WULA compliant geohydrological assessment for Afrimat on Farm Welverdiend (RE 511) near Vanrhynsdorp.

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11 August 2020

GROUNDWATER AND EARTH SCIENCES
GEOSS
SOUTH AFRICA (Pty) Ltd

EXECUTIVE SUMMARY

Afrimat appointed GEOSS South Africa (Pty) Ltd to carry out the task of conducting a geohydrological assessment for Farm Welverdiend (RE Farm 511), Vanrhynsdorp, for the mining of Dolomitic Limestone Deposits. The Applicant has been awarded a Mining Right in terms of Section 22 of the Mineral and Petroleum Resources Development Act 2002 (Act No. 28 of 2002) for the mining of limestone and dolomite within a 321.11 ha mining rights area. The proposed expansion activities are intended to expand the already authorised mining activities of 6 ha.

The proposed site is underlain by a deposit of high-grade (97.3%) limestone (dolomitic limestone). This deposit (the ore body) is located in the Widouw Formation of the late Precambrian Gifberg Group. The Precambrian bedrocks underlying the site (including the target limestone ore body) are metamorphosed, recrystallized and highly deformed. The limestone deposit manifests as a light-grey fine- to medium/coarse-grained, crystalline, exceptionally homogenous, very high-grade calcium carbonate/ marble rock. The thickness of the ore-body (limestone deposit) varies from 20 m in the west to 66 m in the eastern section of the deposit. The ore body itself is underlain by siliceous graphitic and phyllitic rock and the contact between the ore body and the foot-wall schist is sharp.

Cape Lime (Pty) Ltd is the holder of a Mining Right in terms of Section 22 of the Mineral and Petroleum Resources Development Act 2002 (Act No. 28 of 2002) for the mining of limestone and dolomite within a 321.11 ha mining rights area of which proposed mining activities will take place in only a small (±6.3 ha) section.

The proposed mining area is located in an extremely sparsely populated area. No groundwater use occurs within a 2 km radius of the proposed site. The nearest production borehole is located 3 km from the site. Thus, within the region groundwater is not deemed a major source of water for socio-economic purposes. In general, groundwater levels are deep in the area (>66 mbgl) and considering the hydrogeological setting groundwater will not be impacted by any surface-based activities.

The groundwater quality in the vicinity of the proposed mine is classified as "marginal" and all standard measures must be taken to protect the groundwater quality. This means there are to be no oil leaks from vehicles, generators and heavy machinery. Storage of fuels and lubricants must be on a hardened surface, as well as where the vehicles are filled with fuel. When vehicles/machinery is serviced the old oil must be correctly disposed of.

Recommendation regarding license application and proposed license conditions:

- Based on information obtained and analysed in the geohydrological assessment the following license conditions related to the mining operation should be proved on condition that:
    a. The mining operation does not exceed the proposed excavation of 60 mbgl.
    b. The mining operation should not extend up to depths within 5 meters of the groundwater level. In the unlikely event where layers such as clay lenses are intersected or groundwater is intersected a specialist should be consulted to assess and provide mitigation measures.

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ABBREVIATIONS

Approx	Approximately
BH	Borehole
°C	degrees Celsius
CGS	Council for Geoscience (Est 1993 formerly the Geological Survey of South Africa)
DD	Decimal degrees
DWA	Department of Water Affairs (pre- 1994)
DWAF	Department of Water Affairs and Forestry (Est. 1994 up until May 2009)
DWS	Department of Water and Sanitation (DWS was established in May 2009 until present.
EC	Electrical Conductivity
ET	Evapotranspiration
FC	Flow Characteristic
GIS	Geographical Information System
ha	hectare
hr/day	hours per day
ID	Identity
km	kilometre
km^2	square kilometre
L/hr	litres per hour
L/s	litres per second
$L/s/km^2$	litres per second per square kilometre
m	metres
m^2	Square metres
m^3/a	metres cubed per annum
m^3/day	metres cubed per day
$m^3/ha/a$	metres cubed per hectare per annum
$m^3/month$	metres cubed per month
MAE	Mean annual evaporation
mamsl	metres above mean sea level
MAP	Mean annual precipitation

MAR	Mean annual run-off
Max	Maximum
mbgl	metres below ground level
mg/L	milligrams per litre
Min	Minimum
mm	millimetre
mm/a	millimetres per annum
Mm^3/a	Million cubic metres per annum
mS/m	milliSiemens per meter
NGA	National Groundwater Archive
PVC	Polyvinyl chloride
Q	Discharge/yield
RWL	Rest water level
S	Storativity
SANAS	South African National Accreditation System
SANS	South African National Standard
SAR	Sodium Absorption Ratio
Std. Dev	Standard deviation
T	Transmissivity
Temp	Temperature
WARMS	Water Authorisation and Registration Management System
WGS84	The official co-ordinate system for South Africa
WL	water level
WRC	Water Research Commission
WULA	Water Use Licence Application.

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)].

Drawdown: The distance between the static water level and the surface of the cone of depression (DWS, 2011).

Fractured aquifer: Fissured and fractured bedrock resulting from decompression and/or tectonic action. Groundwater occurs predominantly within fissures and fractures.

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.

Quaternary Catchment: A fourth order catchment in a hierarchal classification system in which a primary catchment is the major unit (DWS, 2011).

Transmissivity: the rate at which a volume of water is transmitted through a unit width of aquifer under a unit hydraulic head (m^2/d); product of the thickness and average hydraulic conductivity of an aquifer.

Suggested reference for this report:

GEOSS (2020). WULA compliant geohydrological assessment for Afrimat on Farm Welverdiend (RE 511) near Vanrhynsdorp. GEOSS Report Number: 2020/06-11. GEOSS South Africa (Pty) Ltd. Stellenbosch, South Africa.

Cover photo:

Feld view of the study area.

GEOSS project number:

2018_03-2872

Reviewed by:

Neville Paxton and Julian Conrad (26 June 2020).

1. INTRODUCTION

Afrimat appointed GEOSS South Africa (Pty) Ltd to carry out the task of conducting a geohydrological assessment for Farm Welverdiend (RE Farm 511), Vanrhynsdorp, for the mining of Dolomitic Limestone Deposits. **(Figure 1)**. The Applicant has been awarded a Mining Right in terms of Section 22 of the Mineral and Petroleum Resources Development Act 2002 (Act No. 28 of 2002) for the mining of limestone and dolomite within a 321.11 ha mining rights area. The proposed expansion activities are intended to expand the already authorised mining activities of 6 ha.

The proposed project entails the clearing of 45 ha of virgin (undeveloped) land for the purposes of mining limestone deposits, the erection of a crushing plant, four (4) Fluid Bed Lime Calciners and associated supporting services. The total footprint of the mining development on the Remainder of Farm 511 (Welverdiend), Vanrhynsdorp, will be ± 34 ha and the process plant and logistical facilities will have a maximum footprint of 11ha.

It is envisaged that the following supporting service infrastructure will be provided on site:

- Workshops for mechanical and electrical maintenance.
- Laboratory for quality control test-work.
- Administrative offices including a weighbridge.

The layout will be planned to allow the phasing in of the four (4) kilns to the process line as and when required and justified. It will also include related logistical facilities, workshops and an office complex. The mining would be operated as an open pit strip mining operation. The actual, strip mine would mine to typically a depth of 40 to 60 meters below the surface with an anticipated life of mine (LOM) of approximately 10 years.

2. TERMS OF REFERENCE (ToR)

The main objectives of this project are to:

- Complete a geohydrological characterization of the groundwater, in the vicinity of the property.
- Complete an assessment of the importance of groundwater (both socio-economic and environmental) in the area by means of a public participation hydrocensus.
- Document the above findings in a format fully compatible with the requirements for a water use license application (which is to be submitted to Department Water and Sanitation (DWS)).

3. REGIONAL SETTING

3.1 General

The Farm Welverdiend (RE Farm 511) is located just south of Vanrhynsdorp in the Western Cape. The property is located within quaternary catchment E33G which forms part of the Berg-Olifants Water Management Area. The quaternary catchment E33G is approximately 894.2 km^2. The site is located on an undulating plain, with relatively flat areas interspersed with low-undulating hills. Mauwerskop is located 5.5 km north-east of the site, while the Matzikama mountains are 7.5 km due east, and the Gifberg, Windhoekberg and Spitsberg mountain ranges are located 4 – 6 km south of the proposed mining site. The major watercourses in the surrounding landscape include the Wiedou River, which flows along the southern boundary of Welverdiend (120 – 200 m south/ south-west of the development site), and the Troe-Troe River which flows 3.5 km north-west of the site.

The study area, within a regional context, is shown in **Figure 1**. **Figure 2** and **Figure 3** show more detailed views of the site with relevant information (borehole positions on the property) superimposed on a 1:50 000 topo-cadastral map and aerial image respectively.

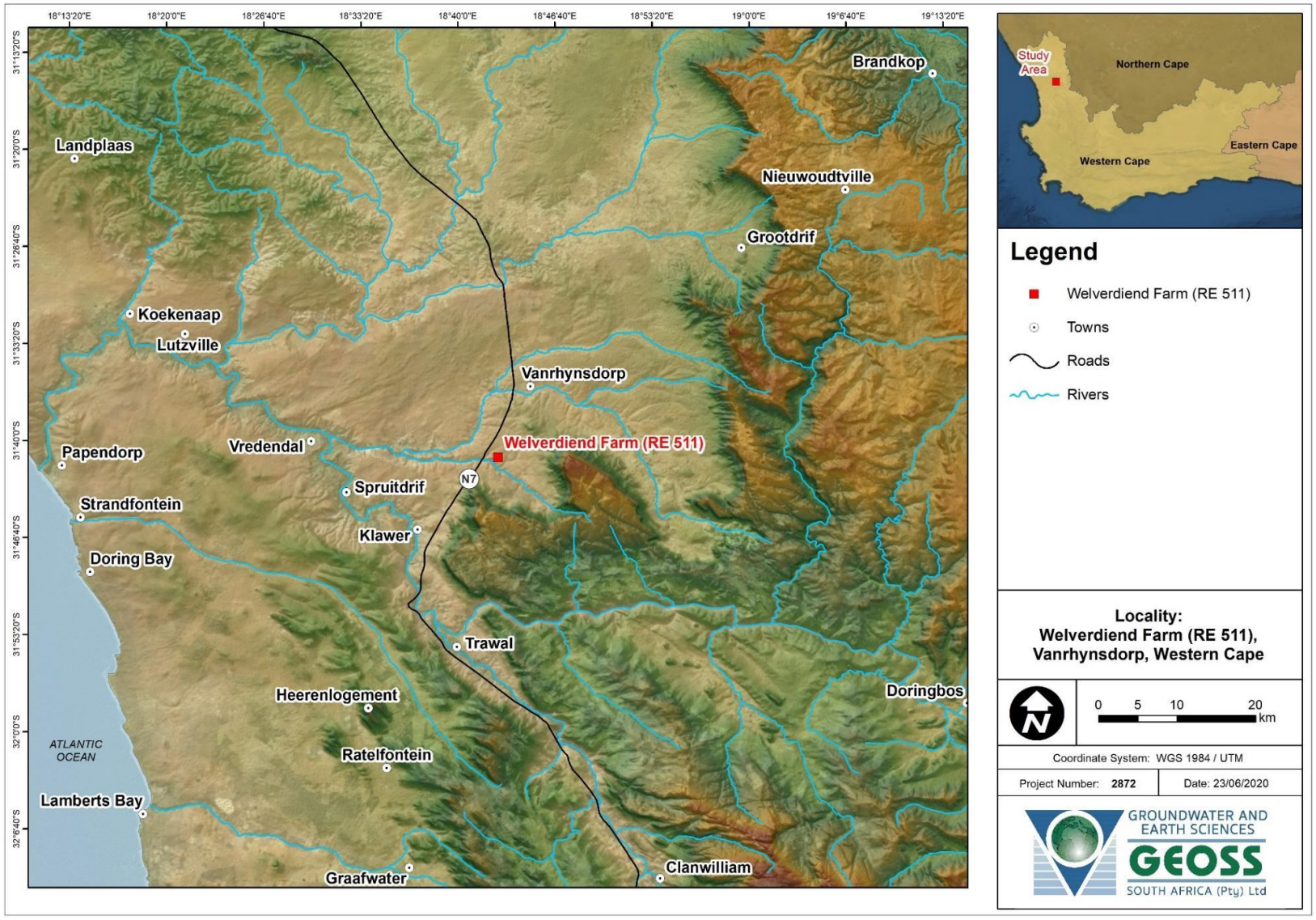

Figure 1: Location of the study area within a regional setting.

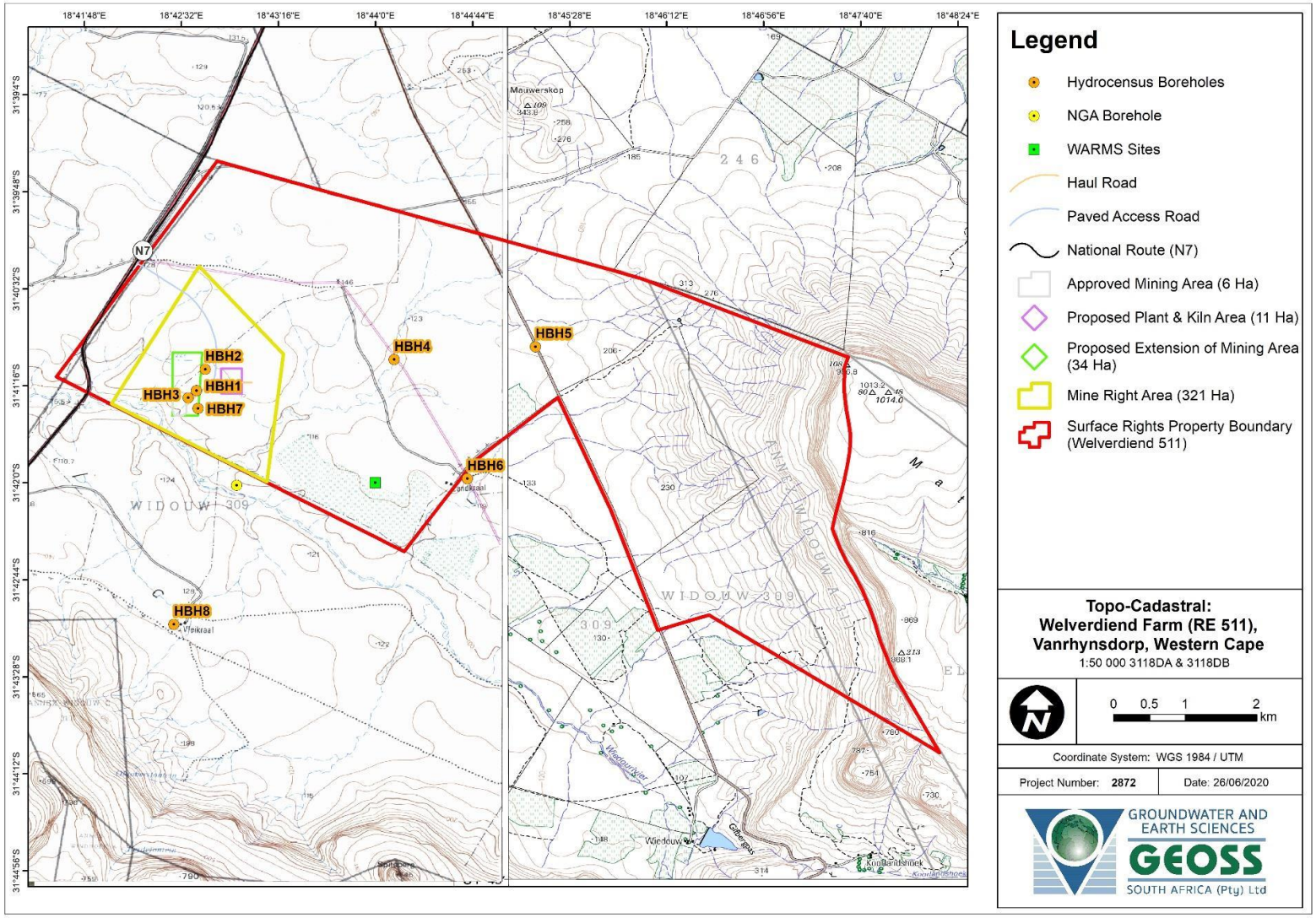

Figure 2: The study site, production borehole, NGA boreholes, WARMS sites and hydrocensus boreholes superimposed on a 1:50 000 scale topo-cadastral map (3318DB & 3318 DD).

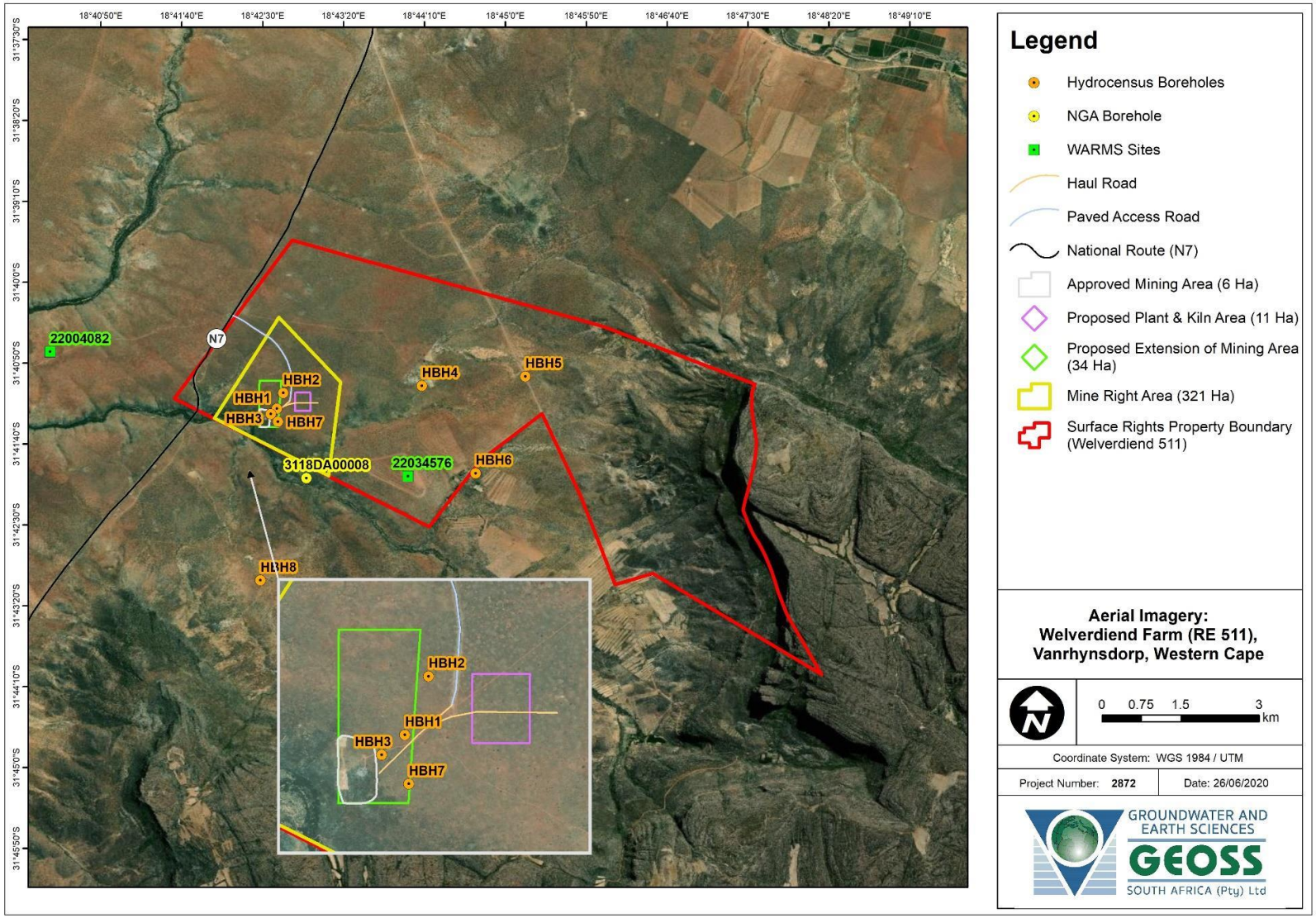

Figure 3: The study site, production borehole, NGA boreholes, WARMS sites and hydrocensus boreholes superimposed on an aerial photograph.

3.2 Climate

The mining site experiences an Arid Climate with hot dry summer months and cold wet winter months with low rainfall. **Figure 4** shows the monthly average minimum and maximum air temperature distribution and **Figure 5** shows the monthly median rainfall and evaporation distribution for the site (Schulze, 2009). The long term (1950 – 2000) mean annual precipitation for the area is 160 mm/a. The area experiences the highest rainfall during the winter months and the peak groundwater recharge period will thus be in the winter. During the summer months groundwater assists in meeting the water requirements for nearby agricultural holdings and other land use.

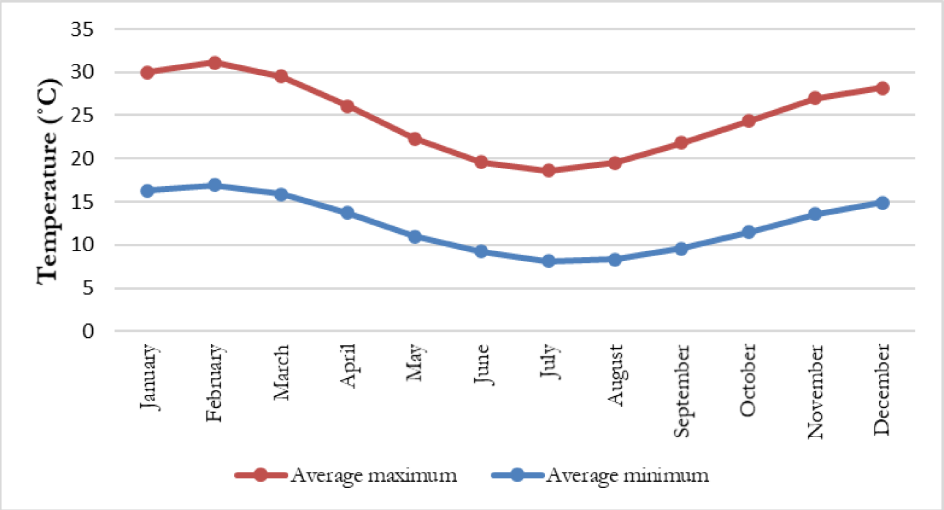

Figure 4: Monthly average air temperature distribution for the study area (Schulze, 2009).

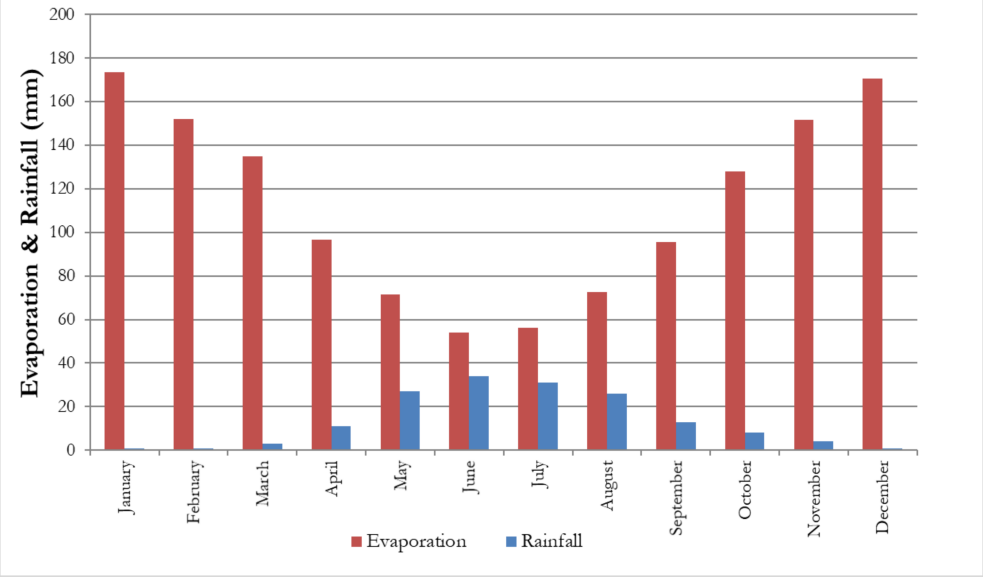

Figure 5: Monthly average rainfall and evaporation distribution for the study area (Schulze, 2009).

4. REGIONAL GEOLOGY

The Geological Survey of South Africa (now the Council for Geoscience) has mapped the area at 1: 250 000 scale (3318, Cape Town). The main geology of the area is listed in **Table 3** and the geological setting is shown in **Figure 6**.

Table 1: Geological Formations in the study area

CODE	Formation		Group
Q-r2	-		Quaternary
Nwi	Widouw	Siliceous graphitic and phyllitic rock.	Gifberg (Gariep Supergroup)

The proposed site is underlain by a deposit of high-grade (97.3%) limestone (dolomitic limestone). This deposit (the ore body) is located in the Widouw Formation of the late Precambrian Gifberg Group.

The Precambrian bedrocks underlying the site (including the target limestone ore body) are metamorphosed, recrystallized and highly deformed. The limestone deposit manifests as a light-grey fine- to medium/coarse-grained, crystalline, exceptionally homogenous, very high-grade calcium carbonate/ marble rock. The thickness of the ore-body (limestone deposit) varies from 20 m in the west to 66 m in the eastern section of the deposit. The ore body itself is underlain by siliceous graphitic and phyllitic rock and the contact between the ore body and the foot-wall schist is sharp.

The limestone ore body is covered by an overburden which comprises clay, silt and sand as well as hard silcrete bands. These superficial deposits of the overburden date from the Late Cenozoic (Late Tertiary or Neogene, to Recent) age. The overburden is 0.75 m thick over the southern portion of the ore body and increases in thickness in a northerly direction, to 1.6 m thick in the north of the proposed mining area. A geological survey conducted in 2008 determined that the sub-outcrop is uniformly flat, with no karsts penetrating into the ore body. No water fissures or solution channels were intersected during extensive prospecting of the site – only minor water intersections were encountered, particularly when the footwall contact was intersected (BolandEnviro, 2013).

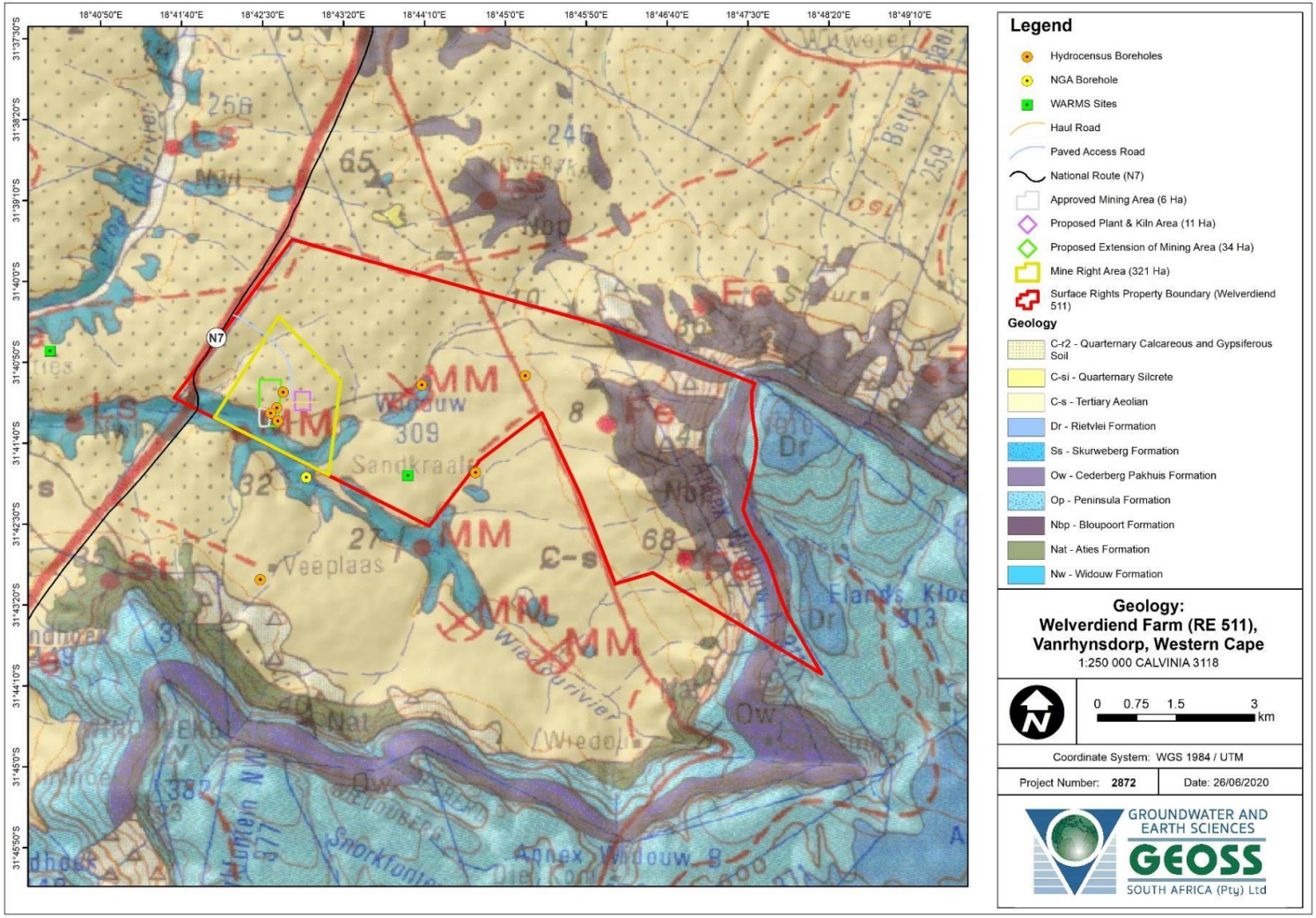

Figure 6: Geological setting of the study area, showing production borehole, NGA boreholes, WARMS sites and hydrocensus boreholes (Cape Town, 3318) (CGS, 1984) Geological cross-section profile line shown as well.

5. REGIONAL HYDROGEOLOGY

The aquifer yield and aquifer quality classifications are based on regional datasets, and therefore, only provide an indication of conditions to be expected. As detailed earlier in this report the geological setting of the study area is complex, with a multitude of lithologies. This complex geological setting is then also reflected in the geohydrology of the area. There are both primary porosity and fractured bedrock aquifers within this area. Recharge rates and mechanisms are variable throughout the area. Flow paths and mechanisms also differ throughout the area. Geology plays a major role controlling geohydrological conditions and for this reason, groundwater response units do not conform to surface water catchment boundaries. In addition, the amount of groundwater inflow and outflow also needs to be taken into account when carrying out water balance equations for the area. The following section outlines some of the key geohydrological characteristics of the area.

5.1 Aquifer Yield

According to the 1:500 000 scale groundwater map of Calvinia (3117) the area does host a karst aquifer (i.e. the bedrock constitutes an aquifer) with an average borehole yield of 0.5 L/s to 2.0 L/s directly underlying the property **(Figure 7)** (DWAF, 2005). The Welverdiend Farm is located on a Karst aquifer (dolomite) which is characterised by water stored and moving through fractures and dissolution cavities.

5.1 Aquifer Quality

Electrical conductivity (EC) is a measure of the ability of the groundwater to conduct electricity and this is directly related to the concentration of ions in the water. This parameter is used as an indication of the quality of the groundwater. The groundwater map indicates that the karst aquifer has "marginal" water quality as indicated by electrical conductivity (EC) in the range of 70 – 300 mS/m (DWAF, 2005). In terms of domestic supply this is poor quality groundwater (DWAF, 1998) **(Figure 8)**.

5.1 Aquifer Vulnerability

The national scale groundwater vulnerability map for South Africa (Conrad and Munch, 2007), which was developed according to the DRASTIC methodology (Aller et al, 1987), shows that groundwater under the property has a very-low to low vulnerability to surface based contaminants **(Figure 9)**.

The DRASTIC method takes into account the following factors:

D	=	depth to groundwater	(5)
R	=	recharge	(9)
A	=	aquifer media	(5)
S	=	soil type	(4)
T	=	topography	(9)
I	=	impact of the vadose zone	(3)
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 mining area is underlain by a Karst aquifer (Dolomite of the Widouw Formation) overlain by several meters (>25 meters) of relatively impermeable limestone and unconsolidated material at shallow depth. This "low to very low" rating is likely associated with the depth to groundwater being greater than 60 meters in boreholes within the regional setting.

6. SITE SPECIFIC ASSESSMENT

6.1 Existing Groundwater Information

A desktop hydrogeological assessment was carried out using a minimum of 1 km search radius around the Welverdiend Farm, to determine if there are any groundwater users in the area. This part of the study was completed by studying and inquiring from existing databases that contain groundwater information and did not include any fieldwork. 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 is a single site located within the search radius. A previous geohydrological assessment entailed a site visit which included a site walkover and a hydrocensus was completed within a 2 km radius of the site. This included the identification of the single NGA borehole and other boreholes in the area. Three boreholes were identified including boreholes used for agricultural purposes and exploration boreholes. The the sites identified are indicated on the maps in **Figure 2** and **Figure 3** and the information is summarised in **Table 2**.

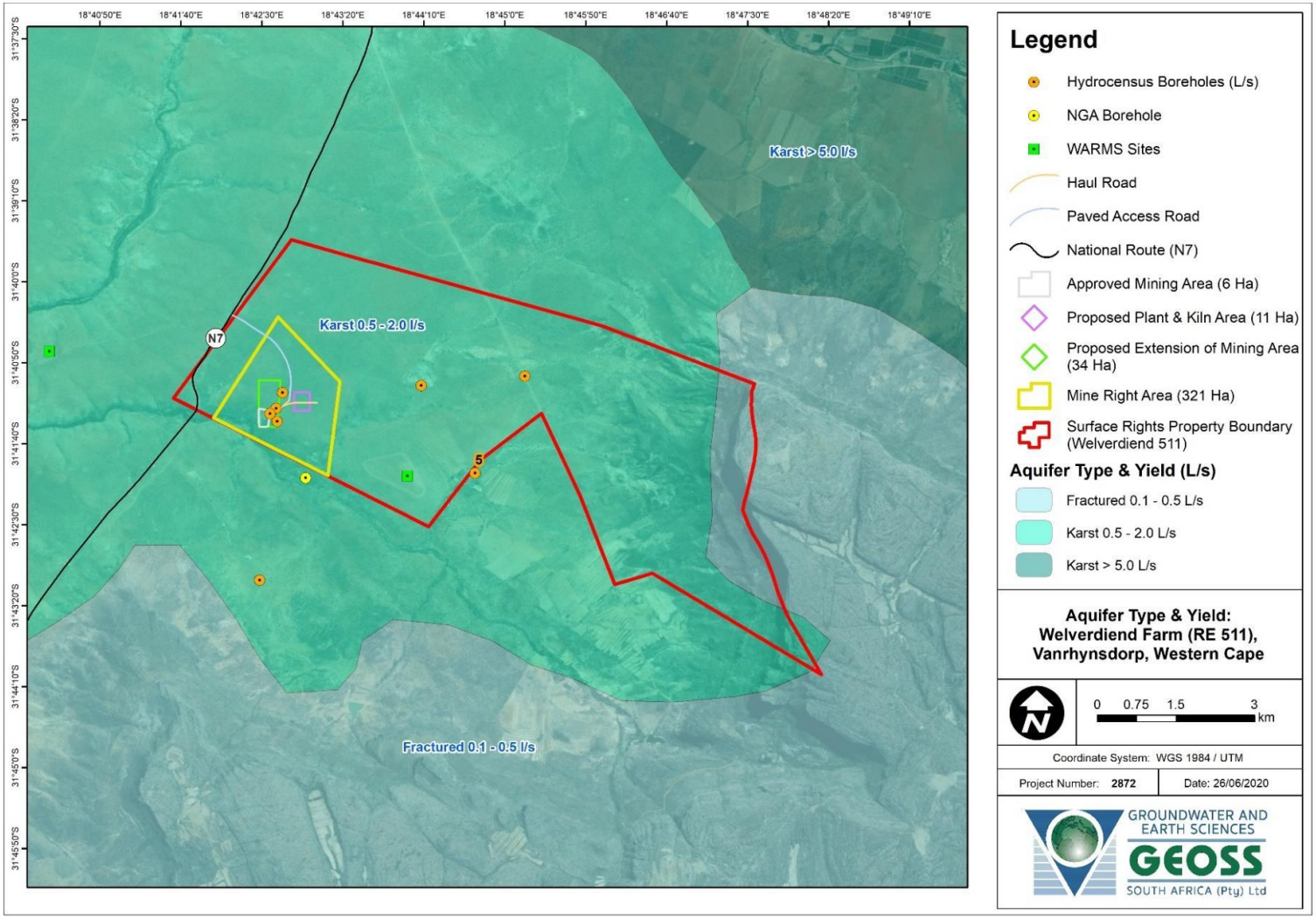

Figure 7: Regional aquifer yield from the 1:500 000 scale groundwater map (3318 –Cape Town) (DWAF, 2005), showing production borehole, NGA boreholes, WARMS sites and hydrocensus boreholes.

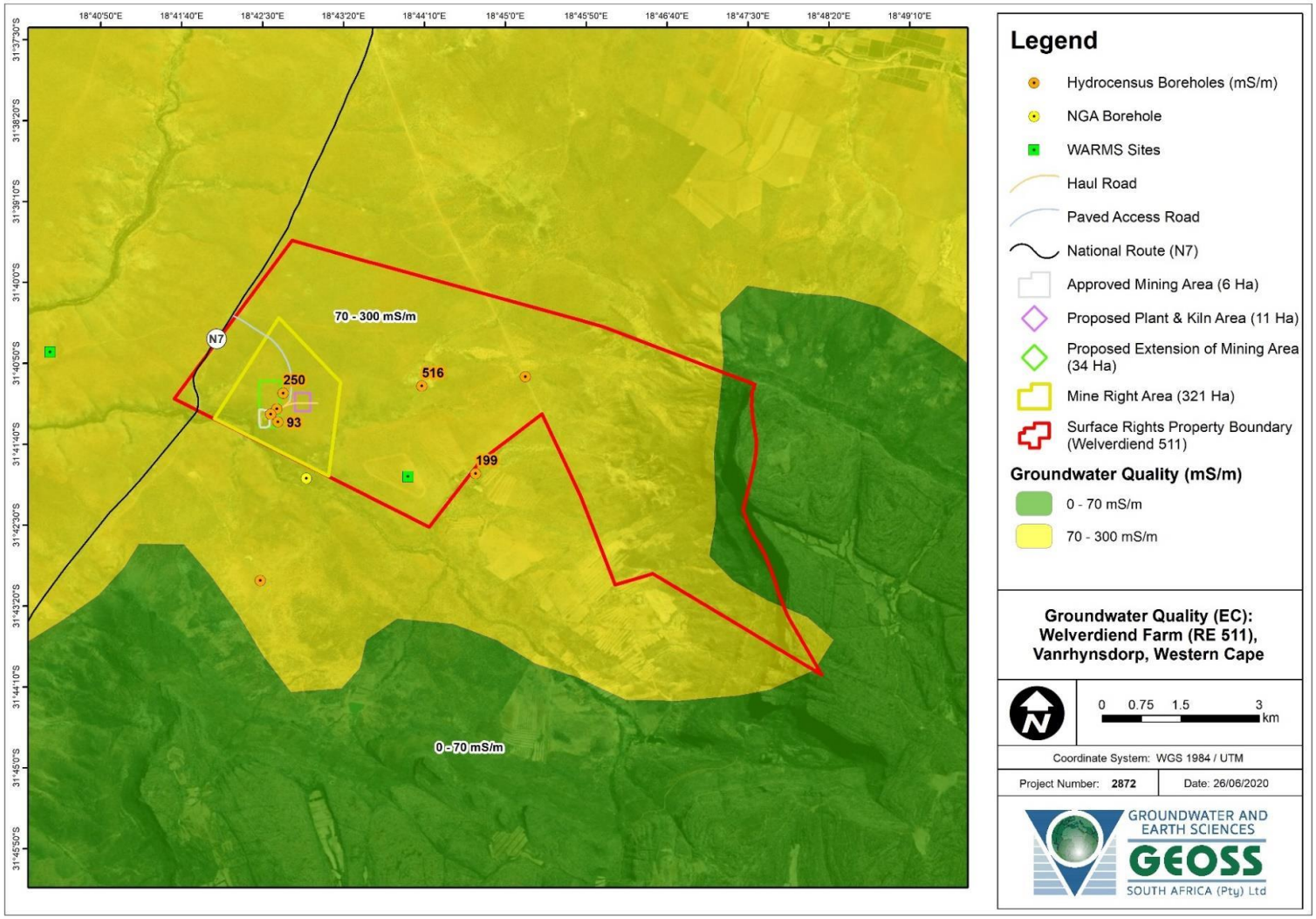

Figure 8: Regional groundwater quality (EC in mS/m) from (DWAF, 2005), showing production borehole, NGA boreholes, WARMS sites and hydrocensus boreholes.

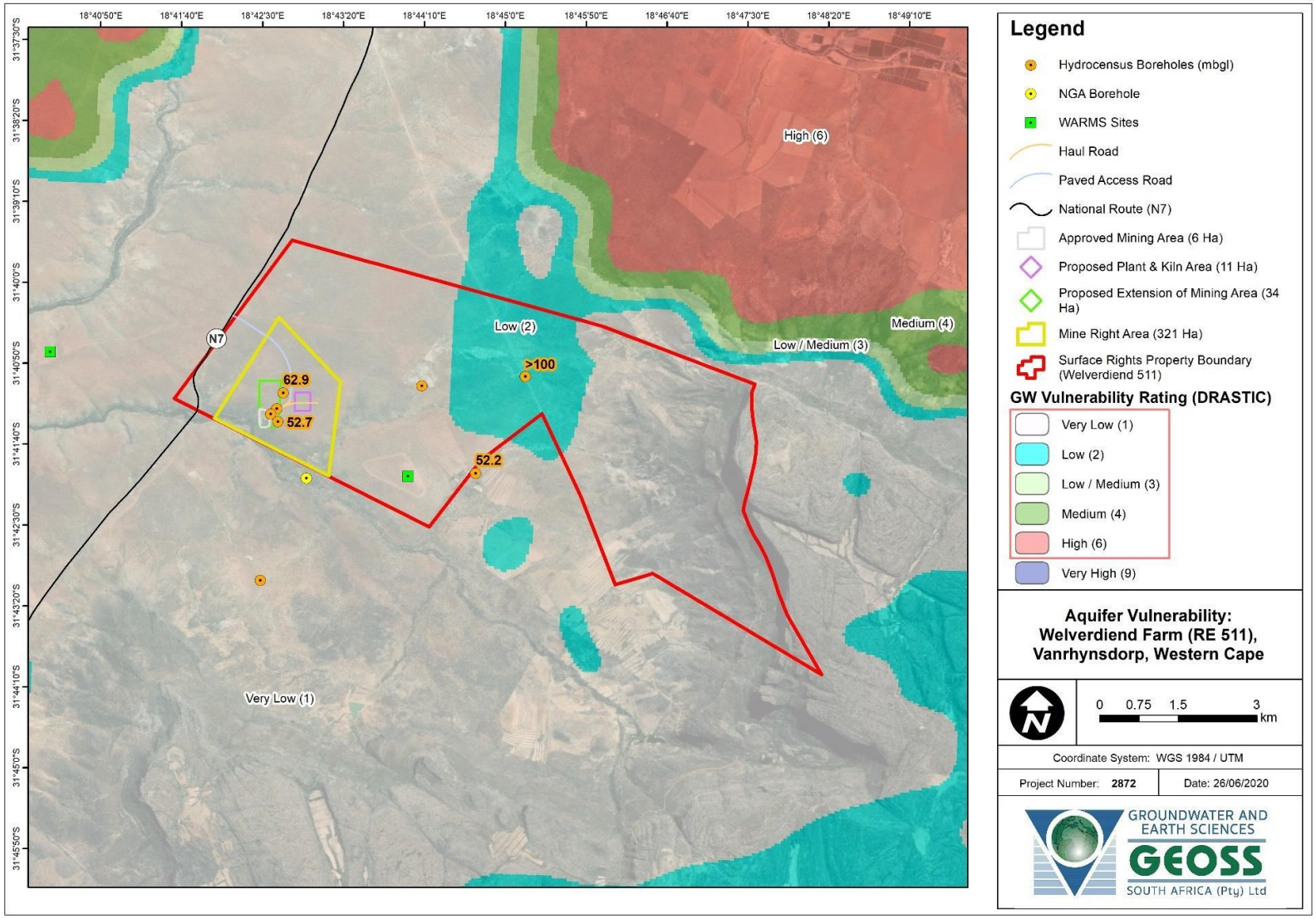

Figure 9: Regional groundwater vulnerability for the study area (DWAF, 2005), showing production borehole, NGA boreholes, WARMS sites and hydrocensus boreholes and groundwater depths.

Table 2: Summary of NGA borehole details

Site ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Elevation (mamsl)	RWL (mbgl)	RWL (mamsl)	pH	Temp (°C)	EC (mS/m)	Salinity (mg/L)	RP (mV)	Comments
3118DA00008	-31.70032	18.71588	91	-	-	-	-	-	-	-	NGA borehole - not accessible. Not found.
Marble_Quarry _BH (OD00249)	-31.68448	18.73571	119	-	-	7.65	11.2	568	2 980	-68	Base plate closed. Production borehole (equipped). Database indicates high yielding 27.78 L/s Site visit indicates a lower yield possibly 5 L/s
Maskam_BH1	-31.69948	18.74495	130	57.225	72.775	6.79	22.4	244	1 228	-27	Borehole not equipped. Weld shut with steel plate. Small square hole in steel plate. sample using bailer. Rain water in borehole because of opening.
Wind pump	-31.71785	18.70799	139	-	-		-	-	-	-	Old wind pump, broken. Bees in hole.
ZC-32	-31.69063	18.71102	119	52.72	66.280	7.29	22.1	127.6	627	-51	Exploration hole. Opened cover. Bailer sample. Limestone in water (cement). Grey colour.
ZC-36	-31.68929	18.7098	115	-		-	-	-	-	-	Exploration hole. Borehole closed with cover. Unable to open. Bees in cover.
ZC-46	-31.68842	18.71086	126	Dry		-	-	-	-	-	Within 2 km. Exploration hole. Opened cover. Dip meter dry. No water.

The information obtained for the NGA sites and the previous assessment indicated that there is minimal groundwater use. Three samples were submitted for chemical analysis discussed in succeeding sections in this report

There are 2 registered boreholes (WARMS sites) located within a few kilometres from the property boundary, that are also indicated on the detailed maps in **Figure 2** and **Figure 3**. The information for this is summarised in **Table 3**.

Table 3: Summary of WARMS borehole details.

WARMS no.	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Registered Volume (m^3/a)	Use
22004082	-31.678600	18.671900	90 000	Agriculture: Irrigation
22034576	-31.700000	18.733330	600 000	Mining

Groundwater users are Existing Lawful Uses (ELU) registered for both agricultural use and mining. The total registered groundwater use in the area is 6900000 m^3/a.

6.2 Site Visit and Hydrocensus

A site visit was completed on the 25th of May 2020 comprising of a site walkover and hydrocensus. Most of the borehole identified during the initial assessment in 2014 were revisited along with new sites. During the site visit there was no evidence of springs or seepage whatsoever. No new groundwater users have been identified within a 2-kilometre radius of the site. Details pertaining sites identified during the hydrocensus are summarised in **Table 4** and shown spatially in **Figure 3**.

Table 4: Summary of borehole identified and visited during May 2020

Site ID	Alternative_Name	Latitude (DD, WGS 84)	Longitude (DD, WGS84)	Elevation (mamsl)	RWL (mbgl)	RWL (mamsl)	Temp (°C)	EC	Comments
HBH1	ZC-46	-31.68839	18.71084	122					Could not access, lid locked with bolt rusted
HBH2		-31.68571	18.71192	128	62.95	65.05	24.4	250	Quality measured with TLC dipmeter (calibrated)
HBH3	ZC-36	-31.68930	18.70977	117					EOH 57 mbgl. Did not intersect groundwater.
HBH4	Marble_Quarry_BH (OD00249)	-31.68448	18.73571	119				516	Could not measure water level. Old Quarry borehole.
HBH5		-31.68288	18.75350	152	>100				Borehole drilled for road building purposes. Could not measure water level as it was >100 mbgl
HBH6	Maskam BH	-31.69948	18.74495	130	52.2	77.8		199	Site visit indicates a lower yield possibly 5 L/s
HBH7	ZC-32	-31.69063	18.71102	121	52.72	68.28		93	From previous assessment
HBH8	Wind pump	-31.71785	18.70799	139					> 2 km away. Old wind pump, broken. Bees in hole. Could not access during 2020

6.3 Groundwater Quality

A groundwater sample was collected during the 2014 site visit and submitted for inorganic chemical analysis to a SANAS accredited laboratory (Bemlab) in Somerset West, Western Cape. The certificate of analysis for the sample is presented in **Appendix A**.

The chemistry results obtained have been classified according to the SANS241-1: 2015 standards for domestic water. **Table 5** enables an evaluation of the water quality with regards to the various limits. **Table 6** presents the water chemistry analysis results, colour coded according to the SANS241-1: 2015 drinking water assessment standards.

Table 5: Classification table for specific limits (SANS241-1:2015)

Acute Health
Aesthetic
Chronic health
Operational
Acceptable

Table 6: Production borehole results classified according the SANS241-1: 2015

Analyses	Maskam BH1	Marble Quarry BH (OD00249)	ZC-32 BH
pH (at 25 °C)	7.0	7.5	7.5
Conductivity (mS/m) (at 25 °C)	199.0	516.0	93.0
Total Dissolved Solids (mg/L)	1192.0	3100.0	561.0
Sodium (mg/L as Na)	288.8	756.6	96.3
Potassium (mg/L as K)	3.8	9.4	1.4
Magnesium (mg/L as Mg)	40.2	105.0	24.4
Calcium (mg/L as Ca)	121.4	168.0	126.3
Chloride (mg/L as Cl)	570.4	1443.9	187.0
Sulphate (mg/L as SO_4)	103.66	329.56	194.59
Total Alkalinity (mg/L as $CaCO_3$)	350.40	648.08	362.44

The chemistry results obtained have been classified according to the DWAF (1998) standards for domestic water. **Table 7** enables an evaluation of the water quality with regards to the various parameters measured (DWAF, 1998). **Table 8** presents the water chemistry analysis results, colour coded according to the DWAF drinking water assessment standards.

Table 7: Classification table for the 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 8: Classified production borehole results.

Sample Marked :	**Maskam BH1**	**Marble Quarry BH (OD00249)**	**ZC-32 BH**	**DWA (1998) Drinking Water Assessment Guide**				
				Class 0	**Class I**	**Class II**	**Class III**	**Class IV**
pH	7.0	7.5	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)	199.0	**516.0**	93.0	<70	70-150	150-370	370-520	>520
	mg/L							
Total Dissolved Solids	1192.0	**3100.0**	561.0	<450	450-1000	1000-2400	2400-3400	>3400
Sodium (as Na)	288.8	**756.6**	96.3	<100	100-200	200-400	400-1000	>1000
Potassium (as K)	3.8	9.4	1.4	<25	25-50	50-100	100-500	>500
Magnesium (as Mg)	40.2	105.0	24.4	<70	70-100	100-200	200-400	>400
Calcium (as Ca)	121.4	168.0	126.3	<80	80-150	150-300	>300	
Chloride (as Cl)	570.4	1443.9	187.0	<100	100-200	200-600	600-1200	>1200
Sulphate (as SO4)	103.7	329.6	194.6	<200	200-400	400-600	600-1000	>1000

From the chemical results presented in **Table 6** and **Table 8** it is clear that the groundwater quality is highly variable across the study area in terms of dissolved minerals. Where Maskam BH1 has an EC of 199 mS/m, OD00249 with an EC of 516 mS/m and the is of ZC-32BH was measured at 93 mS/m. The EC of a single borehole on site was measured on site at 250 mS/m using a TLC dipmeter. The dissolved sodium and chloride concentrations along with total dissolved solids (TDS) are elevated in boreholes located towards the east and northeast of the site, and within acceptable range concentrations on site. The pH of all groundwater samples taken are relatively neutral, measuring between 7 – 7.5.

A number of chemical diagrams have been plotted for the groundwater sample and these are useful for chemical characterisation of the water. The chemistry of the sample has been plotted on a tri-linear diagram known as a Piper Diagram. This diagram indicates the distribution of cations and anions in separate triangles and then a combination of the chemistry in the central diamond. From **Figure 10** (central diamond) the borehole groundwater sample is classified as sodium and chloride hydrofacies.

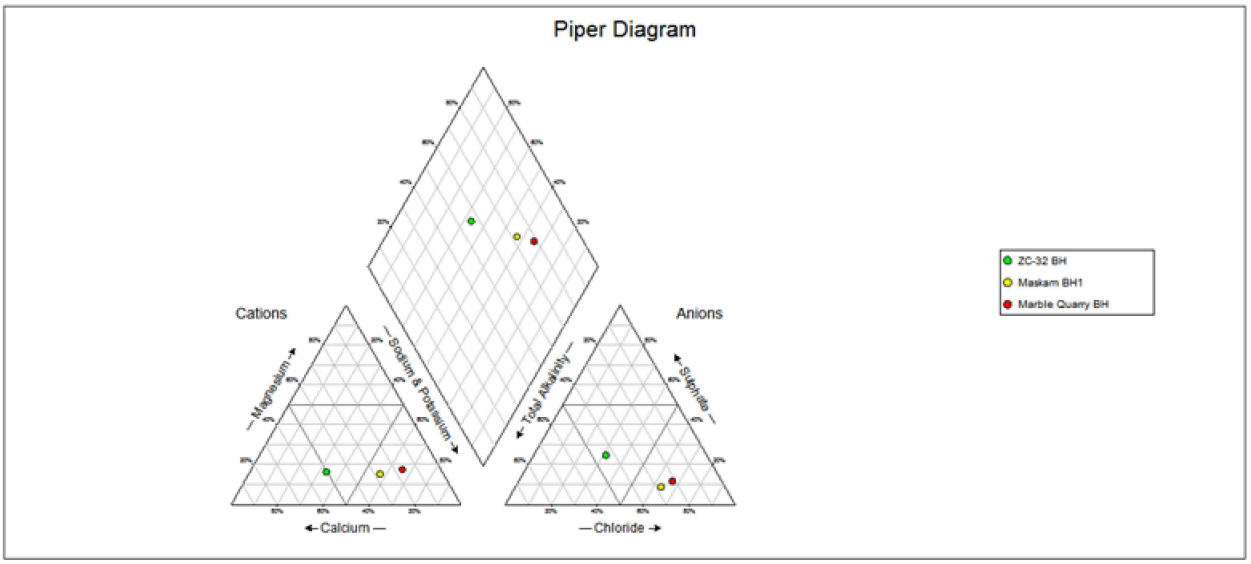

Figure 10: Piper Diagram of the production borehole groundwater sample.

The Stiff Diagram is a graphical representation of the relative concentrations of the cations (positive ions) and anions (negative ions). This diagram shows concentrations of cations and anions relative to each other (not as a percentage as with Piper) and direct reference can be made to specific salts in the water. The Stiff Diagram for the sample from the borehole is shown in **Figure 11.**

A distinct profile is observed from the sample taken from the production borehole. The borehole is primarily dominated by sodium, potassium and chloride.

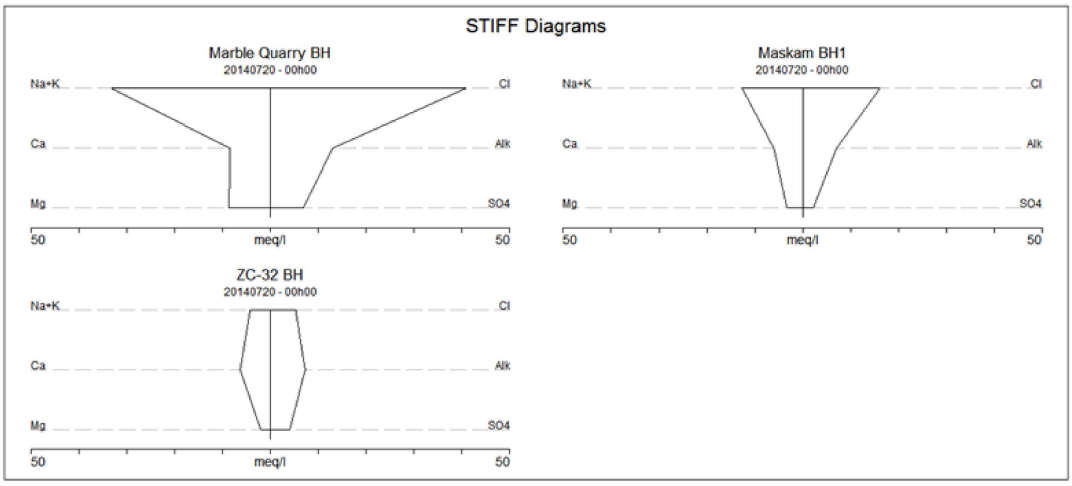

Figure 11: Stiff Diagram for the production borehole groundwater sample

7. RISK ASSESSMENT AND MATRIX.

The risk assessment includes the identification and rating of the potential risks associated with the mining operation at Welverdiend Re/511 and any proposed mitigation measures where possible.

The risk associated with the mining operation is for lowering groundwater levels and or point and non-point source pollution on site. Each risk is qualitatively assessed based on the existing information. The risk rating is done according the criteria in **Table 9**.

Table 9: Impact rating

Category		Rating	Description
Probability	Improbable	0	Less than 40 % sure of a particular fact or of the likelihood of that impact occurring
	Possible	1	40 to 70 % sure of a particular fact or of the likelihood of that impact occurring
	Probable	2	70 to 90 % sure of a particular fact or of the likelihood of that impact occurring
	Definite	3	More than 90 % sure of a particular fact or of the likelihood of that impact occurring
Extent	Site	1	Immediate project site
	Local	2	Up to 5 km from the project site and outside the footprint of associated activities
	Regional	3	20 km radius from the project site
	Provincial	4	Provincial
	National	5	South African
	International	6	Neighbouring countries/overseas
Duration	Very short-term	1	Less than 1 year
	Short-term	2	1 to 5 years
	Medium-term	3	5 to 10 years
	Long-term	4	10 to 15 years
	Very long-term	5	Greater than 15 years

	Permanent	6	Permanent
Intensity	Very low	0	Where the impact affects the environment in such a way that natural, cultural and social functions are not affected
	Low	1	Where the impact affects the environment in such a way that natural, cultural and social functions are only marginally affected
	Medium	2	Where the affected environment is altered but natural, cultural and social function and processes continue albeit in a modified way
	High	3	Where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease
	Very high	4	Where natural, cultural or social functions or processes are altered to the extent that it will permanently cease
Significance		2-4	Low
		5-7	Low to Moderate
		8-10	Moderate
		11-13	Moderate to High
		14-16	High
		17-19	Very High

The activity related to the WULA relates only to the mining operation. There are two potential impacts associated with the mining operation: the risk of groundwater negatively impacted by intersecting groundwater during the mining operation or point and non-point source pollution from the mining operation that might result in groundwater quality deterioration. These will be discussed separately below.

7.1 Depletion of the Groundwater Resource as a Result of Mining Operation:

The proposed mining area will not intersect any groundwater as it will take place by means of surface drilling and blasting up to a maximum depth of 60 mbgl. No groundwater abstraction will take place on the mining site at this stage, hence impact on other groundwater users due to abstraction. The depletion of the groundwater resource as a result of the abstraction is thus highly improbable to occur. The risk assessment is presented in **Table 10**.

Table 10: Risk assessment for the depletion of the groundwater resource as a result of the mining operation.

Impact	Probability	Extent	Duration	Intensity	Significance
Without mitigation	Possible (1)	Local (2)	Medium-term (3)	Medium (2)	Moderate (8)
With mitigation	Improbable (0)	Site (1)	Short-term (2)	Very low (0)	Low (3)
Mitigation Measures	Don't exceed proposed 25-meter excavation depth. Groundwater levels must be monitored. Monitoring information must be assessed regularly (suggest monthly in summer).				

7.2 Groundwater Quality Deterioration as intersecting groundwater and point and non-point source pollution:

Intersecting of groundwater during excavations and point source pollution can potentially result in the deterioration of groundwater quality and lowering of pH conditions in groundwater which might also impact the Karst aquifer resulting in dissolution cavities. The groundwater quality as indicated by DWAF (2000) for the area is marginal (70 – 300 mS/m). The groundwater quality for boreholes on site are within this range of the regional classification. The proposed mining operations and associated activities are highly improbable to impact the groundwater and groundwater quality if proper mitigation measures are in place and if the applicant adheres to the recommendations. The risk assessment is presented in **Table 11**.

Groundwater monitoring is recommended to ensure that mining operation does not negatively impact groundwater levels, hence intersecting groundwater or cause deterioration of groundwater quality. The monitoring will also indicate if the groundwater resource is impacted and mitigation measures can be instituted before long term impacts occur. Mitigation includes not deviating from the original planned excavation depth and having mitigation measures in place preventing point source pollution.

Table 11: Risk assessment for the groundwater quality deterioration as a result of over-abstraction.

Impact	Probability	Extent	Duration	Intensity	Significance
Without mitigation	Possible (1)	Local (2)	Medium-term (3)	Medium (2)	Moderate (8)
With mitigation	Improbable (0)	Site (1)	Short-term (2)	Very Low (0)	Low (3)
Mitigation Measures	Monitor groundwater levels Do not exceed planned depth of excavation. Groundwater quality must be monitored. Monitoring information must be assessed regularly (suggest monthly in summer). If there are fluctuation in groundwater levels or there is an increase 25 % in electrical conductivity. A hydrogeologist should be approached to assess and provide mitigation measures.				

7.3 Environmental Management Plan.

The management of the above potential impacts will include monitoring and include the following recommendations:

- Identifying existing boreholes on site to be used for water level monitoring purposes.
- Water level and groundwater quality monitoring which includes sampling and analysis of the groundwater at an accredited laboratory. A sampling interval of quarterly is recommended for the first year of monitoring, thereafter, the water quality monitoring should be reviewed and can potentially be reduced to half yearly or yearly.
- The monitoring data must be reviewed quarterly monthly during the summer months when use will be optimal.

8. ASSUMPTIONS AND LIMITATIONS

During this study, certain assumptions limited the certainty of the data acquired and the outcome of this report.

- The number of boreholes identified in the area is limited and they are mostly are limited in depth. Although the population is sparse this is also indicative that the aquifer not ideal for groundwater use, hence limited groundwater users.
- The groundwater quality was determined from one set of test results. Seasonal changes may occur in the chemistry of the water from the borehole and this would not be accounted for.
- The coordinates of the NGA boreholes and WARMS sites are sometimes found to be inaccurate. Hence, it was difficult to incorporate the NGA and WARMS data accurately into the field hydrocensus. Also, access to farms proved difficult, mainly due to the COVID-19 pandemic and data is lacking in this regard.
- Direct vertical groundwater recharge by rainwater in the direct vicinity of the borehole is considered insignificant, but largely an unknown. The main recharge is thought to occur where the fractured rock is exposed at the surface. The area is mostly overlain by several meters of Quaternary age deposits and competent limestone in which no water bearing fractures were intersected during the exploration phase of the proposed mining operation. Furthermore, the mining operation is located in an arid region, which experiences low rainfall and high evaporation rates.

9. CONCLUSION AND RECOMMENDATIONS

Cape Lime (Pty) Ltd is the holder of a Mining Right in terms of Section 22 of the Mineral and Petroleum Resources Development Act 2002 (Act No. 28 of 2002) for the mining of limestone and dolomite within a 321.11 ha mining rights area of which proposed mining activities will take place in only a small (±6.3 ha) section.

The proposed mining area is located in an extremely sparsely populated area. No groundwater use occurs within a 2 km radius of the proposed site. The nearest production borehole is located 3 km from the site. Thus, within the region groundwater is not deemed a major source of water for socio-economic purposes. In general, groundwater levels are deep in the area (>66 mbgl) and considering the hydrogeological setting groundwater will not be impacted by any surface-based activities.

The groundwater quality in the vicinity of the proposed mine is classified as "marginal" and all standard measures must be taken to protect the groundwater quality. This means there are to be no oil leaks from vehicles, generators and heavy machinery. Storage of fuels and lubricants must be on a hardened surface, as well as where the vehicles are filled with fuel. When vehicles/machinery is serviced the old oil must be correctly disposed of.

Recommendation regarding license application and proposed license conditions:

1. Based on information obtained and analysed in the geohydrological assessment the following license conditions related to the mining operation should be proved on condition that:

    a. The mining operation does not exceed the proposed excavation of 60 mbgl.
    b. The mining operation should not extend up to depths within 5 meters of the groundwater level. In the unlikely event where layers such as clay lenses are intersected or groundwater is intersected a specialist should be consulted to assess and provide mitigation measures.

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APPENDIX A: CERTIFICATE OF ANALYSIS

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Water Analyses Report

Date received: 25/07/2014
Date tested: 28/07/2014

Reference No.	Lab. No.	pH	EC mS/m	Na mg/l	K mg/l	Ca mg/l	Mg mg/l	Cl mg/l	CO_3* mg/l	HCO_3 mg/l	SO_4 mg/l	TDS mg/l	Temperature °C	Date Sampled	Alkalinity mg/l
Maskam BH1	6491	7.0	199	288.80	3.79	121.40	40.23	570.39		211.17	103.66	1192	6.7	24/07/2014	350.396
Marble Quarry BH	6492	7.5	516	756.60	9.39	168.00	105.00	1443.87		452.10	329.56	3100	6.8	24/07/2014	648.082
ZC-32 BH	6493	7.5	93	96.28	1.37	126.30	24.44	186.99		240.25	194.59	561	4.5	24/07/2014	362.444
Method#		3136	3135	3132	3132	3132	3132	3138	3137	3137	3132				

#Refer to BemLab work instructions
Order no.: 1197

Sample condition: Sample temperature at reception is stipulated in the results table. Ideally the sample(s) should reach the laboratory within 6 hours, or be kept at <10°C and delivered within 24 hours. If these conditions are not maintained, analysis will proceed but interpretation of the results generated is at the clients own discression.

Statement: The reported results may be applied only to samples received. Any recommendations included with this report are based on the assumption that the samples were representative of the bulk from which they were taken.

Dr. Pieter Raath
.....
on behalf of BemLab

29-07-2014
.....
Date Reported

————END OF REPORT————

This Laboratory participates in the Agrilasa proficiency scheme

APPENDIX B: SITE PHOTOS (24 JULY 2014 & MAY 2020)

Photo 1: Marble_Quarry_BH (OD00249)

Photo 2: Maskam_BH1

Photo 3: Windpump

Photo 4: ZC-32

Photo 5: ZC-36

Photo 6: ZC-46

Photo 7: HBH5

Last page..