

Geological report Polanen

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PanTerra Project G1421

Geological report Polanen

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1 Samenvatting (Nederlands)

1.1 Geplande doubletten en toegepaste parameters

Dit report geeft een samenvatting van het geothermisch potentieel van het geplande doublet MON-GT-01 en -02 in de Monster 2 geothermische opsporingsvergunning in de gemeente Westland, provincie Zuid-Holland. Productie en injectie zal gebeuren binnen de Monster 2 licentie. Het Monster 2 gebied is eigendom van Energie Transitie Partners B.V. (ETP), de ontwikkelaar van het project. De exploitant van het project zal HVC N.V. zijn, of één van zijn dochterbedrijven zoals beschreven in de “Haalbaarheidsstudie SDE+ Polanen”, bijgevoegd bij de SDE subsidie aanvraag. HVC N.V. is 50% aandeelhouder van ETP, de andere 50% is van Capturam B.V.

Het beoogde reservoir zijn de fluviatiele zandafzettingen van het Delft Zandsteen Laagpakket (onderdeel van de Schieland Groep). Dit reservoir is al succesvol getest door naastgelegen geothermische putten NLW-GT-01 en -02, en HON-GT-01 en -02. De eerste van deze putten wordt geopereerd door Trias Westland B.V. HVC N.V. is aandeelhouder in zowel Trias Westland B.V. als ETP B.V. Het nieuwe doublet zal bestaan uit twee putten, injectie- MON-GT-01 en productieput MON-GT-02 (Figure 3-1). De geproduceerde warmte zal gebruikt worden voor de verwarming van kassen en voor stadsverwarming. Dit rapport zal gebruikt worden om de SDE+ aanvraag voor het nieuwe doublet en het toekomstig putontwerp te ondersteunen.

Het energiepotentieel van het doublet is berekend met DoubletCalc 1.4.3, een afbeelding van de ingevoerde parameters is te zien in **Error! Reference source not found.** Het drukverschil van de pomp is ingesteld op 86 bar (zie sectie 10.3). Het drukverschil van de pomp is op dit moment beperkt door het maximale debiet door de buis, welke 525 m³/uur is. Een lagere druk zal leiden tot een lager debiet en een vermindering van het geothermisch vermogen (Figure 2-4), maar zal leiden tot een toename in de COP. De permeabiliteit van het reservoir is de belangrijkste onzekerheid aangezien dit een grote invloed heeft op het vermogen van het doublet. Dit is weerspiegeld door het bereik van de permeabiliteit en de daaraan gerelateerde P10, P50 en P90 geothermisch vermogen schattingen (**Error! Reference source not found.** en Figure 2-2).

1.2 Verwacht geothermisch potentieel

De P50 geothermisch vermogen schatting is 29.2 MW, de P90 vermogen schatting is 22.2 MW. De relevante DoubletCalc afbeeldingen zijn weergegeven in **Error! Reference source not found.** tot Figure 2-4.

2 Summary

2.1 Planned doublets and applied parameters

This report summarizes the geothermal potential of planned doublet MON-GT-01 and -02 in the Monster 2 geothermal exploration concessions in the municipality of Westland in the province Zuid-Holland. Production and injection will occur within the Monster 2 concession. The Monster 2 concession is owned by Energie Transitie Partners B.V. (ETP), the developer of the project. The operator of the project will be HVC N.V. or one of its subsidiary B.V.'s as described in the “Haalbaarheidsstudie SDE+ Polanen” attached to the SDE subsidy request. N.V. HVC is 50% shareholder of ETP, the other 50% is held by Capturam B.V.

The target reservoir is the fluvial sands in the Delft Sandstone Member (part of the Schieland Group). This reservoir have already been successfully tested by nearby geothermal wells NLW-GT-01 and -02 and HON-GT-01 and -02. The first two of those wells are operated by Trias Westland B.V. HVC B.V. is a shareholder in both Trias Westland and ETP B.V. The new doublet will consist of two wells, injector MON-GT-01 and producer MON-GT-02 (Figure 3-1) and the produced heat will be used for greenhouse heating and district heating. This report will be used to underpin the SDE+ application for the new doublet and for future well design.

The doublet performance has been calculated with DoubletCalc 1.4.3, a screenshot of the input parameters is shown in **Error! Reference source not found.** The pump pressure difference is set to 86 bar (see section 10.3). The pump pressure difference is current restricted by the maximum flowrate possible through the tubing which is 525 m³/h. Lower pressures will result in lower flow rates and decrease in geothermal power (Figure 2-4) but would increase the COP. The permeability of the reservoir is the most significant uncertainty as it has major impact on the doublet

performance. This is reflected by the permeability range and the related P10, P50 and P90 geothermal power estimates (**Error! Reference source not found.** and Figure 2-2).

DMO Doublet Calculator 1.4.3

number of simulation runs (-) 1000 Calculate! Open Scenario Save Scenario Exit Program

file: ...geoscience\1421 etp polanen sde\2. data\report work files\doubletcalc\polanen 560 max3.xml

Geotechnical input

A) Aquifer properties

Property	min	median	max	Property	value
aquifer permeability (mD)	330	550	1000	aquifer kh/kv ratio (-)	3.8
aquifer net to gross (-)	0.9	0.93	0.98	surface temperature (°C)	10
aquifer gross thickness (m)	60	70	90	geothermal gradient (°C/m)	0.0325
aquifer top at producer (m TVD)	2055.0	2283	2511.0	[mid aquifer temperature producer (°C)]	0
aquifer top at injector (m TVD)	2036.0	2262	2488.0	[initial aquifer pressure at producer (bar)]	0
aquifer water salinity (ppm)	120000	140000	160000	[initial aquifer pressure at injector (bar)]	0

B) Doublet and pump properties

Property	value
exit temperature heat exchanger (°C)	31
distance wells at aquifer level (m)	1300
pump system efficiency (-)	.70
production pump depth (m)	900
pump pressure difference (bar)	80

C) Well properties

calculation length subdivision (m) 50

Producer					Injector				
outer diameter producer (inch)					outer diameter injector (inch)				
8.5					8.5				
skin producer (-)					skin injector (-)				
0					0				
penetration angle producer (deg)					penetration angle injector (deg)				
31					55				
skin due to penetration angle p (-)					skin due to penetration angle i (-)				
-0.07					-1.08				
Segment	pipe segment sections p (m AH)	pipe segment depth p (m TVD)	pipe inner diameter p (inch)	pipe roughness p (milli-inch)	Segment	pipe segment sections i (m AH)	pipe segment depth i (m TVD)	pipe inner diameter i (inch)	pipe roughness i (milli-inch)
1	800	800	7.921	1.8	1	150	150	9.760	1.8
2	980	980	12.347	1.8	2	980	980	12.347	1.8
3	2315	2219	14.868	1.8	3	2875	2219	14.868	1.8
4	2391	2283	9.760	1.8	4	2945	2262	9.760	1.8
5					5				
6					6				

Figure 2-1: DoubletCalc 1.4.3 input screen for the planned MON-GT-01 and MON-GT-02 doublet.

2.2 Expected geothermal power

The P50 geothermal power estimate is 29.2 MW, the P90 power estimate is 22.2 MW. Relevant DoubletCalc screenshots are displayed in **Error! Reference source not found.** to Figure 2-4.

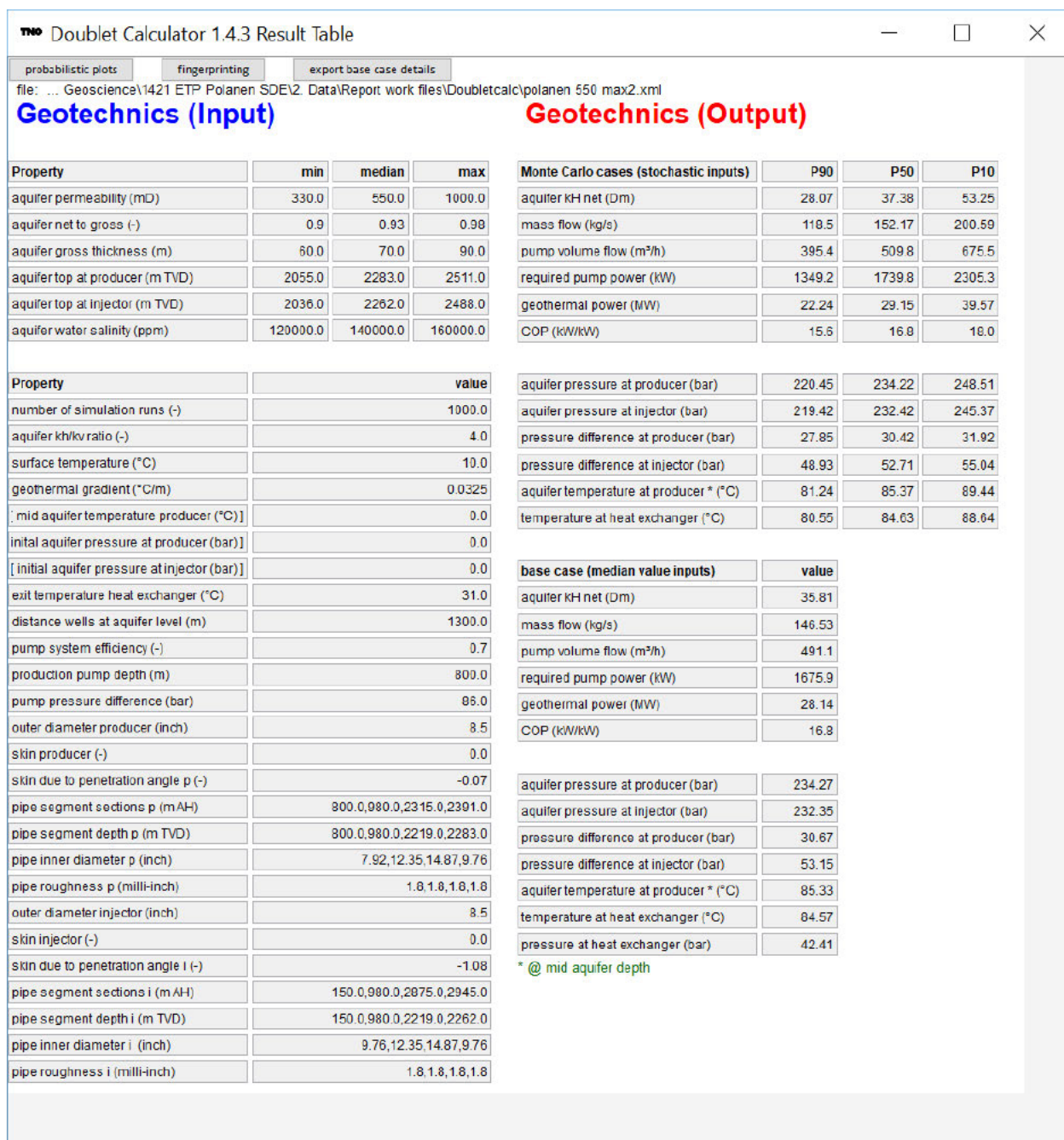


Figure 2-2: Output screen from DoubletCalc for the planned MON-GT-01 and MON-GT-02 doublet.

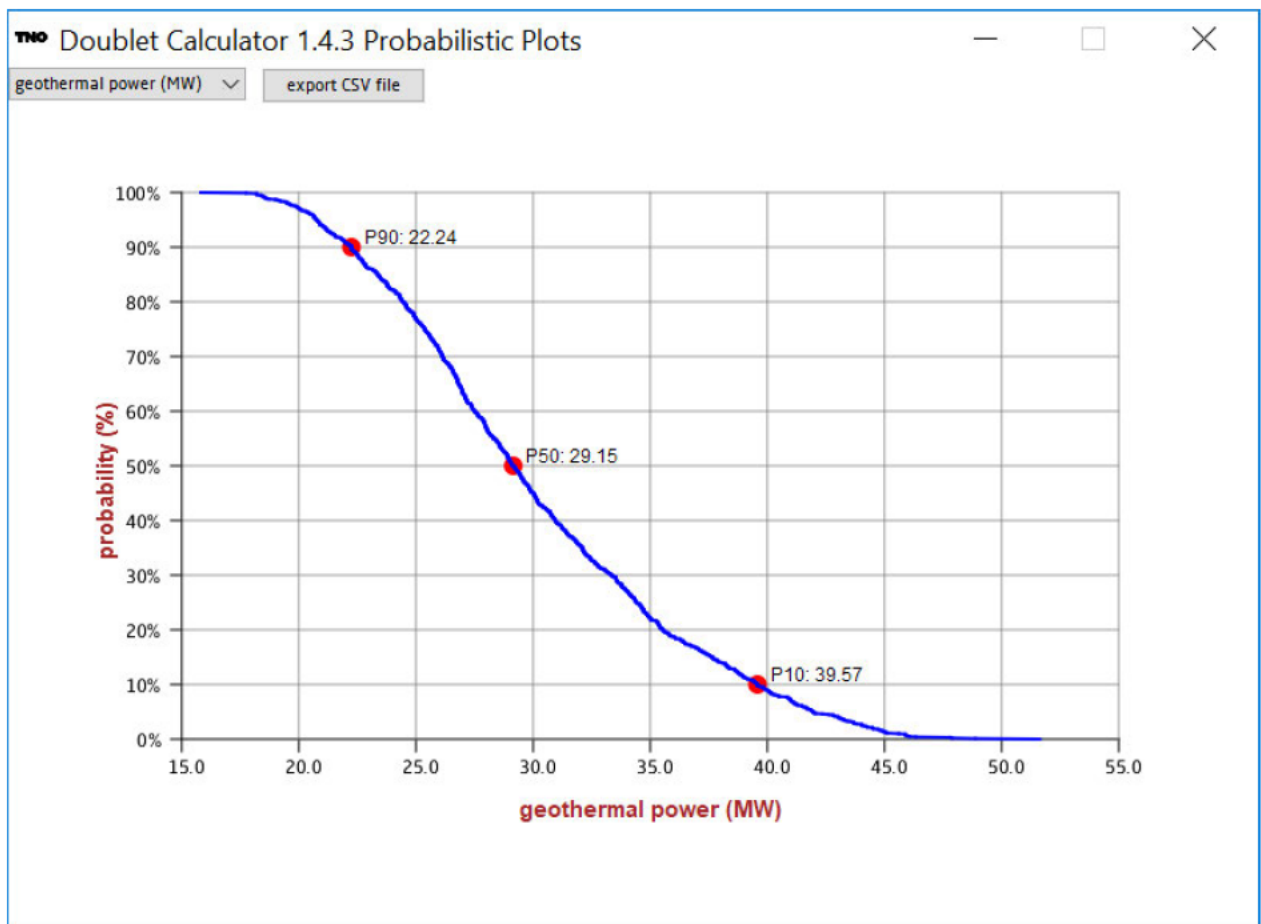


Figure 2-3: Probability versus geothermal power for the planned MON-GT-01 and MON-GT-02 doublet.

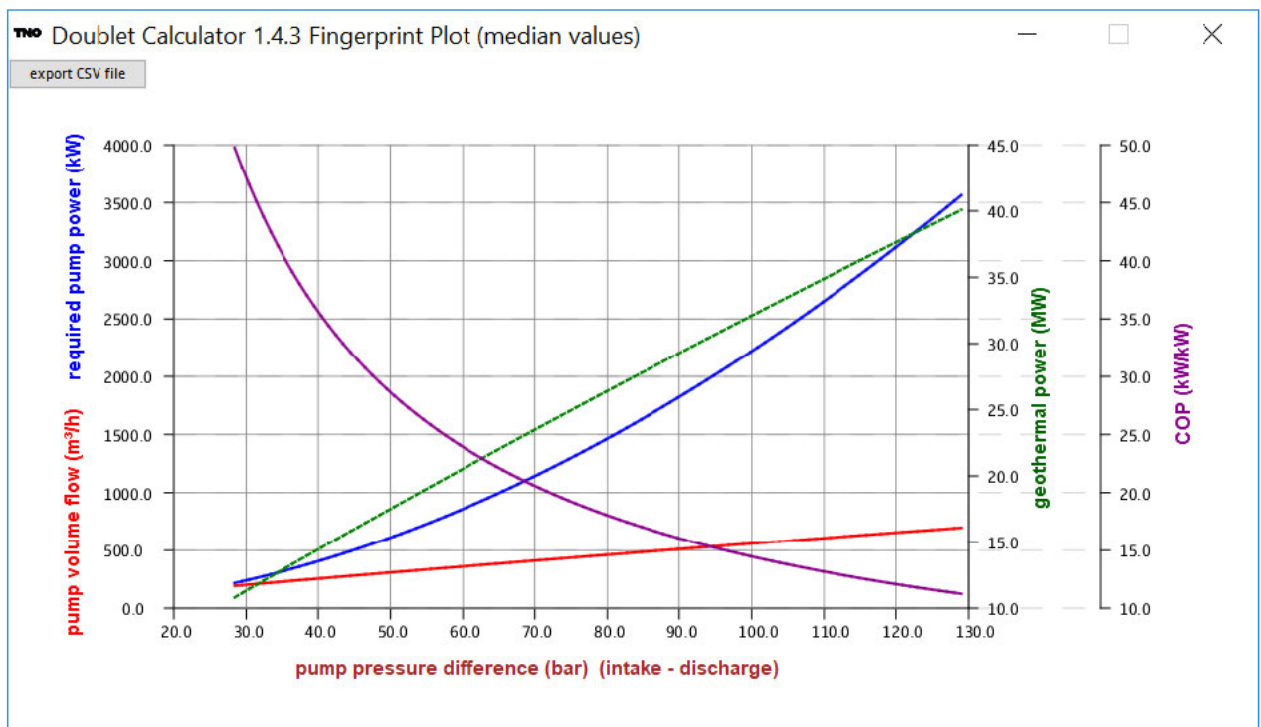


Figure 2-4: Fingerprinting plot for the Delft sandstone reservoir in the planned MON-GT-01 and MON-GT-02 doublet.

3 Doublet location and wells

3.1 Doublet Location

The planned doublet is located in the municipality of Westland, in the geothermal exploration licences Monster 2 owned by Energie Transitie Partners B.V. A detailed geological study has been performed of a larger area which also included exploration licences Naaldwijk 3, Naaldwijk 2II, De Lier V and De Lier IV (Figure 3-1). The reservoir properties and maps produced during that detailed geological study are presented in this report.

3.2 Wells

The new doublet will consist of two wells; injector MON-GT-01 and producer MON-GT-02. The locations of the two wells are displayed in Figure 3-1.

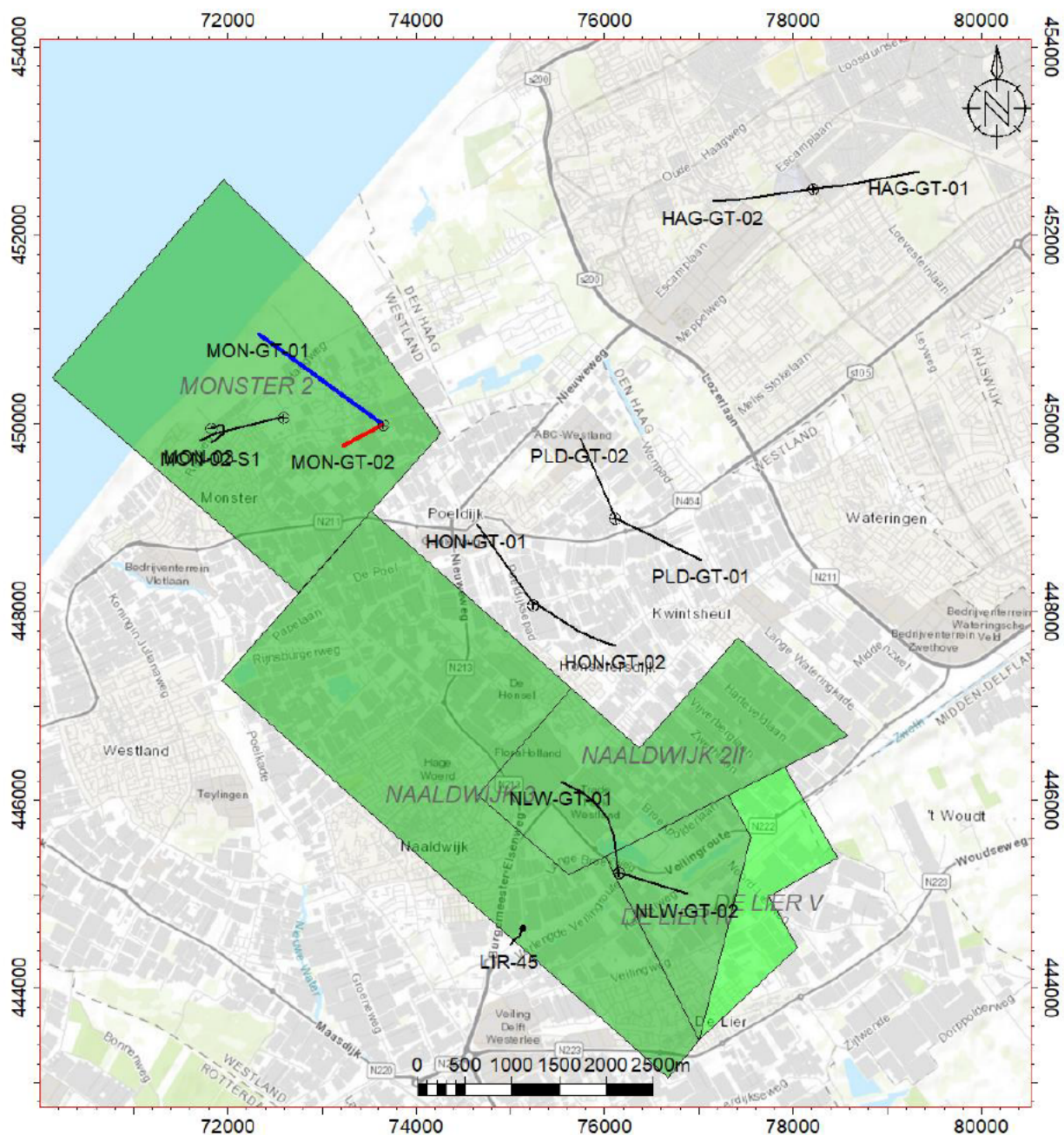


Figure 3-1: Map view of the study area and planned doublet (MON-GT-01 and MON-GT-02). The exploration licences are coloured (dark green for granted and light green for applied). The well trajectory of the producer is shown in red, the injector in blue. Nearby wells, used in this study have been added as well.

4 Application SDE+ Garantieregeling

This report forms the basis of an SDE+ application.

4.1 Application SDE+

SDE+ application is performed for a full doublet, consisting of two new wells, MON-GT-01 and -02.

5 Geological setting

5.1 Structural setting

The study area is located in the West Netherlands Basin which is an inverted rift basin (Figure 5-1). Sediments in this basin range in age from Jurassic to recent and are overlying Triassic and older sediments. The Upper Jurassic and Lower Cretaceous (Figure 5-2) start with the continental sediments of the Nieuwerkerk Formation. These sediments were deposited in subsiding half-grabens, while adjacent highs were subjected to erosion. In the Nieuwerkerk Formation, the Delft Sandstone (Figure 5-3) has good reservoir properties in general. The Delft Sandstone is interpreted to be deposited as stacked distributary-channel deposits in a lower coastal plain setting resulting in massive sandstone sequences. The thickness of the Delft Sandstone is influenced by the syn-rift deposition of the sediments and therefore the Delft Sandstone is of variable thickness, thicknesses of up to 130m are observed. The sandstone consists of fine- to coarse-grained sand, the lateral continuity is difficult to predict.

At the base of the marine Rijnland Group the Rijswijk Sandstone Member, the Berkel Sandstone Member and the Berkel Sand-Claystone Member can be found (Figure 5-2 and Figure 5-3). These members are expected to be good aquifers for geothermal exploitation. The Rijswijk Sandstone consists of coastal sands. The majority of the Rijswijk Sands were deposited as basal transgressive sands unconformably over an uneven surface of the Nieuwerkerk Formation. This caused a reworking of the underlying Nieuwerkerk Formation and an infill of the existing paleotopography. The paleotopography was related to the existing active syn-sedimentary faults that caused variation in thicknesses of 0 to 70 m of the Rijswijk Sandstone Member. The Rijswijk Sands consist of fine-to coarse-grained, cross-bedded sandstone with some thin lagoonal shale intercalations, marine fossils and glauconite. The Berkel Sandstone Member comprising E-W oriented coastal barrier sand or beach complexes is deposited along the fringe of the West Netherlands Basin. It consists of very fine- to medium-grained sandstone. The Berkel Sand-Claystone Member was deposited in a similar setting but comprises more claystone intervals than the Berkel Sandstone. The Berkel and Rijswijk sandstones combined are referred to as the Vlieland formation.

In the Late Cretaceous, during the deposition of the Chalk Group, the West Netherlands Basin was inverted. This was accompanied by compressional movements and resulted in convergent oblique-slip faulting, general uplift, erosion and basin inversion, which reactivated pre-existing normal faults. The major tectonic feature in the region of the license is a NW-SE trending inverted 'pop-up' anticline. The structure is bounded by two faults.

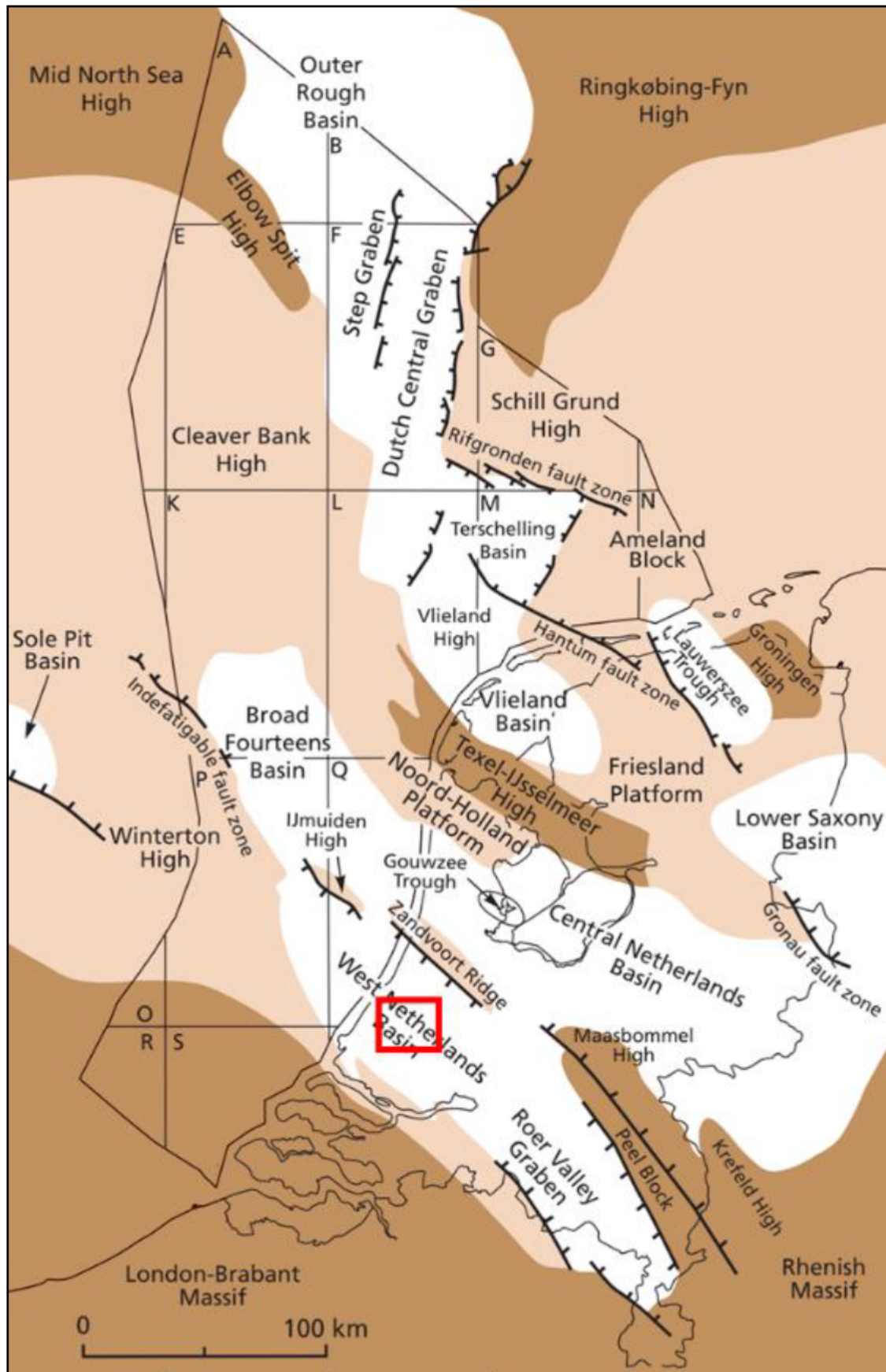


Figure 5-1: Structural elements of Late Jurassic and Early Cretaceous in the Netherlands (from Herngreen & Wong, 2007). The area of interest is highlighted by the red square. Dark brown: structural high, partly subaerial landmass; light brown: platform, intermittently flooded; white: basin.

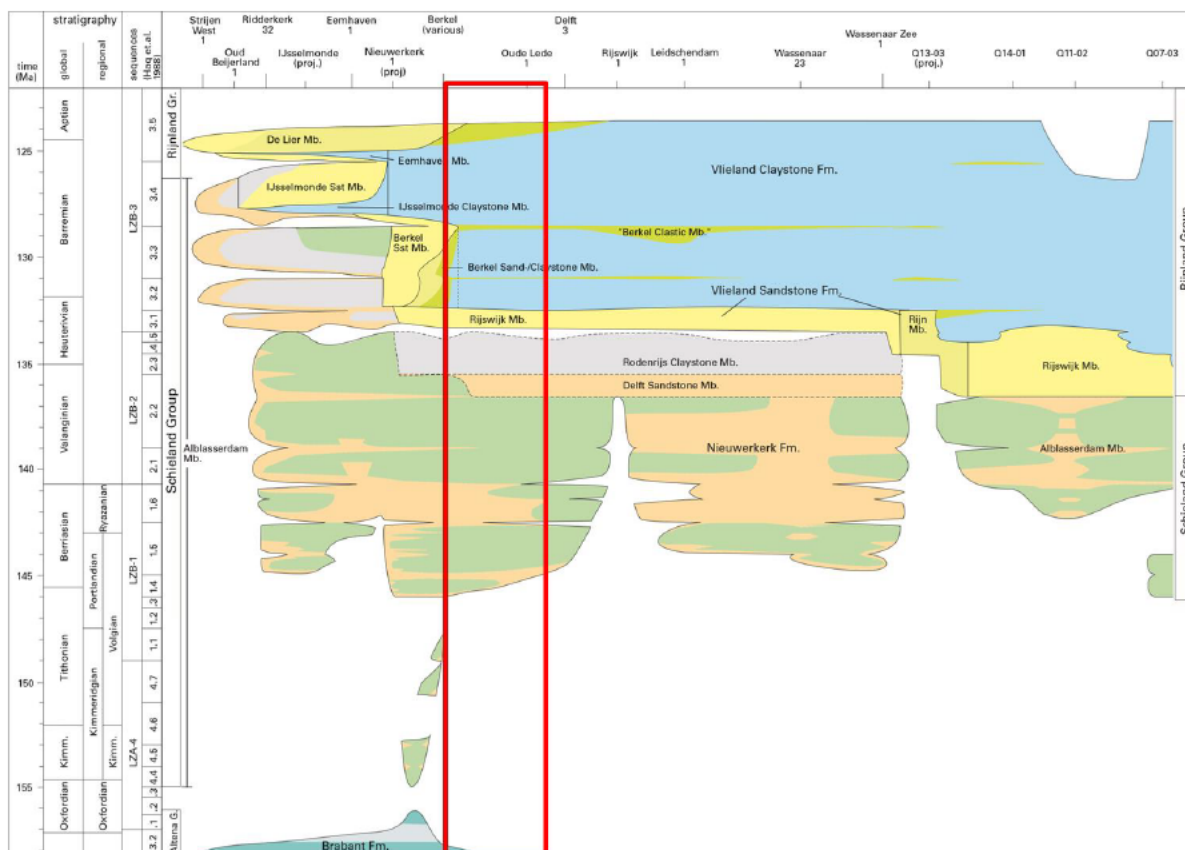


Figure 5-2: Stratigraphy of the West Netherlands Basin. The red rectangle shows the schematic stratigraphy in the subsurface of the area of interest (from van Adrichem Boogaert & Kouwe, 1994).

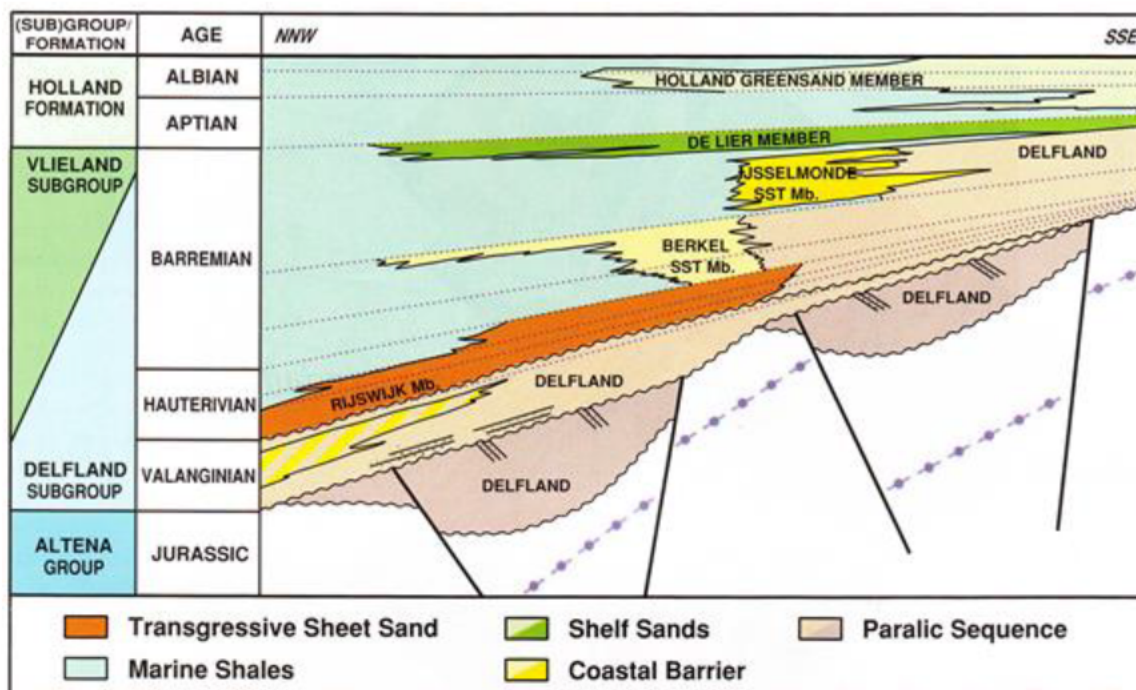


Figure 5-3: Schematic Lower Cretaceous stratigraphy of the West Netherlands Basin. The diagram illustrates the stratigraphic position and geometry of several reservoir layers in this basin (from Racero-Banea & Drake, 1996).

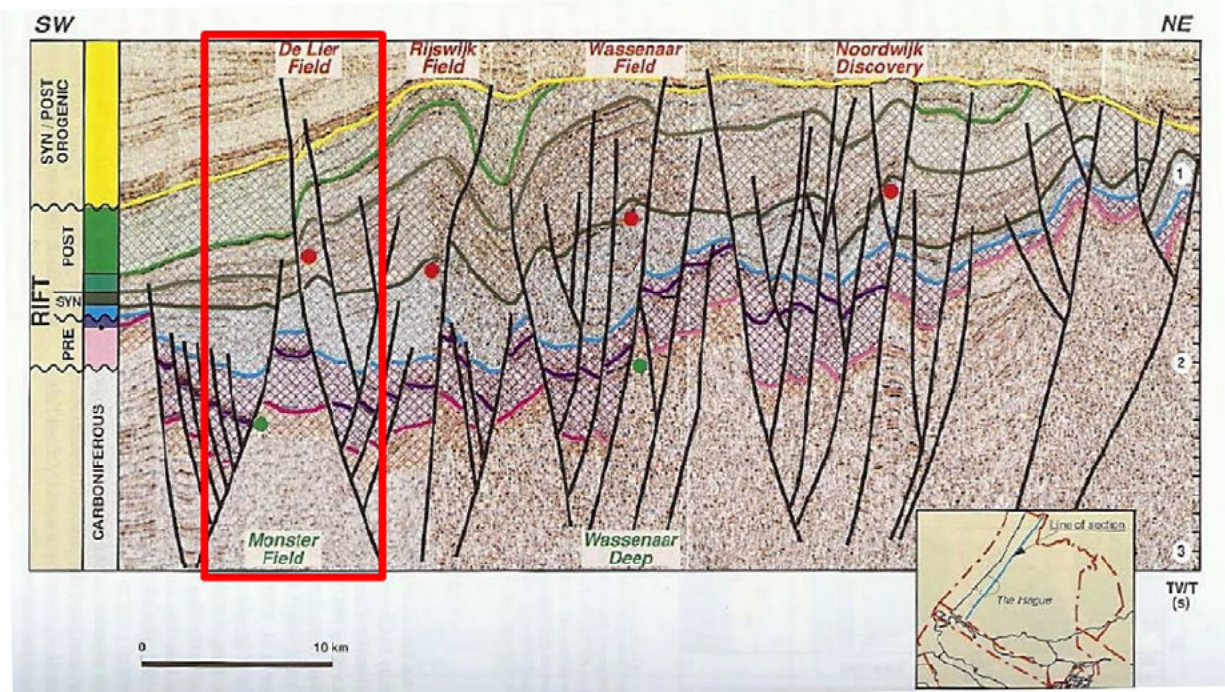


Figure 5-4: Published seismic section showing the structures which dominate the study area. The figure was published by Racero-Baena and Drake (1996). The horst structure related to the De Lier Field extends towards the Southeast. The planned geothermal wells are situated on the southern part of the horst.

5.2 Risk of encountering hydrocarbons

The study area is in a basin with a mature oil and gas source, the Posidonia Formation (De Jager et al. 1996) that has generated and still is generating large quantities of oil and gas. Many oil and gas fields are present in close proximity to the proposed doublet (Figure 5-6). Hydrocarbons can be present in two forms: 1) oil and gas accumulations or 2) gas dissolved in formation water and oil dispersed in formation water.

The seismic around MON-GT-01 shows an area of increased amplitude (see Figure 10-2). Also, there is an independent closure to the north of the well which can be observed on the top and base reservoir map (see Figure 7-2 and Figure 7-3). The map shown in Figure 5-5 shows the RMS-amplitude of the section between the top and the base of the reservoir with the top reservoir contours overprinted. It shows that anomaly is roughly following the -2,235 m TVDss contour which may be an indication of (dissolved) gas. However, the RMS amplitudes also show an anomaly past the saddle towards MON-02 and -03. Since these wells don't free show gas in the Delft, this anomaly does not indicate free gas and could, just as the northern anomaly be related to other effects.

In order to avoid drilling into a possible gas reservoir, the MON-GT-01 well is planned below the -2,235 m TVDss contour. Also, this well is assigned an injector to avoid gas production. The anomaly will be further investigated and discussed with the NAM. As such, a more recent processing will have to be interpreted to discuss any further implications, because the quality of the used seismic is relatively poor in this section.

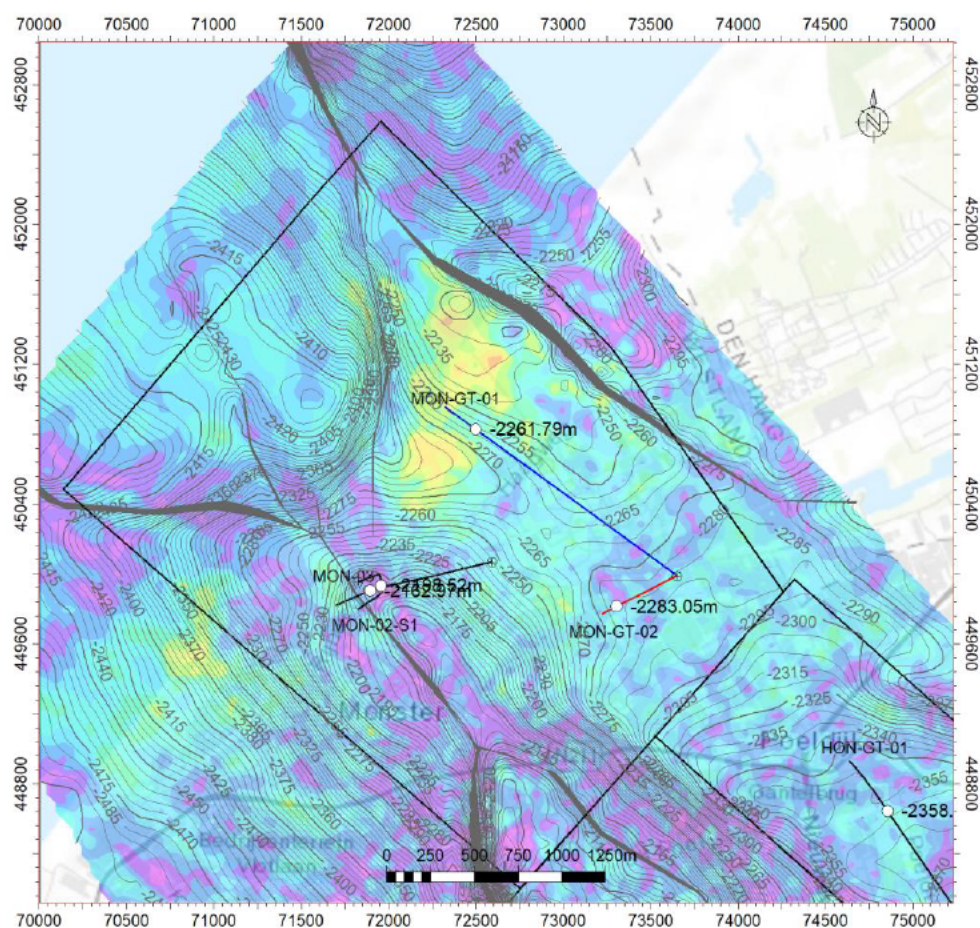


Figure 5-5: RMS amplitude map made between top and base reservoir with the contours of the top overprinted.

5.2.1 Traps with accumulations of free oil and/or gas

Several oil and gas fields are present near the planned doublet (**Error! Reference source not found.**). De Gaag and Maasdijk fields produce gas from the Triassic Buntsandstein, the De Lier field produces oil and gas from the Cretaceous De Lier Member and Holland Greensand Member. None of these fields have produced or produce from the Delft sandstone, the target geothermal reservoir.

Table 5-1: Oil- and gas fields near the planned doublet.

Field	Content	Status	Reservoir
De Lier	Oil & Gas	Producing	De Lier Member/Holland Greensand Member
Gaag	Gas	Producing	Bunter
Maasdijk	Gas	Producing	Bunter

5.2.2 Hydrocarbons dissolved or dispersed in formation water

In most surrounding geothermal wells, dispersed oil and/or dissolved gas is present in the produced formation water from the reservoirs (Vlieland Sandstone Formation and/or Nieuwerkerk Formation). The reservoirs acted and may still act as migration paths for hydrocarbons. Four out of the six doublets in the West Netherlands Basin (Table 5-2) co-produce gas in quantities between 1 and 1.5 Nm³ for each produced m³ of formation water. The first Ammerlaan doublet PNA-GT-01 and -02 also produced small quantities of oil. After the completion of the doublet, production was halted temporarily in 2011 but continued a few weeks after. Since then minor to no oil was (co)produced. It is likely that the planned doublet will produce small quantities of dissolved gas, similar to other geothermal doublets in the area. Free oil and gas is not expected because no structural or stratigraphic trap is observed. The nearby well LIR-45 did encounter some oil from a sample of a RFT tool, but this was from the Rijswijk Member.

Table 5-2: Hydrocarbon observations in nearby geothermal doublets. Data from Bakker (2010).

Geothermal doublet	Normalized volume of gas per volume of produced water
Den Haag	1.5 Nm ³ /m ³
PNA-GT-01 and 02	0.5 Nm ³ /m ³ ; small amounts of oil are present
PNA-GT-03 and -04	1 Nm ³ /m ³
VDB-01, -02, 03, 04	traces
HON-GT-01 and -02	1 to 1.5 Nm ³ /m ³

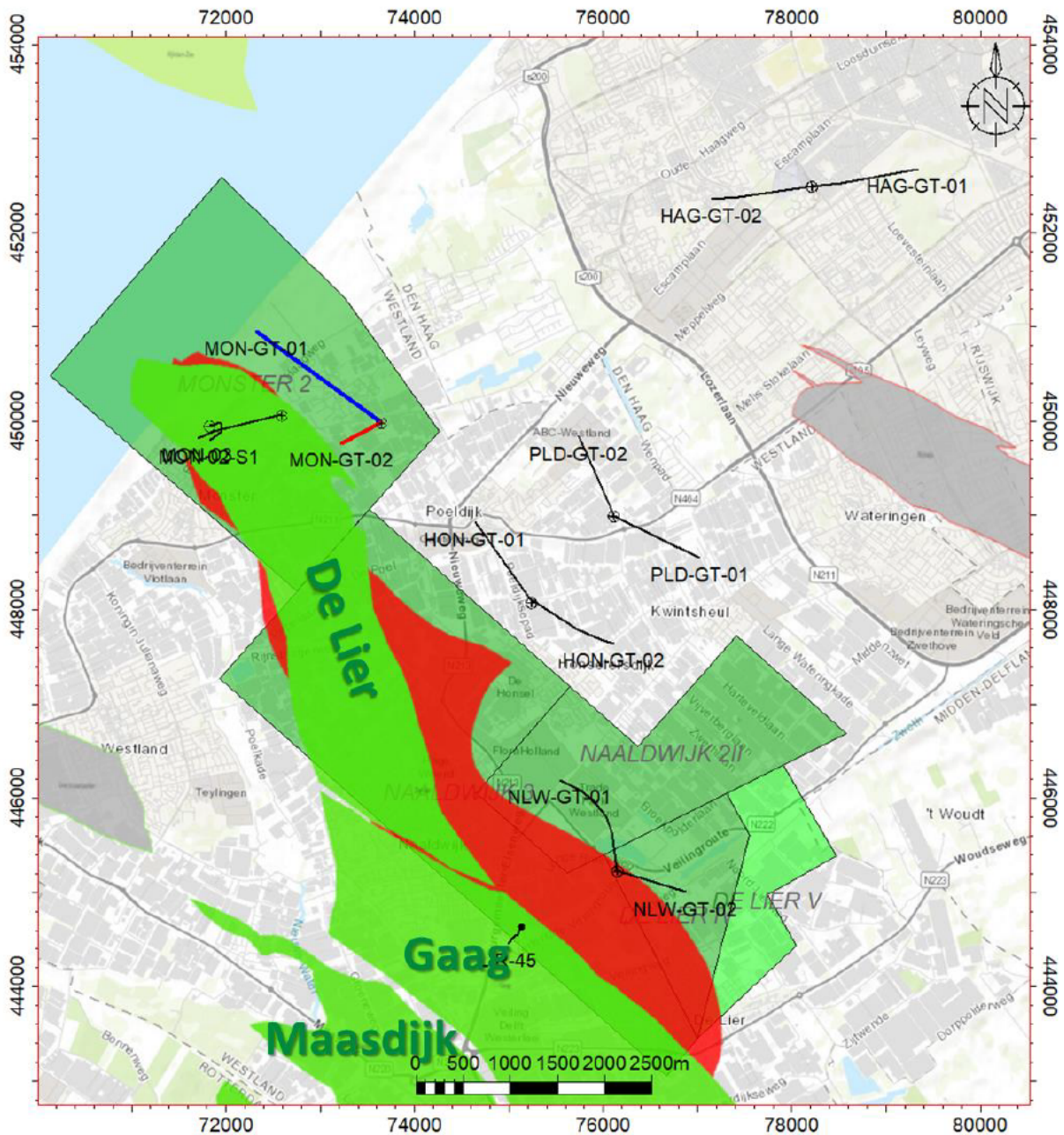


Figure 5-6: Location of the planned doublet with respect to oil and gas fields (source www.nlog.nl).

6 Available well and seismic data

6.1 Reference wells

Reference wells are listed in Table 6-1 and plotted in Figure 6-1. Wells were chosen based on proximity to the target area, data availability and quality and reservoir characteristics. The most important wells are HON-GT-01/02 and MON-02 as they are located close to the new doublet. There is significant well control in and around the study area; the well data quantity and seismic quality is sufficient for determination of reservoir characteristics and to tie wells to seismic.

Table 6-1: Selected wells for the study and the purpose for which well data were used.

Well	Year drilled	Seismic (correlation or QC Velocity model)	petrophysics	correlation	notes
HAG-GT-01	2010		yes*		
HAG-GT-02	2010		yes*		
HON-GT-01	2012	yes	yes	yes	
HON-GT-02	2012	yes	yes	yes	
LIR-45	1982	yes	yes	yes	
PLD-GT-01	2016		yes		No logs in public domain
PLD-GT-02	2016		yes		No logs in public domain
MON-02-S1	1982	yes	yes		
MON-03	1990	yes	yes*		
NLW-GT-01	2018	yes	yes	yes	
NLW-GT-02	2018	yes		yes	

*petrophysical interpretation performed by TNO in 2013 (www.NLOG.nl)

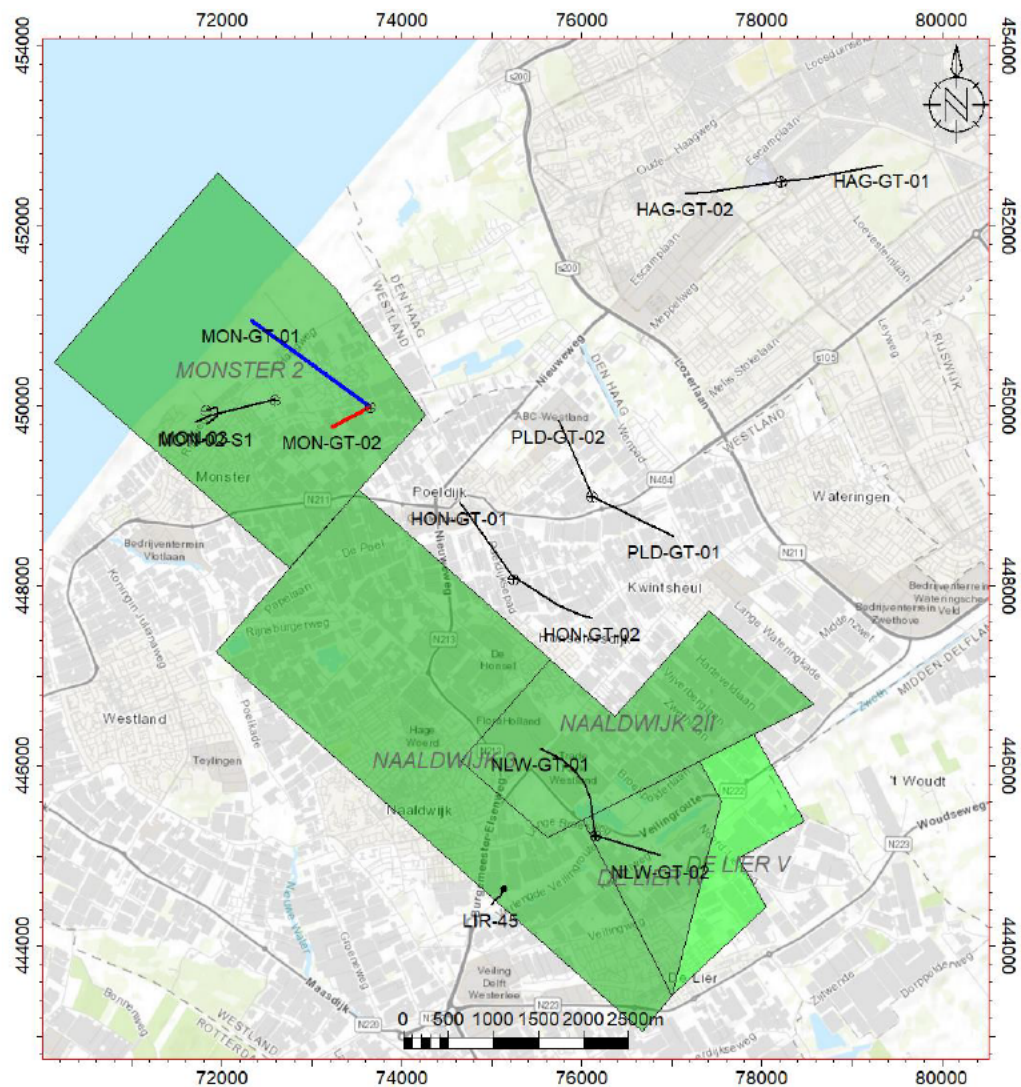


Figure 6-1: Map of the reference wells. The license boundaries are outlined in black.

6.2 Seismic data

The interpretations were made based on the L3NAM1990c time survey that is available via NLOG.nl. The survey covers most of the map area displayed in Figure 6-2. The geometries of the surveys are given in Figure 6-3.

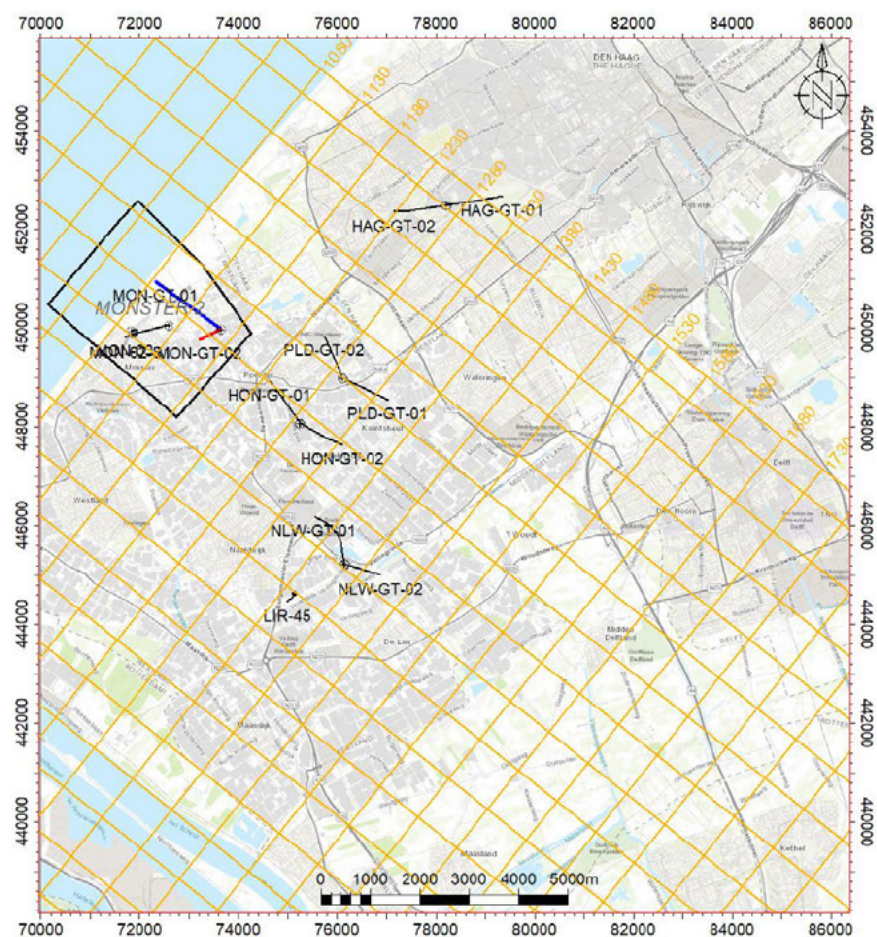


Figure 6-2: Location of the planned doublet and geothermal licence (in black) with respect to the large L3NAM1990c survey (in orange).

Settings for 'L3NAM1990C [Realized] 1'

Metadata		Opacity		Quality attributes	
Style	Info	Statistics	Colors	Operations	Geometry
Original Coordinate Reference System					
Select: Netherlands RD-New (MENTOR; Netherlands RD-New; RI)					
Annotation					
Start	End	Step			
Inline: 580	2500	1			
Xline: 110	1140	1			
Lateral geometry					
Origin	End first inline	End first crossline			
X: 54987.63	67837.58	84999.82			
Y: 445383.53	461486.38	421434.03			
Intervals:	19.998	20.001			
Rotation [degrees]:	38.590	128.590			
Lateral translation/rotation					
X: 0.0	Y: 0.0	Translate			
Rotation [degrees]:	0.0	Rotate			
Get from selected					
Vertical geometry					
Time/depth top:	0				
Sample interval:	4				
Time/depth bottom:	-4996				
Shift:	0.0	Shift			

Figure 6-3: Geometry of the L3NAM 1990c survey.

6.3 Coordinate system and system of units

The location of most data is in the new Netherlands National Triangulation System (*Rijksdriehoekstelsel*). Georeferenced data of different projection systems were converted to this system.

Name:	Netherlands National System new: <i>Rijksdriehoekstelsel</i> new
Type:	Double Stereographic
Central Meridian:	5.387638889
Origin Latitude:	52.156160556
Scale Factor:	0.999907900
False Northing:	463000.000000
False Easting:	155000.000000

Units:	Meters
--------	--------

Datum:	Netherlands
Ellipsoid:	Bessel 1841
Prime Meridian:	Greenwich
Transform Method:	Molodensky
Delta x (m):	593
Delta y (m):	26
Delta z (m):	478

The units used in this report relate to the International System of Units (abbreviated SI from the French *Système International*). All distances are expressed in metres or in kilometres. Temperatures are expressed in degrees Celsius.

6.4 Additional data

GIS files (shapefiles and raster data) have been downloaded from the TNO portal in order to compare results and create maps:

- Well locations
- Seismic data
- Licenses
- Oil and gas fields

All shapefiles and raster files have been transformed from the UTM 31, ED50 to the *Rijksdriehoekstelsel* coordinate system with the Netherlands datum if necessary.

6.5 Database

Seismic data, formation tops, time-depth relations and deviation data were loaded in Petrel (version 2017) for seismic interpretation and time-depth conversion. The velocity model was derived in through regression of velocity data in excel. Well data (logs, formation tops, core data, etc.) were also loaded in Interactive Petrophysics (version 4.4) for curve QC. Maps were created using Petrel 2017.

7 Seismic interpretation and depth model

7.1 Method

Seismic interpretation was performed in Petrel 2017. Horizons were interpreted using auto-tracking where possible and otherwise picked every 10th in- and crossline.

7.2 Well to seismic ties

Within the exploration licence, there are no wells with checkshots. For the well to seismic tie, the regional time-depth model was applied. The match between the tops and the interpretations was found to be satisfactory (Figure 7-1). In general, there is good confidence in the seismic picks based on the well tie; the seismic character of the horizons (e.g. hard kick, soft kick, see Table 7-1) is in good agreement with the sonic logs of the wells. An example of a well tie is displayed in Figure 7-1. The seismic loops belonging to the base Vlieland (or top Rodenrijs Member) and the base of the delft sandstone could not be established with great certainty. The picks are therefore referred to as Near Base Vlieland and Near Base Delft. The Near Base Vlieland pick is tracked on the continuous event nearest the appropriate well top which was a through. The Base Delft has been picked on the through which forms the first angular unconformity below the Near Base Vlieland pick. This is in accordance with the geological model presented in section 8.1.

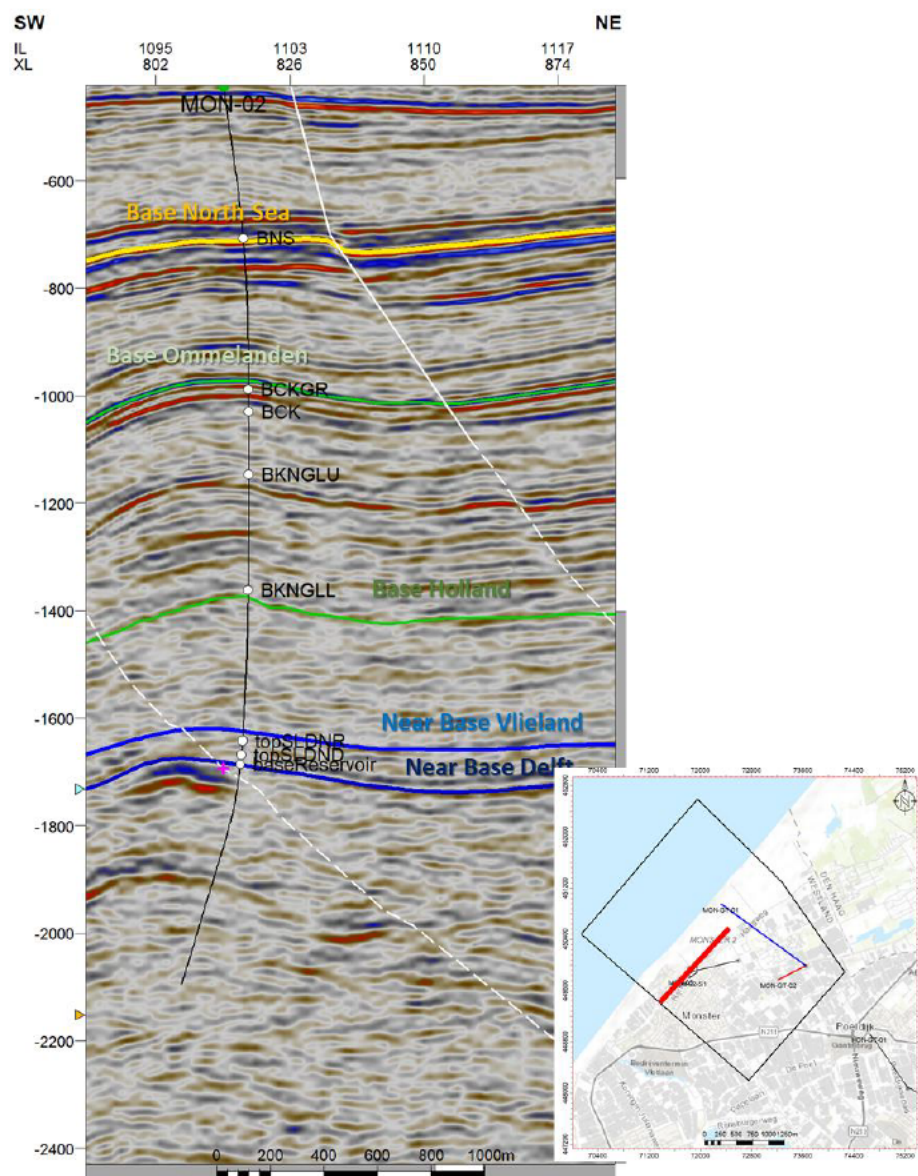


Figure 7-1: Well tie for well MON-02-S1. There is a good match between picked reflectors and well tops.

Table 7-1: Interpreted horizons used for this study.

Horizon	Lithostratigraphic code	Seismic character	Quality	Interpretation method
Base North Sea	BNS	Strong hard kick	Excellent	Auto-tracked
Base Ommelanden	BCKGR	Strong soft kick	Excellent	Auto-tracked
Base Holland	BKNGL	Hard kick, lowest hardkick above 'transparent' Vlieland section	Moderate to good	Auto-tracked /Manual pick
Near base Vlieland	BSLDNR	Hard kick, sometimes difficult to map	Moderate	Manual pick
Near base Delft	BaseSLDND	Very weak hard kick, often difficult to map	Very poor	Manual pick

7.3 Gridding algorithm

All horizons were gridded using the convergent interpolation methodology after which grids were minimally smoothed. Cell size is 50m x 50m.

7.4 Time-depth conversion

A depth dependent linear velocity function is used to convert the time interpretations to depth. The V_0 , k function applied describes the interval velocity as a function of depth, Z , and has the following form:

$$V_{int} = V_0 + k * Z \quad (1)$$

Vertical lithological changes are not modelled with this function and the V_0 and k parameters describe the combined effects of burial and lateral lithological changes. The input data consists of interval time and interval depth pairs derived from checkshot calibrated integrated sonic logs. In order to improve the robustness of the model the input dataset from NLOG (used for VELMOD 1 through 4) has been used. The wells with velocity data within a ~24 km square around the target location have been included (see Figure 6-1).

In total, four velocity layers have been defined; The North Sea Supergroup, Chalk Group (down to Base Ommelanden), a combined Texel, Holland Formation and Vlieland subgroup and Schieland Group. The V_0 and k parameters for the best fit model for each layer are summarized in Table 7-2. Table 7-3 summaries the error of the velocity model between the picks in the well and the depth of the calculated seismic horizon of Base Vlieland. This is the base of the velocity layer nearest the top of the Delft Sandstone Member. Please note that the numbers in this table represent the uncorrected results i.e. no well correction has been applied at any level. Also, the evaluation is limited to the wells which are inside the area of interpretation. As seen in the table of the Base Vlieland, the V_0 , k model results in an average absolute depth error of 0.22% with a maximum of 3.25 % for NLW-GT-02. The calculated error for the other horizons are given in Appendix 10.8, The generated depth maps are shown in Appendix 10.4.

Table 7-2: V_0 - and k parameters of the velocity layers of the updated velocity model.

Velocity layer	V_0 (m/s)	k (s ⁻¹)
North Sea	1,780	-0.435
Chalk	1,550	-1.485
Holland+Vlieland	2,200	-0.69
Schieland	2,900	-0.28

Table 7-3: Residuals per well at the Base Vlieland before applying well adjustment.

Base Vlieland			
Well	Base in well (mTVDss)	Residual (m)	Residual (%)
MON-02	-2152.48	-30.03	1.40%
MON-03	-2120.72	-0.48	0.02%
HON-GT-01	-2277.63	-3.93	0.17%
HON-GT-02	-2308.84	-23.05	1.00%
LIR-45	-2069.51	0.68	0.03%
LIR-GT-01	-2190.08	-29.74	1.36%
LIR-GT-02	-2256.13	3.57	0.16%
NLW-GT-01	-2229.63	20.33	0.91%
NLW-GT-02	-2211.54	71.93	-3.25%
Average		1.03	0.20%

7.5 Top and base reservoir map

The top and base reservoir maps are displayed in Figure 7-2 and Figure 7-3. The new Monster geothermal wells are located in the same fault block as HON-GT-01 and -02. A series of NW-SE trending normal and thrust faults are present in the study area. The target locations of the planned doublet are situated in the centre of the fault block and the pair is oriented parallel to the local major fault trend, minimizing the risk of the presence of faults in between the injector and producer.

As the Top of the reservoir could not be picked, a top reservoir map was created by shifting the Near base reservoir map up to the top reservoir well tops with an isochore map. For the Base of the reservoir, the Near base reservoir map was well top corrected to the base reservoir tops.

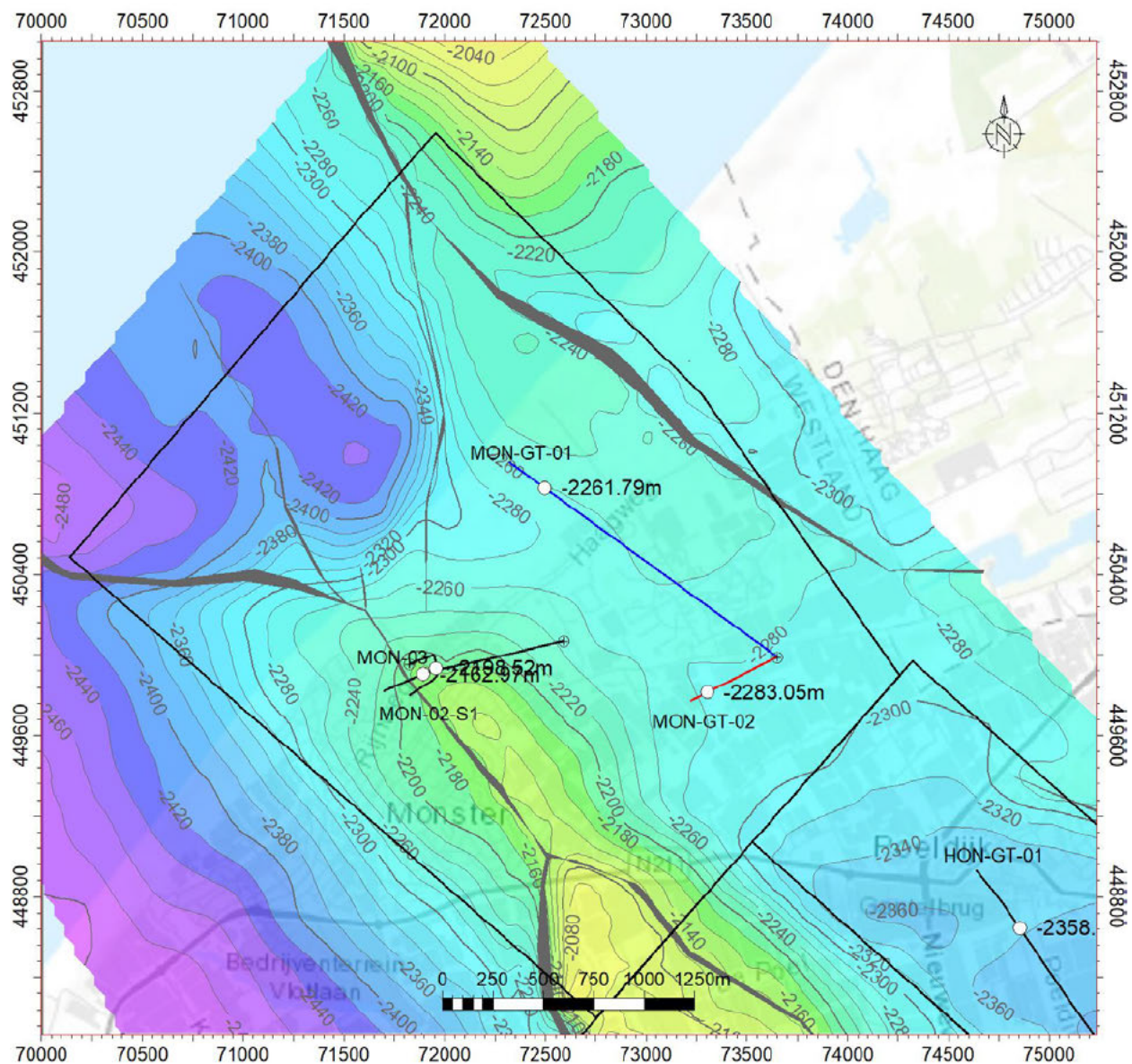


Figure 7-2: Depth map of top Delft reservoir with the well trajectories of the planned doublet (MON-GT-01 and -02) and other nearby wells.

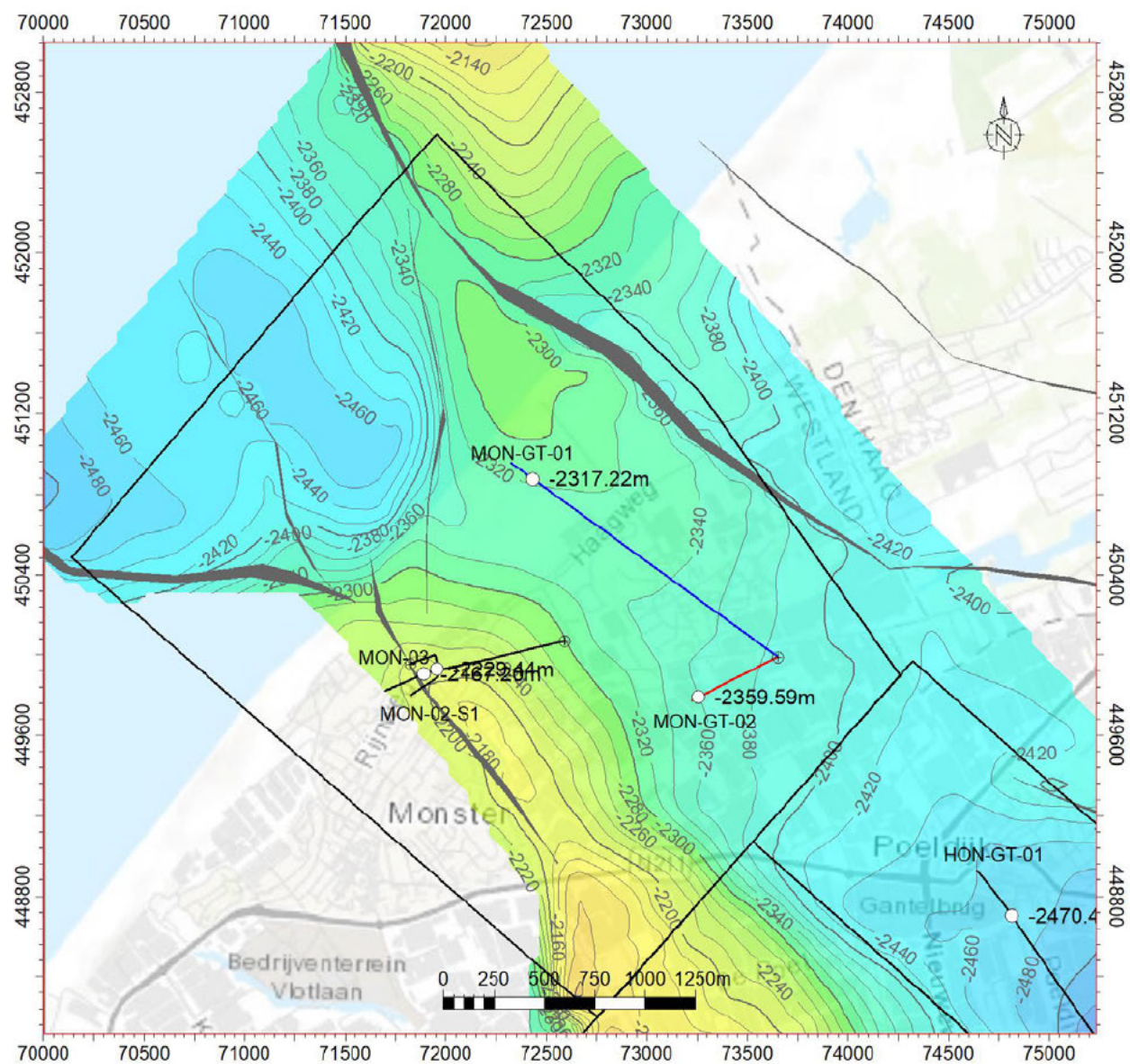
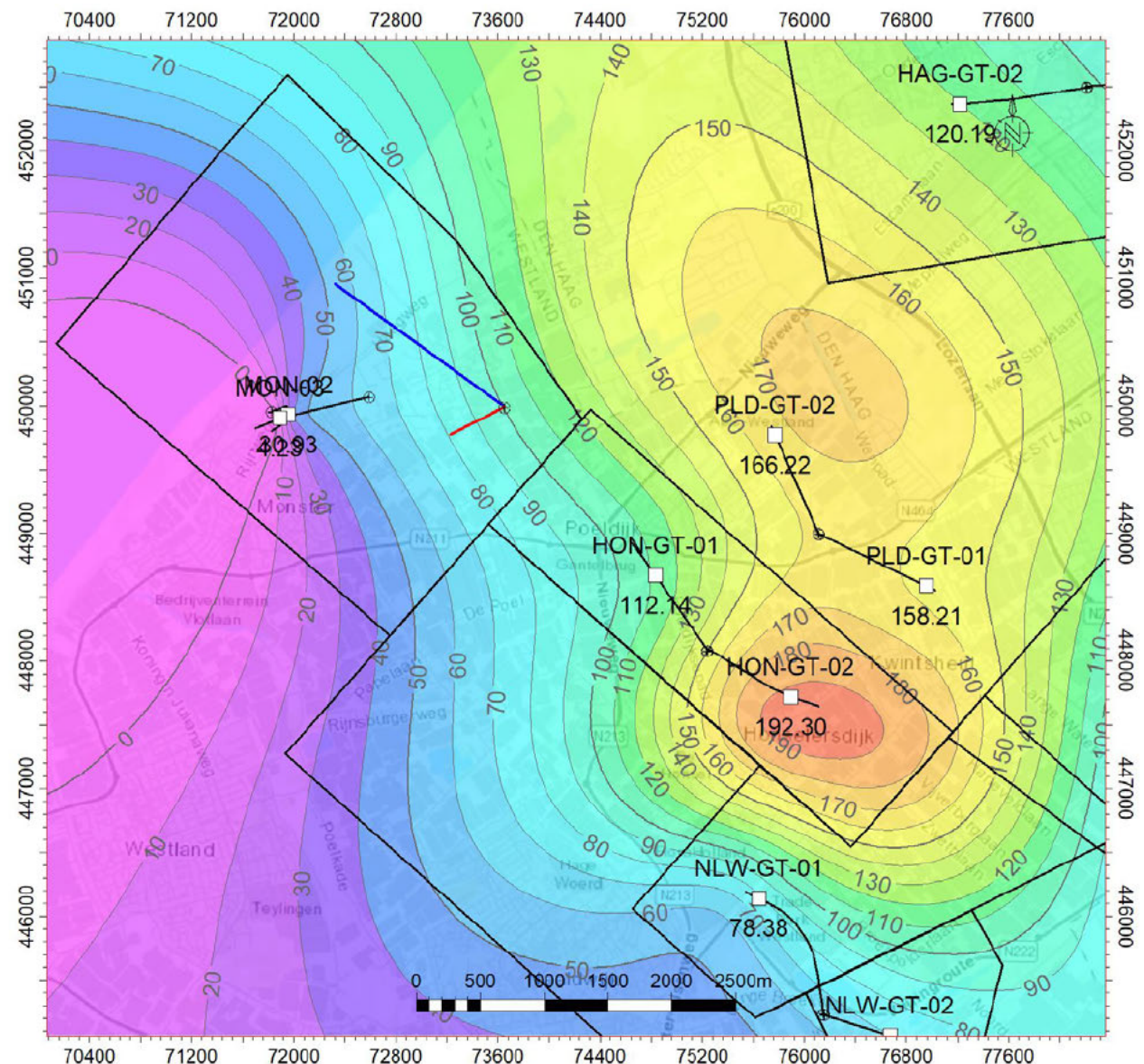


Figure 7-3: Depth map of base reservoir with the well trajectories of the planned doublet (MON-GT-01 and -02) and other nearby wells.

The reservoir thickness map was created by mapping the isochore points based on top Delft and Base reservoir.

Figure 7-4: Thickness map of the reservoir based on isochore data. The isochore points of the wells used in the analysis are highlighted by the white squares.



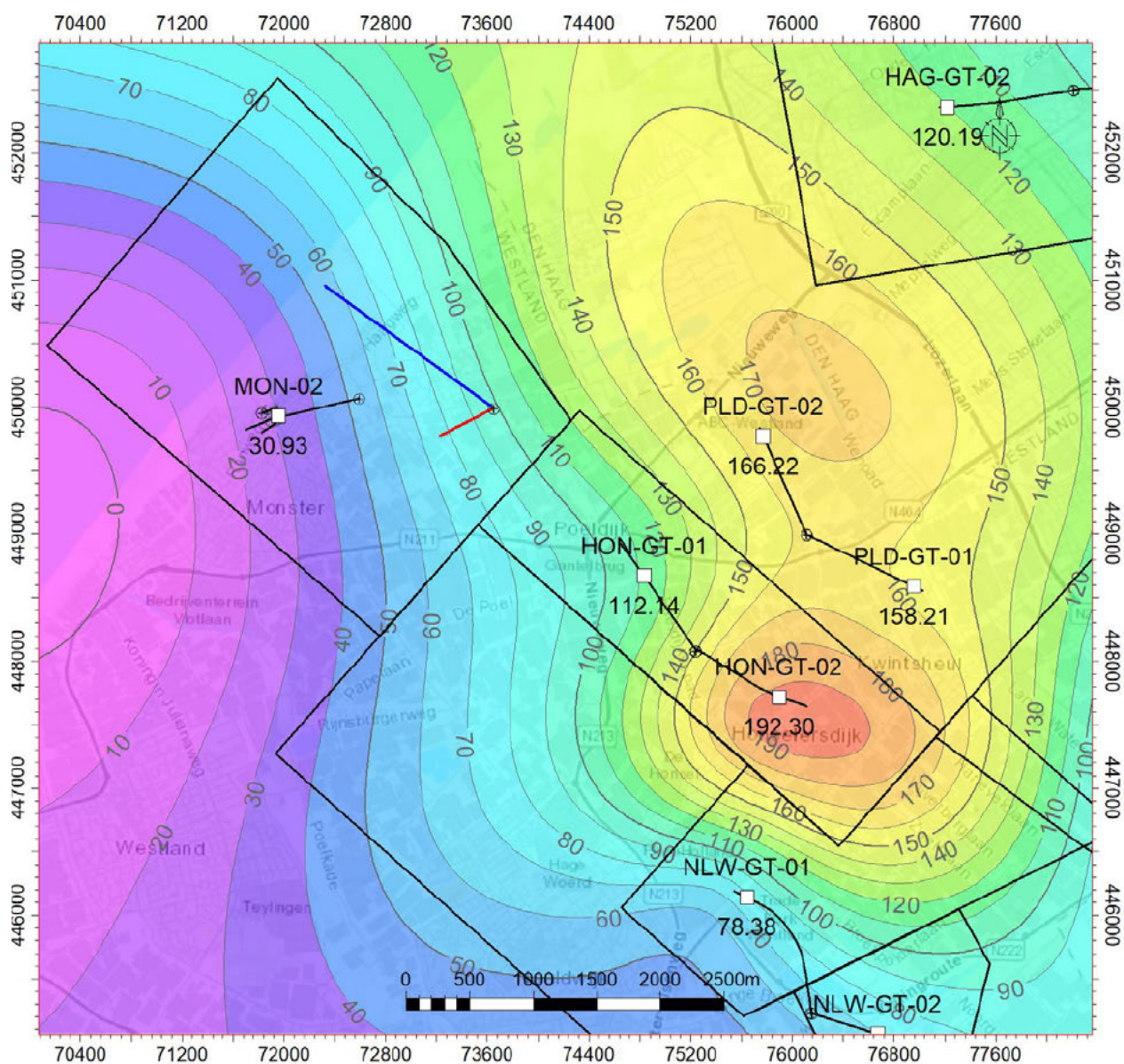


Figure 7-5: Thickness map of the reservoir based on isochore data without the MON-03 data point. The isochore points of the wells used in the analysis are highlighted by the white squares.

7.5.2 Coordinates of the planned wells

Coordinates for the planned wells are listed in Table 7-4 and Table 7-5.

Table 7-4: RD coordinates of the top and base reservoir, surface location and TD location of the planned well MON-GT-01.

MON-GT-01			
Pick	X (RD)	Y (RD)	TVDSS (m)
Surface location	73650.0	449990.0	0.0
Top Reservoir	72498.2	450826.8	-2261.8
Base Reservoir	72434.1	450873.4	-2317.2
TD	72324.4	450953.1	-2412.2

Table 7-5: RD coordinates of the top and base reservoir, surface location and TD location of planned well MON-GT-02.

Pick	MON-GT-02		TVDSS (m)
	X (RD)	Y (RD)	
Surface location	73650.0	449990.0	0.0
Top Reservoir	73303.8	449813.6	-2283.1
Base Reservoir	73256.0	449789.3	-2359.6
TD	73222.7	449772.3	-2412.9

7.6 Uncertainty in the depth maps

The low residuals (see Appendix 10.8) give confidence in the accuracy of the depth maps. Moreover, there is a good match between the well tops of nearest wells MON-02, -03 and HON-GT-01 with the seismic reflectors. The uncertainty of 10% used in DoubletCalc is more than sufficient to cover the uncertainty range. The actual uncertainty should be in the range of 1%.

8 Aquifer Characteristics

8.1 Stratigraphic correlation and lateral variety of the reservoirs

In Figure 8-1, a correlation panel is given for the wells in the area which drill into the Delft Sandstone Member and the Alblasserdam sands closest to the target location. The character of the Delft Sandstone Member is quite varying in terms of thickness and sand distribution. The screened intervals of the NLW-GT and HON-GT wells are also shown in Figure 8-1. The screen settings are quite inconsistent, especially in the HON-GT doublet. In this doublet there appears to have been considerable issues with placing the screens. Also note that the documentation provided by the operator on NLOG is sometimes contradictory and should be considered with care.

To achieve a correlation which is consistent throughout all local wells, the gamma ray logs have been transformed into INPEFA logs. These logs are particularly powerful in discriminating trends and cycles in the shale content which are much more difficult to discriminate in the gamma ray log. These logs have been created in the Cyclog software package. The INPEFA logs show a clear and reoccurring pattern in all of the wells (see Figure 8-1). The Alblasserdam is subdivided into four parts; a sandy part at the base, followed by central shaley part, a smaller sandy interval near the top followed by a shaley fining upwards top part. Overlying is a transition zone which in this study is designated Base reservoir. The sandier trend that follows is associated with the Delft Sandstone Member. Note that Base reservoir is used here instead of Base Delft Sandstone Member. This is because Base reservoir may be a local feature restricted to the few fault blocks surrounding the Naaldwijk and Honselaarsdijk geothermal wells. However, the INPEFA trends seen in these wells also occur in the Maasland geothermal and the De Lier (hydrocarbon) wells. Importantly, the screens in the wells considered are placed over the section that covers top Delft Sandstone Member (topSLDND) to Base reservoir, except in HON-GT-02. Below, to make the discussions easier, when the Delft sandstone is mentioned in reservoir context, the combination Delft sandstone plus transition zone is referred to.

The lithologs made by the well site geologist at NLW-GT and HON-GT place the base of the Delft at the Base reservoir pick and correspond to a change in colour of the clays (from grey to red). This is inconsistent with the geological atlas published by TNO (TNO, 2002). There the change from grey to red clays occurs within the Alblasserdam Member. The petrophysical analysis (see section 8.3) shows that sands in the transition zone are less porous therefore likely less permeable. The transition zone described here could therefore just be a productive upper part of the Alblasserdam. In any case, it is expected that the production in the NLW-GT and HON-GT doublets is dominated by flow from the upper parts of the screen. Please note that no flow meter measurements are available for either doublet.

The MON-02 and MON-03 wells have relatively thin sections of Delft Sandstone when compared to the other wells in the area. The transition zone as well as the Alblasserdam appear to be absent in these wells. This is due to their location relative to the local half graben (see section 8.1.1). The seismic shows a lot of faulting around these wells, so it is possible that part of the lower sections have been faulted out. However, this cannot be established with certainty due to the quality of the seismic and inaccuracies in the time-depth model. Also, the composite well logs are not conclusive in this respect.

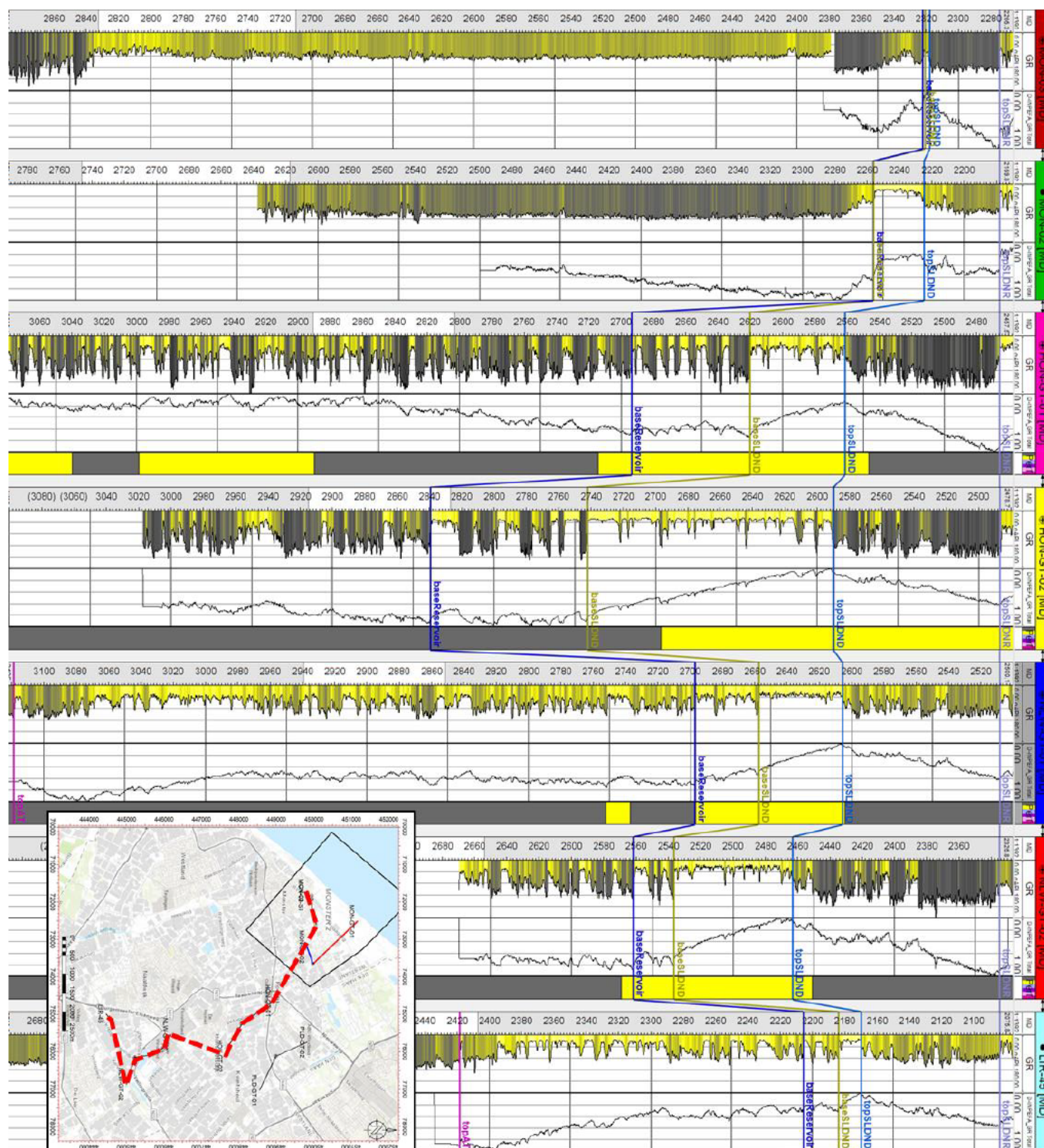


Figure 8-1: Regional correlation panel showing the gamma ray logs (non-normalised) flattened with respect to the top Rodenrijs Member (the inlay map shows the location of the wells used, connected by the red, dashed line). Also shown is the INPEFA log.

8.1.1 Delft Sandstone and Alblasserdam

The Delft Sandstone is thought to be deposited in a floodplain by a river system flowing from southeast to northwest (Figure 8-4). The Delft Sandstone consists of fine- to coarse-grained sand. The thickness of the Delft Sandstone is influenced by the syn-rift deposition of the sediments (see Figure 8-2). The depositional model described by Den Hartog Jager (1996) is found to correspond well with the observations made in the seismic and in the wells (see Figure 8-2 and Figure 8-3).

The well logs show an upper section with the clean, often blocky sands of the Delft Sandstone Member overlain by the shales of the Rodenrijs Claystone Member and a lower section with the alternating sands and shales of the Alblasserdam Member (see Figure 8-1). In the seismic, an angular unconformity is observed near the depth of the base of the Delft- and base reservoir well top and is picked as the Near base Delft (see Figure 7-1, Figure 10-2 and Figure 10-3). At this moment, it is unclear to which if the two well tops the unconformity is truly related.

The half-graben in Figure 8-2 is representative of the half graben in which the planned wells are situated. The planned wells are located on the more stable side of the half-graben where the overall sequence is relatively thin. This thinning however, mostly affects the Alblasserdam Member. This can also be observed in the seismic sections presented in Figure 10-2 and Figure 10-3.

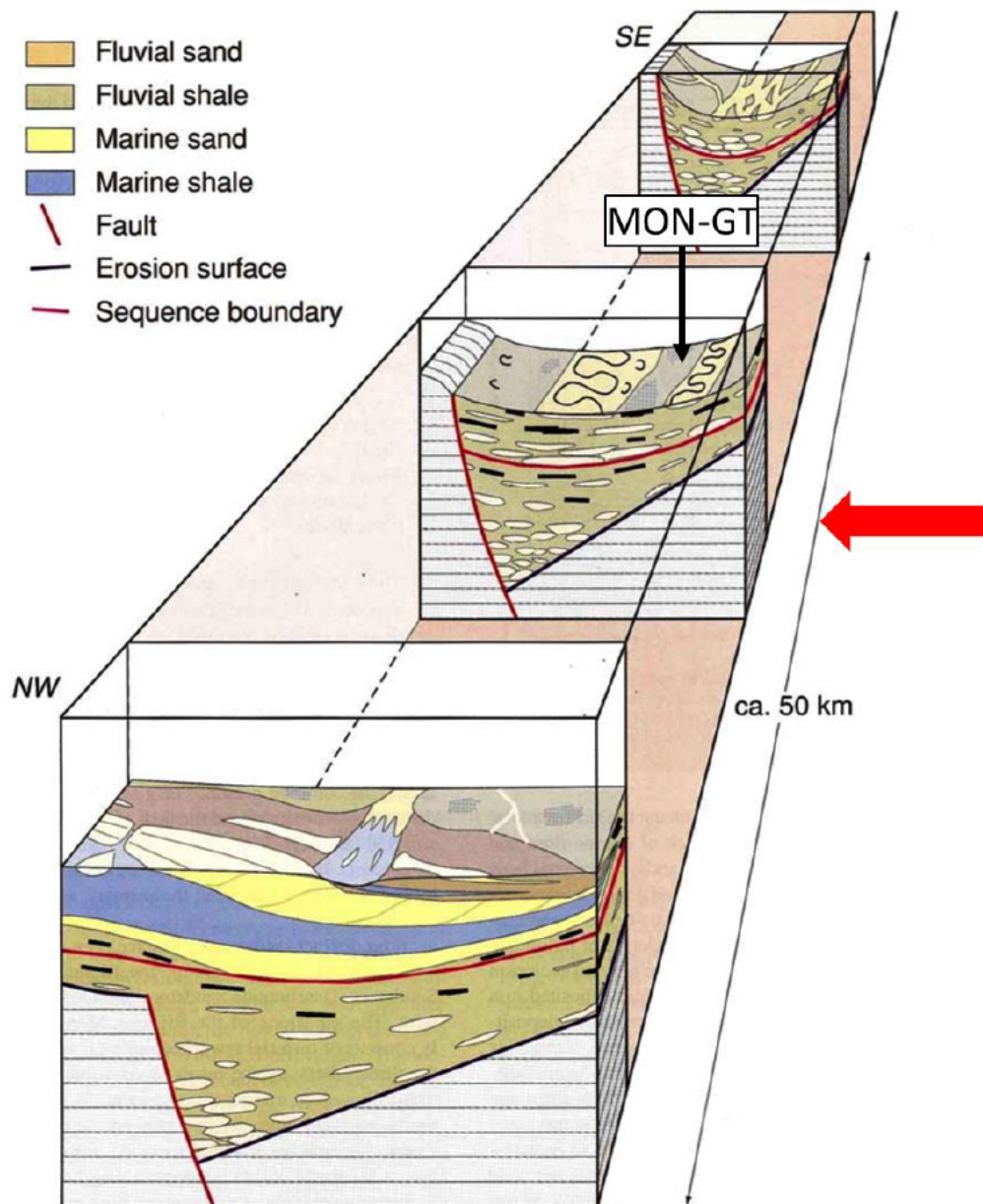


Figure 8-2: Model for the deposition of the Delfland Subgroup in the West Netherlands Basin (from den Hartog Jager, 1996). The red arrow highlights the part of the mode which is appropriate for the current application. In this image the subgroup is divided into two parts; an upper and a lower part divided by a sequence boundary (red line). In the geological model presented here, this sequence boundary is the boundary between the Rodenrijs Mbr. plus Delft Sst Mbr. (top) and the Alblasserdam Mbr. (base).

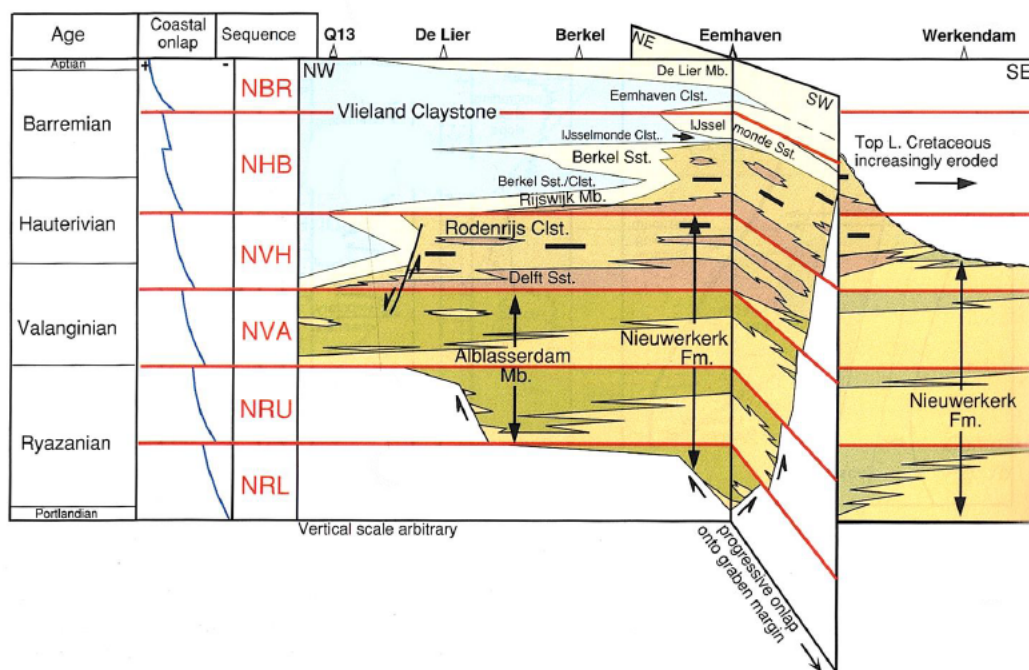


Figure 8-3: Sequence stratigraphic scheme for the Lower Cretaceous of the West Netherlands Basin based on seismic and biostratigraphic data (from den Hartog Jager, 1996). Of particular importance to the current application are the Neocomian/Valanginian (NVA) and the Neocomian/Valanginian – Hauterivian (NVH) sequences.

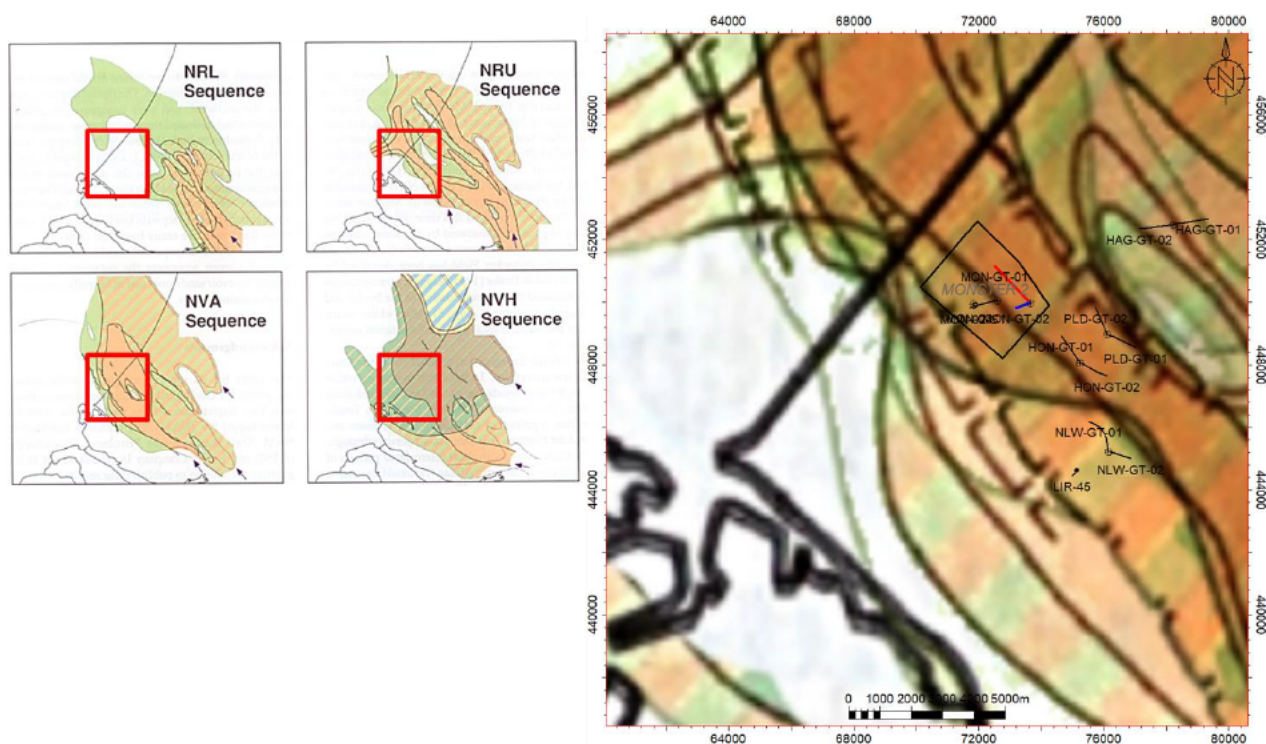


Figure 8-4: (Left) Facies distribution maps for the lower four stratigraphic sequences (see Figure 8-3) with the area mapped on the right in red. (Right) stacked overlay of the four facies distribution maps with the Monster 2 license outlined in black.

8.2 Gross thickness of the aquifer

The seismic interpretations of the near Top Rodenrijs and near Base Delft Sandstone Member show general thickening of the sequence towards the Northeast within the fault block (part of a larger half-graben). This can be explained by the influence of fault movement (specifically along the major faults which bound the syncline to the Northeast), in relation to the accommodation versus sediment supply during deposition. During deposition in the Early Cretaceous, the Late Kimmerian extension was still taking place.

The planned MON-GT wells are situated in the same faultblock as the HON-GT and PLD-GT wells. As the logs in well HON-GT-02 and MON-02 and -03 show, this thickening affects both the Delft Sandstone and the Alblasserdam Member (Figure 8-1). In the MON-02 and -03 wells the Alblasserdam Member may not even be present. The thinning effect is thus more pronounced for the Alblasserdam Member. Note however that both MON-02 and -03 are situated in a highly faulted part and that the Alblasserdam and part of the Delft may also have been faulted out.

The seismic section running from the PLD-GT wells through the planned MON-GT-02 well to MON-02 suggest a gradual decrease in thickness of the Delft (and transition zone) (see Figure 8-5). Similarly, the thickness of the reservoir is expected to gradually decrease from HON-GT-02 towards MON-02 with the planned wells in between. A seismic section running roughly perpendicular to the major faults suggest the thickness of the Delft increases towards the Northeast (see Figure 8-6). To estimate the thickness at the new doublet, care was taken to honour the above considerations. A gross thickness map was made through isochore interpolation while applying a mild WNW-ESE (fault parallel) trend (see Figure 7-4 compared to Figure 8-4). Based on these figures, a minimum thickness of 60m can be expected. A maximum of 90m and a median thickness of **70m** is used for DoubletCalc calculations.

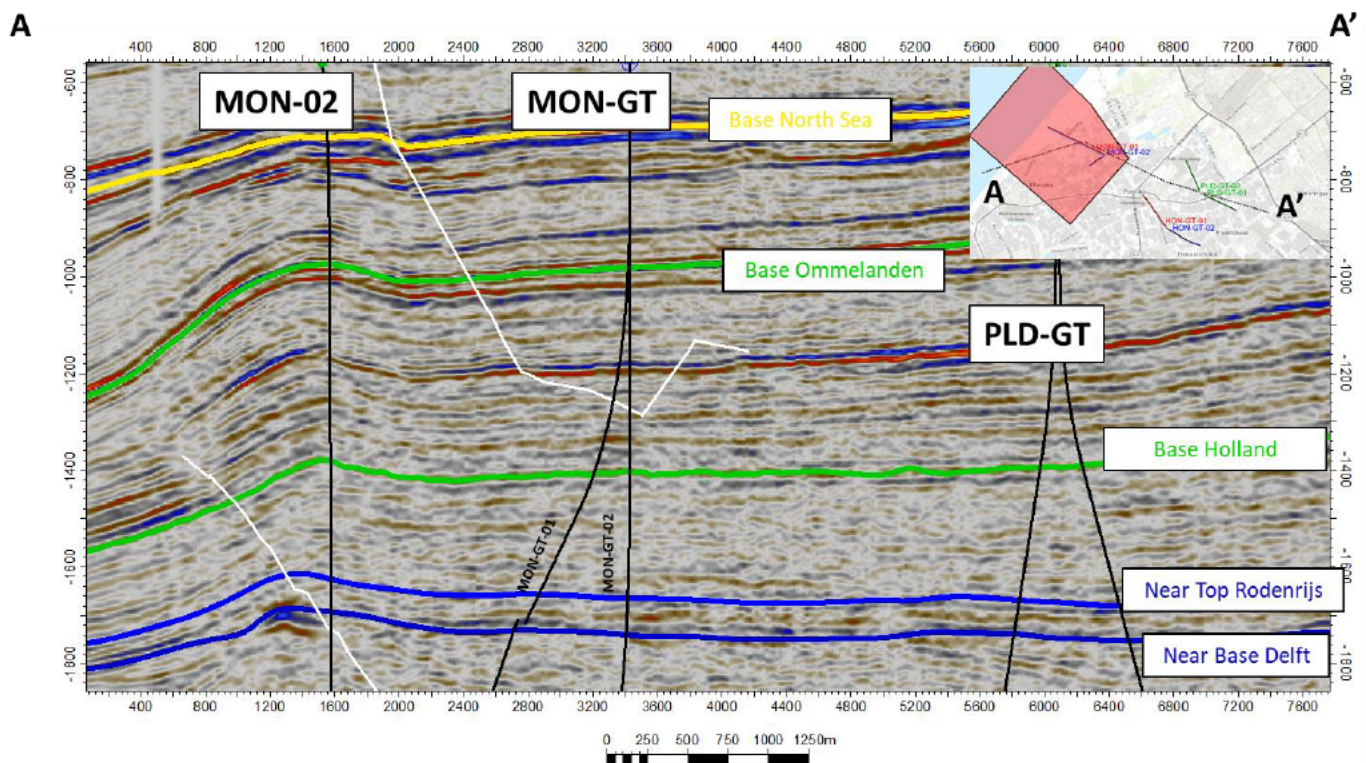


Figure 8-5: Cross section running from MON-02 well through the planned MON-GT doublet and through the existing PLD-GT doublet.

8.2.1 Net to gross (N/G)

For the N/G calculation of the Delft Sandstone, the HON-GT-01, MON-02 and NLW-GT-01 wells are considered most representative as these are closest to the new doublet and are situated along the depositional direction. The petrophysical evaluation summarised in Table 8-1, shows that the N/G increases from 0.63 in HON-GT-01 to 1.00 in MON-02. With an N/G of 0.9 in NLW-GT-01, trend shows a reversal when compared to the thickness which decreases towards MON-02. This is caused by the fact that the lower part of the reservoir i.e. the transition zone is no longer present in MON-02, but the clean upper part remains. A higher N/G is expected for a lower reservoir thickness. For this reason, a minimum N/G is set higher than HON-GT-01. The maximum N/G is based on the MON-02. In the

DoubletCalc calculations, a **median N/G of 0.93** is assumed. The **minimum** has been set to **0.90** and the **maximum** to **0.98**.

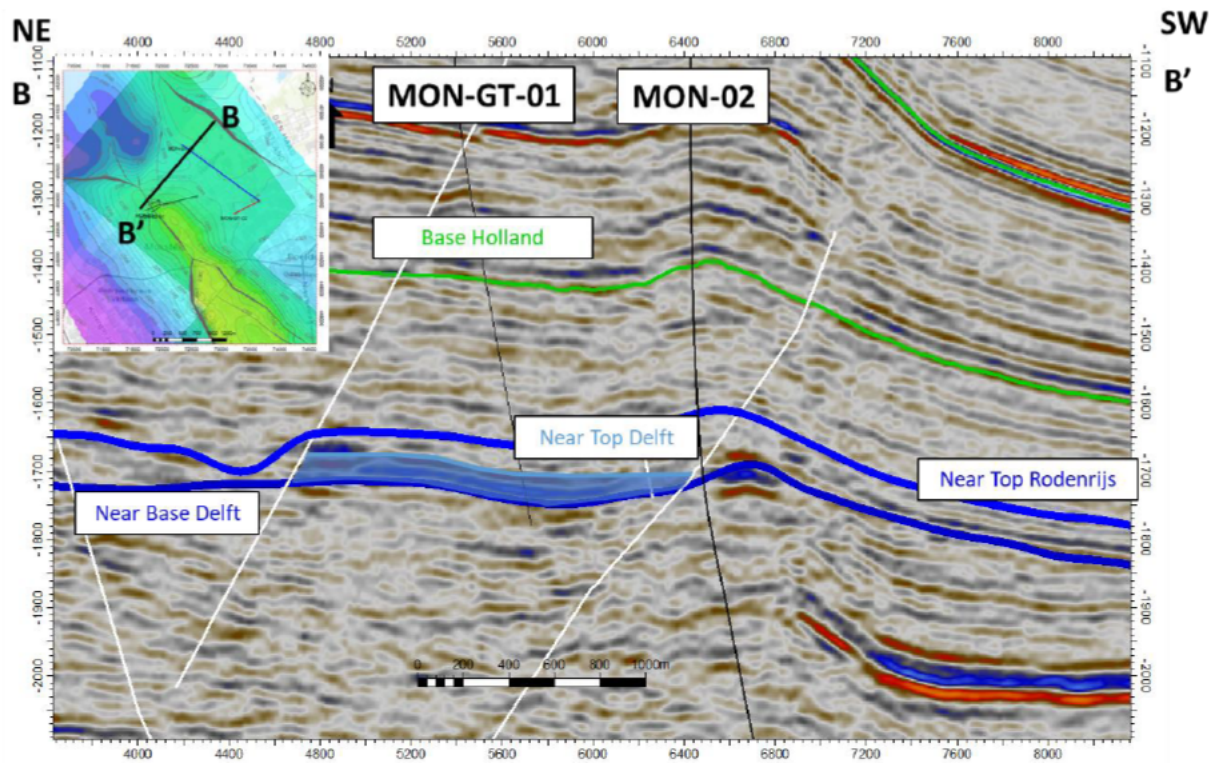


Figure 8-6: Cross section perpendicular to major faults also crossing through well MON-02 and planned well MON-GT-01. Approximate extent of Delft shows thickening towards the NE where MON-02 is minimal thickness.

8.3 Petrophysical evaluation

Reservoir parameters are mainly based on the nearby wells MON-02, HON-GT-01 and NLW-GT-01 which were petrophysically evaluated for this study. The two geothermal wells have an evaluated production test from the Delft Sandstone Member. Also, these are the only geothermal wells with an extended logging suite. Both MON-02 and HON-GT-01 are situated in the same fault block as the planned doublet.

8.3.1 Core data consolidation

Regional routine core analysis (RCA) data were collected to build the porosity-permeability relationships reported in section 8.3.2.

RCA Helium porosities were reportedly measured under near-atmospheric stress conditions and thus require correction for overburden stress, e.g. by the method of Hakvoort [1]. The average correction factor is 0.96. The RCA data relate to the total porosity system as sample preparation involved conventional (hot) oven drying. Juhasz-type stressed-brine correction was applied to the air permeability data [2] before application of the Phi-K transform (discussed in section 8.3.2).

The cored target sections have not seen XRD analyses that could give calibration points for clay content. Electrical parameters from regional knowledge indicate a cementation factor m at around 2.0 and tortuosity pre-factor of 1.0 (default). Saturation exponents were assumed at $n=m=2.0$.

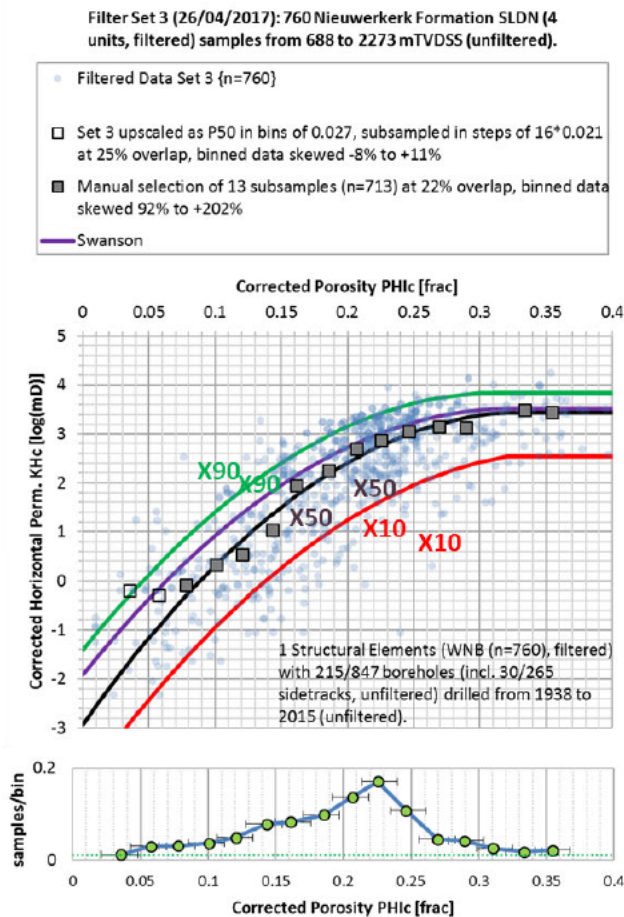
8.3.2 Phi-K transform

Horizontal permeability (k_h) was modelled via Phi-K transform of RCA poro-perm data as described in the literature [3]. The database was compiled from screening of public RCA data (www.nlog.nl) that was filtered for core analyses from the target interval in the West Netherlands Basin.

All data were corrected as described in section 8.3.1 prior to processing. The Phi-K transform was executed for the 10th, 50th (median) and 90th percentile (X10, X50 and X90, resp.) for the RCA data cloud from the target interval

(SLDN), according to best practices described in the literature [3] and consistent with SDE+ specifications. These regressions were used to calculate the scale-independent Swanson mean [4]. The median regression was used to calculate the base case permeability curve for the Alblasterdam Member. The Delft Sandstone Member in this part of the West Netherlands Basin has proven to exhibit significantly higher permeabilities than expected from petrophysics (e.g. well test Honselersdijk, De Lier). In order to better approximate these higher well test permeabilities, the Swanson Mean regression is preferred as the base case permeability model for the Delft Sandstone Member in this part of the West Netherlands Basin.

Regressions for the Nieuwerkerk Formation (SLDN) are shown in Figure 8-7. Note that all regional SLDN core data are assumed representative for both the Delft Sandstone Member (SLDND) and the Alblasterdam Member (SLDNA) due to inconsistencies in the SLDND picks in the public database (www.nlog.nl) that cannot be resolved within the scope of this study. Deployment of the permeability model is documented in section 8.3.7.



Plugs from West Netherlands basin RCA regressions (Nieuwerkerk Formation):

$$\begin{aligned} kh\{X10\}: \ln(KHc[mD]) = & -116.148 * PHlc[frac]^2 \\ & + 85.2254 * PHlc[frac] - 9.5401, \\ & r^2 = 0.974 \end{aligned}$$

$$\begin{aligned} kh\{X50\}: \ln(KHc[mD]) = & -130.7246 * PHlc[frac]^2 \\ & + 87.5695 * PHlc[frac] - 6.7235, \\ & r^2 = 0.98 \end{aligned}$$

$$\begin{aligned} kh\{X90\}: \ln(KHc[mD]) = & -122.6917 * PHlc[frac]^2 \\ & + 77.024 * PHlc[frac] - 3.2422, \\ & r^2 = 0.951 \end{aligned}$$

Swanson mean (Delfiner, 2007):

$$0.3 * kh\{X10\} + 0.4 * kh\{X50\} + 0.3 * kh\{X90\}$$

k-truncation at PHI=0.32

Figure 8-7: Composite display of the Phi-K transform for the cored West Netherlands Basin Nieuwerkerk Formation Sandstone (SLDN) sections. The bottom histogram shows the bin size (displayed as horizontal error bars) and the normalized number of samples per bin. See text for brief description of methodology.

TNO has kindly provided a conceptual porosity-permeability relationship they have derived for the Delft Sandstone Member (see Figure 8-8). This relationship has been shifted upward manually (with respect to the mathematical regression made on all core measurements, including Delft and Alblasterdam) to achieve an average permeability match with the geothermal well tests. This relationship has also been used during the current evaluation as an alternative permeability estimation (see Table 8-1).

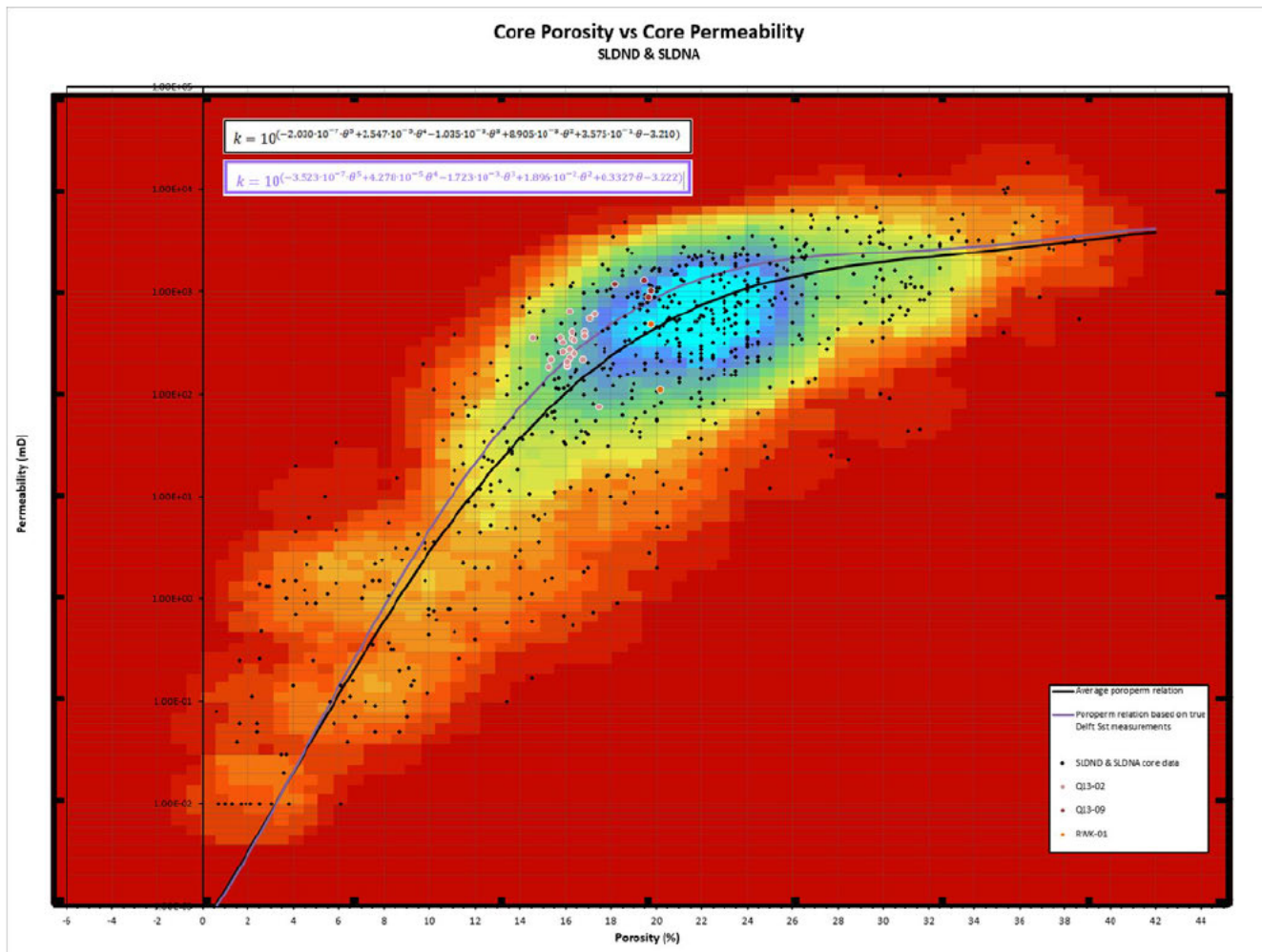


Figure 8-8: Core porosity versus permeability measurements of the Alblasserdam- and Delft Sandstone Members plotted in a density plot. The black curve and equation represent the mathematical regression of all data points. The purple curve and equation represent the relation derived for only the Delft Sandstone based on the few confirmed core measurements and which has been forcibly shifted to match the geothermal well test results.

8.3.3 Log curve consolidation

Digital logs of the well NLW-GT-01 HON-GT-01 and MON-02 were loaded and processed in Interactive Petrophysics (IP). Quality control involved curve selection based on comparison of signals from different vintages (wireline, repeat runs etc.).

Wireline neutron signals were thus corrected for mud weight, mudcake, borehole salinity (WBM wells only) and formation temperature using the vendor's correction charts where considered necessary. All bulk density logs were already pre-corrected for hole size. The caliper is engaged in all processed sections and porosity logs (density, neutron, also sonic) are not notably affected by borehole washout effects.

All processed well logs were measured in water-based mud systems. In well NLW-GT-01 and HON-GT-01 resistivity logs were not run. Mud and invasion corrections for electric logs were not conducted. The use of uncorrected resistivity curves is not critical for the purposes of this study.

8.3.4 Conventional log processing workflow

Following standard processing procedure, clay volume is modelled prior to deployment of the integrated porosity (PHI) and water saturation (SW) module of the processing software (IP). VCL is used to estimate clay bound water (CBW) in order to model effective porosity (PHIE) from the total porosity signal (PHIT) that is picked up by the porosity logs (bulk density, neutron and sonic curves). PHIT and SW are solved simultaneously because the saturation determines the bulk fluid signal (e.g. brine density) whereas SW is coupled to porosity.

8.3.5 Shale and clay volume

Clay content is first modelled in the shale domain (VSH) before it is cast into the clay mineral domain (VCL). This procedure has the advantage that shale end-member at VSH=100% can be picked from the well log signals whereas VCL=100% is always located outside the data range (since rocks entirely composed of clay minerals do not exist in nature). The following relationship represents the default estimate for the clay mineral content of a 'standard shale':

$$VCL = VSH * 0.7 \text{ [vol.frac]}$$

In other words, shales are approximated to contain an average of about 70% clay minerals. Calibration of VSH was performed iteratively using the Gamma Ray method (VSH_GR) and the neutron-density method (VSH_ND). End-members for the VSH_GR linear model were picked in histograms for each individual well in order to compensate for vintage-related differences between the Gamma Ray logs.

Calibration of the neutron-density cross-plot (for VSH_ND) was done by iterative matching of VSH_GR versus VSH_ND. Overestimation of clay content is avoided by determination of the minimum VSH curve for further petrophysical processing: $VSH = \min\{VSH_ND, VSH_GR\}$.

8.3.6 Porosity and water saturation

Total porosity curves (PHIT) were calculated using the density method, neutron-density method and sonic method. Model parameters are adopted from the VSH parameters on a well-by-well basis (8.3.5). The different methods result in similar porosity logs. The neutron-density derived porosity logs were selected for further calculations. In the Alblasserdam Member of well LIR-45, neutron and density logs were not run successfully; porosity is therefore calculated from the sonic log. Effective porosity (PHIE) is modelled by stripping the clay-bound water (CBW) off the PHIT curve. CBW is a function of the VCL curve, wet clay densities as picked in the neutron-density cross-plot for each well, and the average dry clay density of 2.78 g/cm³ for Illite-prone clay mineralogy.

The SCAL-based electrical parameters discussed in section 8.3.1 plug into the Archie water saturation equation (only well LIR-45, NLW-GT-01 does not have the required log suite). Deployment of the Archie-type saturation model is important for the purposes of this study as the final porosity curve is impacted by the formation water salinity that plugs into the simultaneous analytical solution for porosity and water saturation. Formation water salinity was obtained by the Pickett calibration method. The equivalent fluid density in conjunction with the matrix density (shale+quartz) is utilized by the interpretation software to solve for total and effective porosity curves (PHIT and PHIE, resp.).

8.3.7 Permeability modelling

Horizontal permeability (kh) curves were modelled via application of the Phi-K transforms (section 8.3.2) to the effective porosity curves (PHIE). Low (X10), mid (X50 for the Alblasserdam Member and Swanson Mean for the Delft Sandstone Member) and high case (X90) permeabilities were calculated. As described in section 5.2.2, all model-derived permeabilities are truncated near the maximum measured core porosity.

8.3.8 Reservoir definition

Reservoir zones are defined as such if they have a minimum (horizontal) permeability of 1 mD and Vshale of <50%. In the reservoir, arithmetic averaging of the kh-curves was used to obtain regular horizontal permeability values for each zone of interest. Reservoir properties for the evaluated wells are shown in Table 8-1.

Table 8-1: Aquifer characteristics based on log evaluation.

Well	Zone Name	Top	Bottom	Gross	Net	N/G	Av Phi	Av Perm	Av Perm
		m TVDSS	m TVDSS	m TVDSS	m TVDSS	Dec	%	P50 PTG mD	P50 TNO mD
HON-GT-01	SLDND	2364.7	2418.2	53.6	49.7	0.93	0.17	409	596
HON-GT-01	Transition zone	2418.2	2483.5	65.2	24.6	0.38	0.18	217	686
HON-GT-01	Alblasserdam sands	2483.5	2854.9	371.4	71.4	0.19	0.13	48	-
NLW-GT-01	SLDND	2313.2	2357.7	44.4	44.4	1.00	0.20	627	962

NLW-GT-01	Transition zone	2357.7	2391.7	34.0	26.4	0.78	0.18	368	679
NLW-GT-01	Alblasserdam sands	2426.3	2439.8	13.5	11.3	0.84	0.17	95	-
MON-02	SLDND	2198.4	2229.2	30.8	30.3	0.98	0.16	212	334

8.4 Well test evaluation

8.4.1 Honselaarsdijk

Well tests were performed for both wells, but were evaluated by different consultancy companies. The report for HON-GT-01 was made in 2012 by a German consultant and written by Hon. Prof. Dipl.-Ing.Dr.mont Ch.j. Schmid. This report a transmissivity range between 1.25 to $1.47 \cdot 10^{-3} \text{ m}^2/\text{s}$. For the purpose of this SDE application, this report has been re-evaluated by PanTerra and Pieter Lingen and found to be inapplicable. An update was written recently by Pieter Lingen based on the current knowledge of the reservoir and the other comparable well tests (PanTerra, 2018). It was concluded that the transmissivity is 49 Dm leading to a permeability of 454 mD (if 108 m of reservoir contributes).

The well test for HON-GT-02 was evaluated by PanTerra in 2012 (described in *advies aanvraag Garantieregeling AARD03002 Geothermie De Lier* found on www.rvo.nl). This evaluation concluded that the permeability of the Delft Sandstone Member is 1,190 mD. The reservoir at HON-GT-02 is situated approximately 1.9 to 4.5 km from the targets of MON-GT-01 and -02.

8.4.2 Poeldijk

The PLD-GT wells have also been tested and evaluated by PanTerra (PanTerra, 2016). These reports are available in the public domain (on www.rvo.nl) and conclude that the average permeability is 1.650 mD for PLD-GT-01 (if 133 m reservoir contributes) and 1,325 mD for PLD-GT-02 (if 117 m net sand contributes). The Poeldijk wells are situated 2.4 to 4.8 km from MON-GT-01 and -02.

8.4.3 Naaldwijk

Well tests and an interference test were performed on the Delft Sandstone Member in wells NLW-GT-01 and -02 (PanTerra, 2018).

During the 30 hours test (with 9 hours of water production) of well NLW-GT-01, starting 28 Feb. 2018, the water production rates varied between 215 and 428 m³/hr with a cumulative production of 3,350 m³.

Evaluation of the test indicates an average reservoir permeability of about 700 mD if all layers of the 82 m thick cumulative perforation intervals contribute. It is likely however, that the lower perforation interval assigned to the Alblasserdam contributes relatively little.

For NLW-GT-02, a 33 hours test was performed (with 9.5 hours of water production), starting 31 May 2018, in which water production rates varied between 219 and 450 m³/hr with a cumulative production of 2,990 m³. The average reservoir permeability was assessed 800 mD if 57 m contributes.

The interference test report concludes a (radial) permeability of 800 mD. The NLW-GT wells are separated some 4,300 to 7,000 m from the planned MON-GT wells.

8.5 Evaluation production data

Production data were not evaluated.

8.6 Permeability estimates from the public domain

A petrophysical evaluation of the Delft Sandstone was performed by TNO. Porosity and permeability averages of 20 wells were calculated. Figure 8-9 shows the range of calculated porosities and permeabilities. The well closest to the NLW-GT doublet is MON-02. According to this 2013 interpretation, the average permeability in this well is 235 mD.

The well tops picked by TNO for MON-03 do not comply to the correlation presented in Figure 8-1 or with the composite well log (the Aalborg Formation is included) and will therefore not be considered here.

Important to note is that most of the results from the petrophysical analysis give permeabilities which are lower than those from the well tests described above. These well tests give the most reliable measure of average permeability for the whole producing reservoir. Also note that the porosity-permeability relationship applied by TNO in 2013 was much more conservative than their new relation presented in section 8.3.2.

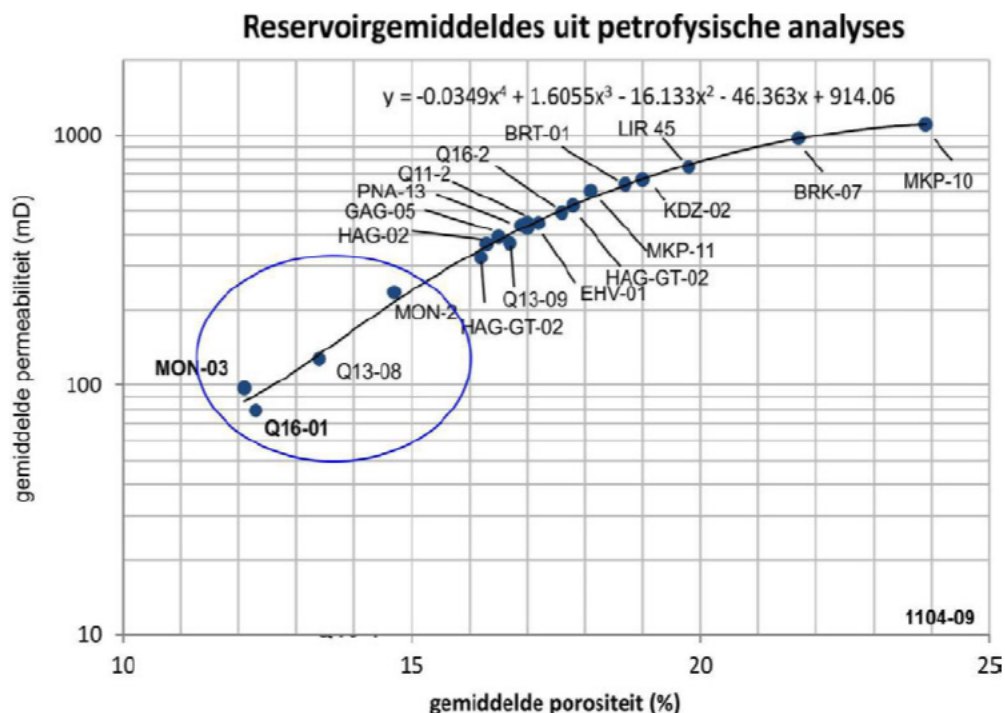


Figure 8-9: Mean porosity vs. mean permeability (per well) of the Delft sandstone, resulting from the petrophysical analysis performed by TNO in 2013.

8.7 Detailed comparison between the well test- and petrophysical permeability

The permeability derived from the well tests is consistently higher than the permeability derived from the petrophysical analysis with the porosity permeability relationship derived by PanTerra (see Table 8-1). This is also partly true for the function derived by TNO. Please note that the permeability from the well test is regarded as a more reliable estimate.

A true comparison between the results from the well test and the results from petrophysics is not straightforward. This is due to the fact that the screens are mostly covering reservoir intervals that differ from the true reservoir tops (as can be observed in Figure 8-1). To achieve a more honest comparison, the permeability has to be scaled to the according thicknesses.

Appendix 12.4 shows the excel sheets which were used for this comparison in the wells NLW-GT-01 and HON-GT-01. Based on these calculations, the transmissivity from the well tests can be nearly matched to those of from petrophysics by applying the (most recent) porosity-permeability relationship derived by TNO (49.0 versus 48.1 Dm for HON-GT-01 and 56.4 versus 61.8 Dm for NLW-GT-01). Also, this relation applies to both the Delft Sandstone member and the transition zone. As such, the TNO-derived porosity-permeability relationship is deemed most appropriate. The scaled average reservoir properties for the Delft transition zone combination are given in Table 8-2.

Table 8-2: Aquifer characteristics for the combination of Delft and the transition zone.

Well	Zone Name	Top	Bottom	Gross	Net	N/G	Av Phi	Av Perm
		m TVDSS	m TVDSS	m TVDSS	m TVDSS	Dec	%	P50 TNO mD
HON-GT-01	SLDND + Transition zone	2364.7	2483.5	53.6	49.7	0.63	0.19	626
NLW-GT-01	SLDND + Transition zone	2313.2	2391.7	44.4	44.4	0.90	0.19	857
MON-02	SLDND + Transition zone	2198.4	2229.2	30.8	30.3	0.98	0.16	334

The same sheets are used to derive the well test based average permeability for the Delft Sandstone - transition zone combination. The proportions between the different zones found in the petrophysical analysis have been used to accomplish this.

For NLW-GT-01, the average permeability is 783 mD for the Delft and transition zone combination (compared to 700 mD for the total screened thickens). For HON-GT-01 an average permeability of 638 mD is derived for the Delft and transition zone combination (compared to 454 mD for all the entire screened sections).

8.8 Overview of all permeability sources

To visualise the permeability measurements from all sources a bit more comprehensively, the data has been gridded (see Figure 8-10). For each location the most representative source is chosen; well test have priority over petrophysical evaluations. Fault lines have not been included, but there appears the be a permeability trend in the MON-GT fault block where permeability reduces towards the West.

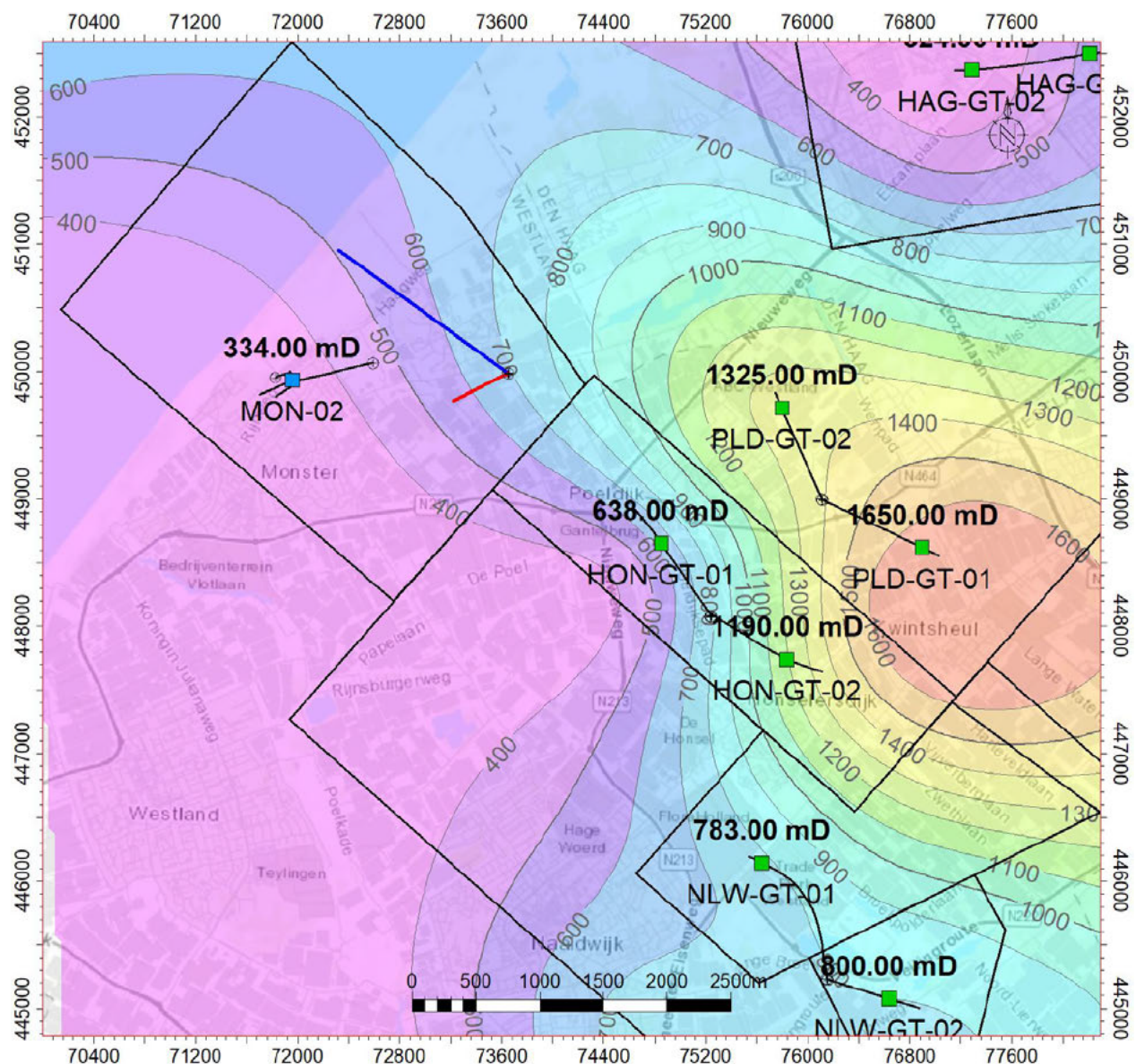


Figure 8-10: Contour map of publicly available the average permeabilities calculated for the Delft Sandstone Member in the area around the planned doublet (red and blue). The data points are marked by squares which are colour coded according to source; well test in light green, and petrophysical analyses in blue.

8.9 Reservoir properties at the target location

The nearest well test, which is considered to give the most reliable measure of average permeability for MON-GT-01 and -02, is performed in the HON-GT-01 well. This well is also situated on roughly the same trendline in a depositional and structural sense. The petrophysical results performed for this study on MON-02, show that towards the Southwest, permeability decreases. However, this can also occur towards the Northwest.

For the DoubletCalc calculations the P10, P50 and P90 permeability estimates are based on the numbers and considerations presented in the above sections. Given the trend observed in the map of Figure 8-10, the permeability is assumed to be lower than that found in the well test of HON-GT-01, but higher than the permeability found in MON-02. The permeability range determined for the new doublet is: **330 (minimum) – 550 (median) – 1,000 mD (maximum)**.

8.10 Anisotropy

Anisotropy of the reservoir can be expressed as the ratio between horizontal and vertical permeability; K_h/K_v . This ratio is usually relatively high when the reservoir is layered and low when the reservoir is homogeneous (in horizontal and vertical sense). K_h/K_v can be expressed as the ratio between the arithmetic and harmonic permeability. The

arithmetic average is considered to be representative for horizontal permeability and the harmonic average for vertical permeability. The report on the interference test in the NLW-GT wells infers a K_h/k_v of 3.8 (PanTerra, 2018). This value is used in the DoubletCalc calculations.

8.11 Results and uncertainty discussion

The resulting reservoir parameters with uncertainty ranges are summarized in Table 8-3.

Table 8-3: Min, median and max estimates for the Delft Sandstone.

MON-GT-01 & -02			
Parameter	Min	Median	Max
Gross thickness (m)	60	70	90
N/G (dec)	0.90	0.93	0.98
Average permeability (mD)	330	550	1,000
Salinity (ppm)	120,000	140,000	160,000
K_h/K_v	-	3.8	-
Temperature gradient (°C/100m)	-	3.25	-

9 Evaluation of water temperature and salinity

9.1 Temperature

Based on temperature maps of the subsurface of the Netherlands (Figure 9-1) the subsurface temperature below Monster is approximately 70-72°C at 2,000 m depth. This corresponds to a temperature gradient of approximately 3.4°C/100m-3.6°C/100m, assuming a surface temperature of 10°C.

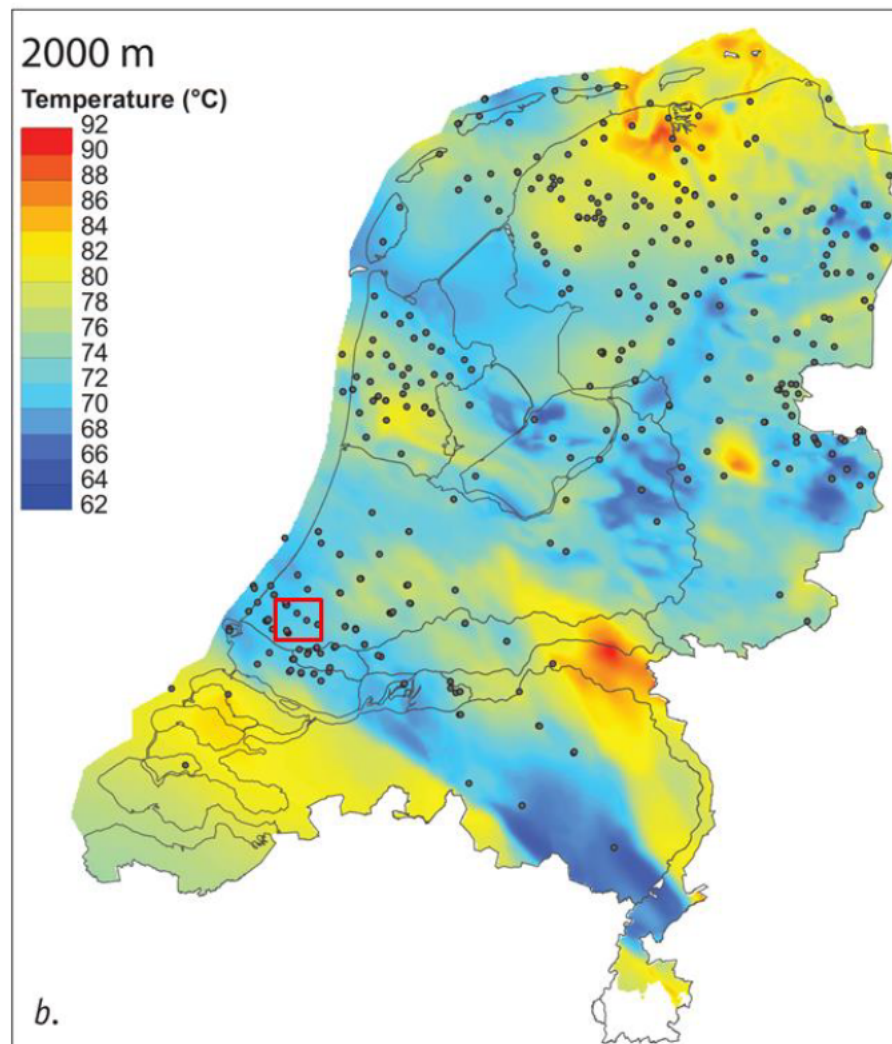


Figure 9-1: Subsurface temperature maps of the Netherlands at a depth of 2000m (Bonté et al., 2012). This map is generated from thermal-tectonic forward modelling, calibrated with BHT measurement in wells (corrected for thermal perturbation during drilling) and few DST measurements in wells. Used wells are indicated by black dots.

Temperature data from six nearby geothermal wells were used to estimate the temperature gradient for the planned doublet (Table 9-1). All measured temperatures are from produced reservoir water. These are considered to be more reliable than BHT and RFT temperature data. Temperature gradients are inferred assuming a linear gradient from the surface to mid-reservoir depth where the surface is considered 10°C. It is assumed the contributions of the Alblasterdam sands to the well tests are negligible. The calculated temperature gradients were used to create a temperature gradient map (Figure 9-2).

This leads to a temperature gradient of approximately 3.3°C/100m which is somewhat lower than the average geothermal gradient of the local geothermal gradient in the study area (Figure 9-1). However, no large deviations in geothermal gradient are expected for the planned MON-GT wells.

Table 9-1: Temperature data and gradients from nearby wells.

Well	Measured °C	Depth (TVDSS)	Gradient (°C/100m)
PLD-GT-01	90	2362	3.39
PLD-GT-02	87.5	2329	3.33
HON-GT-01	87.8	2422	3.22
HON-GT-02	90.9	2460	3.29
NLW-GT-01	87	2350	3.28
NLW-GT-02	3.3	2410	3.22

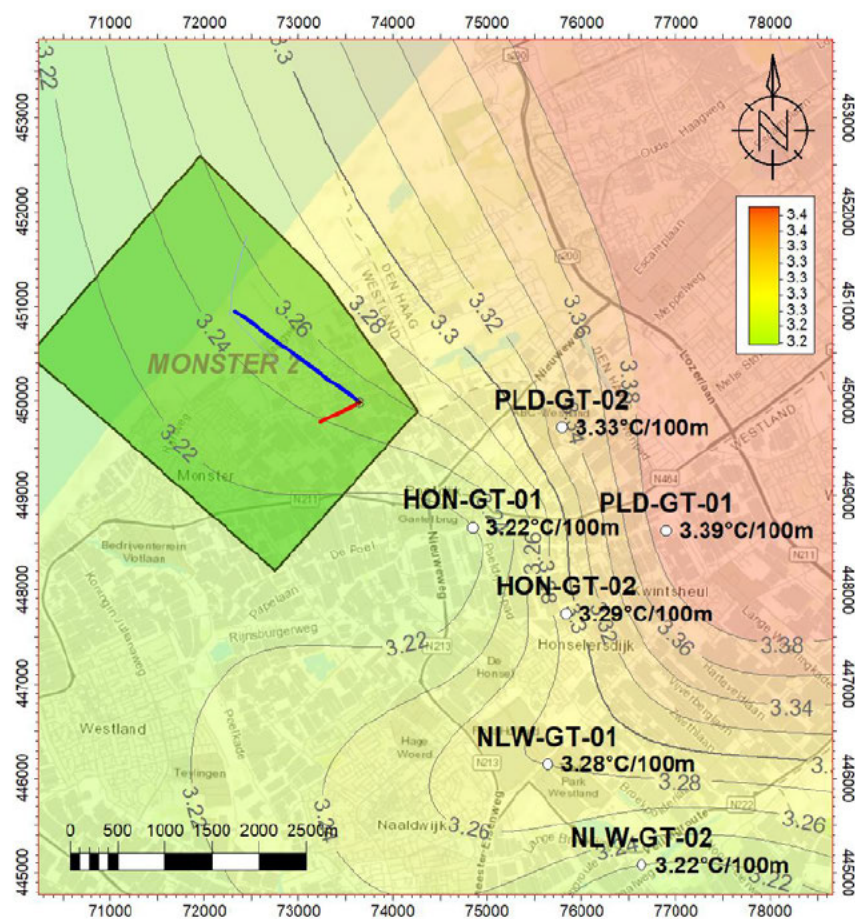


Figure 9-2: Contoured temperature gradient data.

Based on these data the following gradient is used as input for DoubletCalc:

$$T = 10 + 0.0325 \cdot h$$

in which T = temperature in °C and h = depth in meters.

9.2 Salinity

Based on the well tests of NLW-GT-01, -02 and HON-GT-01, the formation water has a salinity of approximately 130,000 to 145,000 ppm NaCl equivalent, which is roughly in line with other geothermal doublets in Westland. A

formation water sample has been analysed but does not directly measure the NaCl equivalent (see appendix 10.9) The salinity estimate from the petrophysical evaluation of well LIR-45 supports a salinity of approximately 120,000 ppm NaCl equivalent. The salinity range for DoubletCalc calculations is listed in Table 9-2.

Table 9-2: Estimated salinities of the formation water.

	Min	Median	Max
Salinity Nieuwerkerk Fm. (ppm NaCl equivalent)	120,000	140,000	160,000

9.3 Aquifer pressure

The aquifer pressure is expected to be hydrostatic. The nearby doublets (NLW, PLD and HON) show no unexpected pressures at reservoir depth, nor is there any indication of overpressures in the nearby area. A hydrostatic gradient of 0.106 bar/m would result in an aquifer pressure of 240 and 238 bar at the injector and producer respectively.

The nearest operating doublet is the HON-GT-01/02 configuration. A previous analysis on pressure difference from nearby wells resulted in a maximum pressure difference of 1.8 bar when operating within 700m. At reservoir level, the producer of the HON-GT doublet is 1.7km removed from the MON-GT producer. Therefore, the current doublet setting is not expected to have significant pressure impact on the initial reservoir pressure.

10 Doublet performances

10.1 Doublet configurations in the subsurface

The planned doublet will consist of wells MON-GT-01 and MON-GT-02 with MON-GT-02 as the injector and MON-GT-01 as the producer. Figure 10-1 shows the trajectory of the doublet and the planned wells on the top reservoir depth map.

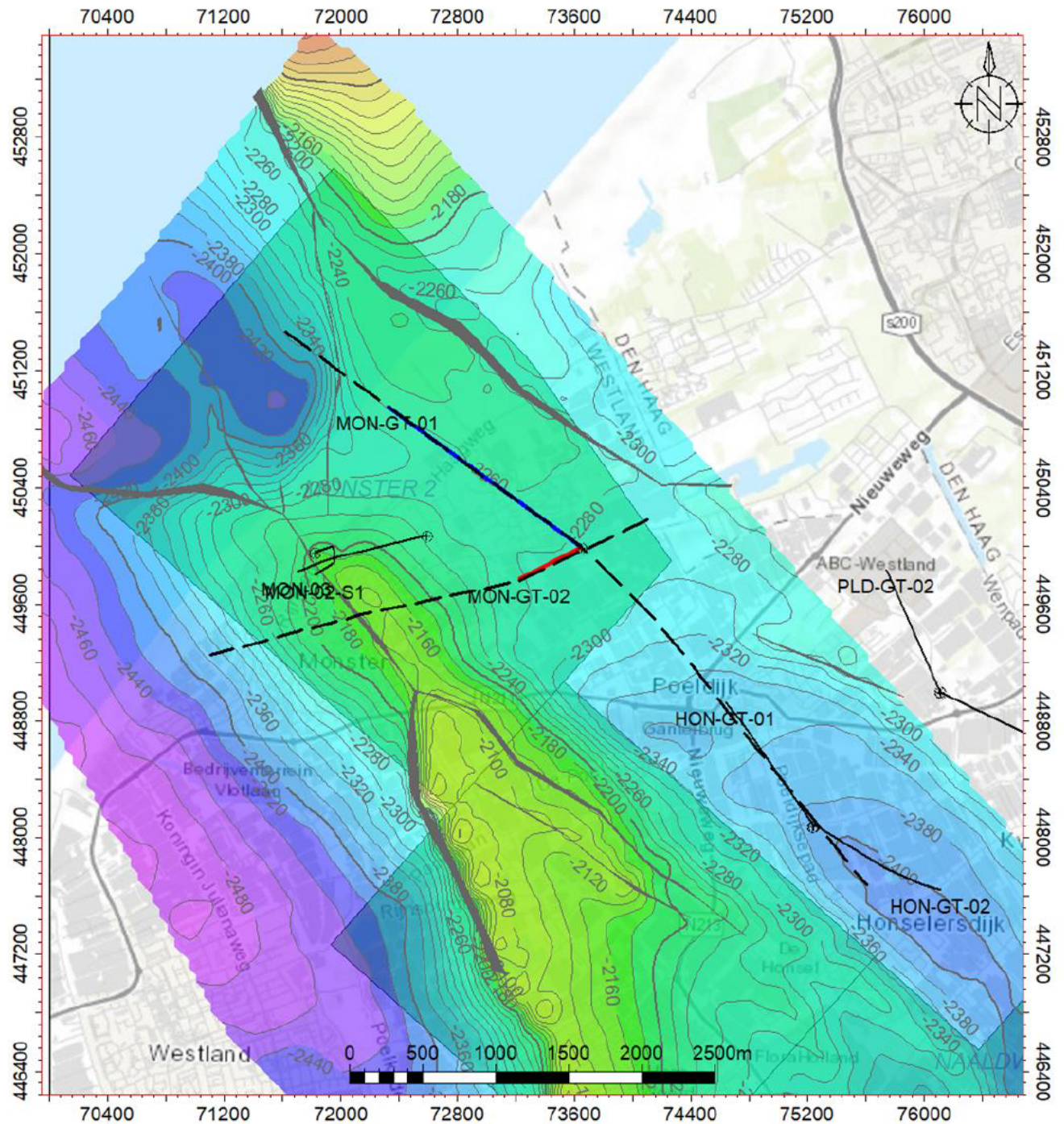


Figure 10-1: Top reservoir map with the MON-GT wells and the existing HON-GT-01 well. The intersections of the planned wells with top reservoir are indicated by white the circles. The contour interval is 20 m. The seismic lines of Figure 10-2 and Figure 10-3 are indicated with the black dashed lines.

The subsurface mid reservoir distance between the wells is approximately 1,300m. The doublet is situated between two major faults to avoid influence and the locations were optimised using an analytical simulation model to avoid influence on neighbouring licenses.

The wells are projected on the seismic in (see Figure 10-2 and Figure 10-3). Both large faults are approximately 1000m from the injector. The producer is approximately 500m from the fault to the northeast. Minor faults may also be present near the wells, but they cannot be distinguished on seismic. Because these faults are so small it is not expected that they form a significant barrier for flow or cause geomechanical problems.

The RD coordinates of the surface location, reservoir top and base and Total Depth (TD) are listed in Table 7-4 and Table 7-5.

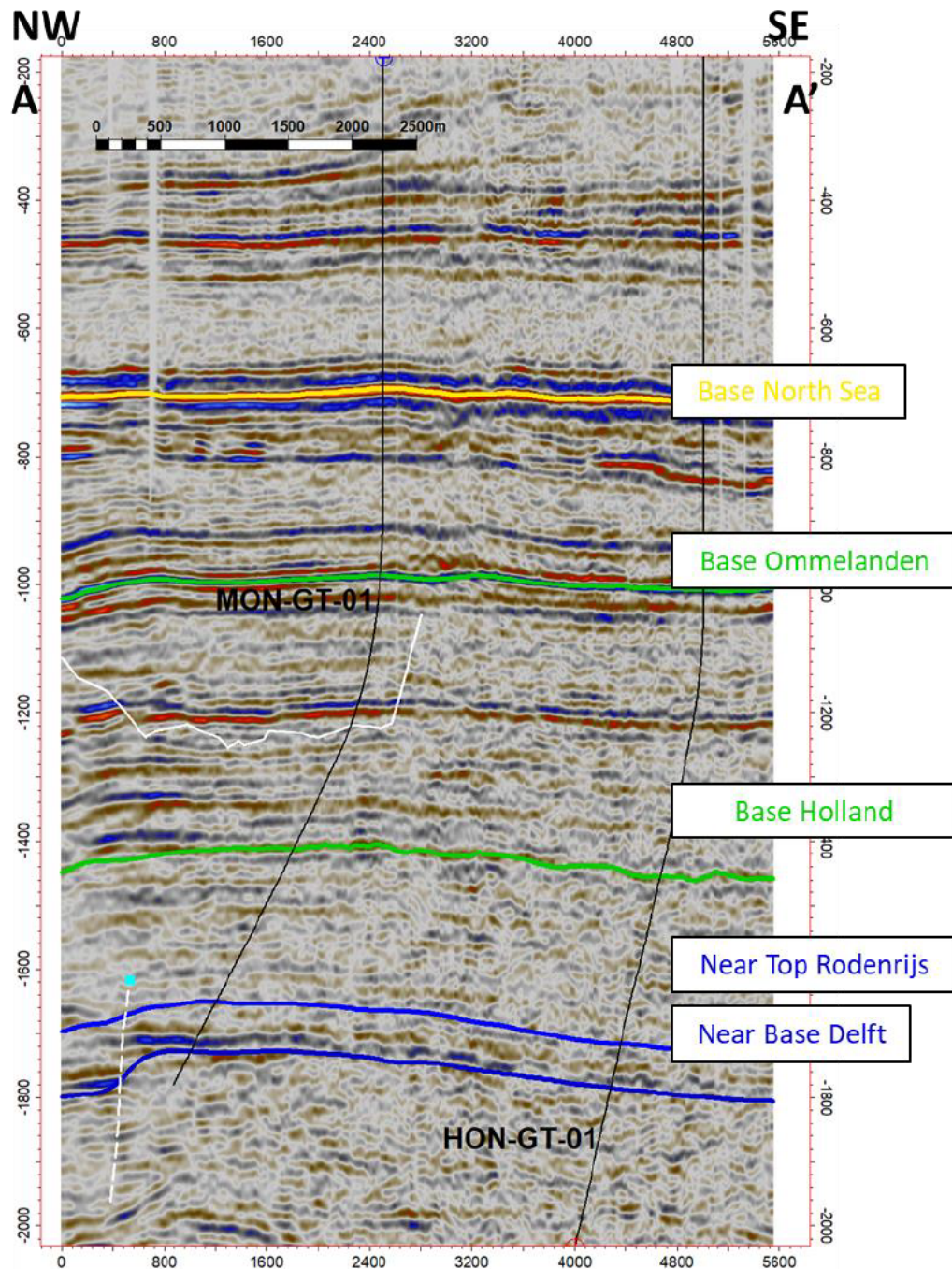


Figure 10-2: MON-GT-01 projected on the seismic, also showing the existing HON-GT-01 well. The location of the line is indicated in Figure 10-1. Please note the amplitude anomaly NW of MON-GT-01.

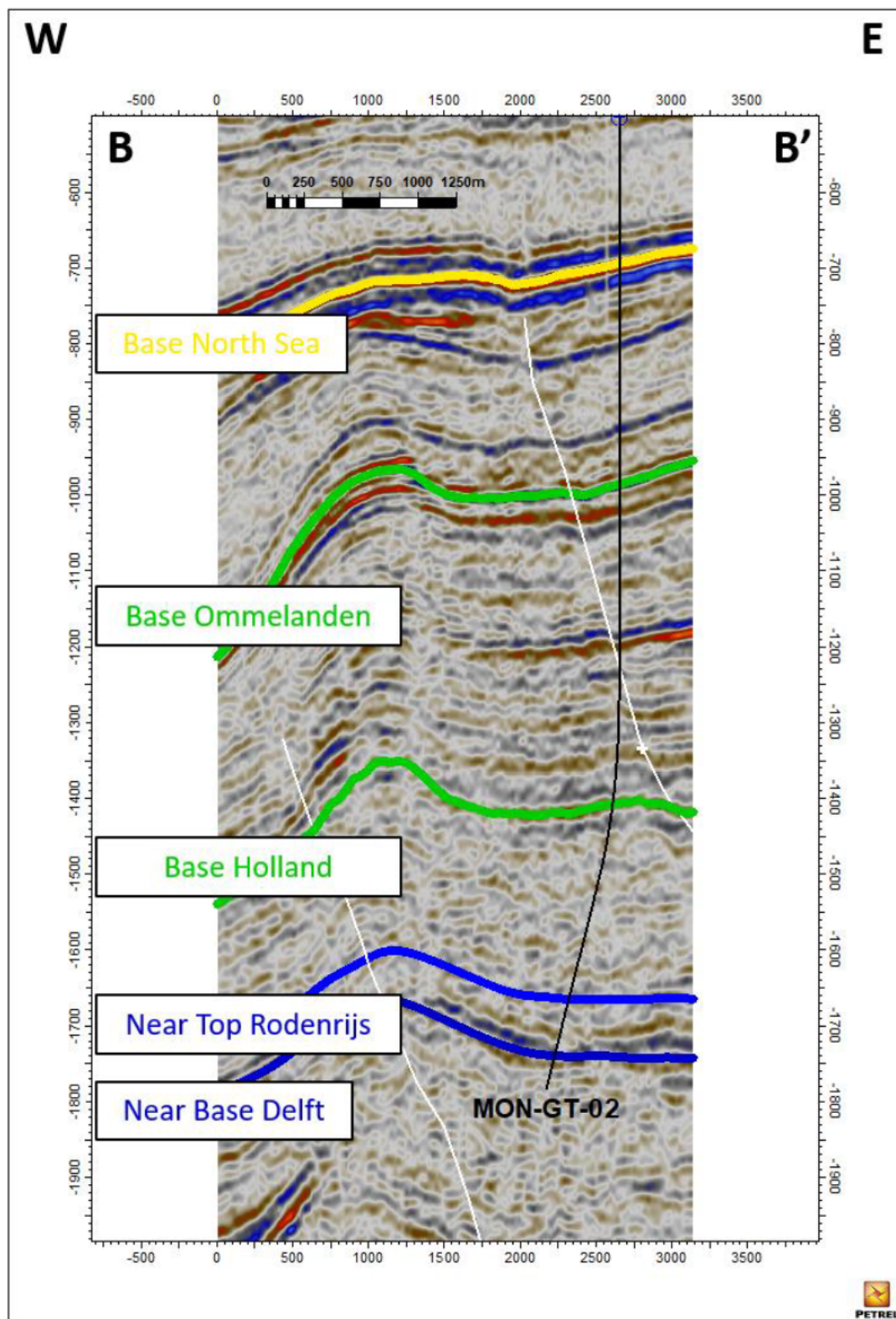
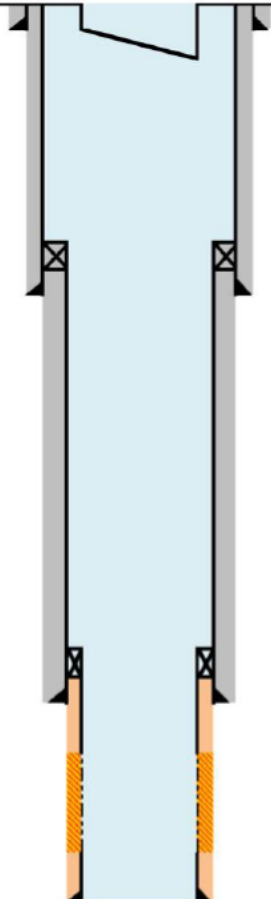


Figure 10-3: MON-GT-02 projected on the seismic, the location of the line is indicated in Figure 10-1.

10.2 Well architecture

Conceptual casing schemes for wells MON-GT-01 and MON-GT-02 are shown in Figure 10-4 and Figure 10-5 (the report by WEP regarding the basic well design is added to the SDE+ request). The Electronic Submersible Pump (ESP) is located at a depth of 800 m TVD in the producer. The open hole diameter is 9.5 inch in the reservoir, which is completed with wire wrapped screens. The inclination of the producer and injector in the reservoir are 55° for MON-GT-01 and 35° for MON-GT-02. The reservoir itself is approximately horizontal. The well trajectories are listed in Appendix 10.6.

Nr.	Item Description All depths from NAP	Wellhead and Xmastree MON-GT-01	Depth	Depth	Hole ID	Pipe OD	Collar OD	Pipe ID	Pipe ID
			m tvd	m ah	in	in	in (nom)	in	in (drift)
1	24" 0,5" WT Conductor		140	140	-	24,000	welded	23,000	23,000
	Injection tubing		150	150		10,750	11,565	9,760	9,625
2	16" x 10 3/4" liner hanger 16" 95# L80 casing		980	980	Top of liner (100 m liner lap)				
			1078	1080	20,00	16,000	16,993	14,868	14,679
			1083	1085	section TD				
3	10 3/4" x 7 5/8" Liner Hanger + Packer 10 3/4" 55,5# L80 Liner		2219	2875	Top of liner (50 m liner lap)				
			2248	2925	14,000	10,750	11,565	9,760	9,625
			2251	2930	section TD				
			2262	2945	Top Delft Sandstone				
4	7 5/8" 26,4# L80 liner with WWS		2406	3202	9 1/2"	7,625	8,132	6,969	6,844
			2410	3207	TD				

*Not in scale

Figure 10-4: Conceptual casing scheme of well MON-GT-01.

11 References

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Appendices

12.1 Details used data

TNO Petrophysics

Put	Stratigrafie	Top (m)	Basis (m)	Diepte Dimensie	Percentiel	Porositeit (%)	Permeabiliteit (mD)	Netto-Bruto (%)	Gebruikt voor	Referentie nr.
BRK-07	SLDND	1921.00	1936.00	MD	P50	21.7	974	94.0	Y	1129
BRT-01	SLDND	2082.00	2146.00	MD	P50	18.7	637	64.0	Y	1129
EHV-01	SLDND	2043.00	2063.00	MD	P50	17.2	445	68.0	Y	1129
GAG-05	SLDND	2817.00	2978.00	MD	P50	15.7	367	52.0	Y	1129
HAG-02	SLDND	1730.00	1770.00	MD	P50	16.5	391	79.0	Y	1129
HAG-GT-01	SLDND	2546.00	2702.00	MD	P50	17.8	523	69.0	Y	1129
HAG-GT-02	SLDND	2150.00	2330.00	MD	P50	16.2	324	83.0	Y	1129
HON-GT-01	SLDND	2553.00	2620.00	MD	P50	17.0	446	77.0	Y	1129
KDZ-02	SLDND	1891.00	1936.00	MD	P50	19.0	666	79.0	Y	1129
LIR-45	SLDND	2163.00	2183.00	MD	P50	19.8	747	83.0	Y	1129
MKP-10	SLDND	647.00	720.00	MD	P50	23.9	1110	76.0	Y	1129
MKP-11	SLDND	860.00	910.00	MD	P50	18.1	599	63.0	Y	1129
MON-02	SLDND	2224.00	2256.00	MD	P50	14.7	235	86.0	Y	1129
MON-03	SLDND	2317.00	2347.00	MD	P50	12.1	97.0	27.0	Y	1129
PNA-13	SLDND	1864.00	1939.00	MD	P50	17.2	435	69.0	Y	1129
Q11-02	SLDND	1028.00	1168.00	MD	P50	17.0	425	58.0	Y	1129
Q13-01	SLDND	1904.60	1974.00	MD	P50	13.4		72.0	Y	328
Q13-02	SLDND	1950.70	2163.80	MD	P50	14.8		50.4	Y	328
Q13-02	SLDND	1951.00	2164.00	MD	P50	14.8		50.4	Y	314
Q13-04	SLDND	1535.20	1668.40	MD	P50	16.0		72.7	N	328
Q13-07-52	SLDND	2018.00	2130.00	TVD NAP	P50	13.8	19.6	55.8	Y	160
Q13-08	SLDND	1891.34	1908.79	MD	P50	13.4	127	58.0	Y	1129
Q13-08	SLDND	1905.00	1907.00	MD	P50	18.4		100.0	Y	314
Q13-09	SLDND	1872.99	1984.13	MD	P50	17.5		60.5	N	328
Q13-09	SLDND	1873.00	1909.00	MD	P50	16.9		76.1	N	314
Q13-09	SLDND	1913.45	2028.00	MD	P50	16.7	370	60.0	Y	1129
Q16-01	SLDND	1993.90	2077.00	TVD NAP	P50	11.2		48.5	N	160
Q16-01	SLDND	1994.00	2077.00	MD	P50	12.3	79.0	38.0	Y	1129
Q16-02	SLDND	2089.00	2131.00	TVD NAP	P50	17.7		90.0	Y	160
Q16-02	SLDND	2089.00	2183.00	MD	P50	17.6	490	62.0	Y	1129

PanTerra Petrophysics

Well	Zone Name	Top m TVDSS	Bottom m TVDSS	Gross m TVDSS	Net m TVDSS	N/G TVDSS	Av Phi %	Av Perm P90 mD	Av Perm P50 mD	Av Perm P1 mD
LIR-45	SLDND	2154.93	2190.44	26.36	22.05	0.84	0.19	21.7	573.6	1486.1
NLW-GT-01	SLDND	2313.26	2391.74	74.53	70.13	0.94	0.19	20.9	534.4	1381.3
LIR-45	SLDNA_upper	2273.83	2378.07	104.26	73.52	0.705	0.168	9.249	137.707	773.14
NLW-GT-01	SLDNA_upper	2646.94	2748.93	101.89	65.5	0.643	0.143	2.423	39.552	278.76
LIR-45	SLDNA_lower	2378.07	2400.95	22.97	1.44	0.063	0.139	2.448	39.901	278.905
NLW-GT-01	SLDNA_Lower	2748.93	2797.24	48.29	\$2.90	0.06	0.111	1.529	24.802	172.917

12.2 Well tests

Resultaten van de put test

Gegevens voor test interpretatie	Waarde	Dimensie
Naam van de put	NLW-GT-01	
Top aquifer	2604	m (langs boorgat)
"	2312	en m (TVD)
Basis aquifer	2752	m (langs boorgat)
"	2440	en m (TVD)
Netto dikte Aquifer	83.4	m (TVD)
Netto/bruto aquifer	89	%

Gemiddelde porositeit aquifer	18.7	%
Zoutgehalte formatiewater van sample	120	kg/m3
Verwachte max. temperatuur geproduceerde water ¹	87	°C
Casing 20"	1158	m tv
Casing 13 3/8"	2168	m tv
Casing 9 5/8"	3773	m tv
Diameter boorgat bij aquifer	9 5/8	Inch
Top productie-interval/filter (6 5/8 x 7")	2604	m (langs boorgat)
"	2312	m (TVD)
Basis productie-interval/filter (6 5/8 x 7")	2752	m (langs boorgat)
"	2440.4	m (TVD)
Weerstand over screens ²	0	bar
Locatie pomp	752	m (ah)
Locatie meetsonde voor druk	752	m (tv)
Locatie diepe wireline gauge	2600	m (langs boorgat)
"	2317	m tv
Meetreeksen Puttest:		
	Eind ESP druk, bar	Eind Debiet, m3/uur
Flow 1	64.4	215
Flow 2	61.1	327
Flow 3	57.1	428
Flow 4	64.7	226
Flow 5	56.4	427
BU	70.65	0
Uitkomsten test interpretatie en analyses		
Skin	-0.25 to 1.43	
H	83.5	m
K	700	mD
KH	58.1	D*m
PI (transient 30 hrs)	24.1	m ³ /hr/bar
Two flow-barriers/baffles at approximately	270 and 670	m from well
Deviatie		
Diepte langs boorgat	Diepte m tv	East North
0	0	76147,00 445237,00
2604	2312	
Mid reservoir ~2670	2376	
2752	2440	

¹ Deze temperatuur wordt als gemiddelde aquifer temperatuur beschouwd

² Geen meting van weerstand over filter

12.3 Production data

Not used

12.4 Well test derived versus petrophysically derived permeability

HON-GT-01																			
zone	Petrophysics								Well test					SDE+					
	Boundaries (m TVDs)	PHIE (Dec)	perm (mD)	N/G	gross thickness (mTVT)	nett thickness (mTVT)	Kh (mDm)	perm total (mD)	Screens (m TVDs)	net thickness (mTVT)	Kh	Kh petrophysical for screens (mDm)	Kh sub total	perm total	perm sub	perm Delft + Trans well test (mD)	Perm N/G Delft + Trans petrophysicals (mD)	PHIE Delft + Trans n (dec)	
Delft	2364.68	0.19	596	0.93	53.51		49.66	29595.74	2364.68	49.66			29596	30149	607				
Transition	2418.19								2418.19								637.5397	625.84	0.63
	2418.19	0.18	686	0.38	65.34		24.63	16898.36	2418.19	24.63			16898	17214	699			0.15	
								342.70			49000	48101			454				
Ablasserdam	2483.53								2483.53										
	2483.5	0.17	48	0.19	371.4		71.31	3402.86	2483.50	33.67			1607	1637	49				
									2509.53										
									2667.77										
									2765.85										
									2803.63										
									2854.90										
SUM					490.25		145.60	49896.96		107.96		48101							

NLW-GT-01																	
zone	Petrophysics							Well test							SDE+		
	Boundaries PHIE (m TVDs)	perm (Dec)	perm (md)	N/G	gross thickness (mTVT)	nett thickness (mTVT)	Kh (mDm)	perm total (md)	Screens (m TVDs)	net thickness (mTVT)	Kh (mDm)	Kh petrophysical for screens (mDm)	Kh sub total (md)	perm sub total (md)	perm Delft + Trans well test (md)	Perm delft + Trans petrophysicals (md)	N/G Delft + Trans + Transition (dec)
Delft	2313.26	0.2	962	1.00	44.48	44.48	42789.76		2313.26	44.48		42790	39089	879			
Transition	2357.74	0.18	679	0.78	34.00	26.38	17914.74		2357.74	26.384		17915	16365	620	783	857	0.90
																	0.19
								751.63									
Alblasserdam	2391.74								2391.74								
	2426.33	0.17	95	0.84	13.51	11.33	1079.04		2426.33	11.33		1079	986	87			
SUM	2439.84				91.99	82.20	61783.53		2439.84	82.20		61784					

12.5 Maps

12.5.1 Time maps

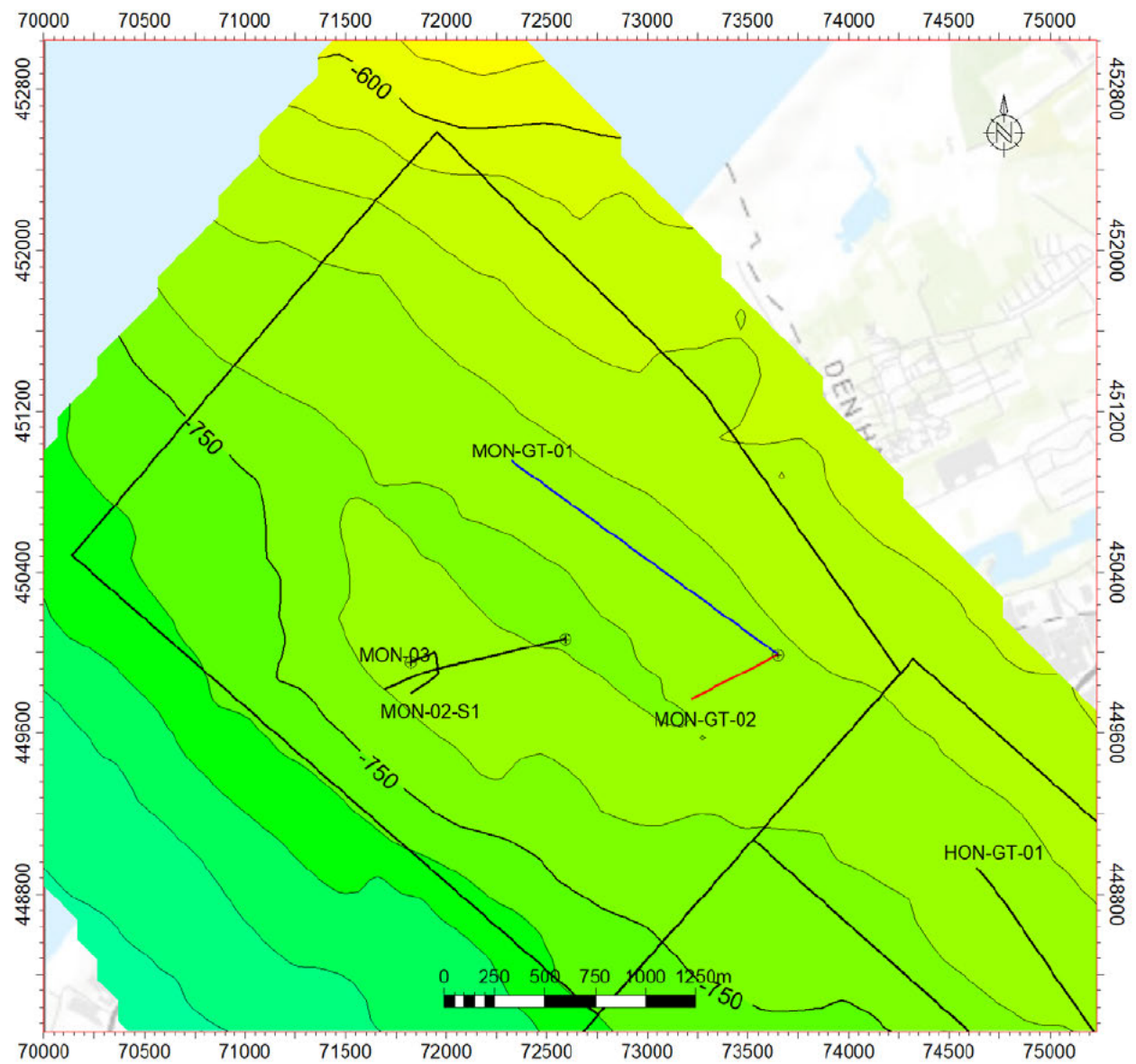


Figure 1: Time map of the base of the North Sea Supergroup.

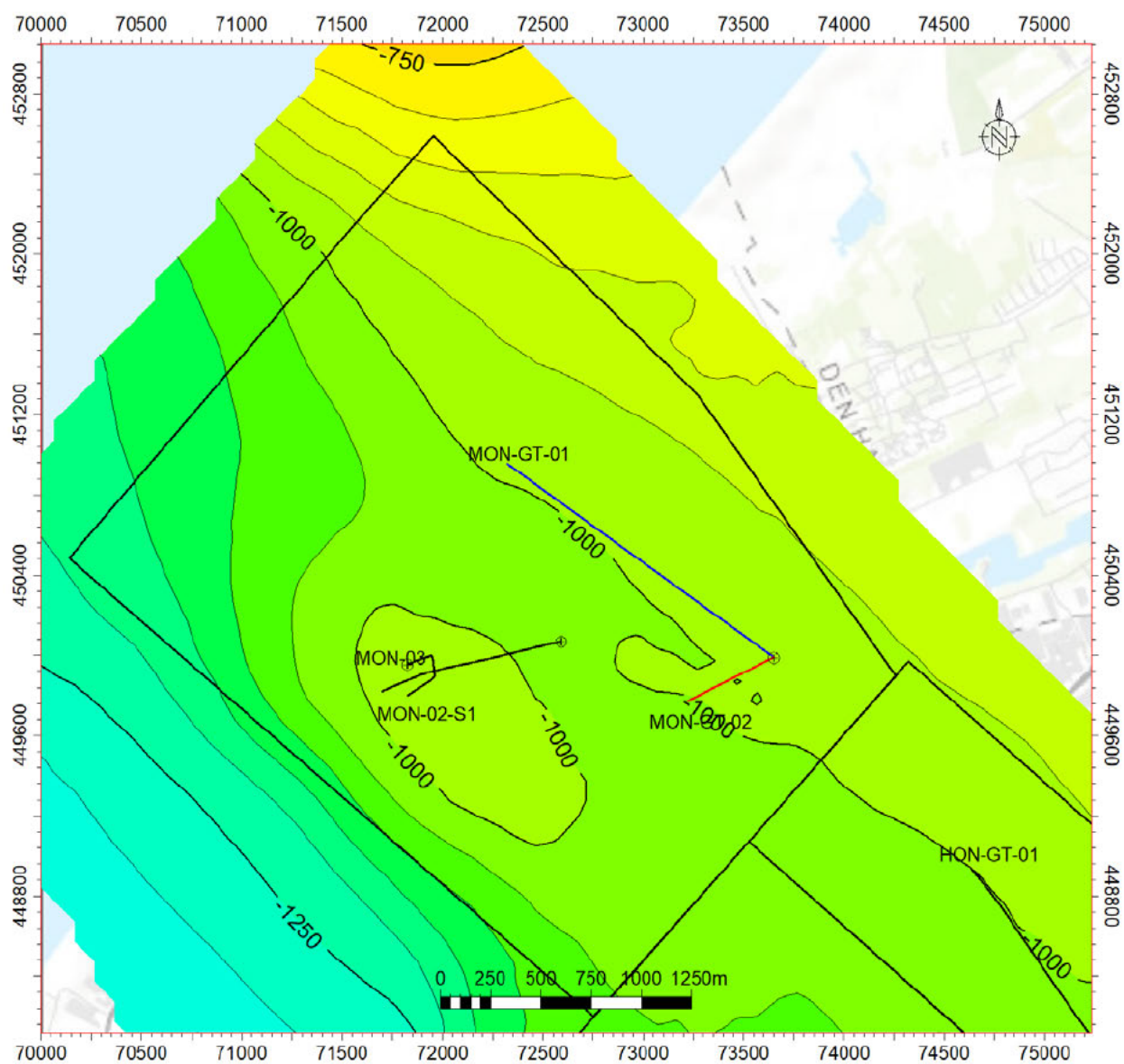


Figure 2: Time map of the base of the Ommelanden member.

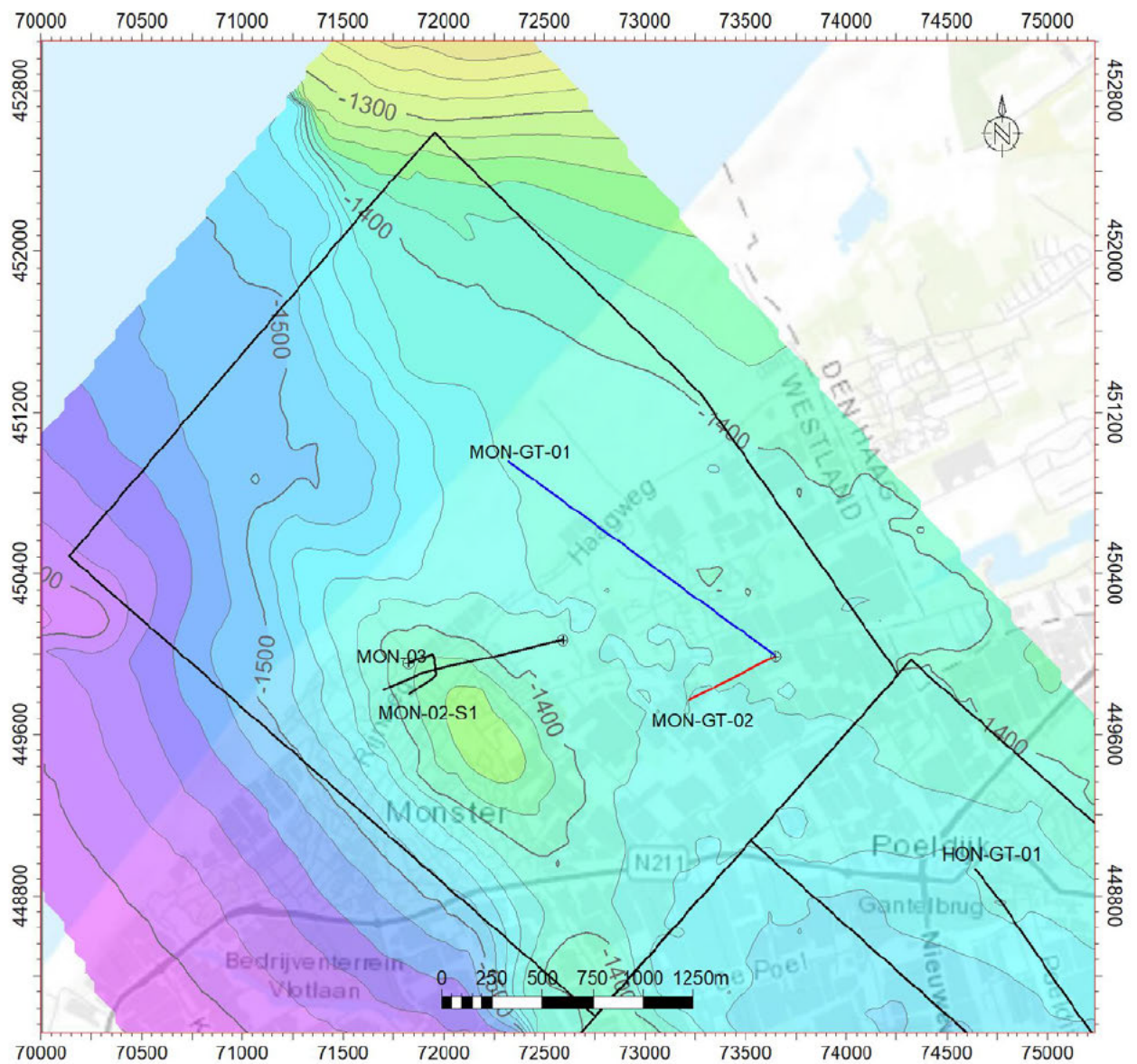


Figure 3: Time map of top of the Rijswijk member.

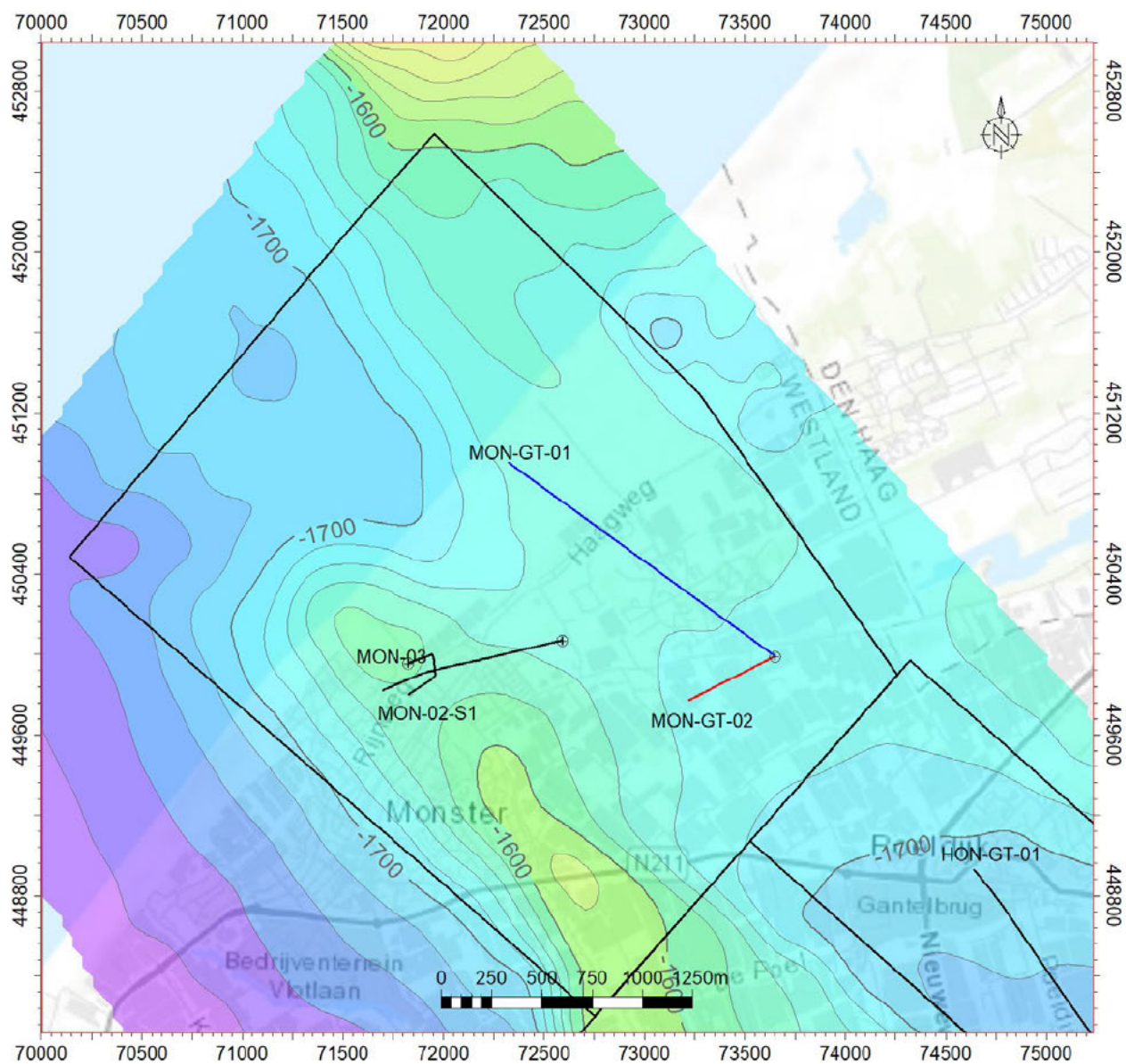


Figure 4: Time map of the top of the Rodenrijs member.

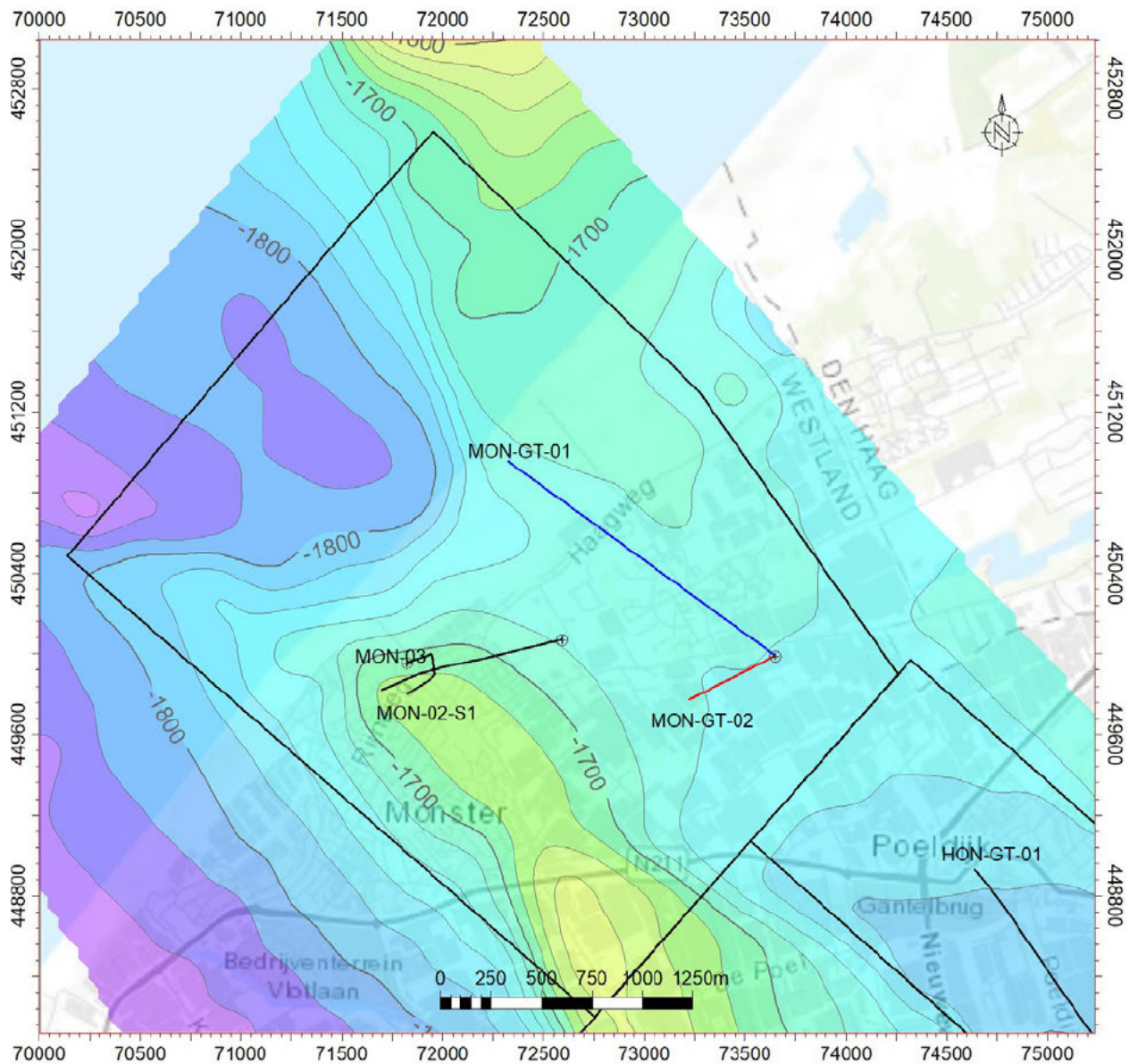


Figure 5: Time map of the base reservoir.

12.5.2 Depth maps

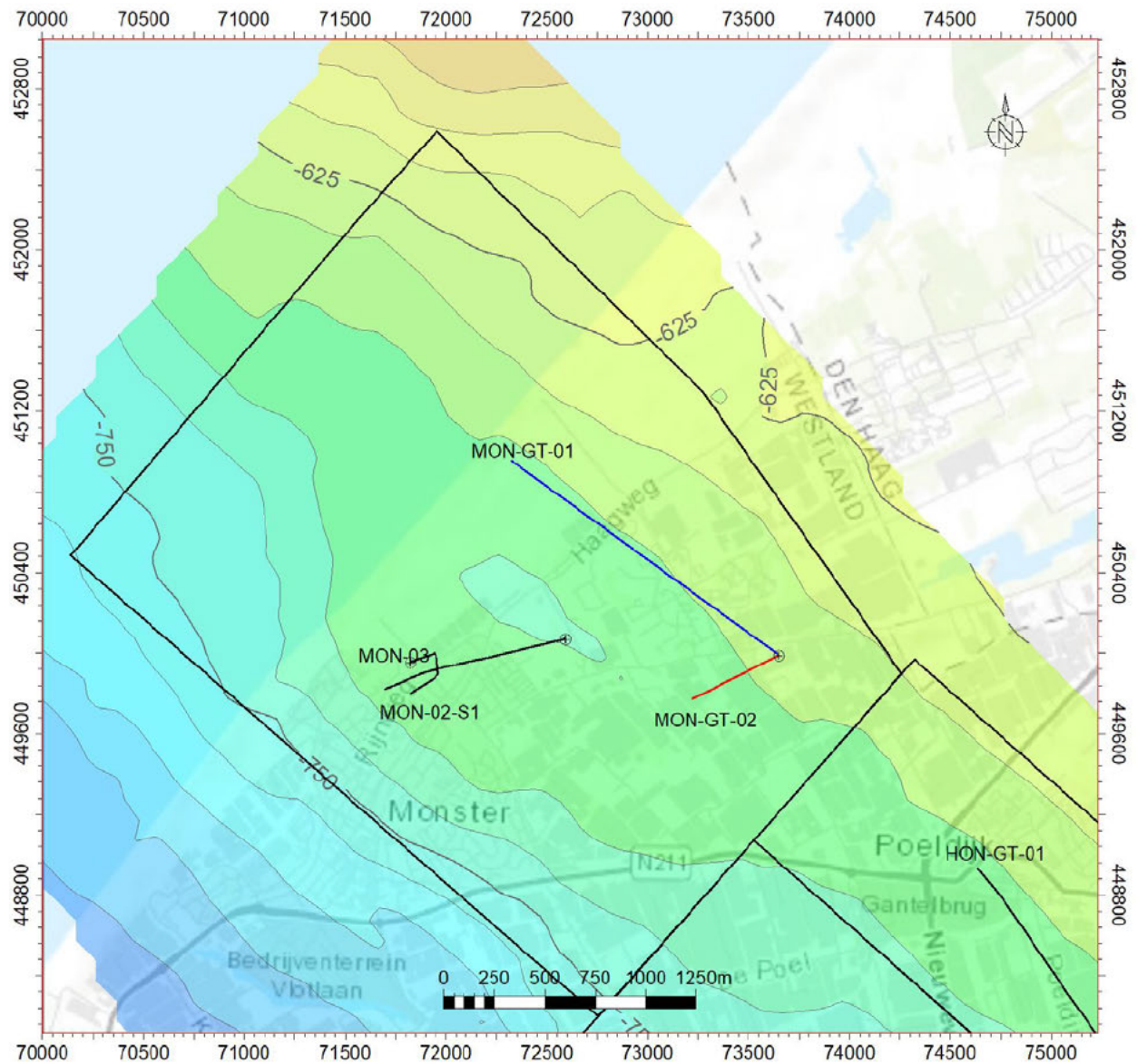


Figure 6: Depth map of the base of the North Sea Supergroup.

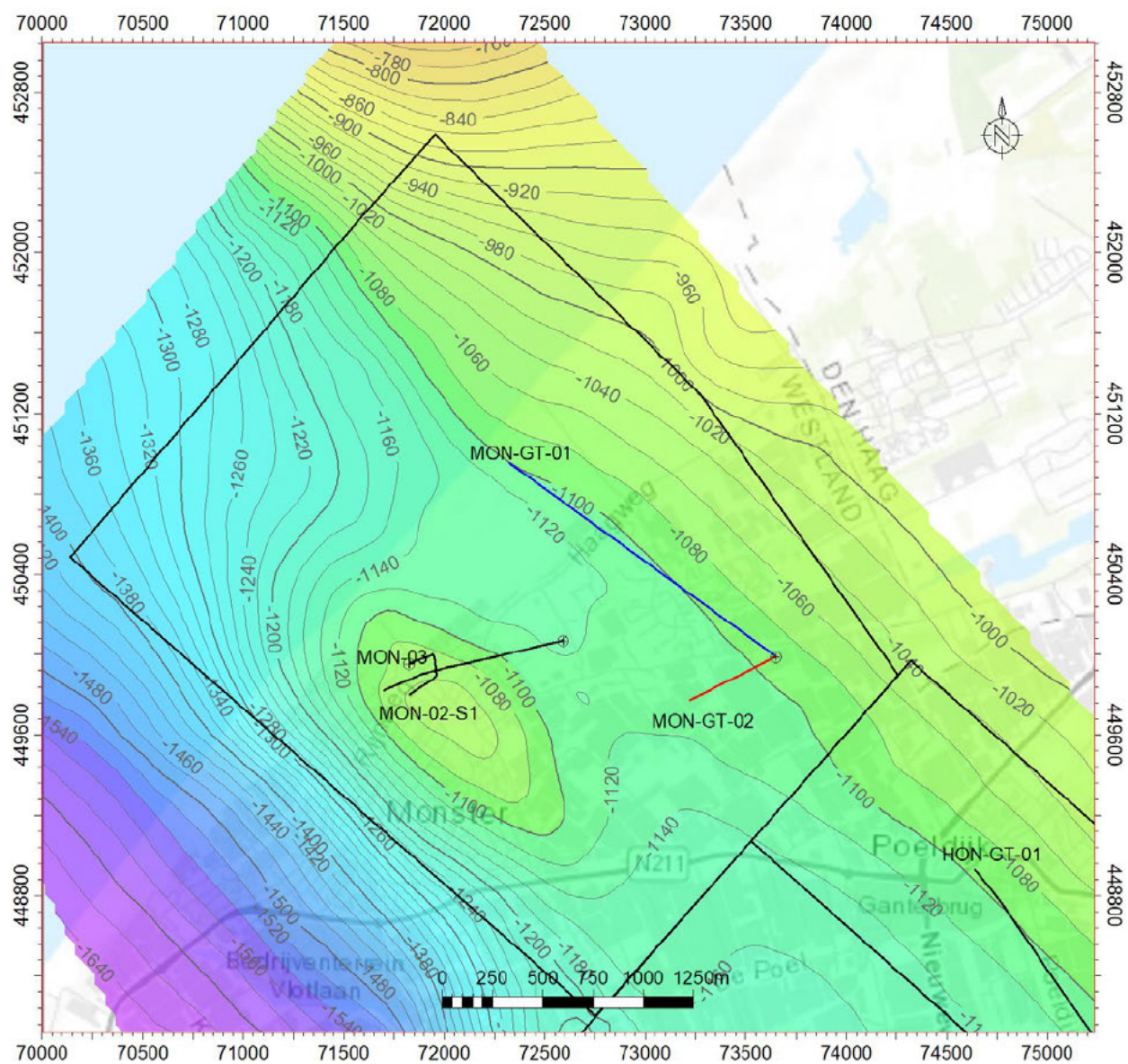


Figure 7: Depth map of the base of the Ommelanden member.

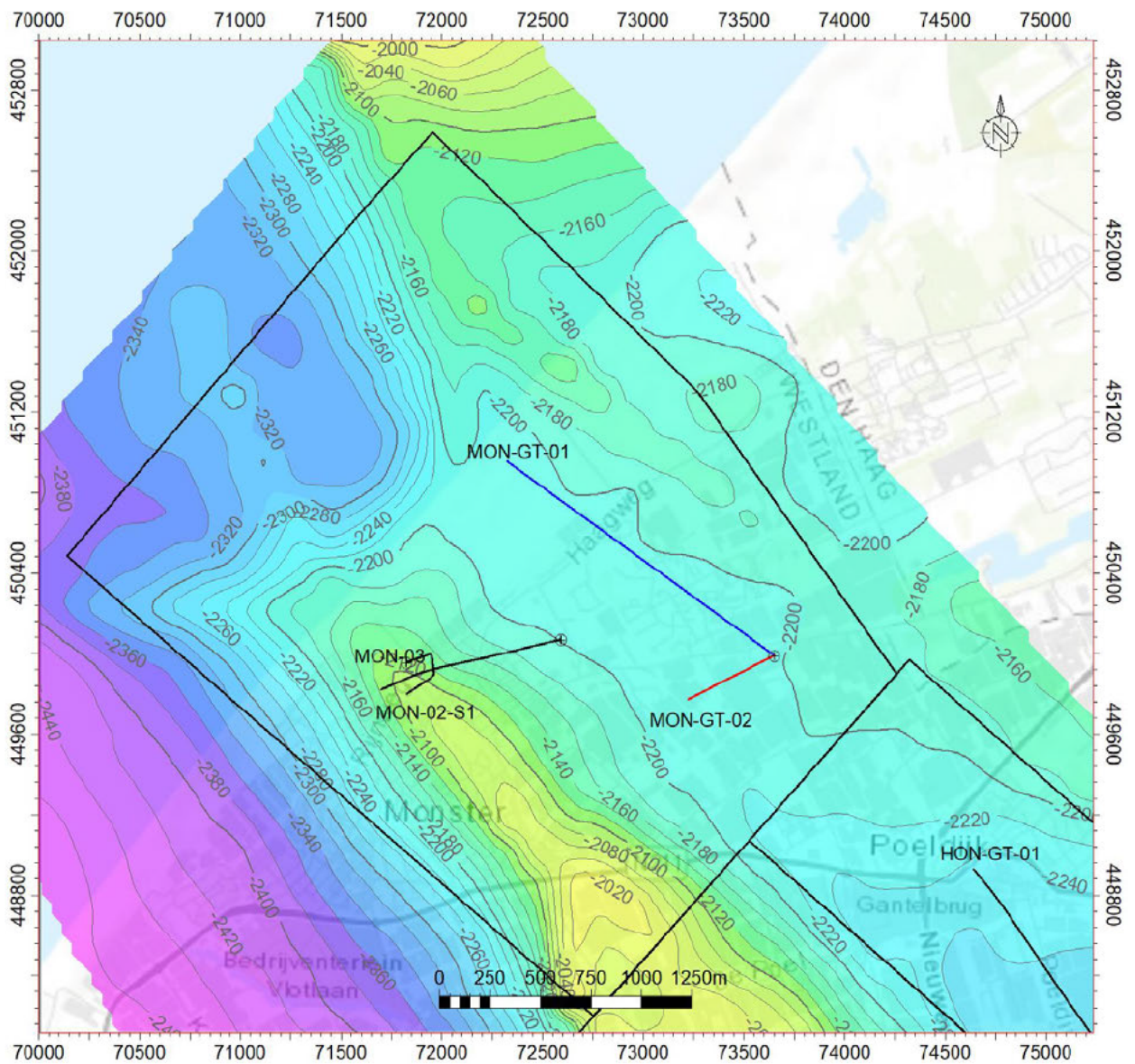


Figure 8: Depth map of the top of the Rijswijk member.

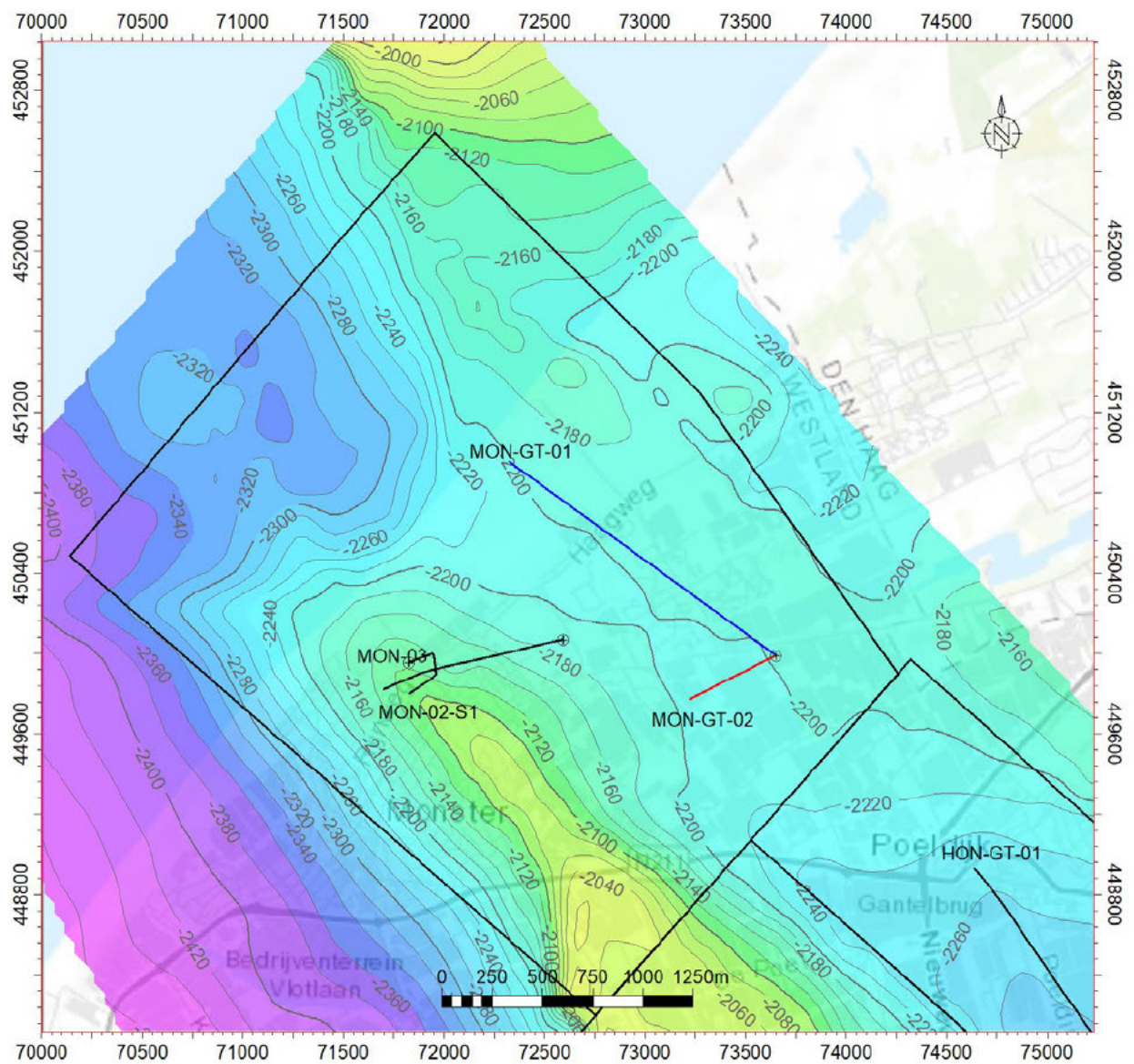


Figure 9: Depth map of the top of the Rodenrijs member.

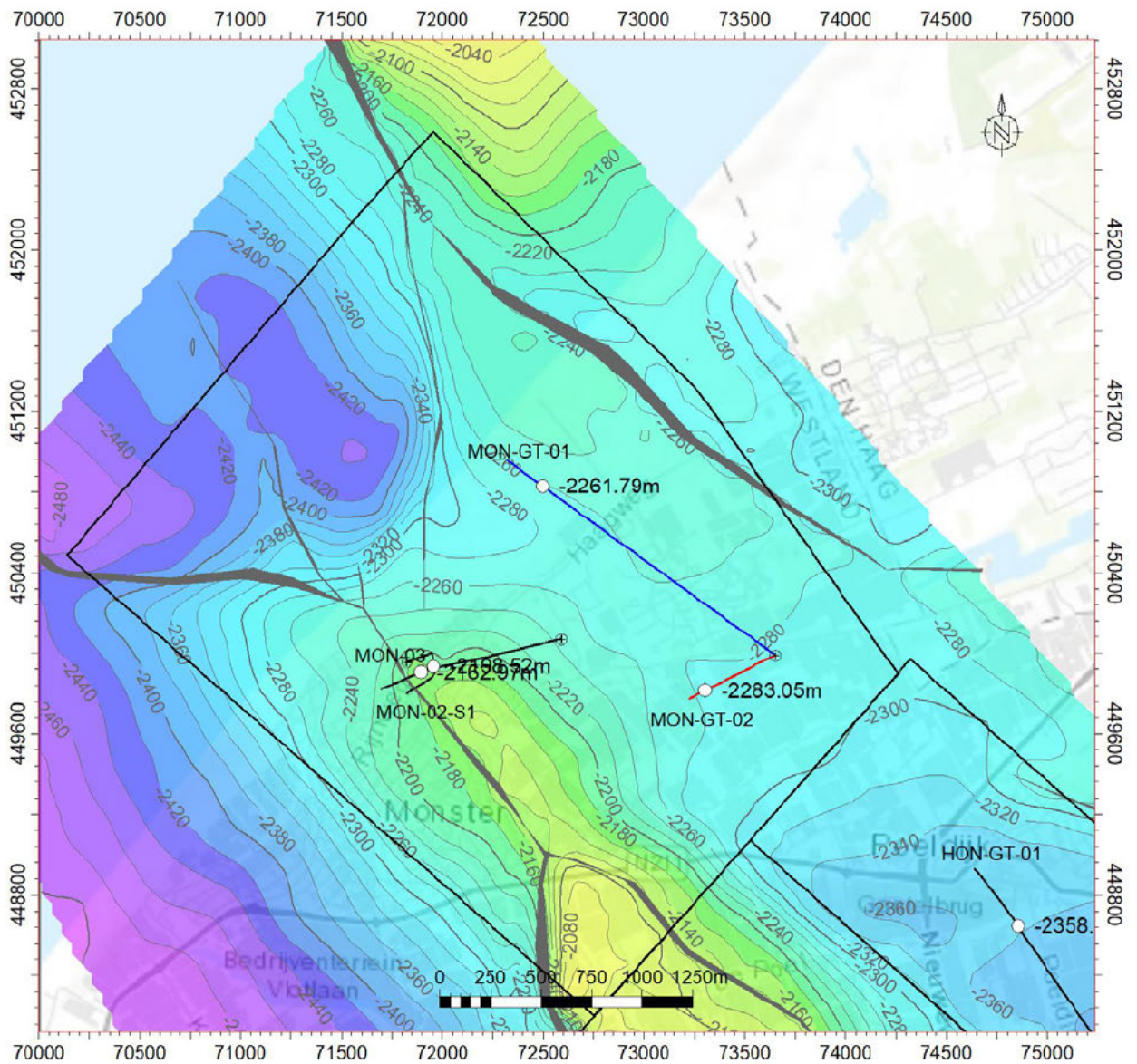


Figure 10: Depth map of the top of the Reservoir.

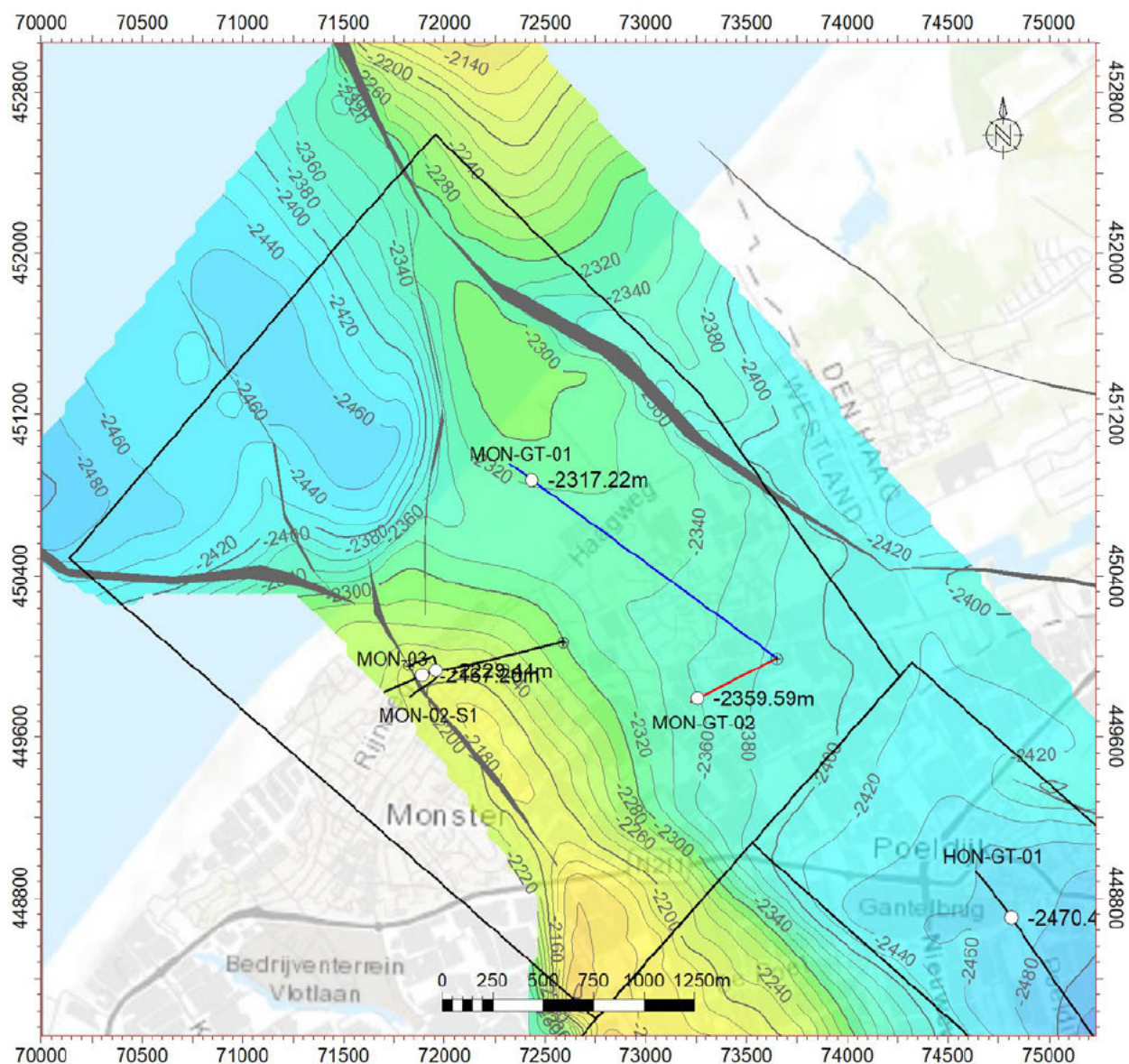


Figure 11: Depth map of the base of the reservoir.

12.6 Deviation data planned wells

12.6.1 MON-GT-01

X	Y	Z	MD	Inc	Dec (GN)
73650.00	449990.00	0.00	0	0	306
73650.00	449990.00	-892.00	892	0	306
73649.99	449990.01	-897.00	897	0.4	306
73649.95	449990.05	-902.00	902	0.8	306
73649.89	449990.11	-907.00	907	1.2	306
73649.81	449990.20	-912.00	912	1.6	306
73649.70	449990.31	-916.99	917	2	306
73649.56	449990.45	-921.99	922	2.4	306
73649.41	449990.62	-926.99	927	2.8	306
73649.22	449990.80	-931.98	932	3.2	306
73649.02	449991.02	-936.97	937	3.6	306
73648.79	449991.25	-941.96	942	4	306
73648.53	449991.52	-946.95	947	4.4	306
73648.26	449991.81	-951.93	952	4.8	306
73647.95	449992.12	-956.91	957	5.2	306
73647.63	449992.46	-961.89	962	5.6	306
73647.27	449992.82	-966.86	967	6	306
73646.90	449993.21	-971.83	972	6.4	306
73646.50	449993.62	-976.80	977	6.8	306
73646.08	449994.06	-981.76	982	7.2	306
73645.63	449994.53	-986.72	987	7.6	306
73645.16	449995.01	-991.68	992	8	306
73644.66	449995.53	-996.62	997	8.4	306
73644.14	449996.06	-1001.57	1002	8.8	306
73643.60	449996.63	-1006.51	1007	9.2	306
73643.03	449997.21	-1011.44	1012	9.6	306
73642.44	449997.83	-1016.37	1017	10	306
73641.83	449998.46	-1021.29	1022	10.4	306
73641.19	449999.12	-1026.20	1027	10.8	306
73640.53	449999.81	-1031.11	1032	11.2	306
73639.84	450000.52	-1036.01	1037	11.6	306
73639.13	450001.26	-1040.91	1042	12	306
73638.39	450002.02	-1045.79	1047	12.4	306
73637.64	450002.80	-1050.67	1052	12.8	306
73636.86	450003.61	-1055.54	1057	13.2	306
73636.05	450004.44	-1060.41	1062	13.6	306
73635.22	450005.30	-1065.26	1067	14	306
73634.37	450006.18	-1070.11	1072	14.4	306
73633.50	450007.09	-1074.95	1077	14.8	306
73632.60	450008.02	-1079.78	1082	15.2	306

73631.67	450008.98	-1084.60	1087	15.6	306
73630.73	450009.96	-1089.41	1092	16	306
73629.76	450010.96	-1094.21	1097	16.4	306
73628.77	450011.99	-1099.00	1102	16.8	306
73627.75	450013.04	-1103.79	1107	17.2	306
73626.71	450014.11	-1108.56	1112	17.6	306
73625.65	450015.21	-1113.32	1117	18	306
73624.57	450016.34	-1118.07	1122	18.4	306
73623.46	450017.48	-1122.81	1127	18.8	306
73622.33	450018.66	-1127.53	1132	19.2	306
73621.17	450019.85	-1132.25	1137	19.6	306
73620.00	450021.07	-1136.95	1142	20	306
73618.80	450022.31	-1141.65	1147	20.4	306
73617.58	450023.58	-1146.33	1152	20.8	306
73616.33	450024.86	-1150.99	1157	21.2	306
73615.06	450026.18	-1155.65	1162	21.6	306
73613.77	450027.51	-1160.29	1167	22	306
73612.46	450028.87	-1164.92	1172	22.4	306
73611.13	450030.25	-1169.54	1177	22.8	306
73609.77	450031.66	-1174.14	1182	23.2	306
73608.39	450033.09	-1178.73	1187	23.6	306
73606.99	450034.54	-1183.30	1192	24	306
73605.57	450036.01	-1187.86	1197	24.4	306
73604.12	450037.51	-1192.41	1202	24.8	306
73602.65	450039.03	-1196.94	1207	25.2	306
73601.16	450040.57	-1201.46	1212	25.6	306
73599.65	450042.14	-1205.96	1217	26	306
73598.12	450043.73	-1210.45	1222	26.4	306
73596.56	450045.34	-1214.92	1227	26.8	306
73594.99	450046.97	-1219.37	1232	27.2	306
73593.39	450048.62	-1223.81	1237	27.6	306
73591.77	450050.30	-1228.23	1242	28	306
73590.13	450052.00	-1232.64	1247	28.4	306
73588.46	450053.72	-1237.03	1252	28.8	306
73586.78	450055.47	-1241.40	1257	29.2	306
73585.08	450057.23	-1245.76	1262	29.6	306
73583.35	450059.02	-1250.10	1267	30	306
73581.60	450060.83	-1254.42	1272	30.4	306
73579.83	450062.66	-1258.72	1277	30.8	306
73578.05	450064.51	-1263.01	1282	31.2	306
73576.24	450066.38	-1267.28	1287	31.6	306
73574.41	450068.28	-1271.53	1292	32	306
73572.56	450070.20	-1275.76	1297	32.4	306

73570.68	450072.13	-1279.97	1302	32.8	306
73568.79	450074.09	-1284.16	1307	33.2	306
73566.88	450076.07	-1288.34	1312	33.6	306
73564.95	450078.07	-1292.49	1317	34	306
73563.00	450080.10	-1296.63	1322	34.4	306
73561.02	450082.14	-1300.74	1327	34.8	306
73559.03	450084.20	-1304.84	1332	35.2	306
73557.02	450086.28	-1308.91	1337	35.6	306
73554.99	450088.39	-1312.97	1342	36	306
73552.94	450090.51	-1317.00	1347	36.4	306
73550.87	450092.66	-1321.02	1352	36.8	306
73548.78	450094.82	-1325.01	1357	37.2	306
73546.67	450097.00	-1328.98	1362	37.6	306
73544.54	450099.21	-1332.94	1367	38	306
73542.39	450101.43	-1336.86	1372	38.4	306
73540.22	450103.68	-1340.77	1377	38.8	306
73538.04	450105.94	-1344.66	1382	39.2	306
73535.83	450108.22	-1348.52	1387	39.6	306
73533.61	450110.53	-1352.36	1392	40	306
73531.37	450112.85	-1356.18	1397	40.4	306
73529.11	450115.19	-1359.98	1402	40.8	306
73526.83	450117.55	-1363.75	1407	41.2	306
73524.53	450119.93	-1367.50	1412	41.6	306
73522.22	450122.32	-1371.23	1417	42	306
73519.88	450124.74	-1374.93	1422	42.4	306
73517.53	450127.17	-1378.61	1427	42.8	306
73515.17	450129.63	-1382.27	1432	43.2	306
73512.78	450132.10	-1385.90	1437	43.6	306
73510.38	450134.59	-1389.51	1442	44	306
73507.95	450137.09	-1393.10	1447	44.4	306
73505.52	450139.62	-1396.66	1452	44.8	306
73503.06	450142.16	-1400.19	1457	45.2	306
73500.59	450144.72	-1403.70	1462	45.6	306
73498.10	450147.30	-1407.19	1467	46	306
73495.59	450149.90	-1410.65	1472	46.4	306
73493.07	450152.51	-1414.09	1477	46.8	306
73490.53	450155.14	-1417.50	1482	47.2	306
73487.97	450157.79	-1420.88	1487	47.6	306
73485.40	450160.45	-1424.24	1492	48	306
73482.81	450163.13	-1427.57	1497	48.4	306
73480.20	450165.83	-1430.88	1502	48.8	306
73477.58	450168.54	-1434.16	1507	49.2	306
73474.94	450171.28	-1437.41	1512	49.6	306

73472.29	450174.02	-1440.64	1517	50	306
73469.62	450176.79	-1443.84	1522	50.4	306
73466.94	450179.56	-1447.01	1527	50.8	306
73464.24	450182.36	-1450.16	1532	51.2	306
73461.53	450185.17	-1453.28	1537	51.6	306
73458.80	450188.00	-1456.37	1542	52	306
73456.05	450190.84	-1459.44	1547	52.4	306
73453.29	450193.70	-1462.47	1552	52.8	306
73450.52	450196.57	-1465.48	1557	53.2	306
73447.73	450199.46	-1468.46	1562	53.6	306
73444.93	450202.36	-1471.42	1567	54	306
73442.11	450205.27	-1474.34	1572	54.4	306
73439.28	450208.20	-1477.24	1577	54.7	306
73436.44	450211.15	-1480.12	1582	55	306
73430.75	450217.04	-1485.85	1592	55	306
73425.06	450222.93	-1491.59	1602	55	306
73419.37	450228.82	-1497.33	1612	55	306
73413.68	450234.71	-1503.06	1622	55	306
73407.99	450240.61	-1508.80	1632	55	306
73402.30	450246.50	-1514.53	1642	55	306
73396.61	450252.39	-1520.27	1652	55	306
73390.92	450258.28	-1526.01	1662	55	306
73385.23	450264.18	-1531.74	1672	55	306
73379.54	450270.07	-1537.48	1682	55	306
73373.85	450275.96	-1543.21	1692	55	306
73368.16	450281.85	-1548.95	1702	55	306
73362.47	450287.74	-1554.68	1712	55	306
73356.78	450293.64	-1560.42	1722	55	306
73351.09	450299.53	-1566.16	1732	55	306
73345.40	450305.42	-1571.89	1742	55	306
73339.71	450311.31	-1577.63	1752	55	306
73334.02	450317.20	-1583.36	1762	55	306
73328.33	450323.10	-1589.10	1772	55	306
73322.64	450328.99	-1594.83	1782	55	306
73316.95	450334.88	-1600.57	1792	55	306
73311.26	450340.77	-1606.31	1802	55	306
73305.57	450346.67	-1612.04	1812	55	306
73299.88	450352.56	-1617.78	1822	55	306
73294.19	450358.45	-1623.51	1832	55	306
73288.50	450364.34	-1629.25	1842	55	306
73282.81	450370.23	-1634.98	1852	55	306
73277.12	450376.13	-1640.72	1862	55	306
73271.43	450382.02	-1646.46	1872	55	306

73265.74	450387.91	-1652.19	1882	55	306
73260.05	450393.80	-1657.93	1892	55	306
73254.36	450399.70	-1663.66	1902	55	306
73248.67	450405.59	-1669.40	1912	55	306
73242.98	450411.48	-1675.14	1922	55	306
73237.29	450417.37	-1680.87	1932	55	306
73231.60	450423.26	-1686.61	1942	55	306
73225.91	450429.16	-1692.34	1952	55	306
73220.22	450435.05	-1698.08	1962	55	306
73214.53	450440.94	-1703.81	1972	55	306
73208.84	450446.83	-1709.55	1982	55	306
73203.15	450452.73	-1715.29	1992	55	306
73197.46	450458.62	-1721.02	2002	55	306
73191.77	450464.51	-1726.76	2012	55	306
73186.08	450470.40	-1732.49	2022	55	306
73180.39	450476.29	-1738.23	2032	55	306
73174.70	450482.19	-1743.96	2042	55	306
73169.01	450488.08	-1749.70	2052	55	306
73163.32	450493.97	-1755.44	2062	55	306
73157.63	450499.86	-1761.17	2072	55	306
73151.94	450505.76	-1766.91	2082	55	306
73146.25	450511.65	-1772.64	2092	55	306
73140.56	450517.54	-1778.38	2102	55	306
73134.87	450523.43	-1784.11	2112	55	306
73129.18	450529.32	-1789.85	2122	55	306
73123.49	450535.22	-1795.59	2132	55	306
73117.80	450541.11	-1801.32	2142	55	306
73112.11	450547.00	-1807.06	2152	55	306
73106.42	450552.89	-1812.79	2162	55	306
73100.73	450558.78	-1818.53	2172	55	306
73095.04	450564.68	-1824.26	2182	55	306
73089.35	450570.57	-1830.00	2192	55	306
73083.66	450576.46	-1835.74	2202	55	306
73077.97	450582.35	-1841.47	2212	55	306
73072.28	450588.25	-1847.21	2222	55	306
73066.59	450594.14	-1852.94	2232	55	306
73060.90	450600.03	-1858.68	2242	55	306
73055.21	450605.92	-1864.42	2252	55	306
73049.52	450611.81	-1870.15	2262	55	306
73043.83	450617.71	-1875.89	2272	55	306
73038.14	450623.60	-1881.62	2282	55	306
73032.45	450629.49	-1887.36	2292	55	306
73026.76	450635.38	-1893.09	2302	55	306

73021.07	450641.28	-1898.83	2312	55	306
73015.38	450647.17	-1904.57	2322	55	306
73009.69	450653.06	-1910.30	2332	55	306
73004.00	450658.95	-1916.04	2342	55	306
72998.31	450664.84	-1921.77	2352	55	306
72992.62	450670.74	-1927.51	2362	55	306
72989.78	450673.68	-1930.38	2367	55	306
72984.09	450679.57	-1936.11	2377	55	306
72978.40	450685.47	-1941.85	2387	55	306
72972.71	450691.36	-1947.58	2397	55	306
72967.02	450697.25	-1953.32	2407	55	306
72961.33	450703.14	-1959.06	2417	55	306
72955.64	450709.04	-1964.79	2427	55	306
72949.95	450714.93	-1970.53	2437	55	306
72944.26	450720.82	-1976.26	2447	55	306
72938.57	450726.71	-1982.00	2457	55	306
72932.88	450732.60	-1987.73	2467	55	306
72927.19	450738.50	-1993.47	2477	55	306
72921.50	450744.39	-1999.21	2487	55	306
72915.81	450750.28	-2004.94	2497	55	306
72910.12	450756.17	-2010.68	2507	55	306
72904.43	450762.07	-2016.41	2517	55	306
72898.74	450767.96	-2022.15	2527	55	306
72893.05	450773.85	-2027.88	2537	55	306
72887.36	450779.74	-2033.62	2547	55	306
72881.67	450785.63	-2039.36	2557	55	306
72875.98	450791.53	-2045.09	2567	55	306
72870.29	450797.42	-2050.83	2577	55	306
72864.60	450803.31	-2056.56	2587	55	306
72858.91	450809.20	-2062.30	2597	55	306
72853.22	450815.10	-2068.03	2607	55	306
72847.53	450820.99	-2073.77	2617	55	306
72841.84	450826.88	-2079.51	2627	55	306
72836.15	450832.77	-2085.24	2637	55	306
72830.46	450838.66	-2090.98	2647	55	306
72824.77	450844.56	-2096.71	2657	55	306
72819.08	450850.45	-2102.45	2667	55	306
72813.39	450856.34	-2108.19	2677	55	306
72807.70	450862.23	-2113.92	2687	55	306
72802.01	450868.13	-2119.66	2697	55	306
72796.32	450874.02	-2125.39	2707	55	306
72790.63	450879.91	-2131.13	2717	55	306
72784.94	450885.80	-2136.86	2727	55	306

72779.25	450891.69	-2142.60	2737	55	306
72773.56	450897.59	-2148.34	2747	55	306
72767.87	450903.48	-2154.07	2757	55	306
72762.18	450909.37	-2159.81	2767	55	306
72756.49	450915.26	-2165.54	2777	55	306
72750.80	450921.16	-2171.28	2787	55	306
72745.11	450927.05	-2177.01	2797	55	306
72739.41	450932.94	-2182.75	2807	55	306
72733.72	450938.83	-2188.49	2817	55	306
72728.03	450944.72	-2194.22	2827	55	306
72722.34	450950.62	-2199.96	2837	55	306
72716.65	450956.51	-2205.69	2847	55	306
72710.96	450962.40	-2211.43	2857	55	306
72705.27	450968.29	-2217.16	2867	55	306
72699.58	450974.18	-2222.90	2877	55	306
72693.89	450980.08	-2228.64	2887	55	306
72688.20	450985.97	-2234.37	2897	55	306
72682.51	450991.86	-2240.11	2907	55	306
72676.82	450997.75	-2245.84	2917	55	306
72671.13	451003.65	-2251.58	2927	55	306
72665.44	451009.54	-2257.32	2937	55	306
72659.75	451015.43	-2263.05	2947	55	306
72654.06	451021.32	-2268.79	2957	55	306
72648.37	451027.21	-2274.52	2967	55	306
72642.68	451033.11	-2280.26	2977	55	306
72636.99	451039.00	-2285.99	2987	55	306
72631.30	451044.89	-2291.73	2997	55	306
72625.61	451050.78	-2297.47	3007	55	306
72619.92	451056.68	-2303.20	3017	55	306
72614.23	451062.57	-2308.94	3027	55	306
72608.54	451068.46	-2314.67	3037	55	306
72602.85	451074.35	-2320.41	3047	55	306
72597.16	451080.24	-2326.14	3057	55	306
72591.47	451086.14	-2331.88	3067	55	306
72585.78	451092.03	-2337.62	3077	55	306
72580.09	451097.92	-2343.35	3087	55	306
72574.40	451103.81	-2349.09	3097	55	306
72568.71	451109.71	-2354.82	3107	55	306
72563.02	451115.60	-2360.56	3117	55	306
72557.33	451121.49	-2366.29	3127	55	306
72551.64	451127.38	-2372.03	3137	55	306
72545.95	451133.27	-2377.77	3147	55	306
72540.26	451139.17	-2383.50	3157	55	306

72534.57	451145.06	-2389.24	3167	55	306
72528.88	451150.95	-2394.97	3177	55	306
72523.19	451156.84	-2400.71	3187	55	306
72517.50	451162.74	-2406.45	3197	55	306
72511.81	451168.63	-2412.18	3207	55	306

12.6.2 MON-GT-02

X	Y	Z	MD	Inc	Dec (GN)
73650.00	449990.00	0.00	0	0	243
73650.00	449990.00	-1502.21	1502.21	0	243
73649.98	449989.99	-1507.21	1507.21	0.4	243
73649.93	449989.98	-1512.21	1512.21	0.8	243
73649.85	449989.95	-1517.21	1517.21	1.2	243
73649.74	449989.90	-1522.21	1522.21	1.6	243
73649.59	449989.85	-1527.20	1527.21	2	243
73649.41	449989.79	-1532.20	1532.21	2.4	243
73649.20	449989.71	-1537.20	1537.21	2.8	243
73648.95	449989.62	-1542.19	1542.21	3.2	243
73648.67	449989.52	-1547.18	1547.21	3.6	243
73648.36	449989.40	-1552.17	1552.21	4	243
73648.02	449989.28	-1557.16	1557.21	4.4	243
73647.64	449989.14	-1562.14	1562.21	4.8	243
73647.23	449988.99	-1567.12	1567.21	5.2	243
73646.79	449988.83	-1572.10	1572.21	5.6	243
73646.31	449988.66	-1577.07	1577.21	6	243
73645.81	449988.47	-1582.04	1582.21	6.4	243
73645.27	449988.28	-1587.01	1587.21	6.8	243
73644.69	449988.07	-1591.97	1592.21	7.2	243
73644.09	449987.85	-1596.93	1597.21	7.6	243
73643.45	449987.62	-1601.89	1602.21	8	243
73642.78	449987.37	-1606.83	1607.21	8.4	243
73642.08	449987.12	-1611.78	1612.21	8.8	243
73641.34	449986.85	-1616.72	1617.21	9.2	243
73640.58	449986.57	-1621.65	1622.21	9.6	243
73639.78	449986.28	-1626.58	1627.21	10	243
73638.94	449985.98	-1631.50	1632.21	10.4	243
73638.08	449985.66	-1636.41	1637.21	10.8	243
73637.18	449985.34	-1641.32	1642.21	11.2	243
73636.25	449985.00	-1646.22	1647.21	11.6	243
73635.29	449984.65	-1651.12	1652.21	12	243
73634.30	449984.29	-1656.00	1657.21	12.4	243
73633.28	449983.91	-1660.88	1662.21	12.8	243
73632.22	449983.53	-1665.75	1667.21	13.2	243

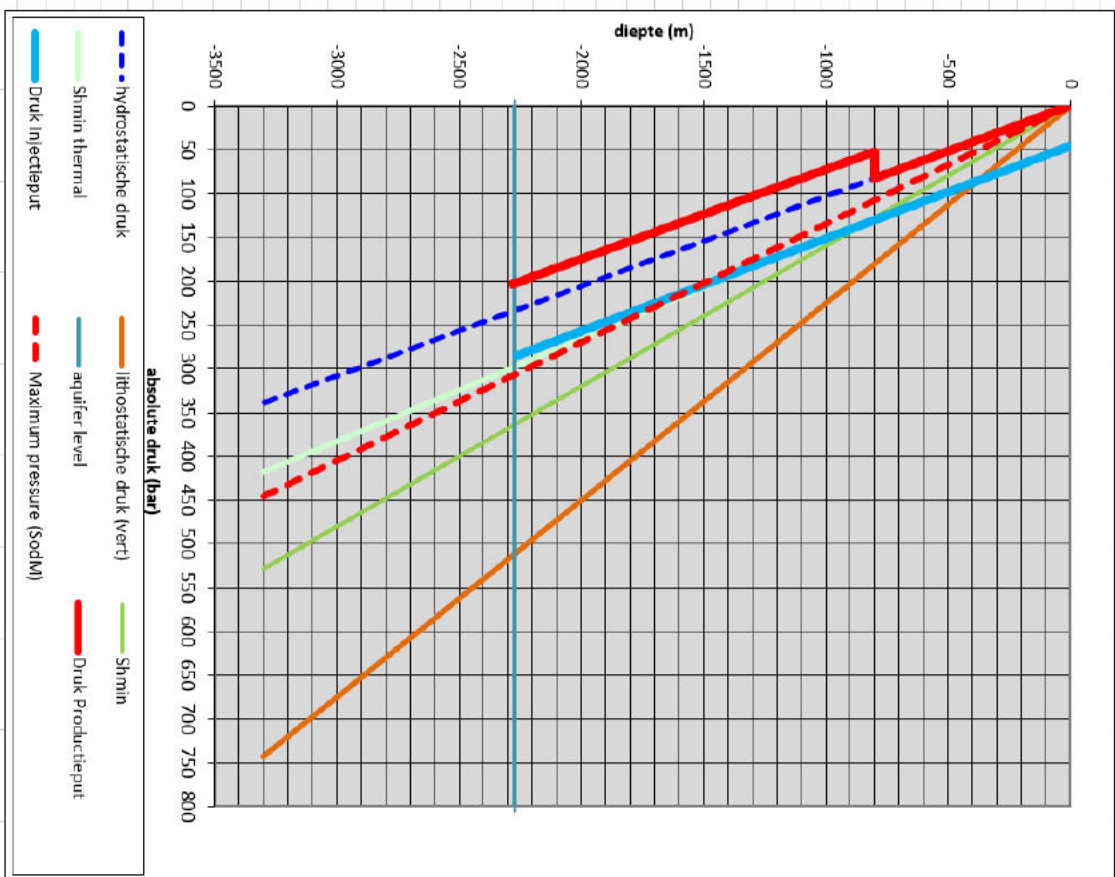
73631.13	449983.13	-1670.62	1672.21	13.6	243
73630.01	449982.72	-1675.47	1677.21	14	243
73628.86	449982.30	-1680.32	1682.21	14.4	243
73627.67	449981.87	-1685.16	1687.21	14.8	243
73626.46	449981.43	-1689.99	1692.21	15.2	243
73625.21	449980.98	-1694.81	1697.21	15.6	243
73623.93	449980.51	-1699.62	1702.21	16	243
73622.62	449980.03	-1704.42	1707.21	16.4	243
73621.28	449979.55	-1709.21	1712.21	16.8	243
73619.90	449979.05	-1714.00	1717.21	17.2	243
73618.50	449978.53	-1718.77	1722.21	17.6	243
73617.06	449978.01	-1723.53	1727.21	18	243
73615.60	449977.48	-1728.28	1732.21	18.4	243
73614.10	449976.93	-1733.02	1737.21	18.8	243
73612.57	449976.38	-1737.74	1742.21	19.2	243
73611.01	449975.81	-1742.46	1747.21	19.6	243
73609.41	449975.23	-1747.16	1752.21	20	243
73607.79	449974.64	-1751.86	1757.21	20.4	243
73606.14	449974.04	-1756.54	1762.21	20.8	243
73604.46	449973.42	-1761.20	1767.21	21.2	243
73602.74	449972.80	-1765.86	1772.21	21.6	243
73601.00	449972.16	-1770.50	1777.21	22	243
73599.22	449971.52	-1775.13	1782.21	22.4	243
73597.42	449970.86	-1779.75	1787.21	22.8	243
73595.58	449970.19	-1784.35	1792.21	23.2	243
73593.71	449969.51	-1788.94	1797.21	23.6	243
73591.82	449968.82	-1793.51	1802.21	24	243
73589.89	449968.12	-1798.07	1807.21	24.4	243
73587.94	449967.41	-1802.62	1812.21	24.8	243
73585.95	449966.69	-1807.15	1817.21	25.2	243
73583.94	449965.95	-1811.67	1822.21	25.6	243
73581.89	449965.21	-1816.17	1827.21	26	243
73579.82	449964.46	-1820.66	1832.21	26.4	243
73577.71	449963.69	-1825.13	1837.21	26.8	243
73575.58	449962.91	-1829.58	1842.21	27.2	243
73573.42	449962.13	-1834.02	1847.21	27.6	243
73571.23	449961.33	-1838.44	1852.21	28	243
73569.01	449960.52	-1842.85	1857.21	28.4	243
73566.76	449959.70	-1847.24	1862.21	28.8	243
73564.48	449958.87	-1851.61	1867.21	29.2	243
73562.17	449958.03	-1855.97	1872.21	29.6	243
73559.84	449957.18	-1860.31	1877.21	30	243
73557.48	449956.32	-1864.63	1882.21	30.4	243

73555.08	449955.45	-1868.93	1887.21	30.8	243
73552.66	449954.57	-1873.22	1892.21	31.2	243
73550.22	449953.68	-1877.49	1897.21	31.6	243
73547.74	449952.78	-1881.74	1902.21	32	243
73545.24	449951.87	-1885.97	1907.21	32.4	243
73542.71	449950.95	-1890.18	1912.21	32.8	243
73540.15	449950.02	-1894.37	1917.21	33.2	243
73537.56	449949.08	-1898.55	1922.21	33.6	243
73534.95	449948.12	-1902.70	1927.21	34	243
73532.31	449947.16	-1906.84	1932.21	34.4	243
73529.64	449946.19	-1910.96	1937.21	34.7	243
73526.96	449945.22	-1915.06	1942.21	35	243
73521.57	449943.25	-1923.25	1952.21	35	243
73516.18	449941.29	-1931.44	1962.21	35	243
73510.79	449939.33	-1939.63	1972.21	35	243
73505.40	449937.37	-1947.83	1982.21	35	243
73500.01	449935.41	-1956.02	1992.21	35	243
73494.62	449933.45	-1964.21	2002.21	35	243
73489.23	449931.48	-1972.40	2012.21	35	243
73483.84	449929.52	-1980.59	2022.21	35	243
73478.45	449927.56	-1988.78	2032.21	35	243
73473.06	449925.60	-1996.97	2042.21	35	243
73467.67	449923.64	-2005.17	2052.21	35	243
73462.28	449921.68	-2013.36	2062.21	35	243
73456.89	449919.71	-2021.55	2072.21	35	243
73451.50	449917.75	-2029.74	2082.21	35	243
73446.11	449915.79	-2037.93	2092.21	35	243
73440.72	449913.83	-2046.12	2102.21	35	243
73435.33	449911.87	-2054.32	2112.21	35	243
73429.94	449909.91	-2062.51	2122.21	35	243
73424.56	449907.94	-2070.70	2132.21	35	243
73419.17	449905.98	-2078.89	2142.21	35	243
73413.78	449904.02	-2087.08	2152.21	35	243
73408.39	449902.06	-2095.27	2162.21	35	243
73403.00	449900.10	-2103.46	2172.21	35	243
73397.61	449898.14	-2111.66	2182.21	35	243
73392.22	449896.17	-2119.85	2192.21	35	243
73386.83	449894.21	-2128.04	2202.21	35	243
73381.44	449892.25	-2136.23	2212.21	35	243
73376.05	449890.29	-2144.42	2222.21	35	243
73370.66	449888.33	-2152.61	2232.21	35	243
73365.27	449886.37	-2160.80	2242.21	35	243
73359.88	449884.40	-2169.00	2252.21	35	243

73354.49	449882.44	-2177.19	2262.21	35	243
73349.10	449880.48	-2185.38	2272.21	35	243
73343.71	449878.52	-2193.57	2282.21	35	243
73338.32	449876.56	-2201.76	2292.21	35	243
73332.93	449874.60	-2209.95	2302.21	35	243
73327.54	449872.64	-2218.15	2312.21	35	243
73322.15	449870.67	-2226.34	2322.21	35	243
73316.76	449868.71	-2234.53	2332.21	35	243
73311.37	449866.75	-2242.72	2342.21	35	243
73305.98	449864.79	-2250.91	2352.21	35	243
73300.59	449862.83	-2259.10	2362.21	35	243
73295.21	449860.87	-2267.29	2372.21	35	243
73289.82	449858.90	-2275.49	2382.21	35	243
73284.43	449856.94	-2283.68	2392.21	35	243
73279.04	449854.98	-2291.87	2402.21	35	243
73273.65	449853.02	-2300.06	2412.21	35	243
73268.26	449851.06	-2308.25	2422.21	35	243
73262.87	449849.10	-2316.44	2432.21	35	243
73257.48	449847.13	-2324.64	2442.21	35	243
73252.09	449845.17	-2332.83	2452.21	35	243
73246.70	449843.21	-2341.02	2462.21	35	243
73241.31	449841.25	-2349.21	2472.21	35	243
73235.92	449839.29	-2357.40	2482.21	35	243
73199.38	449825.99	-2412.93	2550	35	243

12.7 Geomech pressure calculation sheet

Invoer parameters		waarde	Default	eenheid
Diepte top aquifer in productieput		-2283	x	m
Diepte top aquifer in injectieput		-2262	x	m
Gemiddelde diepte top aquifer		-2273	x	m
Diepte pomp		-800	-500	m
Aquiferdruk Productieput				
Aquiferdruk Injectieput		234	x	bar
Bottom hole pressure Productieput		232	x	bar
Bottom hole pressure Injectieput		204	x	bar
		285	x	bar
Drukverschil over put-aquifer interface in productieput				
Drukverschil over put-aquifer interface in injectieput		30	x	bar
		53	x	bar
Hydrostatische gradient in injectieput				
Hydrostatische gradient in injectieput		0.106	0.106	bar/m
Lithostatische gradient		0.225	0.225	bar/m
minimale horizontale spanningsgradient (bar/m)		0.16	0.16	bar/m
Injectietemperatuur				
Aquifer temperatuur @ productieput		35	x	°C
Aquifer temperatuur @ injectieput		84	x	°C
Delta temperatuur @ injectieput		84	x	°C
Temperatuurgradient		49	x	°C
		0.033	0.032	°C/m
Gemiddelde oppervlaktetemperatuur		10	10	°C
Youngs modulus				
Youngs modulus		10000	10000	Mpa
Poisson's ratio		0.25	0.25	frac
Arching coefficient		0.4	0.4	
Blot coefficient		0.75	0.75	
Linear thermal expansion coefficient (°C ⁻¹)		1.00E-05	1.00E-05	°C ⁻¹
Cohesie				
Cohesie		0	0	bar
Hoek van inwendige wrijving				
Hoek van inwendige wrijving		33	33	°
Invoerd thermische stress				
Invoerd thermische stress		Ja		
Uitvoer				
Tubing Head Pressure toegestaan volgens SodM protocol		66	Ja	
Maximale verschildruk injectieput top reservoir		73.0	Ja	
Fracking			NEE	
Kans op breukreactivatie			Ja	



12.8 Velocity model residuals

Base Tertiary_50.dat	Well	X-value	Y-value	Z-value	Horizon a	Diff after	Corrected	Information
	MON-02	71927.4	449990.7	-680.78	-684.7	3.92	No	
	LIR-GT-01	79083.1	443758.4	-683.66	-709.09	25.43	No	
	LIR-45	75124.1	444624.2	-725.67	-721.96	-3.71	No	
	NLW-GT-01	76128.4	445365.5	-710.56	-739.84	29.28	No	
	LIR-GT-02	79091	443735	-702.99	-710.16	7.17	No	
	HON-GT-01	75244.2	448079.7	-651.41	-691.72	40.31	No	
Base Ommelande	Well	X-value	Y-value	Z-value	Horizon a	Diff after	Corrected	Information
	MON-02	71944.4	449999.5	-1078.96	-1059.52	-19.44	No	
	HON-GT-02	75244.5	448093.9	-1112.38	-1111.44	-0.94	No	
	LIR-GT-01	79076.4	443787	-1101.63	-1102.56	0.92	No	
	LIR-45	75112.2	444576.8	-1122.64	-1118.22	-4.42	No	
	NLW-GT-01	76088.4	445630.8	-1187.48	-1188.42	0.94	No	
	LIR-GT-02	79091	443735	-1100.64	-1104.16	3.51	No	
	HON-GT-01	75245.1	448078.6	-1110.83	-1112.74	1.91	No	
Top Rijswijk	Well	X-value	Y-value	Z-value	Horizon a	Diff after	Corrected	Information
	MON-02	71957.6	449940.7	-2152.48	-2122.45	-30.03	No	
	HON-GT-02	75778.5	447771.5	-2308.84	-2285.79	-23.05	No	
	LIR-GT-01	78936.2	444466.5	-2256.13	-2259.69	3.57	No	
	LIR-45	75072.3	444545.5	-2069.51	-2070.19	0.68	No	
	NLW-GT-01	75708.8	446109.4	-2229.63	-2249.96	20.33	No	
	NLW-GT-02	76551.9	445105	-2211.54	-2283.48	71.93	No	
	HON-GT-01	74884.2	448601.7	-2277.63	-2273.69	-3.93	No	
Top Altene_ajust_to_TopS_29May2017	Well	X-value	Y-value	Z-value	Horizon a	Diff after	Corrected	Information
	LIR-45	75045.5	444515.6	-2401.01	-2477.04	76.03	No	
	NLW-GT-01	75538.8	446192	-2797.19	-2787.6	-9.6	No	

12.9 Water Analysis



ALcontrol Laboratories

Trias Westland B.V.

Analyserapport

Blad 2 van 8

Projectnaam Geothermie monsters
 Projectnummer 2018-234-0404-05-FV
 Rapportnummer 12730507 - 1

Orderdatum 01-03-2018
 Startdatum 01-03-2018
 Rapportagedatum 09-03-2018

Nummer	Monstersoort	Monsterspecificatie		
001	Grondwater	Phase 5 2H NLW-GT-01		
002	Grondwater	Phase 5 3H NLW-GT-01		
Analyse	Eenheid	Q	001	002
pH		Q	6.2	6.2
geleidingsvermogen (25°C)(EC)	µS/cm	Q	111000	111000
temperatuur t.b.v. pH	°C		19.4	19.4
<i>METALEN</i>				
filtreren metalen	-		1 ¹⁾	1 ¹⁾
cadmium	µg/l	Q	<0.20 ¹⁾	<0.20 ¹⁾
kwik	µg/l	Q	<0.05 ¹⁾	<0.05 ¹⁾
lood	µg/l	Q	42 ¹⁾	33 ¹⁾
nikkel	µg/l	Q	6.7 ¹⁾	6.5 ¹⁾
zink	µg/l	Q	180 ¹⁾	180 ¹⁾
<i>ANORGANISCHE VERBINDINGEN</i>				
Carbonaat	mg/l	Q	<10	<10
<i>VLUCHTIGE AROMATEN</i>				
benzeen	µg/l	Q	280	290
tolueen	µg/l	Q	40	44
ethylbenzeen	µg/l	Q	1.2	1.4
o-xyleen	µg/l	Q	3.3	3.2
p- en m-xyleen	µg/l	Q	3.8	3.6
som BTEX	µg/l		330	340
<i>MINERALE OLIE</i>				
fractie C10-C12	µg/l		65	75
fractie C12-C22	µg/l		130	120
fractie C22-C30	µg/l		85	70
fractie C30-C40	µg/l		65	50
totaal olie C10 - C40	µg/l	Q	350	310
<i>DIVERSE NATCHEMISCHE BEPALINGEN</i>				
chloride	mg/l	Q	86000	87000
onopgel. best./zweev. stof	mg/l	Q	64	410
monstervolume tbv analyse	ml		500	500
soortelijk gewicht	g/l		1091	1089
Speciaal onderzoek	-		zie bijlage	zie bijlage