MANUPOINT 124 (PTY) LTD

GEOHYDROLOGICAL INVESTIGATION FOR PURPOSES OF A WATER USE LICENCE APPLICATION

GEOHYDROLOGICAL INVESTIGATION

AT

EKLAND SAFARIS

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EXECUTIVE SUMMARY

Ekland Safaris is an existing private reserve of which the facilities within the reserve were constructed prior to 2000. In 2017, the owner decided to upgrade and refurbish the existing facilities on the property to become one of the top lodges in the world with only selected wealthy guests to be accommodated at this luxury facility. As part of various environmental authorisations, the water use needs to be licenced.

Manupoint 124 (Pty) Ltd therefore appointed Aurecon to conduct a geohydrological investigation at Ekland Safaris. The combined surface area of the registered properties totals 14 000 hectares.

The objective of the assessment was as follow:

- Evaluate selected existing production boreholes in term of yield and quality;
- Perform a Rapid Reserve Determination in support of a Water Use License Application (WULA) in terms of Section 21 of the National Water Act (NWA), 1998 (Act 36 of 1998).

This report is not intended to be an exhaustive description of all the tasks performed, but rather a summary of the most important findings.

Based on existing and newly acquired data, the following can be concluded:

- The majority of the project area consists of Karoo Supergroup faulted against and overlying the Soutpansberg Group to the far south. Strike faulting, parallel to the ridges is common and a number of fault lines is evident on the published geological map.

- The study area can be regarded as having a moderate to high groundwater potential with groundwater occurrences confined to several major structures present within the property boundaries. These fractured systems are recharged by the Mutamba River where high yielding boreholes associated with these fault systems have been drilled. The Mutamba River also has well developed alluvial deposits.

- The results of the hydrocensus confirmed that groundwater plays an important role within the project area and is used for agricultural and domestic applications. Boreholes with significant yields occur within the project area (ranging from 900 to 39 600 litres/hour with an average yield of 13209 litres/hour). The static water level as measured within the boreholes during the hydrocensus ranges between artesian and 52 meters below ground level with the majority of the boreholes having a static water level of less than 25 meters below ground level.

- The groundwater quality of boreholes located within the property boundaries varies. Twelve water samples were collected from the boreholes during the constant discharge tests and submitted for a water quality analysis. The results were compared to the SANS 241-1:2015 Drinking Water Standards. Seven of the twelve boreholes complied with the SANS standards. The remaining five boreholes reported water quality not fit for human consumption without prior treatment.

- Based on the results of the constant discharge tests performed on the production boreholes, the tested boreholes can supply a total volume of 1394 ML/annum which can supply in the calculated annual demand of 270 ML.

- Based on the results of the reserve calculations and the submission of the WULA, it is advised to apply for an allocation of 0.6 Mm^3/annum from the total property in order to

make provision for future expansions and development (current calculated demand is 0.27 Mm^3/annum). An application of 0.6 Mm^3/annum (36.6% of the local recharge) places the application in Category A (small scale abstractions - <60% recharge on the local catchment).

- Based on information collected during the hydrocensus it can be concluded that aquifer system in the study area can be classified as a “Sole Aquifer System”. Aquifers is used to supply in excess of 50% or more of water for domestic and agricultural purposes and there are no reasonably available alternative sources should the aquifer be impacted upon or depleted. One can also assume that the aquifer is important for supplying base flow to the local streams and their tributaries.

Based on the above conclusions, the following recommendations are made:

- In order to mitigate potential contamination of the aquifers underlying the project area, a groundwater management program needs to be developed and implemented as part of the environmental management program.
- As part of the groundwater management program, a groundwater monitoring program should be implemented. Should it become evident from the monitoring program that pollution of the groundwater occurs or anomalous lowering in static water levels occur, corrective and remedial actions should be implemented.

1 INTRODUCTION

Ekland Safaris is an existing private reserve of which the facilities within the reserve were constructed prior to 2000. In 2017, the owner decided to upgrade and refurbish the existing facilities on the property to become one of the top lodges in the world with only selected wealthy guests to be accommodated at this luxury facility. As part of various environmental authorisations, the water use needs to be licenced.

Manupoint 124 (Pty) Ltd therefore appointed Aurecon to conduct a geohydrological investigation at Ekland Safaris. The combined surface area of the registered properties totals 14 000 hectares.

The objective of the assessment is as follow:

- Evaluate selected existing production boreholes in term of yield and quality;
- Perform a Rapid Reserve Determination in support of a Water Use License Application (WULA) in terms of Section 21 of the National Water Act (NWA), 1998 (Act 36 of 1998)[1].

This report is not intended to be an exhaustive description of all the tasks performed, but rather a summary of the most important findings.

2 METHODOLOGY

The work completed for the purposes of compiling a geohydrological report was executed as per the requirements from the Department of Water Affairs and Sanitation (DWS) presented in Appendix A and comprised of the following:

2.1 Desk Study & Site Visit

All existing and published data as well as data from the client was collated. Aerial photos and geological maps were studied to identify possible structural features. This data was used to familiarise ourselves with the site conditions and project objectives. A site visit was conducted to evaluate the geology, geohydrology and potential receptors of possible groundwater pollution emanating from the property. An assessment of the production boreholes was also done to plan for the pump testing of the relevant boreholes.

2.2 Hydrocensus

A hydrocensus was carried within the boundaries of the property to identify existing boreholes, springs and groundwater dependent ecosystems.

2.3 Pumptesting

Twenty four hour constant discharge tests followed by recovery monitoring was conducted on potential production boreholes. Test pumping was conducted as per SANS 10299-4:2003 standards[2]. The data was scientifically analysed to determine the sustainable yield of the tested boreholes. Groundwater samples were collected towards the end of the constant discharge tests

[1] South African National Water Act (Act 36 of 1998)

[2] South African National Standard. Development, maintenance and management of groundwater resources. Part 4: Test-pumping of water boreholes (SANS 10299-4:2003, edition 1.1). ISBN 978-0-626-32920-4

and submitted to an SANAS accredited laboratory for a "Drinking Water Standard" analysis (SANS 241:2015)[3].

2.4 Rapid Reserve Determination

The "Reserve" and groundwater available for abstraction was calculated through a "Rapid Reserve Determination" using the "Groundwater Resources Directed Measures" software [4]developed by the then DWA.

2.5 Aquifer Classification

The aquifer(s) underlying the project area was classified in accordance with "A South African Aquifer System Management Classification"[5] developed by the Water Research Commission and the DWA.

2.6 Reporting

A technical report was compiled summarising the findings of the above mentioned tasks which needs to be submitted in support of the WULA.

3 PHYSIOGRAPHY

3.1 Site Location

Ekland Safaris is located on a 14 000-hectare area, located along the N1, between Louis Trichardt and Musina in the Limpopo province (Figure 1). The surrounding land uses are mainly agricultural for the purposes of game farming. There are also mining activities located north east of Ekland Safaris (east of the N1). The project area can be divided into two sections:

- Lion Farm Section (located east of the N1)
- Ekland Section (located to the west of the N1)

3.2 Topography & Drainage

The area comprises hilly terrain that is drained by the Mutamba River and its tributaries which have their source areas within the Soutpansberg Mountains at about 1670 metres above mean sea level (mamsl). The Mutamba River flows in a north-easterly direction into the Nzhelele River which flows in a north easterly direction to the Limpopo River.

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[3] SABS drinking water standards (SANS 241-1:2015) Second Edition. SABS Standards Division, March 2015. ISBN 978-0-626-29841-8

[4] "Groundwater Resources Directed Measures" Software (Version 4.0.0.0). Department of Water Affairs & Water Research Commission.

[5] Department of Water Affairs and Forestry & Water Research Commission (1995). A South African Aquifer System Management Classification. WRC Report No. KV77/95.

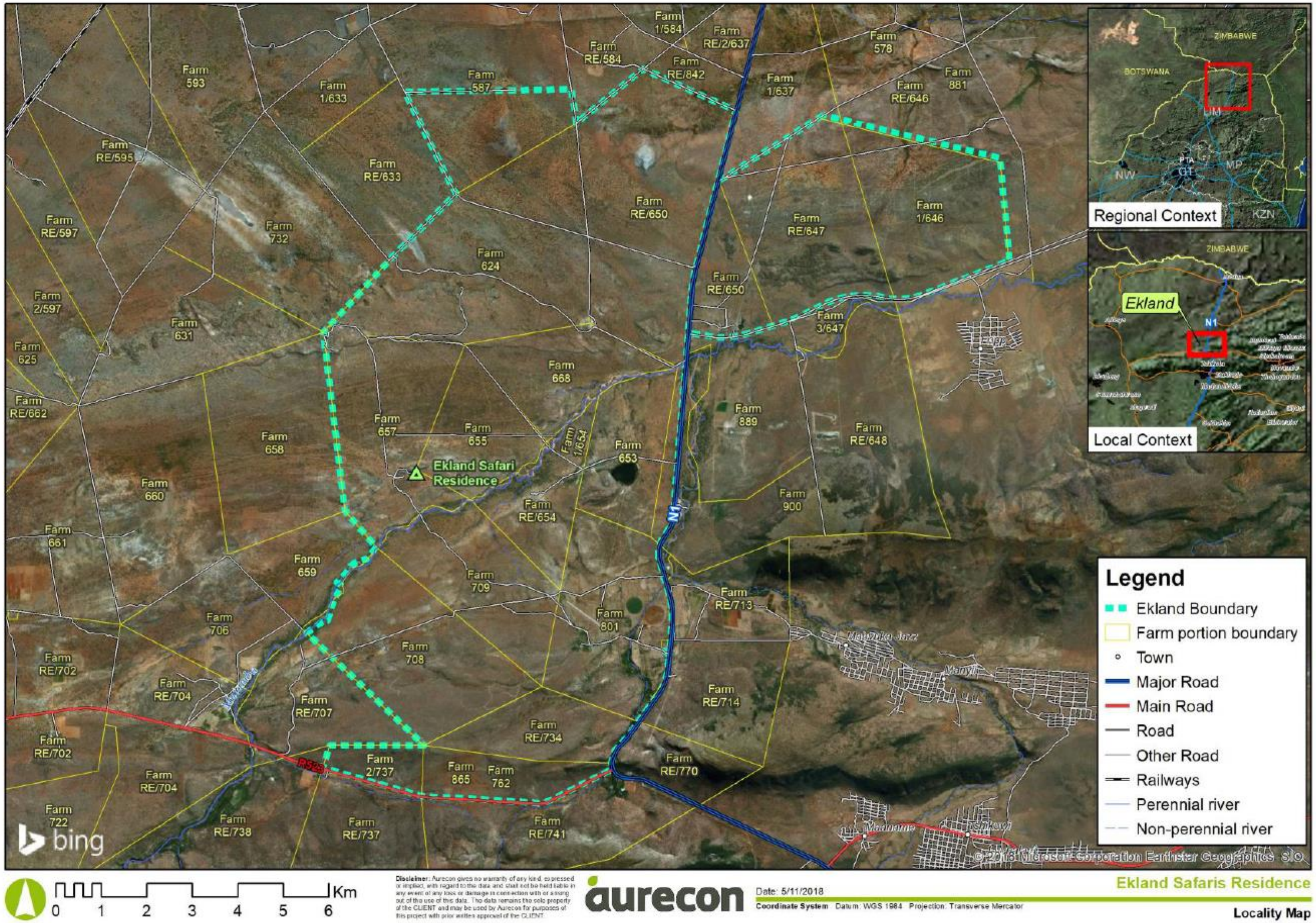

Figure 1. Locality Map of Ekland Safaris

3.3 Geology & Hydrogeology

The geology of the project area was described using the 2228 Alldays Geology Map (scale 1: 250 000) from the Council of Geoscience as basis (Figure 2).

3.3.1 Geology

3.3.1.1 Lion Farm Section

The southern section of the Lion Farm is underlain by Karoo Supergroup continental sediments of Triassic to Jurassic age that form part of the fault-bound Tshipise Basin of Limpopo.

Rock units mapped within the broader project area include the Red Rocks Member (TRcr, pink with dark stipple) and the overlying Tshipise Member (TRct, pink). Both of these sandstone-dominated units were originally included within the Clarens Formation.

However, the Red Rocks Member has since been correlated with the Elliot Formation of the Main Karoo while the Tshipise Member is now equated with the Clarens Formation (cf).

The Red Rocks Member (local Elliot Formation) comprises up to 150 m of fine-grained, pinkish to reddish or mottled argillaceous sandstone with occasional thick limestone interbeds towards the base. The overlying Tshipise Member (Clarens Formation) is also up to 150 m thick and consists of pale white to cream-hued aeolianites, variously massive or showing large-scale aeolian cross-beds reflecting deposition as barchan dunes in an arid sandy desert setting. Calcareous diagenetic concretions may occur towards the base which has a gradational contact with the underlying, poorly-exposed Red Rocks Member.

The Tshipise beds tends to weather prominently and often build cliffs and caves (“Cave Sandstone”).

Secondary silicification along well-defined fractures is commonly seen. The Bobbejaankop outcrops east of the N1 are among the best known exposures of the Tshipise Member in the Alldays sheet area. A series of equally rugged koppies of Clarens sandstone extend west of the Castle Koppies area.

The Karoo sedimentary succession in the Tshipise Basin was terminated by voluminous eruption of basaltic lavas of the Letaba Formation (Lebombo Group) which forms part of the Early Jurassic Karoo Igneous Province. Lenticular arenitic (sandy) units up to a few meters thick are locally interbedded with the dark grey lavas in the Alldays sheet area. A small area of Letaba lavas is mapped close to the N1 on the south-western margins of the Lion Farm area.

The lower-lying, and topographically more subdued, northern half of the Lion Farm area contrasts strongly with the southern, Karoo Supergroup-dominated half, from which it is separated by a major E-W trending fault (local margin of the Tshipise Basin). The northern sector is underlain at depth by a range of Precambrian bedrocks assigned to the Archaean Beit Bridge Complex, the Proterozoic Soutpansberg Group and unnamed diabase intrusions (weathered dolerite) of pre-Karoo age. The Beit Bridge Complex, with only a narrow outcrop area in the northeast, is represented here by the metaquartzite dominated Mount Dowe Group which also contains a range of other high-grade metasedimentary facies.

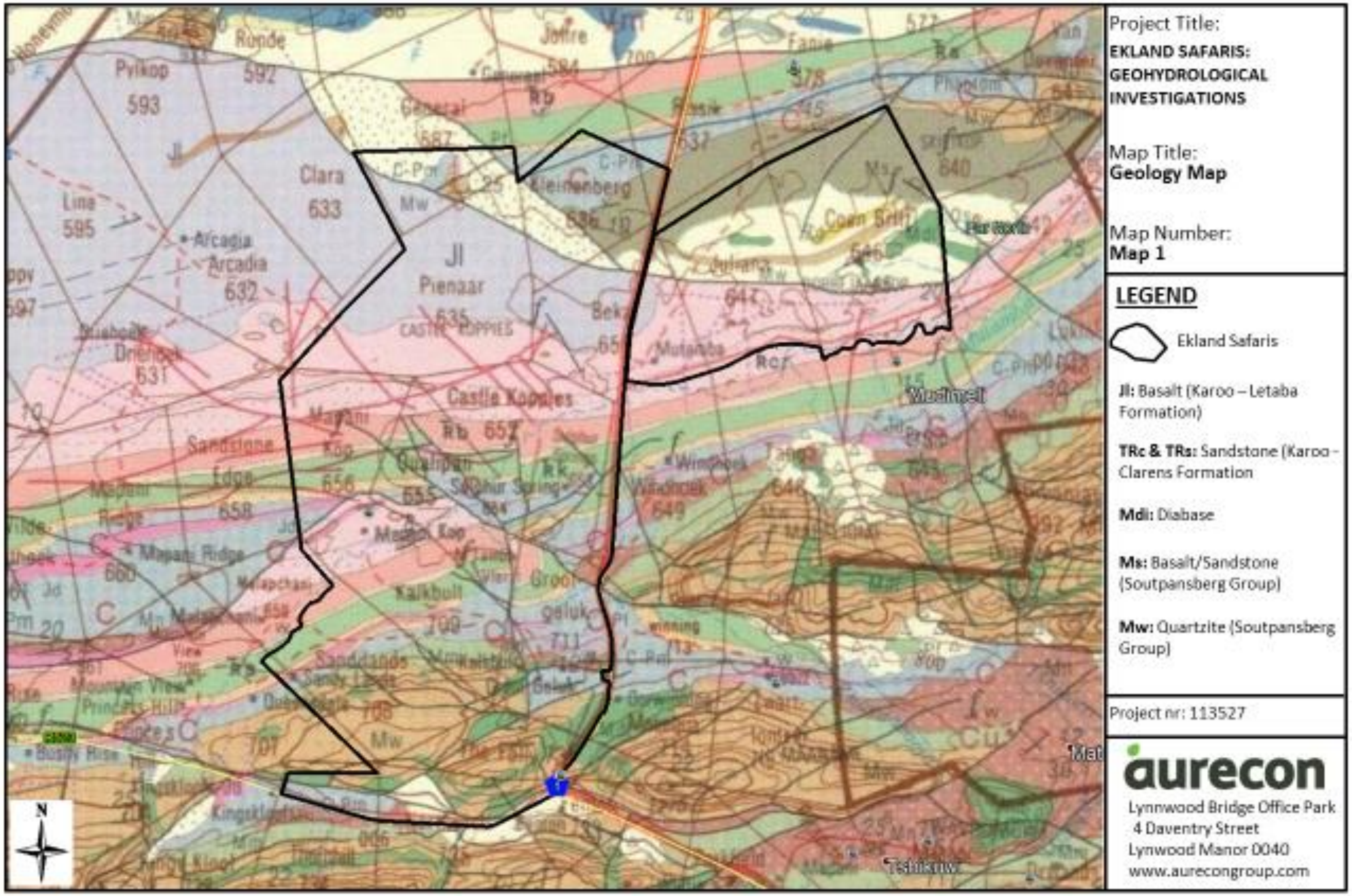

Figure 2. Geology Map of the Study area

The Soutpansberg Group is represented by braided alluvial quartzites (often cross-bedded and rippled) of the Wyllie's Poort Formation with subordinate pebbly conglomerates and shales, as well as by basaltic lavas of the Sibasa Formation that may also have sandy interbeds. The outcrops of these ancient basement rocks are extensively mantled by Quaternary sandy soils and downwashed rubbly gravels, and locally by sandy to gravelly along drainage lines.

3.3.1.2 Ekland Section

The majority of the Ekland Section consists of Karoo Supergroup faulted against and overlying the Soutpansberg Group to the far south.

The Soutpansberg Group to the south mainly comprise of quartzite from the Wyllie's Poort Formation.

Moving north, pale, fine-grained, yellowish weathering sandstones belonging to the Clarence Formation makes up the low hills. The Castle Koppies forms a prominent feature in the central and northern part of the project area displaying characteristic large-scale cross-bedding due to their wind-blown origin.

To the far north lenticular arenitic (sandy) units up to a few meters thick are locally interbedded with the dark grey basalt of the Letaba Formation (Karoo Supergroup).

Strike faulting, parallel to the ridges is common and a number of fault lines is evident on the published geological map.

3.3.2 Geohydrology

Groundwater in the occurring geology would be limited to secondary fractured aquifers and the occurrence of groundwater would be influenced by the presence of geological structures i.e. faults, fissures, fracture zones and intrusions like diabase sills and dykes. The product of weathering of the dominant rock is such that groundwater usually occurs in association with the transition zone from weathered to more solid rock. Breccia and joint zones as well as lithological and dyke contact zones also store and yield significant groundwater.

During 2013, WSM Leshika Consulting was appointed to conduct the groundwater flow study for the Environmental Impact Assessment (EIA) for the proposed Generaal Colliery Project[6]. The study did not only focus on the Generaal Coal Project, but was expanded to include other planned coal projects adjacent to the study area. A numerical groundwater flow model was also developed, and the model boundaries included the Ekland Safari Property. The EIA report described the groundwater status and groundwater flow. To date, none of the coal projects were commissioned and land and groundwater use did not change significantly since this study was done. In addition to Aurecon's own studies, findings of WSM's groundwater study and outputs of this numerical flow model was used to describe the local geohydrological conditions.

Due to the presence of the Soutpansberg rocks to the south, a local northward hydraulic gradient is present due to high recharge in the Soutpansberg Mountains. Under natural conditions, groundwater drains via localised springs, as baseflow to the Mutamba River and perennial tributaries flowing from the Soutpansberg, and by evapotranspiration by riverine vegetation along the main river channels.

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[6] Generaal Coal Project – Groundwater Flow Impact Assessment Report. Report WH13078 11 December 2013 Final (WSM Leshika Consulting (PTY) LTD)

Groundwater is of good quality in the Soutpansberg rocks, which is the main recharge zone; however, increased salinity occurs northwards as groundwater flows through saline Karoo sediments, accumulating salts. Low recharge rates in the drier terrain north of the Soutpansberg also results in low recharge rates to dilute these salts. The movement of groundwater passing through saline deposits of the Karoo rocks, and subsequent evapotranspiration by riverine vegetation, causes a rapid salt accumulation northward, with a peak salt load along the fringes of the channels lying over Karoo rocks, like the Mutamba Rivers, resulting in poor natural water quality.

The upper reaches of the Mutamba emerging from the Soutpansberg are perennial, but lose water to groundwater as they flow out of the Soutpansberg, becoming ephemeral. Very little surface runoff is believed to recharge the regional aquifers north of the Soutpansberg, since high salinity levels in the Karoo aquifers suggest it is not recharged by fresh water from the river.

The Mutamba River contains significant alluvium, which is tapped in places by irrigators. These rivers can be considered as drains, as river losses to the alluvium remains in the alluvium and is utilised by riverine vegetation and irrigators, and does not recharge the regional aquifer since hydraulic gradients are oriented towards these channels.

The study area can be regarded as having a moderate to high groundwater potential with groundwater occurrences confined to several major structures present within the property boundaries. These fractured systems are recharged by the Mutamba River where high yielding boreholes associated with these fault systems have been drilled. The Mutamba River also has well developed alluvial deposits.

4 GROUNDWATER USE

A hydrocensus was carried out on the 8th and the 9th of April 2019. The hydrocensus was conducted within the property boundary, as required by the DWS guidelines for "Category A Abstraction" (small scale abstraction). A total of 13 boreholes were identified within the property boundary (7 boreholes on the Ekland section and 5 boreholes on the Lion Farm section). A sulphur spring was also identified on the Ekland side (Figure 4).

The boreholes were yield and quality tested. The results of the yield and quality testing is discussed in sections 5 and 6 respectively. The location of the boreholes is indicated in Figure 3. Table 1 summarises the most important details of the boreholes identified during the hydrocensus.

Table 1. Details of boreholes within the property boundary identified during hydrocensus

Borehole nr.	Coordinates (WGS84)		Depth (m)	Static Water Level (m)	Sustainable Yield (l/h) Pumping 24 hours/day	Water Use	Water Quality (SANS 241 Drinking Std)	Equipment
	S	E						
Main Lodge	22.83072	29.83282	119	52.00	9000	Domestic	Unacceptable	Mono pump
Pienaar	22.78789	29.82865	55	25.00	12600	Domestic	Acceptable	Mono pump
Pienaar BU	22.78870	29.82798	51	25.00	9000	Domestic	Unacceptable	Submersible
K Smith	22.86611	29.81472	49	19.00	5400	Domestic	Acceptable	Submersible
GG1-BH1	22.87839	29.87815	72	15.00	28800	Domestic	Acceptable	Submersible
GG1-BH2	22.87601	29.87853	75	10.00	39600	Domestic	Acceptable	Submersible
GG1-BH3	22.87612	29.88017	67	10.00	36000	Domestic	Acceptable	Submersible
Sunpump	22.78518	29.87920	111	29.00	<900	Domestic	Acceptable	Submersible
Sulphur Spring	22.81879	29.85640	~	0.00	3600	Recreational	Not tested	None
BH_L1 (Lodge)	22.79898	29.89564	27	11.00	2880	Domestic	Acceptable	Submersible
BH_L2 (Old Mono)	22.80059	29.89682	58	10.00	10800	Domestic	Unacceptable	Mono pump
BH_L3 (Leeukamp)	22.78452	29.91362	78	37.00	1440	Domestic	Unacceptable	Submersible
BH_L4 (WBHO)	22.78734	29.90984	138	20.00	1800	Domestic	Unacceptable	None
BH_L5 (Re-Drill)	22.79019	29.90225	71	13.00	10800	Domestic	Acceptable	None
		Average	75	19.71	13209			

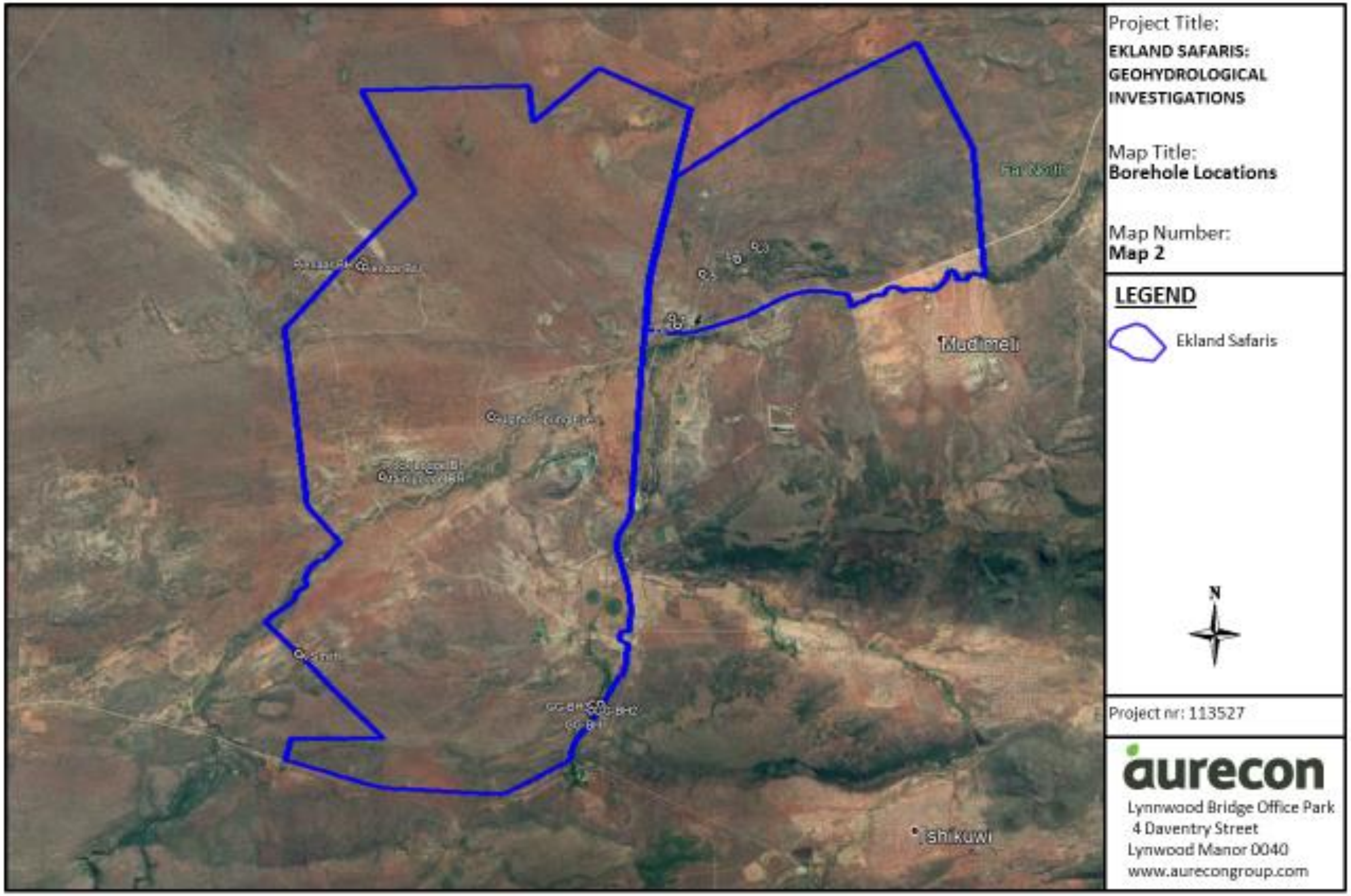


Figure 3. Map indicating borehole positions

From Figure 3 the following can be concluded:

- Groundwater plays an important role within the project area and is used for agricultural and domestic applications.
- Boreholes with significant yields occur within the project area (ranging from 900 to 39 600 litres/hour with an average yield of 13209 litres/hour)
- The static water level as measured within the boreholes during the hydrocensus ranges between artesian and 52 meters below ground level with the majority of the boreholes having a static water level of less than 25 meters below ground level.

Figure 4. The Sulphur Spring on the Ekland side

It can be safely assumed that the “Sulphur Thermal Spring” originates in a non-volcanic region, where faults in the earth’s crust allow water to penetrate to great depths. Due to increased pressure at depth, the rocks and water are heated. The rate of heating (the geothermal gradient) differs from one place to another, but is generally in the region of 2-3°C per 100 m. When the hot, circulating underground water encounters an impermeable dyke or a fault, it is forced to the surface as a thermal spring.

Geological studies have shown conclusively that the origin of each individual thermal spring in South Africa is associated with the local presence of deep geological structures, such as folds, faults and dykes.[7] These structures provide continuously circulating artesian systems where rain and surface water descends to depth, is heated by the rocks, before rapidly returning to the surface without losing much heat. At many of the thermal springs, the water rises along fault zones or fissures associated with seismic activity, while other springs rise along wall-like bodies of impermeable rock (dykes) which impede the free movement of ground water. These impermeable

[7] Optimal Utilisation of Thermal Springs in South Africa (WRC Project No. K5/1959). WRC Report No. TT 577/13. November 2013.

sections of fault zones, folds or dykes may restrict the direct percolation of water from the intake area to the spring eye, forcing the hot groundwater to the surface.

If the above is kept in mind, one can assume that the thermal sulphur spring is fed by a deep aquifer system different to the shallow aquifer from which the production boreholes tap water. Impacts due to groundwater abstraction from the production boreholes on the sulphur spring is thus unlikely.

A hydrocensus was conducted by WSM Leshika Consulting for the proposed Generaal Colliery Project[8]. They concluded that that groundwater abstraction within the study area is on a small scale mainly for farmsteads, hunting/game lodges and game and stock watering. Irrigation occurs on some farms, but they utilize surface water from the Nzhelele Irrigation Scheme with groundwater as a back-up when surface water is not available. There are numerous high yielding boreholes developed for this purpose, as gauged from pump installations, although mostly in a state of disrepair. These holes have not been used for several years and quantitative data was not available from the owners/managers at the time of census. The boreholes abstract water mostly from the fractured rock aquifers consisting of the E-W fault systems within the Karoo and Soutpansberg strata.

To date, none of the coal projects were commissioned and land and groundwater use did not change significantly since this study was done. It can be safely assumed that the findings of the WSM study is still valid.

5 PUMPTESTING

5.1 Description of a Pumptest

The efficient operation and utilisation of a borehole requires insight into and an awareness of its productivity and that of the groundwater resource from which it draws water. This activity, which is also known as test pumping, provides a means of identifying potential constraints on the performance of a borehole and on the exploitation of the groundwater resource. It also provides data to calculate aquifer parameters such as Transmissivity (T) values.

Selected boreholes (13 boreholes in total) were pumptested by Twin Drilling & Testing. The locations of the boreholes are presented in Figure 3.

The following tests were performed on the borehole: (1) stepped discharge test; (2) constant discharge test and (3) recovery monitoring.

5.1.1 Stepped Discharge Test

Also known as a step drawdown test, it is performed to assess the productivity of a borehole. It also serves to more clearly define the optimum yield at which the borehole can be subjected to constant discharge testing. The test involves pumping the borehole at three or more sequentially higher pumping rates each maintained for an equal length of time, generally not less than 60 minutes. The magnitude of the water level drawdown in the borehole in response to each of these pumping rates is measured and recorded in accordance with a prescribed time schedule.

[8] Generaal Coal Project – Groundwater Flow Impact Assessment Report. Report WH13078 11 December 2013 Final (WSM Leshika Consulting (PTY) LTD)

5.1.2 Constant Discharge Test

A constant discharge test is performed to assess the productivity of the aquifer according to its response to the abstraction of water. This test entails pumping the borehole at a single pumping rate which is kept constant for an extended period of time. In this instance the boreholes were pumped for 24 hours.

5.1.3 Recovery Monitoring

This test provides an indication of the ability of a borehole and groundwater system to recover from the stress of abstraction. This ability can again be analysed to provide information with regards to the hydraulic properties of the groundwater system and arrive at an optimum yield for the medium to long term utilisation of the borehole.

5.2 Results & Data Interpretation

The data acquired during the pump tests were analysed and the sustainable yield of the tested boreholes were calculated using the Flow Characterization Method (FC-Method)[9] developed by the Institute for Groundwater Studies from the University of the Free State.

5.2.1 Sustainable Yield

The FC-Method calculates the sustainable yield of a borehole by using derivatives, boundary information and error propagation. Data used for input into the software was obtained from the pumping tests conducted on the boreholes. As described above a pump test basically entails continues monitoring of the water level over a given time while pumping water from the borehole at a constant pre-determined yield. After the pump has been switched off, continues measuring of the recovering water level takes place. The data was analysed to obtain a sustainable pumping yield. The available drawdown is a critical parameter during this exercise and if the sustainable yield is not exceeded, the water level should never drop beyond this level.

The FC Solution for the boreholes is presented in Appendix B. The calculated sustainable yield, as well as all the necessary information to equip the boreholes are presented in Table 2 and Table 3.

[9] FC program for Aquifer Test Analysis (2013 version). Prof. Gerrit van Tonder, Fanie de Lange and Modreck Gomo. Institute for Groundwater Studies, University of the Free State.

Table 2. Management Recommendations for the tested boreholes on the Ekland section

Borehole nr.	Coordinates (WGS84)		Depth (m)	Static Water Level (m)	#Dynamic WL (m)	Sustainable Yield (l/h) Pumping 24 hours/day	Volume/day (m^3)	Proposed depth of pump installation (m)	Water Quality (SANS 241)	Comments
	S	E								
Main Lodge	22.83072	29.83282	119	52.00	60	9000	216.00	80	Unacceptable	Treatment required
Pienaar	22.78789	29.82865	55	25.00	35	12600	302.40	45	Acceptable	Pienaar & Pienaar BU not to be pumped similtaniously but on alternating cycles
Pienaar BU	22.78870	29.82798	51	25.00	33	9000	216.00	45	Unacceptable	
K Smith	22.86611	29.81472	49	19.00	25	5400	129.60	40	Acceptable	
GG1-BH1	22.87839	29.87815	72	15.00	20	28800	691.20	30	Acceptable	
GG1-BH2	22.87601	29.87853	75	10.00	12	39600	950.40	25	Acceptable	
GG1-BH3	22.87612	29.88017	67	10.00	12	36000	864.00	25	Acceptable	
Sunpump	22.78518	29.87920	111	29.00		<900			Acceptable	Yield too low to equip.
				TOTAL VOLUME/DAY (m^3)			**3153.60**			

 # Dynamic water level - Level at which the water level in the borehole stabilises after continuous pumping. To be used to calculate hydraulic heads when sizing submersible pumps.

Table 3. Management Recommendations for the tested boreholes on the Lion Farm section

Borehole nr.	Coordinates (WGS84)		Depth (m)	Static Water Level (m)	#Dynamic WL (m)	Sustainable Yield (l/h) Pumping 24 hours/day	Volume/day (m^3)	Proposed depth of pump installation (m)	Water Quality (SANS 241)	Comments
	S	E								
BH_L1 (Lodge)	22.79898	29.89564	27	11.00	16	2880	69.12	20	Acceptable	
BH_L2 (Old Mono)	22.80059	29.89682	58	10.00	15	10800	259.20	30	Unacceptable	Treatment required
BH_L3 (Leeukamp)	22.78452	29.91362	78	37.00	57	1440	34.56	65	Unacceptable	Treatment required
BH_L4 (WBHO)	22.78734	29.90984	138	20.00	32	1800	43.20	50	Unacceptable	Treatment required
BH_L5 (Re-Drill)	22.79019	29.90225	71	13.00	20	10800	259.20	40	Acceptable	
				TOTAL VOLUME/DAY (m^3)			**665.28**			

 # Dynamic water level - Level at which the water level in the borehole stabilises after continuous pumping. To be used to calculate hydraulic heads when sizing submersible pumps.

The tested boreholes can supply a total volume of 1394 ML/annum which can supply in the calculated annual demand of 270 ML.

6 GROUNDWATER CHEMISTRY

Groundwater samples were collected towards the end of the constant discharge tests and submitted to a SANAS accredited Laboratory for a SANS 241-1:2015 drinking water analysis. The laboratory reports are presented in Appendix C.

The analytical results were compared with the SABS drinking water standards (SANS 241-1:2015, edition 2) (Table 4 & Table 5). Water is classified unfit for human consumption if the Standard Limits are exceeded.

Table 4. Water quality at Ekland compared to SANS 241-1:2015 (edition 2) drinking water standards

Sample Nr.	GG1-1	GG1-2	GG1-3	Main Lodge	Pienaar	Pienaar BU	King Smith		Standard Limits
Ca	22.01	22.12	22.29	64.48	20.25	54.28	46.90		~
Mg	24.45	24.17	23.77	41.52	21.62	61.24	28.11		~
Na	16.87	16.51	16.29	305.88	19.87	29.06	22.48		200
K	1.19	1.68	1.24	4.16	5.07	12.54	2.37		~
Mn	0.00	0.02	0.00	0.11	0.01	0.04	0.03		0.1
As	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.01
Fe	0.01	0.00	0.00	0.01	0.12	0.49	0.00		0.3
F	0.14	0.13	0.13	2.15	0.22	0.18	0.25		1.5
NO_3-N	1.22	1.08	1.30	0.63	4.69	27.00	0.13		11
NH_4-N	0.00	0.00	0.00	0.00	0.44	0.00	0		1.5
Al	0	0	0	0	0	0.01	0.00		0.3
PO_4-P	0.00	0.00	0.00	0.00	0.00	0.00	0.00		-
Cl	30.3	28.4	29.9	447.4	29.2	92.6	48.4		300
SO_4	7.5	8.4	6.4	232.5	10.7	41.3	9.7		250
TDS	244	237	239	1210	291	627	363		1200
T-Alk	134	138	129	143	159	387	205		~
pH	7.00	6.90	7.40	7.10	7.00	6.60	7.30		5.0 - 9.7
EC	38	36	37	214	44	96	56		170
E.Coli									0
Heterotrophic Plate Count									≤1000
Total Coliform									≤10

Notes
Yellow = Acceptable
Exceeds standard limits
0 = below detection limit of analytical technique

EC measurements in mS/m, other parameters in mg/ℓ

Except for boreholes "Main Lodge" and "Pienaar Back Up", all of the boreholes at Ekland falls within the SANS 241 Drinking Water Standards.

The water quality in the "Main Lodge" borehole exceeds the standard limits due to elevated Na, Mn, F, Cl, TDS and EC concentrations.

The water quality in the "Pienaar Back Up" borehole exceeds the standard limits due to elevated Fe and NO_3 concentrations.

Table 5. Water quality at Lion Farm compared to SANS 241-1:2015 (edition 2) drinking water standards

Sample Nr.	L1	L2	L3	L4	L5		Standard Limits
Ca	46.92	52.40	61.96	27.16	84.86		~
Mg	43.60	57.40	33.22	13.06	81.44		~
Na	84.42	142.26	85.16	30.72	132.94		200
K	5.96	8.72	7.98	9.75	5.78		~
Mn	0.00	0.27	0.77	0.09	0.04		0.1
As	0.00	0.04	0.00	0.00	0.00		0.01
Fe	0.00	0.01	0.02	3.84	0.00		0.3
F	0.46	0.52	0.28	0.17	0.45		1.5
NO_3-N	6.45	4.25	0.00	0.00	7.74		11
NH_4-N	0.00	0.71	0.00	0.44	0		1.5
Al	0	0	0	0.00	0.00		0.3
PO_4-P	0.13	0.27	0.22	0.22	0		-
Cl	70.8	143.6	111.9	40.0	251.8		300
SO_4	15.0	17.9	35.3	17.1	89.6		250
TDS	598	873	592	321	1070		1200
T-Alk	348	473	290	188	363		~
pH	7.20	7.40	6.70	6.70	7.30		5.0 - 9.7
EC	92	134	94	49	165		170
E.Coli		0					0
Heterotrophic Plate Count		1345					≤1000
Total Coliform		179					≤10

Notes
Yellow = Acceptable
Exceeds standard limits
0 = below detection limit of analytical technique

EC measurements in mS/m, other parameters in mg/ℓ

Boreholes "L1" and "L5" falls within the SANS 241 Drinking Water Standards.

The water quality in borehole "L2" exceeds the standard limits due to elevated Mn and As concentrations, as well as microbial plate counts.

Borehole "L3" exceeds the Mn standard limits and borehole "L4" exceeds the Fe standard limits.

7 RAPID RESERVE DETERMINATION

7.1 Introduction

Definition of Reserve: *"The quantity and quality of water required to supply basic needs of people to be supplied with water from that resource and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of water resources".*

To be able to quantify the groundwater component of the Reserve, the following relationship has to be solved:

$$\mathbf{GW_{allocate} = (Re + GW_{in} - GW_{out}) - BHN - GW_{Bf}}$$

where:

where:	$GW_{allocate}$	=	groundwater allocation
	Re	=	recharge
	GW_{in}	=	groundwater inflow
	GW_{out}	=	groundwater outflow
	BHN	=	basic human needs
	GW_{Bf}	=	groundwater contribution to baseflow

Under the National Water Act (Act No. 36 of 1998) the water use at Ekland Safaris must be authorised. The water will be abstracted from boreholes, stored in a reservoir(s) and used as a source of potable water and irrigation purposes. Under these circumstances, the following (ground) water use is recognised as being relevant to the licence application:

- Section 21 (a) – taking water from a resource.

7.2 Approach

The assessment was done on a "rapid" level using the software GRDM version 4.0.0.0 (2010). The data used for the calculation was derived from the WRC90 dataset contained in the "GRDM" software driven by the Resource Directed Measures from the Department of Water Affairs.

The majority of the property falls within quaternary catchment A80F with a small portion falling with quaternary catchment A80E (Figure 5). The rainfall and recharge default values for catchment A80E is significantly higher than that of catchment A80F. A conservative approach was followed and the lower rainfall and recharge values of quaternary catchment A80F was used in the assessment in order to develop some guidance on the potential impact of the proposed abstraction on the overall groundwater use in the catchment.

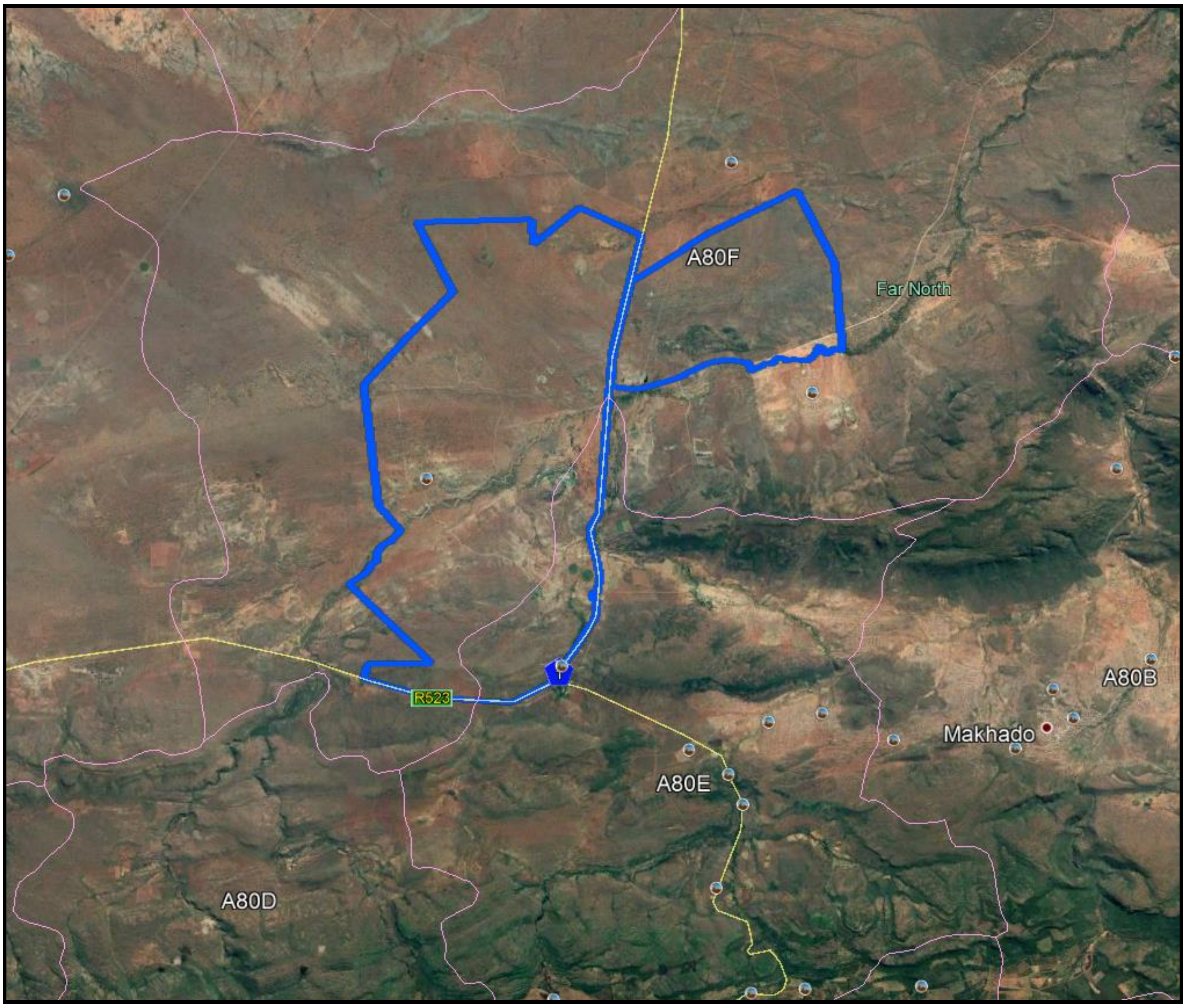


Figure 5. Location of Ekland Safaris in relation to the South African Quaternary Catchments

7.3 Description of the Study Area

Ekland Safaris, covers a total area of 14 000 ha.

The study area falls within the Limpopo Water Management Area.

On a national level, the study area is situated within the savannah biome, and is classified by Acocks (1953) as Sourish Mixed Bushveld (A19) and Mixed Bushveld (A18). Classified on a local scale and according to a more detailed system (Mucina & Rutherford, 2006) these areas are classified as Musina Mopane Bushveld (SVmp 1) on the plains and Limpopo Ridge Bushveld (SVmp 2) on the scattered ridges and outcrops.

The area comprises hilly terrain that is drained by the Mutamba River and its tributaries which have their source areas within the Soutpansberg Mountains at about 1670 metres above mean sea level (mamsl). The Mutamba River flows in a north-easterly direction into the Nzhelele River which flows in a north easterly direction to the Limpopo River.

The upper reaches of the Mutamba emerging from the Soutpansberg are perennial, but lose water to groundwater as they flow out of the Soutpansberg, becoming ephemeral. Very little surface runoff is believed to recharge the regional aquifers north of the Soutpansberg, since high salinity levels in the Karoo aquifers suggest it is not recharged by fresh water from the river.

7.4 Present Water Demand

The current calculated water demand is 270 ML/annum (0.27 Mm^3/a). DWS categorises the water use licence applications in 3 categories based on the amount of recharge that is used by the applicant in relation to the specified property[10]:

- Category A: Small scale abstractions (<60% recharge on property)
- Category B: Medium scale abstractions (60-100% recharge on property)
- Category C: Small scale abstractions (>100% recharge on property)

7.5 RDM Assessment

The following table summarises the most salient parameters relevant to this catchment (A80F):

Table 6. Most salient parameters relevant to catchment A80F.

Area km²	Population	General Authorisation (m³/ha/a)	Rainfall (mm/a)	Current use (Mm³/a)
630	5171	0	388	0.09

It is assumed that General Authorisation as a possible route can be excluded.

7.5.1 Classification

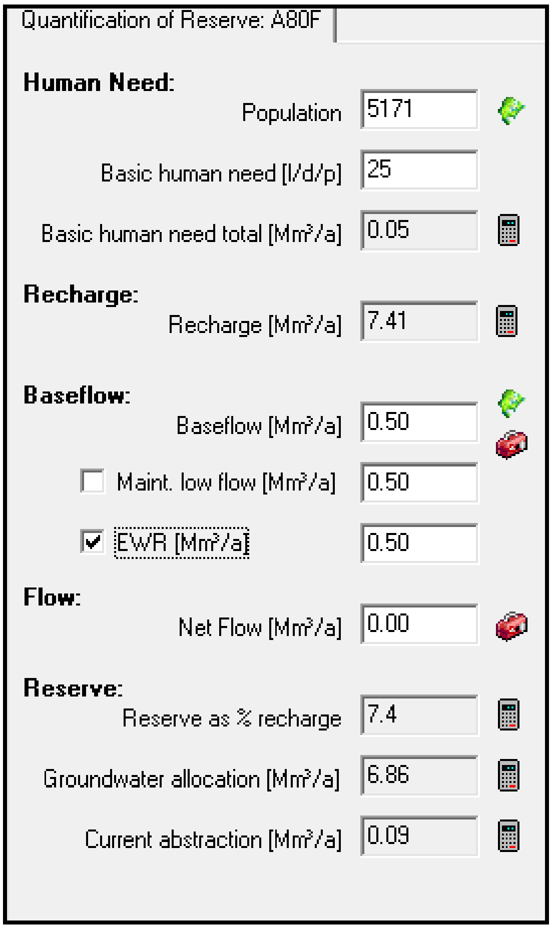
Groundwater classification is currently based on a Stress Index which relates water use to recharge. The catchment is classified as category A, which indicates unstressed in terms of abstraction/recharge. The resource is still being used sustainably. At this stage Classification is not directly linked to potential abstraction, but is only indicative of the current situation. A category C classification implies that ~2.9 (Mm^3/a) can still be abstracted from the quaternary catchment before very detailed studies will be required.

[10] http://www.dwa.gov.za/Groundwater/Documents/WULAAbstaction.pdf (presented in Appendix A)

7.5.2 Reserve

The following table summarizes the reserve for the quaternary catchment.

Table 7. A summary of the Reserve for the catchment.


Quantification of Reserve: A80F

Human Need:

Population	5171
Basic human need [l/d/p]	25
Basic human need total [Mm³/a]	0.05

Recharge:

Recharge [Mm³/a]	7.41

Baseflow:

Baseflow [Mm³/a]	0.50
☐ Maint. low flow [Mm³/a]	0.50
☑ EWR [Mm³/a]	0.50

Flow:

Net Flow [Mm³/a]	0.00

Reserve:

Reserve as % recharge	7.4
Groundwater allocation [Mm³/a]	6.86
Current abstraction [Mm³/a]	0.09

The allocable portion is still very high.

If this calculation is based on the actual area of the property, the following emerges:

Table 8. Recharge to the Ekland Safaris

Property	Actual area (ha) of property	Recharge in Quartenary Catchment (mm/a)	Recharge on property	
Ekland	14000	11.7	1638000	m^3/a
Total	*14000*		*1638000*	m^3/a
			1.638	Mm^3/a
			4487671	l/day
			51.9	l/second

From Table 8 it becomes evident that local recharge (1.638 Mm^3/annum) will not supply in the allocatable portion (6.86 Mm^3/annum) for the quaternary catchment A80F.

There will be applied for an allocation of 0.6 Mm^3/annum from the total property in order to make provision for future expansions and development (current calculated demand is 0.27 Mm^3/annum). An application of 0.6 Mm^3/annum (36.6% of the local recharge) places the application in Category A (small scale abstractions - <60% recharge on the local catchment) (see section 0).

7.5.3 Resource Quality Objectives

Maintain regional groundwater table through a groundwater monitoring program to:

- Ensure that Schedule 1 water users within the catchment have adequate water supply to sustain the basic human need.
- Ensure that adequate water is available to maintain base flow in the upper sections of the Mutamba River and springs located on the property.
- Ensure that adequate water is available to the Ecological Water Reserve (EWR).

8 AQUIFER CLASSIFICATION

The aquifer(s) underlying the project area were classified in accordance with "A South African Aquifer System Management Classification, December 1995" by Parsons. Classification has been done in accordance with the following definitions for Aquifer System Management Classes:

- Sole Aquifer System: An aquifer which is used to supply 50% or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.
- Major Aquifer System: Highly permeable formations, usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (Electrical Conductivity of less than 150 mS/m).
- Minor Aquifer System: These can be fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important for local supplies and in supplying base flow for rivers.
- Non-Aquifer System: These are formations with negligible permeability that are regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

Based on information collected during the hydrocensus it can be concluded that aquifer system in the study area can be classified as a "Sole Aquifer System". Aquifers is used to supply in excess of 50% or more of water for domestic and agricultural purposes and there are no reasonably available alternative sources should the aquifer be impacted upon or depleted. One can also assume that the aquifer is important for supplying base flow to the local streams and their tributaries.

In order to achieve the Groundwater Quality Management Index a points scoring system as presented in Table 9 and Table 10 was used.

Table 9. Ratings for the Aquifer System Management and Second Variable Classifications:

Aquifer System Management Classification		
Class	Points	Study area
Sole Source Aquifer System:	6	6
Major Aquifer System:	4	
Minor Aquifer System:	2	
Non-Aquifer System:	0	
Special Aquifer System:	0 – 6	
Second Variable Classification (Weathering/Fracturing)		
Class	Points	Study area
High:	3	3
Medium:	2	
Low:	1	

Table 10. Ratings for the Groundwater Quality Management (GQM) Classification System:

Aquifer System Management Classification		
Class	Points	Study area
Sole Source Aquifer System:	6	6
Major Aquifer System:	4	
Minor Aquifer System:	2	
Non-Aquifer System:	0	
Special Aquifer System:	0 - 6	
Aquifer Vulnerability Classification		
Class	Points	Study area
High:	3	
Medium:	2	2
Low:	1	

The occurring aquifer(s), in terms of the above definitions, is classified as a sole aquifer system.

The vulnerability, or the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer, in terms of the above, is classified as medium. A relatively deep water table (~20 mbgl) and rocks with high weathering/fracturing occurs at certain locations. The level of groundwater protection based on the Groundwater Quality Management Classification:

GQM Index = Aquifer System Management x Aquifer Vulnerability

= 6 X 2 = 12

Table 11. GQM index for the study area

GQM Index	Level of Protection	Study Area
<1	Limited	
1 - 3	Low Level	
3 - 6	Medium Level	
6 - 10	High Level	
>10	Strictly Non-Degradation	12

8.1 Aquifer Susceptibility

Aquifer susceptibility, a qualitative measure of the relative ease with which a groundwater body can be potentially contaminated by anthropogenic activities and which includes both aquifer vulnerability and the relative importance of the aquifer in terms of its classification, in terms of the above, is classified as high.

8.2 Aquifer Protection Classification

The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a Groundwater Quality Management Index of 12 for the study area, indicating that “Strictly Non-Degradation” groundwater protection is required.

Due to the high GQM index calculated for this area, a strictly non-degradation level of protection is needed to adhere to the Department of Water and Sanitation’s (DWS) water quality objectives. Reasonable and sound groundwater protection measures are imperative to ensure that no cumulative pollution affects the aquifer, even in the long term.

In terms of DWS’s overarching water quality management objectives which is (1) protection of human health and (2) the protection of the environment, the significance of this aquifer classification is that if any potential risk exist, measures must be triggered to limit the risk to the environment, which in this case is the (1) protection of the Secondary Underlying Aquifer, (2) the Mutamba River and its tributaries which drains the subject area and (3) the external users of groundwater in the area.

9 GROUNDWATER MANAGEMENT FRAMEWORK

It is stated in several DWS publications, such as main policy documents[11], requirements of waste handling[12] and pollution prevention guidelines[13], that waste should be reduced to the minimum and pollution should preferably be prevented at the source. Should this fail, impacts must be minimised by reuse, reclamation and treatment. In the last instance, waste water can be discharged on a risk based approach, but at the cost of polluter pays principle. A groundwater management framework for Ekland Safaris was drafted to address and adhere to these principles.

Objectives:

- Minimisation of waste.
- Contain pollution as far as is practicably possible.
- Adopt a user driven approach for the ground water quality.
- Implement a suitable ground water monitoring programme (section 10).

[11] Department of Water Affairs and Forestry, Number W.1.0: First Edition 2000. Policy and Strategy for Groundwater. Quality Management in South Africa.

[12] Department of Water Affairs and Forestry, Second Edition, 1998. Waste Management Series. Minimum Requirements for Water Monitoring as Waste Management Facilities.

[13] Department of Water Affairs and Forestry, 2007. Best Practice Guideline H2: Pollution Prevention and Minimisation of Impacts.

Table 12. Groundwater Management Framework for Ekland Safaris

Action	Objective	Management & Mitigation
Solid waste management	Prevent contamination of groundwater resources	1. Responsible handling of waste streams. 2. Installation of adequate containment areas. 3. Implementation of Storm Water Management Plans. 4. Implementation of leak detection monitoring procedures at the waste water treatment works. 5. Groundwater monitoring in accordance with appropriate legislation. 6. Implementation of an Emergency Response Plan including the actions to be taken in the event of groundwater contamination occurring.
Liquid waste management	Nutrient-rich wastewater contained should not contaminate the groundwater resource.	1. Clean storm water should be channelled away from containment ponds, using bunds, culverts or drains, to ensure it does not become contaminated. 2. Adequate free board should be provided to prevent stormwater overflowing from ponds. 3. If alternative treatment plants are planned, wastewater should be disposed of in a responsible manner.
Fuel Storage	Prevent contamination of soil, surface and groundwater resources	1. Fuel containers exceeding 200 litres capacity should be stored in a manner that will prevent escape of contents to the environment in the case of accidents. 2. Fuel containers should be stored in a secure weatherproof building or within a secondary containment compound. 3. Above and underground ground fuel storage installations should adhere to the relevant SABS specifications.

Action	Objective	Management & Mitigation
Quantify & verify the impact of the activities on the groundwater environment.	Implement a ground water monitoring programme (see section 10)	1. Monitor the water quality from the boreholes. 2. Measure water levels within the respective boreholes as presented in Section 10. 3. Record monthly abstraction from calibrated flowmeters.
	General	1. Address the concerns and complaints of affected parties regarding the ground water issues. 2. All remedial action should be done in close liaison with the Department of Water and Sanitation. 3. Ensure that all surface and groundwater related EMP's are adhered to.

10 GROUNDWATER MONITORING PROGRAM

A groundwater monitoring network has been developed for Ekland Safaris incorporating all of the production boreholes.

Table 13. Monitoring boreholes to be included into the monitoring program

Borehole	Objective
Main Lodge	Impact Monitoring.
Pienaar	Impact Monitoring.
Pienaar BU	Impact Monitoring.
K Smith	Impact Monitoring
GG-BH1	Impact Monitoring
GG-BH2	Impact Monitoring
GG-BH3	Impact Monitoring
Sunpump	Impact Monitoring
BH-L1	Impact Monitoring
BH-L2	Impact Monitoring
BH-L3	Impact Monitoring
BH-L4	Impact Monitoring
BH-L5	Impact Monitoring

Water samples must be taken from all the monitoring boreholes by using approved sampling techniques and adhering to recognised sampling procedures. Table 14 below presents the parameters and frequency that should form part of the groundwater monitoring program. The results should be recorded on a data base and reported annually to the DWS.

Table 14. Proposed monitoring requirements

Class	Parameter	Frequency	Motivation
Physical	Static groundwater levels	Monthly	Time dependant data is required to understand the groundwater flow dynamics of the site. A lowering in the static water levels may indicate that the aquifer is utilised in an unsustainable way and abstraction rates need to be decreased. Requirement of the Water Use Licence.
	Rainfall	Daily	Recharge to the saturated zone is an important parameter in assessing groundwater vulnerability. Time dependant data is required to understand the groundwater flow dynamics of the site.
	Groundwater abstraction volumes	Monthly	Response of groundwater levels to abstraction rates could be useful to calculate aquifer storativity – important for groundwater management. Calculate monthly & annual abstraction volumes. Requirement of the Water Use Licence.
Chemical & Microbial	SANS 241-1:2015 Drinking Water Parameters.	Monthly	Changes in chemical composition may indicate areas of groundwater contamination and be used as an early warning system to implement management/remedial actions. To determine whether the water is fir for human consumption. Requirement of the Water Use Licence.

11 CONCLUSIONS & RECOMMENDATIONS

Based on existing and newly acquired data, the following can be concluded:

- The majority of the project area consists of Karoo Supergroup faulted against and overlying the Soutpansberg Group to the far south. Strike faulting, parallel to the ridges is common and a number of fault lines is evident on the published geological map.
- The study area can be regarded as having a moderate to high groundwater potential with groundwater occurrences confined to several major structures present within the property boundaries. These fractured systems are recharged by the Mutamba River where high yielding boreholes associated with these fault systems have been drilled. The Mutamba River also has well developed alluvial deposits.
- The results of the hydrocensus confirmed that groundwater plays an important role within the project area and is used for agricultural and domestic applications. Boreholes with significant yields occur within the project area (ranging from 900 to 39 600 litres/hour with an average yield of 13209 litres/hour). The static water level as measured within the boreholes during the hydrocensus ranges between artesian and 52 meters below ground level with the majority of the boreholes having a static water level of less than 25 meters below ground level.
- The groundwater quality of boreholes located within the property boundaries varies. Twelve water samples were collected from the boreholes during the constant discharge tests and submitted for a water quality analysis. The results were compared to the SANS 241-1:2015 Drinking Water Standards. Seven of the twelve boreholes complied with the SANS standards. The remaining five boreholes reported water quality not fit for human consumption without prior treatment.
- Based on the results of the constant discharge tests performed on the production boreholes, the tested boreholes can supply a total volume of 1394 ML/annum which can supply in the calculated annual demand of 270 ML.
- Based on the results of the reserve calculations and the submission of the WULA, it is advised to apply for an allocation of 0.6 Mm^3/annum from the total property in order to make provision for future expansions and development (current calculated demand is 0.27 Mm^3/annum). An application of 0.6 Mm^3/annum (36.6% of the local recharge) places the application in Category A (small scale abstractions - <60% recharge on the local catchment).
- Based on information collected during the hydrocensus it can be concluded that aquifer system in the study area can be classified as a “Sole Aquifer System”. Aquifers is used to supply in excess of 50% or more of water for domestic and agricultural purposes and there are no reasonably available alternative sources should the aquifer be impacted upon or depleted. One can also assume that the aquifer is important for supplying base flow to the local streams and their tributaries.

Based on the above conclusions, the following recommendations are made:

- In order to mitigate potential contamination of the aquifers underlying the project area, a groundwater management program needs to be developed and implemented as part of the environmental management program.

- As part of the groundwater management program, a groundwater monitoring program should be implemented. Should it become evident from the monitoring program that pollution of the groundwater occurs or anomalous lowering in static water levels occur, corrective and remedial actions should be implemented.

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APPENDIX A

DWS GUIDELINES FOR WATER USE LICENCE APPLICATIONS

APPENDIX B

FC-SOLUTIONS FOR TESTED BOREHOLES

APPENDIX C

LABORATORY REPORTS