




## **End of Well Report PNA-GT-06 / S1 / S2 / S3**

**Ammerlaan Geothermie B.V.**

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## GLOSSARY

AH	Along hole	PDM	Positive displacement (mud) motor
AKO	Adjustable Kick-Off	PJSM	Pre-job safety meeting
BGL	Below ground level	POA	Plan of action
BHA	Bottom hole assembly	POOH	Pull out of hole
BOP	Blowout preventer	ppf	pounds per foot
CBL	Cement bond log	P/U	Pick Up
CHH	Casing head housing	PUW	Pick up weight
C/O	Change Out	PV	Plastic viscosity
CP	Conductor Pipe	R/D	Rig Down
CRT	Casing running Tool	RF	Rig Floor
DC	Drill Collar	RIH	Run in hole
DP	Drill pipe	ROP	Rate of penetration
DSV	Drilling supervisor	RSS	Rotary steerable system
EMW	Equivalent mud weight	RT	Rotary table
ESP	Electric submersible pump	RTTS	Retrievable Test-Treat-Squeeze (packer)
FMS	Flush Mounted Spider	R/U	Rig Up
FIT	Formation integrity test	s.g.	Specific gravity
FOSV	Full opening safety valve	SodM	Staatstoezicht op de Mijnen
GL	Ground level	SOW	Slack off weight
GR	Gamma-Ray	Spm	Strokes per minute
HSE	Health, Safety & Environment	SPP	Stand pipe pressure
HWDP	Heavyweight drillpipe	TD	Total depth
IR	Iron Roughneck	TDS	Top Drive Swivel
LCM	Lost circulation material	TOC	Top of cement
LOT	Leak Of Test	TOL	Top of liner
LTi	Lost Time Incident	TRS	Tubular Running Services
MD	Measured Depth	TP	Toolpusher
MW	Mud Weight	TSP	Top Set Packer
MWD	Measurement while drilling	TVD	True vertical depth
NAP	Normaal Amsterdams Peil	TWCV	Two Way Check Valve
NDSV	Night Drilling Supervisor	WBM	Water Based Mud
NPT	Non-productive time	WOB	Weight on bit
OH	Open hole	WOC	Wait on cement
PBL	Circulation sub	WWS	Wire-wrapped screen
PBR	Polished Bore Receptacle	YP	Yield point
PDC	Polycrystalline diamond compact		

## 1. Project Details


### 1.1 Organisation

Project Management:

<b>Project Director</b>	
<b>Project Manager</b>	
<b>Drilling Manager</b>	
<b>Sr. Drilling Engineer</b>	
<b>Drilling Engineer</b>	
<b>Sr. Well Site Geologist</b>	
<b>HSE Manager</b>	

Drilling Supervisors on 2 week rotational scheme:

<b>Drilling Supervisor</b>		24-04-2018 / 07-05-2018 23-05-2018 / 05-06-2018 19-06-2018 / 03-07-2018 17-07-2018 / 31-07-2018 14-08-2018 / 17-08-2018
<b>Drilling Supervisor</b>		08-05-2018 / 22-05-2018 05-06-2018 / 19-06-2018 03-07-2018 / 17-07-2018 31-07-2018 / 03-08-2018 01-08-2018 / 14-08-2018
<b>Night Drilling Supervisor</b>		28-04-2018 / 11-05-2018
<b>Night Drilling Supervisor</b>		29-05-2018 / 12-06-2018 26-06-2018 / 10-07-2018 24-07-2018 / 07-08-2018
<b>Night Drilling Supervisor</b>		12-06-2018 / 26-06-2018 10-07-2018 / 24-07-2018 07-08-2018 / 17-08-2018
<b>ESP installation, Clean out and completion</b>		
<b>Drilling Supervisor</b>		02-08-2019 / 13-08-2019

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## 1.2 *Operational summary*

Field	Pijnacker-Nootdorp 4
Well Number:	PNA-GT-06 / S1 / S2 / S3
Well Name	Pijnacker-GT-06 / Sidetrack-1 / Sidetrack-2 / Sidetrack-3
Well Type	Geothermal Injection
Start operations	24-04-2018; 06:00 hr
Spud date	30-04-2018; 20:00 hr
Start rig skidding (end of well)	18-08-2018; 18:00 hr
Days Operational	108.2 days
ESP installation, Clean out and completion	
Start operations	09-08-2019; 13:00 hr
End operations	13-08-2019; 17:00 hr

	Latitude & Longitude (ETSR89)	Geographical
Surface Location	52° 01' 18,655"N 4° 25' 21,938"E	X: 88781,798m (RD) Y: 448498,242m (RD)

Grid Coordinate System	Rijksdriehoeksmeting / Netherlands New
Depth reference	Rotary Table (RT)

## 1.3 *Drilling rig*

Drilling Contractor	Innodrill
Drilling Rig	LOC400 – “Heracles”

## 2. Well summary

The table below gives a summary of the drilling operation per hole section.

Table 1: Well summary

Item	MD (m)	TVD (m)	Comments
24" Conductor	102	102	Hammered to resistance.
16" Hole	931	917	Drilled vertically to 570 m & directionally to 931 m, inclination 25°.
13 3/8" Casing	927	914	Ran casing to 927 m. Cemented casing to surface with a stab-in sub on DP. Installed CHH and 13 3/8" BOP.
12 1/4" Hole	2807	2007	Drilled directionally, building inclination to 57° at 1340m and held inclination and azimuth to TD at 2807m. While reaming out of the hole the TDS gearbox failed at 2711m. The string was hung of in slips and TDS removed. After repairs and installation of TDS the string was worked free. Bit was reamed to bottom and back reamed to the 13 3/8" casing shoe with several difficulties. BHA was pulled out and due to the observed issues, a check trip was performed. This check trip took several days due to hole issues.
9 5/8" Liner	(TOL) 861 (Shoe) 2803	(TOL) 853 (Shoe) 2004	Ran liner to 1932 m and installed liner hanger on string. During the pull test the running tool came loose from the hanger assembly. Circulated and reciprocated the liner and waited for replacement liner hanger. New liner hanger was installed, and liner was washed down to a shoe depth 2803 m
8 1/2" x 9 1/2" Hole	3295	2333	Drilled to 3295 m but could not steer and where unable to hold inclination; final inclination 46.85°.
7 5/8" Liner	3300	2336	Ran WWS liner till 3130m where it stood up. Liner was pulled back to surface. The hole was under reamed to 9 7/8" till 2940m where progress halted. POOH and found wash out in bottom sub of under reamer. Performed wiper trip with 8 1/2" bit to bottom while waiting for spares. Heavy reaming required to get to bottom, drilled extra 5 m to deepen hole to 3300 m (TD). Increased mud weight from 1.12 to 1.15sg and POOH. While changing out bottom sub of under-reamer found damaged seal face on body of under reamer (unable to re-run). Organised replacement under reamer (12 1/4"). Under reamed from 2930m to 3071m, where the string got stuck. Unable to jar free. Severed string with a wire line string shot, 28.5m of the BHA left in the hole; top of fish at 3041m. POOH. Ran a 2 7/8" cement stinger spotted a 50m long viscous pill on top of the fish followed by a 1.94 sg cement plug to 120 m in the 9 5/8" casing.
8 1/2" Hole – Sidetrack #1	2998	21222	Ran a kick-off BHA. Ream down 2684-2803 m, observed no cement. Ream down with 450lpm and observe more resistance (5t WOB and torque) at 2821m. Set tool face 70° left and start time drilling from 2829m to 2830 with 0,3m/hr. Samples showing no more cement & surveys showing drilling old hole. Washed and reamed down looking



			for resistance to 3035 m. POOH. Ran in hole cement stinger and set cement plug from top of fish to 2670 m. Ran kick off BHA. Washed down from 2640 m to 2760 m, without finding cement. Stopped washing down and waited for cement to harden. After 10 hours additional waiting time, started with time drilling and initiate 8 ½" sidetrack from 2818 m to 2843 m. Sidetrack successful, confirmed by surveys. Drilled to 2998 m. Stopped drilling due to bit hours. POOH.
8 ½" Hole – Sidetrack #2	3097	2189	RIH 8 ½" PDC BHA to 2816 m, resistance. Attempted to RIH through kick off point, unsuccessful. Started to drill from 2851 m to 2863 m. Kick-off was not going smooth with the PDC bit. Decided to POOH and change it for an insert roller bit. A short BOP test was performed. The Insert bit was RIH to 2863 m. Set up tool face to high side 110° and commence time drilling and drilled new hole from 2909 m to 3097 m. At this point ROP dropped to zero. POOH without issues, at surface found that the bit was severely worn (all 3 cones lost). While waiting for fishing equipment, the drill line was replaced. Fishing was cancelled and decision taken to use a whipstock in the 9 ⅝" liner to initiate a new sidetrack
8 ½" Hole – Sidetrack #3	3357	2318	The whipstock was run and set and the window was milled. A BHA was washed through the window and 2m hole was drilled in rotary mode. While waiting for the survey the string stalled. After that it was impossible to get the bit rotating again. After being stuck a few times, got the bit inside the casing with 45 ton overpull. The bit was pulled and showed a ring groove on the bit shank, caused by the window. A Tri Mill BHA was run, to mill and polish the window. The rathole was extended to 2776m. POOH. Ran a directional BHA with PDC bit through the window to bottom at 2776 m. Drilled directionally to TD at 3357 m.
6 ⅝" slotted x 7" blank Liner	3351	2314	Ran a tapered liner with a 2 ⅞" inner string. Made up liner hanger and run in liner on 5 ½" drill pipe to 3351m (washed down through some resistance). Set hanger and displace annular volume between liner and formation to solids free mud. Set packer and POOH.
Suspend well			Installed tubing hanger with TWCV. Installed tubing head adapter and blind flange.
ESP install, Clean out & completion	87.46	87.46	RIH ESP with cable on 8 ⅝" casing. Land hanger and install tubing head adaptor and X-mas tree. Produce water to clean up well. POOH ESP and RIH 9 ⅝" injection string to 87.46m

## 2.1 Depths and trajectory

<b>Primary Objective</b>		Delft Sandstone	
<b>Primary Objective Depth</b>		2902 m MD	2059 m TVD
<b>Total Depth</b>		3357 m MD	2318 m TVD
<b>Elevation</b>	RT – GL	8.70 m	
	GL – NAP	-1.47 m (NAP is 1.47m above ground level)	
	NAP – RT	7.23 m	

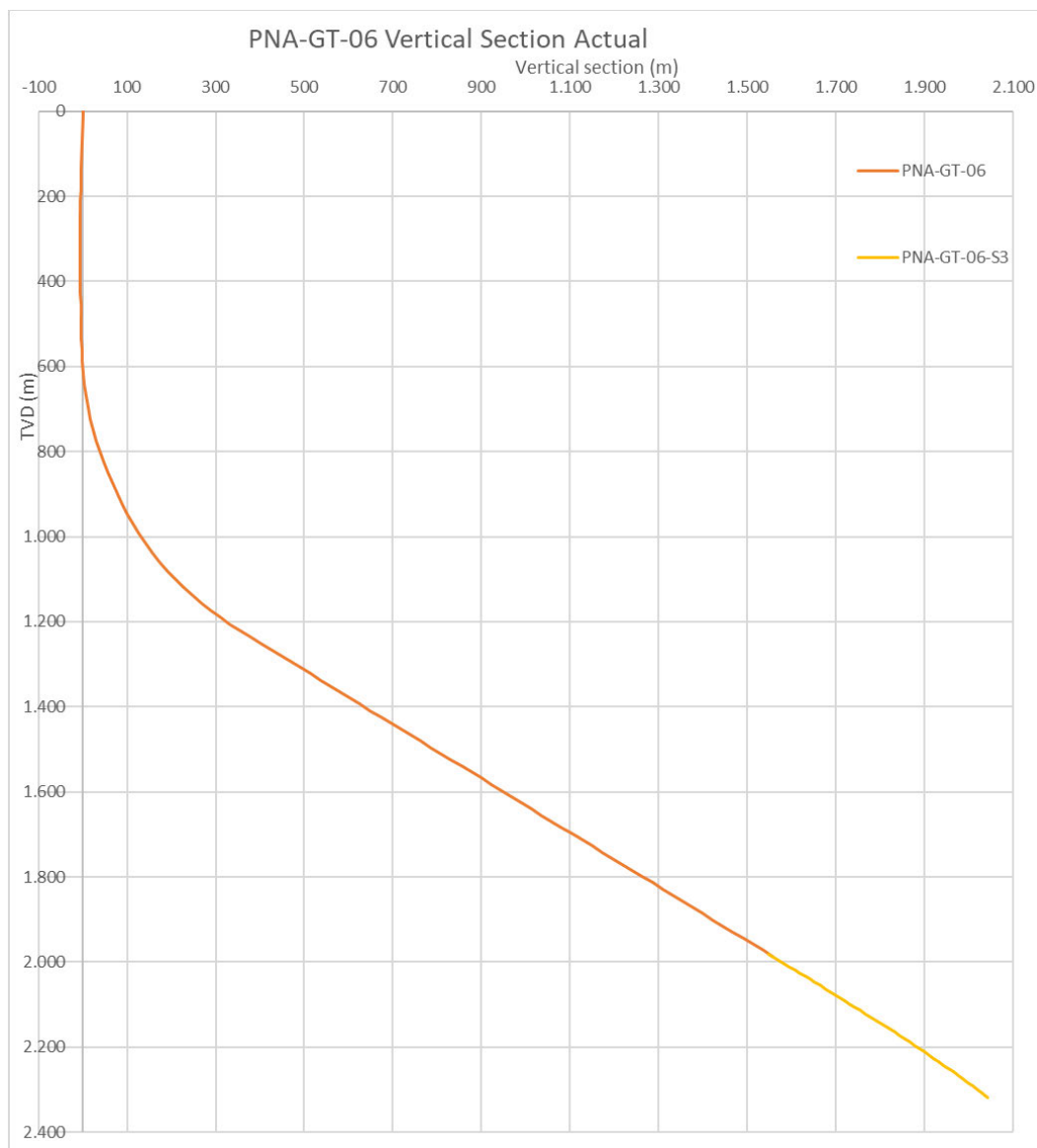


Figure 1. Vertical section

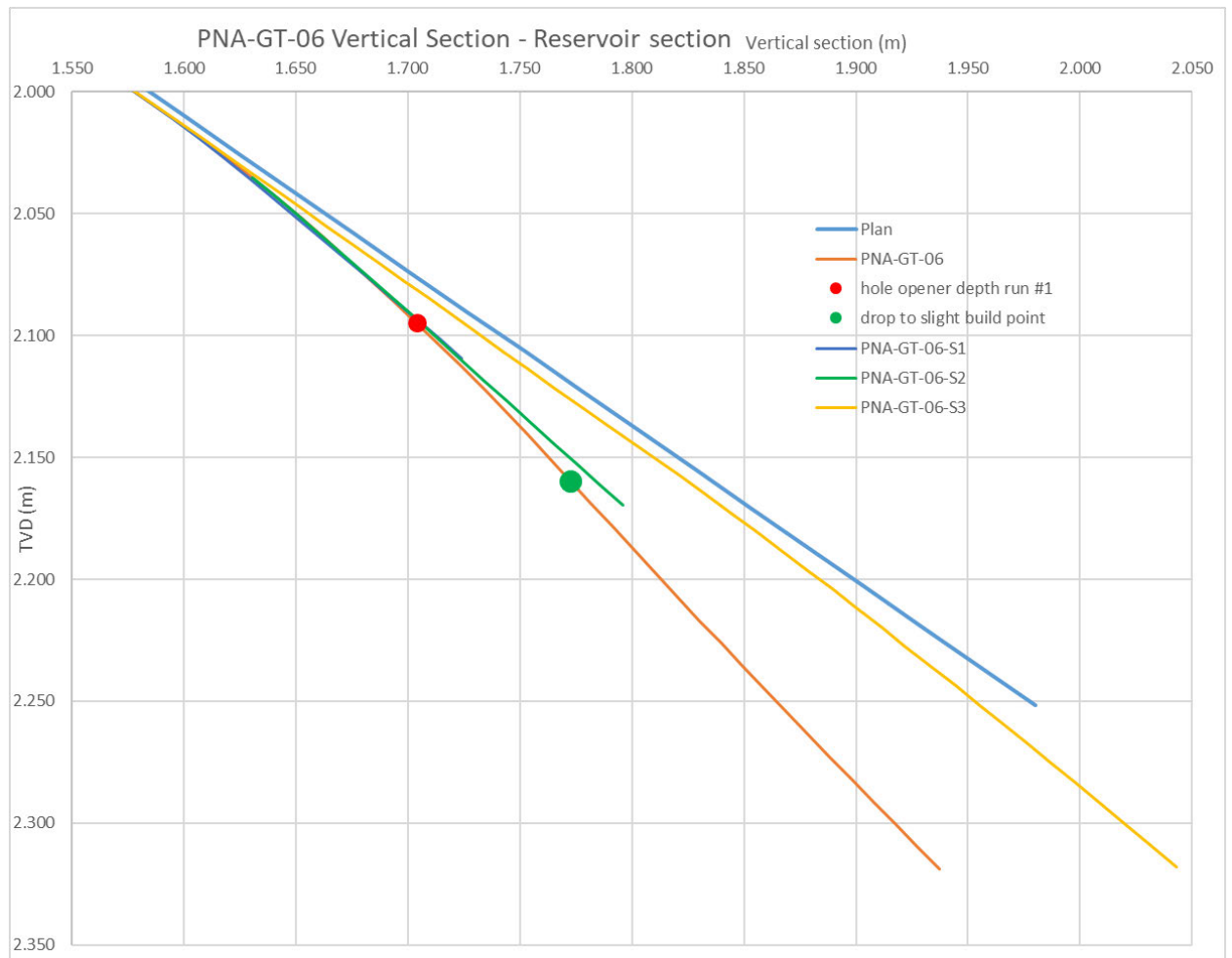


Figure 2. Detail of reservoir – Vertical section

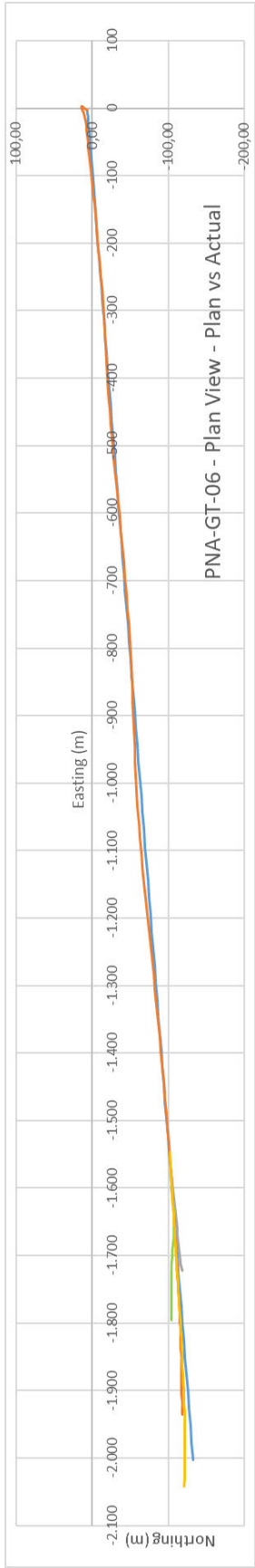


Figure 3. Plan view

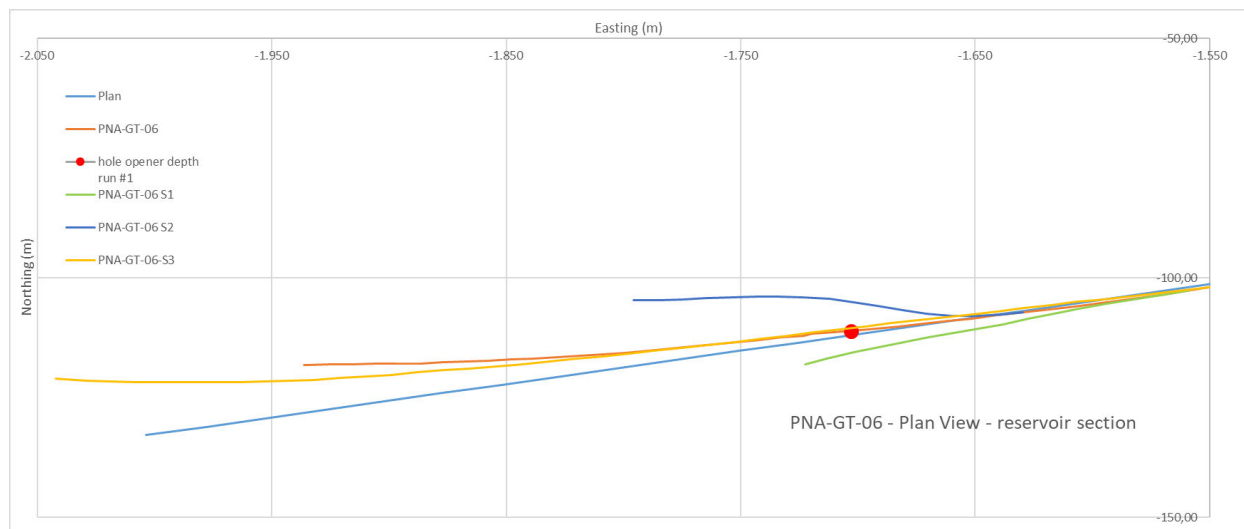



Figure 4. Detail of reservoir - Plan view

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## 2.2 Technical summary

### 2.2.1 Casing

Table 2: PNA-GT-06-S3 tubular summary

Item	Top (m MD)	Bottom (m MD)	Weight	Grade	Connection
24" Conductor	0	102	0.5" WT		BTC
13 3/8" Casing	0	927	72 ppf	L80	VAM TOP
9 5/8" Liner	861	2803	53.5 ppf	L80	VAM TOP
7" Liner	2738	2946	29 ppf	L80	VAM TOP
6 5/8" Slotted Liner	2946	3351	24 ppf	L80	VAGT


Table 3: PNA-GT-06-S3 injection string

Item	Top (m MD)	Bottom (m MD)	Weight	Grade	Connection
9 5/8" injection string	0	87.46	53.5 ppf	L80	VAM TOP

### 2.2.2 Cement

Table 4: PNA-GT-06-S3 cement summary

Item	TOC (m MD)	Lead Slurry Volume (m <sup>3</sup> )	Lead Slurry Weight (s.g.)	Tail Slurry Volume (m <sup>3</sup> )	Tail Slurry Weight (s.g.)	Type
13 3/8" Casing	Surface	79.7	1.57	10	1.67	PozzoCemoil
9 5/8" Liner	1260	76	1.57	10	1.67	PozzoCemoil

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### 2.2.3 Well schematic

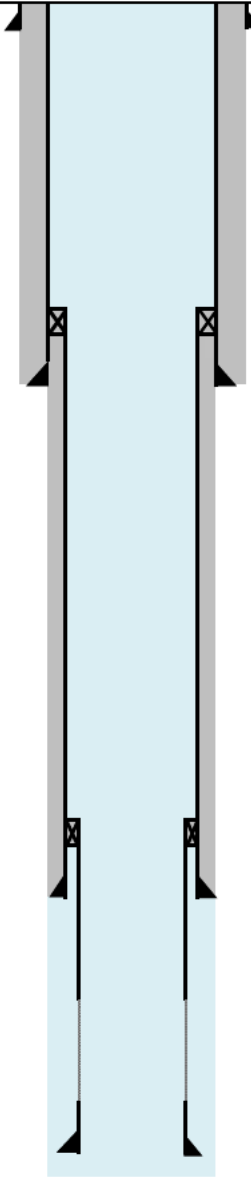

Item Description	Hanger + TWCV installed. Tubing head adapter + blind flange <b>PNA- GT- 06- S3</b>	Dept	Depth	Hole ID	Pipe OD	Collar OD	Pipe ID	
		m	m	in	in	in	in	
		tvd	ah			(nom)	(drift)	
24" Conductor		102	102	Driven	24,000	24,000	23,000	23,000
16" Hole								
13 3/8" x 9 5/8" Liner Hanger		853	861	Top of liner				
13 3/8", L-80, 72#, VAM TOP Production		914	927	16,000	13,375	14,236	12,347	12,250
12-1/4" Hole								
9 5/8" 53.5#, L-80 Production liner, SD, VAM		1970	2738	Top of liner Window in 9 5/8" casing				
		1982	2760	12 1/4	9 5/8	10,311	8,535	8,500
7" 29#, L-80 Blank joints, VAMTOP		2083	2946	8,500	7	7,644	6,180	6,059
Crossover 6 5/8" to 7"		2083	2946,5	8,500	7 x 6		5,920	
		2083	2946,5	Top 6 5/8" slotted joints				
8-1/2" Hole								
6-5/8" 24#, L-80 Slotted pipe + blanks,		2299	3325	Bottom 6 5/8" slotted joints				
		2314	3351	8,500	6,625	7,191	5,920	5,795
		2318	3357					

Figure 5: PNA-GT-06-S3 well schematic after drilling.

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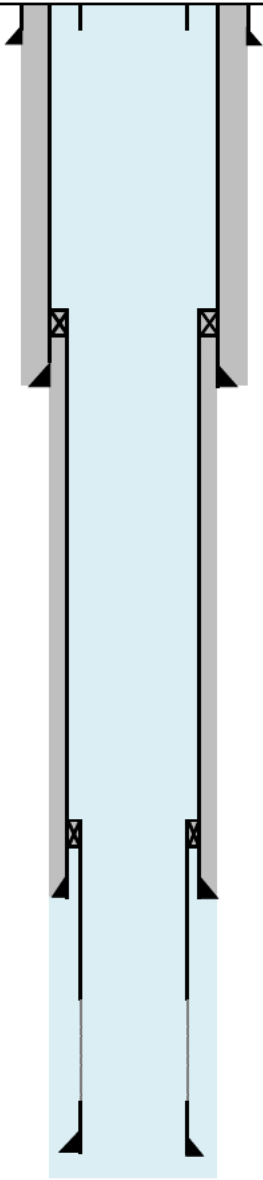
Item Description	Wellhead + X-mass tree <b>PNA- GT- 06- S3</b>	Dept	Depth	Hole ID	Pipe	Collar	Pipe ID
		h			OD	OD	
		m	m	in	in	in	in
All depths from Ground level (RT was 8,1m above GL)		h	ah			(nom)	(drift)
9 5/8" 53,5# L80 VAM TOP tubing		87	87	n/a	9 5/8	10,311	8,535 8,500
24" Conductor		94	94	Driven	24,000	24,000	23,000 23,000
16" Hole							
13 3/8" x 9 5/8" Liner Hanger		845	853	Top of liner			
13 3/8", L-80, 72#, VAM TOP Production		906	919	16,000	13,375	14,236	12,347 12,250
12-1/4" Hole							
9 5/8" 53.5#, L-80 Production liner, SD, VAM		1962	2730	Top of liner			
				Window in 9 5/8" casing			
7" 29#, L-80 Blank joints, VAMTOP		1974	2752	12 1/4	9 5/8	10,311	8,535 8,500
Crossover 6 5/8" to 7"		2075	2938	8,500	7	7,644	6,180 6,059
8-1/2" Hole		2075	2938	8,500	7 x 6		5,920
		2075	2938	Top 6 5/8" slotted joints			
6-5/8" 24#, L-80 Slotted pipe + blanks, VAGT		2291	3317	Bottom 6 5/8" slotted joints			
		2306	3343	8,500	6,625	7,191	5,920 5,795
		2310	3349				
				TD of wel			

Figure 6: PNA-GT-06-S3 well schematic after completion (reference GL) including 9.5/8" injection tubing.



### 3. Drilling fluid summary

Per section the following drilling fluid types have been used:

Table 5: PNA-GT-06 drilling fluid summary

Section	Type	Density (s.g.) Min – Max	PV (cP) Min – Max	YP (lbf/100ft2) Min – Max
16"	TriGuard – Pure bore WBM	1.08 – 1.17	7 – 15	16 – 34
12 ¼"	TriGuard – Pure bore WBM	1.16 – 1.30	10 – 22	13 – 27
8 ½" x 9 ½"	Pure-Bore Drill-in Fluid	1.09 – 1.13	9 – 13	18 – 21
8 ½" (S3)	Pure-Bore Drill-in Fluid	1.15 – 1.18	10 – 14	15 – 22

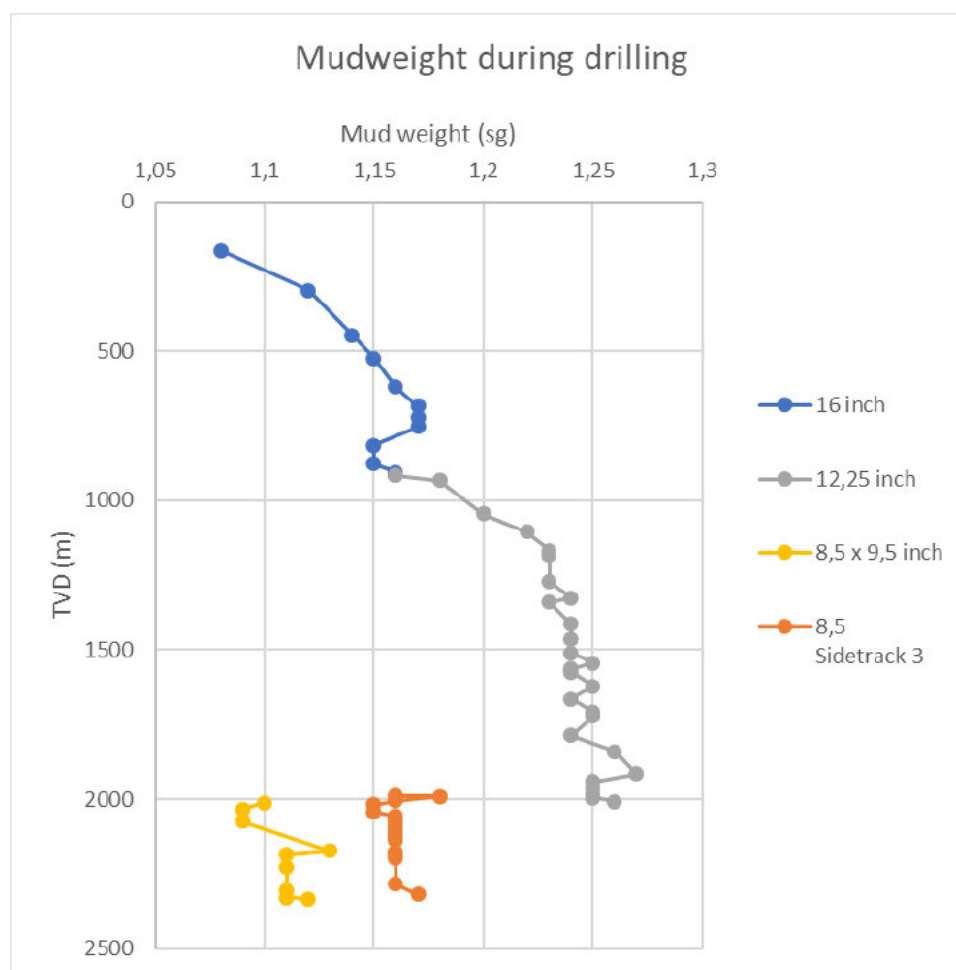


Figure 7: Mud weight vs. depth

## 4. Geology

### 4.1 Lithostratigraphic column


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

Lithostratigraphic Column PNA-GT-06-S3							Julien Smeulders		Expected		Actual	
Era	Group	Period	Formation	Epoch (Age)	Member	Lithology	TV-RT	AH-RT	TV-RT	AH-RT		
Cenozoic	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.	8,7	8,7	8,7	8,7		
			Maassluis NUMS	Early Pleistocene		Deposits of coastal sands, very fine to medium coarse, calcareous, shell and wood bearing, mica rich. Silty to sandy, grey to dark grey clay containing shells and	109	109	no gamma			
	Middle North Sea NM	Tertiary	Oosterhout NUOT	Pliocene		Succession of sands, sandy clays, and grey and greenish clays. The lower part of the formation often consists of sands that are extremely rich in shells and bryozoans.	236	236	241	241		
			Breda NUBA	Miocene		Sequence of marine, glauconitic sands, sandy clays and clays. In places a glauconite-rich layer occurs at the base.	380	380	388	388		
			Rupel NMRF	Oligocene/Eocene Rupelian to Chattian	Rupel Clay NMRF	Clays that become more silty towards basis and top. It is rich in pyrite, contains hardly any glauconite and calcium carbonate tends to be concentrated in the septaria layers.	418	418	426,5	426,5		
					Vessem NMRFV	Silty to clayey sands with a low glauconite content, flint pebbles or phosphorite nodules commonly occur at the base.	440	440	445	445		
			Landen NLLF	Late Paleocene Thanetian	Landen Clay NLLFC	Generally dark-green, hard, flaky clay, somewhat silty, containing glauconite, pyrite and mica. The basal part of the member can be marly and of a lighter colour.	442	442	450	450,5		
Chalk CK	Cretaceous	Ommelanden CKGR	Upper Cretaceous Turonian to Maastrichtian		Succession of white, yellowish-white or light-grey, fine grained limestones, in places argillaceous. Layers of chert nodules can be very common over thick intervals. Along the basin edge coarse, bioclastic limestones and tongues of sandstone occur.	460	460	469	469			
Texel CKTX		Cenomanian	Plenus Marl CKTXP	Dark-grey, partly black, calcareous, laminated claystone.	745	746	756	759				
			Texel Marlstone CKTXM	White to light-grey (locally pinkish) limestones, marls and marly chalks.	750	751	762	764,5				
Rijnland KN		Holland KNGL	Lower Cretaceous Late Albian	Upper Holland Marl KNGLU	Light-grey and red-brown marls, characterised by a carbonate content which gradually increases towards the top.	790	792	787	791 9 5/8" casing shoe @ 2803m			
			Late Aptan 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.	984	1005	995,5	1019			
			Early Albian	Holland Greensand KNGLG	Alternation of greenish grey, very glauconitic, very fine- to fine-grained, argillaceous sandstones, locally siltstones with calcareous or sideritic cement, and olive-grey claystones or grey marlstones.	1069	1111	1047,5	1083,5			
			Early Aptian	Lower Holland Marl KNGLL	Grey and red-brown marl or calcareous, fissile claystone, frequently with intercalated bituminous claystone beds and sandstone beds.	1174	1265	1179,5	1271			
		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.	1335	1558	1338,5	1561			
			Late Barremian	Vlieland Clay KNNSM	Dark brownish-grey to grey claystone. Mica and very fine lignitic matter are common. The formation can be very silty to sandy with many intercalated siltstone and very fine sandstone beds. Slightly calcareous.	1391	1661	1389	1656			
			Late Hauterivian to Mid Barremian	Berkel Sandstone KNNSB	Sandstone, light-grey, very fine- to fine- and medium- to coarse-grained, locally gravelly, lignitic, locally glauconitic or with sideritic concretions. Especially in the upper part calcareous cemented beds are common.	1843	2491	1882,5	2573			
			Late Hauterivian to Early Barremian	Berkel Sand-Claystone KNNSB	Alternation of fine-grained, argillaceous sandstones and brown-grey silty to sandy claystones. Locally sideritic concretions are present.	1894	2585	1924	2651			
		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.	1932	2654	1930,5	2663,5				
		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.	1940	2670	1950	2699,5 Siderack started at 2763m MD		
Valanginian				Delft Sandstone SLDND	Light-grey massive sandstone sequence, fine to coarse-gravelly, fining upward, lignitic. Shale/claystone intercalations.	2056	2890,5	2059	2902			
Lower Cretaceous to Upper Jurassic Ryzanian to Valanginian				Albasserdam SLDNA	Variegated claystones (grey, red, oker yellow, brown) and siltstones, fine to medium grained sandstone beds and massive, thick-bedded, coarse grained sandstones. Coal, lignite beds, shells and siderite are common.	2290,5	3232	(2309)	(3343)			
RT - NAP = 7,23m; NAP - GL = 1,47m above GL; RT - GL = 8,7m							TD		2318	335,5		

RT - NAP = 7,23m; NAP - GL = 1,47m above GL; RT - GL = 8,7m

TD 2318 3357

Table 6: PNA-GT-06-S3 geological lithostratigraphic column

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## 4.2 Hydrocarbons

No hydrocarbons were seen in the well

## 5. Well suspension status

### 5.1 Well status before completion

The well was suspended with an injection 8 5/8" casing pup joint below the tubing hanger at 14m BRT. Seals were pressure tested with 50/210 bar. TWCV was installed and pressure tested with 20-100 bar. BOP stack was nipped down. Installed Tubing head adapter flange & 7 1/16" blind flange and pressure tested 40/210bar.

### 5.2 Well suspension schematic

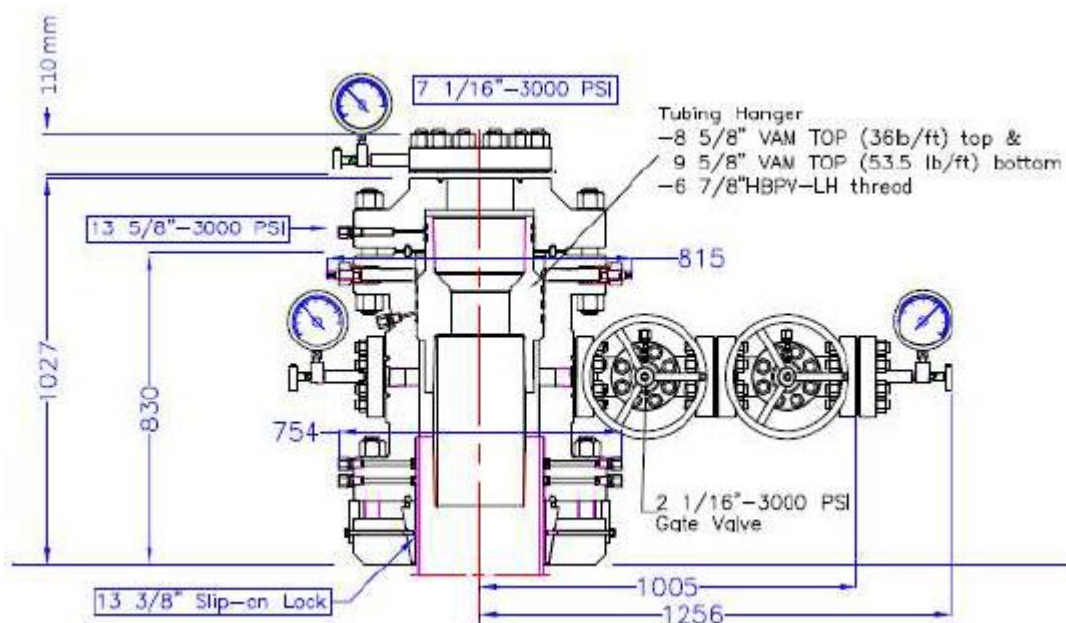


Figure 8: PNA-GT-06-S3 well suspension

### 5.3 Well status after completion

After installation of the injection string in PNA-GT-06-S3 the well was completed with the tubing head adapter and two 7 1/16" gate valves.

### 5.4 Wellhead and Christmas tree drawing

Below is drawing of the final installation.

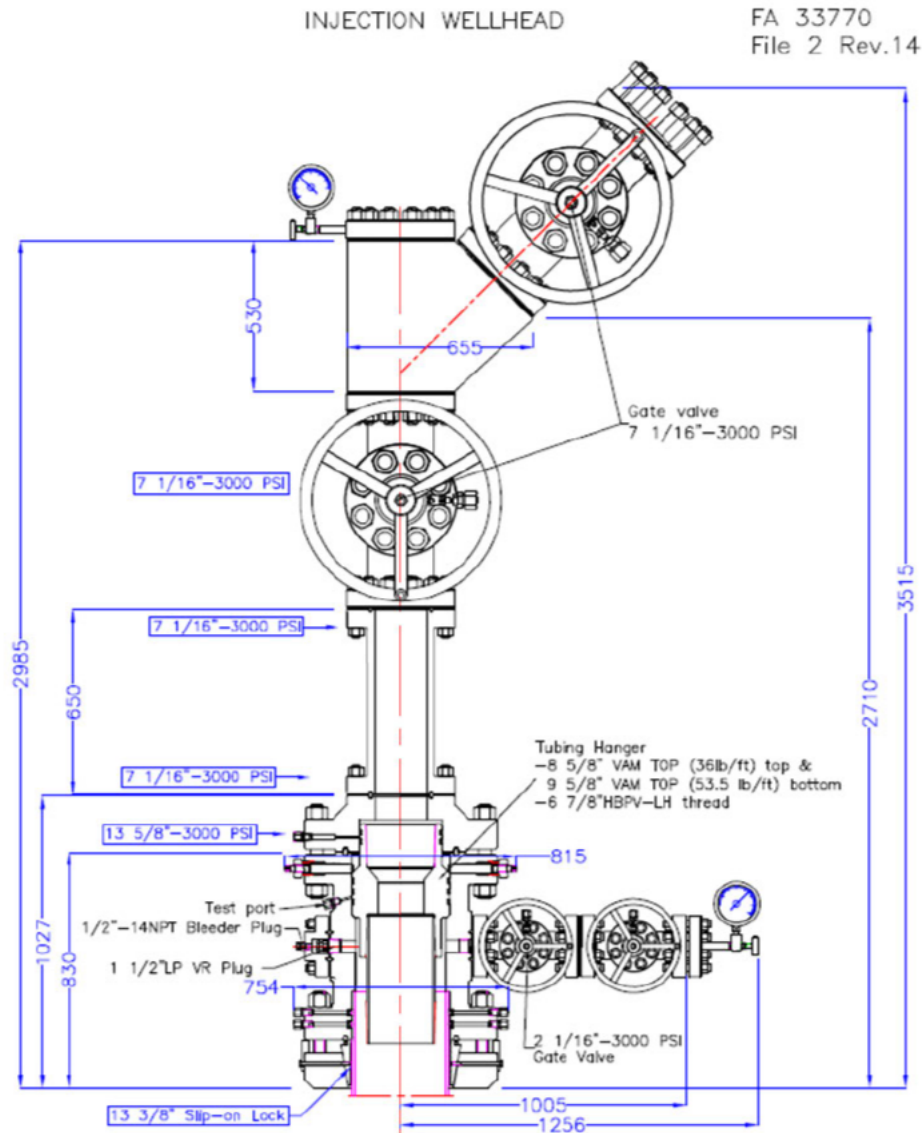



Figure 9: PNA-GT-06-S3 well head and Christmas tree drawing

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## 6. HSE performance

### 6.1 *General*

To ensure that the operation is carried out in a safe manner, several HSE tools have been implemented both by Ammerlaan Geothermie B.V. and Innodrill.

Innodrill's Permit to Work system was a tool used in order to perform additional activities outside regular drilling activities that carry a potential risk. Both the Toolpusher's and DSV's approval were required for a Permit to Work to come into effect.

Other HSE tools utilized on location were:

- Toolbox meeting during every shift change of rig contractor (06:45 & 18:45)
- Pre-job safety meetings (PJSM) before every non-drilling operation (casing running, cementing, well-test etc.)
- General safety meetings with rig crews
- O-card system of Innodrill
- Regular HSE inspections carried out by HSE coordinator
- Weekly HSE meeting day and night shift.

Total exposure hours: 35,800

SodM inspections: 22-05-2018, 23-06-2018

### 6.2 *Incidents*

- 26 April 2018. Greenhouse glass damaged by truck
- 10 May 2018. Collapsed drill pipe as a result of leaving annular preventer closed after BOP test
- 11 June 2018. Back injury after falling backwards from cutting skip (LTI)
- 1 August 2018. Leg injury as result of handling rotary insert bushings

### 6.3 *HSE card overview*


429 O-cards were submitted during PNA-GT-06 / S1 / S2 / S3

### 6.4 *Drills / Emergency exercises, inspections & audits*

Drill / emergency exercises:

- Fire drills: 1/7/2018, 16/07/2018, 04/08/2018,
- Muster drills: 11/05/2018, 27/05/2018, 10/06/2018, 20/06/2018, 1/7/2018, 23/07/2018, 29/07/2018, 4/08/2019
- Kick drills: 19/06/2018, 23/06/2018, 29/06/2018, 7/07/2018, 16/07/2018, 22/07/2018, 4/08/2018, 09/08/2018,
- BOP tests: 10/05/2018, 16/06/2018, 03/07/2018, 10/07/2018, 1/08/2018,
- SodM visits: 22/5/2018, 24/5/2018, 23/07/2018, 03/08/2018



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