFC	Generally dark-green, hard, flaky clay, somewhat silty, containing glauconite, pyrite and mica.	681	682	
	Chalk CK		Ekofisk CKEK	Late Paleocene Danian		White, chalky limestones containing rare white and grey nodular and bedded chert layers, and thin, grey to green (glauconitic) clay laminae.	691	692	
Mesozoicum		Cretaceous	Ommelanden CKGR	Upper Cretaceous Turonian to Maastrichtian		Succession of white, yellowish-white or light-grey, fine grained, dense limestones, in places argillaceous. Layers of chert nodules are very common over thick intervals. Tongues of sandstone occur.	708	709	13 3/8" casing @ 1029m AHD
			Texel CKTX	Cenomanian	Plenus Marl CKTXP	Dark-grey, partly black, calcareous, laminated claystone.	1106.5	1108.5	
					Texel Marlstone CKTXM	Interval of white to light grey chalks, chalky marls and limestones. Increasingly marly with depth. Some interbedded layers of medium dark claystone appear at the base.	1109.5	1111.5	
					Texel Greensand CKTXG	Greenish, glauconitic, calcareous sandstones with intercalated marls.	1150	1152	

Table 6: LIR-GT-01 Mesozoic geological summary

2	07-07-2014	Lithostratigraphic Column	Julien Smeulders				LIR-GT-01		Section TD
Era	Group	Period	Formation	Epoch (Age)	Member	Lithology	TV-RT Depth (m)	AH-RT Depth (m)	
Mesozoicum	Rijnland KN	Cretaceous	*Holland* KNGL	***Lower Cretaceous*** *Late Albian*	Upper Holland Marl KNGLU	Sequence of light to medium grey and white chalks, chalky marls and marls. Increasingly marly with depth.	1162	**1165**	9 5/8" casing @ 2553m AHD
				Late Aptian to Early Albian	Middle Holland Claystone KNGLM	Grey and/or red-brown calcareous shaly claystone with a distinctly lower lime content than the under- and overlying members. Intercation of sandstone beds.	1341	**1347**	
				Early Albian	Holland Greensand KNGLG	Alternation of greenish grey, very glauconitic, very fine- to fine-grained, argillaceous sandstones, locally silt-stones with calcareous or sideritic cement, and olive-grey claystones or grey marlstones.	1398	**1406**	
				Early Aptian	Lower Holland Marl KNGLL	Grey and red-brown marl or calcareous, fissile claystone, frequently with intercalated bituminous claystone beds and sandstone beds.	1542	**1563**	
			Vlieland Sandstone KNNS	*Late Barremian to Early Aptian*	De Lier Sandstone KNNSL	Alternation of thin-bedded, very fine- to fine-grained argillaceous sandstones, generally glauconitic and lignitic, and sandy claystones, commonly glauconitic and with shell fragments and frequent bioturbation.	1686	**1736**	
				Late Barremian	Vlieland Clay KNNCM	Dark brownish-grey to grey claystone. Mica and very fine lignitic matter are common. The formation can be very silty to sandy. It's also slightly calcareous.	1765	**1838**	
				Late Hauterivian to Mid Barremian	Berkel Sandstone KNNSB	Sandstone, light-grey, very fine- to coarse-grained, locally gravelly, lignitic, locally glauconitic or with sideritic concretions. Especially in the upper part calcareous cemented beds are common.	1954	**2084**	
				Late Hauterivian to Early Barremian	Berkel Sand/Claystone KNCC	Alternation of fine-grained, argillaceous sandstones and brown-grey silty to sandy claystones. Locally sideritic concretions are present.	2036	**2191.5**	
				Hauterivian	Rijswijk Sandstone KNNSR	Light- to medium-grey sandstones with a very fine to medium and locally gravelly grain size; mica, lignitic matter and siderite concretions are common.	2163	**2357**	
	Schieland SL		Nieuwerkerk SLDN	*Late Valanginian to Early Hauterivian*	Rodenrijs Claystone SLDNR	Medium- to dark-grey and dark brown, silty to sandy lignitic claystones with laminated or contorted bedding, and lignite/coal beds. Traces of mollusc shells, pyrite and siderite.	2261.5	**2486**	
				Valanginian	Delft Sandstone SLDND	Light-grey massive sandstone sequence, fine to coarse-gravelly, fining upward, lignitic.	2387	**2651**	6 5/8" casing @ 2881m AHD
				Lower Cretaceous to Upper Jurassic *Ryazanian to Valanginian*	Alblasserdam SLDNA	The upper part consists of grey to greyish brown, soft claystone with some intercalated red bands and well sorted, very fine loose sand, sandstone & siltstone.	2481.5	**2776**	
					Pijnacker Zandsteen (submember)	Consists of fine to medium grained argillaceous and glauconitic sandstones, massively bedded up to a few metres thick with inter-bedded layers of thin silty claystone.			
		Jurassic				A succession of typically red and dark to light (brownish) grey clay(stones) and variegated clay- and siltstones, sandstones and massive, thick-bedded, coarse grained sandstones. Coal & lignite beds.	2556	**2871**	
						TD	2575.5	**2897**	

5. WELL SCHEMATIC

A detailed well schematic summarizing all casing sizes is shown below.

Note: well depth is not to scale.

Item Description Depth Reference: Rotary Table (=6,91 m above GL)	LIR-GT-01 13 5/8" 5K Wellhead 7 1/16" Xmastree	Depth m tvd	Depth m ah	Hole ID in	Pipe OD in	Collar OD in (nom)	Pipe ID in	Pipe ID in (drift)
24" welded conductor / stove pipe		140	140		24,000	welded		23,000
13 3/8 x 9 5/8" Liner Hanger + Packer		923	925	Top of liner (top PBR)				
13 3/8" 68ppf L80 VAMTOP		1027	1029	17,5"	13 3/8"	14,175	12,415	12,259
		1078	1080	section TD				
9 5/8" x 6 5/8" BlackCat Packer		2272	2499	Top of liner				
9 5/8"47ppf L80 Premium GT		2313	2553	12,25"	9 5/8"	10,396	8,681	8,525
		2322	2565	section TD				
		2353	2606	Top screens				
		2553	2868	Bottom screens				
6 5/8" 24ppf L80 Polseal Basepipe w/ 7" OD WWS w/ Float shoe		2563	2881	8,500	7,000	7,191	5,921	5,796
Open hole 8.1/2" (TD)		2575	2897	8,500	TD			

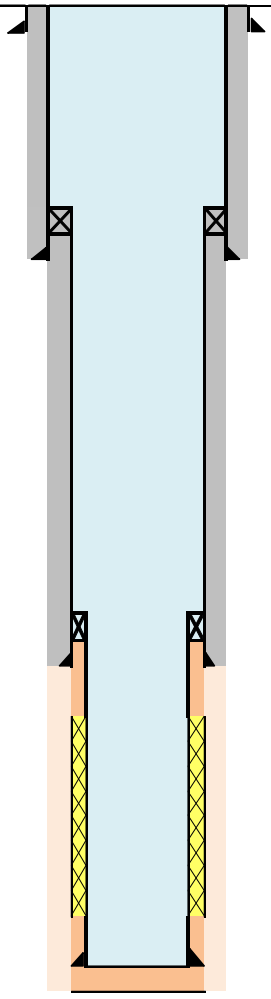

Figure 3: LIR-GT-01 well schematic