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Proposed Arnot South Coal Mining Project, Situated near Hendrina, Mpumalanga Province

Groundwater Baseline Study

Prepared for:
Universal Coal PLC

Project Number:
UCD6802

August 2021

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Report Type:	Groundwater Baseline Study
Project Name:	Proposed Arnot South Coal Mining Project, Situated near Hendrina, Mpumalanga Province
Project Code:	UCD6802

Name	Responsibility	Signature	Date
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Megan Edwards	Hydrogeologist		August 2021

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1. Introduction

Exxaro Coal Mpumalanga (Pty) Ltd (hereafter Exxaro) is applying for environmental authorisations required for the proposed Arnot South Underground Coal Mining Project (hereafter Arnot South Project). Exxaro held a Prospecting Right [Reference No. MP 30/5/1/1/2/360 PR] to min-e coal on various farms covering approximately 16,000 ha in extent.

The prospecting Right was renewed in September 2017 and lapsed on 10 September 2020. However, a Mining Right Application (MRA) and Mine Works Programme (MWP) for underground mining were submitted to the Department of Mineral Resources and Energy (DMRE) prior to the lapsing date. Exxaro was issued a reference number MP 30/05/1/2/2/10292 MR.

The Mining Right boundary includes the following farms:

- Groblersrecht 175 IS
- Mooiplaats 165 IS
- Tweefontein 203 IS
- Vaalwater 173 IS
- Weltevreden 174 IS
- Nooitgedacht 493 JS
- Leeuwpan 494 JS
- Schoonoord 164 IS
- Vlakfontein 166 IS
- Vryplaats 163 LQ
- Helpmakaar 168 IS
- Op Goeden Hoop 205 IS
- Klipfontein 495 JS

The target area for mining and mining-related infrastructure lies mainly on the farms Weltevreden 174 IS, Mooiplaats 165 IS, Vlakfontein 166 IS, and Schoonoord 164 IS. The farms are located within the jurisdictions of Steve Tshwete Local Municipality (STLM) and Chief Albert Luthuli Local Municipality (CALLM), situated in the Nkangala District Municipality (NDM) and Gert Sibanda District Municipality (GSDM), respectively, in the Mpumalanga Province.

The mineral reserve consists of one economically mineable underground block (No. 2 coal seam), producing approximately 2.4 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal for approximately 17 years. Further drilling will be required to confirm a resource to the south of the Mining Right area. The potential future resource of the remaining ROM coal is approximately 32,912,300 tonnes, allowing an additional mining period of approximately 13 years. This application considers the use of underground board-and-pillar mining with continuous miners due to the depth and thickness of the reserve.

The proposed development triggers Listed Activities in terms of the Environmental Impact Assessment (EIA) Regulations, 2014 (GN R 982 of 4 December 2014 as amended by GN R326 of 7 April 2017) (EIA Regulations, 2014), as amended promulgated under the National

Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA). Digby Wells Environmental (hereafter Digby Wells) is the appointed Environmental Assessment Practitioner (EAP) to undertake the environmental applications in support of the proposed Arnot South Project.

Exxaro is applying for the following authorisations and licenses, which are required prior to the commencement of mining operations:

- An Environmental Authorisation (EA) terms of the NEMA;
- A Waste Management License (WML) in terms of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) (NEM: WA); and
- An Integrated Water Use License (IWUL) in terms of the National Water Act, 1998 (Act No. 36 of 1998) (NWA).

This hydrogeological specialist report has been compiled in support of both the NEMA and NWA applications and will also provide input for the EIA, and the Environmental Management Programme (EMPr).

2. Methodology

This section of the report describes the methodology adopted in determining the hydrogeological baseline conditions for the Project Area.

2.1. Desktop Assessment

A desktop review was undertaken to review and collate existing information on the hydrogeological environment of the Project Area. An in-depth analyses of all relevant and available secondary data such as reports, data sheets, proposals and maps were utilised to compile a base of data that feeds into the groundwater impact assessment report.

2.2. Hydrocensus

A hydrocensus survey was conducted from the 7th to the 9th of April 2021. The survey was undertaken to provide insights on the understanding of the current hydrogeological conditions in and around the proposed Arnot South Mining Right boundary. The survey included visits to private water supply boreholes.

A total of forty-three water supply boreholes were identified. The following information was collected at each of the field sites (where possible):

- Sampling coordinates (X, Y and Z position);
- Static (or rest) water level;
- Primary groundwater (borehole) use; and
- Field pH, EC and TDS values.

The information listed above was used to define the groundwater baseline condition and will be used as a reference for future water monitoring and impact assessments. The analysis was performed for inorganic constituents such as major cations, anions and metals as shown in Table 3-3.

2.2.1. Water Level Measurements

The groundwater levels were measured by using a dip meter for identified boreholes. Static groundwater levels were measured through measuring the distance between the borehole collar level on surface and the water table depth within the borehole. The height of the borehole collar was then subtracted from the measured groundwater level to determine the exact groundwater level in metres below ground level (mbgl). Furthermore, the mbgl measurement was then subtracted from the borehole's surface elevation to use a universal unit of metres above mean sea level (mamsl) for all measurements.

2.2.2. Groundwater Sampling

A total of eleven samples were collected for water quality analysis and only four were sent to the lab. Samples were to M and L Laboratories for analysis. The information listed above will be used to define the groundwater baseline condition and will be used as a reference for future water monitoring and impact assessments. The analysis was performed for inorganic constituents such as major cations, anions and metals as show in Table 2-1.

Table 2-1: Analysed parameters

Physical parameters	Nutrients	Dissolved anions	Dissolved metals	Others
pH	Ammonia-N	M Alkalinity	ICP-OES (i.e. major, minor and trace metals)	Total cations
EC in mS/m	Nitrate-N	P Alkalinity		Total anions
Total Suspended Solids	Nitrite-N	Bromide (Br)		% error
Total Dissolved Solids	Total Phosphate (P)	Chloride (Cl)		Total Balance
		Fluoride (F)		Total hardness
		Sulphate (SO_4)		Ca hardness
				Mg hardness

2.3. Geophysical Survey

A geophysical survey was carried out between 3rd and 8th May 2021 to identify any anomalies or structures within the study area that could indicate aquifers and/or preferential groundwater flow paths. The two geophysical methods used to survey the area were the electromagnetic (using the EM34 instrument) and magnetic (using the Geotron G5 instrument) methods. Site specific structures were targeted derived from existing regional structural information and the mining right boundary. Four traverses were surveyed with a total traverse length of 4.84 km (Figure 2-1).

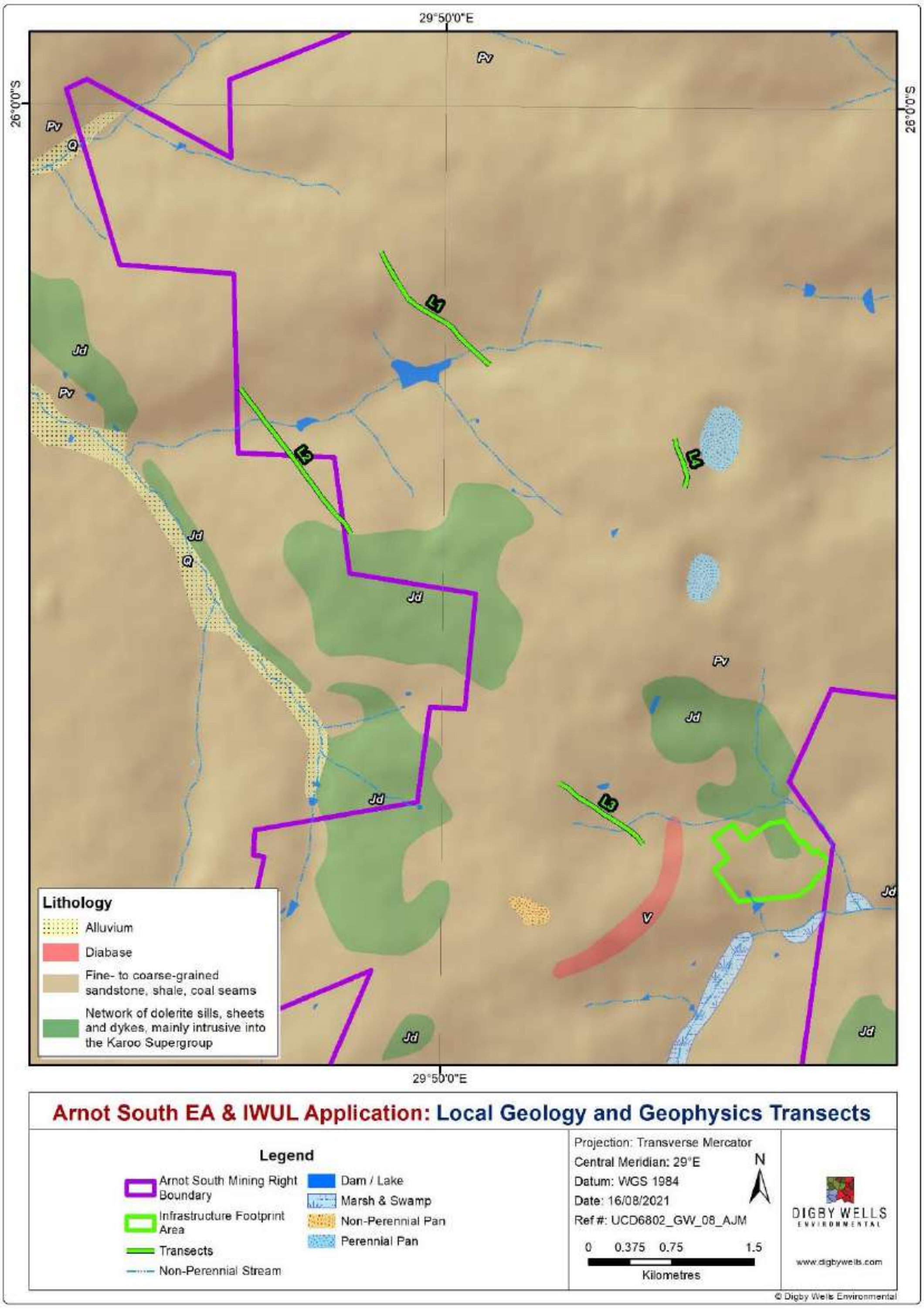


Figure 2-1: Geophysics Transect

2.4. Drilling Programme

A percussion drilling programme was initiated in the area surrounding proposed mining right area to allow for aquifer parameter estimations and to provide an indication of the groundwater storage/flow characteristics of the structural zones verified during the geophysical survey. The boreholes localities were sited based on the interpretation of geophysical survey data, as well as a review of geological and structural data. The boreholes were planned to depths of 5 m below the S2 coal seam.

The drilling programme was undertaken by Dembe Water Drilling company directly contracted by Universal Coal and under supervision of Digby Wells. The rotary air-percussion drilling method was used to drill three (boreholes. Borehole finishing included the installation of uPVC casing and borehole development.

During the drilling supervision the following information were obtained:

- Colour, drilling chip size at 1 m intervals;
- Vertical geology succession and degree of weathering;
- Depth of drilling and borehole construction; and
- Depth of water strikes, individual water strike yield, final / accumulative blow yield and Groundwater Baseline description.

The following borehole construction details were proposed and executed for this study were:

- 10 inch drilling and 7 inch starter casing for the weathered zone;
- 6.5 inch drilling to the end of hole with 5 inch perforated uPVC casing; and
- Complete head works that included gravel pack, concrete plinth, steel cap, bentonite seal and a 1.5 m stand up pole.

2.5. Aquifer Testing

The most strategic and successful boreholes drilled during this investigation will be aquifer tested to determine aquifer responses and to calculate the parameters presenting the aquifer hydro-dynamics underlying the investigation area. Boreholes selected for aquifer testing will undergo a step testing prior to conducting the constant discharge tests. The following activities were conducted for aquifer test analysis:

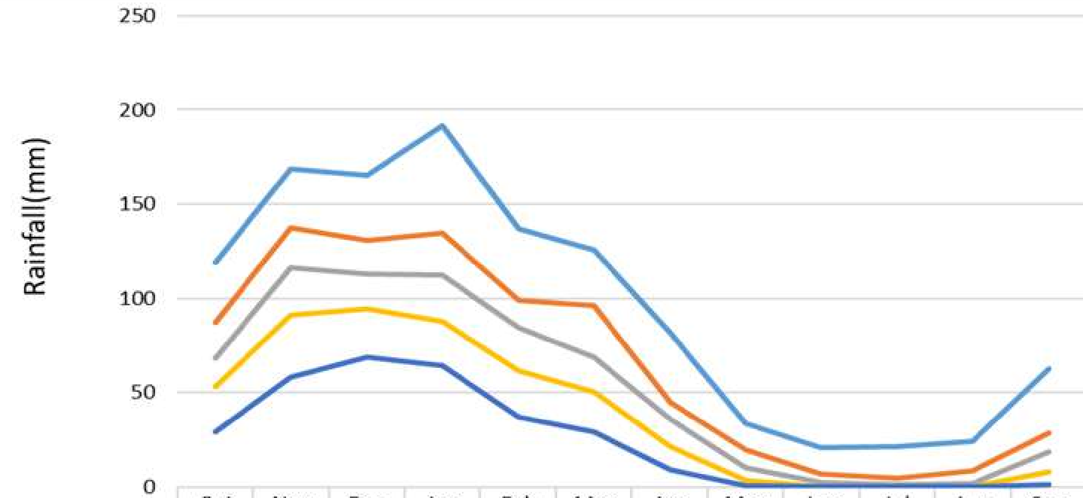
- As the boreholes were dry only slug test were conducted. A slug test is performed by either using a liquid (water) or solid slug of at least 10 litres into the borehole. The response of the water level is then recorded to see how long it takes for the water level to recover to original or 90%.

Aquifer Test Analysis: this will be conducted using Aquifer Test Pro / Aqtesolv software. The aquifer parameter results calculated from these programmes will assist in characterisation of the aquifers present at the proposed site.

3. Hydrogeological Baseline

3.1. Regional Climate

The Arnot South Project area is characterised by warm, rainy summers and dry winters with sharp frost (South African Weather Bureau, 1986). According to the Köppen-Geiger system, the climate here is classified as Cwb (Oceanic Subtropical Highland Climate). The Mean Annual Precipitation (MAP) for B12A, B12B and X11A is 695 mm, 672 mm, and 688 mm, respectively (WRC, 2015). The average MAP for the Arnot South Project area is estimated at 685 mm, which is likely to be distributed as indicated in Figure 3-1. The wettest month is January with a 90th percentile of 192 mm and 10th percentile of 65 mm. This implies that the region experiences moderate to high volumes of rainfall.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
90 Percentile	119	169	165	192	137	126	82	34	21	21	24	62
70 Percentile	87	138	131	135	99	96	45	20	7	5	8	28
50 Percentile	68	116	113	112	85	69	36	10	2	1	2	19
30 Percentile	53	91	95	88	62	50	21	4	0	0	0	8
10 Percentile	29	58	69	65	37	29	9	0	0	0	0	1

Figure 3-1: Monthly Rainfall Distribution

On average, the area has a Mean Annual Evaporation (MAE) of 1358 mm, which is significantly greater than the average MAP of 685 mm. Figure 3-2 indicates the distribution of evaporation, the highest evaporation loss is observed in January (151 mm) which is also the wettest month.

Figure 3-2: Monthly Distribution of Potential Evaporation and Rainfall

3.2. Topography and Drainage

The topography of the Project area is generally flat, with a gentle rise of 15 m over 4 km from the western boundary to the centre of the Project area and dip of 60 m over 7 km to the eastern boundary. The topography ranges from high elevations on the northern and southern side of the Project area to lower elevations in the east and central area (Figure 3-3). The elevation of the Project area ranges from 1,565 to 1,745 metres above mean sea level (mamsl), which equates to a range of 180 m between the lowest and highest points of elevation within the area.

One of the major tributaries of the Olifants River is the Klein Olifants River which flows within the portion of the Project area that is located within the Olifants Water Management Area (WMA). Drainage within the portion of the Project area that is located within the Inkomati-Usuthu WMA is facilitated by the Vaalrivierspruit, which drains into the Nooitgedacht Dam that adjoins the Komati River (Figure 3-3).

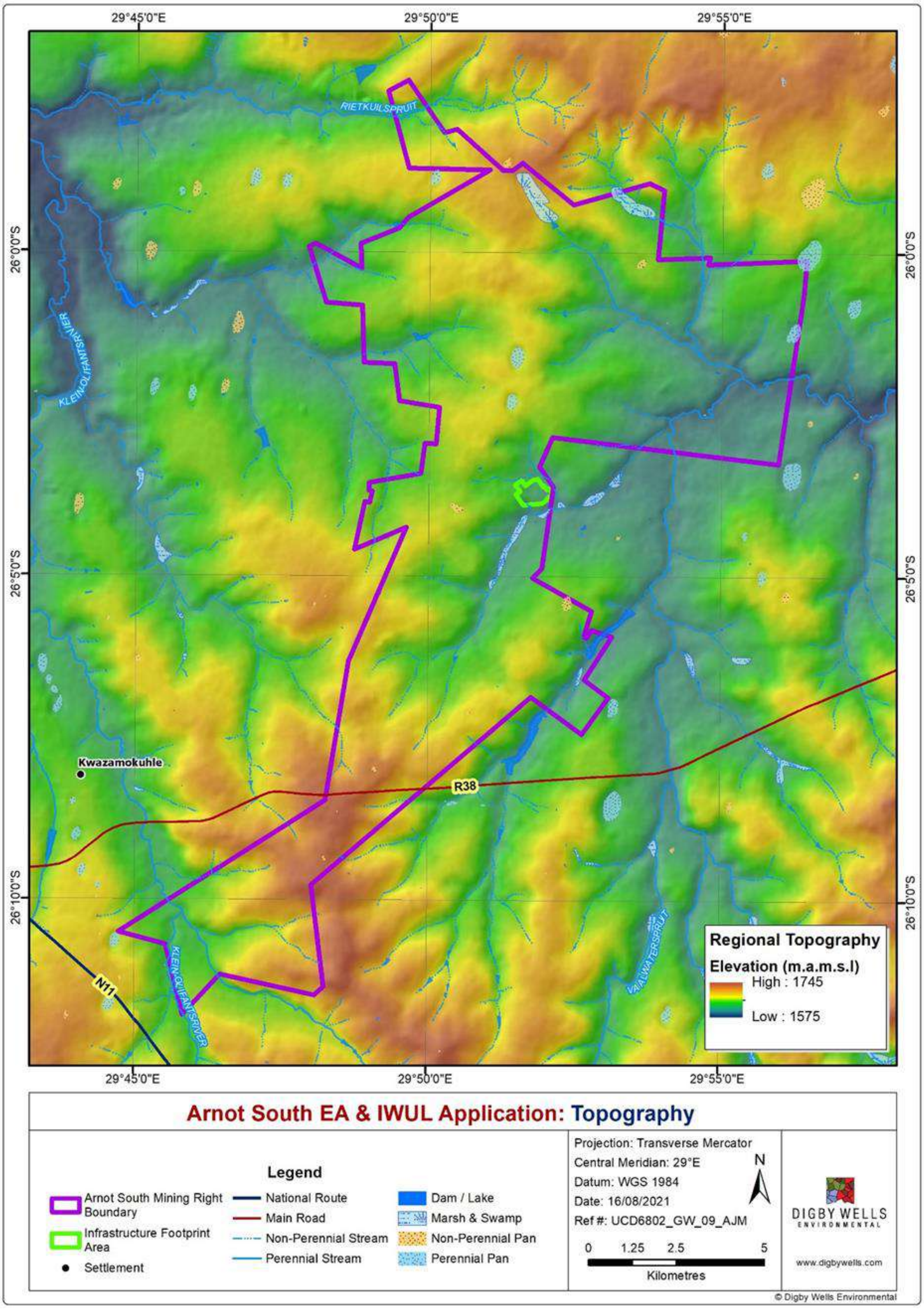


Figure 3-3: Topography of the Arnot South Project Area

3.3. Geology

3.3.1. Regional Geology

The Arnot South Project area is situated within the Witbank Coalfield, which is underlain by formations of the Dwyka and Ecca Groups.

Woodford & Chevallier (2002) states that the Dwyka Group is composed of glacial ice-shelf deposits, displaying well-developed striated glacial pavements in places. The group consists mainly of diamictite (tillite) and to a lesser extent also contains conglomerate, sandstone, rhythmite and mudrock. The Ecca Group comprises a total of 16 formations which are observed from the lateral facies changes that characterise this succession. The Ecca Group is known to host coal seams and sedimentary rocks, such as conglomerates, sandstone, shale and mudstone (siliciclastic rocks). In line with the area being located on the Ecca and Dwyka Groups, the surface geology presented in Figure 3-4 indicates that the Project area is predominantly underlain by siliciclastic rocks of the Ecca Group.

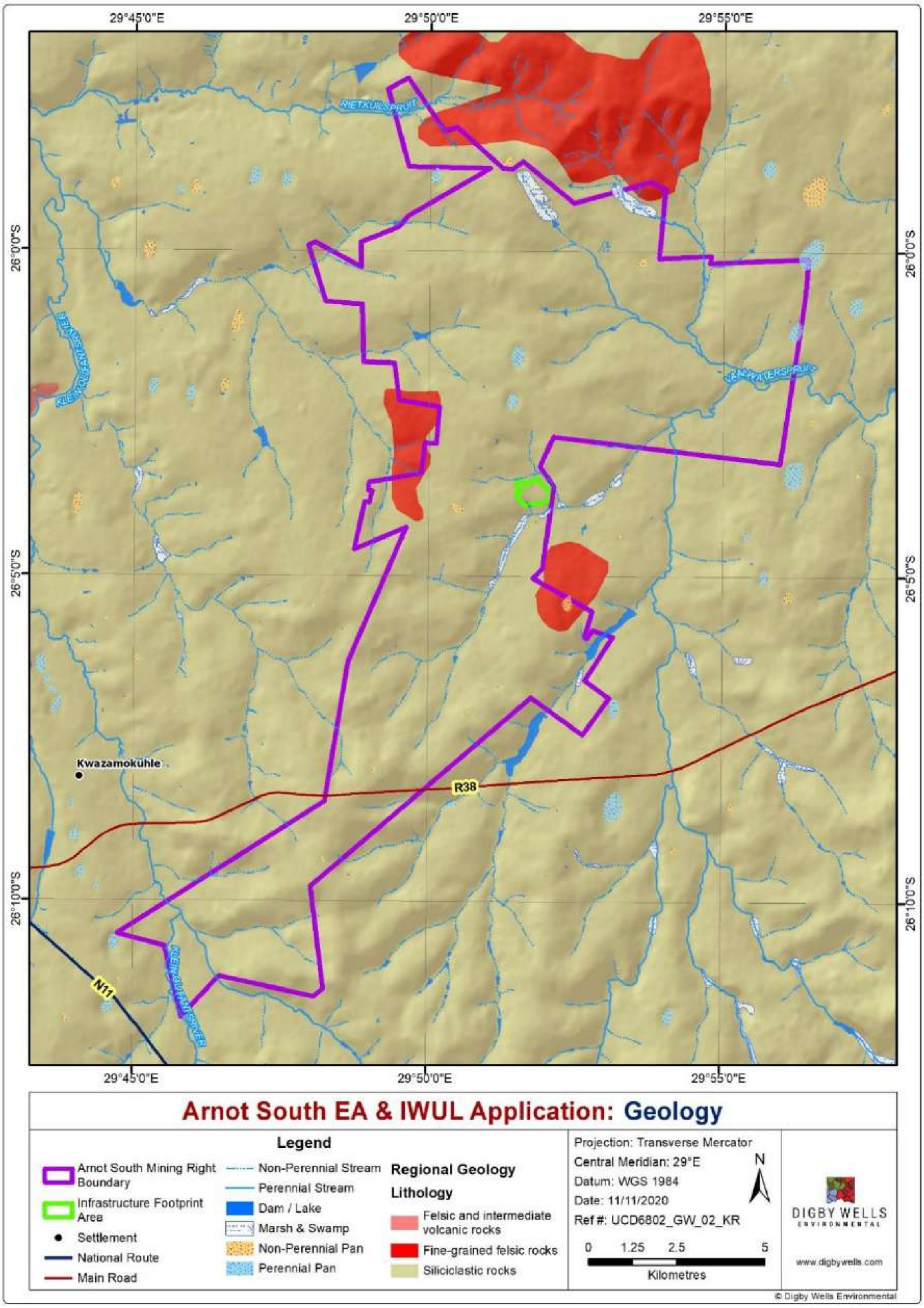


Figure 3-4: Regional Geology

3.3.2. Local Geology

The project area is located within the Vryheid formation of the Ecca Group and comprises predominantly of sandstone, siltstone, carbonaceous shale and coal. Five coal seams have been logged in the exploration data, however the lowest seam (S1) is not very extensive. The available exploration data indicates that the S2 seam varies in depth from approximately 20 m below surface on the eastern and western sides of the project area to approximately 60 m below surface in the central area of the project area. The thickness of the S2 Seam ranges between 0.2 m and 3.5 m, with an average of 1.7 m.

Underlying the Vryheid formation is the Dwyka Group, which is limited in exposure to the vaalwaterspruit channel east of the project area. Multiple dolerite intrusions occur within the Vryheid formation and Dwyka Group lithologies. The exploration drill logs indicate that dolerite is intersected in the project area at depth of between 9 m and 81 m.

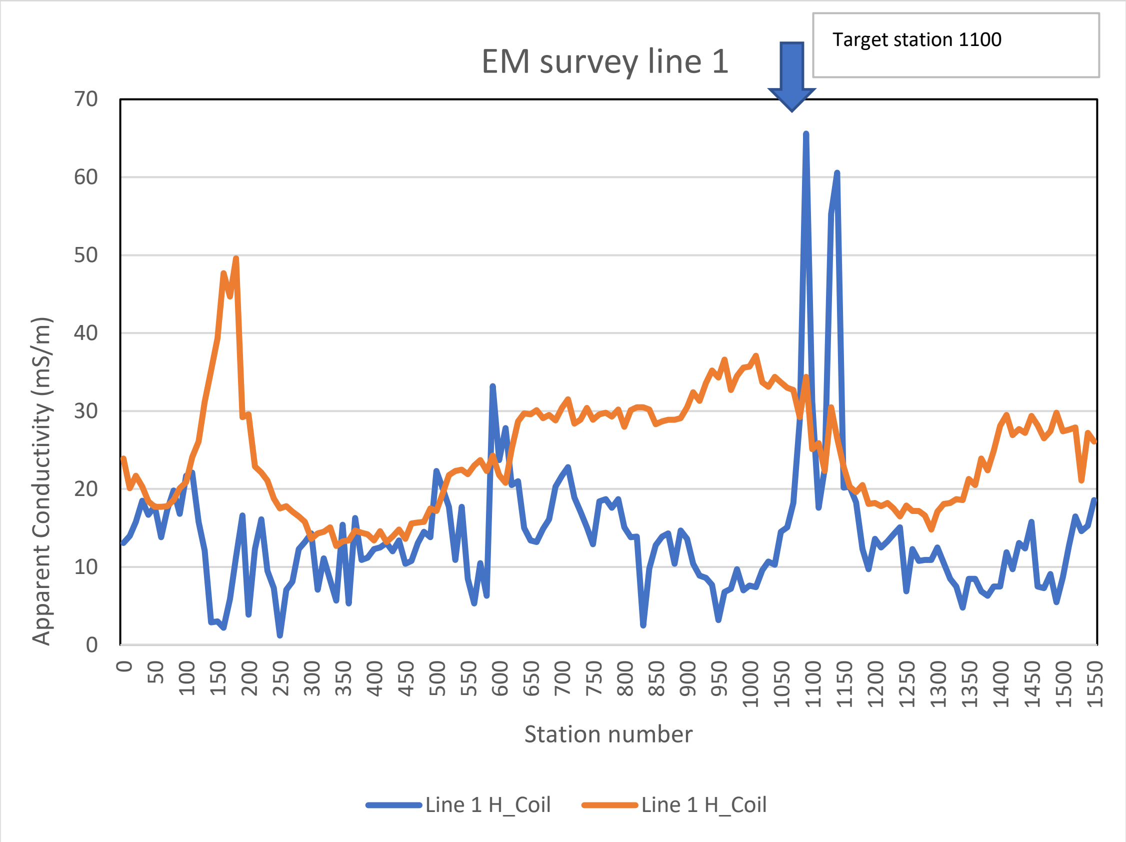
3.3.2.1. Geophysical survey

Digby Wells carried out a geophysical survey for the purpose of generating monitoring borehole drilling targets. A total of four survey lines of between 600 m and 1.7 km in length were carried out in the project area based on the geology, geophysical data, topography and drainage.

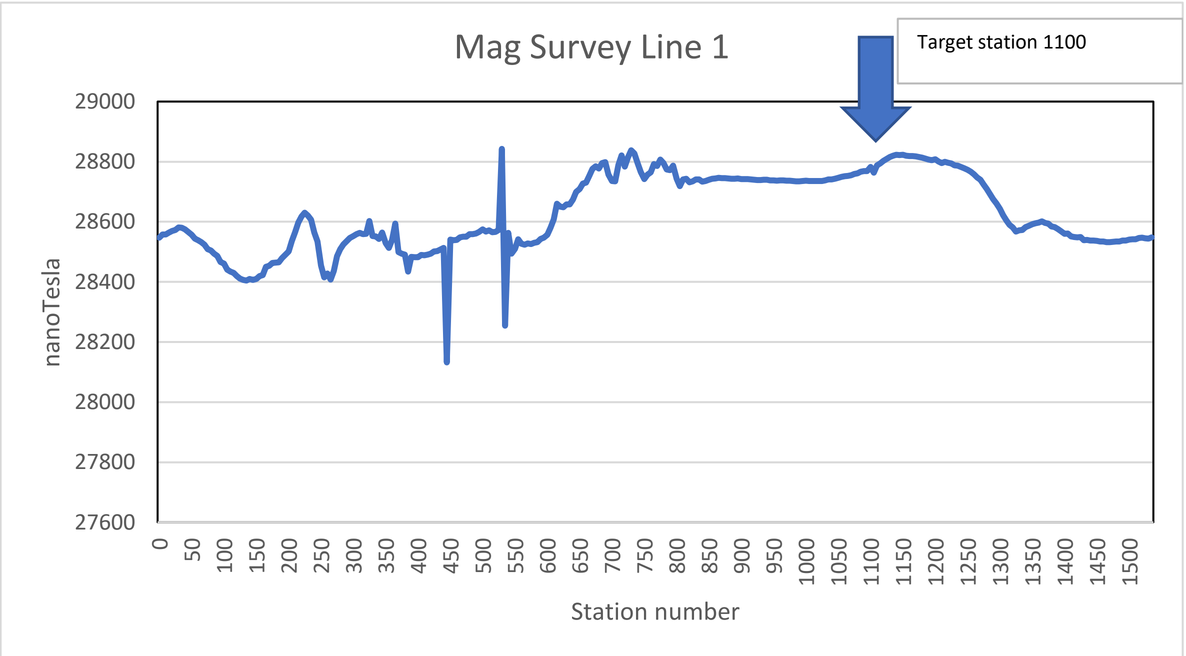
The lines were interpreted based on anomalies in the EM and Mag data in conjunction with lithological units and geological structures as indicated on the regional geological map Figure 3-4 and Table 3-1.

Table 3-1: Identified drill targets with details

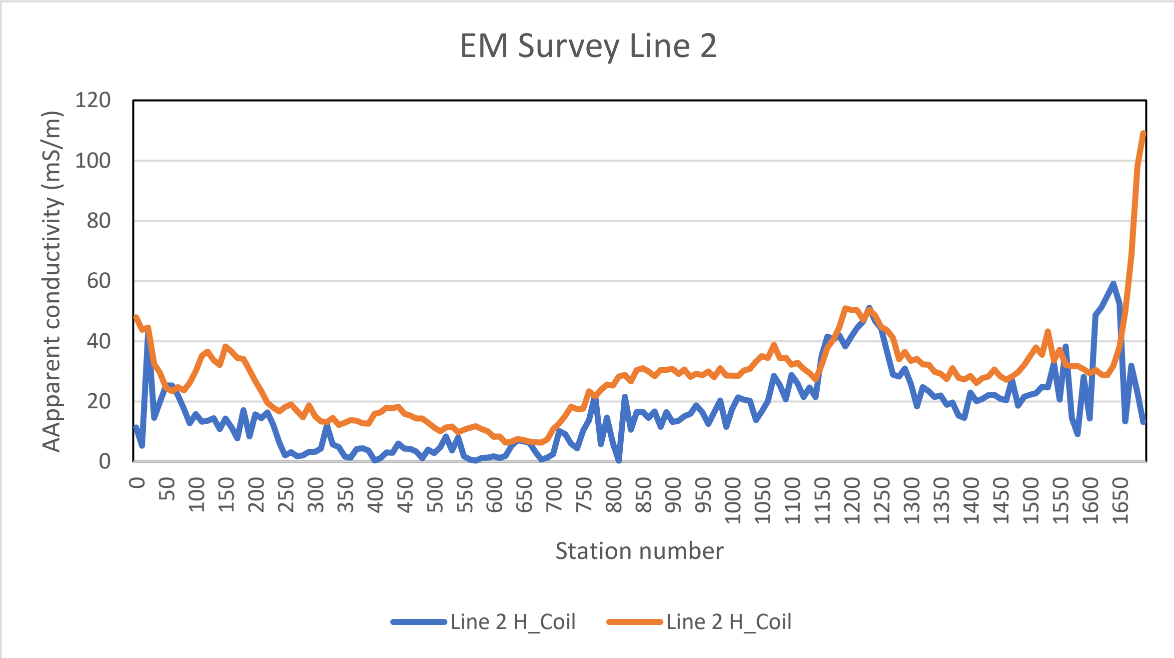
Drill target	Coordinates (UTM 36, WGS 84)		Targeting	Status
	X	Y		
VFBH8	29.834589	-26.01854	Anomaly in EM and Mag data-Line 1	No Access
VFBH9	29.819046	-26.02276	Anomaly in EM and MAG data; regional structure- Line 2	No Access
WVBH2	29.849014	-26.05861	Anomaly in EM and Mag data-Line 3. Target moved due to wetland in vicinity. Borehole was shifted to 29.8508, -26.0569.	Drilled
WVBH3	29.85541	-26.0543	Targeting regional structure- No anomaly in EM and Mag data	Drilled
MPBH3	29.85537	-26.0306	Anomaly in EM and Mag data-Line 4	Drilled



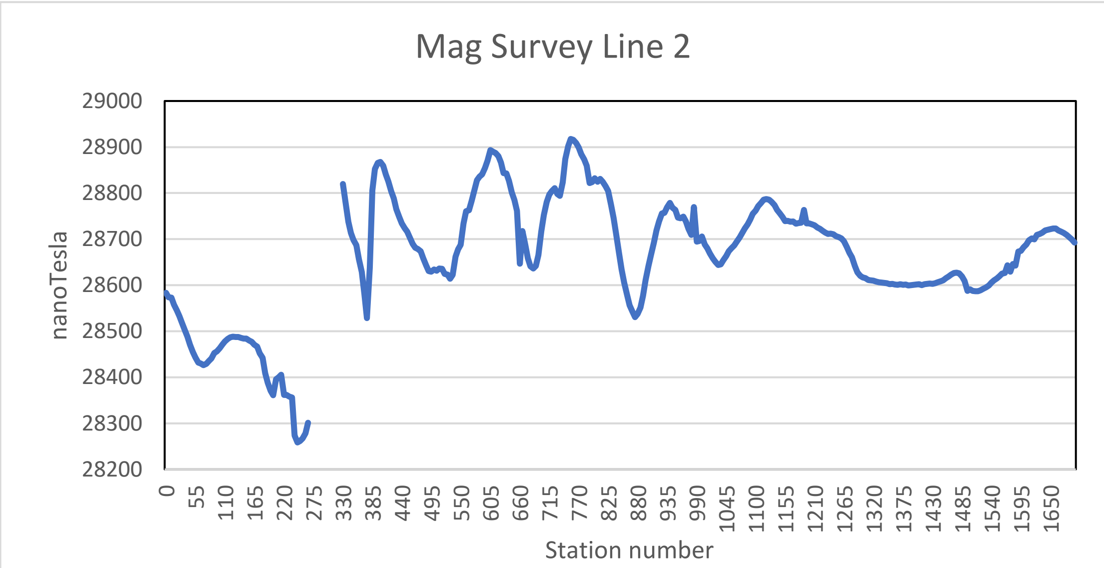
Line 1 Electromag



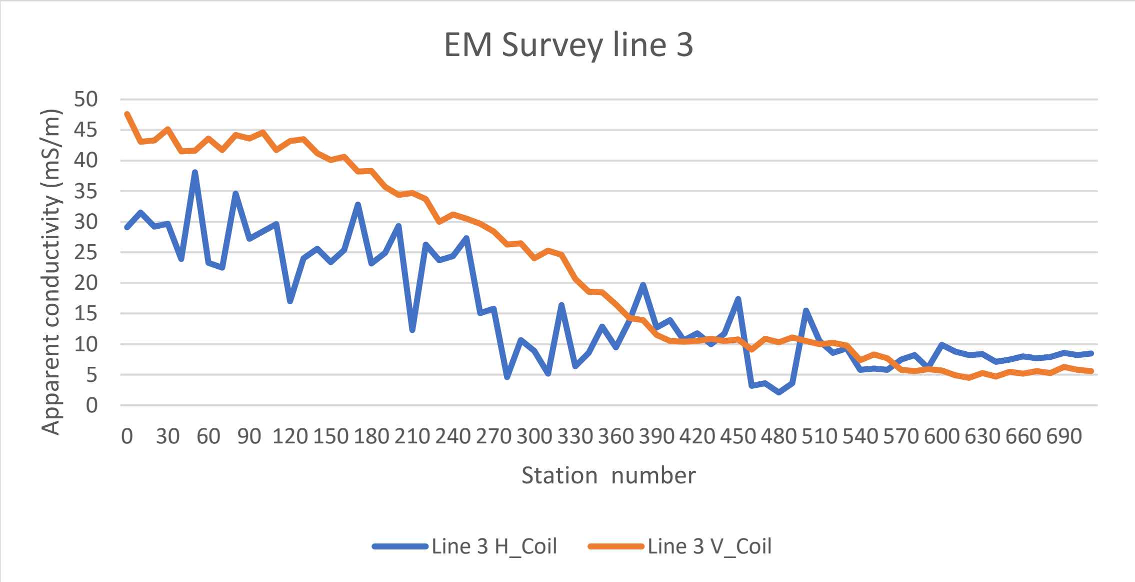
Line 1 Magnetometer



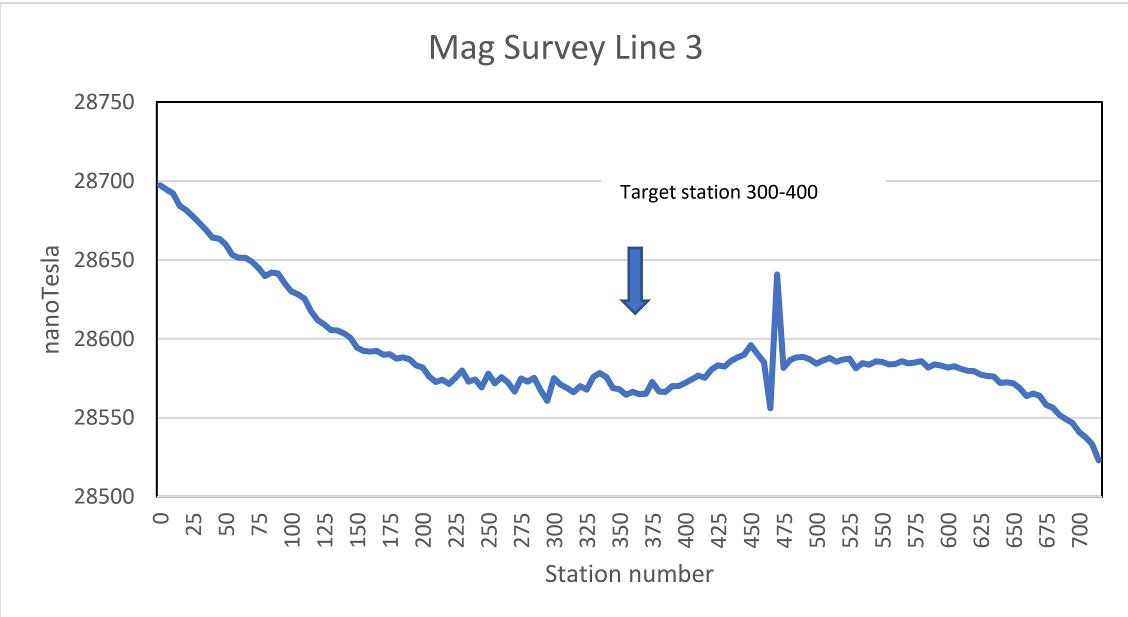
Line 2 Electromag



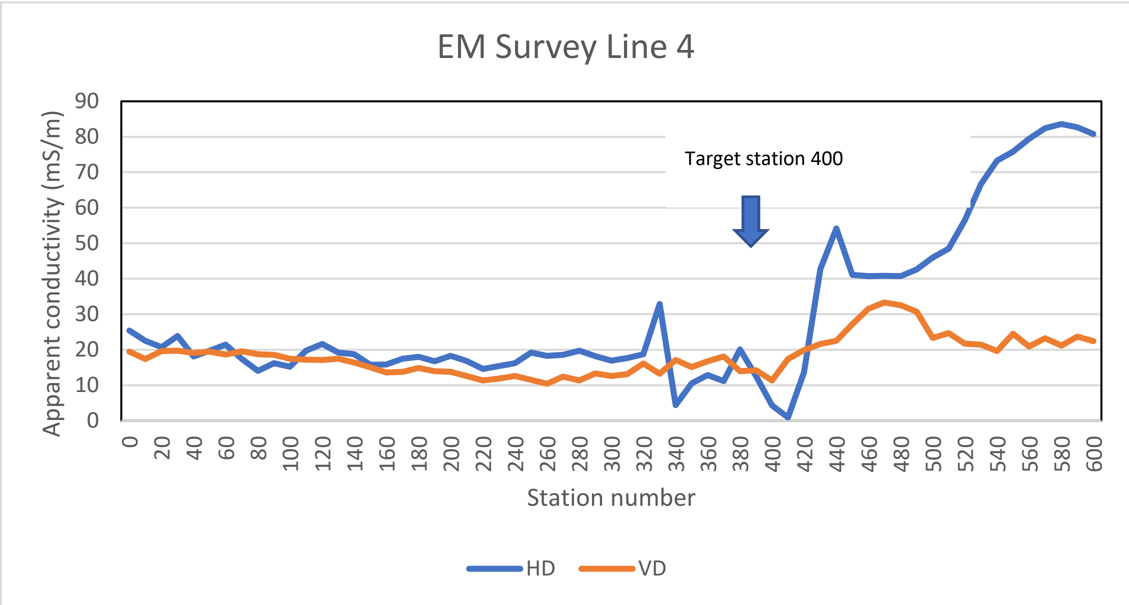
Line 2 Magnetometer



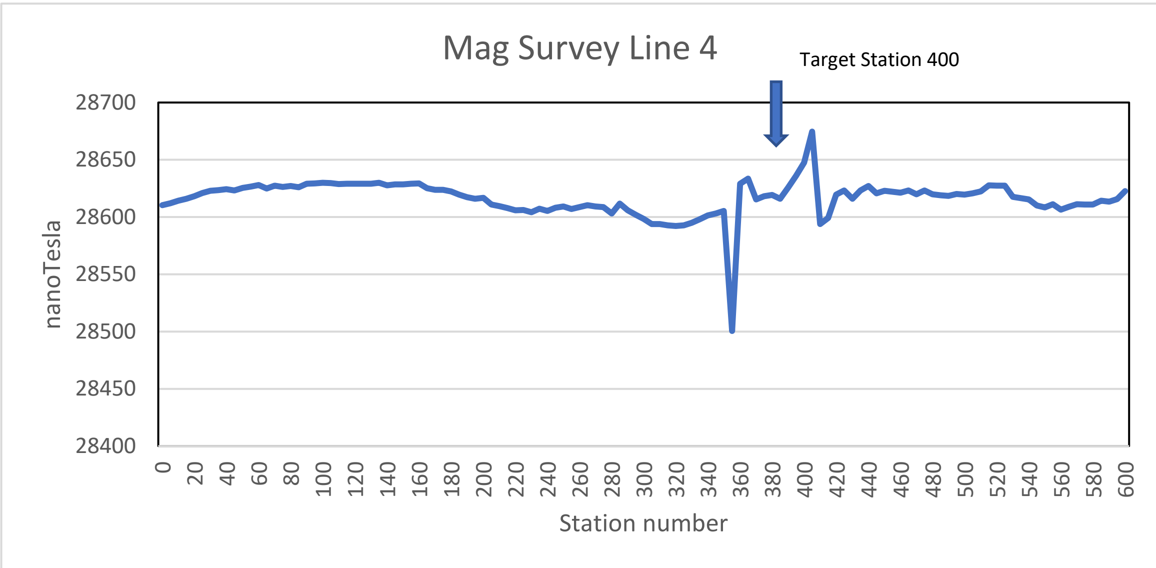
Line 3 Electromag



Line 3 Magnetometer



Line 4 Elctromag



Line 4 Mag

3.3.2.2. Borehole Drilling

Three (3) boreholes were drilled between the 16th of July and the 21st of July. The summary is provided below and in Table 3-2. The borehole logs will be included in the groundwater impact assessment study.

3.3.2.2.1. MPBH3B

MPBH3 was drilled on the 16th of July 2021 to a final depth of 66 m. Alternating layers of sandstone, carbonaceous shale and coal were intersected in MPBH3. The first 15 m of sandstone were moderately to completely weathered. The first coal seam was intersected at approximately 29 m and the last coal seam (S2 seam) was intersected between 56 m and 61 m. There were no water strikes in this borehole. A static groundwater level of 3.7 mbgl was measured in this borehole.

3.3.2.2.2. WVBH2B

WVBH2 was drilled on the 21st of July to a final depth of 41 m. WVBH2 intersected alternating layers of sandstone, mudstone, carbonaceous shale and coal until a depth of 38 m. The first 8 m of sandstone were completely weathered. Dolerite was intersected in the last 3 m. The first coal seam was located between 11 m and 15 m which also contained carbonaceous shale. The last seam (S2 Seam) was located between 24 m and 30 m. There were no water strikes in this borehole. A static groundwater level of 3.59 mbgl was measured in this borehole.

3.3.2.2.3. WVBH3

WVBH3 was drilled on the 18th of July to a final depth of 46 m. Overburden was intersected in the first 3 m after which there were alternating layers of sandstone, carbonaceous shale and coal. Moderate to complete weathering occurred to a depth of 17 m. The first coal seam was intersected at a depth of 25 m and the last seam (S2 Seam) at 38 m. No water strikes were intersected in this borehole and the groundwater level was still recovering by the 22nd of July.

Table 3-2: Borehole Summary

Borehole ID	X	Y	Borehole Depth (m)	Water Strike (mbgl)	Static Water Level (mbgl)	Final Blow Yield (L/s)	Lithology summary
MPBH3B	29.85537	-26.0306	66	-	3.7	n/a	Alternating layers of sandstone, carbonaceous shale and coal
WVBH2B	29.8508	-26.0569	41	-	3.59	n/a	Alternating layers of sandstone, mudstone, carbonaceous shale and coal with dolerite at the base
WVBH3	29.85541	-26.0543	46	-	-	n/a	Alternating layers of sandstone, carbonaceous shale and coal

3.3.3. Hydrocensus

Forty-three (43) boreholes were identified during the hydrocensus (Table 3-3) and Figure 3-5.

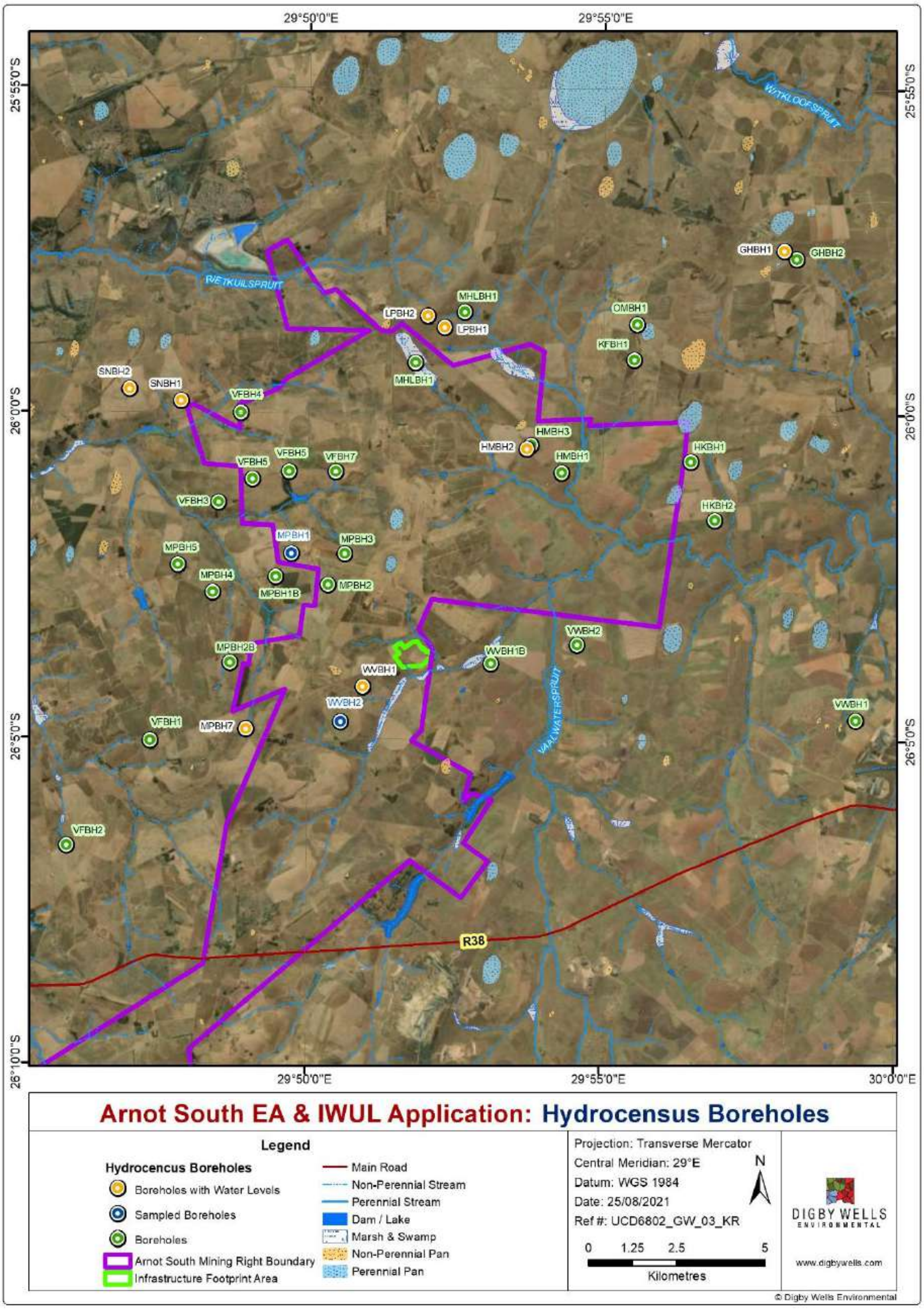


Figure 3-5: Hydrocensus Boreholes

3.3.3.1. Groundwater Use

The following conclusions were drawn from the hydrocensus:

- The main use for the identified privately owned boreholes around the mining right area are for livestock watering and to a lesser extent for domestic purposes. Boreholes are equipped with windmill or submersible pumps;
- The pH values (Field parameters) measured during the survey varied from 6.2 at WVBH1B to 8.4 at MPBH1 with an average pH of 6.9. A pH between 6.2 and 8.4 is indicative of a slightly circum-neautral waters;
- Conductivity values varied from 0.17 µS/m at MPBH2B to 0.66 µS/m at MPBH1 and thus, indicative of moderate low to slightly high conductivity (saline water) values;
- Groundwater level elevations were measured at seven boreholes only as most of the boreholes were equipped with windmill pumps. Based on the seven measurements depth-to-groundwater ranges between 0 mbgl and 24.7 mbgl (average of 7.34 mbgl), with groundwater level elevations ranging between 1 630 mamsl at WVBH1 and 1 691 mamsl at LPBH1; and
- The areas that have no sampling points were areas where access was not granted for the study.

3.3.3.2. Groundwater Levels

Groundwater levels were measured in seven (7) hydrocensus boreholes and two (2) of the newly drilled boreholes. The groundwater levels ranged between 0 mbgl and 24.2 mbgl, with an average of 6 mbgl. The groundwater levels are therefore relatively shallow and can provide a source of water to perennial pans and wetlands in the area. Groundwater levels were compared to surface elevations and a good correlation between surface elevation and groundwater level was found with a correlation coefficient of 0.93, indicating groundwater flow directions will mainly follow topography and the main surface water drainage directions (Figure 3-7).

There are two boreholes with groundwater levels deeper than 20 mbgl. One of the boreholes is equipped and the lower water level could be because of abstraction. The other borehole is not equipped but may be influenced by dewatering from a neighboring mining project.

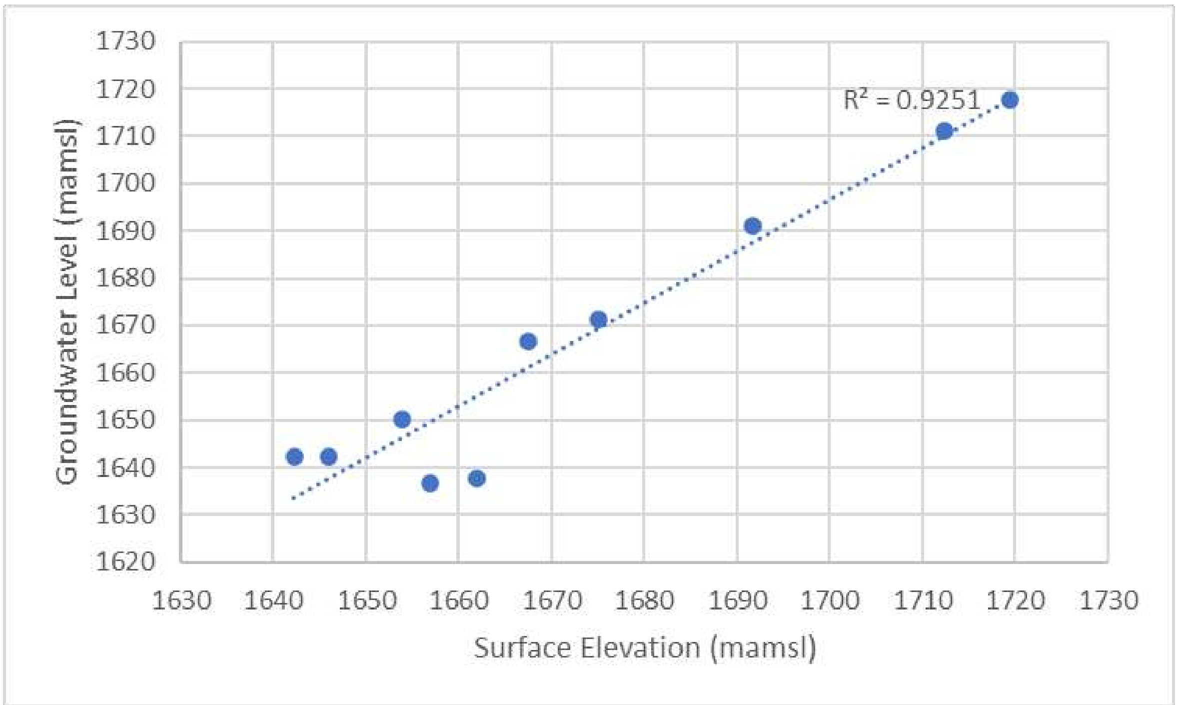


Figure 3-6: Bayesian Correlation between Surface Elevation and Groundwater Levels

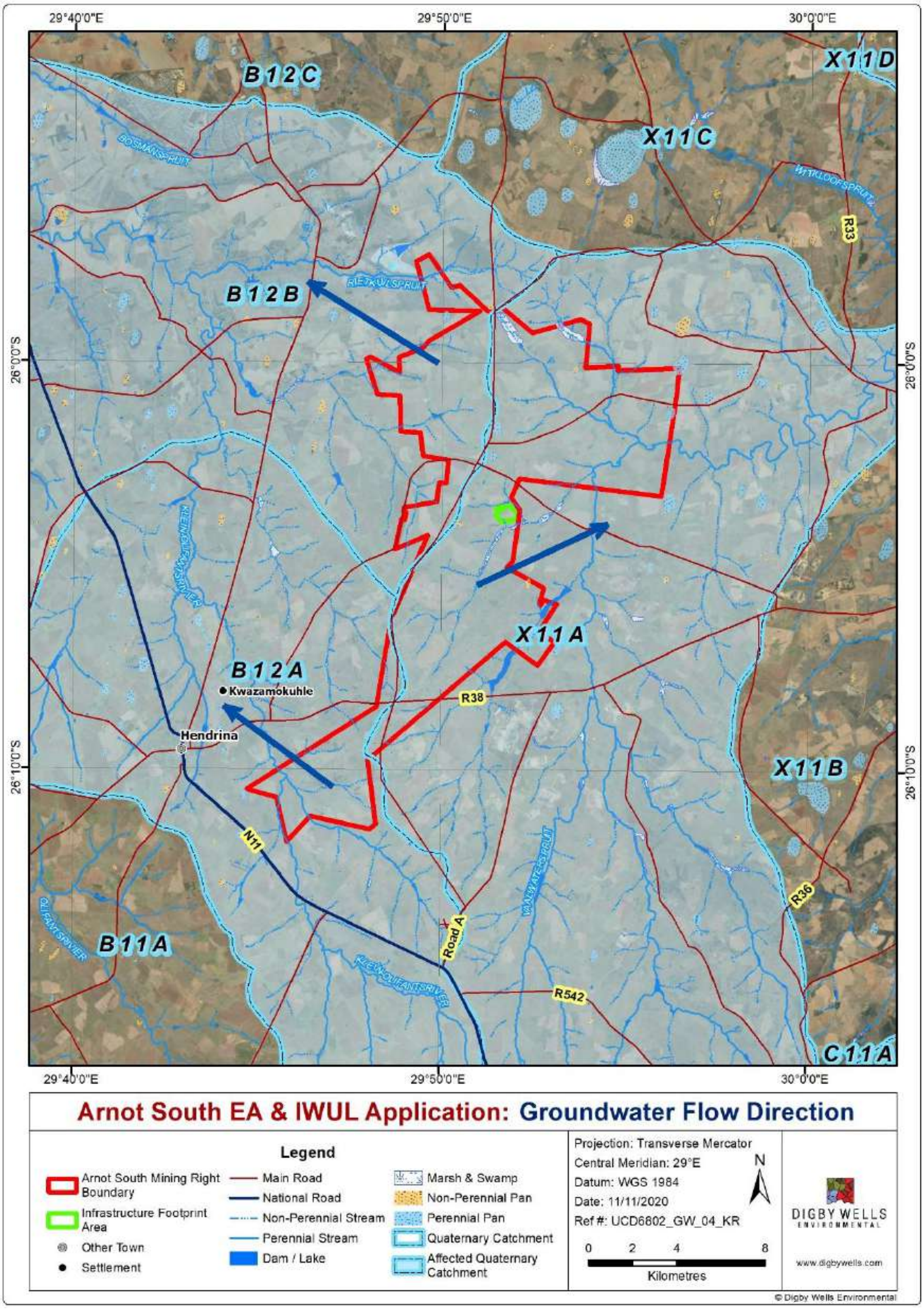


Figure 3-7: Groundwater Flow Direction

Table 3-3: Hydrocensus data

ID	Coordinates			Survey Date	Owner Information		Bore/Spring Status & Equipment					Hydrogeological Information		Water quality (Aug-20)					
	Easting (m)	Northing (m)	Elevation (mbgl)		Owner	Farm Name	Primary Water Application			Equipment	Borehole Depth (mbgl)	Static Water Level (mbgl)	Static Water Level (mamsl)	EC (mS/cm)	TDS (mg/l)	pH	T (C)	Water Sample Taken	Analyzed
							Primary Use	Other Uses											
								Domestic	Stock Watering			Aug-20	Aug-20						
MPBH1	-26.036	29.8287	1651	07/04/2021	Steinburg	MOOIPLAATS 165 IS Portion 4	Livestock	Not Applicable	Yes (Small Scale)	Windmill Pump	16	-		0.66	0.33	8.43	18.5	X	
MPBH2	-26.044	29.8391	1668.036	07/04/2021	Steinburg	MOOIPLAATS 165 IS Portion 12	Livestock	Not Applicable	(previously livestock)	Windmill Pump	40	-							
MPBH3	-26.036	29.8438	1662.523	07/04/2021	Steinburg	MOOIPLAATS 165 IS Portion 4	Livestock	Not Applicable	Not Applicable	Windmill Pump		-							
MPBH4	-26.046	29.8064	1642	07/04/2021	Steinburg	MOOIPLAATS 165 IS Portion	Livestock	Not Applicable	Not Applicable	Windmill Pump	36	-							
MPBH5	-26.039	29.7965	1638.979	07/04/2021	Steinburg	MOOIPLAATS 165 IS Portion	Livestock	Not Applicable	Not Applicable	Windmill Pump		-							
MPBH6	-26.081	29.816	1667.818	07/04/2021	Steinburg	MOOIPLAATS 165 IS Portion 12	Domestic	Yes (Small Scale)	Yes (Small Scale)	Windmill Pump		-							
MPBH7	-26.081	29.8161	1667.562	07/04/2021	Steinburg	MOOIPLAATS 165 IS Portion 12	Unused	Not Applicable	Not Applicable	Unequipped	10	0.82	1667.18	0.26	0.19	6.32	19.5		
WVBH1	-26.07	29.8491	1643.768	07/04/2021	Steinburg	WELTEVREDEN 174 IS Portion 4	Livestock	Not Applicable	Not Applicable	Windmill Pump		0	1630						
WVBH2	-26.079	29.8428	1659	07/04/2021	Steinburg	WELTEVREDEN 174 IS Portion 4	Livestock	Not Applicable	Not Applicable	Windmill Pump		-						X	x
HMBH1	-26.015	29.9051	1630.104	07/04/2021	Steinburg	HELPMAKAAR 168 IS Portion 13	Livestock	Not Applicable	Yes (Small Scale)	Windmill Pump		-							
HMBH2	-26.009	29.8952	1656.804	07/04/2021	Steinburg	HELPMAKAAR 168 IS Portion 13	Livestock	Not Applicable	Not Applicable	Electrical Submersible (Solar)		3.7	1656.3	0.25	0.15	7.01	20.7	X	x
HMBH3	-26.008	29.8964	1658.437	07/04/2021	Steinburg	HELPMAKAAR 168 IS Portion 13	Domestic	Yes (Small Scale)	Yes (Small Scale)	Windmill Pump									
LPBH1	-25.978	29.8717	1692.826	07/04/2021	Exxaro	Leeuwpan 494 Portion 10	Domestic	Yes (Small Scale)	Yes (Small Scale)	Unequipped		0.59	1691.41					x	x

ID	Coordinates			Survey Date	Owner Information		Bore/Spring Status & Equipment					Hydrogeological Information		Water quality (Aug-20)					
	Easting (m)	Northing (m)	Elevation (mbgl)		Owner	Farm Name	Primary Water Application			Equipment	Borehole Depth (mbgl)	Static Water Level (mbgl)	Static Water Level (mamsl)	EC (mS/cm)	TDS (mg/l)	pH	T (C)	Water Sample Taken	Analyzed
							Primary Use	Other Uses											
								Domestic	Stock Watering			Aug-20	Aug-20						
HKBH1	-26.012	29.9417	1639.341	07/04/2021	Steinburg	HELPMAKAAR 171 IS Portion 8	Livestock	Not Applicable	Yes (Small Scale)	Windmill Pump				0.24	0.15	6.83	19		
HKBH2	-26.027	29.9486	1624.847	07/04/2021	Steinburg	HELPMAKAAR 171 IS Portion 8	Livestock	Not Applicable	Not Applicable	Windmill Pump									
MPBH8	-26.036	29.8287	1660.15	07/04/2021	Steinburg	MOOIPLAATS 165 IS Portion 4	Domestic	yes (Small Scale)	Yes (Small Scale)	Electrical Submersible								X	x
SNBH1	-25.997	29.7972	1649.979	08/04/2021	Van de Merwe	SCHOONOORD 164 IS Portion 5	Domestic	yes (Small Scale)	Yes (Small Scale)	Electrical Submersible		Pumping		0.23	0.12	6.87	17.8		
SNBH2	-25.994	29.7826	1663.167	08/04/2021	Van de Merwe	SCHOONOORD 164 IS Portion	Unused	Not Applicable	Yes (Small Scale)	Unequipped		24.17	1644.83						
TFBH1			0	08/04/2021	Van de Merwe	Tweeyfelaar	-	Not Applicable	Yes (Small Scale)	-		-							
GHBH1	-25.958	29.9678	1713.687	08/04/2021	Van de Merwe	Unknown	Unused	Not Applicable	Not Applicable	Unequipped		20.3	1690.7	0.27	0.13	6.06	23.4		
GHBH2	-25.96	29.9713	1703.088	08/04/2021	Van de Merwe	Unknown	Unused	Not Applicable	Not Applicable	Unequipped									
VWBH1	-26.078	29.9889	1673.401	08/04/2021	Steinburg	Unknown	-	Not Applicable	Not Applicable	Unequipped				0.26	0.44	7.13	22.3	X	
VWBH2	-26.059	29.9098	1618.666	08/04/2021	Steinburg	WELTEVREDEN 173 IS Portion 4	-	Not Applicable	Not Applicable	Unequipped									
MPBH1B	-26.042	29.8243	1657.599	08/04/2021	Steinburg	MOOIPLAATS 165 IS Portion	Domestic		Not Applicable	Electrical Submersible				0.18	0.09	6.64	20.4	X	
MPBH2B	-26.064	29.8114	1658.081	08/04/2021	Steinburg	MOOIPLAATS 165 IS Portion 3	Domestic		Not Applicable	Electrical Submersible				0.17	0.11	7.41	21	X	
VBBH1	-26.064	29.8114	1658.045	08/04/2021	Steinburg	Unknown	-	Not Applicable	Not Applicable	Windmill Pump									
VBBH1a	-26.078	29.9889	1673.343	08/04/2021	Steinburg	Unknown	-	Not Applicable	Not Applicable	Windmill Pump									
WVBH1B	-26.064	29.8854	1610.314	08/04/2021	Snyman	WELTEVREDEN 174 IS Portion 3	-	Not Applicable	Not Applicable	Windmill Pump				0.22	0.11	6.18	23.8	X	
VFBH1	-26.084	29.7889	1677.67	08/04/2021	Van de Merwe	VLAKFONTEIN Portion	Livestock	Not Applicable	Yes (Small Scale)	Windmill Pump									

ID	Coordinates			Survey Date	Owner Information		Bore/Spring Status & Equipment					Hydrogeological Information		Water quality (Aug-20)					
	Easting (m)	Northing (m)	Elevation (mbgl)		Owner	Farm Name	Primary Water Application			Equipment	Borehole Depth (mbgl)	Static Water Level (mbgl)	Static Water Level (mamsl)	EC (mS/cm)	TDS (mg/l)	pH	T (C)	Water Sample Taken	Analyzed
							Primary Use	Other Uses: Domestic	Other Uses: Stock Watering			Aug-20	Aug-20						
VFBH2	-26.111	29.7654	1670.583	08/04/2021	Van de Merwe	VLAKFONTEIN Portion	Livestock	Not Applicable	Yes (Small Scale)	Windmill Pump									
VFBH3	-26.023	29.808	1647.508	08/04/2021	Van de Merwe	VLAKFONTEIN Portion	Livestock	Not Applicable	Yes (Small Scale)	Windmill Pump									
VFBH4	-26	29.8142	1641.201	08/04/2021	Van de Merwe	VLAKFONTEIN 166 IS Portion 2	Livestock	Not Applicable	Yes (Small Scale)	Windmill Pump									
VFBH5	-26.017	29.8176	1660.993	08/04/2021	Van de Merwe	VLAKFONTEIN 166 IS Portion 2	Livestock	Not Applicable	Yes (Small Scale)	Windmill Pump									
VFBH6	-26.015	29.8279	1665.904	08/04/2021	Van de Merwe	VLAKFONTEIN 166 IS Portion 2	Livestock	Not Applicable	Yes (Small Scale)	Windmill Pump									
VFBH7	-26.015	29.8411	1651.944	08/04/2021	Van de Merwe	VLAKFONTEIN 166 IS Portion 13	Livestock	Not Applicable	Yes (Small Scale)	Windmill Pump									
KFBH1	-25.986	29.9255	1685.117	08/04/2021	Van de Merwe	Unknown	Unused	Not Applicable	Not Applicable	Windmill Pump									
OMBH1	-25.977	29.9263	1692.753	08/04/2021	Unkown	Unknown	Used Intermittently	Not Applicable	Yes (Small Scale)	Windmill Pump								x	
MHLBH1	-25.974	29.8774	1667.83	08/04/2021	Mahlangu	Leeuwpan 494 Portion 10	Unused	Not Applicable	Not Applicable	Unequipped									
LPBH2	-25.975	29.8669	1721.891	08/04/2021	Exxaro	Leeuwpan 494 Portion 10	Unused	Not Applicable	Not Applicable	Unequipped	50	1.8	1711.2						
WFBH1	-25.987	29.8634	1678.094	08/04/2021		Leeuwpan 494 Portion 8	Blocked	Not Applicable	Not Applicable	Unequipped	Blocked								
WFBH2	-25.987	29.8635	1678.032	08/04/2021		Leeuwpan 494 Portion 8	Blocked	Not Applicable	Not Applicable	Unequipped	Blocked								
WFBH3	-25.987	29.8636	1678	08/04/2021		Leeuwpan 494 Portion RE	Blocked	Not Applicable	Not Applicable	Unequipped	Blocked								
WFBH4	-25.987	29.8635	1678.285	08/04/2021		Leeuwpan 494 Portion RE	Blocked	Not Applicable	Not Applicable	Unequipped	Blocked								

3.3.3.3. Hydrochemistry

The Piper Diagrams (Figure 3-8) and Expanded Durov (Figure 3-9) graphs have been used to describe the hydrochemistry for the sampled boreholes.

The Piper Diagram is particularly useful for identifying groundwater facies which groups groundwater of similar chemistry into one section. The Expanded Durov diagram improves on the Piper Diagram by displaying important hydrochemical processes, such as ion exchange, simple dissolution and mixing of waters of different qualities.

The Piper Diagram (Figure 3-8) shows that there is no dominant cation and bicarbonate as the dominant anion. The Expanded Durov Diagram (Figure 3-9) shows magnesium-bicarbonate type water. Based on these two diagrams it can be noted that the water on site is fresh recently recharged water.

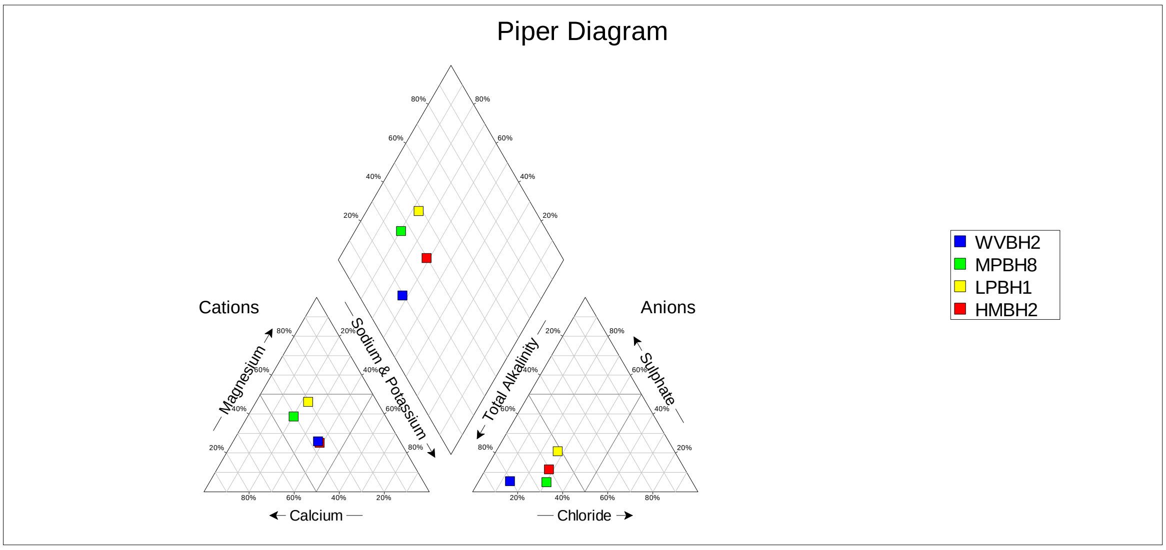


Figure 3-8: Piper Diagram

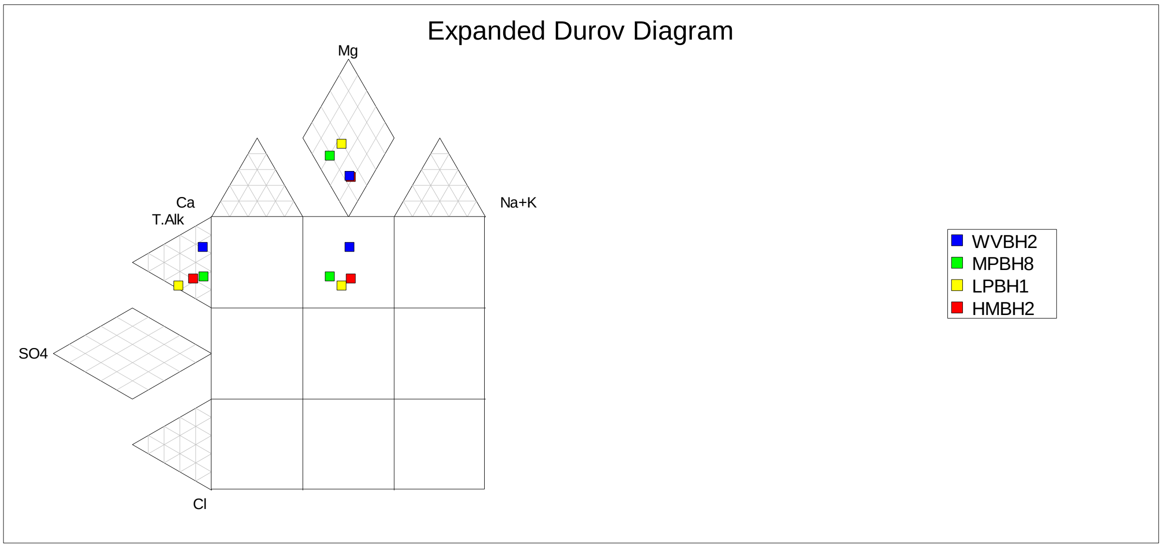


Figure 3-9: Expanded Durov Diagram

3.3.3.4. Groundwater Quality

The groundwater quality results were compared to the South African Water Quality Guidelines (SAWQG): for Drinking Water to provide an indication of the baseline water quality for the project. A total of ten samples were collected and only four were sent to a laboratory for water quality analysis. Samples collected were sent to M and L laboratories (a SANAS accredited lab) for analysis. The results are summarized in Table 3-4: Baseline Water Quality. An additional three water samples were collected from the newly drilled boreholes, however, these results are still outstanding.

The groundwater quality in the project area shows relatively good quality of the groundwater in the area, with a few exceedances. The most notable exceedances are for pH at LPBH1 which was not within the acceptable limit. Nitrate at WVBH2 and MPBH8 was above the ideal limit but withing the acceptable limit, this exceedance can be associated with the widespread use of fertilizer in the area. Additionally, manganese was above the ideal limit at LPBH1 which is associated with the surrounding geology.

Table 3-4: Baseline Water Quality

Site Name	Sample Date	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	Al mg/L	Fe mg/L	Mn mg/L
Ideal			70	450	32	30	100	50	100	200	6	1	0.15	0.1	0.05
Acceptable			150	1000	80	50	200	100	200	400	10	1.5	0.5	0.3	0.1
Unacceptable		<6 or >9	>150		>80	>50	>200	>100	>200	>400	>10	>1.5	>0.5	>0.3	>0.1
WVBH2	2020/04/07	7.26	20.41	136	15.5	6.64	15.05	6.2	8.2	<4	6.2	<0.1	<0.017	0.004	<0.001
HMBH2	2020/04/07	6.38	11.4	98	7.7	3.23	4.76	8.29	9.43	5	2.8	<0.1	<0.017	0.04	0.004
MPBH8	2020/04/07	6.67	26.03	216	22.1	12.64	9.9	5.33	19.59	<4	9.6	<0.1	<0.017	0.007	<0.001
LPBH1	2021/04/07	5.92	22.22	144	14.6	13.34	11.5	2.48	21	21	1.3	<0.1	<0.017	0.006	0.078

3.4. Hydrogeology

3.4.1. General Aquifer description

The groundwater system in the Mpumalanga coalfields is composed of three distinct superimposed aquifers (Hodgson *et al.* 1998), namely:

- the upper weathered Ecca aquifer;
- the fractured Karoo aquifers comprising of unweathered Ecca sediments; and
- the aquifer below the Ecca sediments (the fractured pre-Karoo aquifer).

These aquifers are common to the groundwater regime in the Karoo environment and do not necessarily occur in isolation but often form a composite groundwater regime that is comprised of one, some, or all of the systems. Based on the exploration drilling at the site the upper weathered and fractured Karoo aquifers are present for the project area (Figure 3-10).

The Karoo rocks are not known for large scale development of aquifers, but occasional high-yielding boreholes can be present. The aquifers that occur in the area are therefore classified as minor aquifers (low yielding), but of high importance (Parsons, 1995) and are understood to have a low to medium development potential, mostly being used for small scale domestic purposes or occasionally for large scale irrigation.

3.4.1.1. The Weathered Aquifer

The Ecca sediments are weathered to depths between 5 and 20 m (average of 12 m) below the surface throughout the area. The upper aquifer is associated with this weathered zone and water is often found a few metres below the surface. The weathered layer comprises of residual soils and weathered shales and sandstones. The hydraulic conductivity values are in the order of 10^{-1} m/d to 10^{-2} m/d.

This aquifer is recharged by rainfall. The percentage recharge to this aquifer is estimated to be in the order of 1% to 3% of the annual rainfall based on work by Kirchner *et al*. (1991) and Bredenkamp (1995). It should, however, be emphasised that in a weathered system, such as the Ecca sediments, highly variable recharge values can be found from one area to the next. This is attributed to the composition of the weathered sediments, which range from coarse-grained sand to fine clay.

In terms of susceptibility to pollution, the shallow primary aquifer is understood to be highly susceptible to pollution due to coal mining in the area as the pollutants travel shorter distance to reach the aquifer system (Hodgson and Krantz, 1998). Low-lying wetlands, where groundwater levels are close to the surface, can indicate interaction between groundwater and surface water and can also serve as conduits for potential contamination.

3.4.1.2. Fractured Ecca Aquifer

The fractured aquifer occurs beneath the weathered aquifer, within fresh sediments. The Ecca sediments are generally well-cemented which limits the permeability of the sediments. Groundwater movement, therefore, occurs predominately along secondary structures, such as fractures and faults. However not all secondary structures will be water bearing and fracture density in this aquifer generally decreases with depth. The yields for this aquifer are low, typically in the range of 10^{-3} m/d to 10^{-4} m/d.

3.4.2. Aquifer Testing

The slug test data was analysed using Aqtesolv software. The Bouwer-Rice and Hvorslev methods for unconfined conditions were used to determine the hydraulic conductivity for the aquifer system. The results are summarised in Table 3-5.

The hydraulic conductivities range between 0.003 m/d and 0.6 m/d which are typical for Karoo aquifers. Project experience around Hendrina indicates typical hydraulic conductivities of between 0.25 m/d and 0.06 m/d for the weathered to shallow aquifer and between 0.005 m/d 0.0002 m/d for the deeper fractured aquifer.

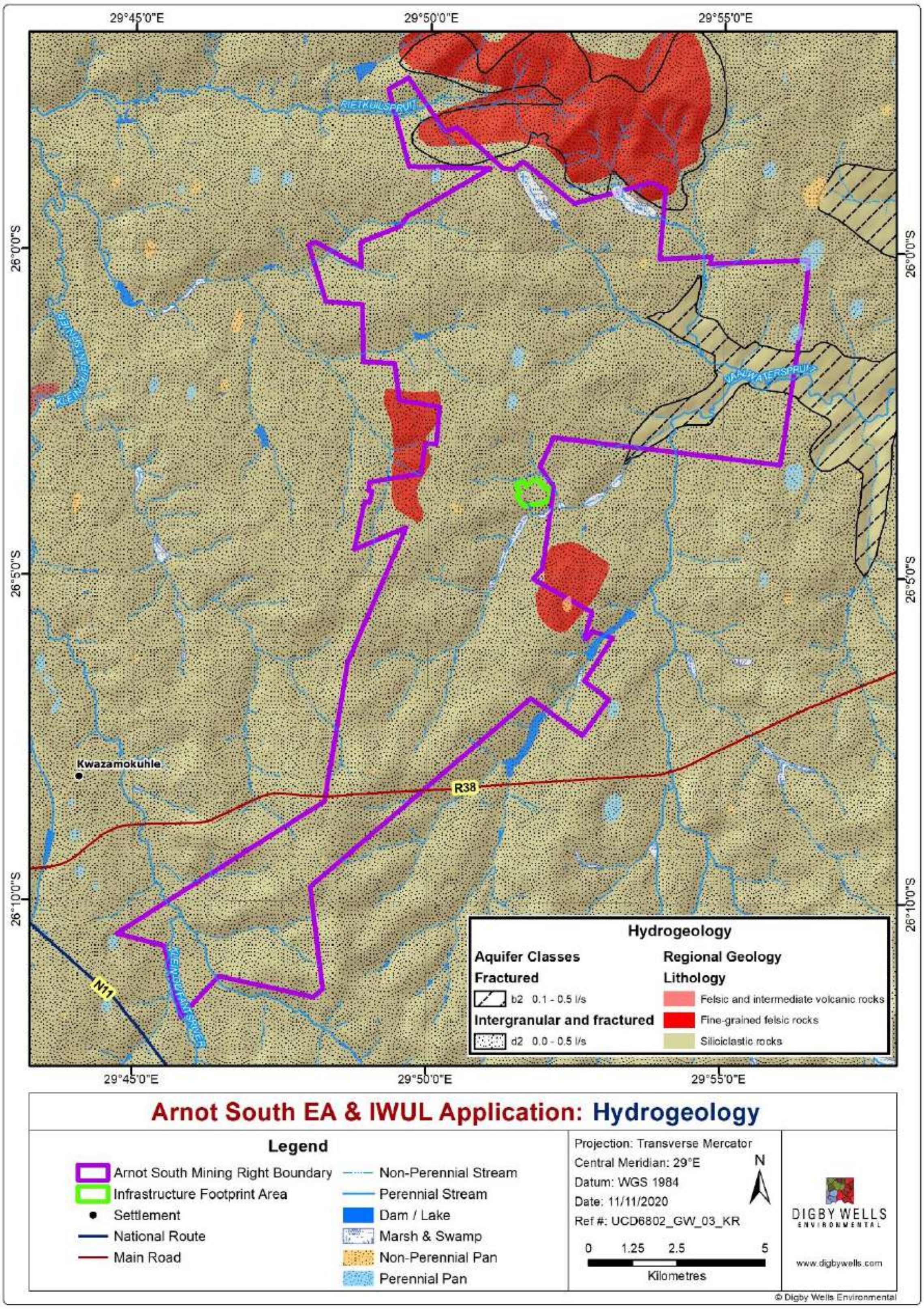


Figure 3-10: General Site Aquifer

Table 3-5: Aquifer Test Summary

BH ID	Blow yield (l/s)	Pump yield (l/s)	Test	Total Displacement (m)	Test duration (min)	Recovery %	Hydraulic Conductivity (m/day)			Transmissivity (m2/day)
							Bouwer-Rice	Hvorslev	Average	
MPBH3B	-	-	Slug (In) Early	0.27	12	26	0.47	0.59	0.53	33.0
MPBH3B	-	-	Slug (In) Late				0.006	0.006	0.006	0.4
WVBH2B	-	-	Slug (In)	0.25	6	52	0.17	0.20	0.18	6.9
WVBH2B	-	-	Slug (Out)	0.25	9.5	91	0.28	0.37	0.32	12.1
WVBH3	-	-	Recovery	33.1	2963	-	0.003	0.004	0.004	0.1
Average									**0.21**	**10.5**
Geometric mean									**0.06**	**2.6**
Harmonic mean									**0.01**	**0.4**

4. High Level Impact Assessment

Impact assessments are tools that are used to avoid damage or loss of the natural resources and ecosystems functioning or mitigate expected damages or losses that cannot completely be avoided. Offsets to compensate for the loss of habitat are regarded as a last resort, after all efforts have been made to avoid, reduce, and mitigate.

High-level impacts of the proposed mining activities on the groundwater environment are shown below per phase of mining. The impacts are discussed below and were identified based on the baseline groundwater assessment for the Project Area as well as the proposed site infrastructure and activities. These impacts will be assessed following the completion of the groundwater numerical model.

4.1. Construction Phase

During the construction phase the following potential impacts may result from the on-site activities:

- Contamination of groundwater due to accidental hydrocarbon spillages and leaks from construction vehicles; and
- Small-scale dewatering during the construction of the adit for the underground mine.

These impacts are of small magnitude and will only pose local, negligible groundwater impacts confined within the site boundaries.

4.2. Operational Phase

During the operational phase of the mine the following potential impacts may result from on-site activities:

- Reduction of groundwater reserves (lowering of the surrounding groundwater levels and reducing of aquifer yield due to mine dewatering);
- Contamination of the groundwater as a result of seepage from mine waste facilities such as the discard dump;
- Contamination from workshops, sewage treatment plant, wash bay or waste collection areas; and
- These impacts are of a larger scale and the potential for severe impacts on groundwater receptors is high. Receptors include private boreholes, springs, pans, wetlands and nearby streams.

4.3. Post-Closure Phase

During the post closure phase of the mine the following main potential impacts may result from on-site activities:

- Contamination of groundwater from surface infrastructure (i.e. discard dump) and subdued groundwater levels due to prolonged mine dewatering; and
- Decant of contaminated water once water levels in the underground void recover.

The impacts are of a large scale and the potential for severe impacts to groundwater receptors is high.

5. Conclusion and Recommendations

5.1. Conclusions

Digby Wells Environmental was appointed by Universal Coal to undertake a hydrogeological baseline study as part of an EIA Process for the Arnot South project.

The following conclusions were drawn from the baseline assessment:

- Climatic, topography and hydrological conditions:
  - The site is located within the Oceanic Subtropical Highland Climate that experiences warm, rainy summers and dry witnters with sharp frost;
  - The mean annual precipitation of the site is between 672 mm and 688 mm;
  - The topography of the Project area is generally flat;
- Regional Geology
  - The Arnot South Project area is situated within the Witbank Coalfield, which is underlain by formations of the Dwyka and Ecca Groups;
- The aquifer zones present on site are as follows:
  - The weathered zone made up of the Ecca sediments. Generally the depth ranges between 5 and 12 mbgl;
  - The fractured aquifer within the Ecca sediments (shale, sandstone and coal seams);
  - Fractured pre-Karoo aquifer comprised of basement granites, dolomites and Ventersdorp lavas;
- Four lines were surveyed within the mining right area for the purpose of target generation for monitoring boreholes that would also be used to obtain aquifer parameters. The total traverse length was 4.84 km.
- A total of three boreholes were drilled between the 16th of July and 21st July. The borehole depth ranged between 41 mbgl and 66 mbgl.
  - Hydrocensus
  - Groundwater uses

- Generally the community uses groundwater for agricultural purposes;
- The groundwater quality from the sampled boreholes shows that the site's groundwater is of good conditions;
- The groundwater levels range between 0 mbgl and 27.4 mbgl with an expected groundwater flow direction to the north-western direction;
- Based on the Piper and Expanded Durov Diagrams, the water type in the region is magnesium-bicarbonate which is associated with freshly recharged groundwater.
- The groundwater qualityin the study area is generally good. A few exceedances were noted for nitrate at WVBH2 and MPBH8 and pH and Manganese at LPBH1.
  - The study area has two main aquifer systems. The weathered aquifer dominated by sediments and the fractured aquifer.
  - Aquifer Testing

- As the drilled boreholes were dry, slug tests were performed. The hydraulic conductivities were found to be between 0.003 m/d and 0.6 m/d which are typical of Karoo aquifers.
  - The following potential impacts and mitigation measures have been drawn from this study:
    - Construction phase: Potential impacts like contamination of groundwater, small-scale dewatering during pit construction. These impacts are believed to be small scale and will pose localised impacts;
    - Operational phase: Due to dewatering reduction of groundwater resources should be expected and contamination of groundwater by WRD; and
    - Post-closure phase: contamination of groundwater in the mined open pit and from seepage from the WRD.
- The following Recommendations can be drawn from this study:
  - Conceptual and numerical groundwater modelling to quantify groundwater qualitative and quantitative impacts for the construction, operational and post-closure phases.

6. References

Bredenkamp Db, Botha Lj, Van Tonder Gj and Van Rensburg Hj (1995) Manual on Quantitative Estimation of Groundwater Recharge and Aquifer Storativity. WRC Report No TT 73/95.

Kirchner R, Van Tonder GJ, and Lucas E (1991). Exploitation Potential of Karoo Aquifers. WRC Report No. 170/1/91.