Local surface runoff catchments with the associated local drainage are shown together with the mining layout in Section 3.7. The way that such local drainage is connected to the pans on the prospecting area is also illustrated.

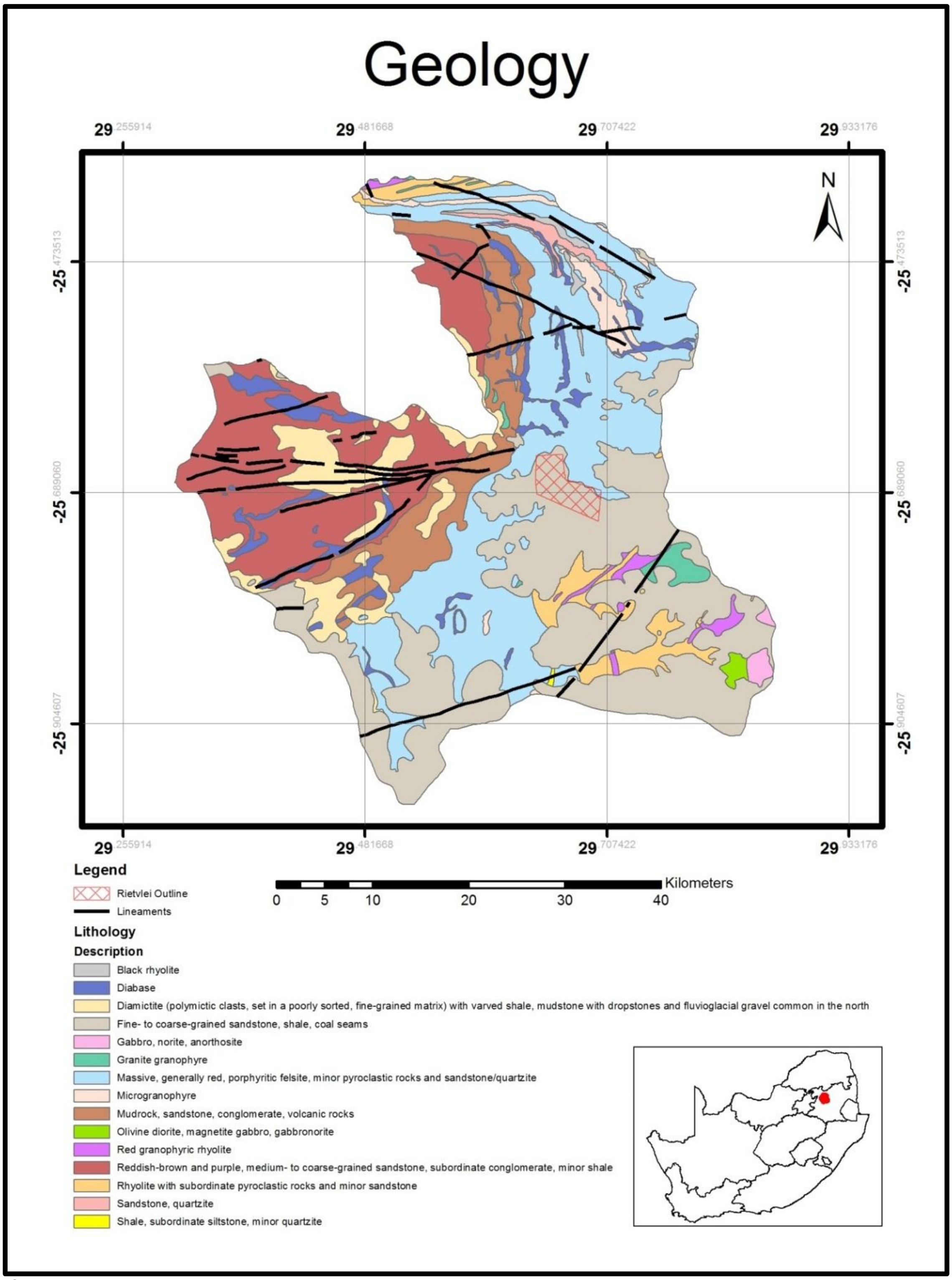
3.5 Surface water quality

Surface water quality were analysed by AEC as part of the baseline groundwater study (2011). Selons River and the dam on the river showed a relatively neutral pH (7.12 and 7.46) and low electrical conductivity values (11mS/m and 13mS/m). All the major and minor constituents analysed for, fell within the recommended operational limits for drinking water (SANS 241; 2005) except for Aluminium, which exceeds the maximum allowable limit for both sampling points. This is likely due to clay particles from incomplete filtering of the sample.

3.6 General geology and groundwater occurrence

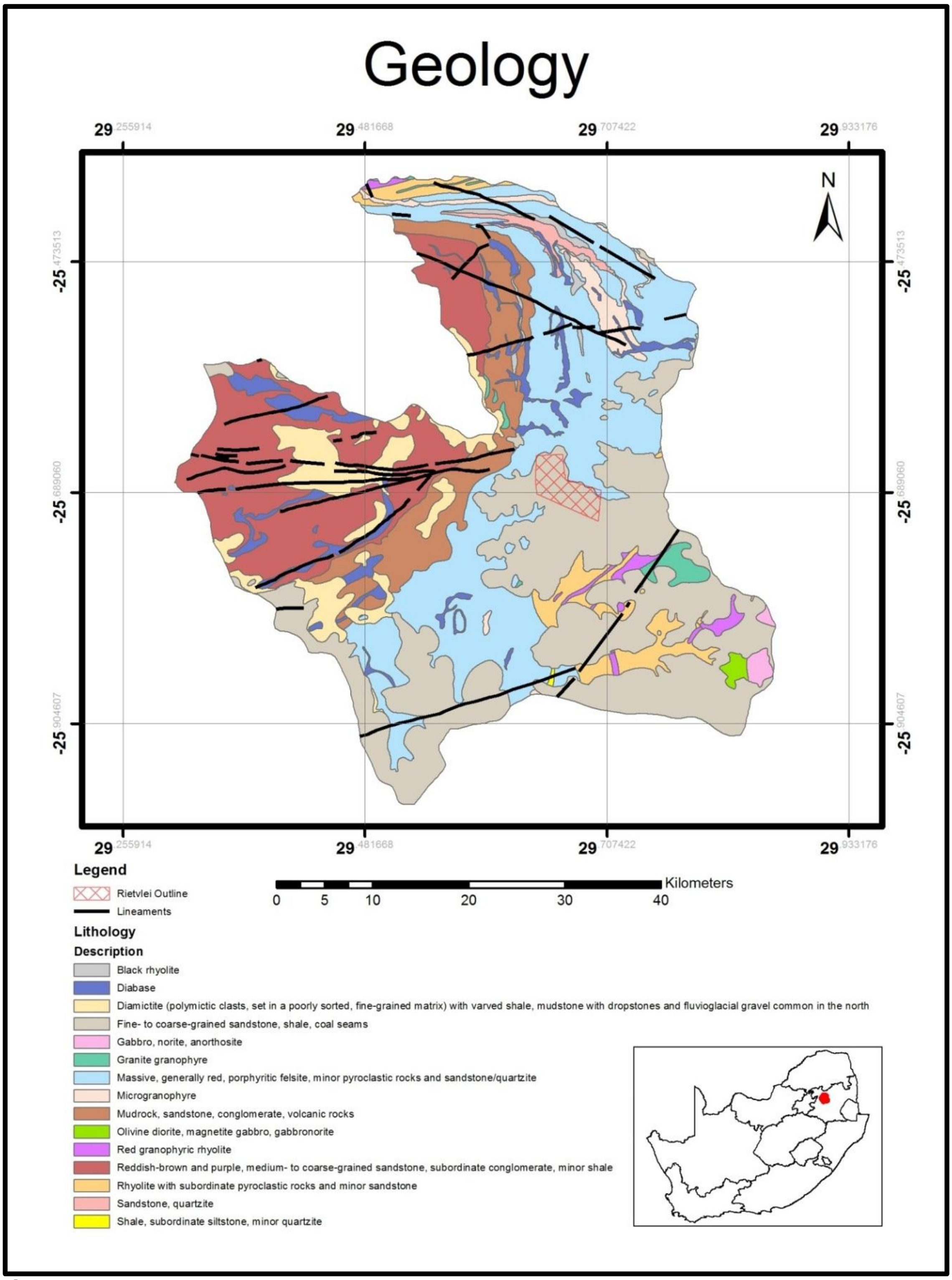
The mine is located in the Karoo Sequence (Vryheid Formation). The Vryheid Formation consists of mudstone, shale, rhythmite, siltstone and fine- to coarse-grained sandstone (pebbly in places). The Formation contains up to five (mineable) coal seams (Figure 17). The different lithofacies are mainly arranged in upward coarsening deltaic cycles. Since the shales are very dense, they are often overlooked as significant sources of groundwater. The permeabilities of these sandstones are also usually very low. The main reason for this is that the sandstones are usually poorly sorted, and that their primary porosities have been lowered considerably by diagenesis. These sedimentary formations have been extensively intruded by dolerite dykes.

The Karoo dolerite, which includes a wide range of petrological facies, consists of an interconnected network of dykes and sills and it is nearly impossible to single out any particular intrusive or tectonic event. Dolerite dykes are vertical to sub-vertical discontinuities that, in general, represent thin, linear zones of a lower permeability sandwiched between fracture zones. These fracture zones can have a relatively higher permeability and can therefore act as conduits for groundwater flow within the aquifer. The dykes on the other hand may also act as semi- to impermeable barriers to the movement of groundwater. The dykes are commonly expressed on the surface as a line of green bushes, which can be readily observed during the dry season. The generalised stratigraphy is summarised in Figure 16. Geology of the area is shown in



Geology
29 255914
29 481668
29 707422
29 933176
-25 473513
-25 689060
-25 904607
N
Legend
Rietvlei Outline
Lineaments
0 5 10 20 30 40 Kilometers
Lithology
Description
Black rhyolite
Diabase
Diamictite (polymictic clasts, set in a poorly sorted, fine-grained matrix) with varved shale, mudstone with dropstones and fluvioglacial gravel common in the north
Fine- to coarse-grained sandstone, shale, coal seams
Gabbro, norite, anorthosite
Granite granophyre
Massive, generally red, porphyritic felsite, minor pyroclastic rocks and sandstone/quartzite
Micrognanophyre
Mudrock, sandstone, conglomerate, volcanic rocks
Olivine diorite, magnetite gabbro, gabbronorite
Red granophyric rhyolite
Reddish-brown and purple, medium- to coarse-grained sandstone, subordinate conglomerate, minor shale
Rhyolite with subordinate pyroclastic rocks and minor sandstone
Sandstone, quartzite
Shale, subordinate siltstone, minor quartzite

Figure 17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Gabbro, norite, anorthosite
Granite granophyre
Massive, generally red, porphyritic felsite, minor pyroclastic rocks and sandstone/quartzite
Microgranophyre
Mudrock, sandstone, conglomerate, volcanic rocks
Olivine diorite, magnetite gabbro, gabbronorite
Red granophyric rhyolite
Reddish-brown and purple, medium- to coarse-grained sandstone, subordinate conglomerate, minor shale
Rhyolite with subordinate pyroclastic rocks and minor sandstone
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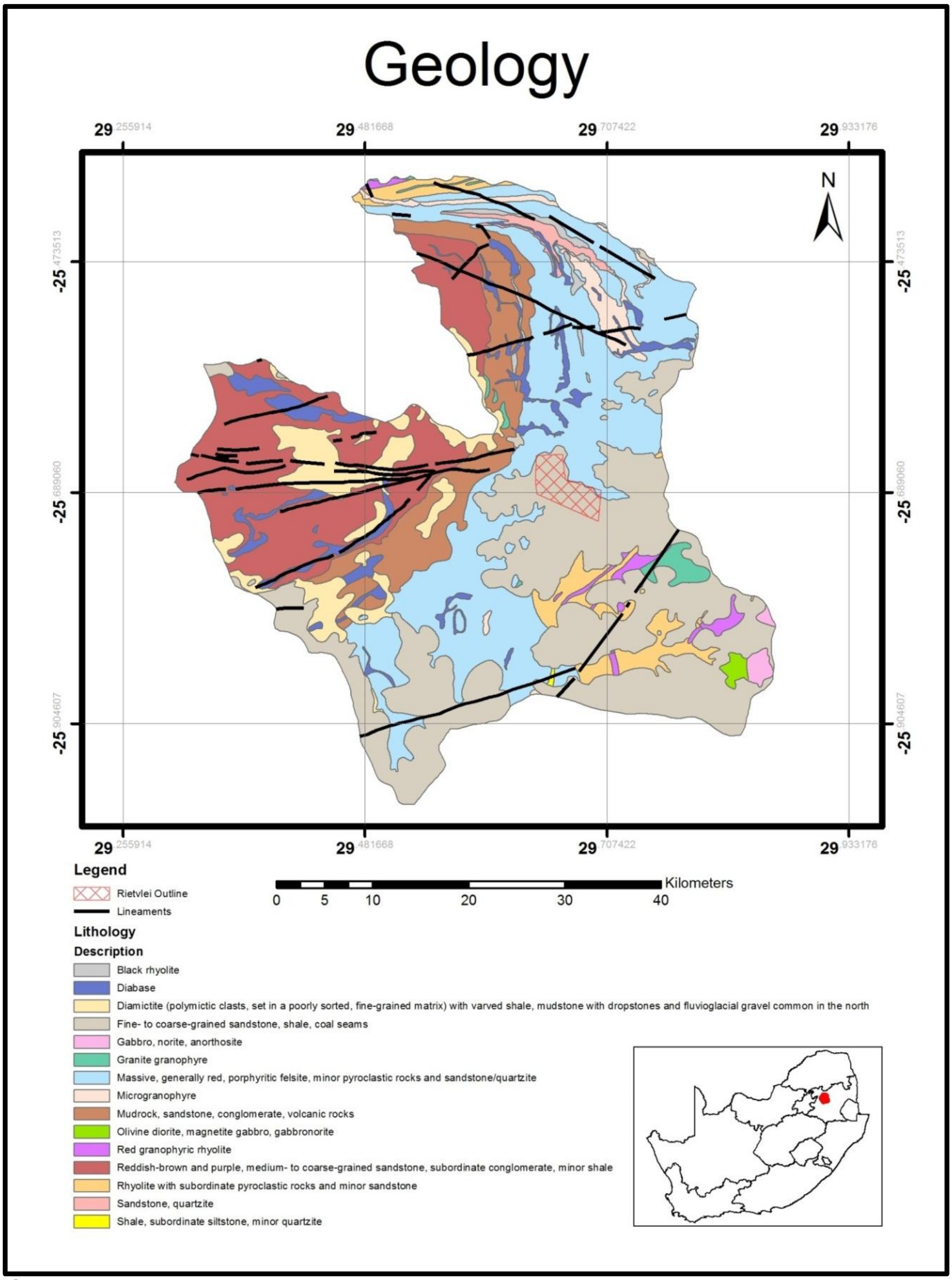
Shale, subordinate siltstone, minor quartzite

Figure 17



Geology
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Reddish-brown and purple, medium- to coarse-grained sandstone, subordinate conglomerate, minor shale
Rhyolite with subordinate pyroclastic rocks and minor sandstone
Sandstone, quartzite
Shale, subordinate siltstone, minor quartzite

Figure 17.

Groundwater studies (GCS, 1999, Golder 2004) carried out in similar geology in the area, have indicated the presence of two aquifer systems (shallower and deeper), with little potential of yielding large volumes of water. Storage coefficients were estimated ranging from 0.001 to 0.01. Mean annual groundwater recharge was estimated at 35mm (Vegter, 1995).

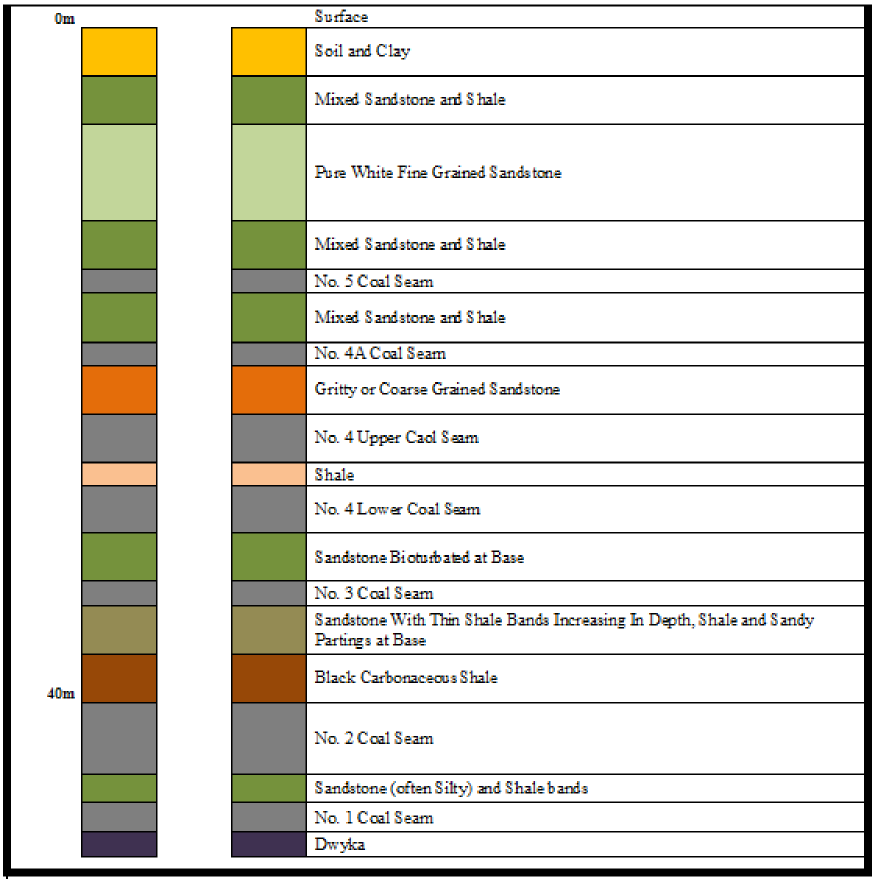

Figure 16: Generalized stratigraphy

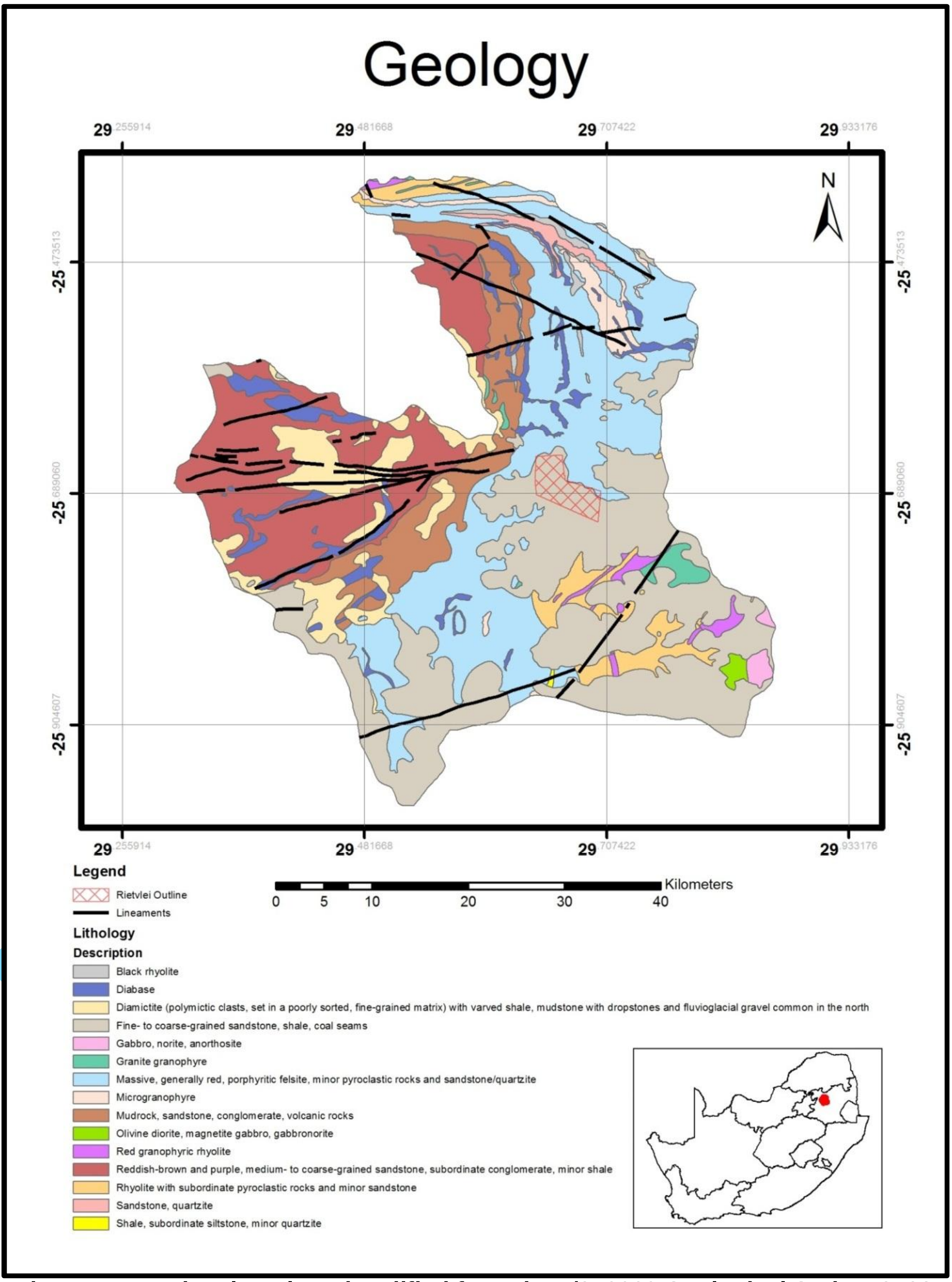

Figure 17: Regional geology (modified from the 1/250000 Geological Series: 2528 Pretoria)

3.6.1 Local geology and groundwater occurrence

According to Mindset Mining Consultants "Feasbility report-Section 3" (04-2013), only the 2- and 1-Seams are currently present at the proposed Rietvlei Mine, since the other seams have been eroded. The aeromagnetic map of the area compiled by CGS shows a NE striking lineament at the SE of the proposed Rietvlei Mine.

Analysis of existing information (including previous boreholes drilled by AEC) indicates fractures associated with sedimentary rocks within the study area. Such fractures are encountered from 8mbgl, up to 50mbgl (in the coal seams). These fractures, form conduits (preferential path) for groundwater flow.Table 8 depicts a typical borehole log of the proposed pit area. These need to be defined according to depth, yield, K.

.Table 8: Typical borehole log

Stratigraphic section	Description
Transport and residual soils	- topsoil - clayey hillwash - clayey siltstone and sandstone
Vryheid Formation	-silty, laminated shale - laminated siltstone with sandstone - No 2 seam (coal) - ripple cross-bedded fine grained sandstone - No 2 seam (coal)
Dwyka Group	Tillite, diamictite and glacial shales
Pre-Karoo basement	Paleo-weathered Selonsrivier felsite

Increasing with depth

3.7 Mining infrastructures

The positions of the surface infrastructure as reported in section 5 of the Rietvlei mining feasibility report are shown together with local runoff catchments and drainage in Figure 18. This map will be used in the establishment of surface water management plans related to each surface infrastructure.

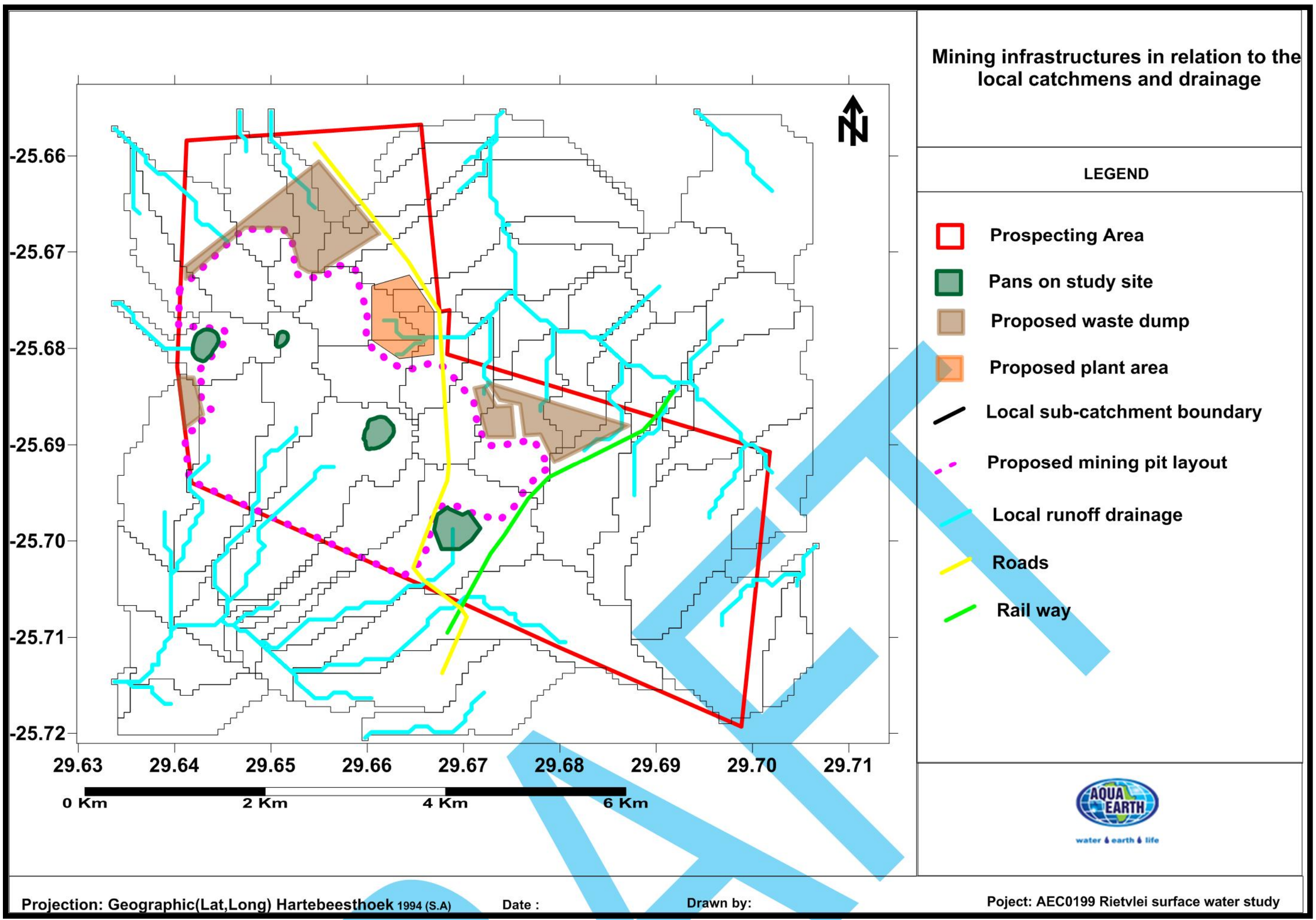

Figure 18: Surface infrastructure and local drainage

The mining sequence (layout) and the associated mining schedule as designed by Mindset are presented respectively in Figure 19 and Figure 20.

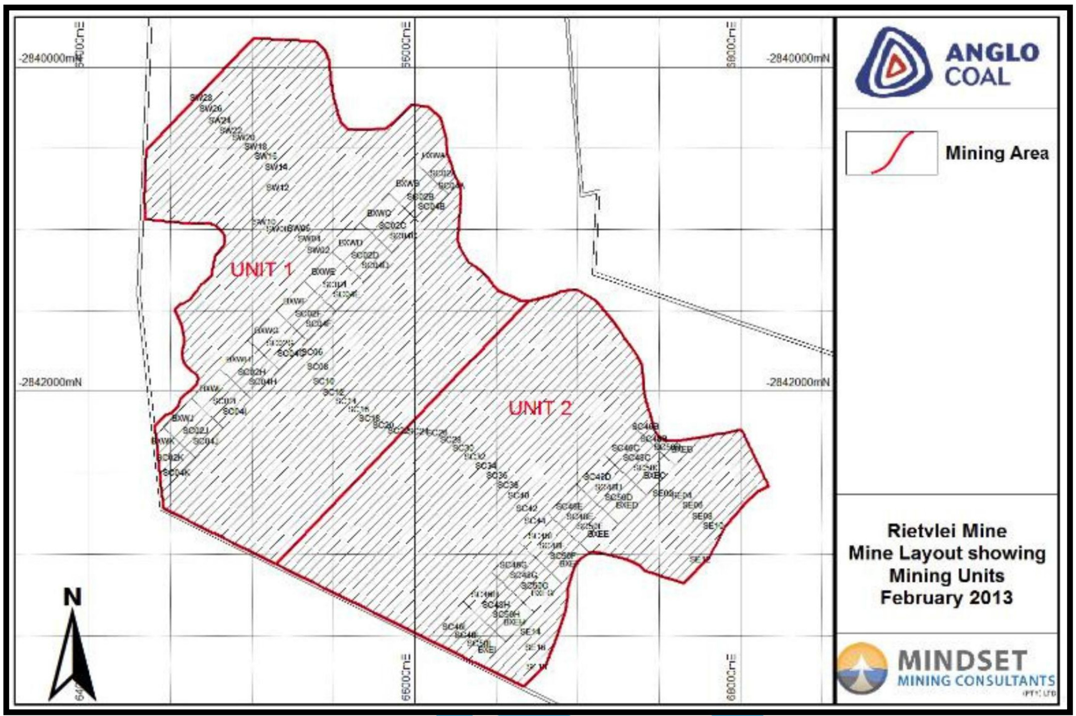

Figure 19 : Mining Layout (from MINDSET)

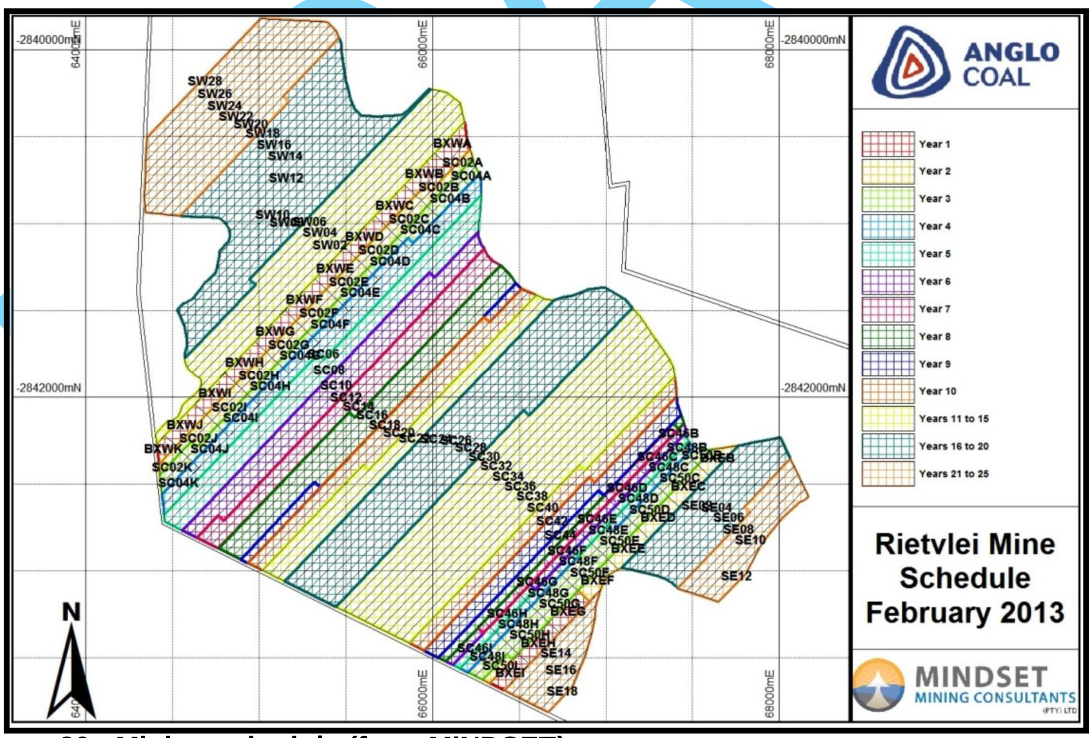

Figure 20 : Mining schedule (from MINDSET)

4 Field investigation results and interpretation

As part the present detailed investigations, several field investigations have been conducted by AEC from February to April 2014 as part of the groundwater investigations, to better understand the prevailing geohydrological conditions (flow and water quality). These activities include geophysical survey, boreholes drilling, soil and water quality testing, and aquifer pumping tests.

4.1 Geophysical surveys

A site walkover and geophysical survey (magnetometer) was carried out from the 3th to 4th of February 2014. Geophysical survey results are presented in Appendix B.

Except for traverse T2, all the walked traverses showed magnetic field anomalies, which had been used for the siting of boreholes (Shallow and Deep) on site. Summary of the geophysical survey interpretation is given in Table 9, and targets' positions for borehole drilling are shown in

Figure **21**.

Table 9: Summary of the geophysical survey interpretation

Target Name	Farm	Geographic Coordinates (WGS84)		Distance from starting points.
		Latitude	Longitude	m
T4D2	Rietvlei 397 JS	-25.700014	29.685798	1690
T4D	Rietvlei 397 JS	-25.697736	29.680776	1190
T4S	Rietvlei 397 JS	-25.697927	29.681179	1240
T5D	Rietvlei 397 JS	-25.661475	29.650723	--
T6D	Rietvlei 397 JS	-25.706538	29.685097	570
T8D	Rietvlei 397 JS	-25.697196	29.657317	290
T7D	Rietvlei 397 JS	-25.685354	29.652838	1500
T7S	Rietvlei 397 JS	-25.685504	29.653166	1450

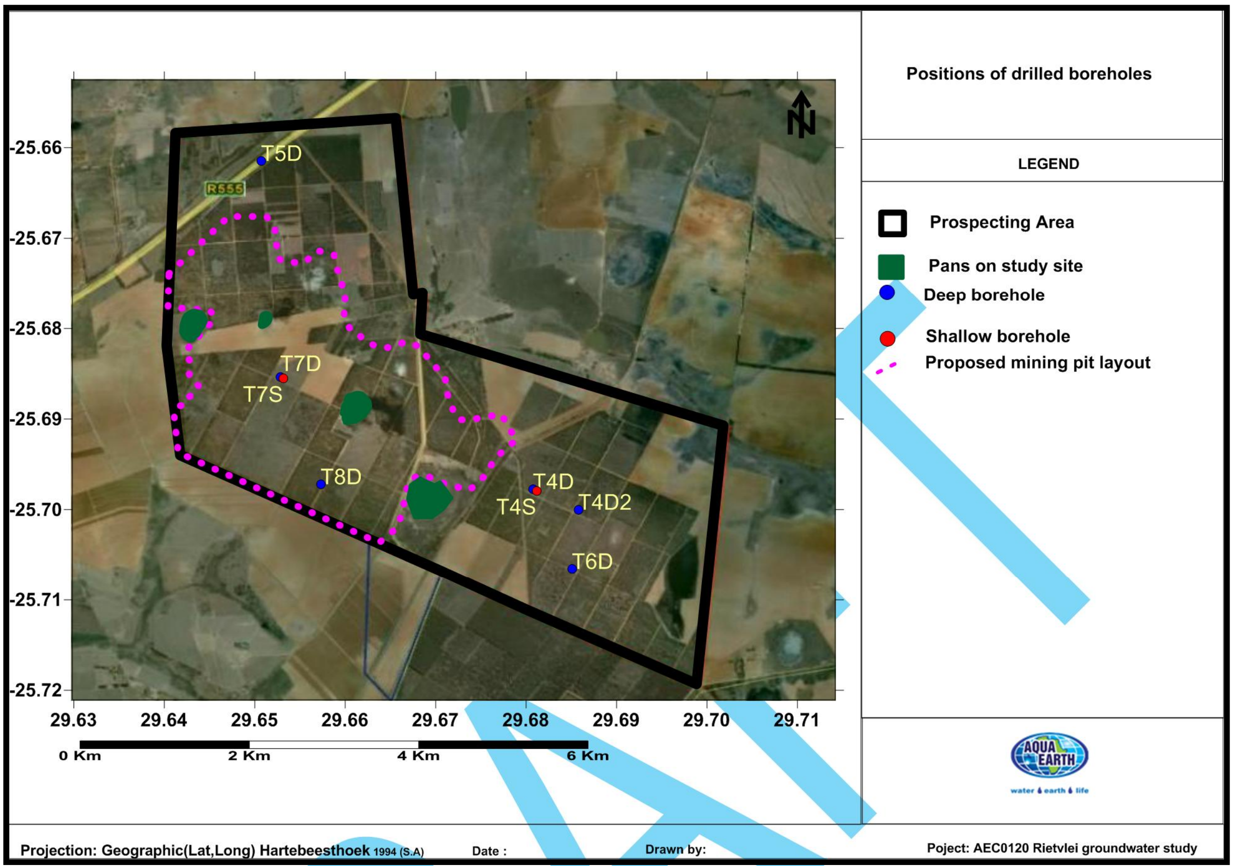

Figure 21: Positions of drilling targets

4.2 Drilling of exploration/monitoring boreholes

Borehole drilling was carried out from the 07th February to 12th February 2014. A total of six (6) deep and two (2) shallow boreholes were drilled on the targets sites as listed in Table 9. All deep boreholes were drilled to final depth of 50m, whereas all the shallow boreholes were drilled to final depth of 24m.

The borehole T4D had been drilled up to 50 m but the drilling crew had faced difficulties during its equipment. T4D was accessible up to only 09 m depth (as indicated on the provided T4D logs), and was then closed down. T4D2 was then drilled in replacement of T4D, and its location (700 m toward the south) was defined according to the closest identified magnetic anomalies (geophysics).

Figure 21 shows the positions of the drilled boreholes.

During drilling water strikes were recorded in six (6) of the boreholes, four at deep boreholes and two at shallow boreholes while borehole T5D drilled was dry. Water strikes in the shallow aquifer were intersected between 10m and 25mbgl, and concentrated at 45 mbgl in the deeper aquifer. 90 % of water strikes recorded during present drilling campaign are located in the shallow aquifer with 80 % between 19m and 25 mbgl. Water levels in the boreholes were measured between 1.7m and 19.2mbgl. The recorded water levels did not show any difference in hydraulic heads between the two aquifers.

AEC constructed the monitoring/observation boreholes drilled as follows:

- Drilled 165mm diameter to bottom;
- Install 125mm steel solid and perforated PVC casing;
- Insert gravel pack to the top;
- Complete the hole with a concrete block, stand pipe, pump and lockable cap.

The drilling information is summarized in Table 10. Detailed drilling and construction logs with the different penetration rates are presented in Appendix C.

Table 10: Summary of the drilling results

Borehole Name	Lat	Long	Depth (mbgl)	Water Strike (mbgl)	S.W.L. (m)
T4D2	-25.700014	29.685798	50	moisture	6.6
T4D	-25.697736	29.680776	50	19 and 25	3.4
T4S	-25.697927	29.681179	24	10	3.1
T5D	-25.661475	29.650723	50	Dry	Dry
T6D	-25.706538	29.685097	50	19	14
T8D	-25.697196	29.657317	50	25	19.2
T7D	-25.685354	29.652838	50	19 and 44	1.7
T7S	-25.685504	29.653166	24	19	4.8

The vertical distribution of recorded water strikes suggests the main preferential path for the groundwater may be located at depth between 15 and 31 mbgl (Figure 22).

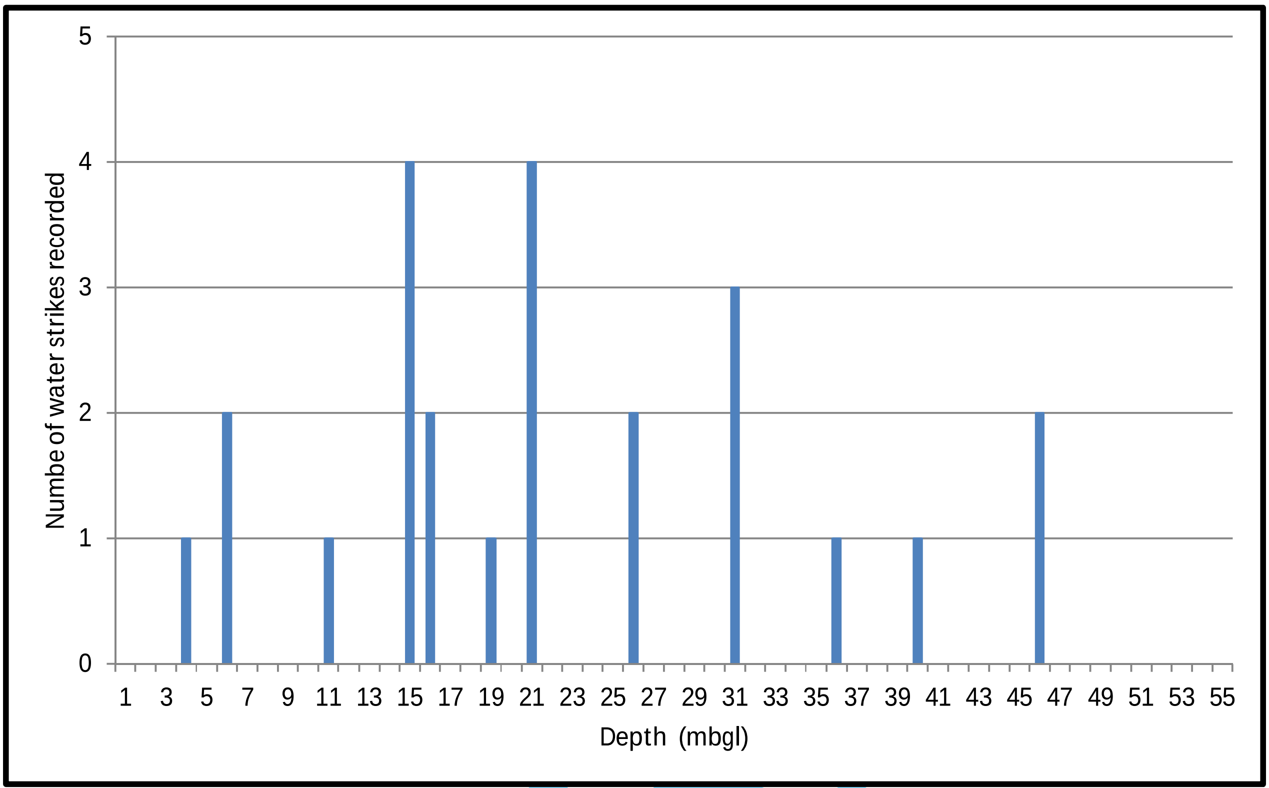

Figure 22: Vertical distribution of recorded water strikes

A shale layer was identified in the southern and western part of the prospecting area (GWOBSBH4, GWOBSBH3, T7D, T8D, T6D, and T4D2) at the headwater of quaternary catchment B12D (Figure 23, Figure 24, and Figure 25). This may be contributing to the occurrence of perennial wetland at this part of the site.

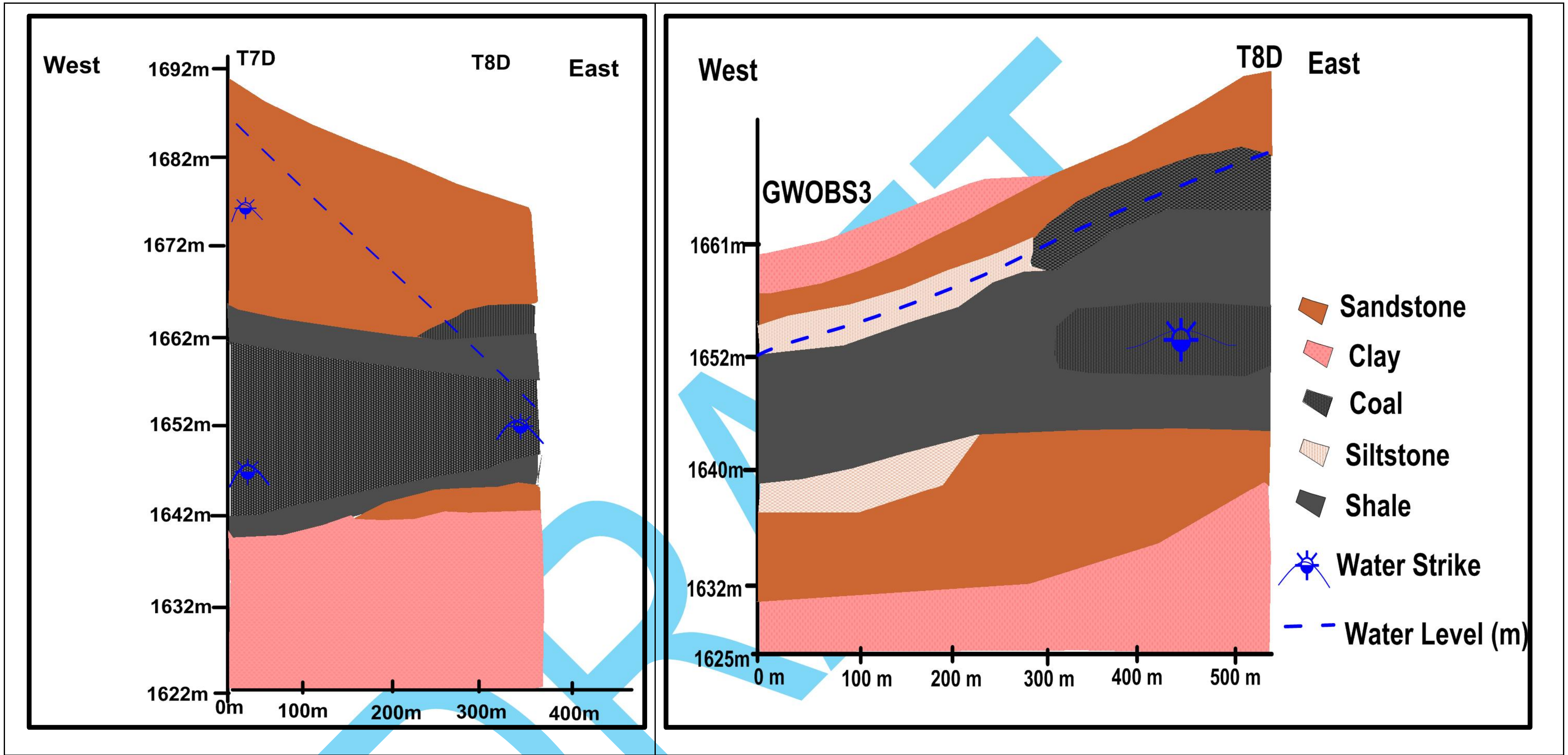

Figure 23: Fence diagrams from geohydrological drilling (T7D, T8D; GWOBSBHBH3)

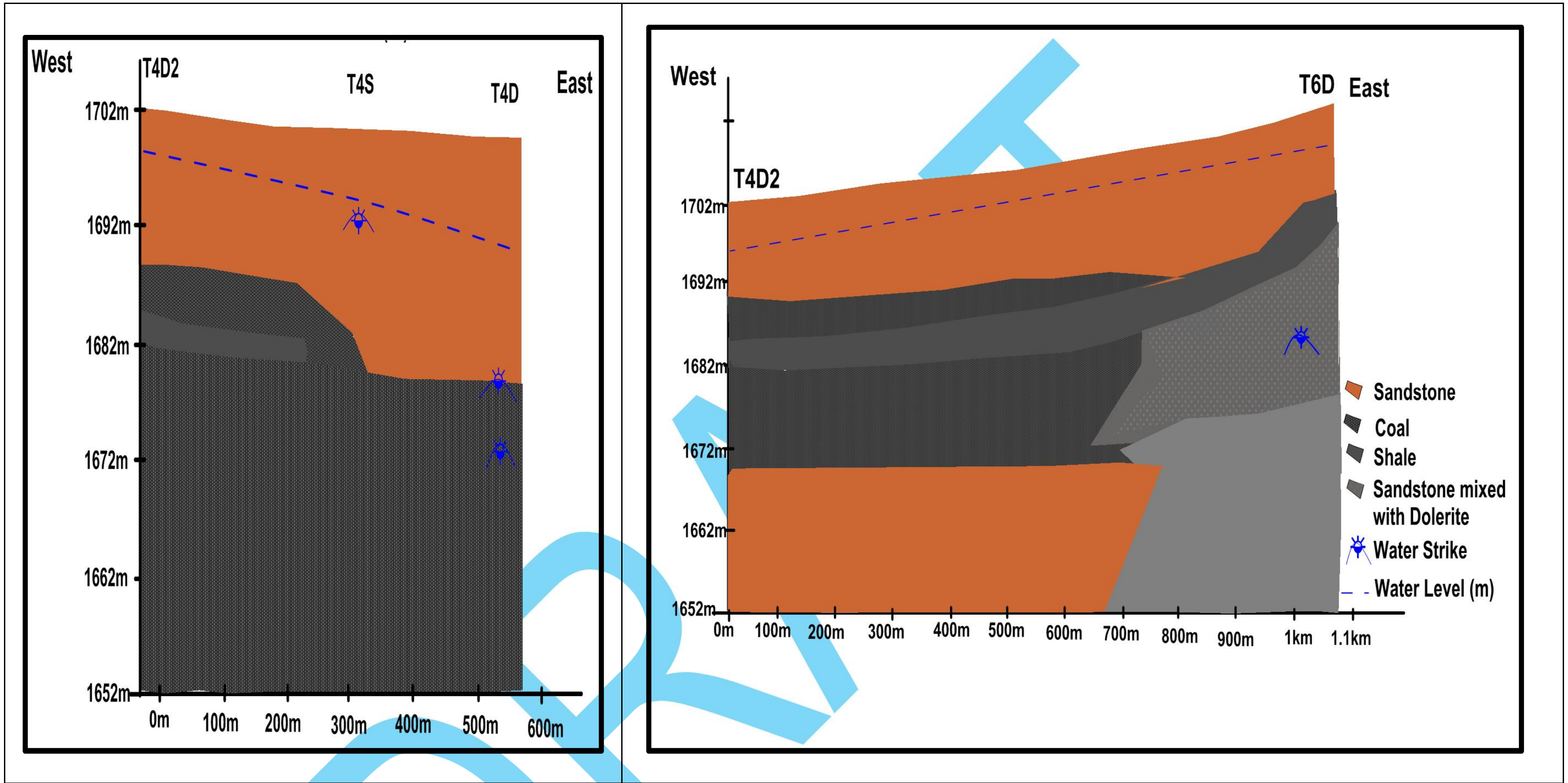

Figure 24: Fence diagrams from geohydrological drilling (T6D, T4D2, and T4D)

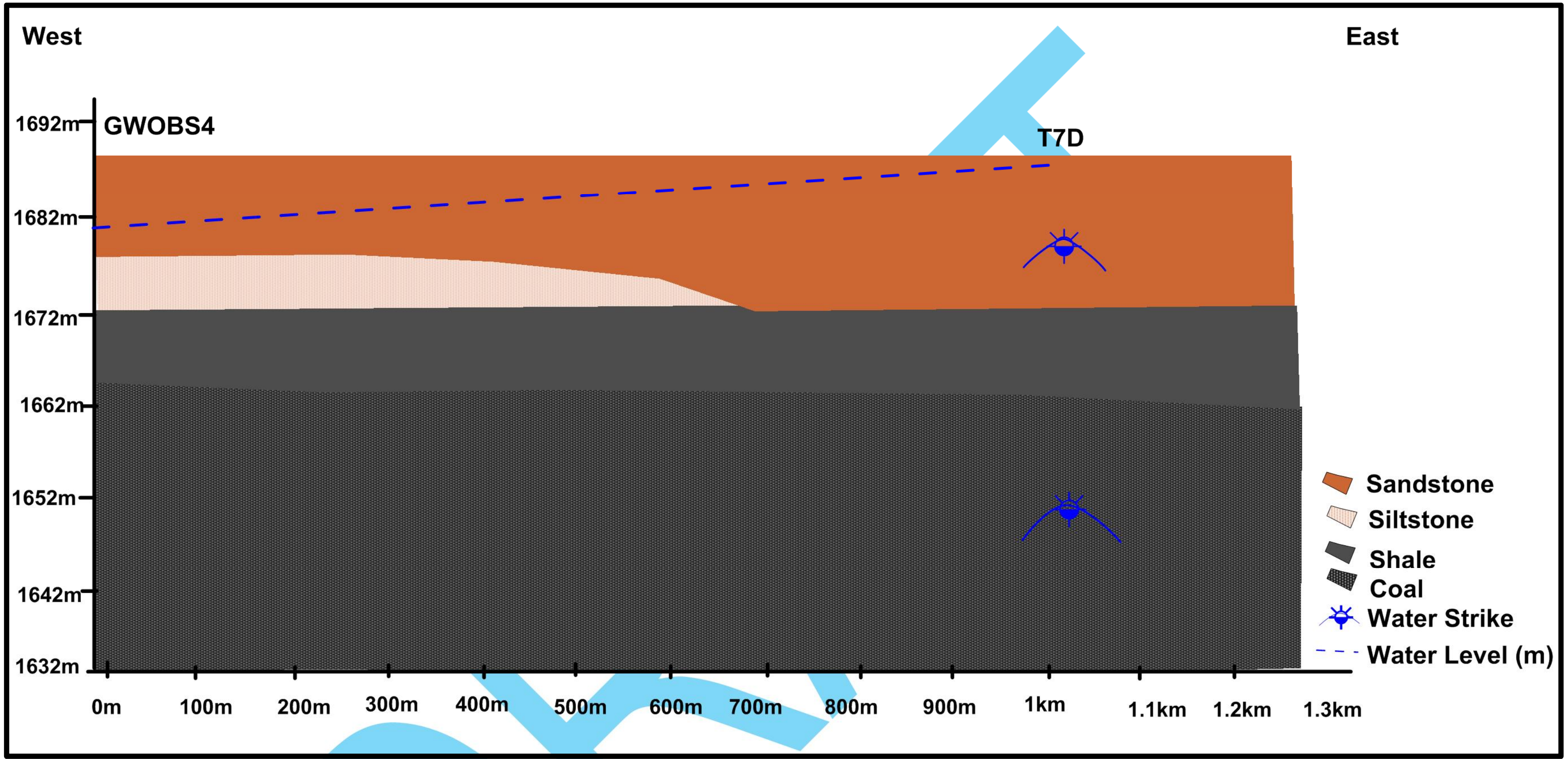

Figure 25: Fence diagram from geohydrological drilling (T6D, T4D2, and T4D)

Using the available data (water elevations), an interpolation technique was used to simulate water elevations over the entire model area. The interpolation technique used is referred to as Bayesian interpolation where water elevations are correlated with the surface topography. All available levels were plotted against topography as shown in Figure 26. The results indicate a correlation of 95 % between the data sets. Therefore, Bayesian interpolation was valid and used to calculate water levels for the entire model area. The distribution of water levels is shown in Figure 27 and groundwater drainage Figure 28. As groundwater levels follow topography it can be assumed that groundwater flow takes place under unconfined to semi-confined conditions.

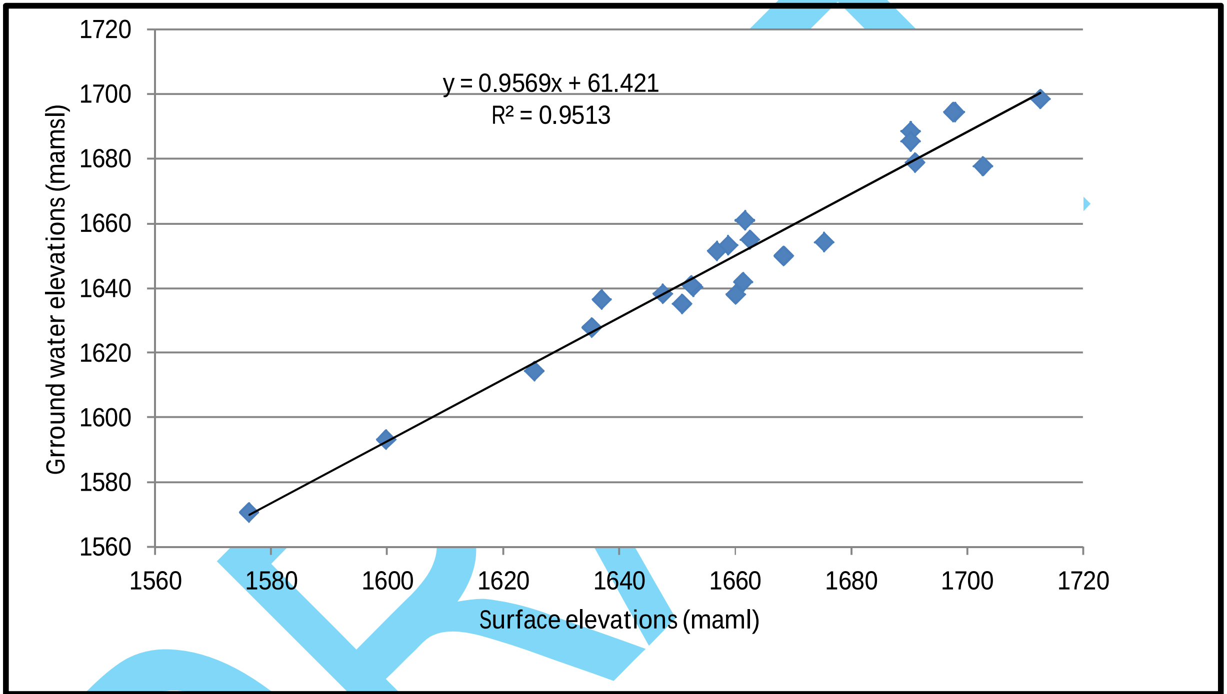

Figure 26: Correlation between groundwater elevations and topography

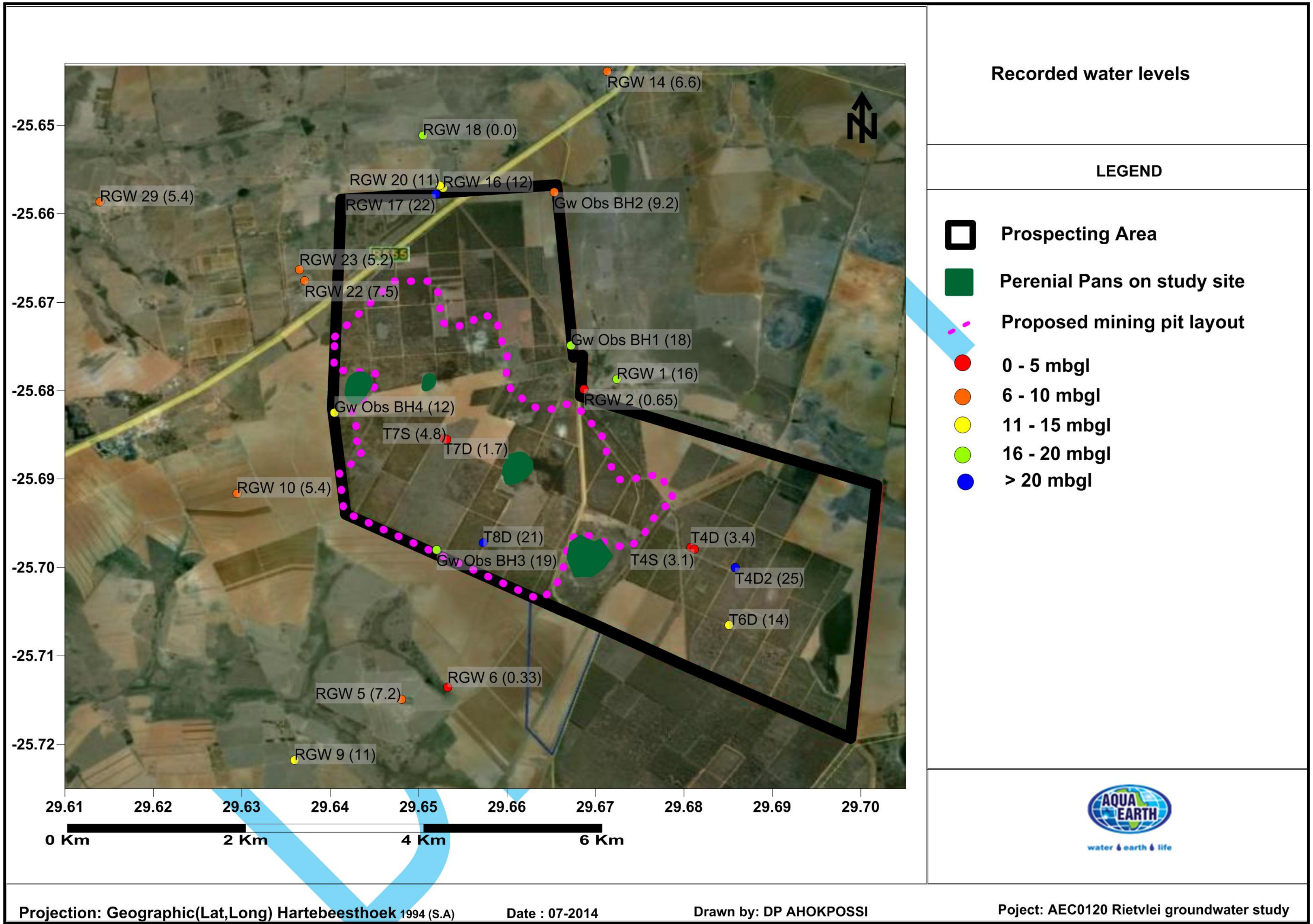

Figure 27: Recorded water levels distribution

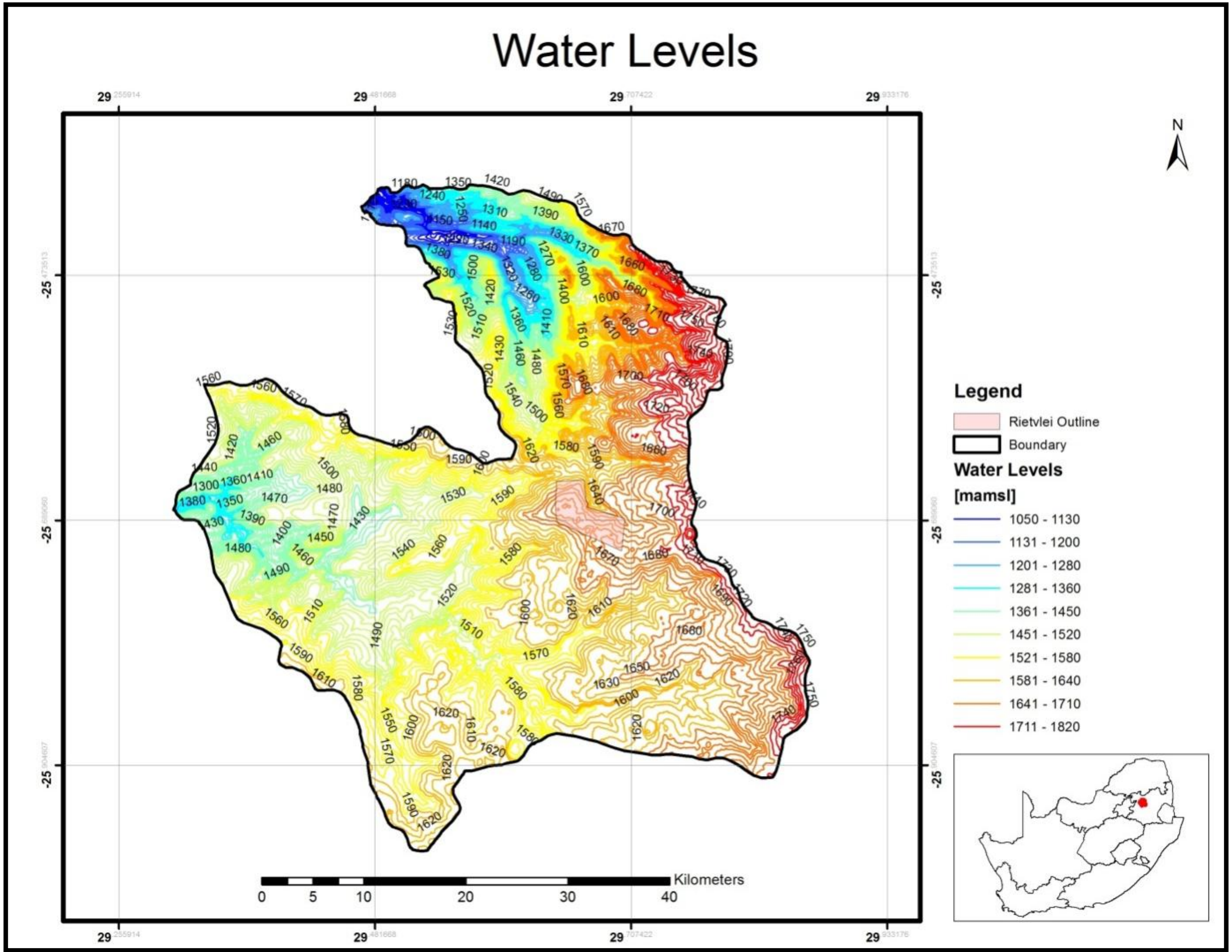

Figure 28: Groundwater elevations and drainage

4.3 Soil analysis results

Acid drainage potential analysis results have been submitted to WSP for geochemistry investigations, and can be found in Appendix D as submitted by the Water Lab. Preliminary geochemical assessment of the proposed Rietvlei mine was conducted by WSP based on leachate test results. The assessment suggests that the rock dumps won't have short term acid generation potential. Further discussion on the results is given in section **7**.

4.4 Groundwater water quality test results

When compared to South African National Standards for domestic use (SANS 241: 2005), the chemical results received from the laboratory, show a general baseline groundwater quality that falls within the recommended operational limits (Class 1) for all the constituents analyzed (Table 11). However F and Fe content are found to be above the maximum allowable limit in respectively T8D and T4S, and Fe in T6D fall in Class II (maximum allowable limit). Considering the location of T8D and T4S such quality may associated to contact with wetland water. The complete result as received from UIS is given in Appendix E. Expanded Durov diagram suggests unpolluted groundwater quality for all the samples collected at proposed Rietvlei Mine. Piper diagram shows calcium/magnesium bicarbonate water as result of freshly recharge to ground's water table. Such water quality results are in agreement with the surrounding general groundwater quality as established by the baseline groundwater investigation conducted by AEC (2011), except for RGW4, RGW1 which returned polluted quality due to high concentration of NO3-N

Table 11: Water chemistry results

	Sample Number	pH	EC mS/m	TDS mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Cl mg/l	SO4 mg/l	NO3-N mg/l	F mg/l	Fe mg/l	Mn mg/l
Groundwater	T4S	6.14	5.9	38.4	13.8	3.54	8.13	5.13	1.83	6.6	<0.3	<0.1	2.1	0.07
	T6D	6.11	4.6	29.9	10	2.26	2.88	3.85	0.796	2.29	<0.3	<0.1	0.99	<0.05
	T8D	7.98	20.1	131	33.5	3.66	32.9	2.57	2.43	3.44	<0.3	3.5	0.07	<0.05
	T7S	6.46	3.7	24.1	9.11	0.66	3.57	2.58	2.26	4.22	<0.3	<0.1	<0.05	0.05
	T7D	6.29	2.5	16.3	5.47	0.57	2.84	1.53	1.88	2.27	<0.3	<0.1	<0.05	<0.05
	T4D2	7.59	22.9	149	72.7	11.6	9.81	9.29	2.71	6.62	<0.3	0.5	<0.05	<0.05
SANS 241; 2005														
CLASS I: Recommended Operational Limit		5-9.5	<150	<1000	<150	<70	<200	<50	<200	<400	<10	<1	<0.2	< 0.1
CLASS II: Max Allowable		4.0-10	150-370	1000 - 2400	150-300	70-100	200-400	50-100	200-600	400-600	10.0-20	1-1.5	0.2-2	0.1-1
Above Class II Limits		>10	>370	2400>	>2400	>100	>400	>100	>600	>600	>20	>1.5	>2	>1

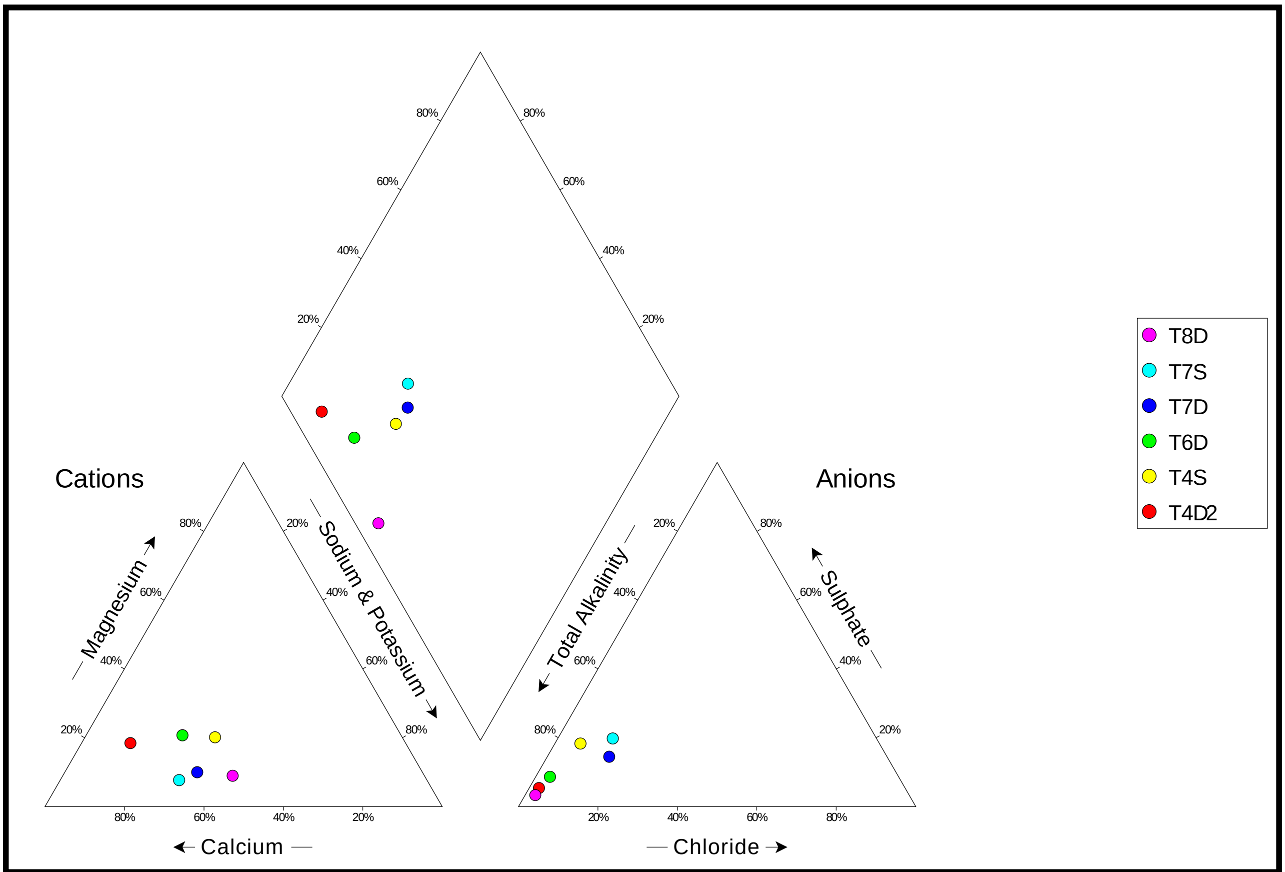

Figure 29: Piper diagram of boreholes within proposed RIETVLEI MINE

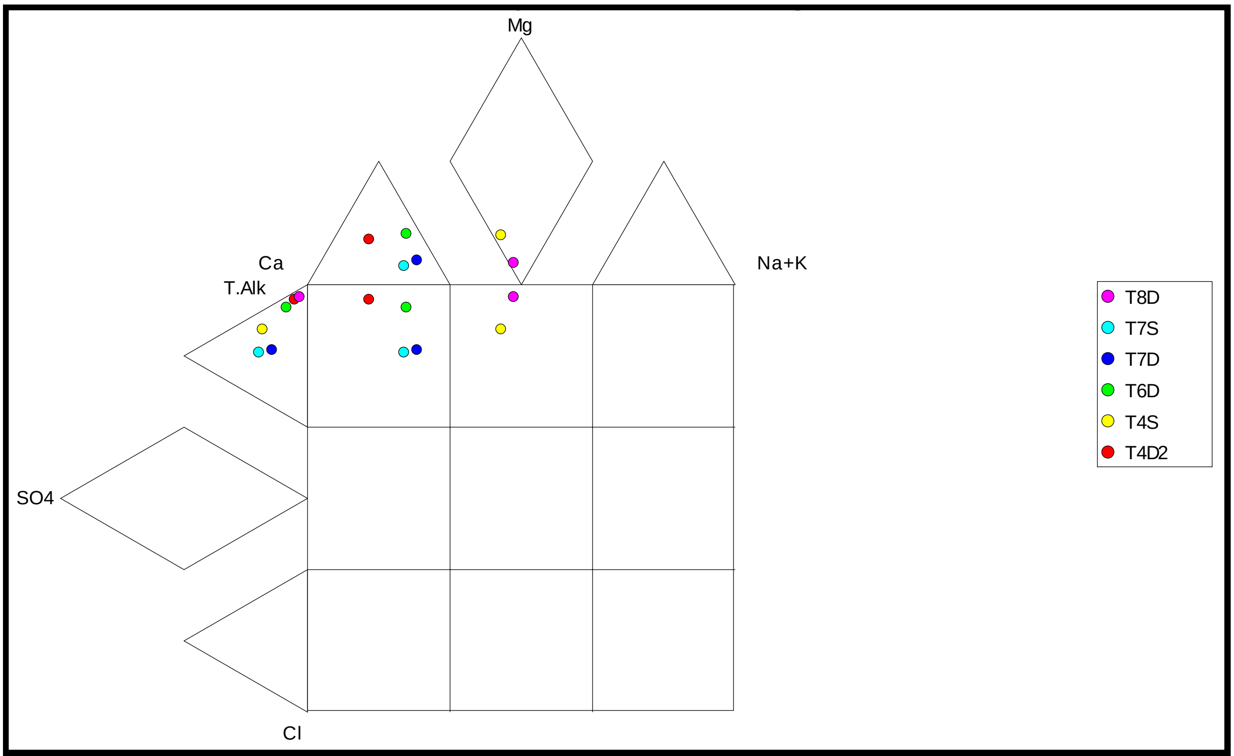

Figure 30: Expanded Durov diagram of boreholes around the proposed RIETVLEI MINE

4.5 Aquifer tests results and interpretation

The aquifer tests conducted in the present detailed groundwater investigation; aim to collect/confirm in-situ properties (flow and storage) to update the existing numerical model to be representative of representative of both shallow and deeper water-bearing formations (shallow and deeper aquifer). The variability of the aquifer properties is also of importance and would be considered for a more representative aquifers numerical model.

4.5.1 Slug tests

Slug tests were conducted from 19th to 20th February 2014 on the new boreholes that were - drilled and the existing Aqua Earth boreholes on the property. In total a sum of 10 slug tests were conducted. The results are illustrated on graphs in Appendix F. Table 12 presents a summary of the slug test results.

Table 12: Slug test results

BH Number	Slug	S.W.L	W.L after slug inserted	Water Rise	Water Drop/ Recovery	Recovery Length
	Mm	mbgl	mbgl	m	m	min
T4S	1500	3.76	3.254	0.506	0.28	128
T6D	1000	14.01	13.81	0.2	0.38	128
T8D	1000	21.69	21.181	0.509	0.45	122
T7D	1500	2.06	1.892	0.168	0.088	88
T7S	1000	4.06	3.41	0.65	0.37	37
Gw Obs BH3	1000	19.41	17.7	1.71	0.01	120
Gw Obs BH4	1500	12.09	11.38	0.71	0.72	98
Gw Obs BH2	1500	9.23	7.9	1.33	0.64	60
Gw Obs BH1	1000	18.31	17.849	0.461	0.47	58

The responses of the water levels in tested boreholes were used to predict borehole yields by correlating the recession time and the yield of borehole (Vivier et al., 1995). The estimated yields are summarised in Table 13.

Table 13 : Borehole yields estimated from slug test

BH Number	Recovery time	Percentage of recovery	Estimated Yield
T4S	128	55	<0.02
T6D	128	100	0.02
T8D	122	88	0.02
T7D	88	52	<0.02
T7S	37	57	<0.02
Gw Obs BH3	120	0.01	<0.02
Gw Obs BH4	98	100	0.03
Gw Obs BH2	60	48	<0.02
Gw Obs BH1	58	100	0.04

4.5.2 Calibration tests

Calibration tests were conducted from 26th to 27th March 2014, to confirm the yielding capacity of the boreholes and determine the pumping rates and length of step test. Summary on the calibration test results is given in Table 14 and the resulting graphs in Appendix G.

Based on the test results, the step tests have been designed as presented in Table 15.

Table 14: Summary on calibration test results

Borehole	Step 1			Step 2			Step 3			Recovery	
	Pumping rate	Step Length	Drawdown	Pumping rate	Step Length	Drawdown	Pumping rate	Step Length	Drawdown	Time Length	Percentage of recovery
	l/s	Min	m	l/s	min	m	l/s	min	m	min	%
T4S	0.06	20	7	0.42	18	3	--	--	---	90	80
T4D2	0.14	15	5	0.48	15	13.5	1.2	3	15.6	60	2.12
T6D	0.51	15	7.5	0.95	15	18.8			--	40	93.53
T8D	0.16	15	5	0.26	15	1.7	0.48	6	5	90	81.55
T7D	0.12	15	13	0.37	23	18	--	--	--	113	87.1
T7S	0.11	7	12	--	--	--	--	--	--	61	83.33
Gw Obs BH3	0.69	12	17	--	--	--	--	--	--	43	35.29
Gw Obs BH4	0.48	18	16	--	--	--	--	--	--	41	81.25
Gw Obs BH2	0.43	13	17	--	--	--	--	--	--	30	58.82
Gw Obs BH1	0.37	49	7.2	0.92	6	2	--`	--	--	33	88.89

Table 15 : Design of step tests

BH Name	Pump Depth	Pumping Rate			Pumping Length
	(mbgl)	(l/s)			(min)
GW OBS BH 1	28	0.04	0.15	0.45	60*3
GW OBS BH4	25	0.04	0.10	0.17	60*3
T4D2	40	0.03	0.08	0.11	60*3
T6D	40	0.09	0.18	0.27	60*3

4.5.3 Recovery tests

Recovery data from the calibration has been used to get a first estimate of transmissivity values over the tested site. The results are summarised in Table 16, where as the distribution of estimated transmissivity with total borehole depth is given in Figure 31.

Table 16: Estimated T values from recovery data

Borehole number	Length of Recovery Phase	Residual Drawdown	Estimated T
	(min)	(m)	(m^2/d)
GW OBS BH1	32.5	0.97	8
GW OBS BH2	35	7.89	6.2
GW OBS BH3	44	11.45	7.9
GW OBS BH4	42	2.99	3.7
T4S	88.5	1.88	6.1
T6D	40.5	1.7	1.6
T7D	115.5	4.52	3.8
T7S	62	2.33	6.9
T8D	600	3.41	2.5

T is estimated between 1.6 to 8 m^2/d with an average of 5m^2/d. Estimated transmissivity values are found to do not really depend on the depth, but rather on fractures, and weathered contact zones intersections. .

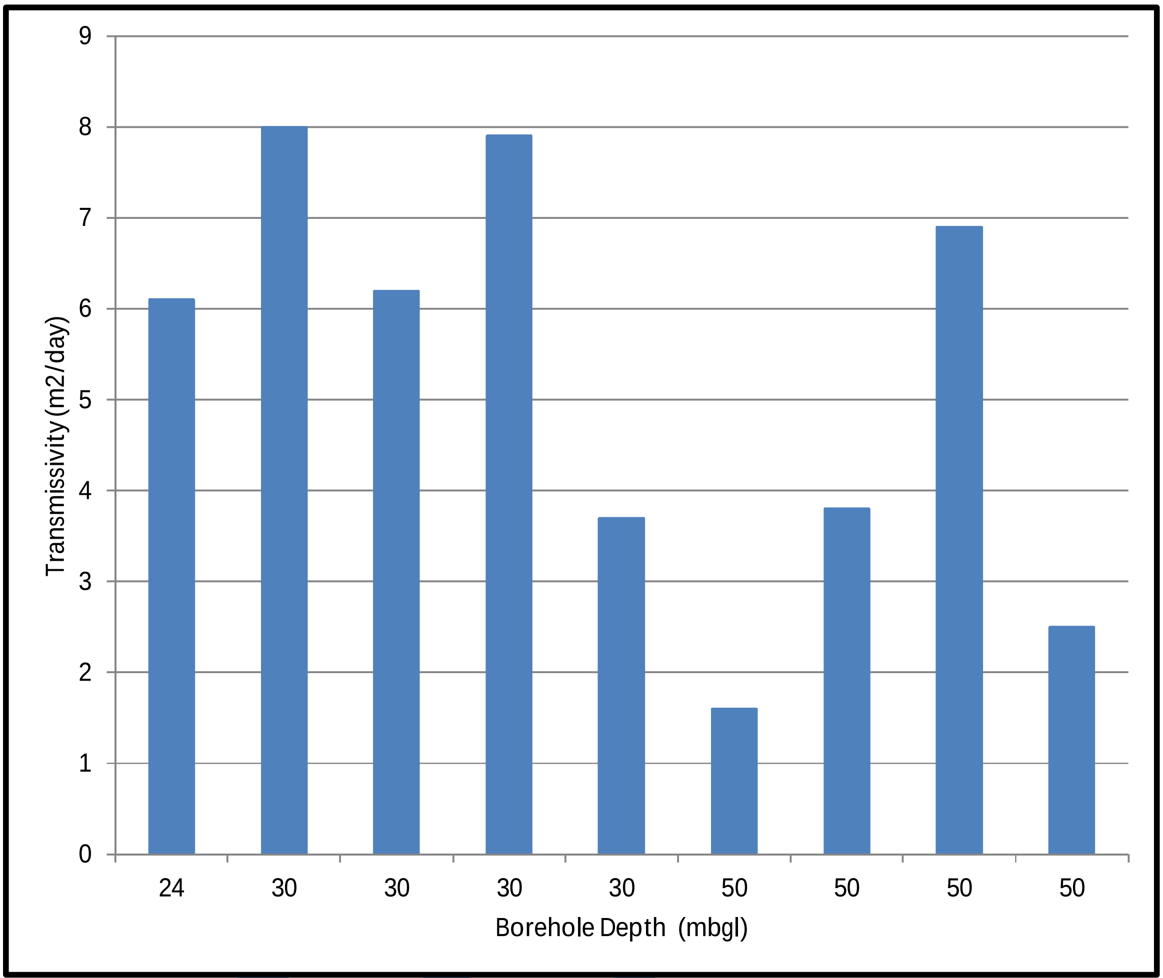

Figure 31: Distribution of estimated transmissivity with total borehole depth

4.5.4 Step tests

Step tests were conducted from 3rd to 4th April 2014, to determine the appropriate pumping rate for the CDT. Except for the T4D, where the step length was not respected due field difficulties, the step tests have been conducted according the design. The summary on the calibration test results is given in Table 14 and the resulting graphs in Appendix H. Based on the step test results (Table 17); the CDT has been designed as presented in

Table 18.

Table 17: Summary on step test results

Borehole	Step 1			Step 2			Step 3			Recovery	
	Pumping rate	Step Length	Drawdown	Pumping rate	Step Length	Drawdown	Pumping rate	Step Length	Drawdown	Time Length	Percentage of recovery
	l/s	Min	m	l/s	min	m	l/s	min	m	min	%
T4D2	0.03	60	0.32	0.08	60	1	0.11	60	8.40	30	95
T6D	0.09	60	1.34	0.18	60	2	0.27	60	1.40	40	93.53
Gw Obs BH4	0.04	60	2.52	0.1	60	1.60	0.17	60	8.80	180	92
Gw Obs BH1	0.04	50	0.32	0.15	15	1	0.45	10	8.4	30	95

Table 18: Design of Constant discharge tests

BH Name	Obsevation BH	Pump Depth	Pumping Rate	Pumping Length
		mbgl	l/s	min
GW OBS BH 1	T7D,T7S	28	0.25	
GW OBS BH4	T7D,T7S	25	0.11	720
T6D	T4D2,T4S,T8D	40	0.28	

4.5.5 Constant discharge tests

12 hours constant discharge tests were conducted on 03 selected boreholes from 03th to 05th May 2014. During the test, drawdown was recorded in pumping and observations boreholes. The tests were conducted successfully according to the design, followed by recovery recording for T6D and GWOBSBHBH4. 03 observations boreholes show responses to pumping. Responses were noticed in observation borehole T4S when T6D was pumped, and in both T7D and T7S when GWOBSBHBH4 was pumped. Observation boreholes did not return any response to the pumping of GWOBSBHBH1. Where no response could be recorded, an increase in water level was observed, instead of decrease. That may be a coincidence with a recovery phase following pumping by nearby farmers.

Table **19** gives the summary on the CDT results, and the time-drawdown plots of the pumped boreholes are presented from Figure 32 to Figure 34.

Table 19: Constant discharge test results

BH Name	Pumping Rate	Drawdown in pumping borehole	Dradown in OBS BH					Residual Drawdown	Recovery Time
			T7D	T7S	T4D	T4S	T8D		
	l/s	m	m					m	min
GW OBS BH 1	0.25	2.15	--	--	--	--	--	0.4	600
GW OBS BH4	0.11	5.26	0.22	0.23	--	--	--	-	--
T6D	0.28	8.49	--	--	0.14	0.13	--	0.91	180

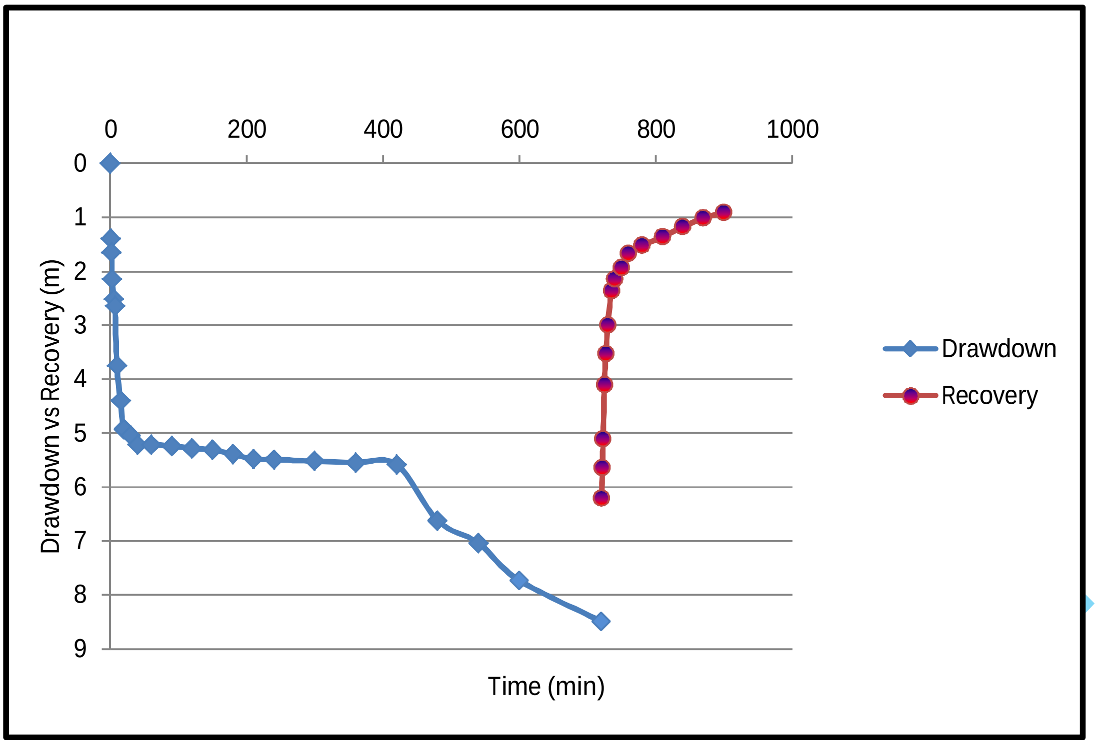

Figure 32: Drawdown to CDT in TD6

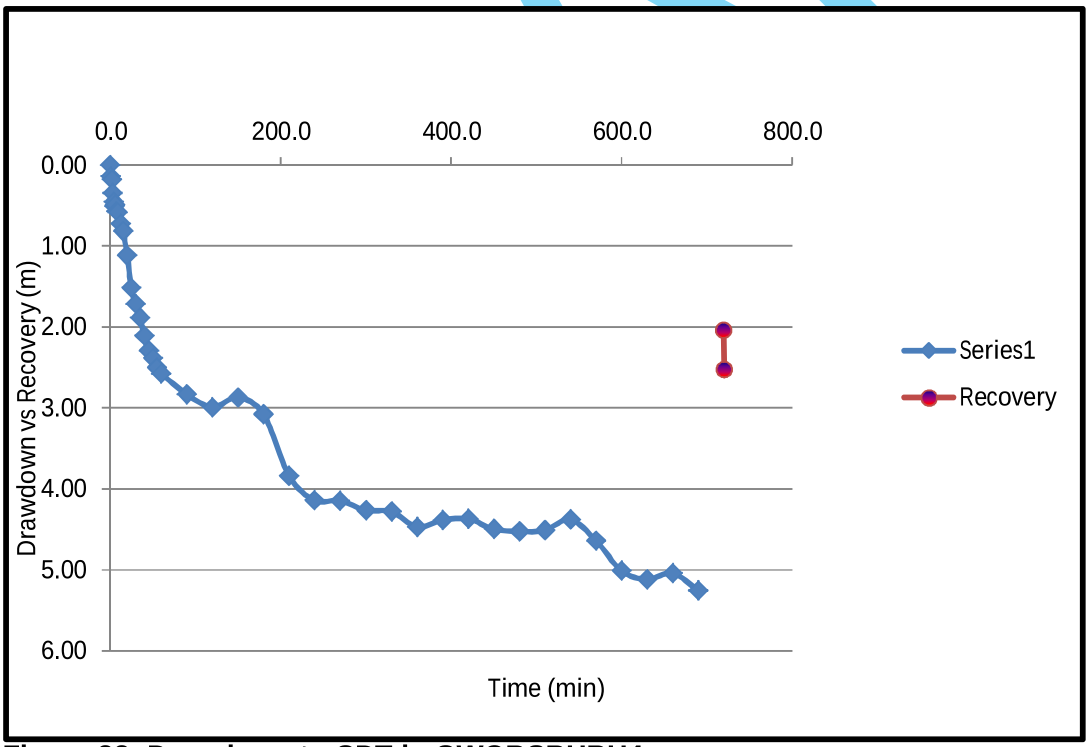

Figure 33: Drawdown to CDT in GWOBSBHBH4

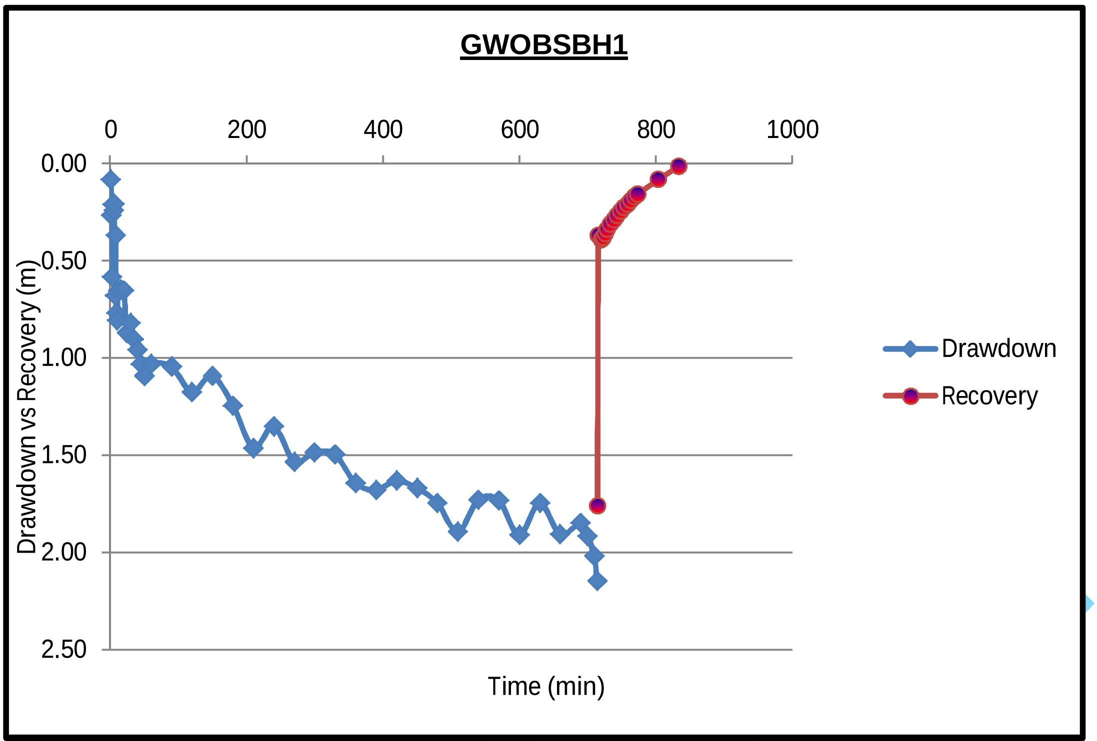

Figure 34: Drawdown to CDT in TD6

The CDT confirms the low yielding potential of the aquifer associated with the prospecting site. The maximum drawdown recorded (8.49m) is associated with a CD rate of 0.28 l/s over 12 hours. Estimated sustainable yield are less than 0.5l/s and are summarised in Table 20

Table 20 Calculated sustainable yields

BH Name	Cooper-Jacob yield	Basic FC yield
	l/s	l/s
GW OBS BH 1	0.06	0.06
GW OBS BH4	0.02	0.02
T6D	0.07	0.03

The diagnostic plots (log-log) of the pumping test data suggests linear (fractures) flow at the beginning of the pumping followed by bi-linear flow (GWOBSBHBH4, GWOBSBHBH1). This suggest that in the aquifer water is first directly discharged from the fractures, and then from the matrix (sandstone) through the fracture. This is a common behaviour of fractured aquifer in South Africa mainly in the Karoo sediments. The diagnostic plots also show a kind of limited closed reservoir from T6D. That may be related to the control that the intersected dolerite has on the aquifer part surrounding T6D.

Estimated transmissivity values, range from 0.6 to 6.1 m^2/d, and are summarised in Table 21.

Table 21 Calculated aquifer parameters

BH Name	Cooper-Jacob Method		Theis Method		Recovery vs. Rise W/L
	T	S	T	S	m^2/d
	m^2/d		m^2/d		
GW OBS BH 1	4	1.58	4	2.00E-04	6.1
GW OBS BH4	0.6	4.50E-01	1	3.00E-05	-
T6D	1.5	1.99E-2	1	3.00E-01	1.3

5 Conceptualisation of the geohydrological system

This section used the current level of site characterization to simplify (conceptualize) the description of the aquifer systems. The conceptualization was done for the purpose of predicting the potential impacts of the opencast mining activities on the aquifer systems. It aims to design and construct equivalent but simplified conditions for the real world problem, which are acceptable in view of the objectives of the modelling and associated groundwater management problems. Transferring the real world situation into an equivalent model system, which can then be solved using existing program codes, is a crucial step in groundwater modelling. The following is included:

- The known geological and geohydrological features and characteristics of the area.
- The static water levels heads in the study area.
- The interaction of the geology and geohydrology on the boundary of the study area.
- A description of the processes and interactions taking place within the study area that will influence the movement of groundwater, and
- Any simplifying assumptions necessary for the development of a numerical model and the selection of a suitable numerical code.

Although it has been found (based on distribution of water strikes) that the main preferential path for the groundwater may be located at depth between 15 and 31 mbgl (Figure 22), the distribution of estimated hydraulic parameters (mainly T), did not show any dependence of depth within the top 50 mbgl as investigated on site. This allows us to conceptualise the aquifer on site as a unique aquifer system. For simplification purpose the shale layer identified in the south western side of the site will not be modelled.

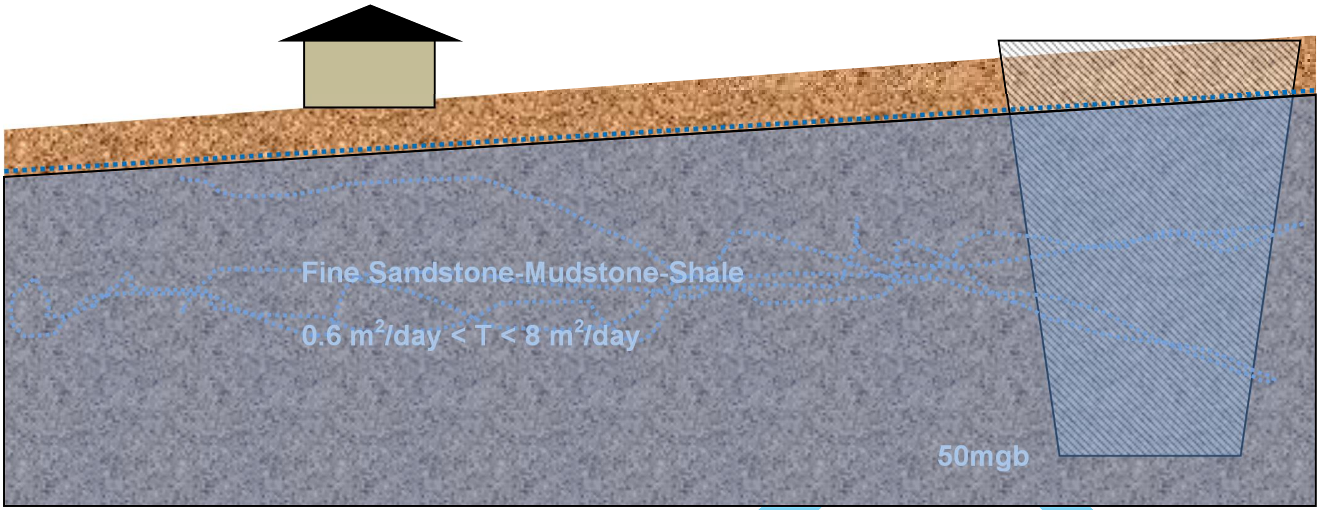

Figure 35: Simplify conceptual model

5.1 Lateral extent and thickness of the aquifers

Since the evidence of physical subsurface no-flow boundaries have been clearly identified at the present level of sites characterisation and a good correlation exists between the groundwater level elevations and the surface topography, it is assumed that the groundwater extends over the geometry of the surface water catchment system(s). Consequently, most of the groundwater recharges occurring within the study area are expected to discharges to the surface drainage systems via springs (wetland in depression) and discharge to the base of the main river drainage systems:

- Selons River in B32B;
- Olifants River in B12C, B12D, and B12E;
- and Keerom stream in B12E.

Aquifer systems are considered up to the 10 m below the bottom the last seam to mined (50mbgl), and are simplified as:

The thickness of the unsaturated zone is determined by the depth to the ground water level that varies between 0.33 and 21mbgl in the vicinity of the area, but range from 1.7 to 19.2mbgl within proposed Rietvlei Mine. In the saturated zone, the generated groundwater elevations contour is considered as the top of the aquifer system.

5.2 Permeability

Falling head tests carried out on auger holes in November 2011 (Aqua Earth Consulting, 2011) have shown that the overlying unsaturated zone is characterized by high hydraulic conductivities at an average of 12m/d.

5.3 Transmissivity

Estimated transmissivity values vary between 0.6 to 8 m^2/d with an average of 4.5 m^2/d. Initial model built by AEC used a transmissivity value of 4m^2/d. However, transmissivities may be much higher in fracturing associated with contact zones between sediments, and dolerite.

5.4 Storativity and Porosity

Estimated storage coefficients fall within the range between $2*10^{-2}$ and $3*10^{-5}$ with an average of $4*10^{-3}$. Initial one layer numerical model considered a Storativity of $4*10^{-3}$, and a porosity value of 6%. It believes that pumping test data will help in inferring their values from numerical model calibration.

5.5 Recharge

Water qualities suggest that the aquifer consists of recently recharged groundwater. According to Vegter (1995) the recharge is 35mm/a, which is equal to approximately 5% of mean annual precipitation. Using the Chloride method, recharge was estimated at 4% (28mm/a). Considering the groundwater chemistry, and the position (water head) of proposed Rietvlei Mine, recharge to water table is expected to prevail in the system. The site vegetation (high evapotranspiration), the soil characteristics (low percolation rate), and depression occurring at the site (soil and groundwater seeping into wetlands) are probably the main factors that contribute at such reduce recharge rate.

5.6 Groundwater flow direction

The groundwater flow direction is as shown in Figure 28, and is considered to be the same for both considered aquifer systems, and groundwater is moving away from proposed Rietvlei Mine in the following direction:

- North-West, probably discharging into the furrows that feed into Olifants River;
- South West, probably discharging into Olifants River;
- And North East, discharging into Selons River which also flows North-West into Olifants River;

5.7 Ground water quality

Based on data from the new groundwater sampling analysis (onsite) and conducted hydrocensus, the groundwater quality is considered generally as unpolluted in proposed Rietvlei Mine and surrounding.

However F and Fe concentration found above the maximum allowable limits on site has to be mentioned and understand as associated with site conditions (geology, contact with wetlands), as no harmful previous activities have been reported.

5.8 Ground water use

Communities in the area surrounding the prospecting area are dependent on ground water sources for domestic use, livestock watering and small-scale irrigation. They abstract water from boreholes situated in the villages (Figure 36).

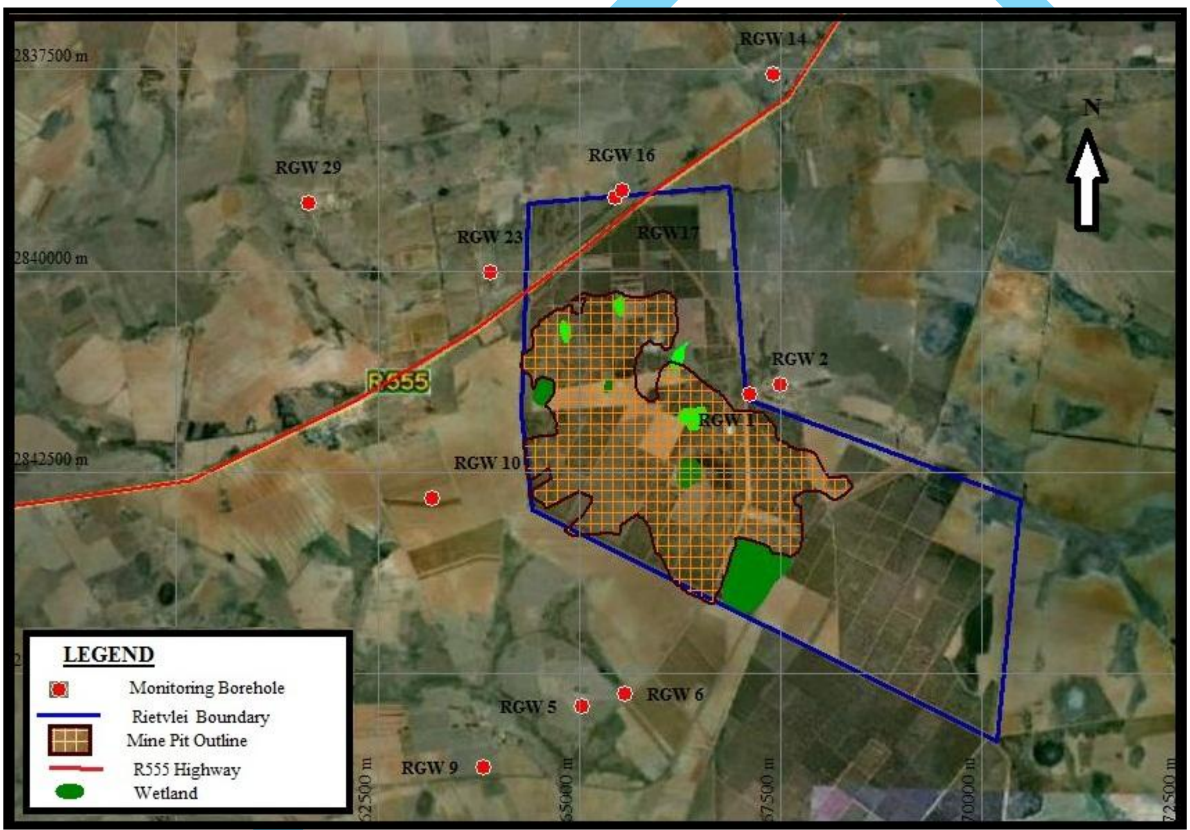

Figure 36: Groundwater abstraction points surrounding the prospecting site

5.9 Aquifer Classification

The classification scheme (Parsons, 1995) was created for strategic purposes as it allows the grouping of aquifer areas into types according to their associated supply potential, water quality and local importance as a resource. The aquifer underlying the prospecting site may be classified in accordance with DWA's aquifer classification system (Parsons, 1995), and the modified version (minimum requirement (1998)) between minor aquifer system and non aquifer system (Table 22). The vulnerability classification (Parsons, 1995) is high considering the important number of users.

Table 22: Aquifer Classification scheme

Aquifer System	Defined by Parsons (1995)	Defined by DWAF Min Requirements (1998)
Sole Source Aquifer	An aquifer which is used to supply 50 % or more of domestic water for a given area, and for which there are no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.	An aquifer, which is used to supply 50% or more of urban domestic water for a given area for which there are no reasonably available alternative sources should this aquifer be impacted upon or depleted.
Major Aquifer	High permeable formations usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (<150 mS/m).	High yielding aquifer (5-20 L/s) of acceptable water quality.
Minor Aquifer	These can be fractured or potentially fractured rocks, which do not have a high primary permeability or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important both for local supplies and in supplying baseflow for rivers.	Moderately yielding aquifer (1-5 L/s) of acceptable quality or high yielding aquifer (5-20 L/s) of poor quality water.
Non-Aquifer	These are formations with negligible permeability that are generally regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer as unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and need to be considered when assessing the risk associated with persistent pollutants.	Insignificantly yielding aquifer (< 1 L/s) of good quality water or moderately yielding aquifer (1-5 L/s) of poor quality or aquifer which will never be utilised for water supply and which will not contaminate other aquifers.
Special Aquifer	An aquifer designated as such by the Minister of Water Affairs, after due process.	An aquifer designated as such by the Minister of Water Affairs, after due process.

6 Numerical groundwater flow model (finite difference)

A modular three-dimensional finite difference groundwater flow model MODFLOW, developed by U.S. Geological Survey is used during the present modelling project. This modelling package, calculates the solution of the groundwater flow equation using the finite difference approach.

A steady state groundwater flow model is constructed to simulate undisturbed groundwater heads distribution, based on the generalised steady state conditions, groundwater flow Equation (1) is as follows:

$$\frac{\partial}{\partial x}(K_x \frac{\partial h}{\partial x}) + \frac{\partial}{\partial y}(K_y \frac{\partial h}{\partial y}) + \frac{\partial}{\partial z}(K_z \frac{\partial h}{\partial z}) \pm W = 0 \qquad (1)$$

Where: h = hydraulic head [L]; Kx,Ky,Kz = Hydraulic Conductivity [L/T]; t = time [T]; W = source (recharge) or sink (pumping) per unit area [L/T]; x,y,z = spatial co-ordinates [L]

These conditions serve as initial heads for the transient simulations of groundwater flow, in which changes with time are simulated, using the three-dimensional groundwater flow model equation:

$$\frac{\partial}{\partial x}(K_x \frac{\partial h}{\partial x}) + \frac{\partial}{\partial y}(K_y \frac{\partial h}{\partial y}) + \frac{\partial}{\partial z}(K_z \frac{\partial h}{\partial z}) \pm W = S\frac{\partial h}{\partial t} \qquad (2)$$

Where: S = storage coefficient.

6.1 Models domain and boundaries conditions

One of the first and most demanding tasks in groundwater modelling is the identification of the appropriate model boundaries. Consequently, a model boundary is the interface between the model area and the surrounding environment. Conditions on the boundaries, however, have to be specified. Boundaries occur at the edges of the model area and at locations in the model area where external influences are represented, such as rivers, wells, and leaky impoundments. Criteria for selecting hydraulic boundary conditions are primarily topography, hydrology and geology. The topography, hydrology, and groundwater drainage have been used mainly in the definition of the lateral boundary, where as the geology and the hydrogeology have been used mainly for the aquifer layer thickness. The boundaries conditions, considered for initial numerical model, have been kept:

- the Klein Olifants River to the west and south of the study area was set as a Dirichlet boundary condition.
- the boundary of quaternary catchment B32B was set as the eastern boundary (no-flow)
- and quaternary catchment B12E was set as the northern boundary (no-flow).

6.2 Initial conditions

Initial conditions are vital for modelling flow problems. Initial conditions have been specified for the entire area. The water elevations distributions shown in Figure 28 were used as initial conditions for the models' steady state calibration.

After steady state calibration, the resultant groundwater elevations (drainage) distributions was used as the new set of initial heads for transient state calibration, and scenarios simulation.

6.3 Sources and sinks

Only recharge due to precipitation was included in the model as explained in 5.5. The list of 10 boreholes that were used in the model as observation boreholes are provided in Table 23.

Table 23 : List of the observations boreholes used in the steady state calibration

Borehole	Main Aquifer intersected
T4S	1
T4D2	1
T6D	1
T8D	2
T7D	1
T7S	1
Gw Obs BH3	1
Gw Obs BH4	1
Gw Obs BH2	1
Gw Obs BH1	1

12 hours CDT data (03 abstraction and 03 observation holes) have been used for transient state calibration (Refer to CDT in 4.5.5.)

6.4 General assumptions and model limitations

A numerical model solves both complex and simple problems, and serves as basis for the simulation of various scenarios. However, it should be reiterated that, a numerical groundwater model is a simplified representation (approximation) of the real system, and the level of accuracy is sensitive to the quality of the data that is available. The available data constituted of information as described from section 3 to section 5.

Errors due to uncertainty in the data and the capability of numerical methods to describe natural physical processes are always associated with groundwater numerical models. The building of a numerical model requires some assumptions to make an easier representation of the real aquifer systems. Such assumptions involve mainly:

- Geological and hydrogeological features;
- Boundary conditions of the study area (based on the geology and hydrogeology);
- Initial water levels of the study area;
- The processes governing groundwater flow; and
- The selection of the most appropriate numerical code.

Based on the available field data, the following assumptions have been made behind the conceptual model develop in section 5:

- The top of the aquifer is represented by the generated groundwater heads;
- Averages of the distribution of the determined parameters have been used as input of the model, and a homogenous and continuous aquifer system has been assumed;
- Where specific aquifer parameters have not been determined for some reason, text book values have been used where applicable, with reasonable estimates of similar geohydrological environments;
- The system is initially in equilibrium and therefore in steady state, even though natural conditions have been disturbed.
- The boundary conditions assigned to the model are considered correct.
- The impacts of other activities (agriculture, etc...) have not been taken into account.

The complexities associated with flow and transport in aquifer systems have not been taken into account. Any interpretation and decision from the model results should be based on these assumptions.

6.5 Flow model calibration

6.5.1 Steady state flow models calibration and numerical model sensitivity

In the present case, the "Preconditioned Conjugated-Gradient 2" (PCG2) solving package has been used. Boundary conditions, and hydrological parameters (recharge and conductivity/transmissivity), were selected by a combination of trial and error and inverse modelling, to generate the result that most strongly matches field measurements of hydraulics heads. Observations boreholes (Table 23) have been chosen to verify the conditions in the boundary of proposed Rietvlei Mine and surrounding. Considering varying transmissivity, the set of hydraulics parameters required for acceptable correlations between observed and calculated heads, are presented Table 24.

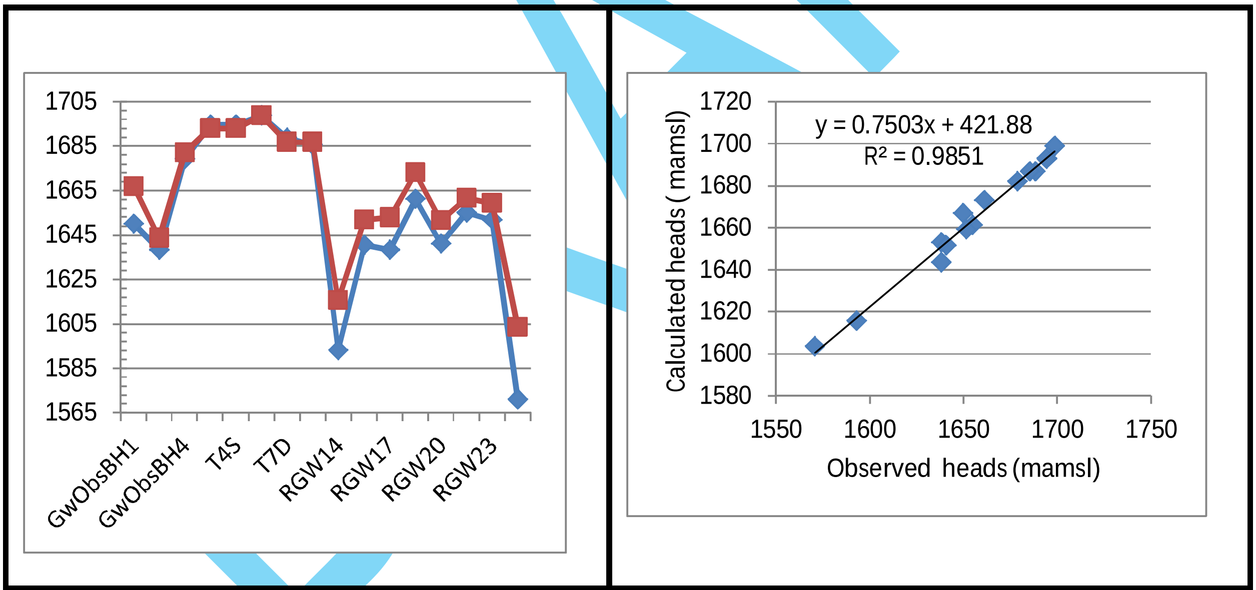

Figure 37: Steady state calibration results

Table 24: Steady state model Calibrations results (input parameters)

Transmissivity	Recharge
m^2/day	mm/year
5	15

6.5.2 Transient state flow model calibration

The transient state flow calibration is highly recommended in groundwater numerical modelling for the following reasons:

- Groundwater flow is dependent on natural processes (geology, climate, ect…) and man-made changes, which may cause changes with time;
- Predictions are time related;
- The storage properties can only be assessed in transient state.

Ideally, transient state flow calibration should involve:

- Monthly hydraulic heads;
- Average monthly groundwater withdrawal;
- Average monthly evapotranspiration in case of shallow water levels (like in riparian zone)
- Monthly precipitation;
- Average monthly river stage;

None of such data were available, and the CDT data were used for transient state model calibration. Specific storage and specific yield have been changed (Table 25) until the measured drawdown in the both abstraction and observation holes, matched with the calculated one (Figure 38, Figure 39, and Figure 40).

Table 25: Transient state model calibrations results (Storativity)

GWOBSBHBH1	GWOBSBHBH4	T6D
$1.5*10^{-3}$	$1.8*10^{-3}$	$3.1*10^{-4}$

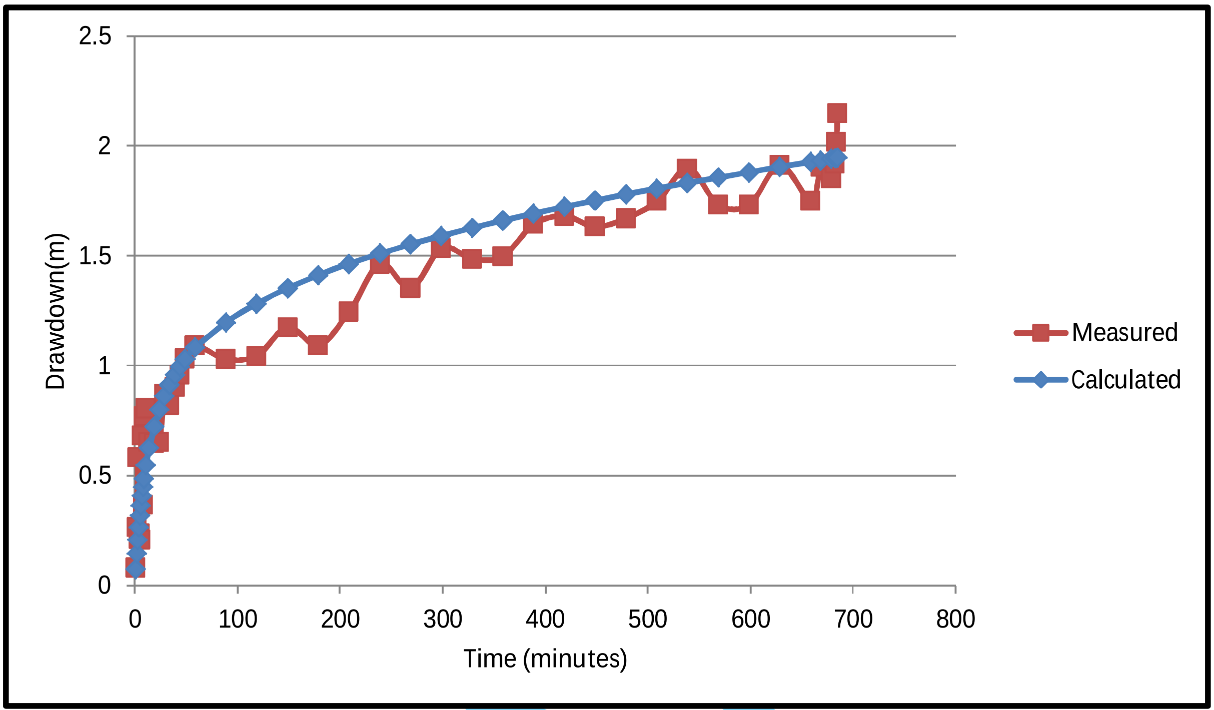

Figure 38 : Transient calibration results (GWOBSBHBH1)

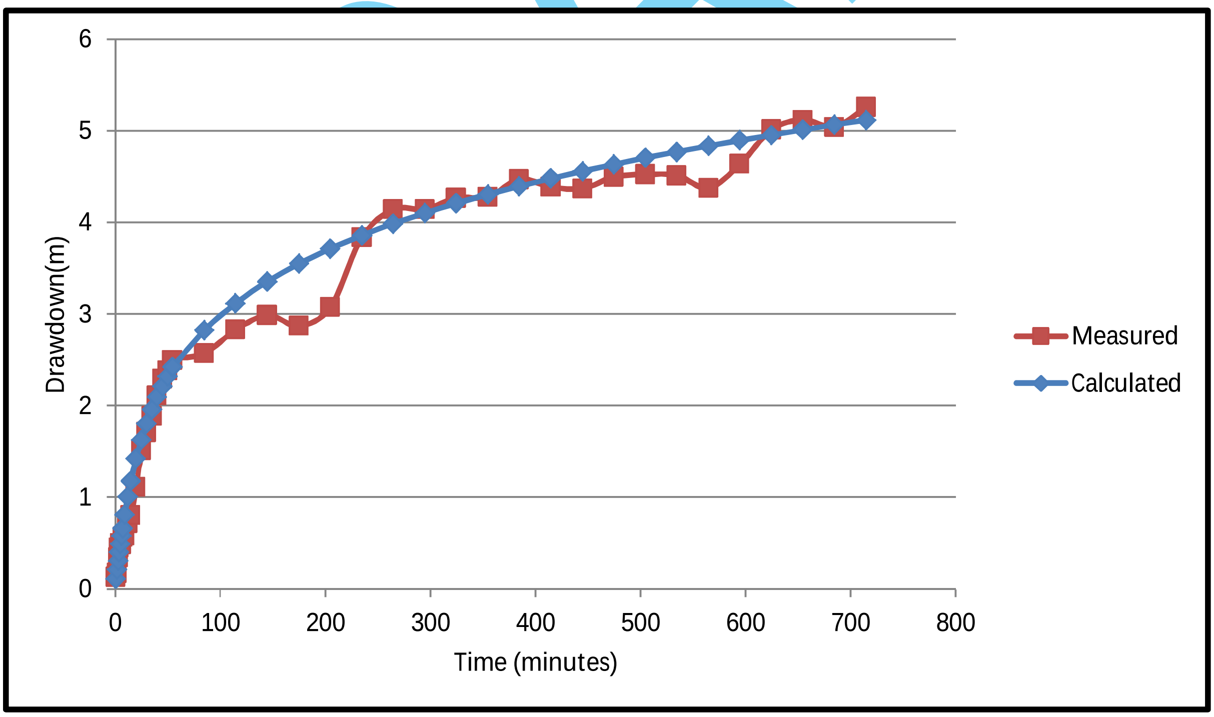

Figure 39: Transient calibration results (GWOBSBHBH4)

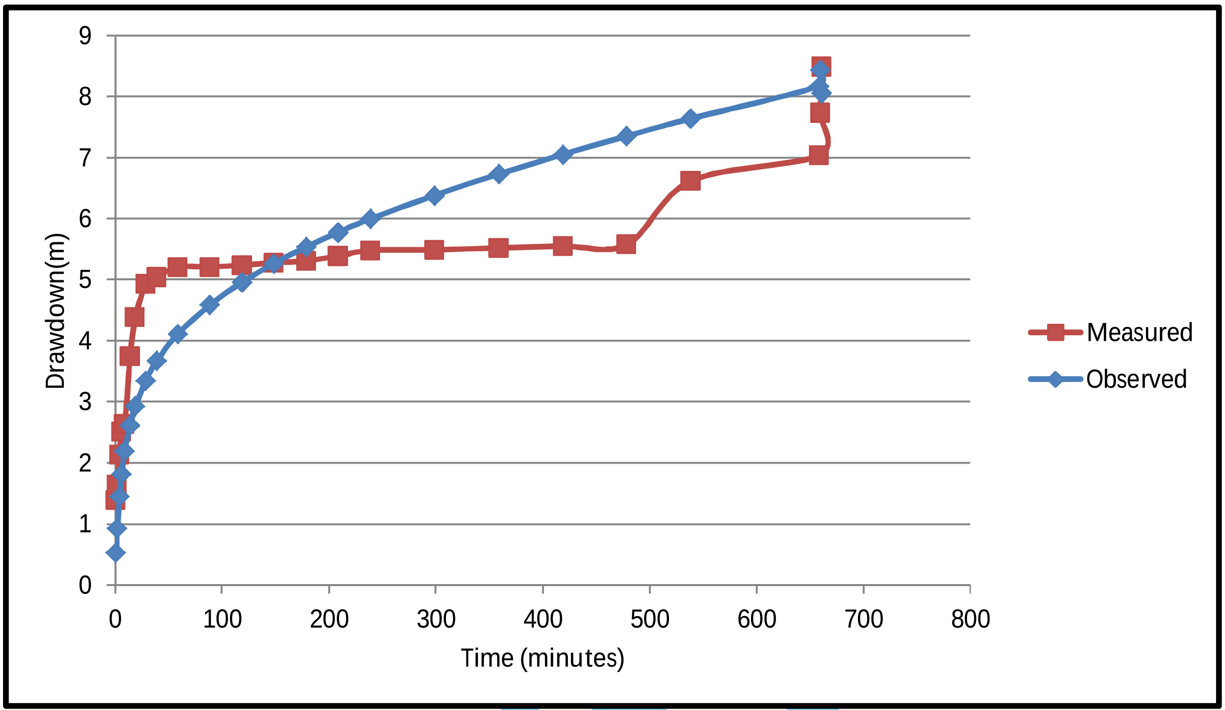

Figure 40: Transient calibration results (T6D)

6.6 Numerical mass transport model

Mass transport modelling consists of the simulation of water contamination or pollution due to deteriorating water quality in response to man's disturbance of the natural system. The most important processes that involved in the transport through a medium are Advection, and the Hydrodynamic dispersion (Mechanical dispersion and Molecular diffusion). Other phenomena (sorption, adsorption, deposition, ion exchange, etc...) may affect the concentrations distribution of a contaminant as it moves through a medium. The effective porosity is required to calculate the average linear velocity of groundwater flow, which in turn is needed to track water particles and to calculate contaminant concentrations in the groundwater.

The MT3DS software was used to provide numerical solutions for the concentration values in the aquifer in time and space. Flow model input parameters (Boundaries conditions, hydraulic conductivity, Recharge, Specific Storage, and Specific Yield) values that serve in flow calibrations were specified for the aquifer. Among the biggest uncertain parameters used during transport modelling of pollutants are the kinematic porosity of the aquifer and the longitudinal dispersivity. Bear and Verruijt (1992) estimated the average transversal dispersivity to be 10 to 20 times smaller than the average longitudinal dispersivity. The transport model input parameters are summarized in

Table 26.

Table 26 Summary on the input for transport simulation

Effective Porosity	Longitudinal Dispersivity	Transversal Dispersivity
--	(m)	(m)
0.06	50	5

6.7 Model Predictive scenarios

Two scenarios of groundwater modelling are necessary for the impact assessment of the extended mine plan:

- Changes (drainage, quality) in the groundwater system due to active mining opencast areas;
- Changes (drainage, quality) in the groundwater system due to backfill and rehabilitation of the opencast pits at closure.

6.7.1 Active mining impact scenarios

6.7.1.1 Scenario 1: Mine dewatering

In the first scenario the opencast pit is dewatered. The cone of depression extends up to 3km away from site when pit floor will reach lower seem bottom (50mgl). The expected inflow is in the vicinity of $300m^3/d$. Please note no concurrent rehabilitation has been included in this scenario and therefore it can be seen as the 'worst-case' scenario. The wetlands are groundwater dependent and will be affected by the dewatering cone, but the current model did not account for such effect. The simulated cone of depressions for different project periods, are shown from Figure 41 to Figure 43. The effect of dewatering on selected boreholes surrounding proposed Rietvlei Mine, are illustrated in Figure 44 and Figure 45 shows the simulated groundwater elevations and drainage at 20 years of operation. All identified boreholes on site would be impacted together with few offsite boreholes (RGW10, RGW23, RGW22, RGW1, and RGW2).

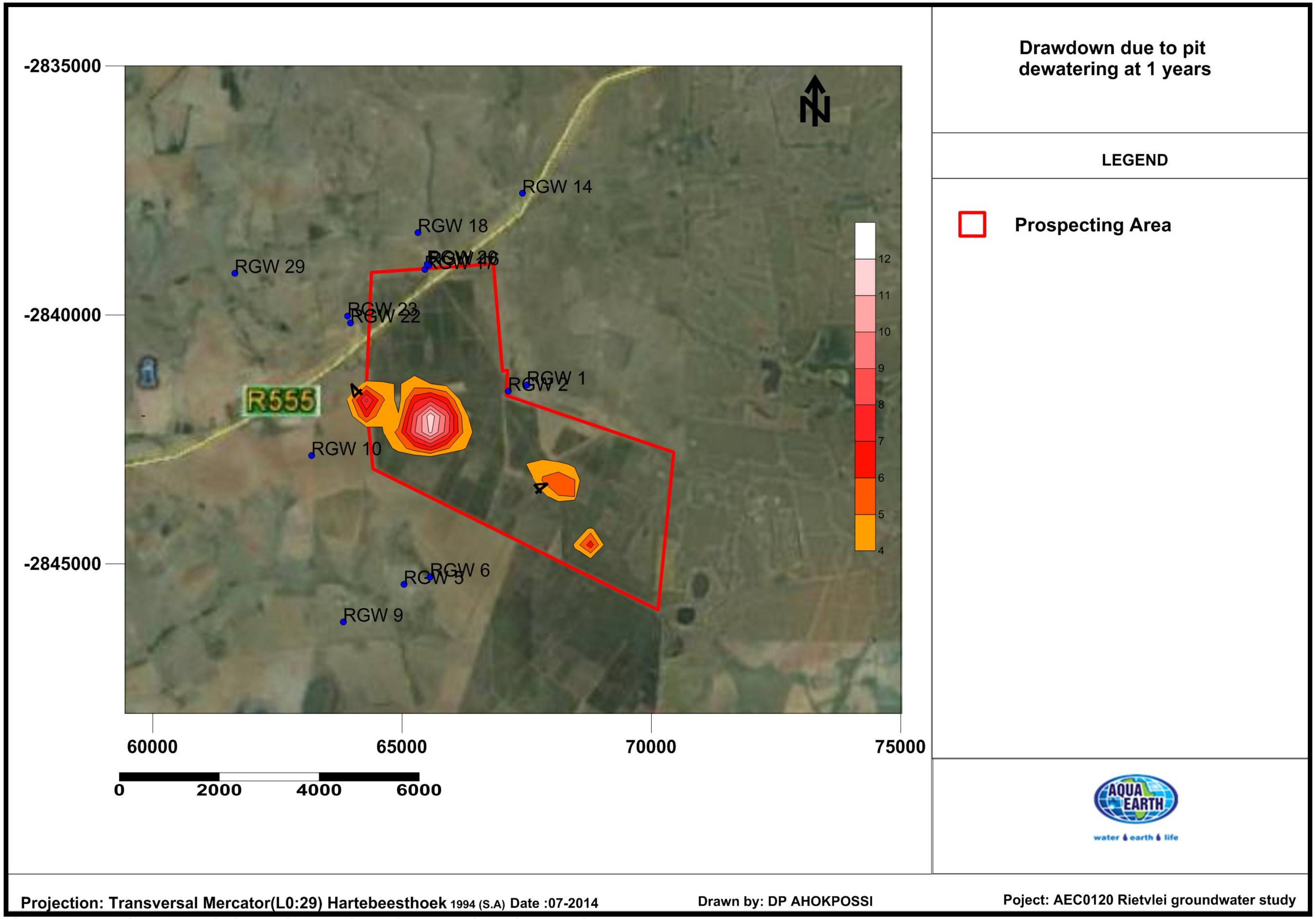

Figure 41: Simulated drawdown due dewatering (1 year)

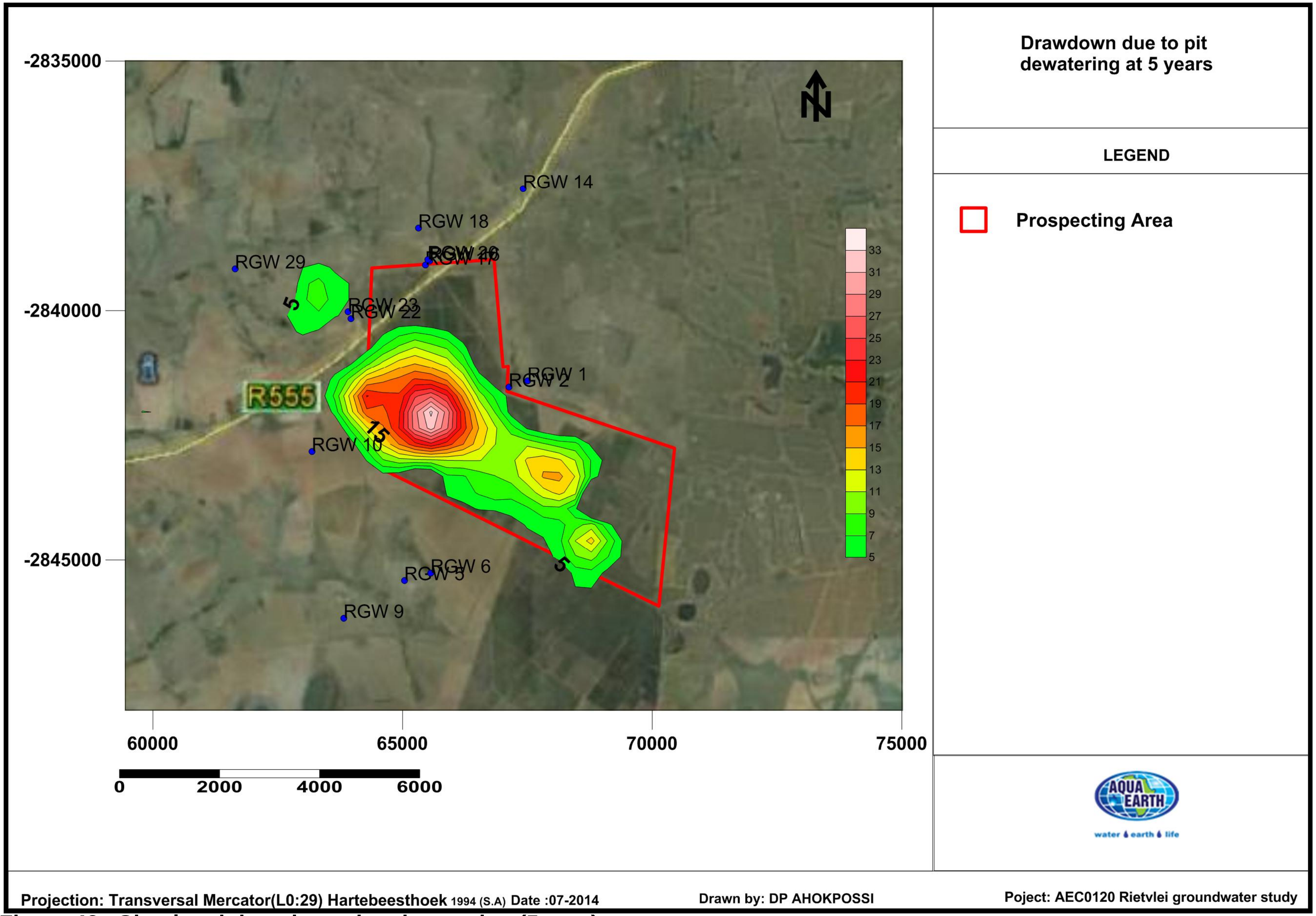

Figure 42 : Simulated drawdown due dewatering (5 year)

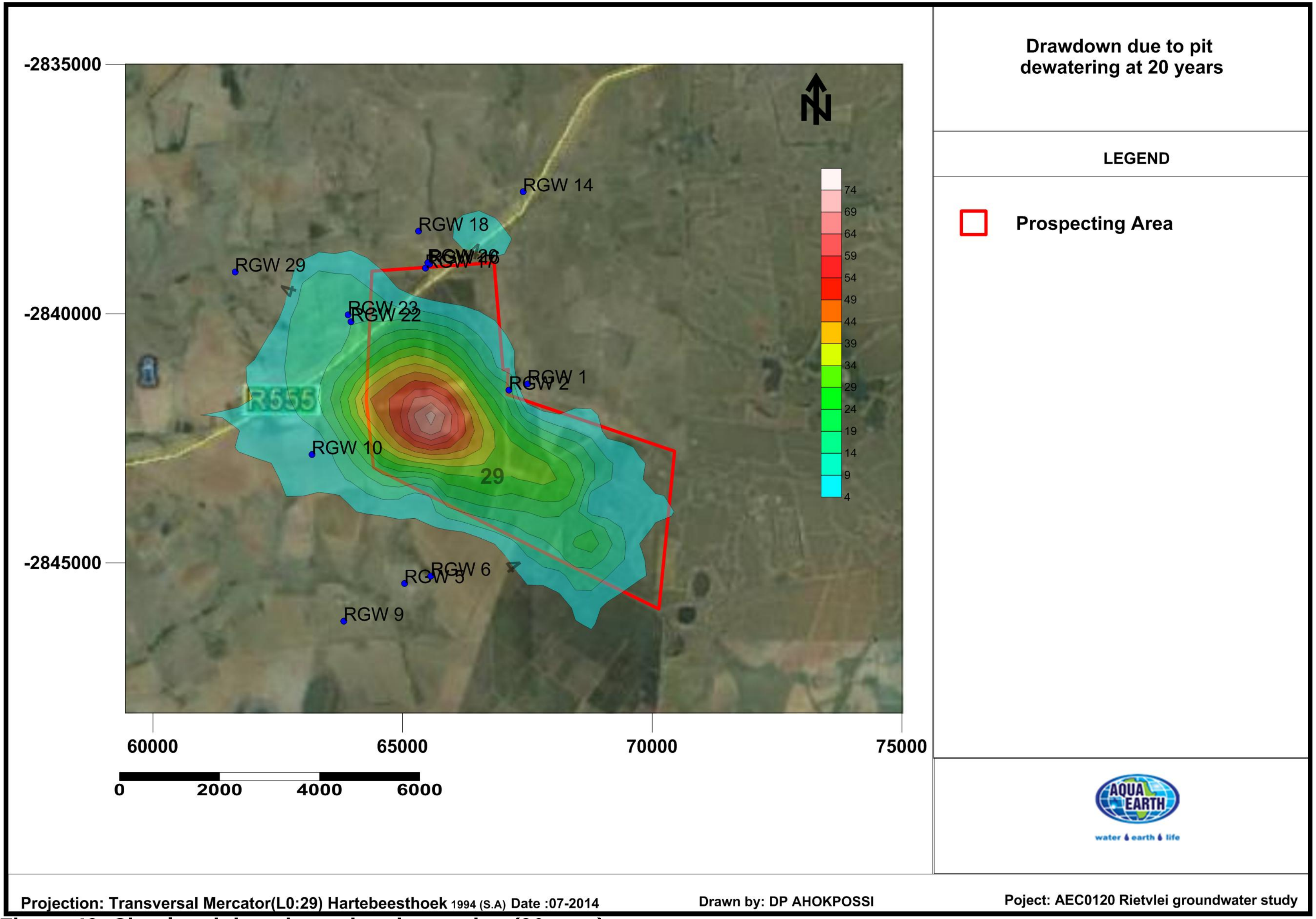

Figure 43: Simulated drawdown due dewatering (20 year)

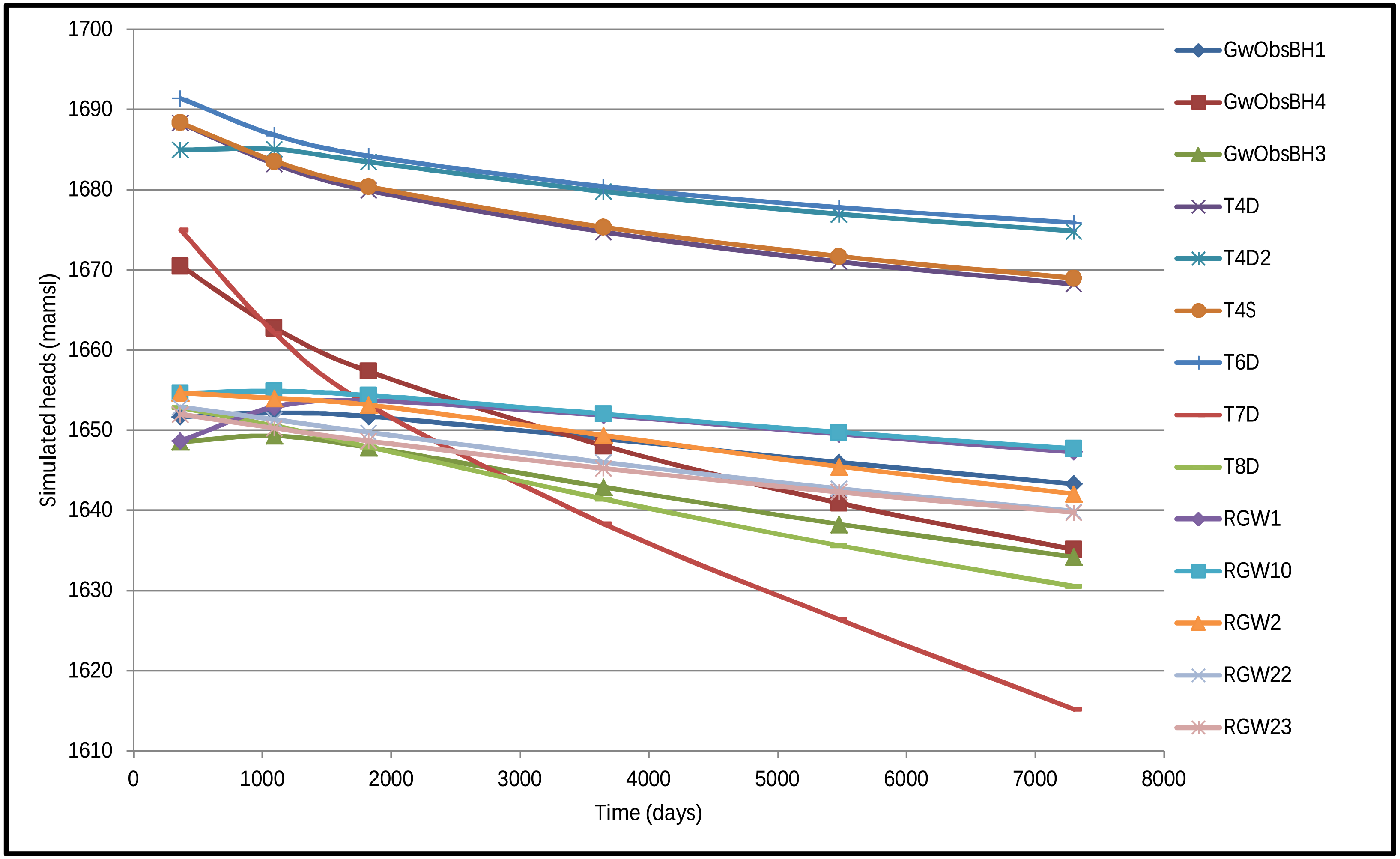

Figure 44: Simulated drawdown over time

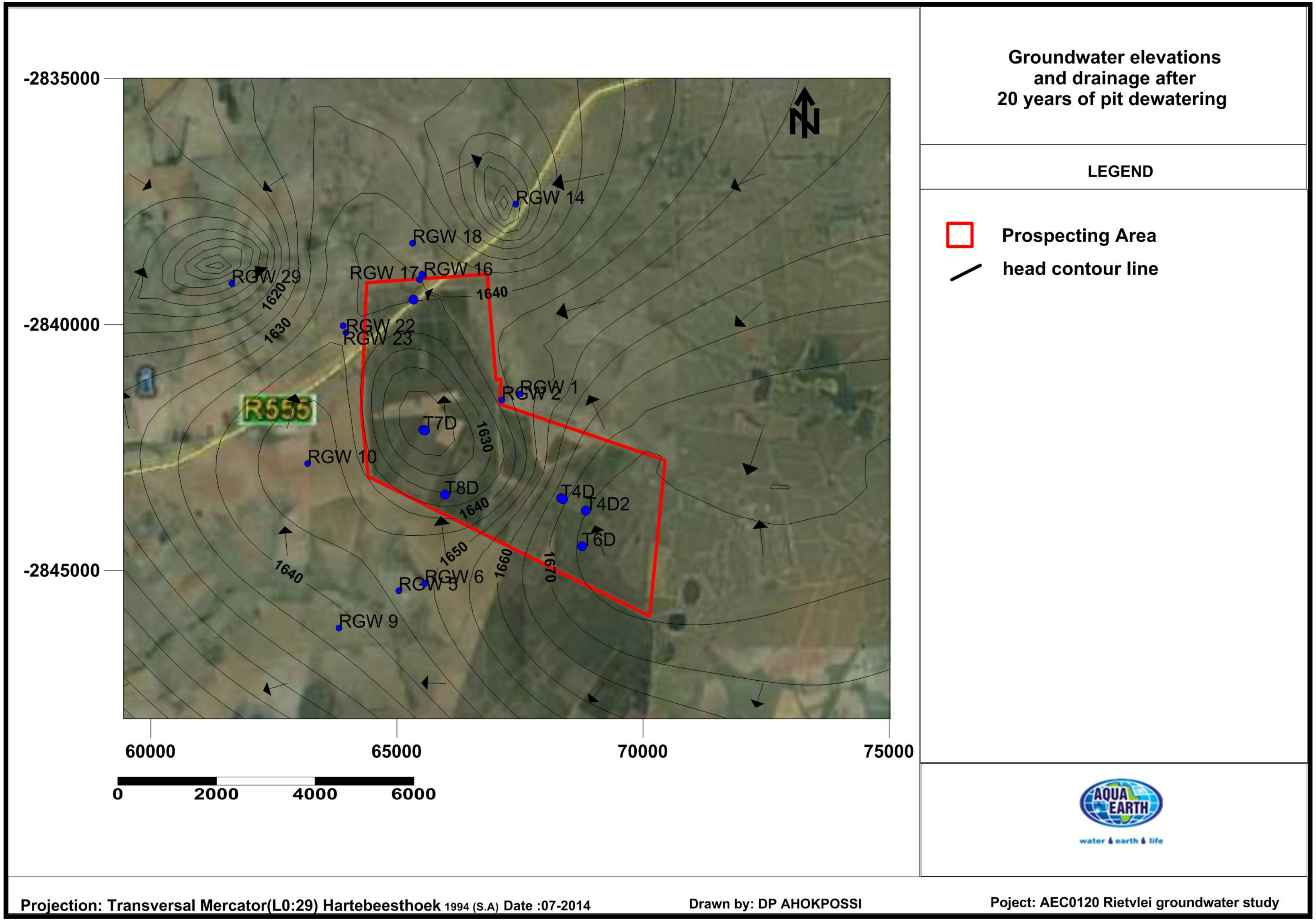

Figure 45: Simulated groundwater elevations drainage after 20 years of pit dewatering

6.7.1.2 Scenario 2: Pollution plume

Groundwater flow during active mining will be towards the open pit. Any pollution plumes emanating from mining activities (dumps, processing plant, water and tailing dams, drains, etc...) will move towards the open pit. The open pit area will be kept dry for mine safety and polluted water seeping through the backfill should be pumped to dirty water dams. Pollution during active mining is expected to be restricted to the mine property. Neighbouring boreholes will not be affected during active mining.

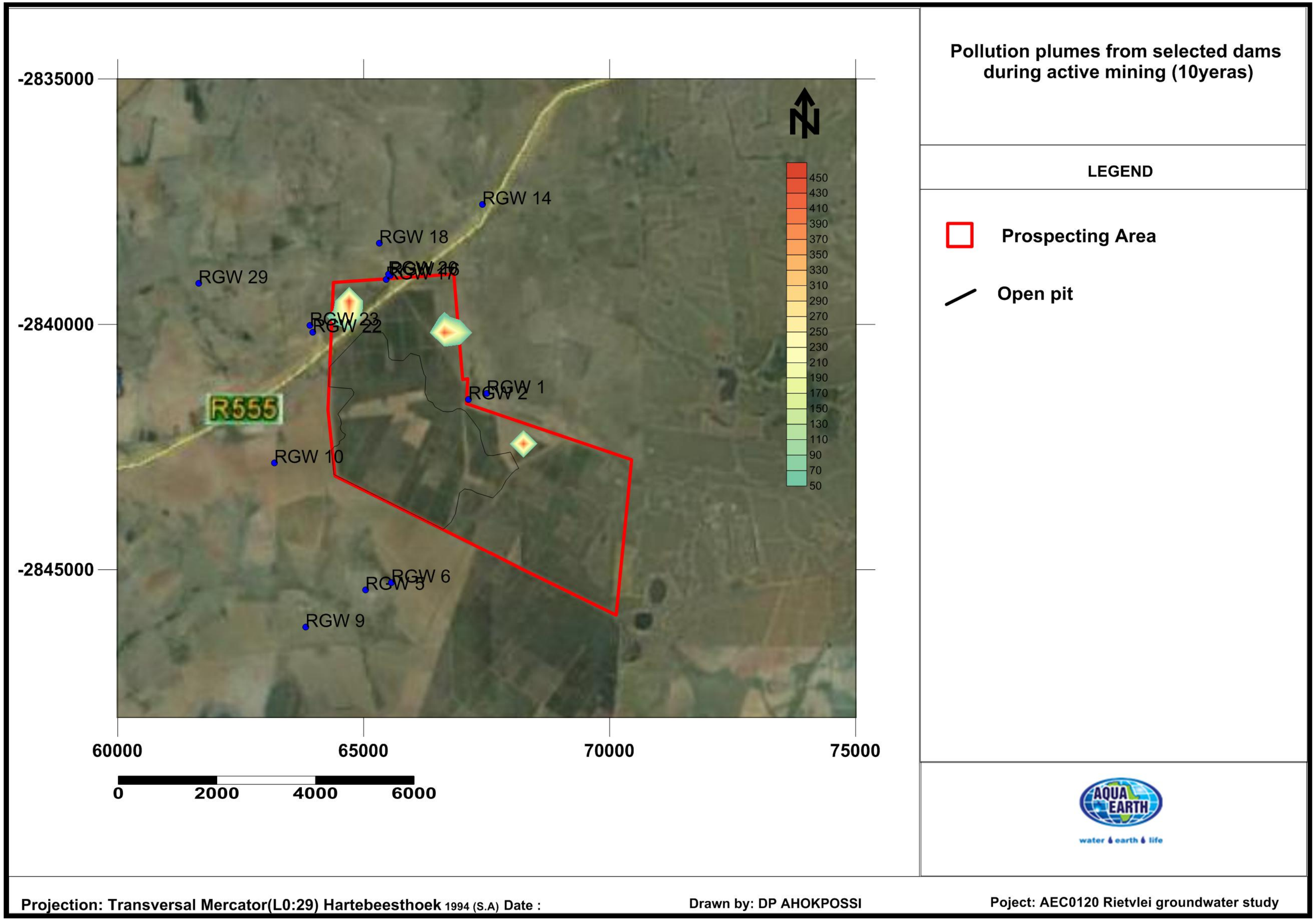

Figure 46: Simulated pollution plumes from selected dams during active mining (10years)

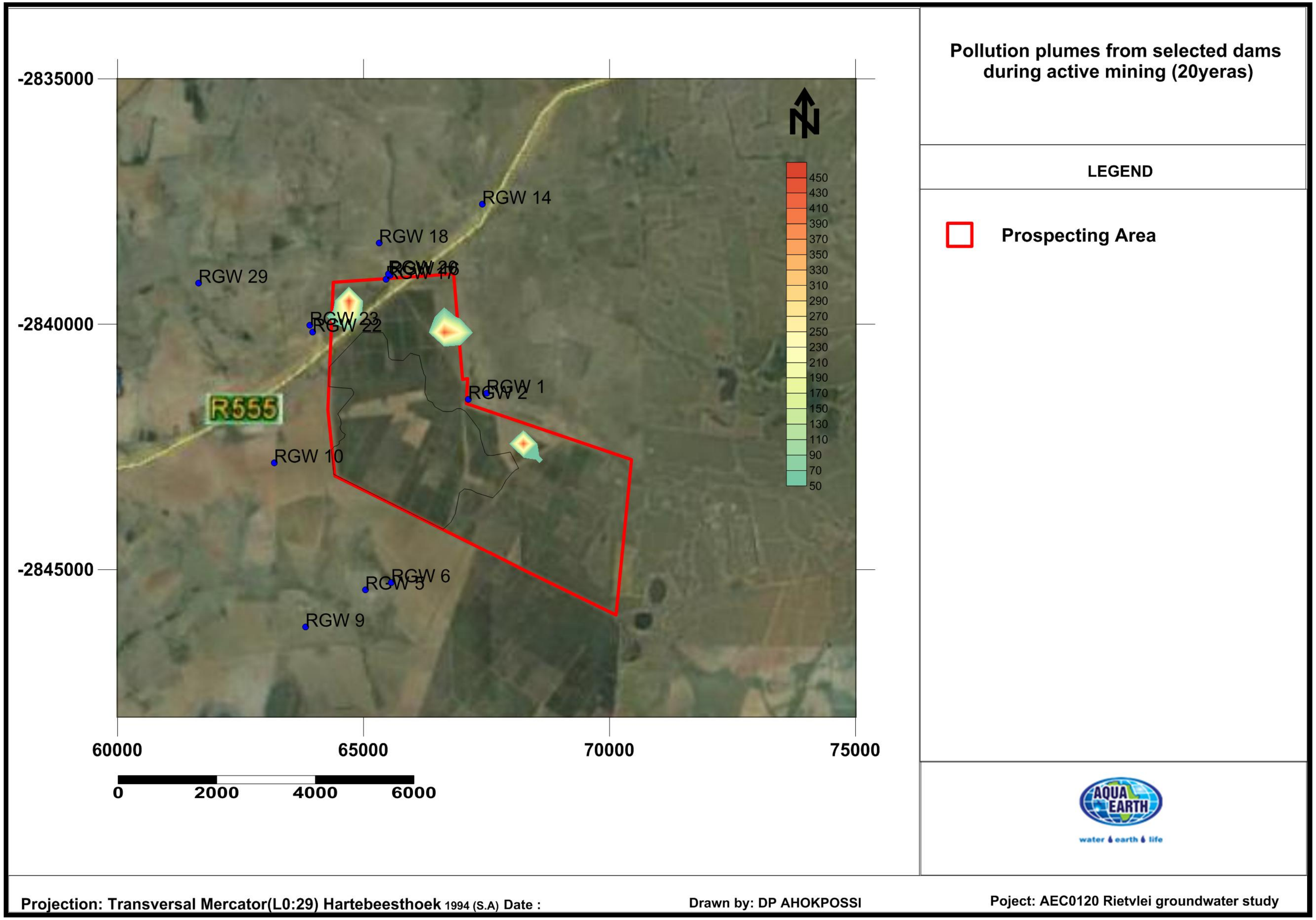

Figure 47: Simulated pollution plumes from selected dams during active mining (20years)

6.7.2 Closure and post closure impact scenario

6.7.2.1 Scenario 3: Backfilled pit flooding

Dewatering would be stopped when mining will reach its full capacity, and open pit flooding will occur, as recovering of groundwater levels. Groundwater flow directions will return to pre-mining conditions.

The flooding of the mine is dependent on a number of factors including preferential flow zones such as geological lineaments. Not all preferential influx zones are known at this point, so the volumes might increase, as more information becomes available.

It will take 40 years (Figure 48) for the pit to flood, thereafter decanting will commence. The position of the expected decant point is shown in Figure 49. The decant volume is estimated at 1420 m^3/d, where as it was estimated (1200 m^3/d) from the initial numerical model.

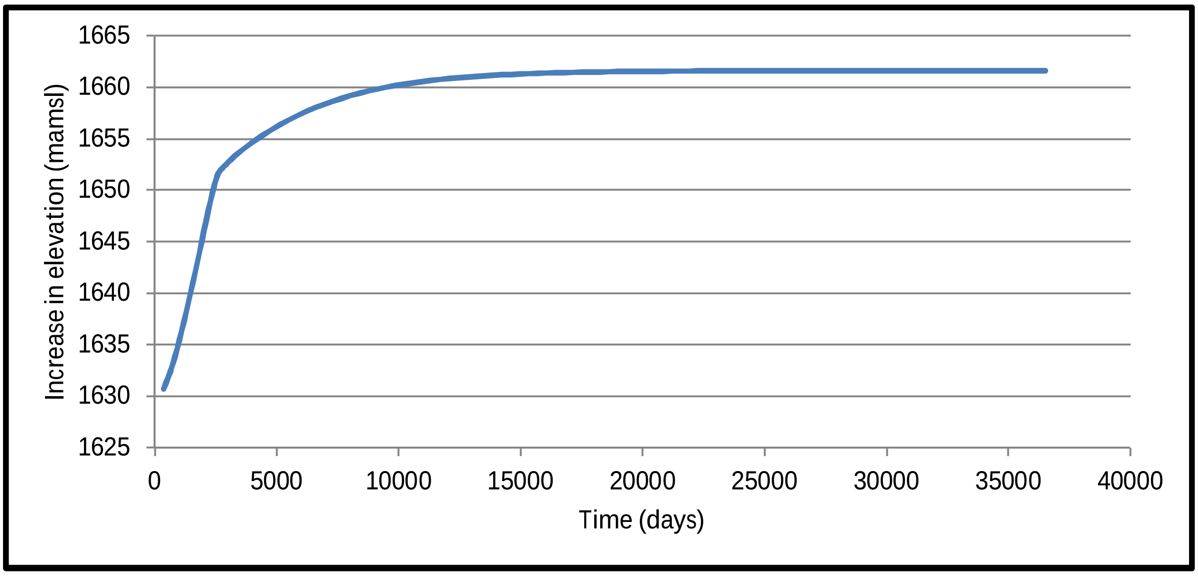

Figure 48: Backfilled pit flooding

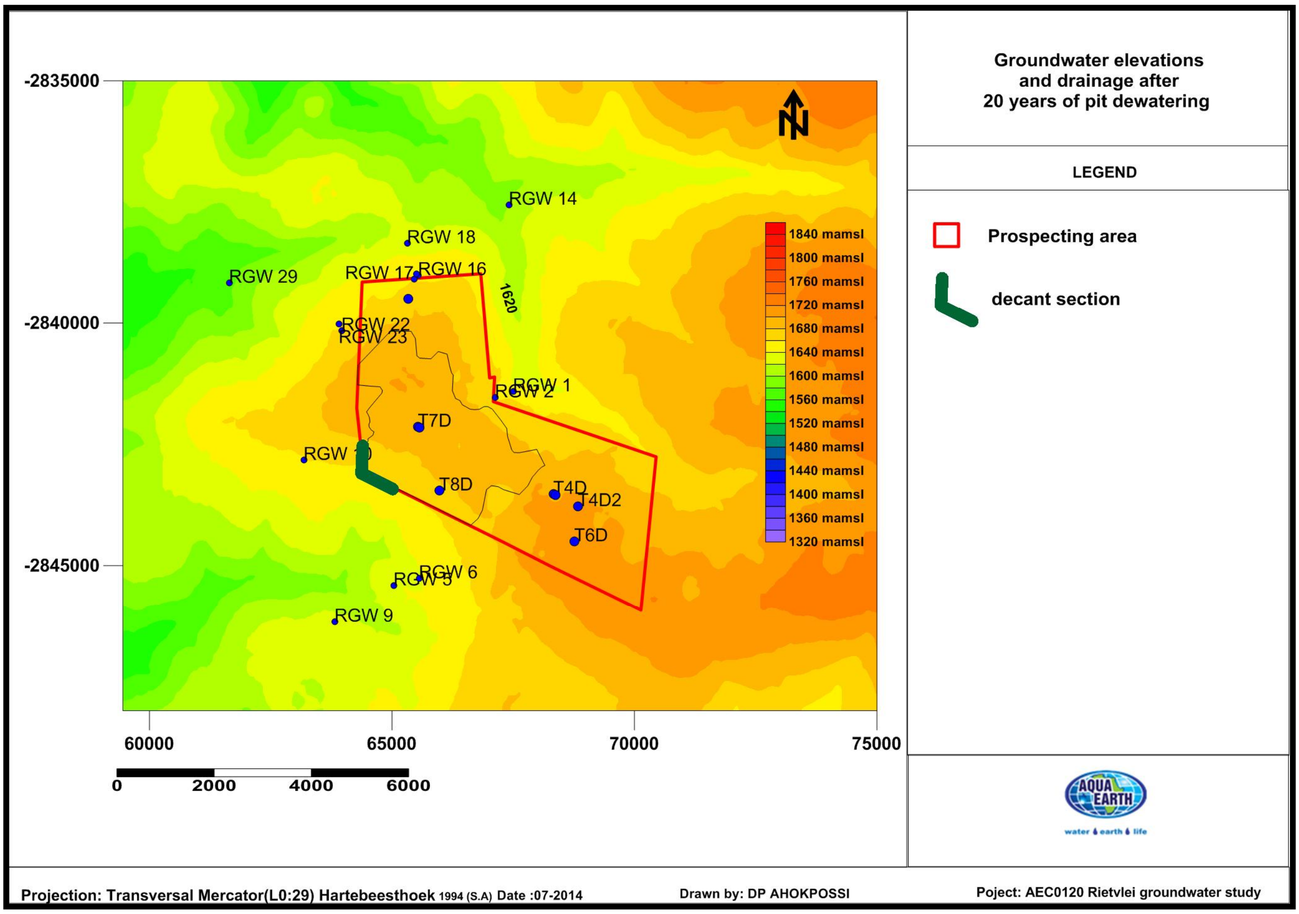

Figure 49 Decant zone shown in purple

6.7.2.1 Scenario 4: Pollution plume (post-closure)

At this point in time it is calculated that it is likely for the mine to decant.

It is expected that poorer quality groundwater will be present in the backfilled pit when total flooding is completed, as result of chemical reaction between backfill material and oxygenated water. The polluted waters in the opencast pit will start to move into the groundwater system if no water management measures are implemented. The pollution plume at 10 and 20 years after flooding is shown respectively in Figure 50.and Figure 51. The boreholes affected by pollution include: RGW4 and RGW11. Slight impacts could be seen in RGW2 and RGW22.

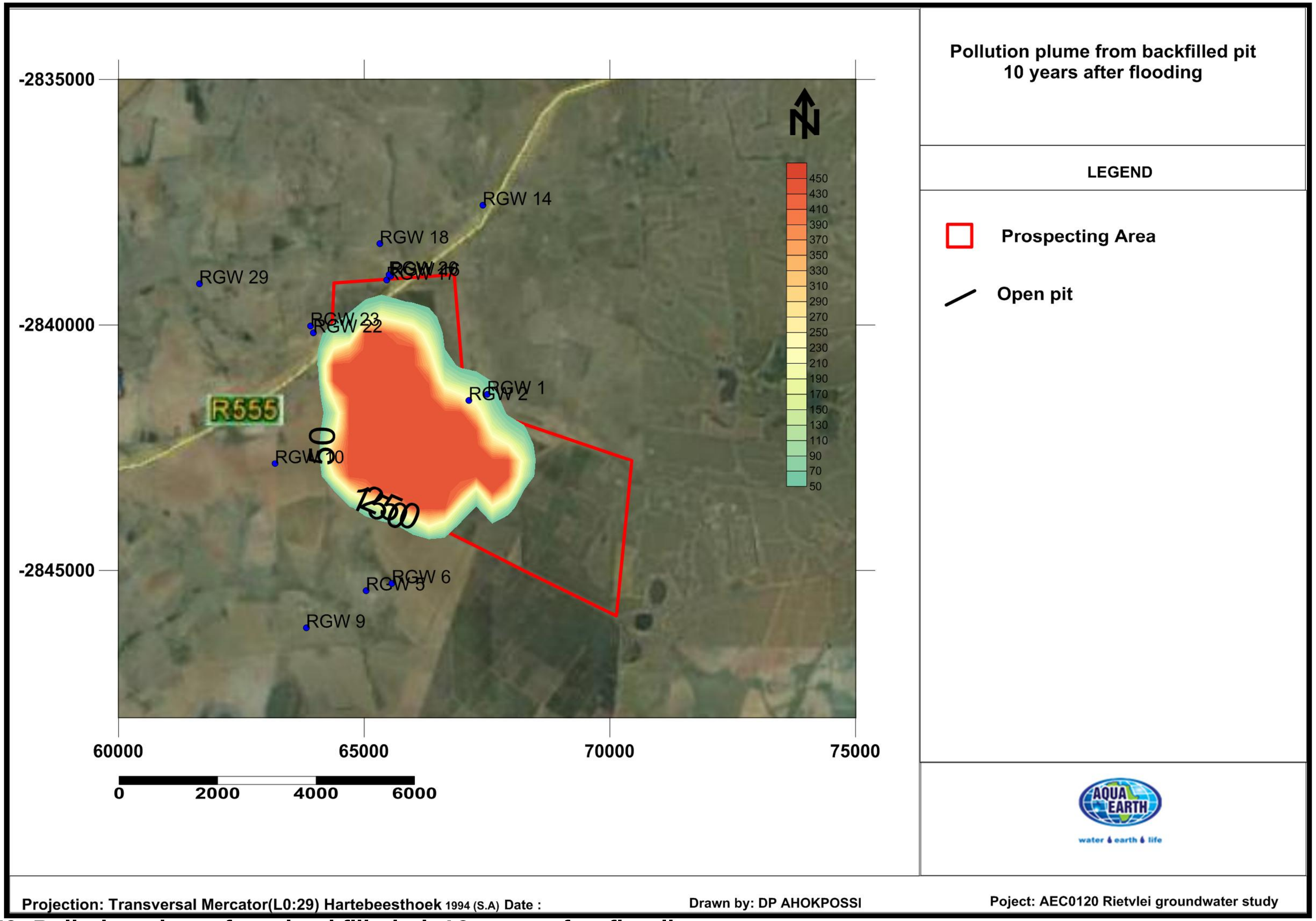

Figure 50: Pollution plume from backfilled pit 10 years after flooding

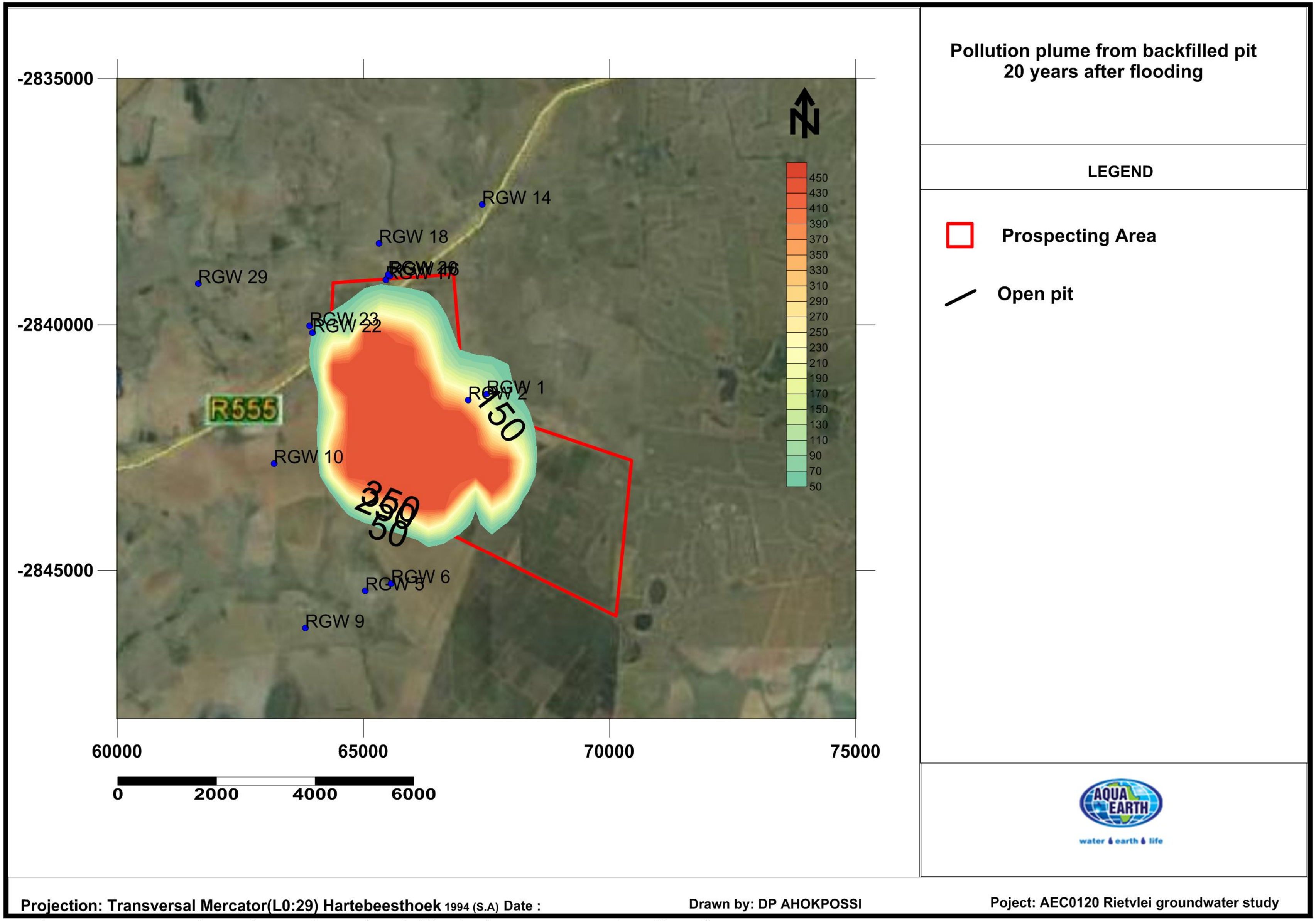

Figure 51: Pollution plume from backfilled pit 10 years after flooding

7 Legislative requirements

7.1 Environmental Impact assessment (EIA) and licensing

Key environmental legislation pertinent to the development of the proposed Rietvlei Mine development includes:

- Constitution of the Republic of South Africa (No 108 of 1996);
- National Environmental Management Waste Act (Act 59 of 2008) – NEM:WA
- National Environmental Management Act (No 107 of 1998) - NEMA and the National Environmental Management Amended Act (No 46 of 2003);
- National Water Act (No 36 of 1998) – NWA; and

Specific provisions of such legislation in relation to Rietvlei Mine development are illustrated in Table 27.

Table 27 : Legislation and specific provisions

Relevant Legislation	Specific provisions
Constitution of the Republic of South Africa (No 108 of 1996)	Section 24 stipulate: • prevent pollution and ecological degradation • promote conservation • secure ecologically sustainable development, and use of natural resources while promoting justifiable economic and social development
NEM: Waste Act (Act 59of 2008)	• the requirements for the environmentally sound management of waste • incorporates a requirements for licensing and control of waste management activities • puts in place a hierarchical approach for waste avoidance • Norms and Standards for the assessment of waste for landfill disposal (R635) • Norms and Standards for the disposal of waste to landfill site
National Environment al Management Act (No 107 of 1998) - NEMA and the National	Principle for decision-making on : • sustainable development • integrated environmental management

Environment al Management Amended Act (No 46 of 2003).	• polluter pays principle • cradle to grave responsibility • precautionary principle • Involvement of stakeholders in decision making.
National Water Act (No 36 of 1998) –NWA.	Chapter 4- Section 21 to 55 describes water uses that need to be licensed: • Water abstraction • Water storage • Alteration of flow in a watercourse • Disposal of waste water from industrial processes • Removing and/or discharging of underground water • Controlled activities (irrigation with waste water and intentional recharging of aquifers with waste)

The current Regulations applicable to the EIA for proposed Rietvlei Mine development include: R543, R544 and R545 that were promulgated in terms of Section24 (5) of the NEMA Act No. 107 of 1998.

The overburden waste will be dispose on site. Leachate test results of such waste, show for elements analysed for, concentrations that fall under Leachate Concentration Treshold “0”, based on NEMWA Norms and Standards (GN 36784-635-636) as effected in August 2013. Such waste is then classifies as type 4 according to the same legislation and would require Class D contaminant barrier type.

At the time of present report, no leachate test has been conducted yet on tailings that would be generated from coal processing, but it anticipated from others experiences, that the tailings may require Class A contaminant barrier type.

8 Impacts on groundwater

The environmental impact assessment has been undertaken using impact assessment methodology provided in Appendix I.

The overall objective of this assessment is to provide recommendations on how to prevent or minimise impacts arising from the proposed Rietvlei Mine development. The specific actions needed to meet this objective for each project phase are set out. The potential impacts are discussed in light of the following:

- potential groundwater impact : the effect on the groundwater with respect to who or what will be impacted and how this impact will be felt;
- natural and existing mitigation conditions : natural conditions, conditions inherent in project design and proposed management measures that modify impacts (control, moderate, enhance);
- significance of impact : the significance of the unmanaged and managed impacts taking into consideration the probability of the impact occurring, the extent over which the impact will be experienced, and the intensity/severity of the impacts (requires consideration of unknown risks, reversibility, violation of laws, precedents for future action and cumulative effects).

8.1 Potential project impacts

The potential impacts on groundwater are associated with activities during the construction phase, operation phase, and the closure and post-closure phases of the coal mining project.

8.1.1 Construction phase

The clearing of topsoil for footprint areas associated with the waste site construction can increase infiltration rates of water to the groundwater system and decrease buffering capacity of soils to absorb contaminants from possible spills on surface. Groundwater recharge from surface may increase, especially in the potential recharge area.

During construction phase, it would be necessary to construct the berms to prevent storm water runoff to enter working area within the prospecting area. The cut and fill activities associated with the construction of infrastructures (waste site, water control infrastructures) may intercept shallow groundwater as static levels are found shallow as 1.7mbgl. In cases where the construction will intercept groundwater, lowering of the groundwater level by dewatering may be needed during construction. This will cause localise cones of groundwater depressions around the waste site area.

Contamination of groundwater can occur as a result of groundwater seeps standing in the footprint area. The construction activities are likely to be associated with accidental spills of hydrocarbons (oils, diesel etc) from the construction vehicles, and other potentially hazardous chemicals during the construction phase. Such spills together with the construction waste can infiltrate and cause contamination of the groundwater system if not properly handled.

The design of the waste disposal sites (rock dumps, tailings) will take into account the specification stipulated in GN 36784. Thus construction will result in:

- the reduction of the recharge potential at proposed site,
- and the disturbance of Sub-catchment storm water runoff.

The following impacts have been considered and quantified during the construction phase:

- Decreasing of the soils buffering capacity and increasing of infiltration rates;
- Deterioration of water quality due to construction waste (Chemical in construction material);
- Deterioration of groundwater quality due to hydrocarbon spills from storage (organic contaminants);
- Altered flow systems due to probable dewatering (if required),
- Groundwater contamination due to groundwater seeps standing in the construction's footprint area.

Without any mitigation measures the impacts significance from construction of the proposed Rietvlei Mine are rated from very low to low (Table 28).

8.1.2 Operational phase

Opencast mining of coal will result in groundwater inflows into the pits, which needs to be pumped out for mine safety. The dewatering of the groundwater system in the immediate vicinity of the pits will become more important and results in wider cone of depression as depth to pit floor will increase. According to the importance of cone of depression surrounding users' boreholes can be impacted.

Exposure of geological strata to rainfall in the opencast areas will result in deterioration in quality of groundwater flowing into the opencast areas. Groundwater will initially be of good quality but will with time deteriorate, due to oxidation of pyrite and/or other chemical processes that can occur as a result of mining activities. This can take place for years, until the neutralizing potential is depleted. Such dirty water in opencast pit, together with groundwater ingress, if not properly handle may infiltrate and contaminate deeper aquifer system. Others mine activities that may impact on groundwater quality are:

- Overburden dumping: the exposure of rock dumps, to water and oxygen, may result in dirty water that may contaminate groundwater systems, if not properly managed.
- Stockpiling and transport: the exposure of stockpiling and transporting of coal, to water and oxygen, together with hydrocarbon spills from storage (organic contaminants) may also result in contamination of the groundwater systems.
- Coal processing: coal will be exposed at the washing plant area to water and oxygen, resulting in dirty water, and spills/slurry from the site can contaminate groundwater.
- Tailing disposal: residual from coal processing will be disposed of onsite as tailings dam. Tailings constitute a potential source of groundwater contamination.

Dirty water from any of these activities should be drained, or pumped (where required) to pollution control dams. Pollution control dams, and contaminated water drains constitute potential sources of groundwater contamination as result of infiltration trough improper barrier system (absent, or leaking). Unlined dams will contribute highly to contamination of the groundwater system, while lined dams might still contaminate but to a lesser degree.

Handling and transport of waste material have some potential of contaminating groundwater, including domestic waste, sewage water, hydrocarbons (storage).

The following impacts have been considered and quantified during the operation phase:

- Deterioration of groundwater quality due to rock dumps;
- Deterioration of groundwater quality due to open pit mining;
- Deterioration of groundwater quality due to coal processing;
- Deterioration of groundwater quality due to tailings disposal;
- Deterioration of groundwater quality due to leaks/spillages from dirty water quality dams and drain;
- Deterioration of groundwater quality due to handling and transport of waste material.

Without any mitigation measures the impacts significance from operation of the proposed Rietvlei Mine are rated from Low Medium to High (Table 29). The High impacts significance, are associated with the potential impacts of groundwater dewatering (Figure 43) and deterioration of groundwater quality due to tailing dams.

8.1.3 Closure phase

The closing of mining activities and rehabilitation will be concurrently undertaken. Compaction equipment will include driving vehicle. All disused infrastructure will be demolished, and waste from demolition has to be removed from site and disposed at designated site.

Contaminants from the mine (including backfilled opencast pits and return water dams) can seep through the unsaturated zone into the groundwater system. Lateral groundwater movement will allow the spread of the contamination within the groundwater system. If this groundwater feeds surface water bodies such as wetlands and streams, these can also be polluted. However dilution will take place therefore the impacts thereof are considered to be moderate.

Activities such as covering of the spillages with sand and collection and possibly treatment etc are likely to be associated with accidental spills of hydrocarbons (oils, diesel etc).

Dewatering would be stopped at that stage, and open pit flooding will occur, as recovering of groundwater levels. At this point in time it is calculated that it is likely for the mine to decant. It is expected that poorer quality groundwater will be present on the mine horizon when total flooding is completed.

Water management activities associated with closure activities will be conducted as appropriate. Generally decommissioning/closure phase is too short to see significant impacts on the groundwater, but in the present context where closure would be progressive, significant reduction of impacts could occur. The risk of such impacts will be reduced over time. With strong management options, the risk is expected to reduce even further. Decommissioning/closure is only complete once the proponent demonstrates no significant impacts

The following impacts have been considered and quantified during the closure phase:

- Flooding and decanting of open pit;
- Deterioration of groundwater quality due to waste, and spills related to closure activities;

Without any mitigation measures the impacts significance from closure of the proposed Rietvlei Mine are rated from Very Low to High (Table 30). The High impact is mainly associated with the potential impacts of flooding and decanting of the backfilled pit.

8.1.4 Post-Closure phase

At post closure phase, the main potential groundwater impacts to be considered and quantify is:

- Flooding and decanting of open pit;

Without any mitigation measures the impacts significance from closure of the proposed Rietvlei Mine are rated as Very High (Table 31).

8.2 Cumulative impacts

No significant pollution source has been identified on site or surrounding, that may cumulatively with the project, impacts on background water quality. However the background high concentration of NO_3-N noticed from two sampling points may be associated with surrounding agricultural activities (fertilizer, pumping). Slight cone of depressions are already developing at local points surrounding proposed Rietvlei Mine.

The following impacts have been considered as cumulative impacts:

- Cumulating of impacts due mine dewatering with existing local cone of depressions;
- Cumulating of contaminants from mine activities with existing contaminants.

8.3 Mitigation measures

- The development of proposed Rietvlei Mine poses risks to groundwater as assessed. The proper design, construction and operation, and maintenance of the appropriate respective liner system below dirty water dams, tailing dams should be implemented as well as the rehabilitation of the open mine, are part of the key focus areas to mitigate groundwater impacts. The following precautions have to be taken into consideration to reduce possible groundwater risks posed by the development of proposed Rietvlei Mine:
- Groundwater management strategies must be implemented to prevent risk of water pollution;
- Groundwater monitoring network should be installed before the starting of any construction activities on site;

- The monitoring network can be updated according to the DWA minimum requirements, if required;
- Monitoring of groundwater must be done once per Quarter;
- Any waste and spills (specially during construction, operation and closure) need to be cleaned up immediately according to the DWA minimum requirements;
- Authorities need to be notified in the event of a spill or leachate during construction, operation and closure;
- Clean and dirty water is to be separated, and any containment of dirty water should be lined.
- Vehicle storage and maintenance areas to be hard-surfaced;
- Regular maintenance of vehicles must be implemented;
- Trucks need to be capped to minimise spillage of coal or wastes, on roads.
- Separate clean water from the stockpiling area to minimise water infiltrating from the site.
- The reusing dirty water from mine activities must be assessed and implemented as much as possible.
- All hazardous substances must be handle according to the requirements of relevant legislation relating to the transport, storage and use of the substance;
- The area to be used for storage of any hazardous waste and items which contains hazardous substance must be lined with bunded walls to prevent pollution of surface or groundwater should a leakage/spillage occur;
- Application for WULA amendment as per DWA requirements must be made for proposed new abstraction boreholes if any required;
- The migration of leachate into the groundwater regime around any potential pollution sources as identified must be prevented at all times;

8.3.1 Prior to construction

- During design phase, the waste and water management infrastructures at proposed Rietvlei Mine (included dams, drains, waste area) must be designed with the appropriate water barrier system if required, and comply with the DWA minimum requirements (1998/2012/2013), with special focus on the R634, R635, R636 of the NEMWA 2008;
- Design of the mine facilities to be conducted by an accredited or recognised professional designer

- The design of the dirty water drains, dams, as well as the waste storage areas should ensure their long term integrity;
- All dirty surface water control facilities (dam, drain) must be designed to have a minimum freeboard above full supply level, at such manner that they can always handle 1:50 year flood-event on top of its mean operation level;

8.3.2 During construction

- A proper construction phase should be carried out under the supervision of an accredited or recognised professional civil engineer, as approved by the designer;
- Storage area for hydrocarbons or any toxic construction material should be bunded according to DWA minimum requirement;

8.3.3 During operation

- Contaminated water drain (within the waste site) and dam must be properly operated and maintained;
- All surface dirty water control facilities (dam, drain) must be operated to have a minimum freeboard above full supply level, at such manner that they can always handle 1:50 year flood-event on top of its mean operation level;
- Effectiveness of existing monitoring borehole position should be re-evaluated;
- The monitoring network can be updated according to the DWA minimum requirements, if required to incorporate the unsaturated zones around proposed Rietvlei Mine.
- Keep contamination to a minimum by keeping the pit as dry as possible (dewatering) to reduce contact time of water and oxygen with exposed strata.
- Spills from the coal processing (crushing, screening and washing) in the plant area needs to be cleaned up immediately according to the DWA minimum requirements and rehabilitation should follow.

8.3.4 At the closure and post closure

- Implement closure of open pit progressively;
- Effectiveness of existing monitoring borehole position should be re-evaluated;
- Rubble from waste or contaminated areas should be dismantled and disposed of accordingly;
- Backfill material to be fully compacted and covered, and the entire foot print of waste to be shaped for free-draining. This will minimise infiltration of oxygen rich water, and reduce geochemical reactions that should occur.
- Rehabilitation to follow backfilling compaction;

- Rehabilitatation should consist of re-vegetating the site using appropriately chosen indigenous grasses;
- A rehabilitation plan must be implemented and the plan should be done in the line with the contents of NWA (Act No 36 of 1998), to avoid subsequent negative environmental impacts that may occur.
- Continue monitoring until it can be demonstrated that vegetation is self-sustaining and no erosion channels exist.
- Effectiveness of existing monitoring borehole position should be re-evaluated;

Table 28: Construction impacts assessment

Potential groundwater Impact	Without mitigation								Recommended mitigation measures	With mitigation							
	S	SE	DI	C	FA	FI	L	IS		S	SE	DI	C	FA	FI	L	IS
Construction Phase																	
Decreasing of the soils buffering capacity and increasing of infiltration rates	1	1	2	4	1	4	5	20	Mitigation is not possible. Construction phase should be carried out under the supervision of an accredited or recognised professional civil engineer, as approved by the designer	1	1	2	4	1	4	5	20
Altered Flow systems due to probable dewatering (if required)	1	2	2	5	2	4	6	30	Mitigation is not possible. Construction phase should be carried out under the supervision of an accredited or recognised professional civil engineer, as approved by the designer	1	2	2	5	2	4	6	30
Deterioration of water quality due to construction waste (Chemical in construction material)	3	2	1	6	2	3	5	30	Any waste and spills (especially during construction and closure) need to be cleaned up immediately according to the departmental minimum requirements.	1	1	1	3	1	1	2	6
Deterioration of water quality due to hydrocarbon spills from storage (organic contaminants)	3	2	3	8	2	3	5	40	Any waste and spills (specially during construction and closure) need to be cleaned up immediately according to the departmental minimum requirements;	1	1	2	4	1	2	3	12

Groundwater contamination due to groundwater seeps standing in the construction's footprint area.	3	1	3	7	2	3	5	35	Groundwater seeps must be dewatered and contained in dirty water dams.	1	1	1	3	1	1	2	6

Table 29: Operation impacts assessment

Potential groundwater Impact	**Without mitigation**								Recommended mitigation measures	**With mitigation**							
	S	**SE**	**DI**	**C**	**FA**	**FI**	**L**	**IS**		**S**	**SE**	**DI**	**C**	**FA**	**FI**	**L**	**IS**
Operation phase																	
Drop of groundwater levels due to open pit dewatering	4	4	4	12	4	5	9	108	Mine needs to agree with affected land owners on friendly solutions for issues related to drawdown cone. This impact needs to be monitored. Application for WULA amendment as per DWA requirements must be made for proposed new abstraction boreholes if any required;	4	4	4	12	4	5	9	108
Deterioration of groundwater quality due to rock dumps.	2	3	4	9	4	3	7	63	Separate clean water from the dumps area, drain dirty water to dirty water dam. Rock dumps areas must be designed with the appropriate water barrier system if required, and comply with the DWA minimum requirements (1998/2012/2013), with special focus on the R634, R635, R636 of the NEMWA 2008	1	1	1	3	1	2	3	9

Deterioration of groundwater quality due to open pit mining.	3	3	4	10	4	5	9	90	Keep contamination to a minimum by keeping the pit as dry (dewatering) as possible to reduce contact time of water and oxygen with exposed strata. Mine water must be contained and/or re used as much as possible. Trucks need to be maintained and capped to minimise loss of coal on roads. Separate clean water from the stockpiling area to minimise water inflitrating from the site. Regular maintenance of vehicles must be implemented; Trucks need to be capped to minimise spillage of coal, on roads.	3	2	3	8	3	3	6	48
Deterioration of groundwater quality due to coal processing;	4	3	4	11	4	5	9	99	Spills from the coal processing (crushing, screening and washing) in the plant area needs to be cleaned up immediately according to the DWA minimum requirements and rehabilitation should follow.	2	2	1	5	1	1	2	10
Deterioration of groundwater quality due to tailings disposal;	4	3	5	12	5	5	1 0	120	Tailings dam must be maintained and operated according to design as approved by DWA. Effectiveness of existing monitoring borehole position should be re-evaluated periodically according DWA requirements. Continuous monitoring should implement.	1	2	1	4	2	2	4	16
Deterioration of groundwater quality due to leaks/spillages from dirty water quality dams and drain;	4	3	4	11	4	3	7	77	Pollution control dams and associated drains should be maintained and operated according design as approved by DWA. Effectiveness of existing monitoring borehole position should be re-	1	1	1	3	1	2	3	9

								evaluated periodically according DWA requirements.								
Deterioration of groundwater quality due to handling and transport of waste material.	3	3	4	10	4	3	7	70	Waste needs to be discarded and spills cleaned up immediately according to the WULA conditions. DWA should be notified in the event of a spill.	1	1	2	4	1	2	3	12

Table 30: Closure impacts assessment

Potential groundwater Impact	Without mitigation								Recommended mitigation measures	With mitigation							
	S	SE	DI	C	FA	FI	L	IS		S	SE	DI	C	FA	FI	L	IS
Closure phase																	
During decommissioning handling of waste and transport of building material can cause various types of spills (domestic waste, sewage water, hydrocarbons) which can infiltrate and cause contamination of the groundwater system.	3	3	3	9	2	3	4	36	Waste needs to be discarded and spills cleaned up immediately according to the WULA conditions. DWA should be notified in the event of a spill. Rubble from waste or contaminated areas should be dismantled and disposed of accordingly. Regular maintenance of vehicles must be implemented; Trucks need to be capped to minimise spillage of wastes, on roads.	2	2	3	7	2	2	4	28

Flooding and decanting of open pit	4	3	5	12	5	5	10	120	Monitoring should continue, and numerical groundwater model updated on annual basis. Backfill material to be fully compacted and covered, and the entire foot print of waste to be shaped for free-draining, rehabilitation to follow.	4	2	3	9	2	3	5	45

Table 31: Post closure impact assessment

Potential groundwater Impact	**Without mitigation**								Recommended mitigation measures	**With mitigation**							
	S	**SE**	**DI**	**C**	**FA**	**FI**	**L**	**IS**		**S**	**SE**	**DI**	**C**	**FA**	**FI**	**L**	**IS**
Post closure phase																	
Flooding and decanting of open pit into surface water drainage channels.	4	4	5	13	5	5	10	130	Backfill material to be fully compacted and covered, and the entire foot print of waste to be shaped for free-draining, rehabilitation to follow. A rehabilitation plan must be implemented and the plan should be done in the line with the contents of NWA (Act No 36 of 1998), to avoid subsequent negative environmental impacts that may occur. Decant water if any, needs to be contained in appropriate dirty water dam.	4	2	5	11	5	5	10	110

9 Monitoring plan

9.1 Preamble

A long-term monitoring programme must be developed based on the guideline documented in Best Practice Guideline G3. Water Monitoring Systems (2007) available from DWA. These guidelines are summarised and implemented in the proposed monitoring plan.

A monitoring plan is necessary because (DWA, 2006):

- Accurate and reliable data forms a key component of many environmental management actions.
- Water monitoring is a legal requirement
- The most common environmental management actions require data and thus the objectives of water monitoring include the following:
- Development of environmental and water management plans based on impact and incident monitoring (facilitate in decision-making, serve as early warning to indicate remedial measures or that actions are required in certain areas) for the mine and region.
- Generation of baseline/background data before project implementation.
- Identification of sources of pollution and extent of pollution (legal implications or liabilities associated with the risks of contamination moving off site).
- Monitoring of water usage by different users (control of cost and maximizing of water reuse).
- Calibration and verification of various prediction and assessment models (planning for decommissioning and closure).
- Evaluation and auditing of the success of implemented management actions (ISO 14000, compliance monitoring).
- Assessment of compliance with set standards and legislation (EMPs, water use licenses).
- Assessment of impact on receiving water environment.

9.2 General principle of monitoring

Monitoring on a mine consists of various components as illustrated by the overall monitoring process (Figure 52). It must be recognized and understood that the successful development and implementation of an appropriate, accurate and reliable monitoring programme requires that a defined structured procedure be followed. A monitoring programme must include the location of all monitoring points (indicated on a map), the type of data to be collected, as well as the data collection (protocol/procedure/methodology, frequency of monitoring and parameters determined, quality control and assurance), management (database and assessment) and reporting procedures. This programme must then be implemented. The results from the monitoring programme should be representative of the actual situation. To ensure that the monitoring programme functions properly, an operating and maintenance programme should be developed and implemented. A data management system is necessary to ensure that data is stored/used optimally and is accessible to all the relevant users. The monitoring programme must include quality control measures. It is important to note that this programme is dynamic and should change as the mine and water management needs change.

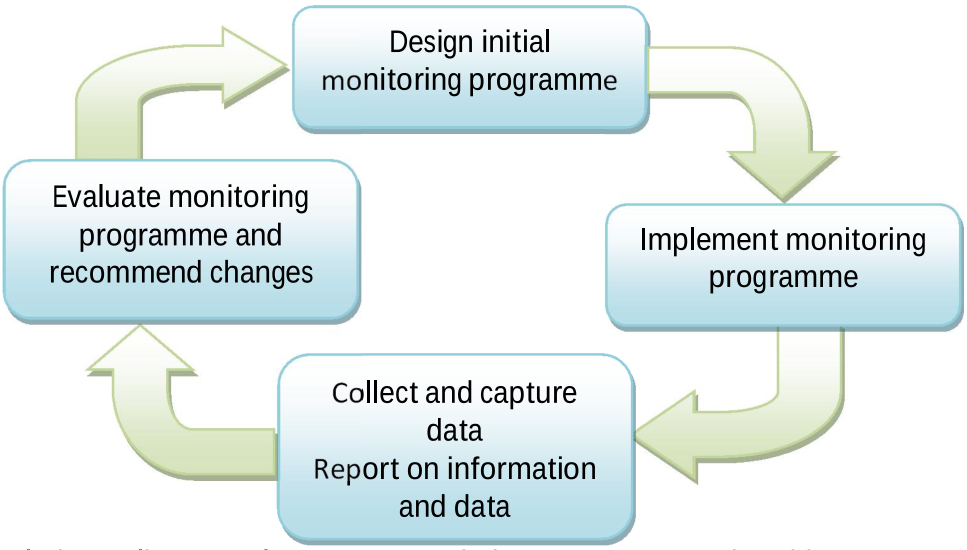

Figure 52: Monitoring process (DWA, 2007)

Effective groundwater monitoring systems on a mine consist of the following components:

- Groundwater quality monitoring system.
- Groundwater flow monitoring system.

- Data and information management system.

When designing the monitoring system the following issues must also be taken into consideration:

- Potential or actual water use
- Aquifer or catchment vulnerability
- Toxicity of chemicals
- Potential for seepage or releases
- Quantities and frequency of release to the environment (point and non-point).
- Management measures in place to minimize risk.

9.3 Monitoring tool

Sampling procedures are discussed in detail in:

- Weaver, J.M.C. 1992a. *Groundwater sampling: A comprehensive guide for sampling methods* (WRC Report No. TT 54/92). Pretoria: Water Research Commission.
- Weaver, J.M.C. 1992b. *Groundwater sampling: An abbreviated field guide for sampling methods* (WRC Report No. TT 56/92). Pretoria: Water Research Commission.

These sampling procedures should be adhered to.

9.4 Monitoring plan for Rietvlei Mine

A comprehensive analysis must be conducted on samples from boreholes and dams locations within or close to the mine (Figure 53). The proposed initial monitoring boreholes consist essentially of existing boreholes (on and off site). In addition samples must be tested for trace elements once a year. The parameters that must be sampled for are listed in Table 32.

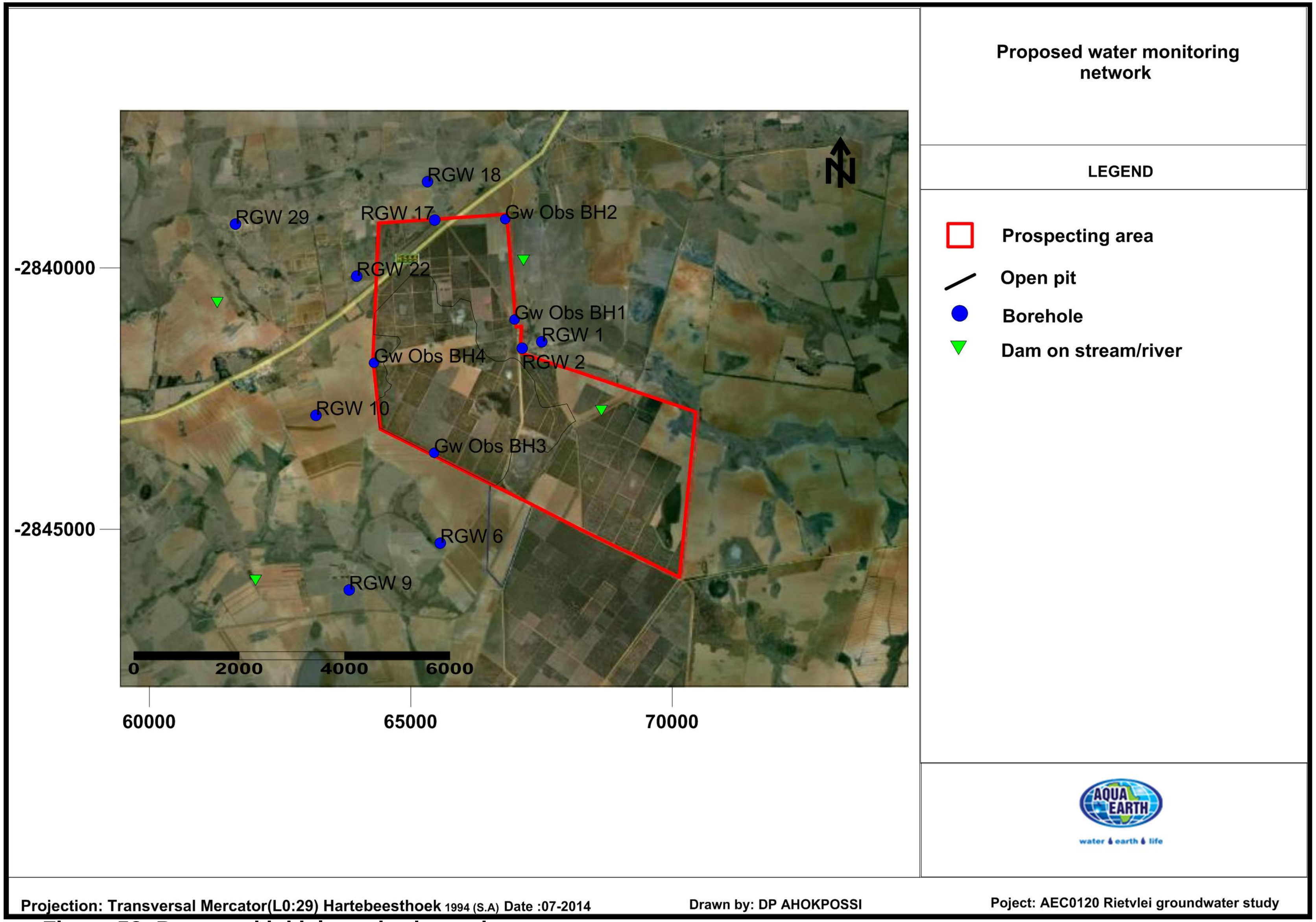

Figure 53: Proposed initial monitoring points

Table 32: Sampling parameters

A (Standard set of parameters)	B (Trace elements)
pH	Ba
EC	As
Ca	Co
Mg	Cr
Na	Ni
K	Pb
Total Alk	Se
F	Sr
Cl	V
NO2(N)	Zn
NH4 (N)	Nb
NO3(N)	Mn
PO4	Cu
SO4	Ga
Al	Ge
Fe	Rb
Mn	Y
	Zr
	Sn

	W
	Bi
	Th
	U
	Hg

Boreholes and surface water points shown in Figure 53 should be sampled every 3 months for the standard list of parameter. Water levels should also be measured. In addition these boreholes must be sampled for trace elements once a year.

Every six months farmer's boreholes within a 2 km radius of the mine should be sampled for the standard list of parameters. Groundwater levels must also be measured.

A borehole must be drilled into backfilled opencast pit to monitor the rise in water level within the pit and the groundwater quality.

10 Conclusions

Based on the scope of work carried out under order from WSP, Aqua Earth has completed a detailed groundwater impact assessment and the following conclusions are reached:

- Field investigations have been conducted according to WSP gap analysis recommendation;
- The conceptual model of the site has been updated base on field investigations results;
- The potential impacts (quality, quantity) have been identified and assessed accordingly;
- The overall project impacts (construction, operation, closure) significance is expected to be from Low to Very High without any appropriate mitigation;
- Thorough planning, design, suitable investment, management measures, workplace procedures and good housekeeping will generally mitigate the potential impacts rising from proposed Rietvlei Mine development will de reduced to Low, Except the for impacts at post closure phase;
- Specific measures have been proposed for certain infrastructure units to address particular potential impacts;
- Monitoring will be necessary to ensure that any impacts on water quality and quantity that do arise are dealt with rapidly;
- An initial monitoring network has been proposed for the management of groundwater resources.

11 Appendixes

11.1 Appendix A: Chains of custody

AQUA EARTH CONSULTING cc

(Consulting and Contracting Environmental Hydrogeologists)

water & earth & life

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CHAIN OF CUSTODY FOR SOIL SAMPLES

Client:	ANGLO AMERICAN
Address:	
Phone:	0737 721 4 2U
Fax:	
Contacts:	pacome@aquaearth.co.za
Sampled at (Project):	RIETVLEI
Date:	14-02-2014
Contact person on site:	D.P. AHOKPOSSI
Signature of the contact person:	

Sampler:	FRANCOIS STASSEN
Sampler's Signature:	
Method of shipment:	
This Section is for Lab use only:	
Laboratory Name:	WATER LAB
Received at Laboratory by:	
Date and Time:	
Number of samples:	
Comments:	

Site description/ name	Sample ID	Sampling Date	Sampling Time	Type of sample	Analysis requested	Sampling method	Method of preservation	
					Acid Base Accounting		at the site	at the lab (intact?)
RIETVLEI	T4D(17-19)	07-02-2014		Soil	✓	Grab	—	—
RIETVLEI	T4D(8-16)	07-02-2014		Soil	✓	Grab	—	—
RIETVLEI	T5D(6-15)	12-02-2014		Soil	✓	Grab	—	—
RIETVLEI	T6D(11-18)	07-02-2014		Soil	✓	Grab	—	—
RIETVLEI	T7D(12-21)	07-02-2014		Soil	✓	Grab	—	—
RIETVLEI	T7D(26-50)	11-02-2014		Soil	✓	Grab	—	—
RIETVLEI	T8D(11-21)	10-02-2014		Soil	✓	Grab	—	—
RIETVLEI	T8D(22-50)	10-02-2014		Soil	✓	Grab	—	—

T8D(11-21)

UIS

analytical services

UIS Analytical Services (Pty) Ltd • Reg. No. 2000/027788/07 • VAT No. 4920202958
13 Eastoring Nook, Highveld Technopark, Centurion • PO Box 8286, Centurion, 0046
Tel +27 12 665 4291 • Fax +27 12 665 4294 • info@uis-as.co.za • www.uis-as.co.za

ANALYSIS REQUEST FORM – Water

CUSTOMER INFORMATION

Company Name: Aqua Earth
Order/Contract No.: 000479
UIS-AS Quote No:

Samples From Site Location: Rietkuil
No. of samples submitted: 6
Sample Type (Borehole Water; Surface Water; Effluent etc): Borehole water

	Contact Name	Land-line No.	Mobile No.	E-Mail Address
Send Result Report To:	D.P. Ahokpossi	073 572 1424		[illegible]@aquaearth.co.za/[illegible]
Send Invoice To:	Tracy	011 791 3490		tracy@aquaearth.co.za

[x] I have read and accept the UIS-AS Terms & Conditions of payment and services. I am a duty authorised signatory of the debtor company with regards to sample submission and analyses payment.

Date: 21/02/2014 Print Name: M[illegible] Designation: Geotech Signature: [signature]

Sample ID and/or Analyses Comments:
T4S; T6D; T8D; T7S; T7D; T4D(2)

ANALYSES REQUIRED

- [ ] Sample Filtration
- [x] pH
- [x] EC (Electrical Conductivity)
- [ ] NH4 (Ammonium by I.C.)
- [x] F (Fluoride by IC)
- [x] Cl (Chloride)
- [x] NO2 (Nitrite)
- [x] NO3 (Nitrate)
- [x] SO4 (Sulphate)
- [ ] PO4 (Phosphate)
- [x] Br (Bromide)
- [x] TSS (Total Suspended Solids)
- [x] TDS (Total Dissolved Solids)
- [x] P & Total (M) Alkalinity
- [ ] NH4 (Ammonium by ISE)
- [ ] Total Oil & Grease
- [ ] Total Phenols
- [x] DO (Dissolved Oxygen)
- [ ] Redox Potential
- [x] Turbidity
- [ ] Cr6+ (Hexavalent Chrome)
- [ ] CN- (Free Cyanide)
- [ ] Total Cyanide

Microbiology

- [ ] Escherichia Coli
- [ ] Total Coliforms
- [ ] Plate Count (Yeasts & Moulds)
- [ ] Total Faecal Coliforms
- [ ] Standard Plate Count
- [ ] Salmonella

ICP-OES

- [ ] Dissolved Cations
- [ ] Total Cations

ICP-MS

- [ ] Dissolved Trace Elements
- [ ] ICP-MS Scan
- [ ] Total Trace Elements

Leaches

- [ ] Acid Digestion
- [ ] Water Leach
- [ ] Acid Rain Leach
- [ ] TCLP Leach

- [ ] Total Organic Nitrogen
- [ ] Total Kjeldahl Nitrogen
- [ ] Biological Oxygen Demand
- [x] Chemical Oxygen Demand
- [ ] Dissolved Organic Carbon

Calculated Parameters

- [ ] Langelier Index
- [x] Total Hardness

ELEMENTS REQUIRED

[x]	Ag	[x]	Hg	[x]	Sb
[x]	Al	[ ]	Ho	[ ]	Sc
[x]	As	[ ]	Ir	[x]	Se
[ ]	Au	[x]	K	[ ]	Si
[x]	B	[x]	La	[ ]	Sm
[x]	Ba	[x]	Li	[x]	Sn
[x]	Be	[ ]	Lu	[x]	Sr
[ ]	Bi	[x]	Mg	[ ]	Ta
[x]	Ca	[x]	Mn	[ ]	Tb
[x]	Cd	[x]	Mo	[x]	Te
[ ]	Ce	[x]	Na	[ ]	Th
[x]	Co	[ ]	Nb	[x]	Ti
[x]	Cr	[ ]	Nd	[x]	Tl
[x]	Cs	[x]	Ni	[ ]	Tm
[x]	Cu	[ ]	Os	[x]	U
[ ]	Dy	[ ]	P	[x]	V
[ ]	Er	[x]	Pb	[x]	W
[ ]	Eu	[ ]	Pd	[ ]	Y
[x]	Fe	[ ]	Pr	[ ]	Yb
[ ]	Ga	[ ]	Pt	[x]	Zn
[ ]	Gd	[ ]	Rb	[ ]	Zr
[ ]	Ge	[ ]	Re	[ ]	[illegible]
[ ]	Hf	[ ]	Rh	[ ]	[illegible]

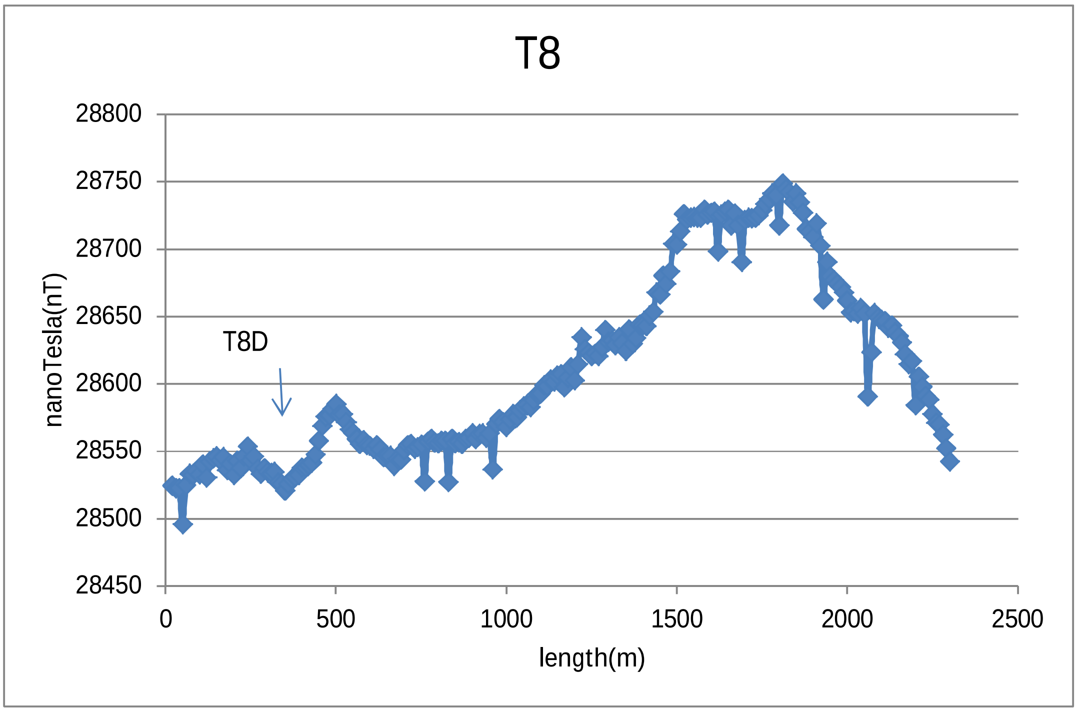
* Denotes SANAS Accredited Test
Non Accredited Test

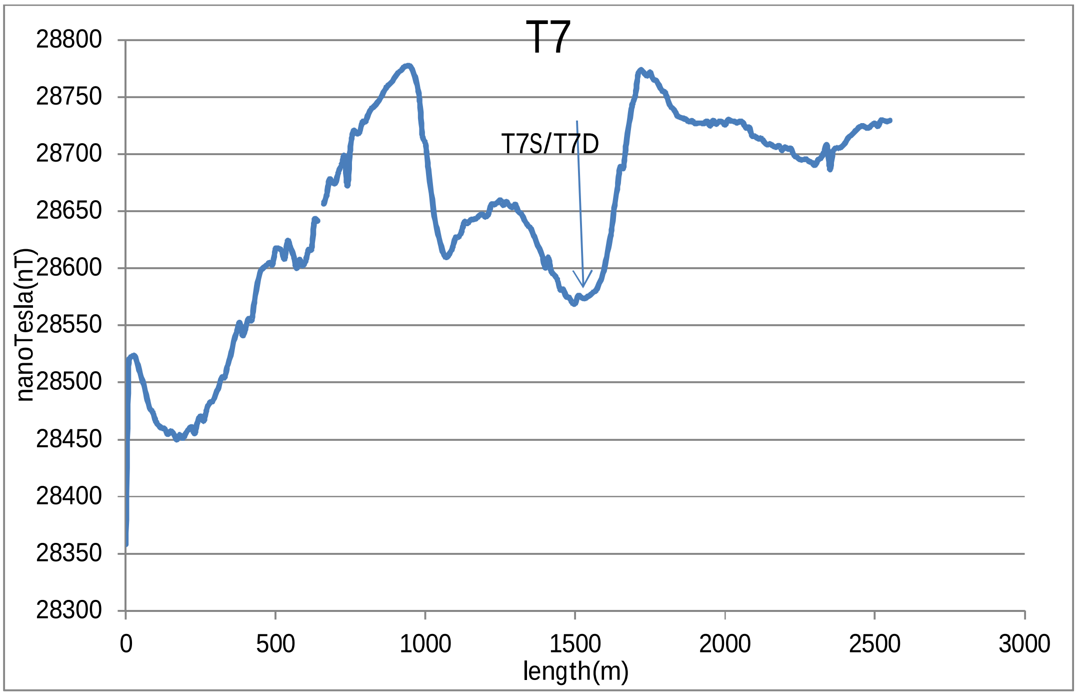
sanas
Testing Laboratory
T0[illegible]

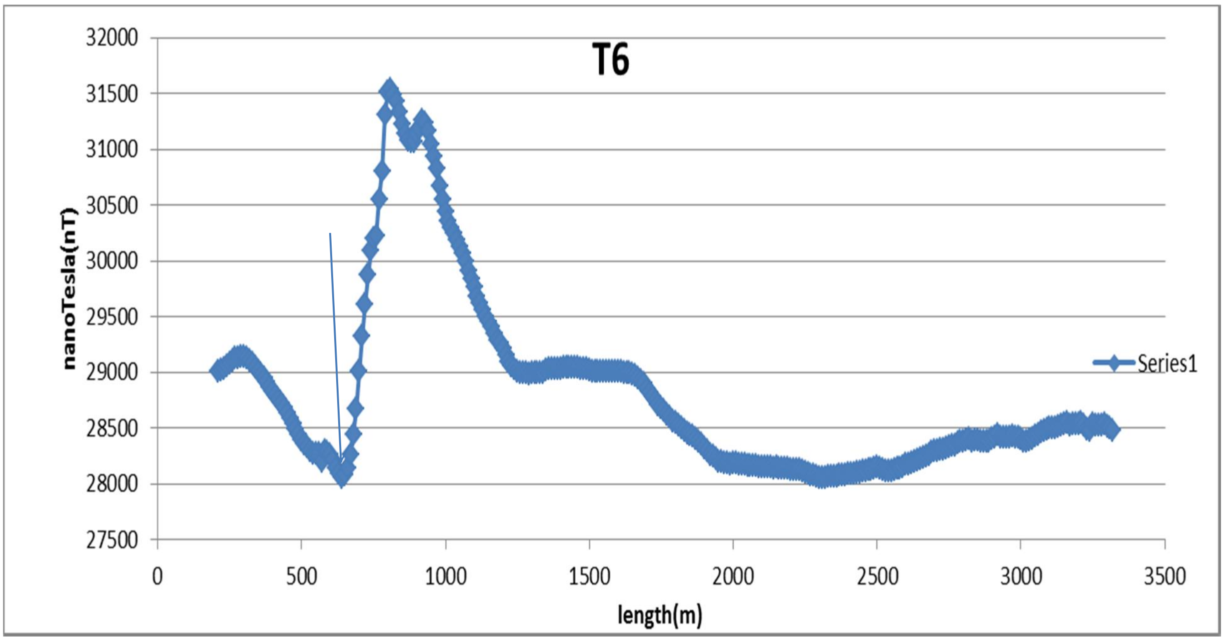
S. DIKOBE 21/02/2014

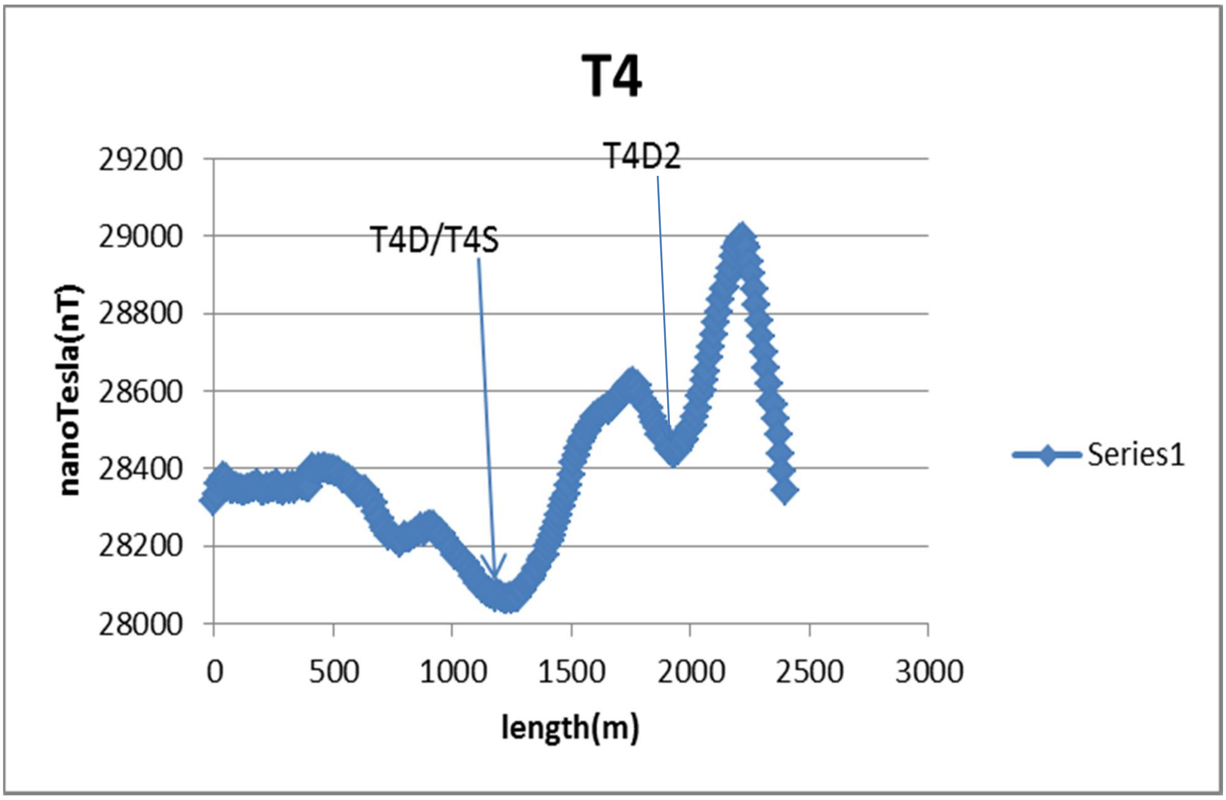
List of Directors available from the registered office

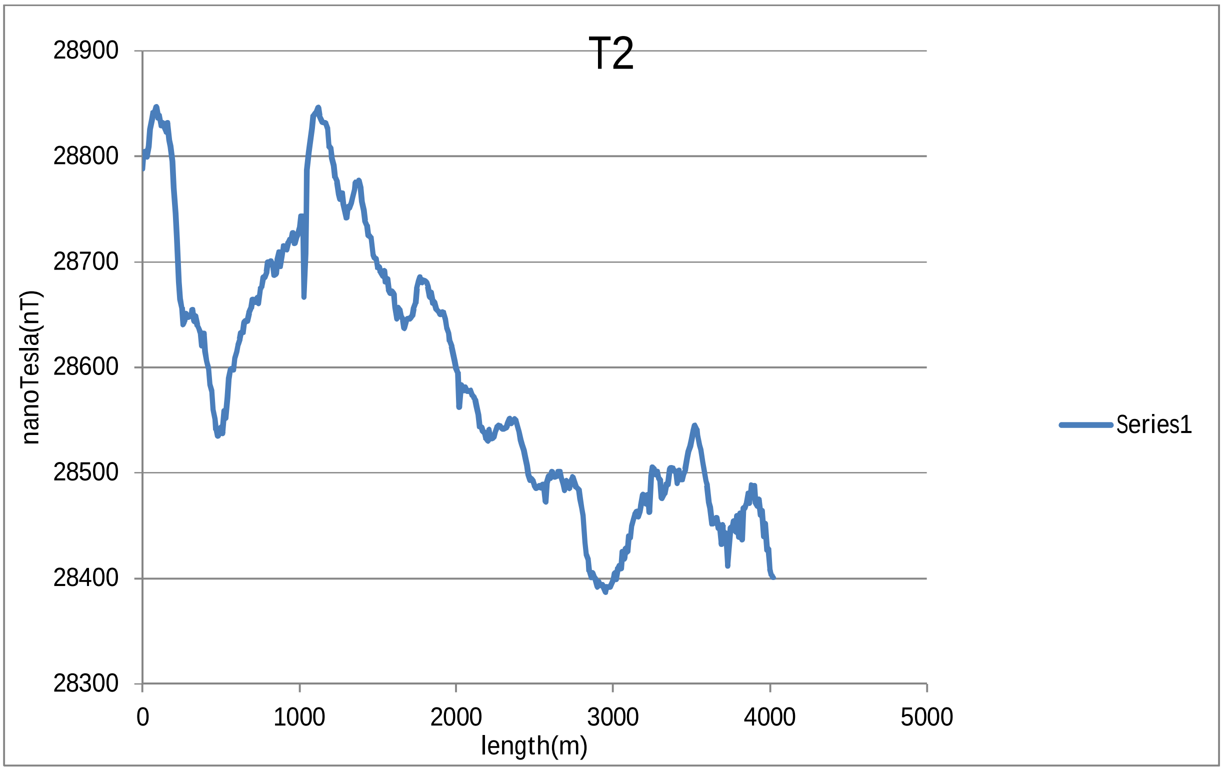
11.2 Appendix B: Geophysical Results






T6
32000
31500
31000
30500
30000
29500
29000
28500
28000
27500
nanoTesla(nT)
0
500
1000
1500
2000
2500
3000
3500
length(m)
Series1


T4
29200
29000
28800
28600
28400
28200
28000
nanoTesla(nT)
T4D2
T4D/T4S
0
500
1000
1500
2000
2500
3000
length(m)
Series1


T2
28900
28800
28700
28600
28500
28400
28300
nanoTesla(nT)
0
1000
2000
3000
4000
5000
length(m)
Series1

11.3 Appendix C: Drilling logs

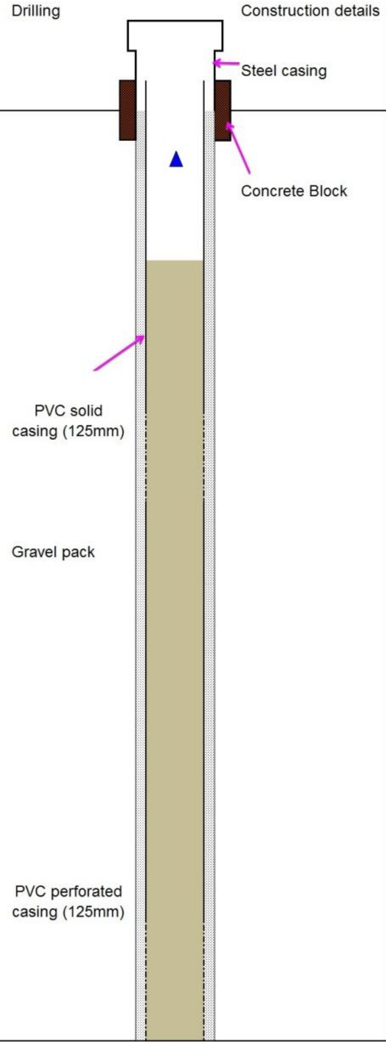
BOREHOLE LOG

AQUA EARTH — water earth life

CLIENT:	Butsanani Joint Ventre	BOREHOLE NO : T4D
PROJECT:	Rietvlei	COORDINATES (WGS84)
SITE:	Rietvlei Colliery	X : 29.680776
DRILLER:	Aqua Earth	Y : -25.697736
DATE DRILLED:	2014/07/02	PLUNGE: Vertical
LOGGED BY:	Francois Stassen	STATUS: Completed

BOREHOLE DRILLING AND CONSTRUCTION DETAILS

Borehole not accessible from 9m



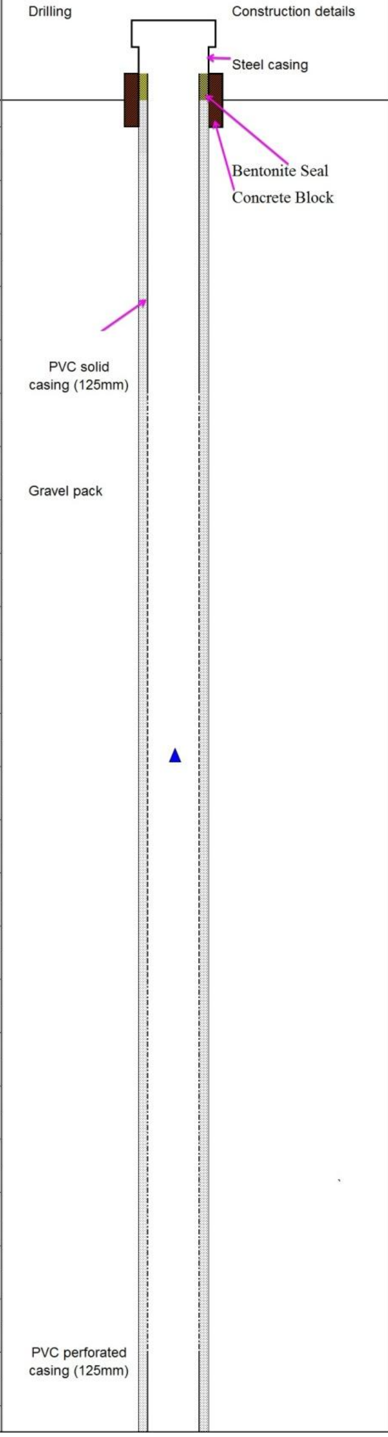
Depth (m)	STRIKES (mbgl)	Water level (m)	Penetration Rate (mbgl)	DEPTH (m)	LITHOLOGICAL DESCRIPTION Rock type, colour, grain size, texture, weathering and fracturing
0				0	
2			0.3	2	Topsoil: Reddish
3		▲	0.45	3	Topsoil: Reddish
4		3.4m	0.4	4	Sand: White
6			1.25	6	Sand: White
8			0.35	8	Sand: White
10			0.3	10	Sand: White
12			2.3	12	Soil and Sand: Reddish White
14			0.45	14	Sand: White
16			0.45	16	Sand: White
17			0.35	17	Sand and Coal: Grey
18			1.05	18	Sand and Coal: Grey
19	19m		0.35	19	Sand and Coal: Grey
20			0.3	20	Coal Seam: Black, Shiny
21			0.4	21	Coal Seam: Black, Shiny
22			0.35	22	Coal Seam: Black, Shiny
24			1.04	24	Coal Seam: Black, Shiny
25	25m		0.42	25	Coal Seam: Black, Shiny
26			1.08	26	Coal Seam: Black, Shiny
28			0.53	28	Coal Seam: Black, Shiny
30			0.51	30	Coal Seam: Black, Shiny
32			1.07	32	Coal Seam: Black, Shiny
34			1.06	34	Coal Seam: Black, Shiny
36			0.49	36	Coal Seam: Black, Shiny
38			1	38	Coal Seam: Black, Shiny
40			0.53	40	Coal Seam: Black, Shiny
42			1.11	42	Coal Seam: Black, Shiny
44			1.16	44	Coal Seam: Black, Shiny
45			1.08	45	Coal Seam: Black, Shiny
46			1.4	46	Coal Seam: Black, Shiny
48			2.18	48	Soil:Brown
50			2.12	50	Clay: Reddish Brown

BOREHOLE LOG

AQUA EARTH — water earth life

CLIENT:	**Butsanani Joint Ventre**	**BOREHOLE NO : T4D(2)**	
PROJECT:	**Rietvlei**	**COORDINATES (WGS84)**	
SITE:	**Rietvlei Colliery**	**X : 29.685798**	
DRILLER:	**Aqua Earth**	**Y : -25.700014**	
DATE DRILLED:	**19/2/2014**	**PLUNGE: Vertical**	
LOGGED BY:	**Mlamleli Chopela**	**STATUS: Completed**	

BOREHOLE DRILLING AND CONSTRUCTION DETAILS



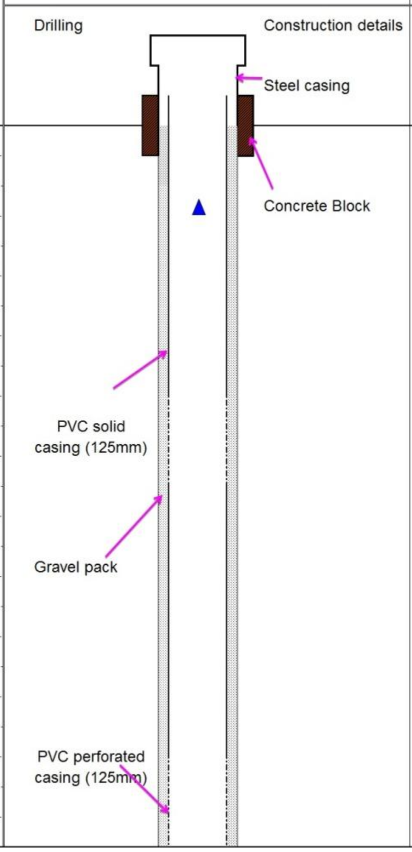
STRIKES (mbgl)	Water level (m)	Penetration Rate (mbgl)	DEPTH (m)	PROFILE	LITHOLOGICAL DESCRIPTION Rock type, colour, grain size, texture, weathering and fracturing
			0		
		0.12	1		Top reddish brown loamy soil
		0.15	2		
		1.11	3		
		2.11	4		
		1.24	5		
		1.37	6		Yellowish, heavely weathered fine grained sandstone
		1.16	7		
		0.37	8		
		0.47	9		
		0.54	10		
		1.07	11		
		1.04	12		
		1.02	13		
		0.49	14		
		0.41	15		Yellowish,moist, fine grained sandstone
		0.57	16		Coal: Black
		1.11	17		
		0.51	18		
		1.17	19		
		1.16	20		Very fine grained(powder),yellowish,moist shale
		1.03	21		Black angular fractured coal
		1.24	22		
		1.03	23		
		1.07	24		
	25m	1.27	25		
		1.07	26		
		0.39	27		
		1.09	28		
		0.46	29		
		0.54	30		
		1.01	31		
		1.06	32		
		1.12	33		Greyish angular to rounded fractured sandstone
		0.55	34		
		1.14	35		
		1.12	36		
		1.43	37		
		1.48	38		
		0.51	39		
		2.17	40		
		1.1	41		
		2.42	42		
		2.39	43		
		3.24	44		
		3.47	45		
		3.52	46		
		3.55	47		
		4.12	48		
		3.49	49		
		3.24	50		

BOREHOLE LOG

water earth life

CLIENT:	Butsanani Joint Ventre	BOREHOLE NO :	T4S
PROJECT:	Rietvlei	COORDINATES (WGS84)	
SITE:	Rietvlei Colliery	X :	29.681179
DRILLER:	Aqua Earth	Y :	-25.697927
DATE DRILLED:	7/2/2014	PLUNGE:	Vertical
LOGGED BY:	Francois Stassen	STATUS:	Completed

BOREHOLE DRILLING AND CONSTRUCTION DETAILS

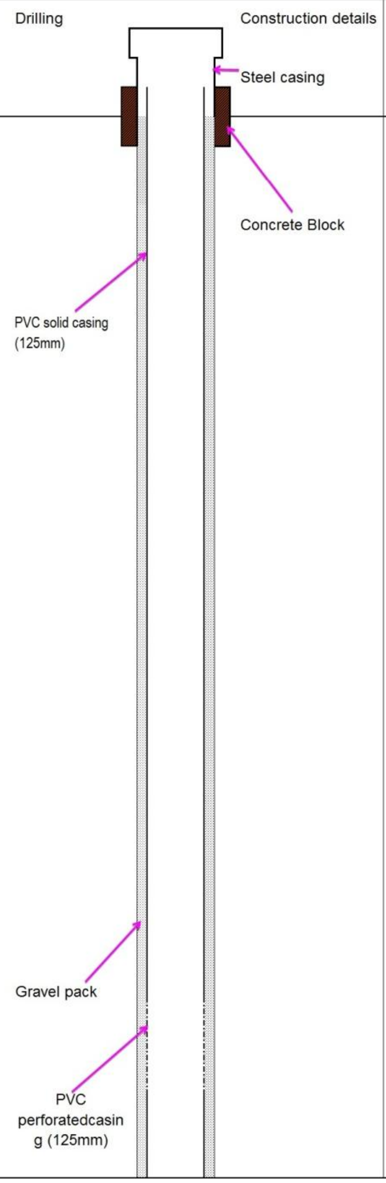


DEPTH (m)	STRIKES (mbgl)	Water level (m)	Penetration Rate (mbgl)	LITHOLOGICAL DESCRIPTION Rock type, colour, grain size, texture, weathering and fracturing
0				
1			0.3	
2			0.2	Topsoil: Reddish
3		3.1m	0.4	
4			0.55	Mixed Sand and Soil: Red
5			0.4	
6			0.5	
7			0.5	Sand: White
8			0.55	
9			1.2	
10	10m		3	Soil: Brownish
11			0.38	
12			1.45	Mixed: Sand and Soil
13			1.05	
14			0.55	
15			1.1	Sand:Greyish
16			0.3	
17			0.35	
18			0.4	Coal: Black
19			0.38	Soil:Brownish
20			0.35	
21			1.15	
22			1	Coal: Black
23			0.5	
24			1.05	

BOREHOLE LOG

CLIENT:	Butsanani Joint Ventre	BOREHOLE NO : T5D	
PROJECT:	Rietvlei	COORDINATES (WGS84)	
SITE:	Rietvlei Colliery	X : 29.650723	
DRILLER:	Aqua Earth	Y : -25.661475	
DATE DRILLED:	11/2/2014	PLUNGE: Vertical	
LOGGED BY:	Francois Stassen	STATUS: Completed	

BOREHOLE DRILLING AND CONSTRUCTION DETAILS



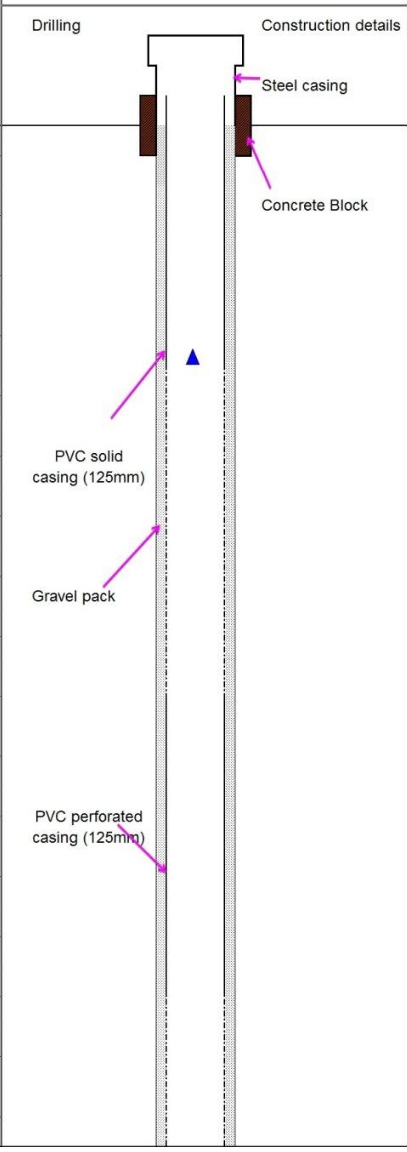
	STRIKES (mbgl)	Water level (m)	Penetration Rate (mbgl)	DEPTH (m)	PROFILE	LITHOLOGICAL DESCRIPTION Rock type, colour, grain size, texture, weathering and fracturing
0				0		
1			0.2	1		Topsoil: Red
2			0.26	2		
3			3.35	3		
4			1.27	4		
6			1.35	5		
8			1.4	6		Sand:Greyish White
9			2.58	7		Clay: Red
10			1.32	8		Sand:Greyish White
12			1.54	9		
14			1.16	10		Clay: Red
15			1.32	11		Mudstone: Reddish White
16			0.4			
17			0.35			
18			1.12			
19			2.4			
20			3.4			
21			5.06			
22			3.04			
24			8.4			
25			3.25			
26			5.05			
27			6.02			
28			4.58			
30			6.45	12		
32			4.58	13		
34			5.15	14		
36			4.58	15		
38			6.11	16		
40			6.23	17		
42			5.58	18		
44			6.26	19		
45			5.48	20		
46			6.47	21		
48			7.14	22		
49			8.42	23		Mudstone: Reddish White
50			6.31	24		

BOREHOLE LOG

water earth life

CLIENT:	Butsanani Joint Ventre	BOREHOLE NO : T6D	
PROJECT:	Rietvlei	COORDINATES (WGS84)	
SITE:	Rietvlei Colliery	X : 29.685097	
DRILLER:	Aqua Earth	Y : -25.706538	
DATE DRILLED:	7/2/2014	PLUNGE: Vertical	
LOGGED BY:	Francois Stassen	STATUS: Completed	

BOREHOLE DRILLING AND CONSTRUCTION DETAILS



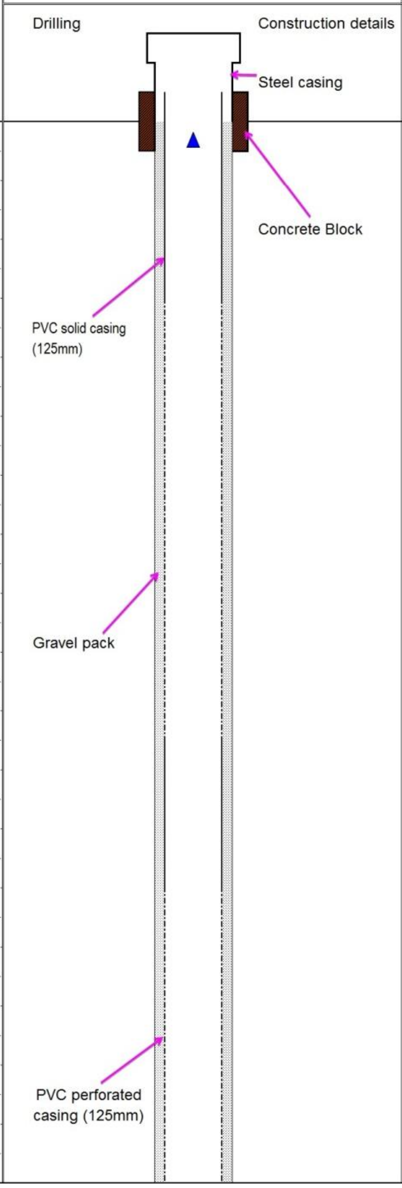
DEPTH (m)	STRIKES (mbgl)	Water level (m)	Penetration Rate (mbgl)	PROFILE / LITHOLOGICAL DESCRIPTION (Rock type, colour, grain size, texture, weathering and fracturing)
0				
2			0.3	Topsoil: Red
3			0.5	
4			1.35	Soil: Brownish
6			4.05	Soil:Yellowsih Brown
8			0.5	Sand: Yellowish
10			0.5	
12			1.35	
14		14m	2	
15			1.05	Shale: Greysih Black
16			0.35	Sand: Yellowish
17			0.4	
18			0.3	
19	19m		0.5	Gravel: Yellowish
20			0.45	
21			0.3	
22			3	
24			2.45	Dolerite: Greyish Black
25			2.05	
26			2.15	
27			4	
28			3.15	
30			5.45	
32			4.5	Basalt: Black
34			3.1	
36			6.45	
38			6.1	
40			5.35	
42			6.18	
44			6.02	Dolerite: Greyish Black
45			6.03	
46			3.11	
48			5.36	
49			3.47	
50			5.12	

BOREHOLE LOG

water earth life

CLIENT:	Butsanani Joint Ventre	BOREHOLE NO : T7D	
PROJECT:	Rietvlei	COORDINATES (WGS84)	
SITE:	Rietvlei Colliery	X : 29.652838	
DRILLER:	Aqua Earth	Y : -25.685354	
DATE DRILLED:	11/2/2014	PLUNGE: Vertical	
LOGGED BY:	Francois Stassen	STATUS: Completed	

BOREHOLE DRILLING AND CONSTRUCTION DETAILS



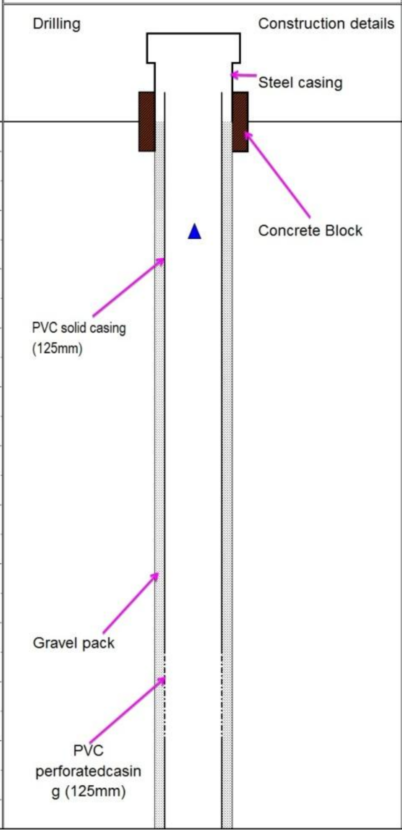
	STRIKES (mbgl)	Water level (m)	Penetration Rate (mbgl)	DEPTH (m)	PROFILE	LITHOLOGICAL DESCRIPTION Rock type, colour, grain size, texture, weathering and fracturing
0				0		
1			0.1	1		Topsoil: Red
2		1.7 m	0.15	2		
3			0.2	3		
4			0.3	4		
6			0.4	6		Sand:Whitish Grey
8			0.45	8		
9			1.16			
10			0.28	10		
12			0.52	12		
14			0.55	14		
15			1.21	15		
16			0.52	16		Sand:Yellowish White
17			1.02	17		
18			1.23	18		Sand:Greyish White
19	19m		0.42	19		
20			1.1	20		
21			1.15	21		
22			0.42	22		
24			1.43	24		
25			0.52	25		Carbonaceous Shale: Greyish Black
26			0.48	26		
27			2.03	27		
28			0.44	28		
30			1.35	30		Coal: Black
32			1.14	32		
34			0.34	34		
36			1.24	36		
38			0.38	38		
40			0.28	40		
42			0.55	42		
44	44m		0.4	44		
45			1.09	45		
46			1.25	46		
48			1.49	48		
49			0.38	49		
50			0.56	50		

BOREHOLE LOG

water earth life

CLIENT:	Butsanani Joint Ventre	BOREHOLE NO : T7S	
PROJECT:	Rietvlei	COORDINATES (WGS84)	
SITE:	Rietvlei Colliery	X : 29.653166	
DRILLER:	Aqua Earth	Y : -25.685504	
DATE DRILLED:	11/2/2014	PLUNGE: Vertical	
LOGGED BY:	Francois Stassen	STATUS: Completed	

BOREHOLE DRILLING AND CONSTRUCTION DETAILS



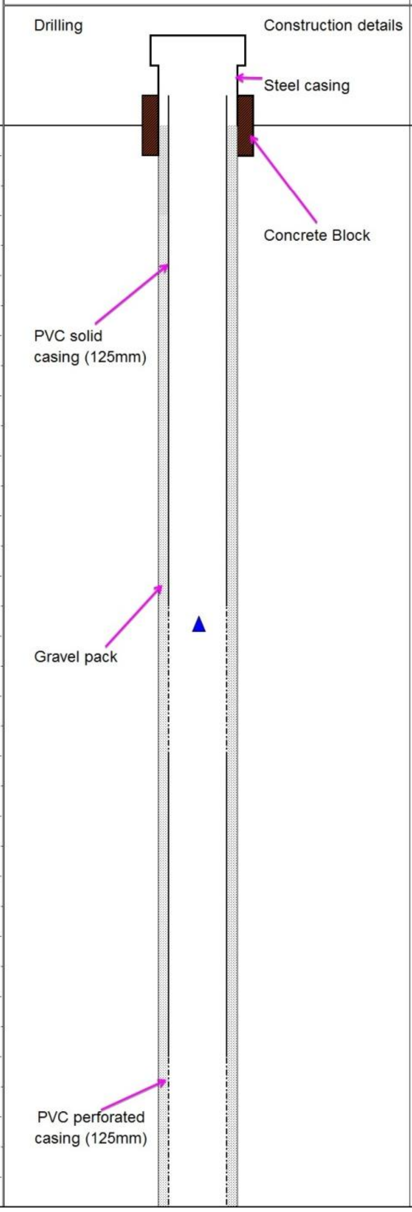
DEPTH (m)	STRIKES (mbgl)	Water level (m)	Penetration Rate (mbgl)	LITHOLOGICAL DESCRIPTION Rock type, colour, grain size, texture, weathering and fracturing
0				
1			0.08	Topsoil: Red
2			0.11	
3			0.17	
4		▲	1.5	
5			1.12	
6		4.8m	0.56	Sand:Greyish White
7			0.49	Clay: Red
8			0.51	Sand:Greyish White
9			1.23	
10			0.34	Clay: Red
11			1.28	Soil: Reddish White
12			0.29	
13			0.31	
14			0.58	
15	19m		1.4	
16			0.48	
17			0.51	
18			1.12	
19			0.56	
20			1.07	
21			0.42	Sand:Greyish White
22			0.4	
23			0.56	Mudstone: Reddish White
24			1.15	

BOREHOLE LOG

water earth life

CLIENT:	Butsanani Joint Ventre	BOREHOLE NO : T8D	
PROJECT:	Rietvlei	COORDINATES (WGS84)	
SITE:	Rietvlei Colliery	X : 29.657317	
DRILLER:	Aqua Earth	Y : -25.697196	
DATE DRILLED:	10/2/2014	PLUNGE: Vertical	
LOGGED BY:	Francois Stassen	STATUS: Completed	

BOREHOLE DRILLING AND CONSTRUCTION DETAILS

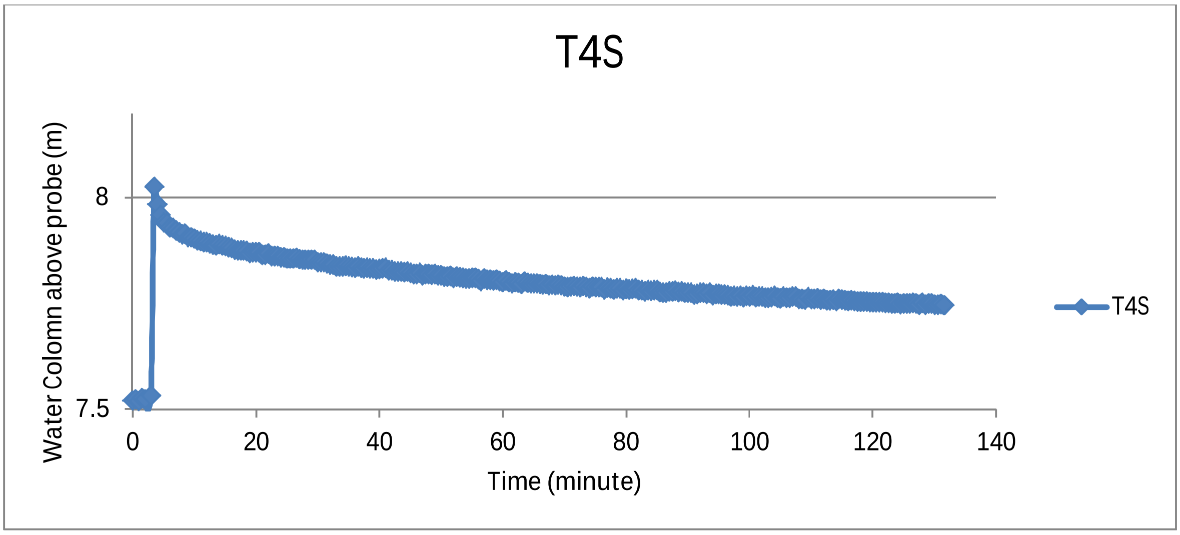


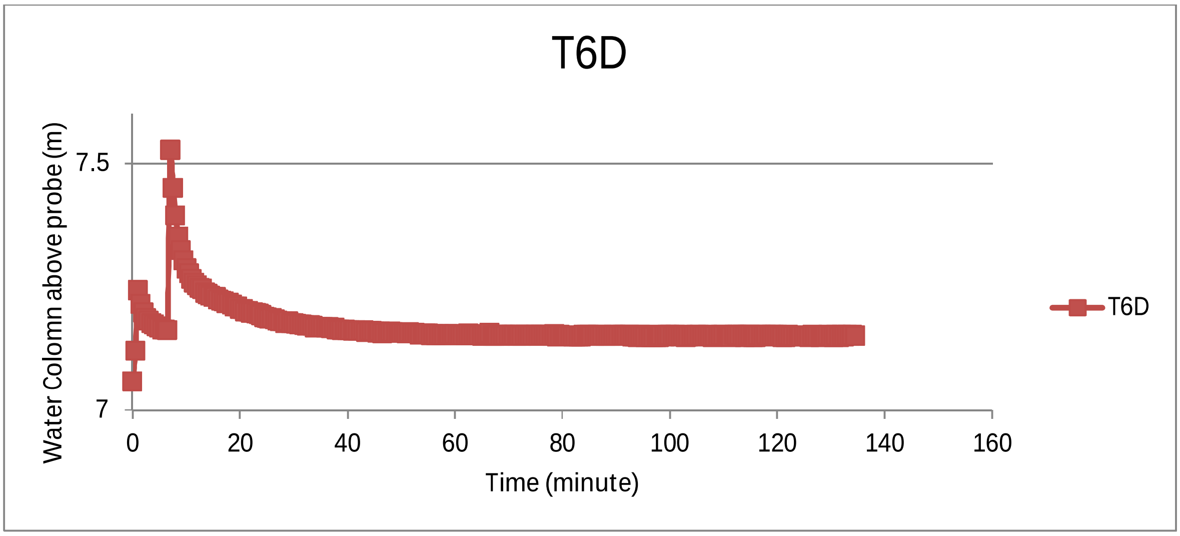
Depth	STRIKES (mbgl)	Water level (m)	Penetration Rate (mbgl)	DEPTH (m)	PROFILE	LITHOLOGICAL DESCRIPTION Rock type, colour, grain size, texture, weathering and fracturing
0				0		
1			0.1	1		Topsoil: Red
2			0.15	2		Topsoil: Red
3			0.3	3		Topsoil: Red
4			0.27	4		Soil: Reddish White
6			0.55	6		Sand:Whitish Grey
8			0.28	8		Sand:Whitish Grey
9			1.04	9		Coal: Black
10			0.35	10		Coal: Black
12			1.1	12		Coal: Black
14			0.5	14		Carbonaceous Shale: Greyish Black
15			0.32	15		Carbonaceous Shale: Greyish Black
16			0.4	16		Carbonaceous Shale: Greyish Black
17			1	17		Carbonaceous Shale: Greyish Black
18			1.45	18		Carbonaceous Shale: Greyish Black
19			0.5	19		Carbonaceous Shale: Greyish Black
20			1.06	20		Carbonaceous Shale: Greyish Black
21		21m	1.3	21		Coal: Black
22			0.25	22		Coal: Black
24			0.4	24		Coal: Black
25	25m		0.3	25		Coal: Black
26			0.4	26		Coal: Black
27			1.55	27		Carbonaceous Shale: Greyish Black
28			1.43	28		Carbonaceous Shale: Greyish Black
30			1.45	30		Carbonaceous Shale: Greyish Black
32			1.12	32		Sand:Whitish Grey
34			2.1	34		Sand:Whitish Grey
36			1.55	36		Clay: Reddish Grey
38			1.4	38		Clay: Reddish Grey
40			1.5	40		Clay: Reddish Grey
42			3.05	42		Clay: Reddish Grey
44			3.5	44		Clay: Reddish Grey
45			3.55	45		Clay: Reddish Grey
46			1.27	46		Clay: Reddish Grey
48			2.35	48		Clay: Reddish Grey
49			1.05	49		Clay: Reddish Grey
50			2.07	50		Clay: Reddish Grey

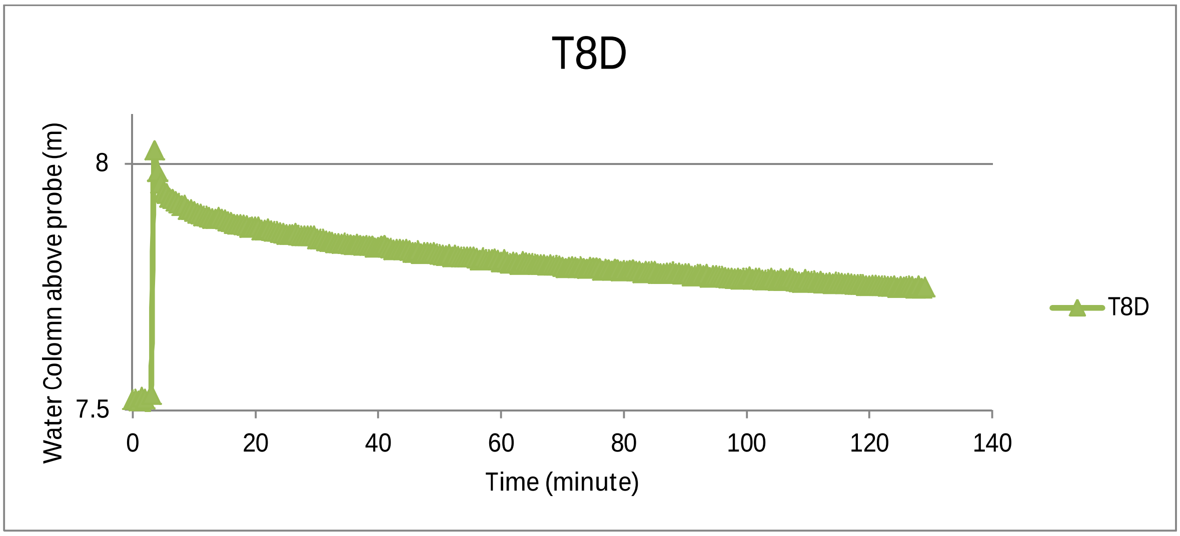
11.4 Appendix D Soil analysis results

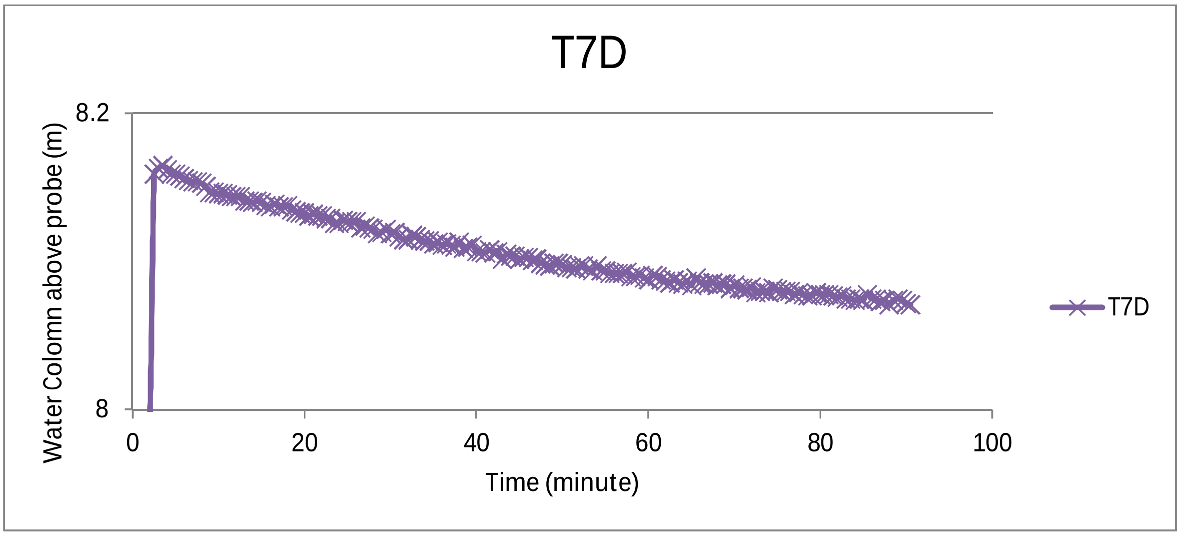
11.5 Appendix E Groundwater quality results

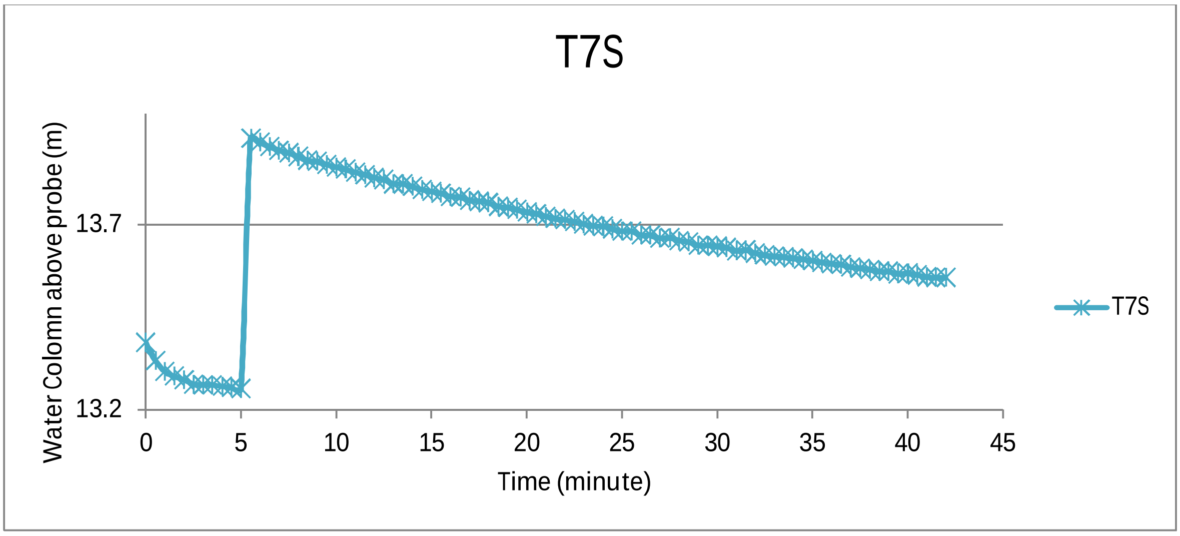
11.6 Appendix F: Slug test results

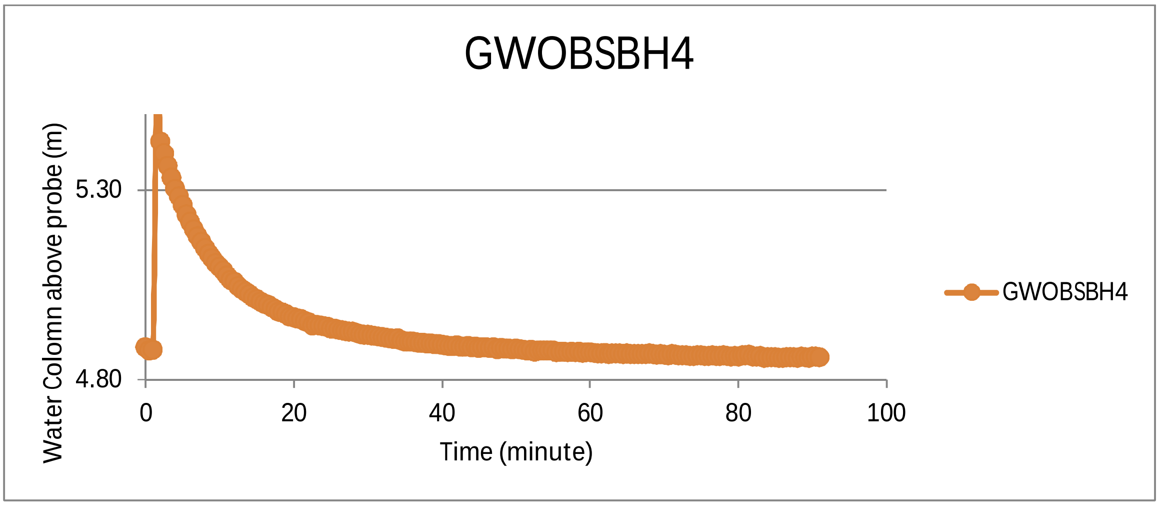


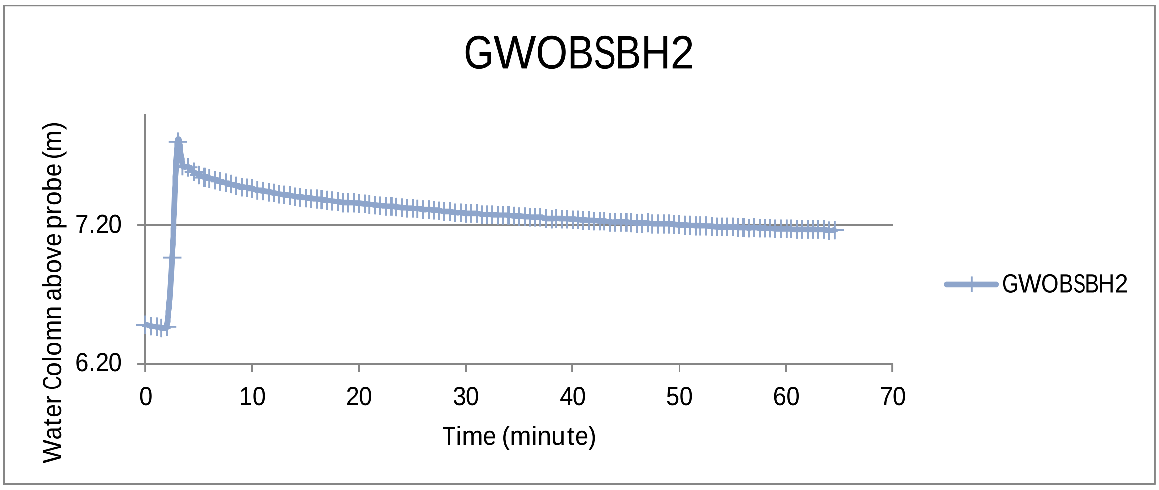


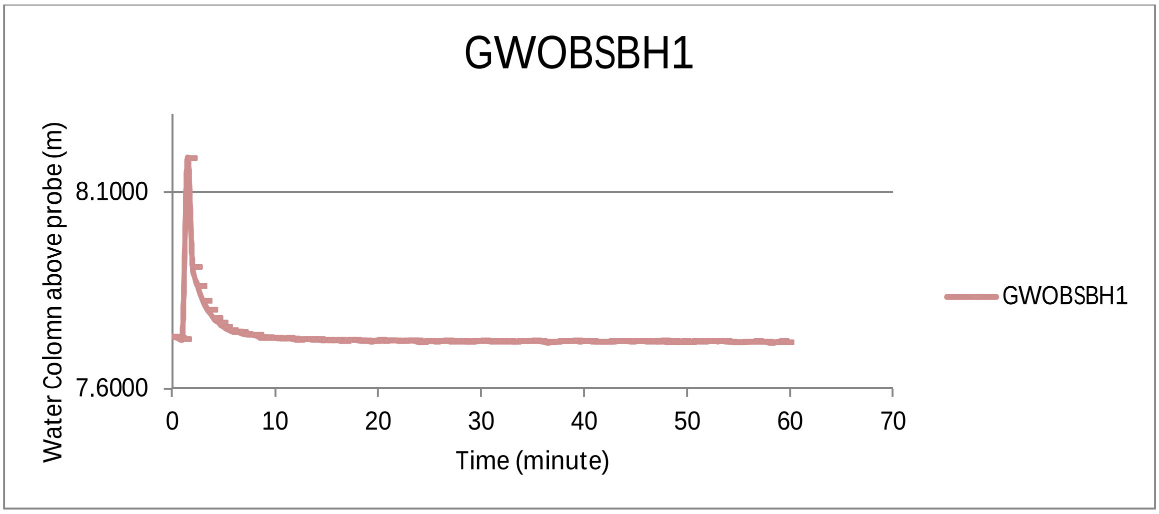

T8D
Water Colomn above probe (m)
8
7.5
0
20
40
60
80
100
120
140
Time (minute)
T8D


T7D
Water Colomn above probe (m)
8.2
8
0
20
40
60
80
100
Time (minute)
T7D


T7S
Water Colomn above probe (m)
13.7
13.2
0
5
10
15
20
25
30
35
40
45
Time (minute)
T7S


GWOBSBH4
Water Colomn above probe (m)
5.30
4.80
0
20
40
60
80
100
Time (minute)
GWOBSBH4


GWOBSBH2
Water Colomn above probe (m)
7.20
6.20
0
10
20
30
40
50
60
70
Time (minute)
GWOBSBH2


GWOBSBH1
Water Colomn above probe (m)
8.1000
7.6000
0
10
20
30
40
50
60
70
Time (minute)
GWOBSBH1

11.7 Appendix G Calibration test results