2024

Corobrik Midrand Groundwater Assessment Report

28 May 2024

Groundwater Abstract (Pty) Ltd

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Rietfontein
Pretoria, 0084
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COROBRIK MIDRAND GROUNDWATER ASSESSMENT REPORT

Corobrik (Pty) Ltd

Report compiled by:

Groundwater Abstract Pty Ltd

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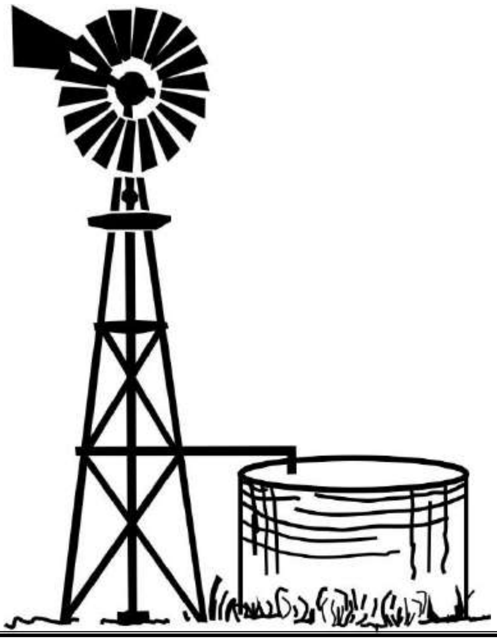

Declaration of Independence

I, Lucas Smith, declare that –

General declaration:

- *I act as the independent Hydrogeology practitioner;*
- *I will perform the work relating to the project in an objective manner, even if this results in views and findings that are not favourable to the applicant;*
- *I declare that there are no circumstances that may compromise my objectivity in performing such work;*
- *I have expertise in conducting hydrogeological assessments, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;*
- *I will comply with the Act, Regulations and all other applicable legislation;*
- *I have no, and will not engage in, conflicting interests in the undertaking of the activity;*
- *I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing*
  - any decision to be taken with respect to the application by the competent authority; and
  - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- *All the particulars furnished by me are true and correct; and*
- *I will perform all other obligations as expected from a hydrogeological practitioner in terms of the Act and the constitutions of my affiliated professional bodies.*

Disclosure of Vested Interest:

- I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remuneration for work performed in terms of the Scope of Work.

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SIGNATURE:

Executive Summary

Corobrik operates factories around South Africa, of which Corobrik Midrand is one of them. Corobrik Midrand is in the Olifantsfontein area, on a Portion of the Farm Olifantsfontein 402 JR, associated with the City of Ekurhuleni Local Municipality, Gauteng Province.

Corobrik Midrand is situated adjacent to the M18 road (Glen Road) between Irene and Tembisa, approximately 5 kilometres (km) north of the Irene Country Club and approximately 1 km east of the Olifantsfontein Wastewater Treatment Works (WWTW). Corobrik Midrand is on the northern boundary of the Olifantsfontein / Clayville area.

Groundwater Abstract (Pty) Ltd (hereafter GWA) was appointed by Corobrik Midrand to assist with an assessment of the groundwater characteristics and provide recommendations regarding the use of one borehole on the Corobrik Midrand property. This document presents the geological and hydrogeological conditions associated with the Corobrik Midrand area and focusses on:

- Identifying existing boreholes in the area;
- Interpretation of test pumping data for borehole on the property;
- Evaluation of groundwater levels in the area; and
- Provide groundwater use and monitoring recommendations to Corobrik Midrand.

Processes at Corobrik Midrand includes mining and beneficiation of raw earth materials. Various clays are quarried and stockpiled on site. The mining operation consists of opencast quarrying involving excavator and trucks, load and haul operations. Raw earth materials are also imported from other areas and stockpiled on site. The clays are drawn from the different stockpiles and pre-blended by volume before being fed into the brick making plant. A total of 30 000 to 40 000 cubic meters of clay per annum is mined from the quarries on site. An additional 30 000 to 60 000 cubic meters of clay is imported from other quarries throughout the year.

The following are key notes in terms of water used at Corobrik Midrand (personal comms with CM Eclectic Pty Ltd):

- For dust suppression on the roads and in the quarry area and for garden irrigation – water from the quarries is used.
- There is one existing borehole which is used for the crushing plant, brickmaking and dehacking.
- Domestic water requirements and water for the brick making plant / process are sourced from Rand Water.

Environmetal setting:

The mean annual precipitation for quaternary catchment A21B is 672 millimetres (WR2012 database). The mean annual evaporation (S-pan evaporation) is 1700 mm (WR2012 database).

According to published geological maps (Geology Map 2528 Pretoria and M Holland, June 2009), the property is underlain by dolomite and chert of the Chuniespoort Group, Transvaal Supergroup, with syenite sills and dykes occurring in the area.

Regional syenite dykes and sills, together with the dolerite dykes compartmentalise the dolomitic areas. The Corobrik Midrand property is associated with the Doornkloof West dolomitic compartment – quarry and plant areas, as well as with the Sterkfontein West dolomitic compartment – southern section of the property, including the borehole locality. The Sterkfontein dyke forms the boundary between the two dolomitic compartments and thus crosses the property in an east-west direction. The Pretoria dyke is approximately 1 km towards the east.

The Corobrik Midrand property is in the A21B quaternary catchment, and forms part of the Limpopo Water Management Area. Locally, the study area is drained by the Olifantspruit, a tributary of the Hennops River. The Olifantspruit merges with the Hennops River near the Irene Country Club. Surface drainage in the Corobrik Midrand area (locally) flows in a westerly direction towards the Olifantspruit.

Hobbs (2004) estimate a recharge value of 11 to 14% for the A21B quaternary catchment. Recharge for the Pretoria/Rietvlei compartment was estimated as 17% of a mean annual rainfall of 682 mm (Bredenkamp, 1988).

Site assessments:

A hydrocensus was conducted across the Corobrik Midrand study area during February 2024. The survey included Corobrik Midrand and neighbouring properties and concentrated on identifying existing boreholes to enhance the knowledge of the groundwater systems and current groundwater use.

During the February 2024 hydrocensus 8 boreholes were identified (Table 3), with only 2 boreholes in a 1-kilometre radius from the Corobrik Midrand BH – borehole Mid BH1 and VMBH1 (Figure 11):

- Corobrik Midrand BH, Mid BH1 and VMBH1 appear to be in the same dolomitic compartment – Sterkfontein West dolomitic compartment. Borehole A2N0687 is possibly in the Sterkfontein East dolomitic compartment. The rest of the boreholes identified during the hydrocensus are in the Doornkloof West dolomitic compartment.
- Only 5 of the 8 boreholes are equipped and in use. The remaining boreholes are old, open boreholes, or used for monitoring purposes – historically used by the DWS as groundwater monitoring boreholes. The boreholes not in use are VMBH1, A2N0687 and G37838.
- Mid BH3 and Mid BH4 are at The Big Red Barn venue, and both are in use. Boreholes Mid BH3 and Mid BH4 are the only water supply source available to the landowner and are between 1.3 km and 1.8 km north of the Corobrik Midrand BH, but they appear to be in a different dolomitic compartment compared to the Corobrik Midrand BH.
- Borehole Mid BH5 is utilised by the Midstream residential area and is approximately 2.1 km northwest of the Corobrik Midrand BH. The borehole is located at the Midstream Indoor Sport Arena and is located behind the golf driving range, close to the Olifantspruit and appears to be in a different dolomitic compartment compared to the Corobrik Midrand BH.
- The Olifantspruit Wastewater Treatment Works (WWTW) is approximately 900 meters west (downstream) from the Corobrik Midrand BH. The WWTW has three monitoring boreholes, but they are potentially not in the same dolomitic compartment as the Corobrik Midrand BH. The exact borehole localities are not known.

The local groundwater level below surface varied between a maximum depth of 14.71 m bgl (borehole G37838), and a minimum of 2.23 m bgl for borehole A2N0687, just north of the Olifantsfontein Dolomite Mine. If the groundwater levels are viewed as an elevation above sea level, then the highest groundwater elevations can be found at borehole Mid BH1 (1496.97 mamsl) (east of Corobrik). The

Corobrik Midrand borehole plus the two neighbouring boreholes present the highest groundwater elevations, as measured during the 2024 hydrocensus. The lowest water table elevations are at borehole G37838 in the north (approximately 1458.46 mamsl). The localised scale the groundwater flow is towards the Olifantspruit (either west or northwest), but regionally it is in a northerly direction.

Three groundwater samples were collected during the Corobrik Midrand hydrocensus. The following conclusions were drawn in terms of the sampled water qualities:

- Aesthetic / Operational effects:
  - Total Hardness – an elevated total hardness level was measured for the Corobrik Midrand borehole (493 mg/L) and for the borehole at Big Red Barn Venue (528mg/L). Water hardness is influenced by the presence of calcium and magnesium salts.
  - Turbidity – The turbidity value exceeded the aesthetic / operational limits for the borehole at Norcros SA (borehole Mid BH1). The Turbidity value of 4.25 is above the aesthetic guideline limit of 1. The borehole is in use and fine material is possibly entering the borehole through the casing slots (if any) or from below the cased zone.

Based on the SANS241 drinking water guideline and on the sampled borehole water results, the water from the sampled sites is fit for human consumption, but treatment is recommended before use as domestic water. No health impact exceedances were noted, based on the health drinking water guideline limits.

Based on the DWS classification system the sampled water is categorized as:

- Corobrik Midrand BH – Class 2 water (water is unsuitable for use) due to the Total Hardness value. Thereafter, Class 1 (good quality) due to the Calcium and Nitrate concentrations. The rest of the parameters fall in the Class O range (ideal water quality range).
- Mid BH1 – Class 1 water (good quality) due to the Fluoride and Turbidity concentrations; and then Class 0 for the rest of the parameters.
- Mid BH3 – Class 2 water (water is unsuitable for use) due to the Total Hardness value. Thereafter, Class 1 due to the Calcium and Sulphate concentrations. The rest of the parameters fall in the Class O range (ideal water quality range).

Groundwater Abstract (Pty) Ltd was appointed by Corobrik Midrand to conduct the aquifer test on the Corobrik Midrand BH, to assess the aquifer response to pumping, plus to determine basic aquifer parameters. The aquifer testing was conducted from 26 April 2024.

Based on the drawdown characteristics and recovery data for this test, the borehole can safely yield the test rate of 102 312 L/hr (102.3 m^3/hr). The borehole has historically been used at a total volume of approximately 53 000 litres per day.

Considering Corobrik Midrand's total daily use of approximately 286 000 litres (sourced from the quarry dam, the 1 borehole and the municipal line), GWA recommends a safe abstraction rate of 7.0L/s (25 200 L/hr, or 25.2 m^3/hr), with borehole abstraction limited to 12 hours of pumping per day. This is approximately a quarter of the maximum volume possible from the current borehole construction limitations. Please note that the borehole / aquifer can yield much more compared to the test rate of 102 312 L/hr (102.3 m^3/hr).

Detailed geological information is not available for the Corobrik Midrand borehole. GWA recommends that the pumping level is managed, and drawdown limited to 1 m, based on the outcome of the aquifer testing.

Potential impacts:

Based on the constant discharge test data for the Corobrik Midrand BH, the calculated radius of influence, at the end of the constant discharge test, was variable, depending on aquifer parameters used:

- If an average T-value of 1000 m^2/d is used, with a Storativity value of 0.5, then the radius of influence at the end of the 24-hour pumping period was 67 m (FC-method calculator).

Several observation boreholes, at various distances from the pumping borehole would be required during an aquifer test to ensure a more accurate radius of influence calculation. Analytical calculations, with only the Corobrik Midrand borehole were used for the calculations, to get an estimate of the radius of influence, and to determine possible impacts associated with abstraction from the Corobrik Midrand borehole.

The closest boreholes to the Corobrik Midrand BH are Figure 11:

- borehole Mid BH1 approximately 250 m to the southwest (Plant and domestic use); and
- borehole VMBH1 approximately 290 m to the south (not in use – groundwater monitoring).

These boreholes are thus outside the potential radius of influence of the Corobrik Midrand. Even though boreholes Mid BH1 and VMBH1 are outside the calculated zone of influence of the Corobrik Midrand, the radius of influence for borehole Mid BH1 might intercept that of the Corobrik Midrand borehole if used simultaneously.

GWA recommends that boreholes Mid BH1, VMBH1 and Mid BH3 serve as groundwater monitoring boreholes, to assess potential groundwater level impacts over time. Additional, new monitoring boreholes might be required in future based on the outcome of the groundwater monitoring program. The groundwater level in the Corobrik Midrand borehole must also be recorded over time to assess what impact the abstraction has on the local aquifer. Abstraction rates can then be adjusted over time and possibly even increase, if the data supports such a request.

The calculated radius of influence does not extend to the Olifantspruit. The stream will serve as recharge mechanism to the underlying dolomitic aquifer and if polluted water flows in the stream it could have a negative impact on the water pumped from boreholes in the same system.

Based on the results of the site investigations, groundwater abstraction for domestic and irrigation use, discharges from sewage systems, industrial waste spills / discharges, and herbicides and pesticides from farming activities, plus hydrocarbon pollution are all potential impacts to the local groundwater environment. With the addition of quarry mining activities, cumulative impacts include:

- drop in the local groundwater level and possible drying up of surrounding boreholes;
- deterioration of the current groundwater quality;

- the backfilled opencast will have a very high hydraulic conductivity, accelerating the movement of any plume in the area;
- changes in turbidity levels in groundwater due to quarry / backfill operations; and
- interruption of groundwater conduit flow paths by rock / clay removal.

These impacts are typical for mining operations and should be managed and mitigated where required. With mitigation measures in place, the significance of the potential impacts on the groundwater was Low.

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Abbreviations

Abbreviation	Description
BH	Borehole
CDT	Constant drawdown test
CFU	Colony forming units
cm	Centimetres
CV	Curriculum Vitae
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
GPS	Global Positioning System
GWA	Groundwater Abstract (Pty) Ltd
ha	hectares
k	Hydraulic conductivity
Km	kilometre
L/s	Litre per second
L/hr	Litre per hour
m	metre
m^3	cubic metre
m^3/day	cubic metre per day
m^3/hr	cubic metre per hour
MAE	Mean Annual Evaporation
m amsl	metres above mean sea level
MAP	Mean Annual Precipitation
m bgl	metres below ground level
mg/L	milligrams per litre
ml	millilitre
mm	millimetre
mm/a	millimetre per annum
mS/m	milli Siemens per metre
NGA	National Groundwater Archive
Ptn	Portion
RT	Recovery test
S	Storativity

SANAS	South African National Accreditation System
SANS	South African National Standards
SDT	Step drawdown test
TDS	Total Dissolved Solids
T	Transmissivity
WRC	Water Research Commission
WMA	Water Management Area
WWTW	Waste Water Treatment Works

1 INTRODUCTION

Corobrik is a major South African manufacturer of masonry, paver and concrete earth retaining systems. With its head office in Durban and 15 factories around South Africa, Corobrik is geared to distribute more than five million products each day and has a footprint in every major centre throughout South Africa (Corobrik Company Profile 2018). For more than 100 years, Corobrik has been manufacturing, distributing, and marketing bricks for the local and international market.

Corobrik operates factories around South Africa, of which Corobrik Midrand is one of them. Corobrik Midrand is in the Olifantsfontein area, on a Portion of the Farm Olifantsfontein 402 JR, associated with the City of Ekurhuleni Local Municipality, Gauteng Province.

Corobrik Midrand is situated adjacent to the M18 road (Glen Road) between Irene and Tembisa, approximately 5 kilometres (km) north of the Irene Country Club and approximately 1 km east of the Olifantsfontein Waste Water Treatment Works (WWTW) (Figure 1). Corobrik Midrand is on the northern boundary of the Olifantsfontein / Clayville area, with the Midstream Estate area situated to the northwest.

Corobrik is in the Manufacturing Sector, but because of their clay quarry operations, to secure raw material for brick manufacture, they fall in the Mining Sector (Corobrik Company Profile 2018).

Groundwater Abstract (Pty) Ltd (hereafter GWA) was appointed by Corobrik Midrand to assist with an assessment of the groundwater characteristics and provide recommendations regarding the use of one borehole on the Corobrik Midrand property. This document presents the geological and hydrogeological conditions associated with the Corobrik Midrand area and focusses on:

- Identifying existing boreholes in the area;
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- Evaluation of groundwater levels in the area; and
- Provide groundwater use and monitoring recommendations to Corobrik Midrand.

1.1 GROUNDWATER STUDY OBJECTIVES

The groundwater assessment will focus on the following objectives:

- Define the aquifers underlying the Corobrik Midrand area;
- Conduct a hydrocensus to define the current groundwater table depth and flow characteristics;
- Use the latest aquifer testing and water quality assessment data to refine the conceptual groundwater model for Corobrik Midrand area; and
- Recommend an initial water monitoring network that will effectively monitor the groundwater quality and groundwater level changes over time.

1.2 COMPLIANCE FRAMEWORK

The water quality assessment was based on South African National Standard (SANS) 241-1:2015, Drinking Water.

1.3 GROUNDWATER ASSESSMENT TEAM

The following hydrogeologist is involved in the Corobrik Midrand groundwater assessment:

- Lucas Smith (MSc Geohydrology) Pr. Sci.Nat:
    - Field work, data analysis, interpretations, and reporting.

A Curriculum Vitae (CV) is appended to Appendix A.

1.4 REPORT STRUCTURE

The remainder of the report is structured as follow:

- Section 2 – Corobrik Midrand.
- Section 3 – Environmental Setting.
- Section 4 – Hydrogeology of the area.
- Section 5 – Site Investigations.
- Section 6 – Aquifer Characterisation.
- Section 7 – Potential Groundwater Impacts.
- Section 8 – Groundwater Management Measures.
- Section 9 – Groundwater Monitoring.
- Section 10 – Conclusions and Recommendations.

APPENDIXES:

- Appendix A: Curriculum Vitae.

2 COROBRIK MIDRAND

Processes at Corobrik Midrand includes mining and beneficiation of raw earth materials. Various clays are quarried and stockpiled on site. The mining operation consists of opencast quarrying involving excavator and trucks, load and haul operations. Raw earth materials are also imported from other areas and stockpiled on site. The clays are drawn from the different stockpiles and pre-blended by volume before being fed into the brick making plant. A total of 30 000 to 40 000 cubic meters of clay per annum is mined from the quarries on site. An additional 30 000 to 60 000 cubic meters of clay is imported from other quarries throughout the year.

The pre-blended clays pass through crushers, and all along the mechanical preparation process, further mixing, and enhancement of the mix takes place. Water is added to the material when it passes through the mixers then passed on to the extrusion point. At the extrusion point, the stiffness of the mix as well as the dimensions of the column is determined and controlled for the next stage of cutting. The cut bricks get loaded onto kiln cars. The loaded cars proceed through to a tunnel dryer for final controlled drying to the desired moisture content. The bricks are passed through the tunnel kiln (firing). Before the bricks are packed, they pass through a de-hacking process where they are dipped into the water using a packing robot. They washed bricks are loaded onto sorting belt for the final stages of, sorting and quality approval, stockpiling and despatch to the customers.

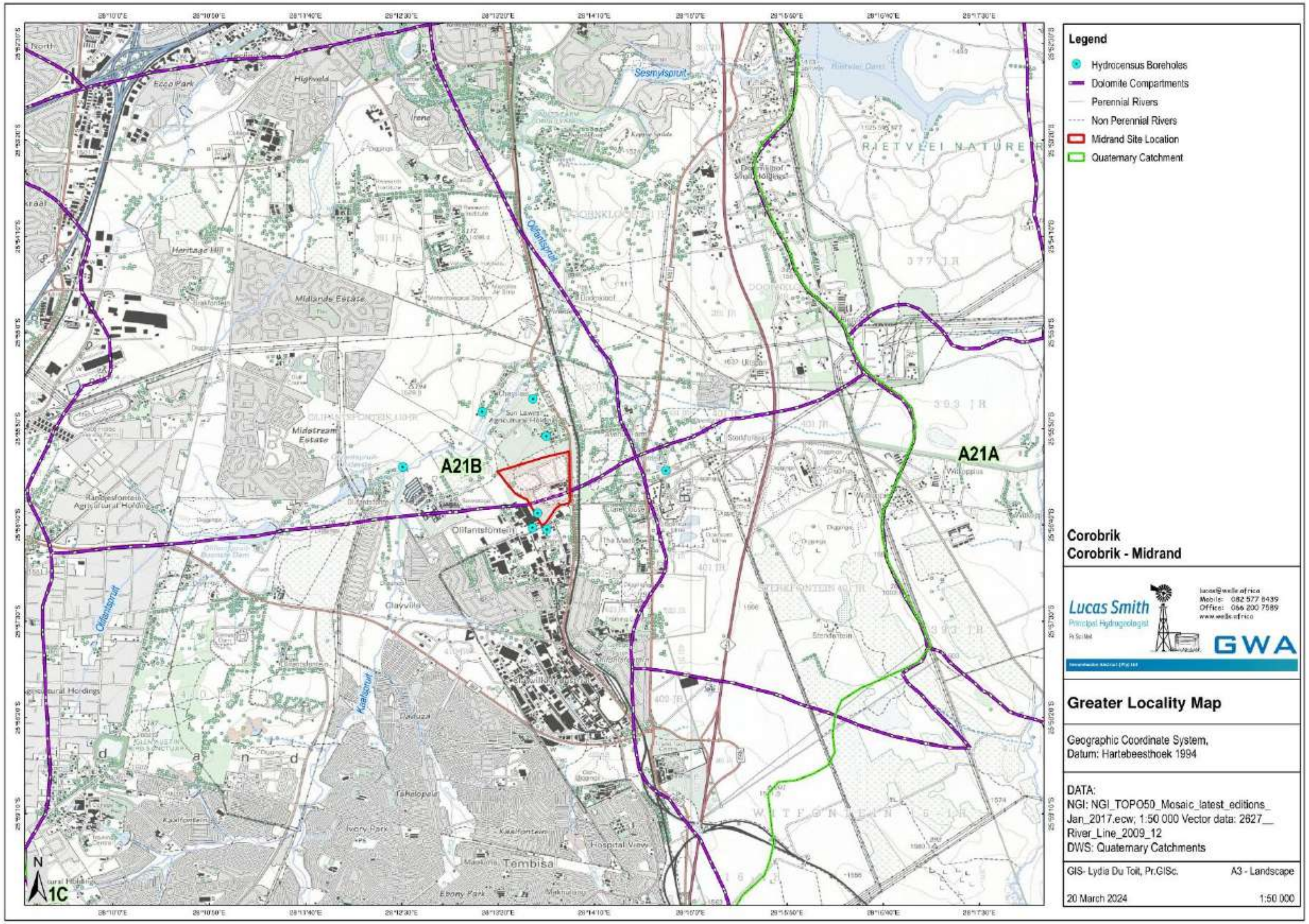

Figure 1. Greater locality map

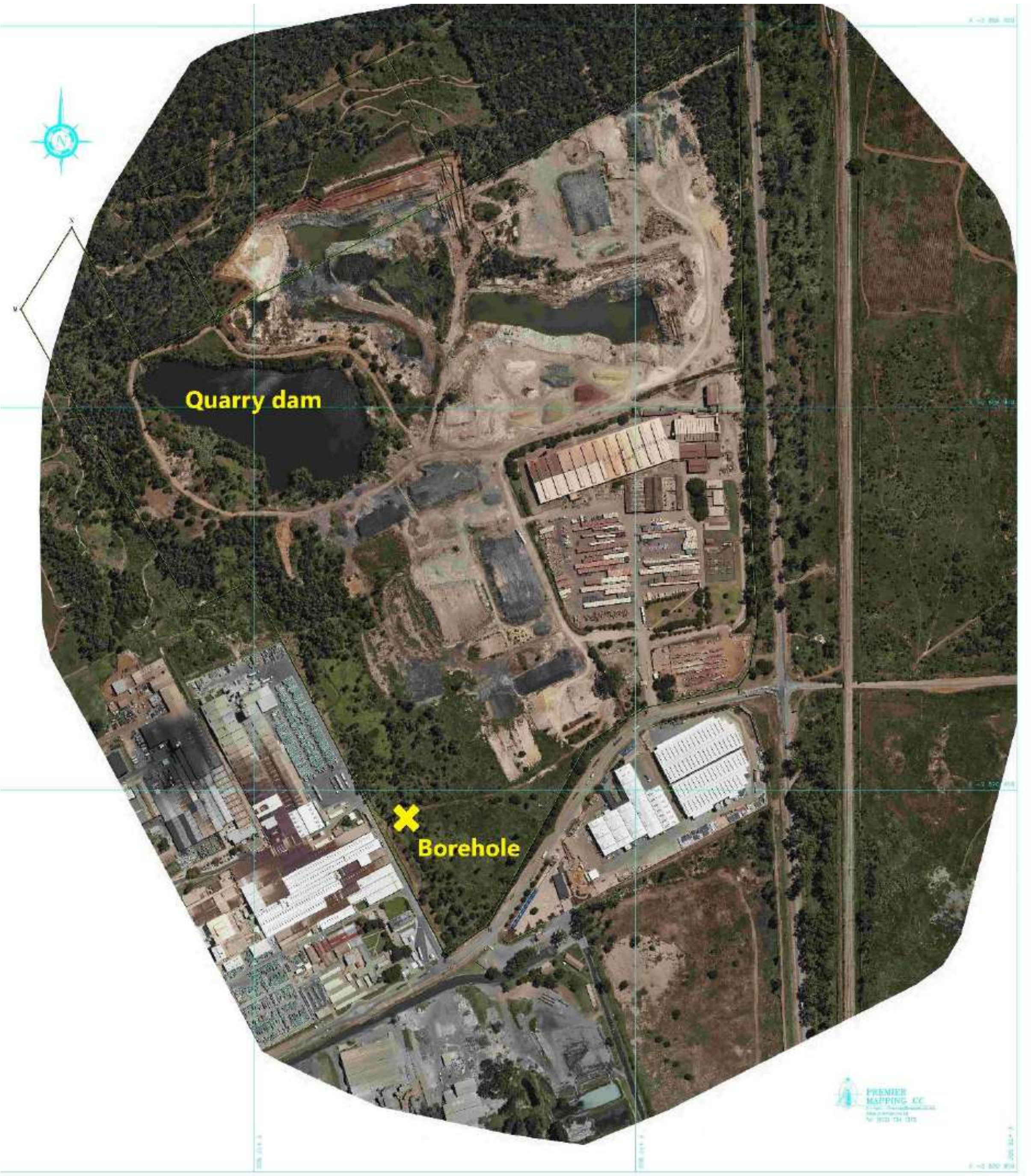

Figure 2. Site locality map

2.1 WATER CIRCUIT

Water sources at Corobrik Midrand are:

- Groundwater and stormwater ingress into the quarry dam.
- Stormwater collected from the dirty catchment including stockpiles and plant area.
- Potable water from the Rand Water Board.
- Water supply borehole.

Process and domestic water are obtained via pipeline from Rand Water, while water for dust suppression is abstracted from the quarry located at the western part of the site.

Water losses are through the following:

- Water evaporation from the quarry dam and sumps in active quarries.
- Interstitial lockup in the stockpiles.
- Water usage for irrigation of the lawns and gardens.
- Water loss during the drying and firing processes in the drier and kilns.
- Dust suppression in the stockpile area, including road dust control.
- Potable water consumption, losses to the municipal sewer system.

The following are key notes in terms of water used at Corobrik Midrand (personal comms with CM Eclectic Pty Ltd):

- For dust suppression on the roads and in the quarry area and for garden irrigation – water from the quarries is used.
- There is one existing borehole which is used for the crushing plant, brickmaking and dehacking.
- Domestic water requirements and water for the brick making plant / process are sourced from Rand Water.

3 ENVIRONMENTAL SETTING

Corobrik Midrand is in an industrial area, with clusters of indigenous and alien vegetation to the west and north. Agricultural land, plus other quarrying and brick making activities are found to the east. The Corobrik Midrand site-topography is generally flat, with a gentle slope towards the Olifantspruit, with the surface elevation ranging from approximately 1500 mamsl (metres above mean sea level) along the southwestern corner of the property to 1460 mamsl in the northeast, near the M18 road (Figure 2). Very few rock outcrops were observed, and areas of solid, continuous outcrop were not found.

3.1 CLIMATE

The area falls in the central Highveld climatic zone. Precipitation occurs as convectional thunderstorms during the summer months (October to March). The winter months are characterized by mild to warm days, with cold nights and frost.

In the Centurion and Irene areas, the climate is warm and moderate. With an average of 28.1°C, January is the warmest month (Table 1). June is the coldest month, with temperatures averaging 18.6°C (www.weather-atlas.com).

The mean annual precipitation (MAP) for quaternary catchment A21B is 672 millimetres (mm) (WR2012 database). The greatest amount of precipitation occurs in December and January, and the lowest in July (Table 1, Figure 3, Figure 4).

The mean annual evaporation (MAE) (S-pan evaporation) is 1700 mm (WR2012 database).

Table 1. Average precipitation data for Irene (www.weather-atlas.com)

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Avg. Temp (°C)	28.1	27.8	26.8	23.6	22.0	18.6	18.5	21.9	26.3	27.5	27.6	28.0
Precipitation (mm)	97	54	44	31	4	3	1	2	8	44	71	87

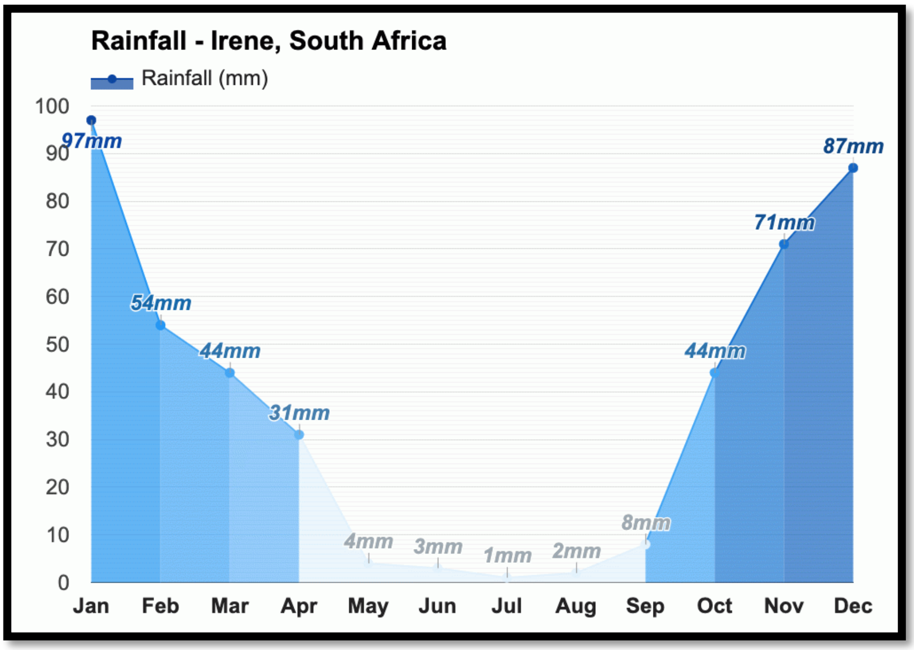

Figure 3. Average precipitation for the Irene area (www.weather-atlas.com)

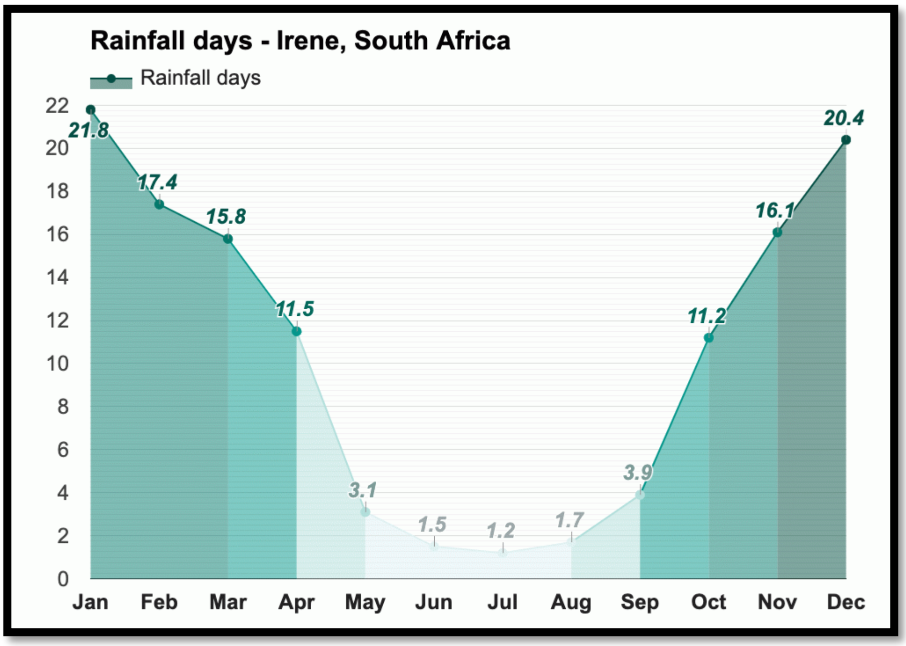

Figure 4. Average number of rainfall days in the Irene area (www.weather-atlas.com)

Recharge is defined as the process by which water is added to the zone of saturation of an aquifer. Groundwater recharge associated with the dolomite in the Centurion area very between 7% and 15% of the mean annual precipitation. Hobbs (2004) estimate a recharge value of 11 to 14% for the A21B quaternary catchment, with a MAP of 672 mm.

3.2 GEOLOGY

According to published geological maps (Geology Map 2528 Pretoria and M Holland, June 2009), the property is underlain by dolomite and chert of the Chuniespoort Group, Transvaal Supergroup, with syenite sills and dykes occurring in the area (Figure 5). The dolomite is underlain by the Black Reef Formation (found along the western boundary of Midstream Estate) and overlain by the Pretoria Group (found to the east of the R21 road, and parallel to the R21).

The Malmani Subgroup dolomite, of the Chuniespoort Group, is subdivided in four formations, with the subdivision being based on chert content and type of algal structures. From a groundwater perspective, the chert content is the most important, with the chert-rich formations forming the main aquifers (DWAF, December 2006). The subdivisions include:

- Eccles – Chert-rich dolomite;
- Lyttleton – Dark, chert-free dolomite;
- Monte Christo – Light coloured, recrystallised dolomite with abundant chert; and
- Oaktree – Darker towards the top, with chocolate coloured weathering.

Dolomite owes its permeability mainly to secondary fissures such as faults, joints and bedding planes which enable circulating groundwater, thus promoting deep weathering of the dolomite, largely by carbonate solution or karstification. The weathering residue is a brown clay / wad, with chert rubble and boulders.

The prominent, near vertical dolerite dyke swarms associated with the Pilanesberg Complex intruded into the Malmani Group rocks. The Pilanesberg dyke swarm is the oldest, together with a younger East Rand dyke swarm. A third group of dykes, with an east-west direction are of post-Karoo age. These dykes are believed to be vertical or near-vertical mafic intrusions (Water Research Commission, March 2014). The dykes are generally considered to be (mostly) impermeable or have a low permeability, and therefor act as barriers to groundwater flow. Close to surface these dykes usually weathered and allow groundwater flow across dykes does occur, while at depth the dykes are essentially impermeable. Bredenkamp (2002) is of the opinion that fracturing at depth due to tectonic activity does occur thereby allowing some trans-compartmental flow, and not necessarily creating a no-flow boundary. The main dykes strike in an approximate north-south and east-west direction (Figure 5) (Water Research Commission, March 2014).

Regional syenite dykes and sills, together with the dolerite dykes compartmentalise the dolomitic areas. The Corobrik Midrand property is associated with the Doornkloof West dolomitic compartment – quarry and plant areas (Figure 2 and Figure 5), as well as with the Sterkfontein West dolomitic compartment – southern section of the property, including the borehole locality. The Doornkloof West dolomitic compartment covers an area of approximately 42.4 km^2 and the Sterkfontein West dolomitic compartment covers an area of approximately 45.9 km^2 (Water Geosciences Consulting, June 2009). The Sterkfontein dyke forms the boundary between the two dolomitic compartments and thus crosses the property in an east-west direction. The Pretoria dyke is approximately 1 km towards the east. The Pretoria dyke is an extensive syenite dyke and extends from Pretoria to Tembisa in the south. These regional dykes create separate groundwater compartments in the dolomite that often influence groundwater movement and often act as barriers, resulting in different responses to groundwater recharge, abstraction or contamination impacts (Water Research Commission, March 2014).

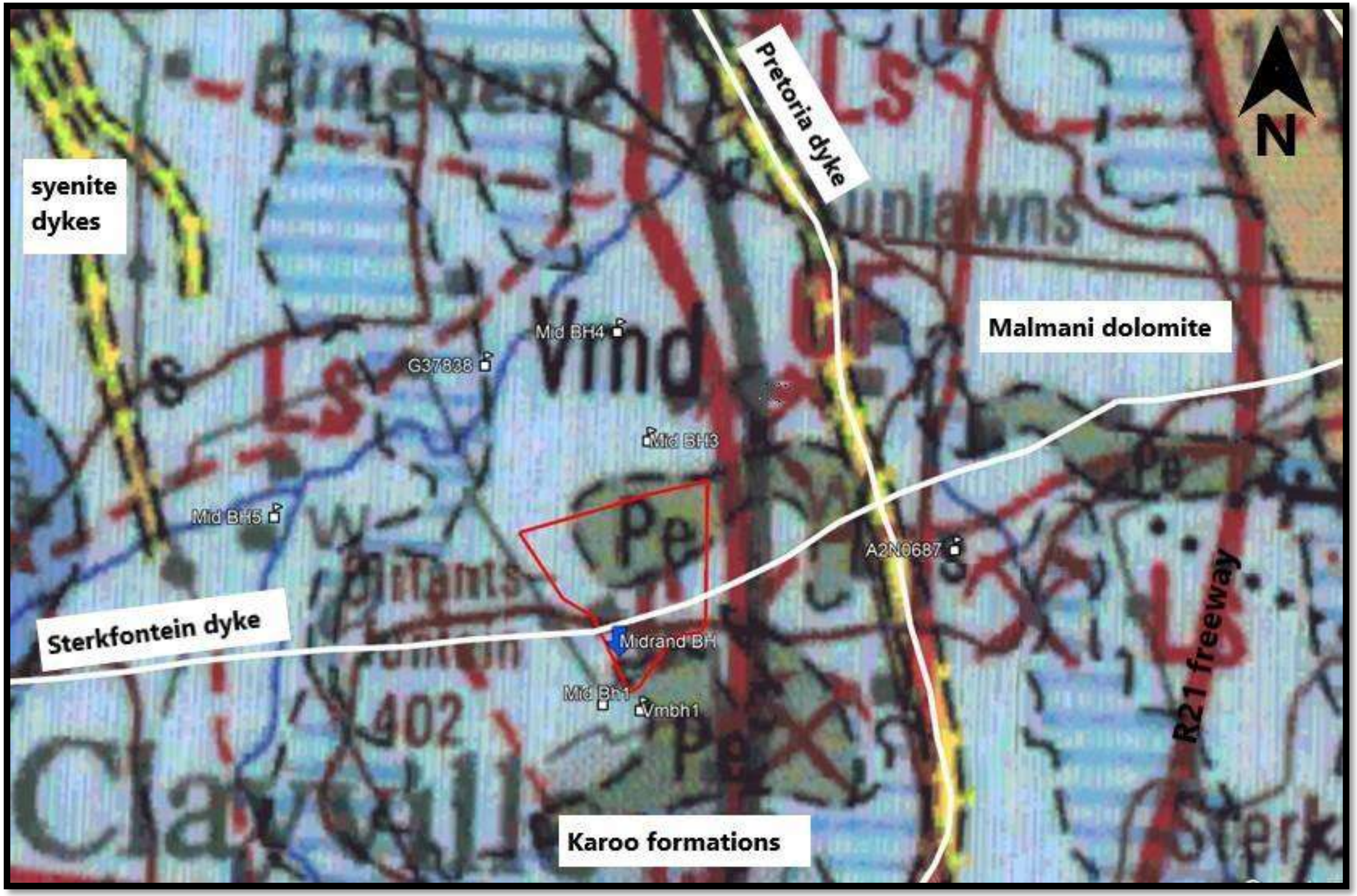

Figure 5. Geology map

The dolomite dips at approximately 20 degrees to the east. This is due largely to the emplacement of the Johannesburg basement granite-gneiss dome, as well as the intrusion of the Bushveld Igneous Complex (Trollip Nicole Yvette-Marie Ghislaine, August 2006).

3.3 SURFACE DRAINAGE

The Corobrik Midrand property is in the A21B quaternary catchment, and forms part of the Limpopo Water Management Area (WMA 1) (Figure 1). Locally, the study area is drained by the Olifantspruit, a tributary of the Hennops River. The Olifantspruit merges with the Hennops River near the Irene Country Club. Surface drainage in the Corobrik Midrand area (locally) flows in a westerly direction towards the Olifantspruit.

Depending on the residual weathering products and the texture of the transported materials, the surface soils may have highly variable permeability. This, together with uncertainty of bedrock properties, changes in land cover and regional groundwater levels, may result in localised zones of increased infiltration or runoff, areas associated with water ponding on surface and/ or groundwater movement possibly mimicking surface topography (KHg Applied Geologists, September 2015).

The A21B quaternary catchment covers an area of approximately 527 km^2 and includes most of the Tembisa, Midrand, Centurion and Tshwane south areas.

4 HYDROGEOLOGY OF THE AREA

According to Barnard (2000) various aquifer types are found in the area i.e., fractured aquifers, karst aquifers, and weathered and fractured aquifers:

- Karst aquifers: The Malmani dolomite aquifers are irregular shaped, with solution cavities and fractures, often associated with faults or dykes.
- Weathered, intergranular and fractured aquifers: The Ecca Group, Karoo Supergroup formations present aquifers that have a combination of loose unconsolidated/ weathered material overlaying hard rock formations, in which fractures, fissures or joints potentially hold water.
- Fractured aquifers: The Ecca formations yield hard rock aquifers where water is stored and moves through fractures.

A study by GPT (2018) stated that the upper, weathered hydrogeological unit is typically found between 5 and 12 m below surface. The study found that groundwater movement in the upper, weathered hydrogeological unit is controlled by the less permeable shale. GPT stated that the matrix of the Ecca geology is often well-cemented, thus lowering groundwater potential in the matrix. They concluded that most water strikes are associated with secondary geological features such as faults, fractured zones, and intrusive contact zones. The Dwyka tillite is hydro-geologically insignificant due to its low yielding nature and low hydraulic conductivity (less than 0.005 m/day), as well as limited recharge potential. GPT did find that high groundwater yields were encountered at the contact zone between the fractured Karoo unit and competent Dwyka tillite. The dolomitic formations are found below the tillite.

The dolomitic aquifer is considered the most significant in the project area. The following is a summary of the main geological units, aquifers in the area:

4.1 VRYHEID FORMATIONS

This unit comprises of sandstone, shale and coal seams and is associated with the Ecca Group, Karoo Supergroup. The sedimentary rocks are widely intruded by diabase sills and dykes, although sill features have not been mapped in the Corobrik Midrand area. According to Vegter et al (1968) different aquifer types can be associated with in the Ecca formations:

- Weathered and fractured shale and sandstone;
- Fractured and jointed sandstone and shale adjacent to the diabase dykes;
- Weathered and fractured diabase dykes;
- Basins of deep weathering in the sandstone, shale and diabase sills;
- Weathered and fractured upper contact zone associated with the sills; and
- Weathered and fractured lower contact zone associated with the sills.

The Ecca Group of the Karoo Supergroup presents aquifers that have a combination of loose unconsolidated/ weathered material overlaying hard rock shale and sandstone, in which fractures, fissures or joints potentially hold water. The Karoo strata are susceptible to preferential weathering. These weathered zones form minor aquifers with low borehole yields. The groundwater yield of the Vryheid Formation is generally below 2 litres per second (L/s). According to a study by AGES (2006) localised perched aquifers occur on the weathered and solid bedrock contact zones. The perched aquifer typically forms on low permeable clays and hardpan ferricrete.

Groundwater quality, distant from pollution sources (e.g., mining) is good, with an average pH of 7.5 and an EC of 57 mS/m.

4.2 DWYKA GROUP

The Dwyka Group comprises glacial deposits (tillite). The permeability of the tillite is generally regarded as very low.

The deeper Ecca, Dwyka and Black Reef quartzite result in hard rock aquifers where water is stored in and moves through fractures. These aquifers are typically low yielding with most water strikes yielding less than 2 L/s. The Dwyka tillite is generally not a well-developed aquifer. Higher groundwater yields are however often present along the contact zone between fractured Karoo aquifers and the Dwyka tillite.

4.3 KARST AQUIFERS

The dolomite of the Chuniespoort Group is associated with karst aquifers (Barnard, 2000), which means that open cavities and even caves have developed below ground level due to the dissolution or chemical weathering of the dolomite. This increases groundwater storage and permeability and is the reason for the high borehole yields when they intercept such an open system. For this reason, the Chuniespoort Group is an important aquifer and water resource (Water Research Commission, March 2014). Large scale leaching and karstification of dolomite can result in very substantial groundwater storage (Avutia Daniel John).

In general, the natural groundwater levels in fractured aquifers across South Africa mimics topography. Unlike these aquifers, natural groundwater levels in dolomite are not always closely related to surface topography, and the water table can be practically flat (Barnard, 2000 and Hobbs, 2004). This is due to the relatively high permeability of dolomite (Water Research Commission, March 2014). The dolomite is divided into units or compartments, by intrusive dykes and other geological structures, which form barriers to the flow of groundwater (faults and topographic groundwater divides can also form compartment boundaries). Thus, the study and management of groundwater resources in the dolomite is often based on the resources which exist in each compartment – pumping in one compartment may not necessarily affect water levels in an adjacent compartment. Groundwater levels frequently vary from one dolomite compartment to another, and springs can occur at the compartment boundaries (Water Research Commission, March 2014).

According to Barnard (2000) the Chuniespoort dolomite cannot be regarded as a single interconnected resource due to the barrier effect that most of the post-Karoo dolerite and syenite dykes create. Based on the delineation of the compartments by Hobbs (2004) the Corobrik Midrand area is associated with the Doornkloof West dolomitic compartment – quarry and plant areas (Figure 2 and Figure 5), as well as with the Sterkfontein West dolomitic compartment – southern section of the property, including the borehole locality. The separate groundwater compartments in the dolomite often responds independently to groundwater recharge, abstraction, or contamination impacts. Bredenkamp et al (1986) concluded that it is very difficult to determine with great certainty that the dykes forming the compartment boundaries are always impermeable. However, groundwater flow does occur between compartments, either through the dykes, or via a near-surface weathered zone, where permeability has been enhanced. The compartment boundaries also do not always coincide with quaternary catchment boundaries (Water Research Commission, March 2014).

The Chuniespoort formations alternate between chert-rich and chert-poor dolomite. Based on the information presented by Barnard (2000) the chert-poor Oaktree Formation is adjacent to the Black Reef quartzite, followed by the chert-rich Monte-Christo Formation; then the Lyttleton, Eccles and lastly the Frisco Formations. The dolomite dips regionally towards the north-northeast beneath the formations of the Pretoria Series (Trollip Nicole Yvette, Marie Ghislaine, August 2006).

The dissolution of calcite along fractures, together with folding and faulting, resulted in well-developed aquifers in the dolomite. The solution features in the dolomite are the result of:

- Dolomite lithology;
- Movement of water through the subsurface – soils and weathered rock;
- Geological features such as fractures and faults; and
- Man-made impacts such as blasting and wastewater / contaminated water discharges.

Borehole yield statistics for the dolomite indicate that most of the borehole yields (50%) fall in the yield category of 5 L/s and more, with 24% of the boreholes yielding 0.5 to 2 L/s (Barnard, October 2000).

A study in the Carletonville area (Barnard, 2000) indicates that the storativity of dolomite tends to decrease with depth. The study shows that the storativity decreases from approximately 9.1% at 61m below surface to 1.3% at 146 m below surface. Storativity is generally between 1% and 5%.

In karst aquifers, groundwater occurrence is greatest where there is a vast network of connected cavities and conduits this is usually limited to a depth of 40 m below ground level (Abiye 2011). Runoff in dolomitic terrains tend to be low and as a result, recharge is usually high. Chert-rich dolomite formations are generally more productive than the chert poor dolomite, this is because of the soluble nature of the chert (Zondi Silindile, May 2017). The dolomite rocks of the Chuniespoort Group have been exploited for groundwater, via springs and boreholes, for many years.

4.4 GROUNDWATER LEVELS – DOLOMITE MONITORING STATIONS

Groundwater in the Tshwane dolomites has been extensively exploited for many years, and natural recharge and discharge mechanisms modified by people (such as altering river flows and capturing springs). It is therefore difficult to determine a natural groundwater state (Hobbs, 2004). The Department of Water and Sanitation (DWS) monitors groundwater levels in the Tshwane dolomites using a network of boreholes. Not all these boreholes are monitored regularly, and monitoring at some boreholes in recent years have stopped, possibly due to access being restricted or boreholes being destroyed (Water Research Commission, March 2014).

An examination of the available groundwater level data shows that, in general, groundwater levels in the Tshwane dolomite appear to have risen slightly from when level monitoring started in 1986–1987. Figure 6 to Figure 10 present the groundwater level data for monitoring boreholes G37835a, A2N0687, A2N0694, A2N0695, and A2N0699, with an average rise in groundwater level between 5 m and 11 m – these are old monitoring boreholes in the Irene – Olifantsfontein areas. This is likely due to borehole monitoring starting in the 1980s, either during or after the drought which occurred at that time. A study by Hobbs (2004) found that groundwater levels in all the compartments, in quaternary catchment A21B had risen since the mid-1980s and attributed this to increased rainfall recharge (Water Research Commission, March 2014). A possible explanation could also be that some part of the rise in dolomite groundwater levels is due to increasing inputs from mains leakage or wastewater returns.

Natural groundwater level fluctuations per annum, in the Tshwane dolomites are thought to be small, often between 2 m and 5 m. This is because groundwater storage in karstic dolomites is relatively large – a lot of water must be added or removed to obtain a moderate change in water levels (Water Research Commission, March 2014).

Table 2 presents a summary of the groundwater levels in the Doornkloof West compartment, as well as with the Sterkfontein West dolomitic compartment (Water Geosciences Consulting, June 2009).

Table 2. Summary of the groundwater levels in the local dolomitic compartments

Compartment Water Level (meters below datum)			
	median	***minimum***	***maximum***
Doornkloof West	15.5	5.6	35.8
Sterkfontein West	20.1	6.6	47.6

The National Groundwater Archive (NGA), maintained by the Department of Water and Sanitation (DWS) was accessed to identify existing borehole and aquifer information for the Corobrik Midrand area. The NGA database indicates that several groundwater (dolomite) monitoring boreholes are in the Corobrik Midrand area, in the Doornkloof West, Doornkloof East, Sterkfontein West and Sterkfontein East Compartments. Groundwater level data for 5 monitoring boreholes were accessed to assess the groundwater level trends for the area and to assess the groundwater level differences between the different dolomitic compartments. The data collection unfortunately stops during December 2004, for the various sites. The monitoring data presented in Figure 6 to Figure 10 presents groundwater level responses across three different dolomitic compartments, in the Corobrik Midrand area, i.e.:

- Borehole G37835a – Doornkloof West dolomitic compartment;
- Borehole A2N0687 – Sterkfontein East dolomitic compartment;

- Borehole A2N0694 – Doornkloof East dolomitic compartment;
- Borehole A2N0695 – Doornkloof East dolomitic compartment; and
- Borehole A2N0699 – Doornkloof East dolomitic compartment.

The closest monitoring borehole to the Corobrik Midrand BH, is borehole A2N0687 (Figure 11), located just north of the Olifantsfontein Dolomite Mine and in a different dolomitic compartment to Corobrik Midrand. The rest of the DWS monitoring boreholes are to the north, approximately 3.5 km to 5 km north of Corobrik Midrand and in a different dolomitic compartment.

An old DWS groundwater monitoring borehole (no longer available) was located near the Corobrik facility. The results of the monitoring of this borehole indicate that until the early 1990s, the water level in the boreholes was resting between 1450 and 1460 mamsl. The dolomite monitoring data / borehole information presented in Figure 6 to Figure 10 indicates:

- Based on the available data there is a 51 m difference in the rest groundwater levels, between the Doornkloof West compartment (borehole G37835a) and the Sterkfontein East compartment (borehole A2N0687), with the level in the Sterkfontein East compartment higher.
    - there is a 23 m difference in the rest groundwater levels, between the Doornkloof West compartment (borehole G37835a) and the Doornkloof East compartment (borehole A2N0699), with the level in the Doornkloof East compartment higher.
    - there is a 20 m difference in the rest groundwater levels, between the Sterkfontein East compartment (borehole A2N0687) and the Doornkloof East compartment (borehole A2N0699), with the level in the Sterkfontein East compartment higher.
    - Thus, between these three dolomitic compartments, the observed groundwater levels are lowest in the Doornkloof West compartment and highest in the Sterkfontein East compartment.
- The 5 dolomite monitoring boreholes have long-term water level data and indicate a water table depth between 2 m and 64 metres below surface. The 5 boreholes are in 3 different dolomitic compartments and at different elevations above sea level.
    - Considering a water level above mean sea level:
        - Borehole G37835a – Doornkloof West compartment – 1431 mamsl.
        - Borehole A2N0687 – Sterkfontein East compartment – 1482 mamsl.
        - Borehole A2N0694 – Doornkloof East compartment – 1462 mamsl.
        - Borehole A2N0695 – Doornkloof East compartment – 1504 mamsl.
        - Borehole A2N0699 – Doornkloof East compartment – 1454 mamsl.
- With the long-term monitoring data, plus the recent levels, it is not possible to identify dewatering impacts. Based on the general rise in the water table, in all boreholes, it does seem as if the groundwater levels in each dolomitic compartment is recovering or at least higher, but stable, compared to the levels pre-2004.
- The groundwater level data for borehole A2N0687 (Figure 7) presents a sharp rise in the groundwater level around the middle of 2000, potentially a very good recharge response after good rains. The rest level rose by approximately 37 m. The groundwater levels were measured by hand; thus, it is unlikely that the data was data logger setup, or even manual measurement errors. Over the same period, the water table in the other boreholes used rose between 1 m and 3 m.
- The most significant step in the water levels, in the other 4 boreholes was over the period mid-1995 to mid-1996 to 1997, where the levels rose between 3 m and 6 m.

  - Borehole G37835a – Doornkloof West dolomitic compartment – 6 m rise.
  - Borehole A2N0687 – Sterkfontein East dolomitic compartment – no change.
  - Borehole A2N0694 – Doornkloof East dolomitic compartment – 5 m rise.
  - Borehole A2N0695 – Doornkloof East dolomitic compartment – 4 m rise.
  - Borehole A2N0699 – Doornkloof East dolomitic compartment – 3 m rise.
- Groundwater level fluctuations in the dolomitic areas are generally small due to the large storage volume in the dolomitic aquifers, thus a large volume of water must be added or removed to result in a signification change in the compartment groundwater level.

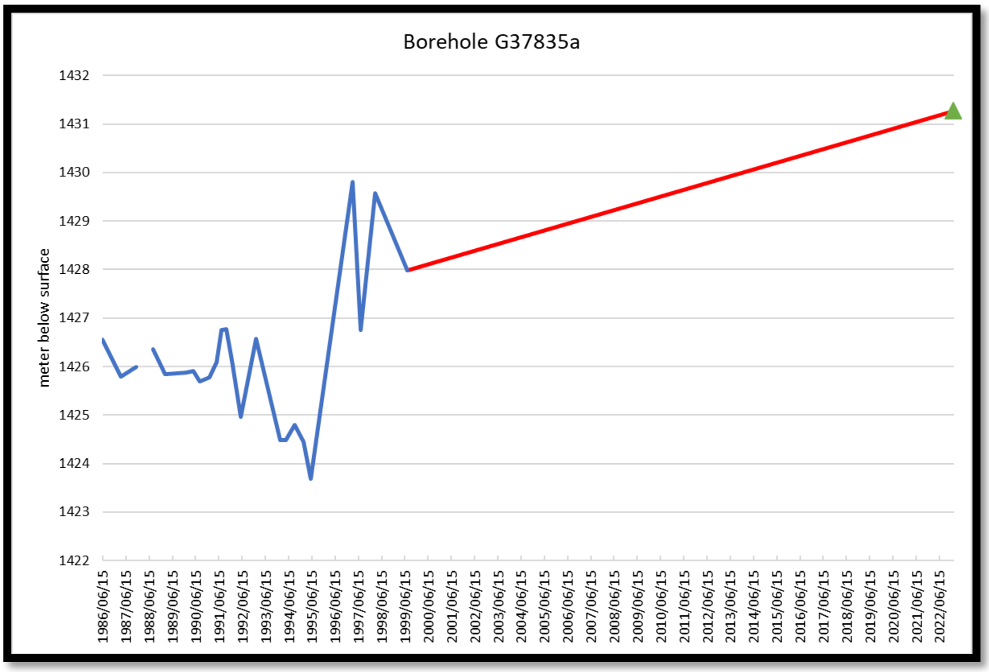

Figure 6. Time series groundwater levels – borehole G37835a (Doornkloof West)

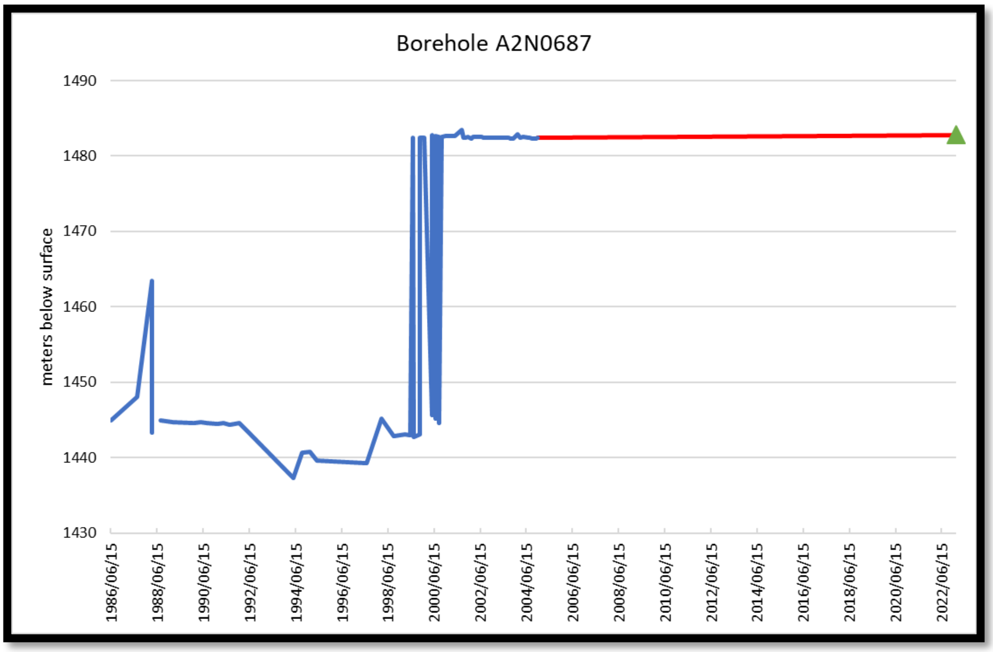

Figure 7. Time series groundwater levels – borehole A2N0687 (Sterkfontein East)

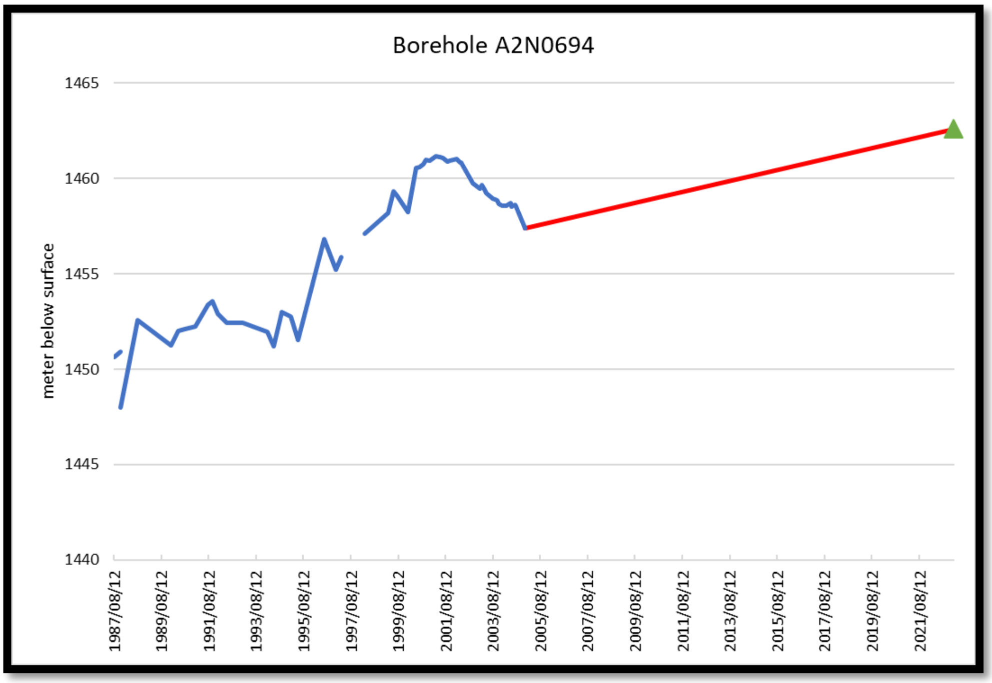

Figure 8. Time series groundwater levels – borehole A2N0694 (Doornkloof East)

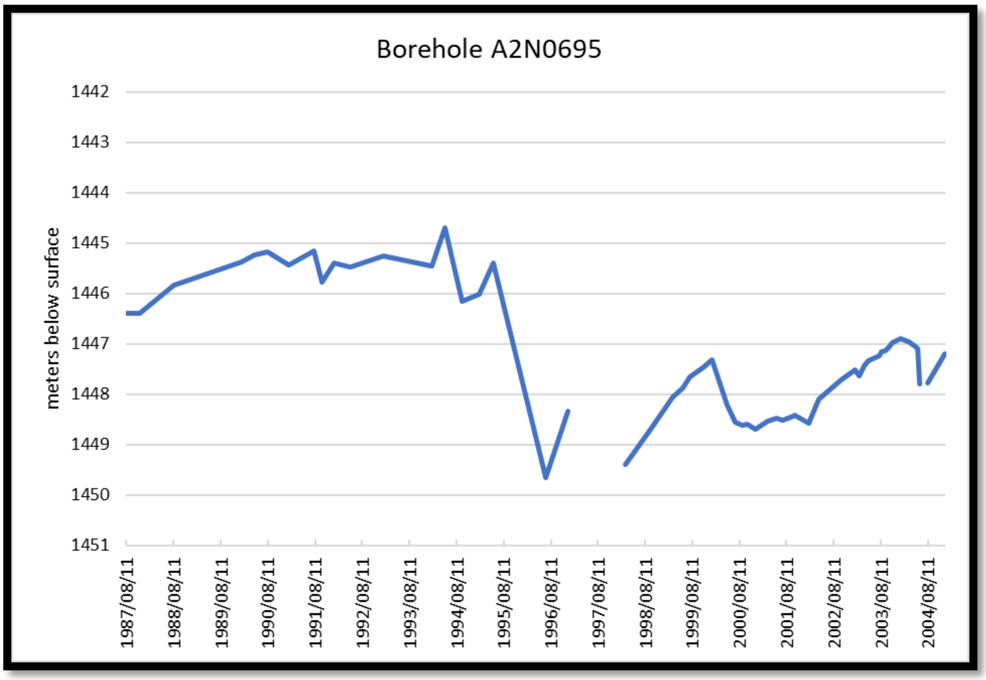

Figure 9. Time series groundwater levels – borehole A2N0695 (Doornkloof East)

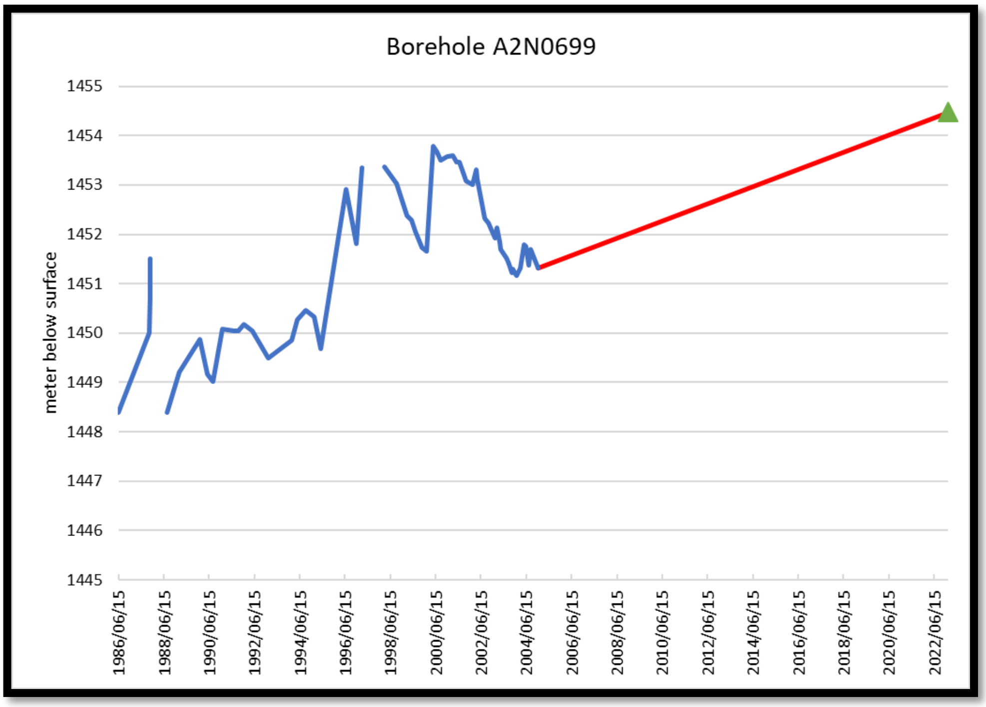

Figure 10. Time series groundwater levels – borehole A2N0699 (Doornkloof East)

4.5 GROUNDWATER RECHARGE

Recharge is defined as the process by which water is added to the zone of saturation of an aquifer. Groundwater recharge associated with the dolomite in the Tshwane area very between 7% and 15% of the mean annual precipitation. Hobbs (2004) estimate a recharge value of 11 to 14% for the A21B quaternary catchment. The A21B quaternary catchment covers an area of approximately 527 km^2 with a MAP of 556 mm. The Doornkloof West dolomitic compartment covers an area of approximately 42.4 km^2.

Recharge can be modified by changes to land-use and may be lowered in areas of dense building development (due to impermeable roads, paving, etc.) or raised due to leakage from water supply and sewage pipes (Water Research Commission, March 2014).

Bredenkamp (1988) used a rainfall–recharge method to estimate recharge for different dolomitic compartments. For the Steenkoppies compartment, which is part of the dolomites west of Tshwane, recharge was estimated as 15% of a mean annual rainfall of 630 mm. Recharge for the Pretoria/Rietvlei compartment, was estimated as 17% of a mean annual rainfall of 682 mm.

There are several routes by which precipitation recharges groundwater in the study area. In addition to direct recharge in parks and gardens, localized recharge often occurs along edges of paths and roads, where no formal storm water drainage exists. Land covered by an impermeable surface decreases recharge.

Water supply infrastructure in urban settings results in large volumes of water circulating below the surface; together with subsequent disposal of most of this water in sewers or on-site facilities such as septic tanks. Water mains are prone to leakage because they are pressurized. The Annual Report for the City of Tshwane (2014/ 2015) reports a water loss / non-revenue water of 23.3%. In terms of total losses per pipe length this is approximately 13,4 litres per minute per km. This water is available for recharge and sometimes is equal to or exceeds the recharge derived from direct precipitation. Recharge from leaking sewer systems unfortunately contributes to aquifer contamination impacts.

4.6 GROUNDWATER QUALITY

Hobbs (2004) described the groundwater quality of the dolomitic aquifers in the Centurion area as good. The water quality for most of the samples captured on the DWS system indicates an ideal or acceptable water quality (Class 0 or 1) (Water Research Commission, March 2014).

Groundwater is predominantly of the calcium-magnesium-bicarbonate type, as expected for a dolomitic groundwater in which dissolution of the rock matrix is the major contributor to chemical quality. The mean pH value was found to be slightly alkaline at 7.62, probably reflecting the buffering capacity of the aquifer. The mean EC value for all the samples was found to be 59.8 mS/m (Water Research Commission, March 2014).

5 SITE ASSESSMENTS

Site-specific groundwater investigations included:

5.1 HYDROCENSUS

A hydrocensus was conducted across the Corobrik Midrand study area during February 2024. The survey included Corobrik Midrand and neighbouring properties and concentrated on identifying existing boreholes to enhance the knowledge of the groundwater systems and current groundwater use.

Corobrik Midrand is bounded by open land and ERWAT's Olifantsfontein Wastewater Treatment Works to the west, the Big Red Barn function venue in the north, the Clayville / Olifantsfontein industrial area to the south and agricultural activities in the east. The Olifantspruit is approximately 700 meters to the northwest. Most of the greater area has access to municipal connections.

During the hydrocensus the following information was collected for each site:

- Borehole position (X, Y, Z-coordinates);
- Information relating to equipment installed;
- Borehole yield – if known;
- Groundwater level, if possible; and
- Current use.

A summary of the hydrocensus information is available in Table 3. All coordinates were taken with a hand-held Garmin GPS (Global Positioning System) (WGS84).

During the February 2024 hydrocensus 8 boreholes were identified (Table 3), with only 2 boreholes in a 1-kilometre radius from the Corobrik Midrand BH – borehole Mid BH1 and VMBH1. The furthest borehole (of the 8 boreholes) is borehole Mid BH5, at Midstream Indoor Sport Arena and golf driving range (approximately 2.1 km to the northwest) (Figure 11):

- Corobrik Midrand BH, Mid BH1 and VMBH1 appear to be in the same dolomitic compartment – Sterkfontein West dolomitic compartment. Borehole A2N0687 is possibly in the Sterkfontein East dolomitic compartment. The rest of the boreholes identified during the hydrocensus are in the Doornkloof West dolomitic compartment.

- Only 5 of the 8 boreholes are equipped and in use. The remaining boreholes are old, open boreholes, or used for monitoring purposes – historically used by the DWS as groundwater monitoring boreholes (Table 3). The boreholes not in use are VMBH1, A2N0687 and G37838.
- Mid BH3 and Mid BH4 are at The Big Red Barn venue, and both are in use. Boreholes Mid BH3 and Mid BH4 are the only water supply source available to the landowner and are between 1.3 km and 1.8 km north of the Corobrik Midrand BH, but they appear to be in a different dolomitic compartment compared to the Corobrik Midrand BH.
- Borehole Mid BH5 is utilised by the Midstream residential area and is approximately 2.1 km northwest of the Corobrik Midrand BH. The borehole is located at the Midstream Indoor Sport Arena and is located behind the golf driving range, close to the Olifantspruit and appears to be in a different dolomitic compartment compared to the Corobrik Midrand BH.
- The Olifantspruit Wastewater Treatment Works (WWTW) is approximately 900 meters west (downstream) from the Corobrik Midrand BH. The WWTW has three monitoring boreholes, but they are potentially not in the same dolomitic compartment as the Corobrik Midrand BH. The exact borehole localities are not known.

Three (3) groundwater samples were collected during the 2024 hydrocensus (Table 4 and see Section 5.1.1). Groundwater level measurements were possible from 6 of the 8 boreholes; the rest are blocked or sealed for security reasons (Table 3). Groundwater levels were measured by using a dip meter to measure the distance from the mouth of the borehole (borehole collar elevation) to the groundwater table depth in the borehole. The height of the borehole collar was subtracted from the measured water level to define a water level below surface (measured in m bgl) (Table 3). The m bgl measurement was subtracted from the borehole's surface elevation to define the groundwater table elevation in metres above mean sea level (m amsl), for all borehole measurements.

The local groundwater level below surface varied between a maximum depth of 14.71 m bgl (borehole G37838), and a minimum of 2.23 m bgl for borehole A2N0687, just north of the Olifantsfontein Dolomite Mine (Table 3). If the groundwater levels are viewed as an elevation above sea level, then the highest groundwater elevations can be found at borehole Mid BH1 (1496.97 mamsl) (east of Corobrik). The Corobrik Midrand borehole plus the two neighbouring boreholes present the highest groundwater elevations, as measured during the 2024 hydrocensus. The lowest water table elevations are at borehole G37838 in the north (approximately 1458.46 mamsl). The regional groundwater flow in the area appears to be in a northerly direction.

The correlation between topography and groundwater elevation is very good (approximately 97%), as shown in Figure 12, considering the hydrocensus boreholes. This means that the groundwater elevations correlate well with the surface elevations (topography), indicating that on a local scale groundwater flow seems to follow the surface topography.

If the groundwater elevation of borehole A2N0687 is included in the analysis then the correlation between topography and groundwater elevation is slightly less, approximately 92%, which is still a good fit, but it also indicates that borehole A2N0687 is in a different hydrogeological unit / dolomitic compartment.

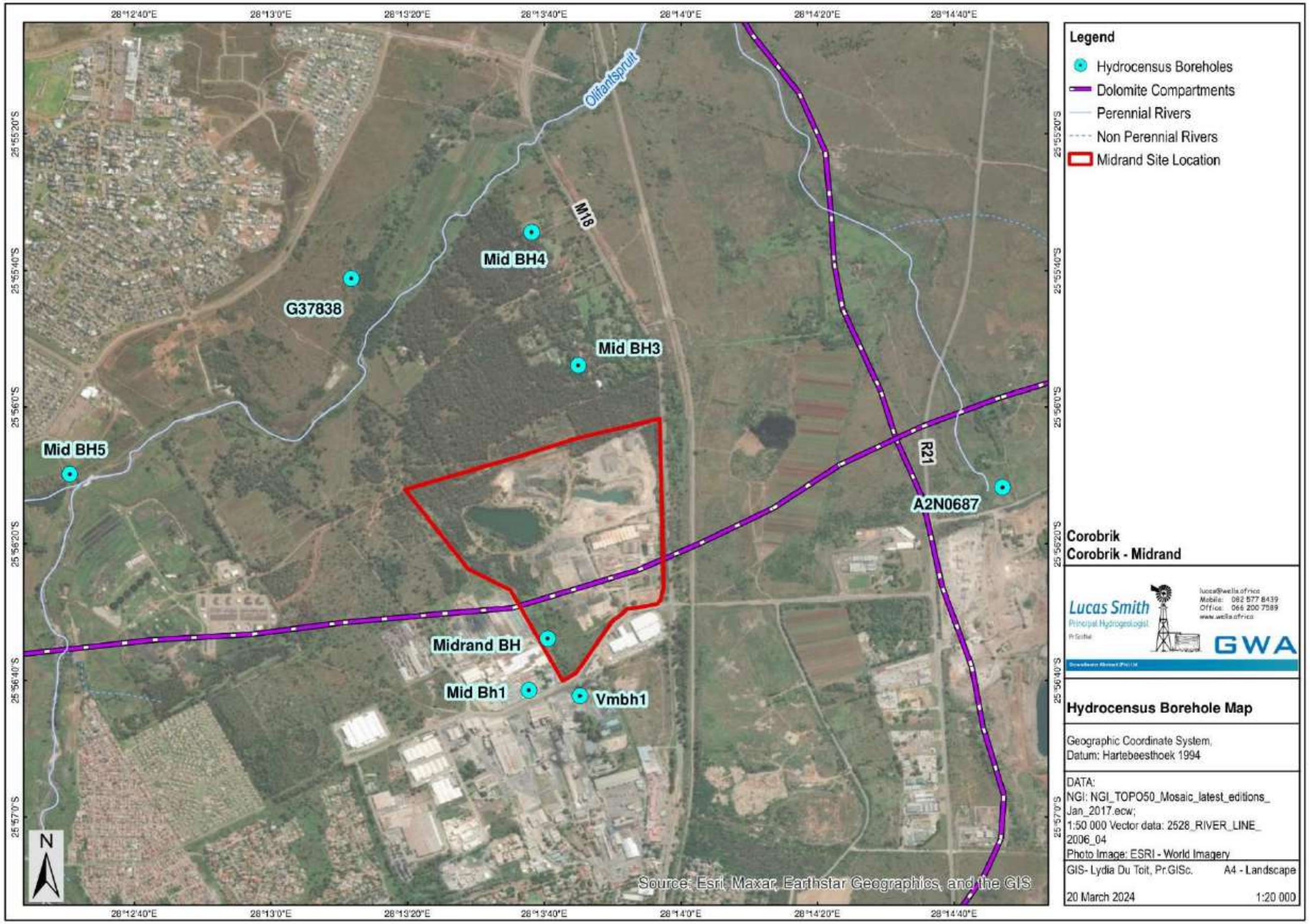

Figure 11. Hydrocensus borehole locality map

Table 3. Hydrocensus summary

Site ID	Lat (WGS84)	Long	Elev (mamsl)	Water depth (mbgl)	Collar height (m)	Water elevation (mamsl)	BH depth (m)	Yield (L/hr)
Midrand BH	25°56'33.87"S	28°13'40.49"E	1502	6,80	0,10	1495,30	20,60	+100000
Mid BH1	25°56'41.45"S	28°13'37.72"E	1509	12,43	0,40	1496,97	---	---
Mid BH3	25°55'53.89"S	28°13'44.98"E	1501	blocked at 30m	0,00	---	--	--
Mid BH4	25°55'34.38"S	28°13'38.13"E	1471	sealed	0,06	---	--	--
Mid BH5	25°56'09.82"S	28°12'30.54"E	1475	8,55	0,35	1466,80	--	--
VMBH1	25°56'42.25"S	28°13'45.21"E	1507	12,81	0,57	1494,76	30,00	---
A2N0687	25°56'11.72"S	28°14'47.03"E	1485	2,23	0,30	1483,07	--	--
G37838	25°55'41.16"S	28°13'11.74"E	1473	14,71	0,17	1458,46	38,00	140000

Site ID	Casing diameter (mm)	Sampled	Pump type	Use	Owner	Note
Midrand BH	230	yes	submersible	Plant	Corobrik	Corobrik Midrand borehole
Mid BH1	165	yes	submersible	Plant and domestic	Norcros SA	Two boreholes next to each other. Only use 1 at a time.
Mid BH3	sealed	yes	submersible	Domestic / farm	Dominique Cullinan	Borehole near houses
Mid BH4	165	no	submersible	Domestic / farm		Borehole at bottom near AcroBranch
Mid BH5	165	no	submersible	Domestic / landscaping	Midstream Electrical Services	Used by Midstream area incl Sports Centre. BH behind golf driving range
VMBH1	100	no	none	monitoring	Vesuvius	Groundwater monitoring borehole
A2N0687	260	no	none	not in use	M&T Development	Old DWS borehole
G37838	265	yes	submersible	Domestic	M&T Development	Old Botha Borehole. Not currently in use.

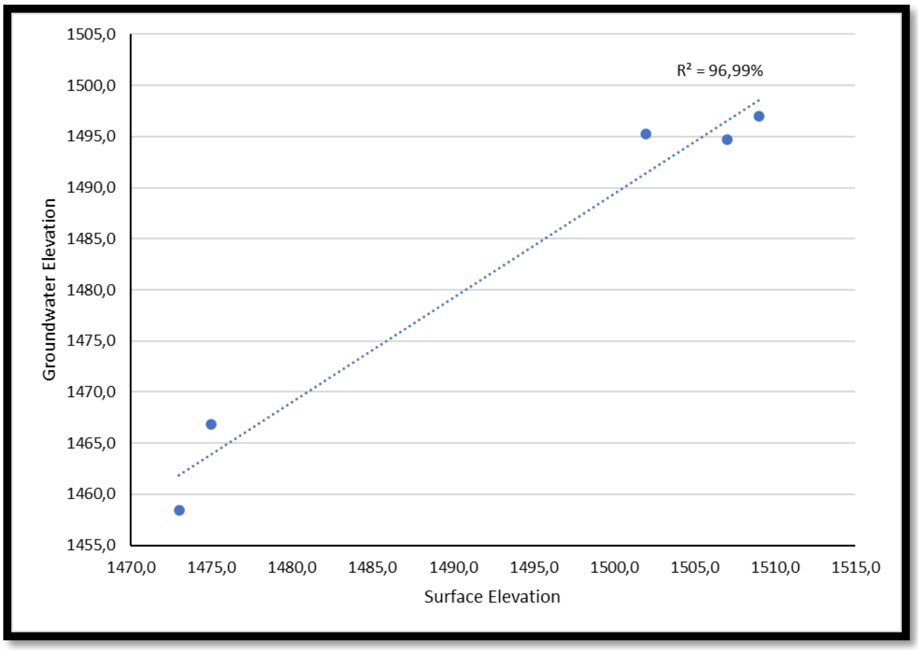

Figure 12. Correlation between surface and groundwater elevations

The groundwater level monitoring information supplied by ERWAT Olifantsfontein WWTW indicates three boreholes on site, with groundwater levels varying between 7.5 m and 11.0 m below surface. This is like the levels measured at the Corobrik Midrand BH, Mid BH1 and VMBH1. Unfortunately, the exact locality of the three boreholes were not provided at the time of writing this report, to include the 3 boreholes in the water elevation assessment.

Thus, on a localised scale the groundwater flow is towards the Olifantspruit (either west or northwest), but regionally it is in a northerly direction. The 8 boreholes identified are potentially in 3 different dolomitic compartments, i.e., Doornkloof West, Sterkfontein West and Sterkfontein East.

The water elevation for the Olifantspruit is roughly 1465 to 1469 mamsl, directly northwest of Corobrik Midrand. If the groundwater elevations for some of boreholes closest to the Olifantspruit is considered:

- Corobrik Midrand BH – groundwater elevation of approximately 1495 mamsl – much higher compared to the stream level.
- For Mid BH5 the groundwater level is similar compared to the nearby stream elevation, therefor there will be groundwater – surface water interaction.

The groundwater elevations versus stream elevation are however very similar. Site-specific, long-term monitoring is required, with accurately surveyed coordinates and borehole collar heights, to accurately assess and monitor the surface water groundwater interaction.

5.1.1 GROUNDWATER QUALITY RESULTS

Three (3) groundwater samples were collected during the Corobrik Midrand hydrocensus (Table 4). Samples were taken using single valve, decontaminated bailers or from pump discharge lines, or water supply taps in the case of boreholes which were equipped and in use. Sterilized 500 millilitre (ml), plus 100 ml sample bottles were used and filled to the top. Samples were stored in a cooler box until delivered to Aquatico for analysis; Aquatico is a SANAS accredited laboratory.

The water samples were analysed for basic inorganic parameters and the results were compared against the SANS 241:2015 Drinking Water Standards (Table 4).

The water sampled from the three boreholes is of acceptable quality, based on the parameters used in the laboratory analysis and the results presented in Table 4. No health impact exceedances were noted, based on the health drinking water guideline limits.

The following conclusions were drawn in terms of the sampled water qualities (Table 4):

- Aesthetic / Operational effects:
  - Total Hardness – an elevated total hardness level was measured for the Corobrik Midrand borehole (493 mg/L) and for the borehole at Big Red Barn Venue (528mg/L). Water hardness is influenced by the presence of calcium and magnesium salts. Other metals such as strontium, iron, aluminium, zinc and manganese may occasionally contribute to the hardness of water, but the calcium and magnesium hardness usually predominates. Temporary hardness is due to the presence of bicarbonates of calcium and magnesium and can be removed by boiling, whereas permanent hardness is attributed to other salts such as sulphate and chloride salts, which cannot be removed by boiling. Excessive hardness of water can give rise to scaling in plumbing and household heating appliances and hence has adverse economic implications. It also poses a nuisance in personal hygiene. Excessive softness may lead to aggressive and corrosive water qualities which are of concern where copper plumbing installations are used. Water hardness depends on whether it is caused by bicarbonate salts or non-bicarbonate salts, such as chloride, sulphate and nitrate. Bicarbonate salts of calcium and magnesium precipitate on heating and cause scaling in hot water systems and appliances, whereas the non-bicarbonate salts do not precipitate on heating.
  - Turbidity – The turbidity value exceeded the aesthetic / operational limits for the borehole at Norcros SA (borehole Mid BH1). The Turbidity value of 4.25 is above the aesthetic guideline limit of 1. The borehole is in use and fine material is possibly entering the borehole through the casing slots (if any) or from below the cased zone.

Based on the SANS241 drinking water guideline and on the sampled borehole water results, the water from the sampled sites is fit for human consumption, but treatment is recommended before use as domestic water.

The DWS uses a water classification system where the water is defined in different classes based on a fitness for use classification (see Table 5). The element concentrations are like the SANS guideline limits, but with the DWS system a classification is assigned to the water sample, e.g., Class 2 water.

Table 4. Hydrocensus Water Quality Data

	DWS Drinking Water Guideline Limits					ANS241:2015 Drinking Water Standard Limits		Corobrik Midrand BH	Mid BH1	Mid BH3
	Class 0	Class 1	Class 2	Class 3	Class 4	Aesthetic effects	Chronic health effects			
pH	*5-9.5*	4.5-5 or 9.5-10	4-4.5 or 10-10.5	3-4 or 10.5-11	<3 or >11	≥5 to ≤9.7		6.97	8.41	7.50
Electrical Conductivity	*<70*	70-150	150-370	370-520	>520	Aesthetic ≤170		**92.7**	36.3	**107**
TDS	*<450*	450-1000	1000-2400	2400-3400	>3400	Aesthetic ≤1200		**594**	245	**684**
Turbidity	*0 - 1*	1 - 5	5 - 10	>10		Operational ≤ 1	Aesthetic ≤ 5	0.5	**4.25**	0.271
Aluminium		0 - 0,15	0,15 - 0,5	>0,5		Operational ≤ 0,30		<0.002	<0.002	<0.002
Calcium	*<80*	80-150	150-300	>300				**98.1**	43.4	**104**
Copper	*<1*	1-1,3	1,3-2	2-15	>15		Chronic health ≤2	<0.002	0.004	<0.002
Iron	*<0,5*	0,5-1	1-5	5-10	>10	Aesthetic ≤0,3	Chronic health ≤2	<0.004	<0.004	<0.004
Magnesium	*<70*	70-100	100-200	200-400	>400			60.2	18.9	65.4
Manganese	*<0,1*	0,1-0,4	0,4-4	4-10	>10	Aesthetic ≤0,1	Chronic health ≤0,4	<0.001	0.005	<0.001
Nickel							Chronic health ≤0.07	<0.002	<0.002	<0.002
Zinc	*0 - 5*	5 - 10	10 - 50	50 - 700	>700	Aesthetic ≤5		<0.002	2.51	<0.002
Chromium	*0 - 0,05*		0,05 - 1	1 - 5	>5		Chronic health ≤0,05	<0.003	<0.003	<0.003
Cadmium							Chronic health ≤0.003	<0.002	<0.002	<0.002
Lead							Chronic health ≤0.01	<0.004	<0.004	<0.004
Potassium	*<25*	25-50	50-100	100-500	>500			0.914	3.67	2.24
Sodium	*<100*	100-200	200-400	400-1000	>1000	Aesthetic ≤200		23.2	16.7	35.2
Chloride	*<100*	100-200	200-600	600-1200	>1200	Aesthetic ≤300		37.3	17.4	72.8
Fluoride	*<0,7*	0,7-1	1-1,5	1,5-3,5	>3,5		Chronic health ≤1,5	<0.263	**0.979**	<0.263
Ammonium (NH_4) as N	*0 - 1*	1 - 2	2 - 10	>10		Aesthetic ≤1,5		0.124	0.27	0.072
Nitrate	*<6*	6 - 10	10 - 20	20-40	>40		Acute health ≤11	**8.73**	1.04	3.69
Total oxidised nitrogen as N								8.73	1.04	3.69
Sulphate	*<200*	200-400	400-600	600-1000	>1000	Aesthetic ≤250	Acute health ≤500	115	32.4	**208**
Total Alkalinity								299	148	295

	DWS Drinking Water Guideline Limits					ANS241:2015 Drinking Water Standard Limits		Corobrik Midrand BH	Mid BH1	Mid BH3
	Class 0	Class 1	Class 2	Class 3	Class 4	Aesthetic effects	Chronic health effects			
Total Hardness	*<200*	**200-300**	300-600	>600		120–180 mg/l, hard // more than 180 mg/l, very hard		**493**	186	**528**
Total organic carbon							Chronic health ≤10	1.53	1.70	1.06
Langelier Saturation Index	A positive Langelier index indicates scale-forming tendency and a negative Langelier index indicates a scale-dissolving tendency, with the possibility of corrosion							0.18	0.29	0.77
Total Coliform Bacteria		***0 - 5***	**5 - 100**	**>100**		≤ 10		6	<1	1
E. coli							Not detected	<1	<1	<1
							DWS Classification	**2**	**1**	**2**

NOTE:

- *Red cells indicate concentrations exceeding the SANS health guideline limits.*
- *Yellow cells indicate concentrations exceeding the SANS drinking water standard limits, but only has an operational / aesthetic impact.*

Table 5. DWS water quality "fitness for use" classes currently used in South Africa

Water use	Categorisation	Description
Domestic	Class 0	Water of ideal quality, which has no health or aesthetic effects, and which is suitable for lifetime use without negative effects. No treatment necessary.
	Class 1	Water of good quality, suitable for lifetime use with few health effects. Aesthetic effects may be apparent. Home treatment will usually be sufficient.
	Class 2	Water which poses a definite risk of health effects, following long term or lifetime use. However, following short-term or emergency use, health effects are uncommon and unusual. Treatment will be required to render the water fit for continued use.
	Class 3	Water is unsuitable for use, especially by children and the elderly, as health effects are common. Conventional or advanced treatment necessary

Based on the DWS classification system (Table 5) the sampled water is categorized as:

- Corobrik Midrand BH – Class 2 water (water is unsuitable for use) due to the Total Hardness value. Thereafter, Class 1 (good quality) due to the Calcium and Nitrate concentrations. The rest of the parameters fall in the Class O range (ideal water quality range).
- Mid BH1 – Class 1 water (good quality) due to the Fluoride and Turbidity concentrations; and then Class 0 for the rest of the parameters.
- Mid BH3 – Class 2 water (water is unsuitable for use) due to the Total Hardness value. Thereafter, Class 1 due to the Calcium and Sulphate concentrations. The rest of the parameters fall in the Class O range (ideal water quality range).

The three boreholes listed above are in daily use. Considering the parameters tested for and the results received it does not appear as if there is any contamination of the sampled groundwater environments, e.g., from agricultural or industrial practices, or from the WWTW.

5.2 AQUIFER TESTING

Groundwater Abstract (Pty) Ltd was appointed by Corobrik Midrand to conduct the aquifer test on the Corobrik Midrand BH, to assess the aquifer response to pumping, plus to determine basic aquifer parameters. This includes defining:

- Borehole drawdown and recovery characteristics.
- Aquifer hydraulic parameters:
    - Transmissivity (T) defined as the product of the average hydraulic conductivity (K) and the saturated aquifer thickness. It is a measure of the rate of flow under a unit hydraulic gradient through a cross-section of unit width over the whole saturated thickness of the aquifer. The unit of measurement is m^2/day.
    - Characterisation of aquifer flow boundaries such as low permeable, no-flow or recharge boundaries. No-flow or low permeable boundaries refer to a lower transmissive structure (e.g., fracture with a lower conductance or low permeable dyke) or aquifer boundary (limit of aquifer – no-flow boundary) that results in an increase in groundwater drawdown during borehole abstraction. Recharge boundaries relate often to leakage from surface water bodies.

The Corobrik Midrand BH has historically been used as one of the water supply sources to the Plant.

The aquifer testing was conducted from 26 April 2024. A summary of the test programme is given in Table 6. Prior to the aquifer testing, static groundwater levels are measured in the pumping and observation boreholes (if any) to enable drawdown calculations during test pumping. During the test, the abstraction rate is continuously monitored by means of electronic flow meters.

No observation boreholes were monitored during the testing of the Corobrik Midrand BH.

The pumping test programme included the following different tests:

- Firstly, a step test was performed. During the step test the borehole was pumped at a constant discharge rate for 60 minutes, where after the step was repeated at a higher discharge rate. During the test the drawdown over time was recorded in the pumping borehole. After the test stopped, residual drawdown (recovery) was measured.

- The constant discharge test (CDT) followed the step test. During the CDT test the drawdown over time was recorded in the pumping borehole and a constant discharge rate was maintained throughout the test. The duration of CDT was 24-hours.
- A recovery test followed directly after pump shut down, at the end of the step test and CDT. The residual drawdown over time (water level recovery) was measured until 90% recovery was reached. Aquifer parameters and sustainable borehole yields can be derived from the time drawdown data of the CDT and recovery tests, by application of a variety of analytical methods.

5.2.1 AQUIFER TEST RESULTS

Step test – four steps were run (60-minute duration), with yields progressively getting higher, from 3.51 L/s (12 643 L/hr) on step 1, to 31.29 L/s (112 644 L/hr) on step 4. Full drawdown was not achieved during the step test with only 8% of the available drawdown (12.6 m) used. The data is presented in Figure 13.

Step drawdown test:

- Step 1 – 3.51 L/s, with 5 cm drawdown at the end of the step.
- Step 2 – 10.71 L/s, with 20 cm drawdown at the end of the step.
- Step 3 – 19.5 L/s, with 59 cm drawdown at the end of the step.
- Step 4 – 31.29 L/s, with 100 cm drawdown at the end of the step. Full drawdown was not achieved due to the high yield of the borehole / aquifer.
- Recovery – 90% in 60 minutes.

The step test data indicates a gradual but minimal drawdown curve for the 4 steps. The maximum drawdown, at a pumping rate of 112 644 L/hr was 1 meter. No flow boundaries were visible but considering a change of only 1 meter.

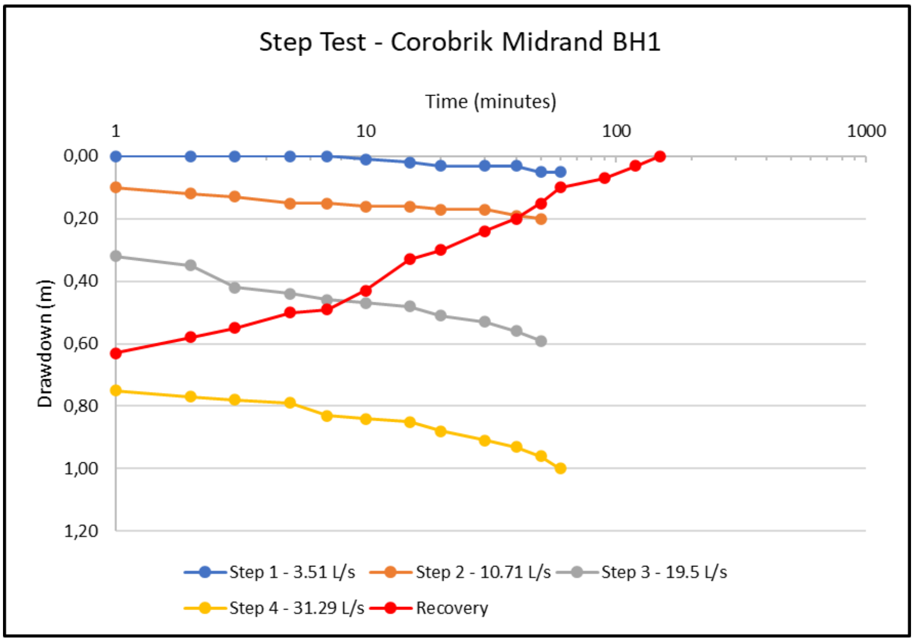

Figure 13. Step test data

The constant discharge test was run at 102 312 L/hr (28.42 L/s,) for 24 hours, followed by recovery measurements. The data is presented in Figure 14.

The step test data indicates that the borehole can yield much more water compared to the selected constant abstraction rate (102 312 L/hr). Borehole diameter and pump limitations defined the maximum pumping rate.

The constant discharge test data indicates a slow but continuous drop in the water level over the duration of the test. The aquifer did not reach a state of equilibrium during this period and only recorded a 1.69 m drawdown, at 28.31 L/s (102 312 L/hr). Minimal drawdown was achieved over the duration of the 24-hour test with only 13% of the available drawdown was used.

The water table recovered 90% in 8 hours, with 100% recovery approximately 16 hours after pump shutdown. The pump was set at 19.4 m below surface during the aquifer test, with a borehole depth of 20.6 m.

Based on the drawdown characteristics and recovery data for this test, the borehole can safely yield the test rate of 102 312 L/hr (102.3 m^3/hr). The borehole has historically been used at a total volume of approximately 53 000 litres per day.

Considering Corobrik Midrand's total daily use of approximately 286 000 litres (sourced from the quarry dam, the 1 borehole and the municipal line), GWA recommends a safe abstraction rate of 7.0L/s (25 200 L/hr, or 25.2 m^3/hr), with borehole abstraction limited to 12 hours of pumping per day. This is approximately a quarter of the maximum volume possible from the current borehole construction limitations. Please note that the borehole / aquifer can yield much more compared to the test rate of 102 312 L/hr (102.3 m^3/hr).

Detailed geological information is not available for the Corobrik Midrand borehole. GWA recommends that the pumping level is managed, and drawdown limited to 1 m, based on the outcome of the aquifer testing.

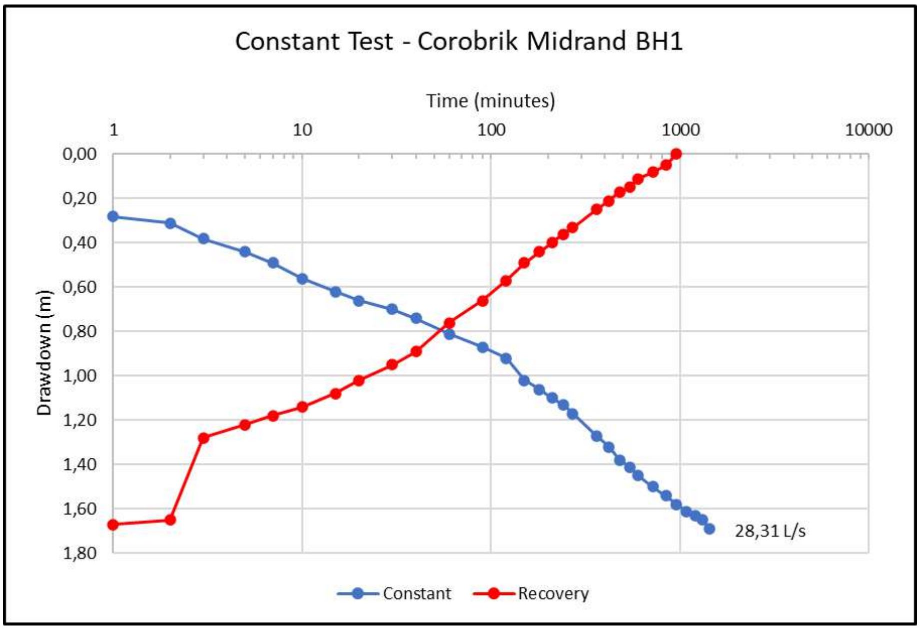

Figure 14. Constant discharge test data

Table 6. Aquifer test information

BH	Test date	BH depth	Rest water level	Available drawdown	Step test max yield	Step test duration	Step test recovery
	26 April 2024	20.6 m	6.80 mbgl	12.6 m	31.29 L/s	60 minutes x 4	90% in 60 min
	Constant discharge test rate	**Constant test duration**	**Constant test recovery**	**T**	**Recommended abstraction rate**		
	28.31 L/s	24 hours	90% in 8 hours	651 m^2/day	25.2 m^3/hour (25 200 L/hr – 12 hours / day)		

5.2.2 Approximate Radius if Influence during Aquifer Test

Analytical calculations were developed to help understand the effect of pumping at select locations, where aquifer properties are either known or can be estimated to a certain degree of certainty. These calculations are however done based on the following assumptions:

- the aquifer is infinite, confined, homogeneous, and isotropic;
- the aquifer is horizontal and groundwater flow is horizontal; and
- the borehole diameter is negligible.

In reality, the geology and associated aquifer units are more complicated and heterogeneous, especially dolomite aquifers. The radius of influence can be determined with more accuracy if more detail is known about each borehole and the geological units it penetrates, together with long term monitoring data, that includes data recorded at several nearby observation boreholes. The impact of groundwater flow barriers or recharge zones further complicates the flow calculations in these heterogenous systems. One of the key problems in this regard is the heterogeneity of the dolomite, so that applying average figures across compartments is largely meaningless. Transmissivity (T) is highly variable in the dolomite, ranging from nearly impervious to approximately 30 000 m^3/day/m. An interesting feature of the dolomite is the apparent increase in transmissivity toward the N-S dykes (Bredenkamp 1995).

The highly transmissive nature of the dolomite results in the water table being very flat, with a very low gradient from one end of a compartment to the other. Because of the nature of karst, the variation in T- and S values (storativity) cannot be assigned to specific areas or zones and conditions vary greatly over short distances (Hodgson et al). Transmissivity and S values obtained from test pumping can be particularly site specific and misleading (Bredenkamp 1995).

Based on the constant discharge test data for the Corobrik Midrand BH, the calculated radius of influence, at the end of the constant discharge test, was therefore variable, depending on aquifer parameters used:

- If an average T-value of 1000 m^2/d is used, with a Storativity value of 0.5, then the radius of influence at the end of the 24-hour pumping period was 67 m (FC-method calculator).

Several observation boreholes, at various distances from the pumping borehole would be required during an aquifer test to ensure a more accurate radius of influence calculation. Analytical calculations, with only the Corobrik Midrand borehole were used for the calculations, to get an estimate of the radius of influence, and to determine possible impacts associated with abstraction from the Corobrik Midrand borehole.

For the radius of influence calculations, the following were assumed:

- All boreholes have the same geological, aquifer and yield properties. Thus, all boreholes pump from the same homogeneous aquifer.
- Pumping time of 24 hours, non-stop.
- Pumping rate of 102 312 L/hr.
- The aquifer is infinite, homogeneous, and isotropic.

The closest boreholes to the Corobrik Midrand BH are (Figure 11):

- borehole Mid BH1 approximately 250 m to the southwest (Plant and domestic use); and
- borehole VMBH1 approximately 290 m to the south (not in use – groundwater monitoring).

These boreholes are thus far outside the potential radius of influence of the Corobrik Midrand. Even though boreholes Mid BH1 and VMBH1 are outside the calculated zone of influence of the Corobrik Midrand, the radius of influence for borehole Mid BH1 might intercept that of the Corobrik Midrand borehole if used simultaneously.

GWA recommends that boreholes Mid BH1, VMBH1 and Mid BH3 serve as groundwater monitoring boreholes, to assess potential groundwater level impacts over time. Additional, new monitoring boreholes might be required in future based on the outcome of the groundwater monitoring program. The groundwater level in the Corobrik Midrand borehole must also be recorded over time to assess what impact the abstraction has on the local aquifer. A reading just before pump start and again just before pump stop will help to determine pumping efficiencies and impacts. Most effective way is with the use of a data logger in the borehole. Abstraction rates can then be adjusted over time and possibly even increase, if the data supports such a request.

The calculated radius of influence does not extend to the Olifantspruit. The stream will serve as recharge mechanism to the underlying dolomitic aquifer and if polluted water flows in the stream it could have a negative impact on the water pumped from boreholes in the same system.

6 AQUIFER CHARACTERISATION

Aquifer characterisation is done based on the information presented thus far, and guidelines and maps provided by the DWS.

6.1 GROUNDWATER VULNERABILITY

Groundwater vulnerability indicates the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer. Based on the aquifer vulnerability map published by the DWS, in July 2013 the dolomite is classified as a vulnerable aquifer, which is vulnerable to pollutants except those strongly absorbed or readily transformed in many pollution scenarios (DWS, July 2013).

Dolomite aquifers are particularly vulnerable to surface pollution due to the relatively rapid rate of groundwater flow, often via fissures where little retardation of pollutants can occur (Barnard, 2000). In addition, sinkholes and other features in karstic environments provide direct routes for surface water into the subsurface (i.e., bypassing the soil zone).

6.2 AQUIFER SUSCEPTIBILITY

Aquifer susceptibility is a qualitative measure of the relative ease with which a groundwater body can potentially be contaminated by anthropogenic activities and includes both aquifer vulnerability and the relative importance of the aquifer in terms of its classification. Based on the classification above the dolomite highly susceptible to contamination.

6.3 AQUIFER CLASSIFICATION

Based on the aquifer classification map published by the DWS in August 2012 the aquifer classification system defines the dolomite in the Centurion area as a major aquifer region, which is a high-yielding system of good water quality.

7 POTENTIAL GROUNDWATER IMPACTS

Based on the results of the site investigations, groundwater abstraction for domestic and irrigation use, discharges from sewage systems, industrial waste spills / discharges, and herbicides and pesticides from farming activities, plus hydrocarbon pollution are all potential impacts to the local groundwater environment. With the addition of quarry mining activities, cumulative impacts include:

- drop in the local groundwater level and possible drying up of surrounding boreholes;
- deterioration of the current groundwater quality;
- the backfilled opencast will have a very high hydraulic conductivity, accelerating the movement of any plume in the area;
- changes in turbidity levels in groundwater due to quarry / backfill operations; and
- interruption of groundwater conduit flow paths by rock / clay removal.

These impacts are typical for mining operations and should be managed and mitigated where required. With mitigation measures in place, the significance of the potential impacts on the groundwater was Low.

Based on the constant discharge test data, the calculated radius of influence at the end of the constant discharge test was variable, and depended on aquifer parameters used:

- If an average T-value of 1000 m^2/d is used, with a Storativity value of 0.5, then the radius of influence at the end of the 24-hour pumping period was 67 m (FC-method calculator).

Transmissivity and S values obtained from test pumping can be particularly site specific and misleading (Bredenkamp 1995).

The closest production borehole to the Corobrik Midrand borehole is borehole Mid BH1, at Norcros SA (Figure 11). All production boreholes are thus far outside the potential radius of influence, of a production borehole at the Corobrik Midrand borehole.

The Olifantspruit, downstream from the Corobrik facility is also a sensitive receptor and must be monitored to ensure no water quality impacts. There are many factors that might influence the shape, depth and extent of the radius of influence.

There is unfortunately no groundwater monitoring site close to the Olifantspruit to assess if they are a losing stream, thus feeding the groundwater system, or a gaining stream – being recharged by groundwater baseflow. The stream will potentially serve as recharge mechanism to the underlying dolomitic aquifer and if polluted water flows in the stream it could have a negative impact on the water pumped from boreholes in the same system.

The response in the different boreholes will depend on the weathered and fractured nature of the dolomite and the fractured / open systems intercepted by each borehole and how interconnected the different dolomite and syenite systems are. The software used in the calculations assumes a homogeneous / uniform aquifer system, but in actual site conditions the radius of impact is usually drawn-out in the direction of a fractured / weathered zone orientation and less pronounced perpendicular to the strike.

The dolomite and associated aquifer units are complicated and heterogeneous. The radius of influence can be determined with more accuracy with long term monitoring data, that includes data recorded at nearby boreholes. The impact of groundwater flow barriers or recharge zones further complicates the flow calculations in these heterogenous systems.

Over utilization of boreholes in the area can negatively influence all water users, but also dolomite stability if not managed effectively. Drawdown of the water table must be considered as a potential triggering mechanism. With effective storm water and sewage management negative impacts on the local groundwater resources will be reduced to a minimum.

Based on the SANS241 drinking water guideline and the sampled groundwater quality results only Turbidity and Total Hardness were highlighted as possible chemicals of concern. The risk of groundwater contamination in the area is low with the local sewer system (only if leakage occurs), industrial discharges / spills and contaminated storm water runoff posing the greatest risk to the groundwater quality.

The following is concluded:

Table 7. Potential impacts summary

Potential impact	1. Contamination of the borehole water with seepage from local, private sewer systems, industrial discharges and contaminated storm water. 2. Poor water quality associated with leachate from material stockpiles, or the carbonaceous shale stockpile areas. 3. Over utilization of the aquifer system intercepted by the various boreholes, including the Corobrik Midrand borehole and the associated dolomite stability issues.
Mitigation	1. A surface and groundwater monitoring programme must be in place to monitor groundwater level and water qualities, to assess what impact the Corobrik Midrand has on the local aquifers and dolomite stability. The level data must be used to effectively manage water abstraction from boreholes and the quarries, plus other production boreholes in the area, on a monthly and seasonal basis. 2. Use a water purification system if the water is to be used for human consumption.

Cumulative impacts result from the incremental impact of the proposed activity on a common resource when added to the impacts of other past, present, or reasonably foreseeable future activities. Cumulative impacts can occur from the collective impacts of individual minor actions over a period and can include both direct and indirect impacts. Land use surrounding the Corobrik facility includes the Clayville / Olifantsfontein industrial zone to the south (upstream), with similar geological units.

The aquifers present neutral pH levels and most of the salt and metal concentrations are within SANS 241 Drinking Water Limits. E. coli and Nitrate levels are low / neglectable.

8 GROUNDWATER MANAGEMENT MEASURES

Groundwater management measures should be implemented to minimise impacts on the groundwater resource, but also infrastructure. Most of these form part of good house-keeping measures. The following objectives and targets are proposed for groundwater management in the area:

- Implement a water management plan aimed at reducing and/or eliminating adverse impacts on sensitive receptors in the area, as well as infrastructure.
- Implement monitoring procedures to measure the effectiveness of groundwater management and impacts on private boreholes and surface water resources.
- Groundwater level and water quality monitoring at:
  - Corobrik Midrand borehole;
  - Mid BH1 at Norcros SA;
  - VMBH1 at Vesuvius; and
  - Mid BH3 at Big Red Barn.
- Analyse the information obtained from all monitoring sites to establish groundwater level and water quality trends. Should the trends indicate negative impacts on groundwater levels and/or water quality, implement suitable measures within the shortest possible time to remediate and/or eliminate such impacts.
- Record groundwater levels, abstraction volumes and pumping timeframes.
- Ensure that drawdown is limited and does not exceed the capacity of the borehole.
- Ensure that sufficient information is available on all private boreholes around the Corobrik Midrand borehole (1 km radius) to quantify groundwater status.
- Ensure sufficient budget to implement and maintain the water monitoring programme.
- Develop effective surface runoff management plans to ensure that all dirty runoff is kept away from all production boreholes or sensitive surface water systems, and no ponding occurs on site.
- Review the groundwater flow and level data for all monitoring sites monthly to ensure effective and safe use of the resource.
- Use the monitoring data to define seasonal groundwater level and water quality trends for the area.

9 GROUNDWATER MONITORING

It is recommended to implement an initial groundwater monitoring programme as presented in this report. The key objectives of a Groundwater Monitoring Programme are to:

- Detect short and long-term groundwater level trends;
- Early detection of changes in groundwater quality and levels;
- Measure impacts and define mitigation options; and
- Improve / adjust the monitoring systems.

9.1 MONITORING LOCATIONS

The preliminary groundwater monitoring network is listed in Table 8. Additional, new monitoring boreholes are not recommended at this stage. If negative groundwater impacts are observed, then the monitoring programme must be expanded.

Table 8. Proposed groundwater monitoring positions

Borehole	Latitude (WGS84)	Longitude	Groundwater level	Groundwater quality
Corobrik Midrand BH	25°56'33.87"S	28°13'40.49"E	Yes	Quarterly
Mid BH1	25°56'41.45"S	28°13'37.72"E	Yes	Quarterly
Mid BH3	25°55'53.89"S	28°13'44.98"E	Yes	Quarterly
VMBH1	25°56'42.25"S	28°13'45.21"E	Yes	Quarterly

The spectrum of metals, salts and microbiology listed in Table 4 is recommended for the groundwater quality analysis.

9.2 MONITORING REQUIREMENTS

The monitoring requirements are presented in Table 8.

All monitoring information must be entered into a spreadsheet for record keeping and analysis. Regular monitoring reports must be prepared for internal use, as well as for submission to the authorities.

10 CONCLUSIONS AND RECOMMENDATION

Groundwater Abstract (Pty) Ltd (hereafter GWA) was appointed by Corobrik Midrand to assist with an assessment of the groundwater characteristics and provide recommendations regarding the use of one borehole on the Corobrik Midrand property.

Environmetal setting:

Corobrik Midrand is in an industrial area, with clusters of indigenous and alien vegetation to the west and north. Agricultural land, plus other quarrying and brick making activities are found to the east. The Corobrik Midrand site-topography is generally flat, with a gentle slope towards the Olifantspruit, with the surface elevation ranging from approximately 1500 mamsl (metres above mean sea level) along the southwestern corner of the property to 1460 mamsl in the northeast, near the M18 road.

The mean annual precipitation for quaternary catchment A21B is 672 millimetres (WR2012 database). The mean annual evaporation (S-pan evaporation) is 1700 mm (WR2012 database).

According to published geological maps (Geology Map 2528 Pretoria and M Holland, June 2009), the property is underlain by dolomite and chert of the Chuniespoort Group, Transvaal Supergroup, with syenite sills and dykes occurring in the area.

Regional syenite dykes and sills, together with the dolerite dykes compartmentalise the dolomitic areas. The Corobrik Midrand property is associated with the Doornkloof West dolomitic compartment – quarry and plant areas, as well as with the Sterkfontein West dolomitic compartment – southern section of the property, including the borehole locality. The Sterkfontein dyke forms the boundary between the two dolomitic compartments and thus crosses the property in an east-west direction. The Pretoria dyke is approximately 1 km towards the east.

The Corobrik Midrand property is in the A21B quaternary catchment, and forms part of the Limpopo Water Management Area. Locally, the study area is drained by the Olifantspruit, a tributary of the Hennops River. The Olifantspruit merges with the Hennops River near the Irene Country Club. Surface drainage in the Corobrik Midrand area (locally) flows in a westerly direction towards the Olifantspruit.

Hobbs (2004) estimate a recharge value of 11 to 14% for the A21B quaternary catchment. The A21B quaternary catchment covers an area of approximately 527 km^2 with a MAP of 556 mm. For the Steenkoppies compartment, which is part of the dolomites west of Tshwane, recharge was estimated as 15% of a mean annual rainfall of 630 mm. Recharge for the Pretoria/Rietvlei compartment was estimated as 17% of a mean annual rainfall of 682 mm (Bredenkamp, 1988).

Site assessments:

A hydrocensus was conducted across the Corobrik Midrand study area during February 2024. The survey included Corobrik Midrand and neighbouring properties and concentrated on identifying existing boreholes to enhance the knowledge of the groundwater systems and current groundwater use.

During the February 2024 hydrocensus 8 boreholes were identified (Table 3), with only 2 boreholes in a 1-kilometre radius from the Corobrik Midrand BH – borehole Mid BH1 and VMBH1 (Figure 11):

- Corobrik Midrand BH, Mid BH1 and VMBH1 appear to be in the same dolomitic compartment – Sterkfontein West dolomitic compartment. Borehole A2N0687 is possibly in the Sterkfontein East dolomitic compartment. The rest of the boreholes identified during the hydrocensus are in the Doornkloof West dolomitic compartment.
- Only 5 of the 8 boreholes are equipped and in use. The remaining boreholes are old, open boreholes, or used for monitoring purposes – historically used by the DWS as groundwater monitoring boreholes. The boreholes not in use are VMBH1, A2N0687 and G37838.
- Mid BH3 and Mid BH4 are at The Big Red Barn venue, and both are in use. Boreholes Mid BH3 and Mid BH4 are the only water supply source available to the landowner and are between 1.3 km and 1.8 km north of the Corobrik Midrand BH, but they appear to be in a different dolomitic compartment compared to the Corobrik Midrand BH.
- Borehole Mid BH5 is utilised by the Midstream residential area and is approximately 2.1 km northwest of the Corobrik Midrand BH. The borehole is located at the Midstream Indoor Sport Arena and is located behind the golf driving range, close to the Olifantspruit and appears to be in a different dolomitic compartment compared to the Corobrik Midrand BH.
- The Olifantspruit Wastewater Treatment Works (WWTW) is approximately 900 meters west (downstream) from the Corobrik Midrand BH. The WWTW has three monitoring boreholes, but they are potentially not in the same dolomitic compartment as the Corobrik Midrand BH. The exact borehole localities are not known.

The local groundwater level below surface varied between a maximum depth of 14.71 m bgl (borehole G37838), and a minimum of 2.23 m bgl for borehole A2N0687, just north of the Olifantsfontein Dolomite Mine (Table 3). If the groundwater levels are viewed as an elevation above sea level, then the highest groundwater elevations can be found at borehole Mid BH1 (1496.97 mamsl) (east of Corobrik). The Corobrik Midrand borehole plus the two neighbouring boreholes present the highest groundwater elevations, as measured during the 2024 hydrocensus. The lowest water table elevations are at borehole G37838 in the north (approximately 1458.46 mamsl). The localised scale the groundwater flow is towards the Olifantspruit (either west or northwest), but regionally it is in a northerly direction.

Three groundwater samples were collected during the Corobrik Midrand hydrocensus. The following conclusions were drawn in terms of the sampled water qualities:

- Aesthetic / Operational effects:
  - Total Hardness – an elevated total hardness level was measured for the Corobrik Midrand borehole (493 mg/L) and for the borehole at Big Red Barn Venue (528mg/L). Water hardness is influenced by the presence of calcium and magnesium salts.
  - Turbidity – The turbidity value exceeded the aesthetic / operational limits for the borehole at Norcros SA (borehole Mid BH1). The Turbidity value of 4.25 is above the aesthetic guideline limit of 1. The borehole is in use and fine material is possibly entering the borehole through the casing slots (if any) or from below the cased zone.

Based on the SANS241 drinking water guideline and on the sampled borehole water results, the water from the sampled sites is fit for human consumption, but treatment is recommended before use as domestic water. No health impact exceedances were noted, based on the health drinking water guideline limits.

Based on the DWS classification system the sampled water is categorized as:

- Corobrik Midrand BH – Class 2 water (water is unsuitable for use) due to the Total Hardness value. Thereafter, Class 1 (good quality) due to the Calcium and Nitrate concentrations. The rest of the parameters fall in the Class O range (ideal water quality range).
- Mid BH1 – Class 1 water (good quality) due to the Fluoride and Turbidity concentrations; and then Class 0 for the rest of the parameters.
- Mid BH3 – Class 2 water (water is unsuitable for use) due to the Total Hardness value. Thereafter, Class 1 due to the Calcium and Sulphate concentrations. The rest of the parameters fall in the Class O range (ideal water quality range).

Groundwater Abstract (Pty) Ltd was appointed by Corobrik Midrand to conduct the aquifer test on the Corobrik Midrand BH, to assess the aquifer response to pumping, plus to determine basic aquifer parameters. The aquifer testing was conducted from 26 April 2024.

Based on the drawdown characteristics and recovery data for this test, the borehole can safely yield the test rate of 102 312 L/hr (102.3 m^3/hr). The borehole has historically been used at a total volume of approximately 53 000 litres per day.

Considering Corobrik Midrand's total daily use of approximately 286 000 litres (sourced from the quarry dam, the 1 borehole and the municipal line), GWA recommends a safe abstraction rate of 7.0L/s

(25 200 L/hr, or 25.2 m^3/hr), with borehole abstraction limited to 12 hours of pumping per day. This is approximately a quarter of the maximum volume possible from the current borehole construction limitations. Please note that the borehole / aquifer can yield much more compared to the test rate of 102 312 L/hr (102.3 m^3/hr).

Detailed geological information is not available for the Corobrik Midrand borehole. GWA recommends that the pumping level is managed, and drawdown limited to 1 m, based on the outcome of the aquifer testing.

Potential impacts:

Based on the constant discharge test data for the Corobrik Midrand BH, the calculated radius of influence, at the end of the constant discharge test, was therefore variable, depending on aquifer parameters used:

- If an average T-value of 1000 m^2/d is used, with a Storativity value of 0.5, then the radius of influence at the end of the 24-hour pumping period was 67 m (FC-method calculator).

Several observation boreholes, at various distances from the pumping borehole would be required during an aquifer test to ensure a more accurate radius of influence calculation. Analytical calculations, with only the Corobrik Midrand borehole were used for the calculations, to get an estimate of the radius of influence, and to determine possible impacts associated with abstraction from the Corobrik Midrand borehole.

The closest boreholes to the Corobrik Midrand BH are Figure 11:

- borehole Mid BH1 approximately 250 m to the southwest (Plant and domestic use); and
- borehole VMBH1 approximately 290 m to the south (not in use – groundwater monitoring).

These boreholes are thus far outside the potential radius of influence of the Corobrik Midrand. Even though boreholes Mid BH1 and VMBH1 are outside the calculated zone of influence of the Corobrik Midrand, the radius of influence for borehole Mid BH1 might intercept that of the Corobrik Midrand borehole if used simultaneously.

GWA recommends that boreholes Mid BH1, VMBH1 and Mid BH3 serve as groundwater monitoring boreholes, to assess potential groundwater level impacts over time. Additional, new monitoring boreholes might be required in future based on the outcome of the groundwater monitoring program. The groundwater level in the Corobrik Midrand borehole must also be recorded over time to assess what impact the abstraction has on the local aquifer. A reading just before pump start and again just before pump stop will help to determine pumping efficiencies and impacts. Most effective way is with the use of a data logger in the borehole. Abstraction rates can then be adjusted over time and possibly even increase, if the data supports such a request.

The calculated radius of influence does not extend to the Olifantspruit. The stream will serve as recharge mechanism to the underlying dolomitic aquifer and if polluted water flows in the stream it could have a negative impact on the water pumped from boreholes in the same system.

Based on the results of the site investigations, groundwater abstraction for domestic and irrigation use, discharges from sewage systems, industrial waste spills / discharges, and herbicides and pesticides from farming activities, plus hydrocarbon pollution are all potential impacts to the local groundwater environment. With the addition of quarry mining activities, cumulative impacts include:

- drop in the local groundwater level and possible drying up of surrounding boreholes;
- deterioration of the current groundwater quality;
- the backfilled opencast will have a very high hydraulic conductivity, accelerating the movement of any plume in the area;
- changes in turbidity levels in groundwater due to quarry / backfill operations; and
- interruption of groundwater conduit flow paths by rock / clay removal.

These impacts are typical for mining operations and should be managed and mitigated where required. With mitigation measures in place, the significance of the potential impacts on the groundwater was Low.

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Appendix A

Consultant CV

Curriculum Vitae

Lucas Andries Smith (Pr. Sci.Nat)

Independent Hydrogeological Consultant

Principal Hydrogeologist

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QUALIFICATIONS

MSc Geohydrology, IGS (UFS) Bloemfontein, South Africa, 2003.

Baccalaureus Technology Geology, Technicon Pretoria, South Africa, 1997.

National Diploma Geotechnology, Technicon Pretoria, South Africa, 1992.

EMPLOYMENT HISTORY

Department of Water and Sanitation – 17 years.

ERM Consulting – 3.5 years.

Digby Wells Environmental – 5.5 years.

ASST Group – 12 months.

Current – Director, Groundwater Abstract Pty Ltd

FIELDS OF SPECIAL COMPETENCE

- Water use assessments (hydrocensus)
- Geophysical investigations
- Borehole drilling and rehabilitation studies
- Aquifer testing
- Community water supply and resource management
- Mine dewatering, water supply and management programmes
- Groundwater quality assessments
- Groundwater, catchment and impact assessments
- Design and management of water monitoring programmes
- Integrated Water and Waste Management Plans
- Water Use License Applications and compliance assessments
- Geochemistry assessments and waste classification
- Staff management
- Project management

SUMMARY OF COMPETENCIES

Lucas has 33 years of experience in the field of hydrogeology. Before moving to environmental consulting, he was a principal hydrogeologist at the Department of Water Affairs and Forestry (now Dept. Water and Sanitation) (South Africa) where he devoted 17 years to groundwater research and exploration programmes; rural water supply-, larger municipal water supply-, and government water supply schemes projects; artificial groundwater recharge projects; as well as borehole and aquifer development and remediation projects.

He executed and managed different hydrogeological projects, focussing on aspects such as community water supply programmes, geophysical investigations, characterisation of aquifers, pollution studies, in-stream flow requirements, hydraulic fracturing, dolomite and karst investigations and monitoring, chemical borehole rehabilitation (biofouling) and hydro-chemical analyses.

Over the past 16 years Lucas' environmental consulting experiences include the Southern African and Central- and West African mining sectors, as well as Energy sectors (Eskom and alternatives) where he manages groundwater and surface water resource evaluations and interaction, as well as conceptualising and quantification of groundwater flow/contaminant transport, ultimately for input to Environmental and Social Impact Assessments (ESIA), Environmental Management Programme reports (EMPr), Feasibility Studies and mine water management. Integrated water management is key to any business, mine, industry, or communities to ensure a sustainable resource for the environment and local communities to benefit from.

At Digby Wells Environmental Lucas was part of the EXCO committee; where he managed a team of 14 surface and groundwater specialists and several projects.

He served on the H&S Committee at ERM and Digby Wells where he also served as Chairperson for the H&S Committee for 1 year.

Lucas is a dedicated employee, husband and farther; and passionate about managing and protecting our natural resources and the environment.

RECENT RELEVANT PROJECT EXPERIENCE

During the 33 years in the Water Geosciences industry Lucas was involved in many projects where he served as team member on many field works and research programmes; he managed staff and various projects throughout Africa and even as far as Pakistan, and played a prominent role in being the overall Sponsor on projects, as well as acting as key client manager for clients like Sasol and Universal Coal.

A list of clients and projects over the last couple of years can be provided on request, but due to the extent of the experience it has been omitted from this CV.