Geohydrological Assessment for Cape Lime - Vredendal Dolomite and Limestone Operations.

REPORT:	***PREPARED BY:***
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GEOSS

06 September 2019

EXECUTIVE SUMMARY

Ntsanko Ndlovu, a senior Environmental Specialist for Cape Lime, appointed GEOSS to conduct a geohydrological assessment on the Cape Lime site north east of Vredendal, Western Cape. Cape Lime, a subsidiary of Afrimat Limited, proposes to upgrade its EMPr in order to be compliant to the NEMA EIA Regulations 2014 as amended. The proposed EMPr upgrade will take place on Remainder of Portion 1 of the Farm Vaderlansche Rietkuil No. 308, Farm Nuwedrift No 450, Portion 162 of the farm Karoovlakte No. 299 and Portion 21 of the Farm KYS No.301 in the Vredendal Magisterial District.

The surficial cover of the Mine site is alluvial/colluvium material which comprises of weathered phyllite and quartzite, the weathered material is generally argillaceous (weathered phyllite) and sandy (weathered quartzite) in nature. The bedrock underlying the Mine comprises of a brown to red phyllite grading into a black graphitic schist (Nat - Aties Formation). The Aties Formation is located in the central section of the site with basement rock is assumed to be the Widouw (Nwi) Formation, located on the eastern and western section of the site. The formation comprises of a "dirty" marble (marl) and dolomite.

The aquifer below the Mine site is classified by DWS as a Karst aquifer with an average yield of 0.5 - 2 L/s. Recharge occurs over much of the surface area of the aquifer through direct infiltration of rain water. The general groundwater flow direction is from North-east to south-west. The groundwater quality according to the electrical conductivity (EC) for the regional aquifer underlying the site has been classified as marginal with an EC of 70 – 300 mS/m.

To prevent or minimize negative impacts on the groundwater and surface water caused by the mine, several mitigation measures are proposed. The risks associated with mining activities on the site include groundwater/surface water contamination. These risks can be mitigated if the appropriate design and construction measures are implemented.

As part of managing the risk, a ground water monitoring system should be installed. Installation of screened boreholes on the proposed site can give valuable groundwater level information. This is an affordable and accurate means of groundwater level monitoring. Monitoring should be conducted by a qualified hydrogeologist on a quarterly basis (every 3 months). Quarterly field chemistry measurements should also be taken, along with annual samples for analysis. This will provide information regarding the impacts of mining.

The proposed site is on a minor aquifer system with a very low – medium vulnerability index and low aquifer susceptibility. Based on the classifications a basic groundwater monitoring system should be put in place near active mine sites and groundwater discharge locations (see Map 7). Surface water samples should also be collected downgradient of site on a quarterly basis.

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ABBREVIATIONS

EC	Electrical conductivity
L/s	litres per second
m	metres
mamsl	metres above mean sea level
mbgl	metres below ground level
mg/L	milligrams per litre
mS/m	milliSiemens per meter
NGA	National Groundwater Archive
TDS	Total dissolved solids
WGS84	Since the 1st January 1999, the official co-ordinate system for South Africa is based on the World Geodetic System 1984 ellipsoid, commonly known as WGS84.

GLOSSARY OF TERMS

Aquifer: a geological formation, which has structures or textures that hold water or permit appreciable water movement through them [from National Water Act (Act No. 36 of 1998)].

Borehole: includes a well, excavation, or any other artificially constructed or improved groundwater cavity which can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and information on water in an aquifer; or recharging an aquifer [from National Water Act (Act No. 36 of 1998)].

Intergranular aquifer: Groundwater occurs predominantly within the pore spaces between sand grains.

Groundwater: water found in the subsurface in the saturated zone below the water table or piezometric surface i.e. the water table marks the upper surface of groundwater systems.

Intergranular Aquifer: Generally unconsolidated but occasionally semi-consolidated aquifers. Groundwater occurs within intergranular interstices in porous medium. Typically occur as alluvial deposits along river terraces.

Unconfined conditions: The aquifer is open to atmospheric pressure.

Suggested reference for this report:

GEOSS (2019). Geohydrological Assessment for Cape Lime - Vredendal Dolomite and Limestone Operations. GEOSS Report Number: 2019/09-04. GEOSS - Geohydrological & Spatial Solutions International (Pty) Ltd. Stellenbosch, South Africa.

Cover photo:

Photograph taken during site visit.

GEOSS project number:

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Reviewed by:

Dale Barrow (06 September 2019)

1. INTRODUCTION

Ntsanko Ndlovu, Senior Environmental Specialist for Cape Lime, appointed GEOSS to conduct a geohydrological assessment on their site north east of Vredendal, Western Cape (**Map 1**). Cape Lime, a subsidiary of Afrimat Limited proposes to upgrade its EMPr in order to be compliant to the NEMA EIA Regulations 2014 as amended. The proposed EMPr upgrade will take place on Remainder of Portion 1 of the Farm Vaderlansche Rietkuil No. 308, Farm Nuwedrift No 450, Portion 162 of the farm Karoovlakte No. 299 and Portion 21 of the Farm KYS No.301 in the Vredendal Magisterial District.

The study included an initial remote geological and topographical investigation of the area and vulnerability assessment; which preceded the site visit. The site visit included an evaluation of the site geology and groundwater as well as a regional groundwater assessment. The geohydrological assessment's primary objective is to assess the potential impact (i.e. risk) of site activities on groundwater in the area surrounding the proposed site.

2. Scope of Work

The scope of work is to provide groundwater specialist services, including the task outlined below:

- A general (desktop) assessment of the Geology of the area.
- A Hydrocensus of the area
- An assessment of the current (baseline) ground water quality of the area in which the activity is taking place.
- An assessment of the depth of the ground water table of the area in which the activity is taking place (through a hydrocensus and hand auguring to water table if practicably possible).
- An assessment of the likely ground water flow direction of the area in question.
- A proposed Monitoring Program indicating how ground water levels and ground water quality should be monitored.

3. SETTING

3.1 General

The site is situated east of Vredendal. The area in general, has a low relief. Two rivers Troe-Troe and Wiedow intersect the property and converge into the Klien River system within the central portion of 1/308. The Klein River joins the primary river system of the Olifants River in Vredendal. The two rivers (Olifants and Klien) are used in conjunction with the Lower Olifants River Water Association (LORWA) canal system to supply water for agricultural use to local farms.

Map 1: Location of Cape Lime mine site

3.2 Climate

Vredendal on average receives about 105 mm of rain per year and receives most of its rainfall during winter. It has a Mediterranean climate, with mild wet winters and warm dry summers. **Figure 1** shows the monthly average air temperature distribution and **Figure** 2 shows average rainfall values for Vredendal per month. On average it receives the lowest rainfall in January and the highest in June.

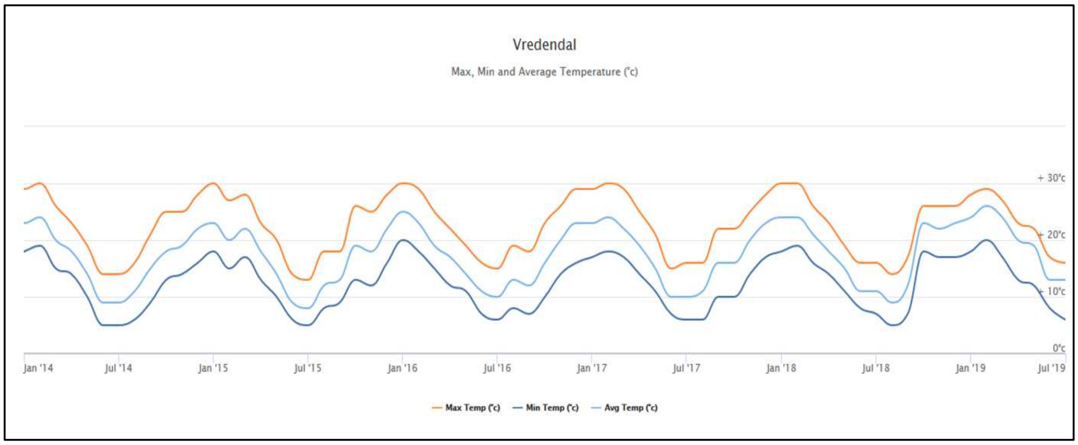


Figure 1: Monthly average air temperature distribution for Vredendal area (2014 – 2018) (weatheronline.com).

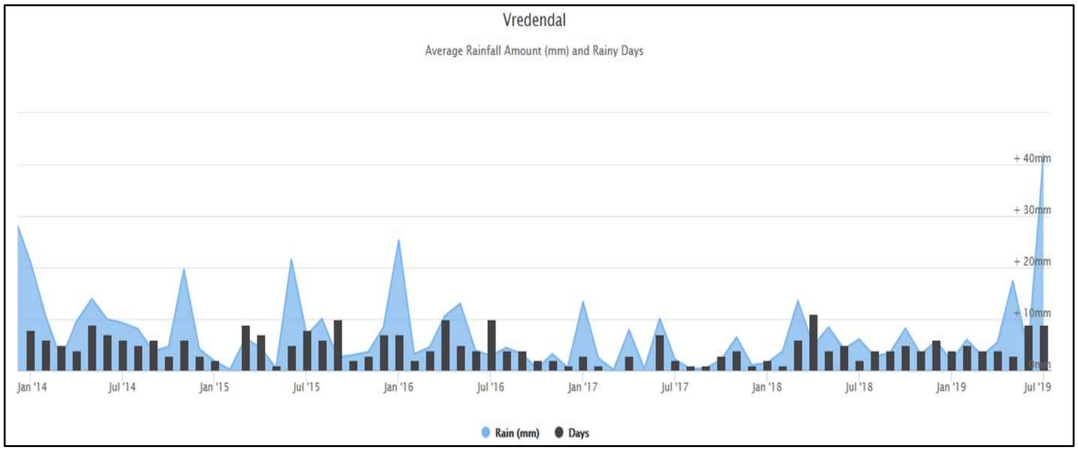


Figure 2: Monthly average rainfall distribution for Vredendal area (2014 – 2018) (weatheronline.com).

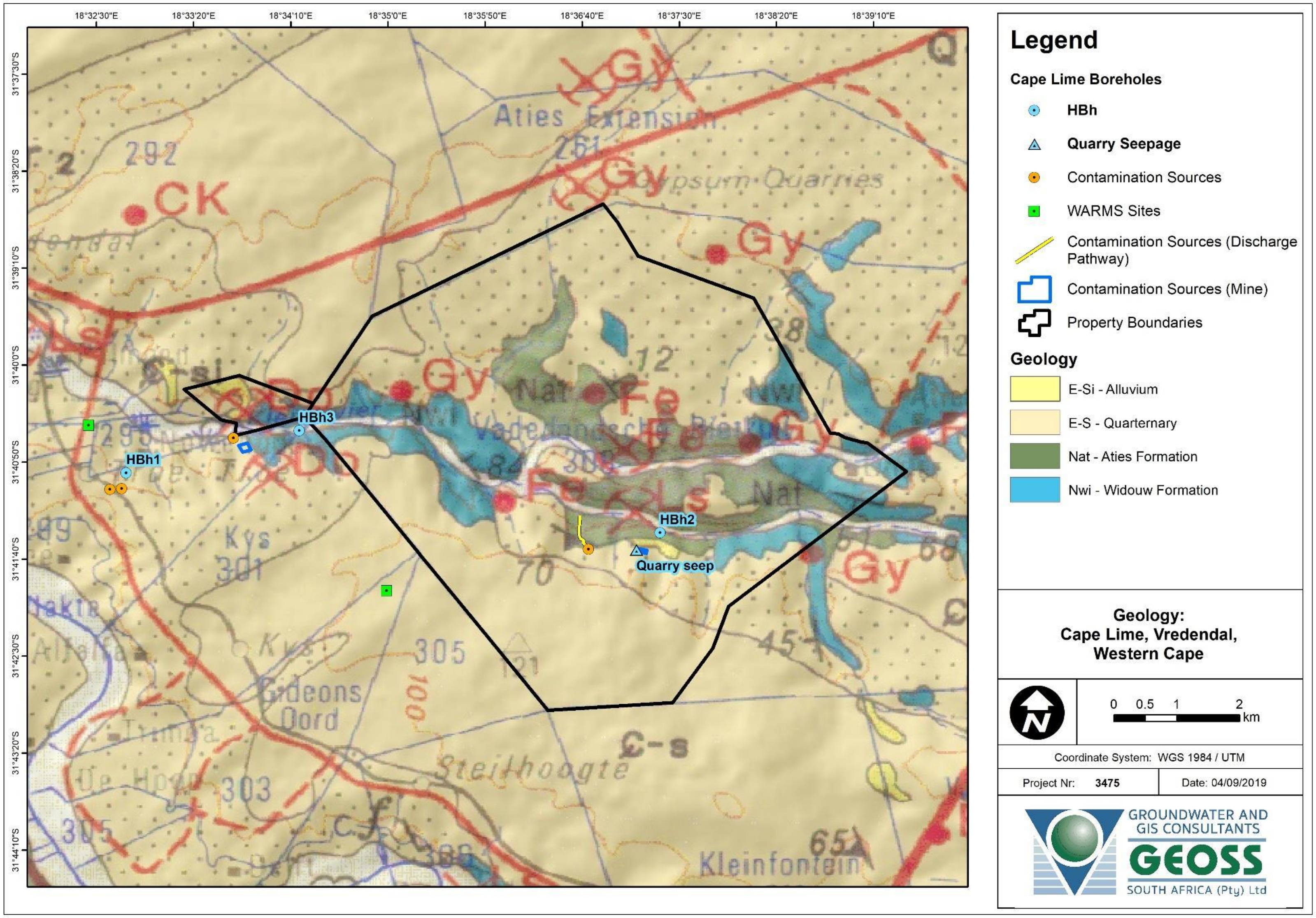
3.3 Geology

The Geological Survey of South Africa (now the Council for Geoscience (CGS)) has mapped the geology at 1:250 000 scale (3118, Calvinia). The geological setting is presented in **Table** 1 and the geological setting is shown in **Map 2**.

Table 1: Geological summary of study area.

Code	Lithology	Formation	Group
	Alluvium	n/a – Quaternary age	
E-Si	White to pale-red sandy soil with silcrete		
Nat	Brown phyllite and black graphitic schist and quartzite	Aties	Gifberg
Nwi	Marble/marl and limestone	Widouw	

The surficial cover of the site is alluvial/colluvium material which comprises of weathered phyllite and quartzite, the weathered material is generally argillaceous (weathered phyllite) and sandy (weathered quartzite) in nature. The bedrock underlying the site comprises of a brown to red phyllite grading into a black graphitic schist (Nat - Aties Formation). The Aties Formation is located in the central section of the site with basement rock assumed to be the Widouw (Nwi) Formation, located on the eastern and western section of the site. The formation comprises of a "dirty" marble (marl) and dolomite.



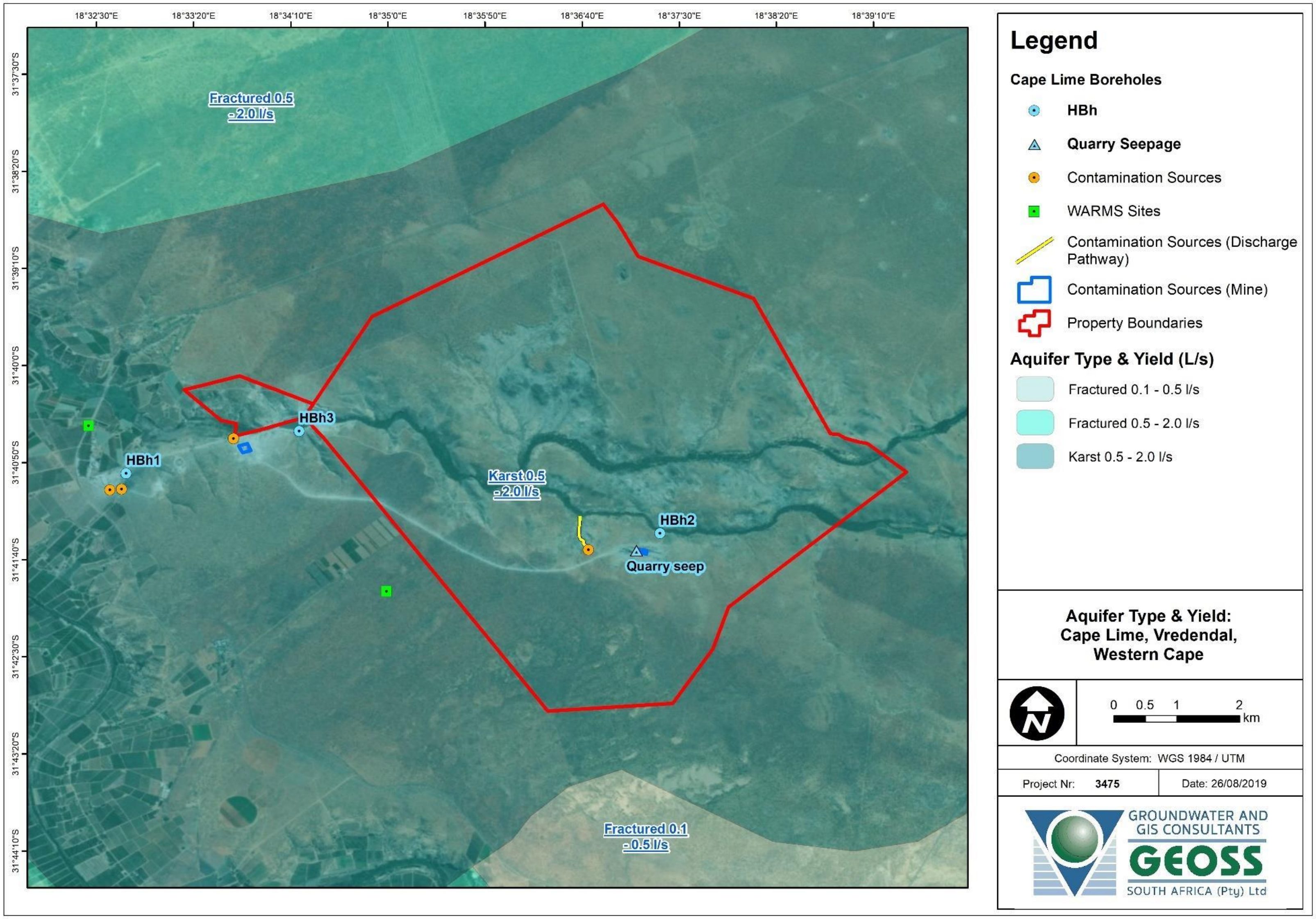
Map 2: Geological map of the study area and surrounds (CGS, 3118 Calvinia)

3.4 Hydrogeology

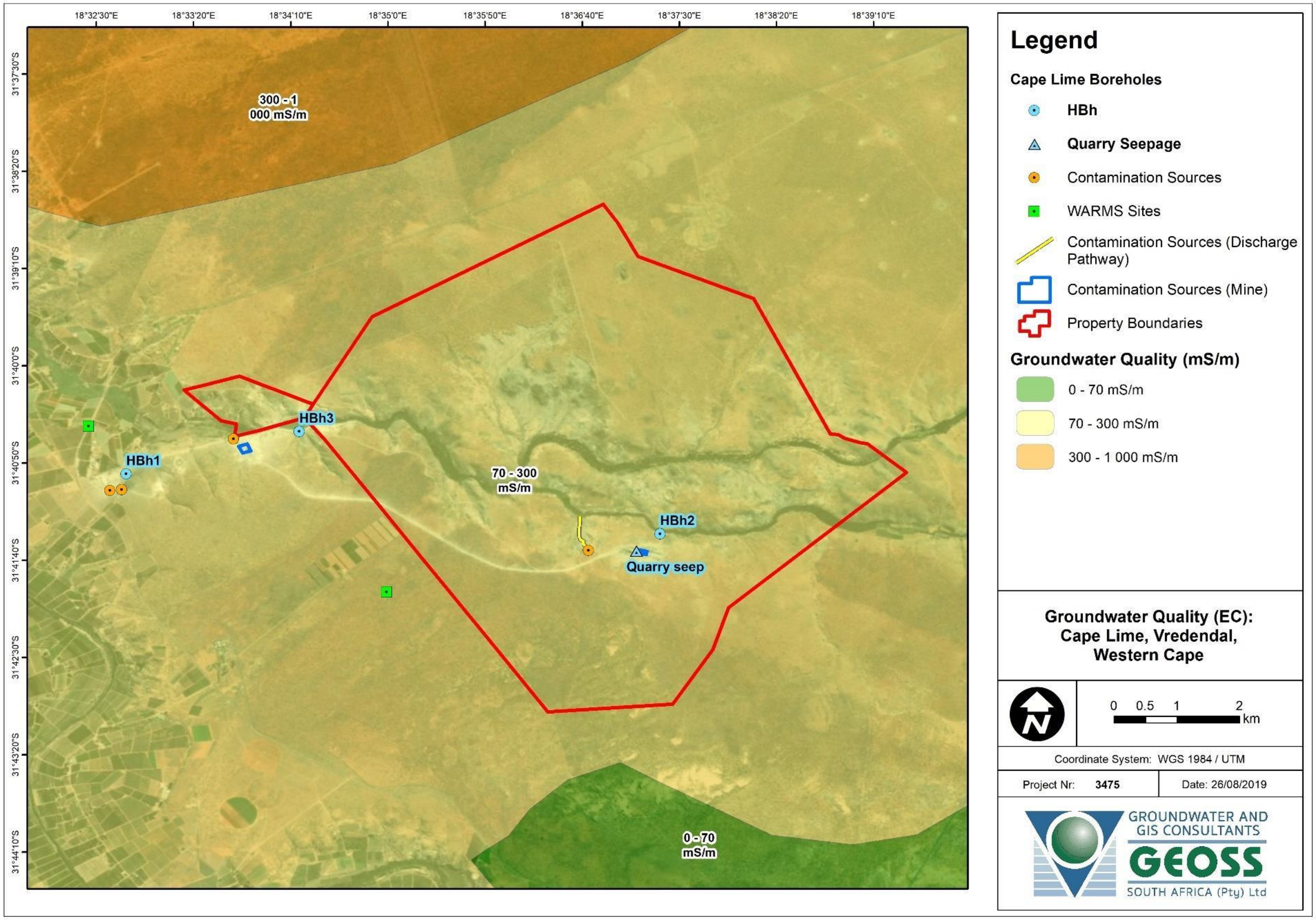
The aquifer below the Mine site is classified by DWS as a Karst aquifer with an average yield of 0.5 - 2 L/s (DWAF, 2000) (**Map 3**).Recharge occurs over much of the surface area of the aquifer through direct infiltration of rain water. The general groundwater flow direction is from north-east to south-west.

The groundwater quality according to the electrical conductivity (EC) for the regional aquifer underlying the site has been classified as average with an EC of 70 – 300 mS/m (**Map 4**) (WRC 2012). During the site visit, field chemistry taken at sampling points results found the range to be between 149.2 – 537 mS/m.

Both these classifications are based on regional datasets, and therefore only provide an indication of conditions to be expected. Groundwater in the area is generally considered as being of marginal quality where yields remain fairly low.



Map 3: Average expected yield and aquifer type (1:500 000 Hydrogeology map 3118 Calvinia, DWA, 2000)



Map 4: Regional groundwater quality (mS/m) from WRC (2012).

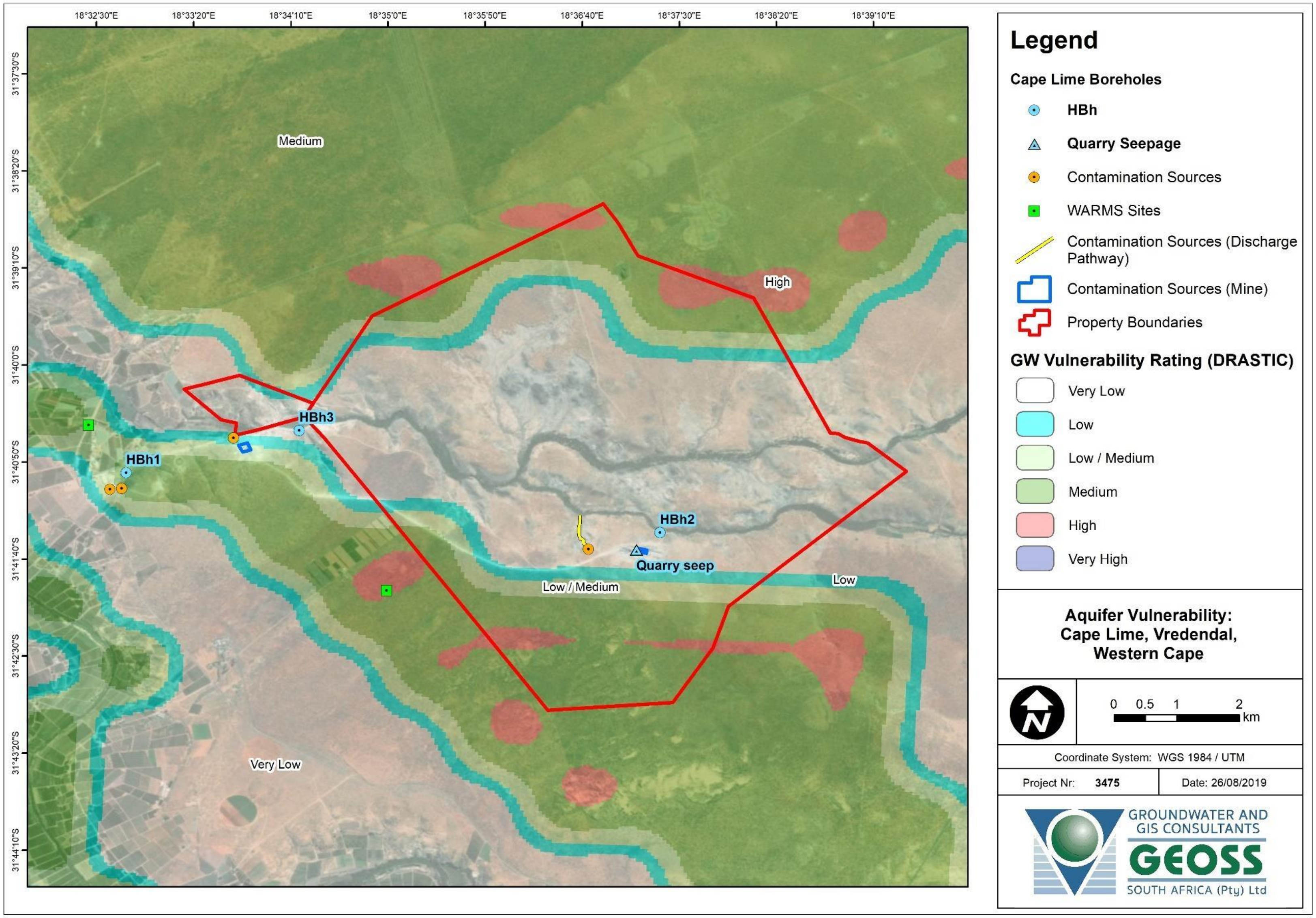
3.5 Aquifer vulnerability classification

The national scale groundwater vulnerability map, which was developed according to the DRASTIC methodology (DWAF, 2005) for vulnerability to surface-based contaminants (**Map 5**).

The DRASTIC method considers the following factors:

D = depth to groundwater (5)
R = recharge (4)
A = aquifer media (3)
S = soil type (2)
T = topography (1)
I = impact of the vadose zone (5)
C = conductivity (hydraulic) (3)

The number indicated in parenthesis at the end of each factor description is the weighting or relative importance of that factor. The majority of the site is classified as having a low vulnerability rating. This is likely due to the crystalline nature of the bedrock which has a very low pore space %. Borehole Bh1 is located on an area classified as medium, this likely due to the alluvial sediment below the site.



Map 5: Regional groundwater vulnerability for the study area with associated groundwater levels (mbgl) (DWAF, 2005).

4. SITE HISTORY

4.1 Historical Chemistry/ Yield test

The site has three reported boreholes of which two have collapsed. One borehole was assumed to be drilled by the previous owners Transhex prior to 1996. A constant head test was performed on the borehole named Factory Borehole. The test was conducted by Nel Pompdienste. **Table 2** below provides a summary of their test.

Table 2: Historical data.

Borehole Name:	Factory borehole (HBh1)
Test date:	10/12/1996
Casing diameter:	6.5 inch
Borehole Depth:	57 m
Water level:	35 mbgl
Test Duration	8 hours
Test pump depth	51 m
Maximum pump Yield (unsustainable)	33 750 L/hr

Historical chemistry data collected at Factory Borehole (Hbh1); the sample was collected on 19th December 1996 (**Table 3**). Historical water use from the borehole (**Table** 4) and the quarry (**Table 5**) is included.

Table 3: Historical groundwater quality

Elements/compounds	Concentrations	Factory borehole
pH	pH at 20 °C	7.1
Conductivity	mS/m	560
Total Dissolved Solids	mg/l	3584
Sodium (as Na)	mg/l	797
Potassium (as K)	mg/l	14.3
Magnesium (as Mg)	mg/l	150
Calcium (as Ca)	mg/l	202
Chloride (as Cl)	mg/l	1554
Sulphate (as SO4)	mg/l	407
Nitrate& Nitrite (as N)	mg/l	0.19
Fluoride (as F)	mg/l	0.2
Ammonia (N)	mg/l	0.1
Iron (as Fe)	mg/l	5.98
Alkalinity (CaCO3)	mg/l	205
Strontium	mg/l	1.42
Total Hardness (CaCO3)	mg/l	1121

Table 4: Historic water use data 2018 – 2019 for factory borehole

Month	Borehole Water 2018				Borehole Water 2019			
	Recording Date	Meter Reading	Volume Used	Dust Suppression Water	Recording Date	Meter Reading	Volume Used	Dust Suppression Water
		m³	*m³*	*Truck*		*m³*	*m³*	*Truck*
January	No record	0.00	0.00	0.00		43 680.00	2 290.00	0.00
February	No record	0.00	0.00			45 740.00	2 060.00	
March	30-Mar	8 920.00	8 920.00			49 660.00	3 920.00	
April	30-Apr	13 800.00	4 880.00			52 692.00	3 032.00	
May	31-May	19 650.00	5 850.00			55 031.00	2 339.00	
June	29-Jun	24 840.00	5 190.00			59 550.00	4 519.00	
July	31-Jul	30 520.00	5 680.00			63 000.00	3 450.00	
August	31-Aug	33 460.00	2 940.00				0.00	
September	September	35 230.00	1 770.00				0.00	
October	October	37 103.00	1 873.00				0.00	
November	November	39 555.00	2 452.00				0.00	
December	December	41 390.00	1 835.00				0.00	
Total			***41 390.00***	***0.00***			***0.00***	***0.00***

NOTE

January 2018 - No records.
February 2018 - Measuring device installed.

Table 5: Historic water use data 2018 – 2019 for quarry

Month	Quarry Water 2018				Quarry Water			
	Recording Date	**Meter Reading**	**Volume Used**	**Dust Suppression Water**	**Recording Date**	**Meter Reading**	**Volume Used**	**Dust Suppression Water**
2018		*m^3*	*m^3*	*Trucks*		*m^3*	*m^3*	*Trucks*
January	No record	0.00	0.00				0.00	
February	No record	0.00	0.00				0.00	
March	No record	0.00	0.00				0.00	
April	No record	0.00	0.00				0.00	
May	No record	0.00	0.00				0.00	
June	04-Jul	11 750.00	11 750.00				0.00	
July			0.00				0.00	
August			0.00				0.00	
September			0.00				0.00	
October			0.00				0.00	
November			0.00				0.00	
December			0.00				0.00	
Total			***0.00***	***0.00***			***0.00***	***0.00***

NOTE

January 2018 - No water removed from quarry during this period.
February 2018 - No water removed from quarry during this period.
11 May 2018 - Measuring device installed
31 May 2018 - No water removed from quarry during this period.

5. SITE VISIT

The field work associated with the geohydrological assessment took place on the 6th August 2019 and comprised of two components:

- a hydrocensus to determine the groundwater use and quality for an area of 1 km radius around the mine site.
- the collection of 3 water samples across the site to determine whether groundwater is present and what depth it occurs.

5.1 Hydrocensus

An initial desktop hydrocensus was carried out using a one-kilometre search radius around the property, to determine if there are any groundwater users in the area. A search of the National Groundwater Archive (NGA), which provides data on borehole positions, groundwater chemistry and yield, when available, was carried out to identify proximal boreholes. These sites are then typically verified in the field and provide background information on the area, should they exist.

The NGA indicated that there were no boreholes located within the 1 km search area of the mine. The WARMS database was then assessed to determine if any registered groundwater exists within the 1km search radius. Two sites were located. The sites are indicated on the maps in **Map 3** and **Map 4** and the WARMS information is summarised in **Table 6**.

Table 6: NGA groundwater information.

Registered ID	Latitude (WGS84)	Longitude (WGS84)	Registered volume m^3/annum
22013704	-31.699000	18.583200	88000
22031962	-31.675280	18.540560	256200

Both boreholes could not be located during the site assessment. The property on which registered borehole 22013704 is located is being rented to a tenant that is unaware of any existing borehole. The land owner also does not know of any groundwater users in the area, with the exception of the mine. He reported that the groundwater in the area is in general saline and low yielding. The majority of farm owners use the canal water system for irrigation

5.2 Site visit and hydrocensus

The site visit was then conducted to identify any boreholes on or in close proximity (1 km) of the site; the hydrocensus information is summarised in **Table 7**. A total of 3 boreholes were identified during the site visit and one seepage point. Two groundwater samples were collected at HBh1 and Quarry seepage, the third sample was collected from a tap that supplies water from the canal system.

It must be noted that groundwater is abstracted from a mining pit. Water is only abstracted when the level rises above a certain point which makes mining unsafe. The water is then discharged downgradient into a valley which feeds into the Wiedou River system and eventually the Olifants River. This activity triggers Section 21 (J) of the National Water Act (1998) that is the removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people. The mine site has submitted an application which is being processed.

Table 7: Hydrocensus boreholes and field chemistry.

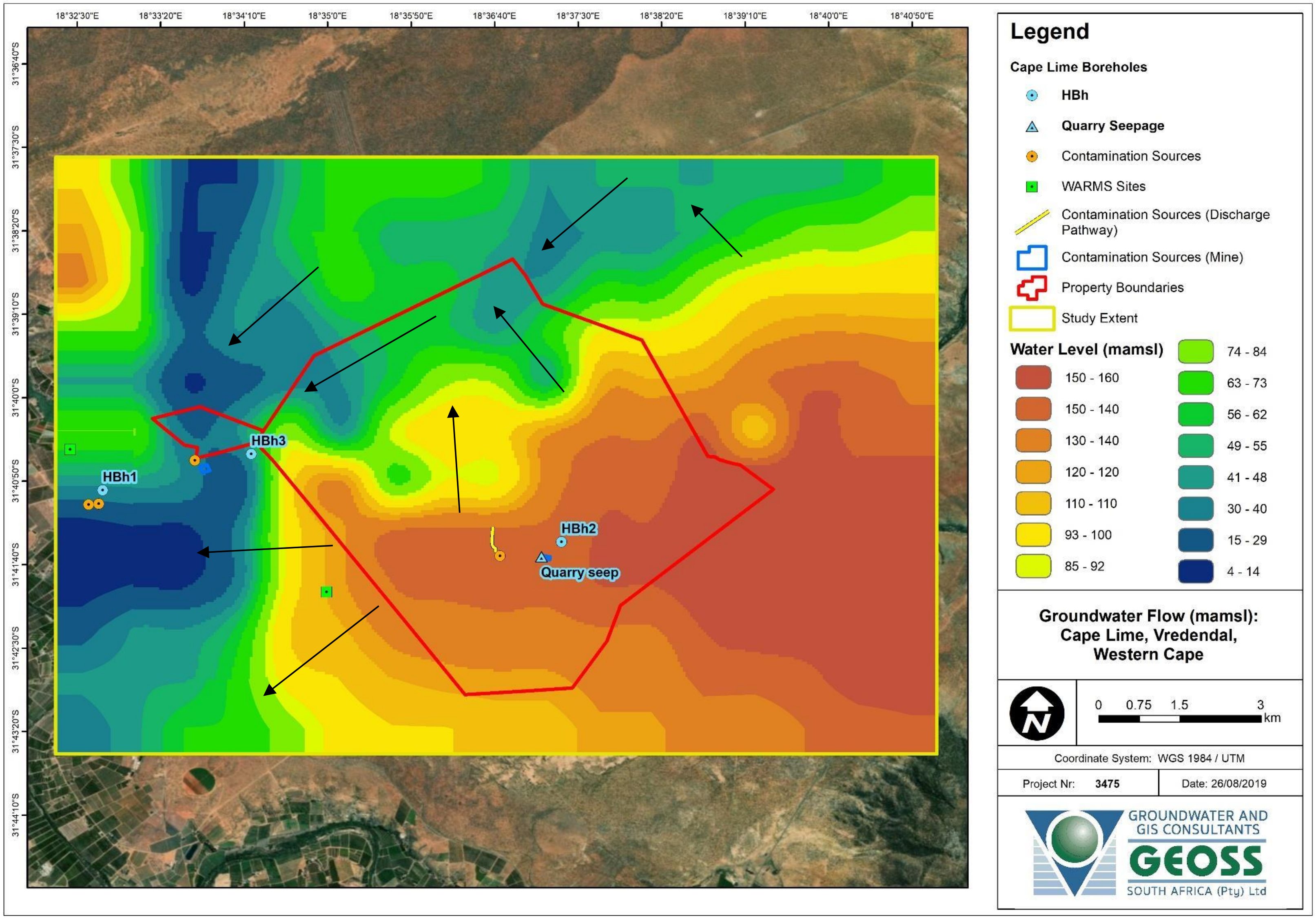
Label_ID	**Alternative name**	**Latitude (WGS84)**	**Longitude (WGS84)**	**Status**
HBh1	Factory borehole	-31.682095	18.545957	In use
HBh2	-	-31.690672	18.622481	collapsed
HBh3	-	-31.676048	18.570688	collapsed
Quarry Seepage	-	-31.693100	18.618891	In use

Label_ID	pH	EC (mS/m)	TDS	Temp (°C)	DO (%)	DO mg/L
HBh1	7.29	532.0	3616	22.7	82.7	7.17
Quarry Seepage	8.27	149.2	1087	19.7	98.5	9.08

- DO - Dissolved Oxygen
- TDS – Total dissolved solids

5.3 Auger holes

Auger holes where not possible due to the hard nature of the soil and the deep groundwater levels in the area > 21 mbgl.



Map 6: Ground water flow direction, indicated by black arrows.

6. GEOCHEMICAL ANALYSIS

Three samples were taken, one from production borehole (HBh_1), one from seepage point (Quarry_seep) within the quarry and one from a sample tap (Canal) on site and submitted for inorganic chemical analysis to SANAS accredited laboratory (Vinlab) in the Western Cape. The certificate of analysis for all the samples is presented in **Appendix A**.

The chemistry results obtained have been classified according to the SANS241-1: 2015 standards for domestic water. **Table 8** enables an evaluation of the water quality with regards to the various limits. **Table 9** presents the water chemistry analysis results, colour coded according to the SANS241-1: 2015 drinking water assessment standards.

Table 8: Classification table for specific limits

Acute Health
Aesthetic
Chronic health
Operational
Acceptable

Table 9: Localised groundwater results classified according the SANS241-1:2015

Analyses	Quarry_seep	Canal	HBh1	SANS 241-1:2015
pH (at 25 ºC)	7.8	7.4	7.5	≥5 - ≤9.7 Operational
Conductivity (mS/m) (at 25 ºC)	160.0	356.0	538.0	≤170 Aesthetic
Total Dissolved Solids (mg/L)	1084.8	2413.7	3647.6	≤1200 Aesthetic
Turbidity (NTU)	0.58	4.32	33.00	≤5 Aesthetic ≤1 Operational
Colour (mg/L as Pt)	<15	<15	37.0	≤15 Aesthetic
Sodium (mg/L as Na)	180.0	492.0	778.0	≤200 Aesthetic
Potassium (mg/L as K)	13.0	36.0	56.0	N/A
Magnesium (mg/L as Mg)	43.0	85.0	129.0	N/A
Calcium (mg/L as Ca)	86.0	119.0	176.0	N/A
Chloride (mg/L as Cl)	323.4	975.2	1498.2	≤300 Aesthetic
Sulphate (mg/L as SO4)	123.16	244.15	380.00	≤250 Aesthetic ≤500 Acute Health
Nitrate Nitrogen (mg/L as N)	2.55	<1.00	<1.00	≤11 Acute Health
Nitrite Nitrogen (mg/L as N)	<0.05	<0.05	<0.05	≤0.9 Acute Health
Ammonia Nitrogen (mg/L as N)	<0.15	<0.15	0.23	≤1.5 Aesthetic
Total Alkalinity (mg/L as CaCO3)	191.50	130.50	205.30	N/A
Total Hardness (mg/L as CaCO3)	391.30	0.00	968.90	N/A
Fluoride (mg/L as F)	1.2	0.5	0.2	≤1.5 Chronic Health
Aluminium (mg/L as Al)	<0.008	<0.008	<0.008	≤0.3 Operational
Total Chromium (mg/L as Cr)	<0.004	<0.004	<0.004	≤0.05 Chronic Health
Manganese (mg/L as Mn)	<0.000	0.00	0.0590	≤0.1 Aesthetic ≤0.4 Chronic Health
Iron (mg/L as Fe)	<0.000	0.08	1.6530	≤0.3 Aesthetic ≤2 Chronic Health
Nickel (mg/L as Ni)	<0.008	<0.008	<0.008	≤0.07 Chronic Health
Copper (mg/L as Cu)	0.0040	0.0060	0.0050	≤2 Chronic Health
Zinc (mg/L as Zn)	0.01	0.01	<0.008	≤5 Aesthetic
Arsenic (mg/L as As)	<0.01	<0.002	<0.002	≤0.01 Chronic Health
Selenium (mg/L as Se)	<0.008	0.0110	<0.008	≤0.04 Chronic Health
Cadmium (mg/L as Cd)	<0.003	<0.003	<0.003	≤0.003 Chronic Health
Antimony (mg/L as Sb)	<0.013	<0.000	<0.000	≤0.02 Chronic Health
Mercury (mg/L as Hg)	<0.001	<0.001	<0.001	≤0.006 Chronic Health
Lead (mg/L as Pb)	<0.008	<0.008	<0.008	≤0.01 Chronic Health
Uranium (mg/L as U)	<0.028	<0.028	<0.028	≤0.03 Chronic Health
Cyanide (mg/L as CN-)	<0.01	<0.01	<0.01	≤0.2 Acute Health
Total Organic Carbon (mg/L as C)	1.40	9.60	18.60	N/A
E.coli (count per 100 ml)	nd	0.0	0.0	Not Det. Acute Health-1
Total Coliform Bacteria (count per 100 ml)	nd	0.0	0.0	Not Det.≤10 Operational
Heterotrophic Plate Count (count per ml)	80.0	0.0	0.0	≤1000 Operational

The chemistry results obtained have been classified according to the DWAF (1998) standards for domestic water. **Table 10** enables an evaluation of the water quality with regards to the various parameters measured (DWAF, 1998). **Table 11** presents the water chemistry analysis results colour coded according to the DWAF drinking water assessment standards.

Table 10: Classification table for the localised groundwater results (DWAF, 1998)

Blue	**(Class 0)**	**Ideal water quality** - suitable for lifetime use.
Green	**(Class I)**	**Good water quality** - suitable for use, rare instances of negative effects.
Yellow	**(Class II)**	**Marginal water quality** - conditionally acceptable. Negative effects may occur.
Red	**(Class III)**	**Poor water quality** - unsuitable for use without treatment. Chronic effects may occur.
Purple	**(Class IV)**	**Dangerous water quality** - totally unsuitable for use. Acute effects may occur.

Table 11: Classified local groundwater results

Sample Marked :	**Quarry_seep**	**Canal**	**HBh1**	**DWA (1998) Drinking Water Assessment Guide**				
				Class 0	**Class I**	**Class II**	**Class III**	**Class IV**
pH	7.8	7.4	7.5	5-9.5	4.5-5 & 9.5-10	4-4.5 & 10-10.5	3-4 & 10.5-11	< 3 & >11
Conductivity (mS/m)	160.0	356.0	538.0	<70	70-150	150-370	370-520	>520
Turbidity (NTU)	0.58	4.32	33.00	<0.1	0.1-1	1.0-20	20-50	>50
	mg/L							
Total Dissolved Solids	1084.8	2413.7	3647.6	<450	450-1000	1000-2400	2400-3400	>3400
Sodium (as Na)	180.0	492.0	778.0	<100	100-200	200-400	400-1000	>1000
Potassium (as K)	13.0	36.0	56.0	<25	25-50	50-100	100-500	>500
Magnesium (as Mg)	43.0	85.0	129.0	<70	70-100	100-200	200-400	>400
Calcium (as Ca)	86.0	119.0	176.0	<80	80-150	150-300	>300	
Chloride (as Cl)	323.4	975.2	1498.2	<100	100-200	200-600	600-1200	>1200
Sulphate (as SO4)	123.2	244.2	380.0	<200	200-400	400-600	600-1000	>1000
Fluoride (as F)	1.2	0.5	0.2	<0.7	0.7-1.0	1.0-1.5	1.5-3.5	>3.5
Manganese (as Mn)	<0.000	0.00	0.06	<0.1	0.1-0.4	0.4-4	4.0-10.0	>10
Iron (as Fe)	<0.000	0.1	1.7	<0.5	0.5-1.0	1.0-5.0	5.0-10.0	>10
Copper (as Cu)	0.00	0.01	0.01	<1	1-1.3	1.3-2	2.0-15	>15
Zinc (as Zn)	0.01	0.01	<0.008	<20	>20			
Arsenic (as As)	<0.01	<0.002	<0.002	<0.010	0.01-0.05	0.05-0.2	0.2-2.0	>2.0
Cadmium (as Cd)	<0.003	<0.003	<0.003	<0.003	0.003-0.005	0.005-0.020	0.020-0.050	>0.050
Hardness (as CaCO3)	391.30	0	968.90	<200	200-300	300-600	>600	
	counts/100 mL							
Faecal coliforms	nd	0	0	0	0-1	1.0-10	10-100	>100
Total coliforms	nd	0	0	0	0-10	10-100	100-1000	>1000

From the results presented in **Table 9** and **Table 11** it is clear that the water quality varies over the site. This is likely due to the different geological formation underlying the site and water sources. The groundwater quality in the borehole ranges from marginal to dangerous water quality as classed by DWAF (1998) ideal to marginal (depending on the parameter), in terms of dissolved mineral concentrations.

Two chemical diagrams have been plotted from the samples which are useful for the chemical characterisation of the water. The chemistry of the samples has been plotted on a tri-linear diagram known as a Piper diagram (**Figure 3**). This diagram indicates the distribution of cations and anions in separate triangles and then a combination of the chemistry in the central diamond.

Figure 4 contains graphical representations of the relative concentrations of the major cations (positive ions) and major anions (negative ions). This diagram shows concentrations of cations and anions relative to each other (meq/L) and direct reference can be made to specific salts in the water. From the shape of the Stiff diagram the major ions present in the water can be compared.

From **Figure 3** (central diamond) and Stiff diagrams (**Figure 4**) it is clear that all samples can be classified as Sodium chloride type waters with the Quarry_seep Water being less mineralised with the lowest EC of 160 mS/m

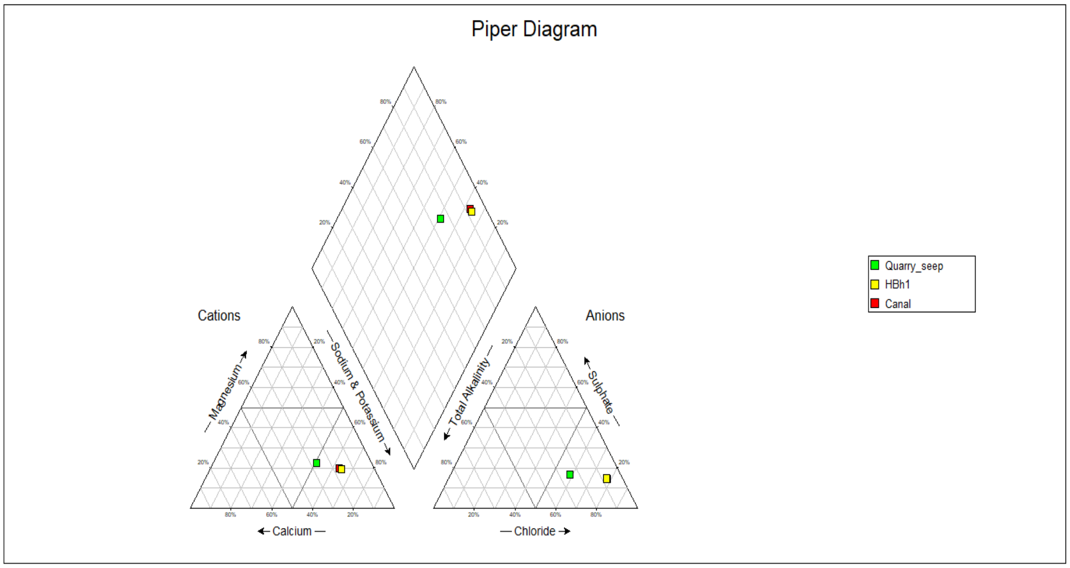


Figure 3: Piper diagram of the groundwater samples.

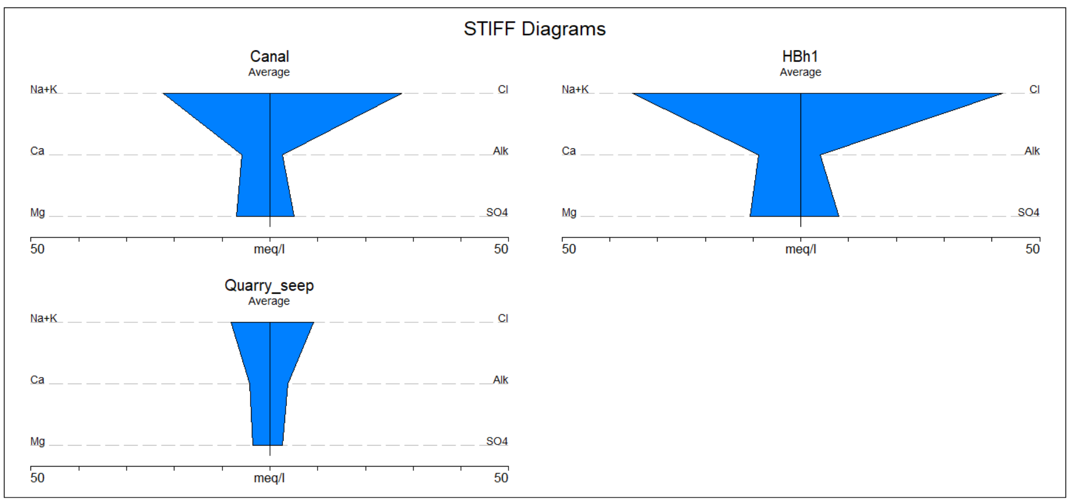


Figure 4: Stiff diagrams of groundwater samples.

7. RISK ASSESSMENT

To evaluate potential risks at the site, the potential sources, pathways and receptors are considered.

7.1 Sources

Many operations on the mine site production plant may contribute to the possible contamination. These include:

- plant effluent
- accidental overflow of Fuel tanks
- Hydraulic fluid and oil leaks from faulty equipment and trucks

- Wash bay for vehicles
- Leachate from coal stockpile
- Workshop leaks

The location of potential point sources has been summarised in **Table 12.**

Table 12: point source locations

Site location	Lat	Long
Wash bay for vehicles	-31.677136	18.561269
leachate from coal stockpile	-31.684354	18.545302
Workshop leaks	-31.684463	18.543600

The exact locations of some of the contamination sources are unknown, but due to the nature and extent of the operations on this site, zones of higher risk area is outlined in **Map** 7.

7.1 Pathways

The site overlies a fractured karst aquifer. The aquifer below the site is classified as having yield potential of 0.5 – 2 L/s. However, it is overlain by alluvial unconsolidated material which may have a high transmissivity rate. The active mining sites are relatively in close proximity to two main rivers which are used by the agricultural sector. There is thus a pathway for both groundwater and surface water contamination

7.2 Receptors

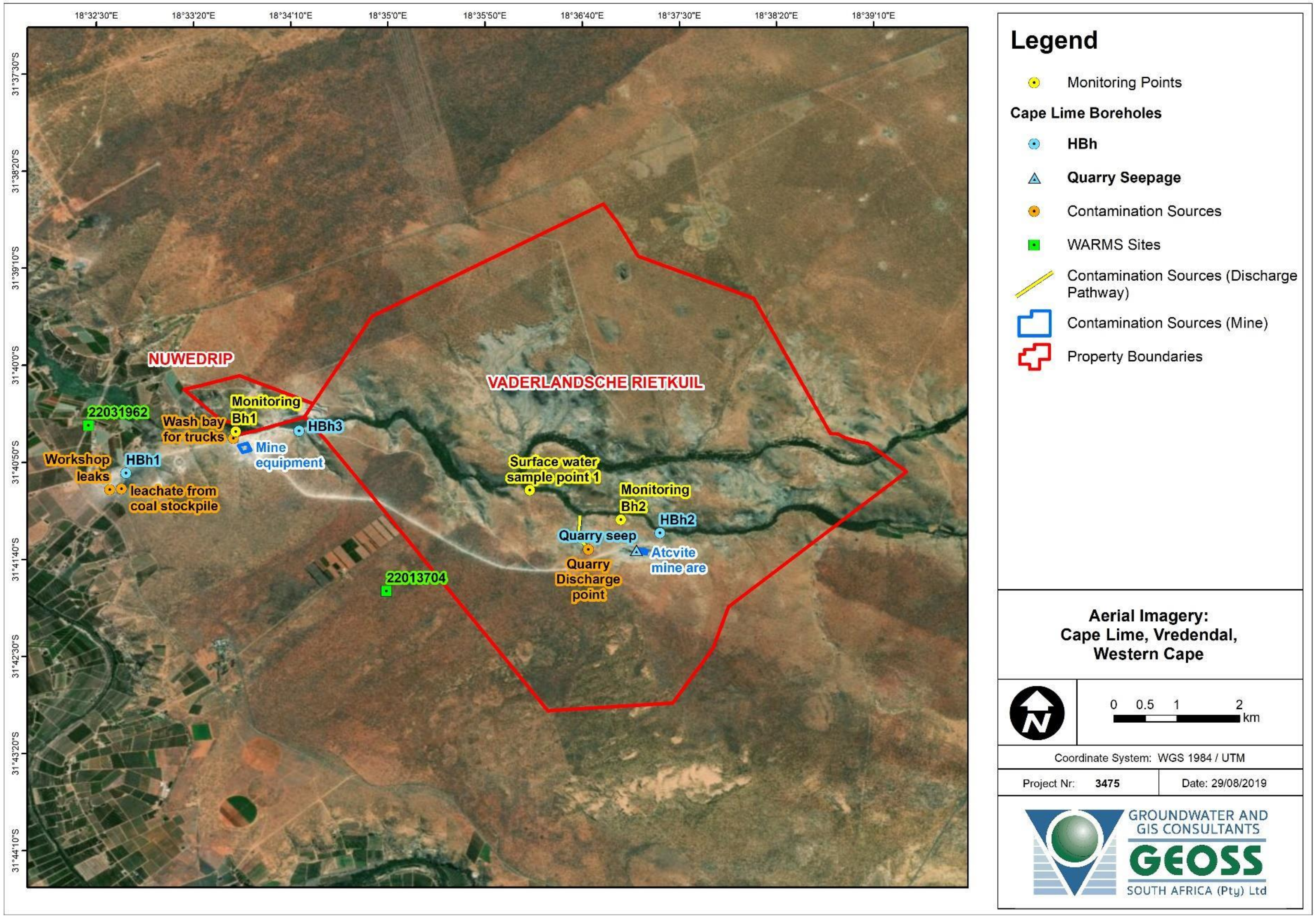
In terms of groundwater users in the area, there is no known private groundwater use. However, during the hydrocensus a farm owner mentioned that he may look to groundwater in the near future.

It has been determined that groundwater flows towards the south-west. Therefore, it can be assumed that groundwater and surface water users towards the south-west of the site could potentially be at risk if water is contaminated and then consumed without the necessary treatment.

7.3 Risk Assessment

The industrial nature of the site and presence of several contaminant sources means that groundwater and surface water contamination may occur.

The risk can be mitigated by implementing monitoring of water quality along the down gradient boundary of the property and at points where groundwater discharge enters rivers.



Map 7: Potential contamination sources on site and proposed monitoring points

8. POTENTIAL IMPACTS AND RECOMMENDATIONS

The above-mentioned risks and their potential impacts on receptors are presented in this chapter.

8.1 Potential Impacts

Table 13 to **Table 14** presents a summary of possible impacts associated with on site activities.

Table 13 : Impact table for surface water.

Removing and discharge of groundwater into a surface water body (river).						
Alternative	**Nature**	**Consequence**	**Extent**	**Duration**	**Probability**	**Significance**
Without Mitigation	Negative	Increase risk of introducing contaminants into surface water body, should vehicle and equipment break downs and leaks occur in mine pit	High	High	Medium	High
With Mitigation	Negative	Increased potential of surface water contamination, although reduced	Low	Low	Low	Low
Extent to which impact can be avoided, managed or mitigated	Impact can be managed and mitigated if all vehicles and machinery are serviced regularly and checked for leaks. Drip trays must be placed under pumps in close proximity to dewatering pit					
Proposed mitigation	Regular maintenance on vehicles and machinery and drip trays underneath of standing vehicles and equipment. **Once the license has been approved, in respect of 21 (j) of the NWA, all license conditions in this regard should also be implemented if not done so already.**					
Cleaning of Mine vehicle near river						
Alternative	**Nature**	**Consequence**	**Extent**	**Duration**	**Probability**	**Significance**
Without Mitigation	Negative	Increase risk of introducing contaminants	High	High	Medium	High

		into surface water body				
With Mitigation	Negative	Increased potential of surface water contamination, although reduced	Low	Low	Low	Low
Extent to which impact can be avoided, managed or mitigated	Impact can be managed and mitigated if the cleaning bays are built to prevent both runoff into river system and infiltration into the subsurface.					
Proposed mitigation	• Installation of wash bays with correct runoff drainage into collection tanks with water systems including settling ponds, sand filtration to remove sediment and contaminants. • Use of environmentally safe detergents.					

Table 14: Impact table for contamination to groundwater

Contamination of groundwater by leaching of coal stock piles.						
Alternative	**Nature**	**Consequence**	**Extent**	**Duration**	**Probability**	**Significance**
Without Mitigation	Negative	Leachate water from stockpiles infiltrating into groundwater system	High	High	High	High
With Mitigation (Storm water management system)	Negative	Potential of groundwater contamination, although reduced	Low	Low	Low	Low
Extent to which Impact can be avoided, managed or mitigated	Impact can be managed and mitigated if the regular clean ups are undertaken on the coal stockpiles. Currently, coal piles are underlain by concrete bunds, however overflow of coal is occurring onto areas without lining.					
Proposed mitigation	• Quarterly clean up around coal stockpile to make sure it is contained within the current bunded area. • Extension or additional concrete bunds to accommodate overflow of coal stock piles.					

Contamination of groundwater by workshop leaks.						
Alternative	**Nature**	**Consequence**	**Extent**	**Duration**	**Probability**	**Significance**
Without Mitigation	Negative	Contaminants from onsite fuel and potential chemical storage.	Low	Low	Low	Medium
With Mitigation (Storm water management system)	Negative	• Potential of groundwater contamination, although reduced • Concrete bunds underneath storage tanks.	Low	Low	Low	Low
Extent to which Impact can be avoided, managed or mitigated	Impact can be managed and mitigated by regular check-ups and maintenance on storage infrastructure.					
Proposed mitigation	Quarterly check-up on storage infrastructure and leak detection. Chemical storage must be contained within a bunded and contained structure.					

8.2 Recommendations

To prevent or minimize negative impacts on the groundwater and surface water caused by the mine, several mitigation measures are proposed. The risks associated with mining activities on the site include groundwater/surface water contamination. These risks can be mitigated if the appropriate design and construction measures are implemented.

The proposed site is on a minor aquifer system with a very low – medium vulnerability index and low aquifer susceptibility. Based on the classifications a basic groundwater monitoring system should be put in place near active mine sites and groundwater discharge locations (see **Map 7**). Installation of screened holes on the proposed site can give valuable groundwater level information. This is an affordable and accurate means of groundwater level monitoring. Monitoring should be conducted by a qualified hydrogeologist on a quarterly basis (every 3 months) for at least 3 years after which a review of the monitoring program should be conducted. Quarterly field chemistry measurements should also be taken, along with annual samples for analysis. This will provide information regarding the impacts of the mine

The risks associated with the mine are groundwater contamination (caused by increased pollutant transportation associated with leachate of coal stock piles and chemical storage facilities onsite), surface water contamination (caused by the dewatering of a mine pit and discharging the excess water downgradient into the Olifants River) and the washing of mine vehicles outside of designated wash bay zones. The discharge of the quarry seep water is currently undergoing a license application. The conditions required by the license should address this and be incorporated into the EMPr.

In addition to monitoring the ground water quality, a surface water management system should be implemented as part of the site duty of care. Surface water samples should be collected downgradient of mining activities within the Olifants river system. This, together with the groundwater samples, will provide a warning system of contamination should it occur, and trigger necessary clean-up and mitigation methods.

9. REFERENCES

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WRC (2012). A Groundwater Planning Toolkit for the Main Karoo Basin: Identifying and quantifying groundwater development options incorporating the concept of wellfield yields and aquifer firm yields. WRC Report No. 1763/1/11, Pretoria, South Africa.

10. APPENDIX A: LABORATORY RESULTS

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13 August 2019

TEST REPORT

Water

Geoss South Africa (Pty) Ltd
Attn: Julian Conrad
Contact No: 0218801079
P.O.Box 12412
Die Boord, Stellenbosch
7613

@VinlabSA

Sample Details							
Sample ID			DW Limit	W4656	Date Tested	W4657	Date Tested
Water Type				Drinking Water		Drinking Water	
Water Source				Borehole			
Sample Temperature							
Description				#3475A_BH1		#3475A_Canal_ Water	
PO Number				#3475A_Mine		#3475A_Mine	
Date Received				2019/08/08		2019/08/08	
Condition				Good		Good	
Water - Routine							
pH@25C* (Water)		VIN-05-MW01	>= 5 to <= 9.7	7.48	2019/08/08	7.37	2019/08/08
Conductivity@25C* (Water)	mS/m	VIN-05-MW02	<= 170	538.0	2019/08/08	356.0	2019/08/08
Turbidity (Water)	ntu		<= 5	33.0	2019/08/08	4.32	2019/08/08
Total dissolved solids (Water)	mg/L		<= 1200	3647.64	2019/08/08	2413.68	2019/08/08
Free Cl (Water)	mg/L		<= 5	<0.02	2019/08/08	<0.02	2019/08/08
Ammonia (NH4) as N (Water)	mg/L		<= 1.5	0.230	2019/08/08	<0.15	2019/08/08
Nitrate as N (Water)	mg/L		<= 11	<1.00	2019/08/08	<1.00	2019/08/08
Nitrite as N (Water)	mg/L		<= 0.9	<0.05	2019/08/08	<0.05	2019/08/08
Chloride (Cl-) - Water	mg/L		<= 300	1498.15	2019/08/08	975.20	2019/08/08
Sulphates (SO4) - Water	mg/L		<= 500	380.00	2019/08/08	244.15	2019/08/08
Fluoride (F) - Water	mg/L		<= 1.5	0.17	2019/08/08	0.49	2019/08/08
Alkalinity as CaCO3 (Water)	mg/L			205.30	2019/08/08	130.50	2019/08/08
Colour (Water)	mg/L Pt-Co		<= 15	37	2019/08/08	<15	2019/08/08
Cyanide (CN) - Water	µg/L		<= 200	<10.0	2019/08/08	<10.0	2019/08/08
Bicarbonate (HCO3) - Water	mg/L			250.47	2019/08/08	159.21	2019/08/08
Total Organic Carbon (Water)	mg/L		<=10	18.6	2019/08/12	9.6	2019/08/12
Water - Metals							
Calcium* (Ca) - Water	mg/L	VIN-05-MW43		176	2019/08/08	119	2019/08/08
Magnesium* (Mg) - Water	mg/L	VIN-05-MW43		129	2019/08/08	85	2019/08/08
Sodium* (Na) - Water	mg/L	VIN-05-MW43	<= 200	778	2019/08/08	492	2019/08/08
Potassium* (K) - Water	mg/L	VIN-05-MW43		56	2019/08/08	36	2019/08/08
Zinc* (Zn) - Water	mg/L	VIN-05-MW43	<= 5	<0.008	2019/08/08	0.012	2019/08/08
Antimony (Sb) - Water	µg/L		<= 20	<13.0	2019/08/12	<13.0	2019/08/12
Arsenic (As) - Water	µg/L		<= 10	<10.0	2019/08/12	<10.0	2019/08/12
Boron (B) - Water	µg/L		<= 2400	1128	2019/08/08	766	2019/08/08
Cadmium (Cd) - Water	µg/L		<= 3	<3	2019/08/08	<3	2019/08/08
Chromium* (Cr) - Water	µg/L	VIN-05-MW43	<= 50	<4	2019/08/08	<4	2019/08/08
Copper* (Cu) - Water	µg/L	VIN-05-MW43	<= 2000	5	2019/08/08	6	2019/08/08
Iron* (Fe) - Water	µg/L	VIN-05-MW43	<= 2000	1653	2019/08/08	80	2019/08/08
Lead* (Pb) - Water	µg/L	VIN-05-MW43	<= 10	<8	2019/08/08	<8	2019/08/08
Manganese* (Mn) - Water	µg/L	VIN-05-MW43	<= 400	59	2019/08/08	4	2019/08/08
Nickel* (Ni) - Water	µg/L	VIN-05-MW43	<= 70	<8	2019/08/08	<8	2019/08/08

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VIN 09-01 08-07-19

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sanas Testing Laboratory T0885

Doc No: V15247

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Geoss South Africa (Pty) Ltd
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Sample ID			DW Limit	W4656	Date Tested	W4657	Date Tested
Selenium (Se) - Water	µg/L		<= 40	<10.0	2019/08/12	11	2019/08/12
Aluminium* (Al) - Water	µg/L	VIN-05-MW43	<= 300	<8	2019/08/08	<8	2019/08/08
Mercury (Hg) - Water	µg/L		<= 6	<1.0	2019/08/12	<1.0	2019/08/12
Barium (Ba) - Water	µg/L		<= 700	53	2019/08/08	53	2019/08/08
Uranium (U) - Water	µg/L		<= 30	<28	2019/08/12	<28	2019/08/12

AEFourie

Adelize Fourie
Laboratory Manager (Waterlab)
VIN-05-M01,M02,M03,M04,M05,MO8,M10,M28, M43, MW01, MW02, MW03, MW04, MW05, MW06, MW07

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Water

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@VinlabSA

Sample Details							
Sample ID			DW Limit	W4658	Date Tested		
Water Type				Drinking Water			
Water Source							
Sample Temperature							
Description				#3475A_Quarry_Seep			
PO Number				#3475A_Mine			
Date Received				2019/08/08			
Condition				Good			
Water - Routine							
pH@25C* (Water)		VIN-05-MW01	>= 5 to <= 9.7	7.79	2019/08/08		
Conductivity@25C* (Water)	mS/m	VIN-05-MW02	<= 170	160.0	2019/08/08		
Turbidity (Water)	ntu		<= 5	0.58	2019/08/08		
Total dissolved solids (Water)	mg/L		<= 1200	1084.80	2019/08/08		
Free Cl (Water)	mg/L		<= 5	<0.02	2019/08/08		
Ammonia (NH4) as N (Water)	mg/L		<= 1.5	<0.15	2019/08/08		
Nitrate as N (Water)	mg/L		<= 11	2.55	2019/08/08		
Nitrite as N (Water)	mg/L		<= 0.9	<0.05	2019/08/08		
Chloride (Cl-) - Water	mg/L		<= 300	323.36	2019/08/08		
Sulphates (SO4) - Water	mg/L		<= 500	123.16	2019/08/08		
Fluoride (F) - Water	mg/L		<= 1.5	1.16	2019/08/08		
Alkalinity as CaCO3 (Water)	mg/L			191.50	2019/08/08		
Colour (Water)	mg/L Pt-Co		<= 15	<15	2019/08/08		
Cyanide (CN) - Water	µg/L		<= 200	<10.0	2019/08/08		
Bicarbonate (HCO3) - Water	mg/L			233.63	2019/08/08		
Total Organic Carbon (Water)	mg/L		<=10	1.4	2019/08/12		
Water - Metals							
Calcium* (Ca) - Water	mg/L	VIN-05-MW43		86	2019/08/08		
Magnesium* (Mg) - Water	mg/L	VIN-05-MW43		43	2019/08/08		
Sodium* (Na) - Water	mg/L	VIN-05-MW43	<= 200	180	2019/08/08		
Potassium* (K) - Water	mg/L	VIN-05-MW43		13	2019/08/08		
Zinc* (Zn) - Water	mg/L	VIN-05-MW43	<= 5	0.009	2019/08/08		
Antimony (Sb) - Water	µg/L		<= 20	<13.0	2019/08/12		
Arsenic (As) - Water	µg/L		<= 10	<10.0	2019/08/12		
Boron (B) - Water	µg/L		<= 2400	266	2019/08/08		
Cadmium (Cd) - Water	µg/L		<= 3	<3	2019/08/08		
Chromium* (Cr) - Water	µg/L	VIN-05-MW43	<= 50	<4	2019/08/08		
Copper* (Cu) - Water	µg/L	VIN-05-MW43	<= 2000	4	2019/08/08		
Iron* (Fe) - Water	µg/L	VIN-05-MW43	<= 2000	<10	2019/08/08		
Lead* (Pb) - Water	µg/L	VIN-05-MW43	<= 10	<8	2019/08/08		
Manganese* (Mn) - Water	µg/L	VIN-05-MW43	<= 400	<4	2019/08/08		
Nickel* (Ni) - Water	µg/L	VIN-05-MW43	<= 70	<8	2019/08/08		

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@VinlabSA

Sample ID			DW Limit	W4658	Date Tested		
Selenium (Se) - Water	µg/L		<= 40	<10.0	2019/08/12		
Aluminium* (Al) - Water	µg/L	VIN-05-MW43	<= 300	<8	2019/08/08		
Mercury (Hg) - Water	µg/L		<= 6	<1.0	2019/08/12		
Barium (Ba) - Water	µg/L		<= 700	<30	2019/08/08		
Uranium (U) - Water	µg/L		<= 30	<28	2019/08/12		

AEFourie

Adelize Fourie

Laboratory Manager (Waterlab)

VIN-05-M01,M02,M03,M04,M05,MO8,M10,M28, M43, MW01, MW02, MW03, MW04, MW05, MW06, MW07

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11. APPENDIX A: SITE PHOTOS

Photo 1: Quarry dewatering pump.

Photo 2: Quarry discharge point into Olifants river

Photo 3: Hbh1(production)

Photo 4: HBh2 (collapsed)

Photo 5: HBh3 (collapsed and inhabited by Bees)

Photo 6: Vehicle wash bay

Photo 7: Coal stockpile (overflow)

Photo 8: Coal stockpile (overflow)

(Last page)