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Corobrik Lawley Groundwater Assessment Report

17 December 2024

Groundwater Abstract (Pty) Ltd

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Rietfontein
Pretoria, 0084
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COROBRIK LAWLEY GROUNDWATER ASSESSMENT REPORT

Corobrik (Pty) Ltd

Report compiled by:

Groundwater Abstract Pty Ltd

Lucas Smith

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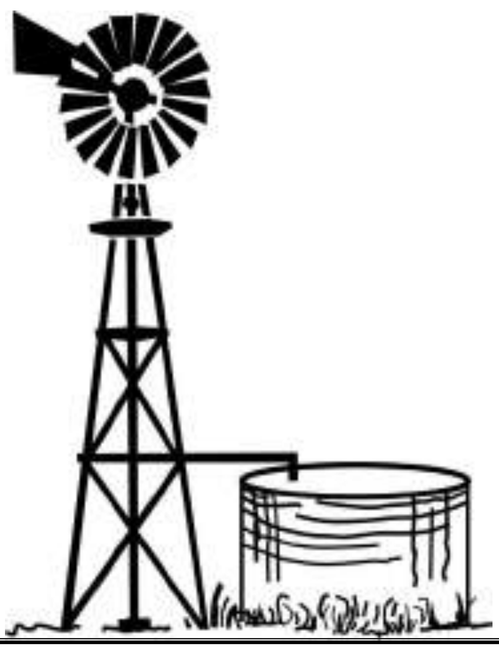

Declaration of Independence

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

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

Lawley Factory mines and processes various raw earth materials and is supported by run of mine stockpiles, offices, sewage treatment works, brick making plant and workshops. Quarrying operations are carried out on an annual basis for approximately four months a year, during the dry winter months.

The factory has a sewage treatment plant which handles waste from all site ablutions. Semi-purified water (effluent) from the treatment plant is discharged to the nearby wetland. This water is regularly tested. Non-degradable or digestible sewage sludge is disposed of at a licensed waste site, using a licensed waste management service provider.

The Lawley property is approximately 336 hectares (ha) in extent of which only 18 ha is quarried. In 2008 the life of the quarry operations was estimated at approximately 40 years.

Water sources at Corobrik Lawley are:

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

The following are key notes in terms of water used at Corobrik Lawley (CM Eclectic Pty Ltd):

- For dust suppression on the roads and in the quarry area – water from the quarries is used.
- There is one existing borehole which is used for the crushing plant, brick making plant / process, and for the domestic water requirements.

<u>Environmental setting:</u>

Corobrik Lawley is remotely located on the northern foot of the east-west striking quarzitic ridge. Agricultural land, plus other quarrying and brick making activities are found to the west. The Ennerdale Landfill Site is located along the eastern boundary of the Corobrik Lawley property. The Corobrik Lawley site-topography has a gentle slope towards the north.

The mean annual precipitation for quaternary catchment C22A is 695 mm according to the WR2012 database. The mean annual evaporation (S-pan evaporation) is 1650 mm (WR2012 database).

The Corobrik Lawley property is in the C22A quaternary catchment, and forms part of the Vaal Water Management Area (WMA 5). Locally, the study area is drained by a tributary of the Klip River. Surface drainage in the Corobrik Lawley area (locally) flows in an easterly direction.

According to published geological maps (Geology Map 2626 West Rand), the property is underlain by dolomite and chert of the Chuniespoort Group, Transvaal Supergroup, with formations of the Karoo, Transvaal and Ventersdorp Supergroups occurring in the area.

South of Corobrik Lawley, formations of the Pretoria Group outcrop, including ferruginous shale and quartzite of the Timeball Hill Formation, Hekpoort lavas, as well as shale outcrops of the Strubenkop and Silverton Formations.

Some Karoo sediments have remained as inliers above the dolomite, delineated as the Vryheid Formation.

The dolomite is divided into units or compartments, by intrusive dykes and other geological structures, which form barriers to the flow of groundwater. Based on the delineation of the compartments the Corobrik Lawley area is associated with the Gemsbokfontein dolomitic compartment.

The NGA database indicates that several groundwater (dolomite) monitoring boreholes are in the Corobrik Lawley area, in the Gemsbokfontein, Zuurbekom and Upper Klip River Compartments. Groundwater level data for 6 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 closest monitoring borehole to the Corobrik Lawley BH, is borehole C2N0849, located approximately 1.2 km northwest of the Corobrik Lawley BH, at the farmhouse. The rest of the DWS monitoring boreholes are to the north and the west, approximately 1.5 km to 6 km from the Corobrik Lawley BH.

The dolomite monitoring data / borehole information indicates:

- Based on the available data the rest groundwater levels are on a similar elevation, across the two dolomitic compartments – between the Gemsbokfontein compartment and the Zuurbekom compartment (borehole C2N0509). The elevation in the Zuurbekom compartment borehole (C2N0509) is 1556,71 mamsl (latest 2024 reading) versus the groundwater elevations in the Gemsbokfontein that varies between 1554.65 mamsl and 1557.26 mamsl.
- Based on the water level data in the 6 boreholes, they respond in a similar way over time, except for borehole C2N0331 located west of the Baragwanath Aerodrome, along the main dirt road.
- The groundwater level data for 5 of the 6 boreholes start on a high elevation in the 1986 / 1987 period, followed by a low in 1992, followed by another rise and peak in 2000 to 2002, another low during 2010, and then a sharp rise during 2022.

Site assessments:

A hydrocensus was conducted across the Corobrik Lawley study area during February 2024. The survey included Corobrik Lawley 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 12 boreholes were identified, with the closest borehole approximately 1-kilometre from the Corobrik Lawley BH – borehole Law1. This borehole is not in use and possibly collapsed. The closest production / private borehole is borehole Law2, at the Tolstoy Farm of Mahatma Gandhi Museum, approximately 1.4 km to the southwest.

Only 3 of the 12 boreholes are equipped and in use, including the Corobrik Lawley BH. The remaining boreholes are old, open boreholes, mostly used for monitoring purposes by the DWS.

Groundwater level measurements were possible from 9 of the 12 boreholes; the rest are blocked. The local groundwater level below surface varied between a maximum depth of 93.31 m bgl (borehole C2N0371), and a minimum of 23.70 m bgl for borehole Law2. If the groundwater levels are viewed as an elevation above sea level, then the highest groundwater elevations can be found at borehole Law3 (1654.09 mamsl). This private borehole along the foot of the east-west striking ridge, plus the neighbouring borehole at Tolstoy Farm of Mahatma Gandhi present the highest groundwater elevations, as measured during the 2024 hydrocensus. The lowest water table elevation is at borehole C2N0849 in the north (approximately 1555.69 mamsl).

The correlation between topography and groundwater elevation is very good (approximately 94%). 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.

Thus, on a localised scale the groundwater flow is towards the north. The 12 boreholes identified are in 2 different dolomitic compartments, i.e., Gemsbokfontein and Zuurbekom. The groundwater elevations appear to be similar across the two dolomitic compartments.

Three groundwater samples were collected during the Corobrik Lawley hydrocensus. The water sampled from the three boreholes is of acceptable quality, based on the parameters used in the laboratory analysis. No health impact exceedances were noted, based on the health drinking water guideline limits. The following conclusions were drawn:

- Aesthetic / Operational effects:
    - Iron – An elevated iron concentration (exceeding the chronic health limits) was recorded for borehole C2N0849 (0.84 mg/L), with the SANS limit set at 0.3 mg/L. Borehole C2N0849 is downstream from Corobrik Lawley, near the farmhouse. The borehole is open, and the sampled water was very dirty. The total iron concentrations were below the detection limit for the other two sampled sites.
    - Manganese – Borehole C2N0849 measured a manganese concentration above the operational limit (0.36 mg/L). The operational limit is set at 0.1 mg/L and the health impact limit is set at 0.4 mg/L. The manganese concentration could be related to the local Karoo and dolomite geology. The manganese concentrations were below detection limit or the SANS aesthetic limit for the other two sampled sites.
    - Ammonium – The ammonium concentration for borehole C2N0849 exceeds the aesthetic limits for drinking water (49.9 mg/L) with the aesthetic limit set at 1.5 mg/L.
    - Total Hardness – an elevated total hardness level was measured for boreholes C2N0849 and C2N0509 (298 and 257 mg/L respectively). Water hardness is influenced by the presence of calcium and magnesium salts.
    - Turbidity – The turbidity value exceeded the aesthetic / operational limits for boreholes C2N0849 and C2N0509 (125 and 15.5 mg/L respectively). The Turbidity value guideline limit is 1. Both boreholes are open and not in use and silt and organic matter was possibly disturbed during the sampling.

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

- Corobrik Lawley BH – Class 0 water (water of ideal quality).
- Borehole C2N0509 – Class 3 water (water is unsuitable for use) due to the Turbidity; and then Class 1 (water of good quality) due to the Total Hardness.

- Borehole C2N0849 – Class 3 water (water is unsuitable for use) due to the Turbidity value and Ammonium concentration. Thereafter, Class 1 due to the Iron and Manganese concentrations and Total Hardness.

Groundwater Abstract (Pty) Ltd was appointed by Corobrik Lawley to conduct an aquifer test on the Corobrik Lawley BH, to assess the aquifer response to pumping, plus to determine basic aquifer parameters. The aquifer testing was conducted from 28 November 2024.

The step test data indicates that the borehole can yield much more water compared to the selected constant abstraction rate (18 684 L/hr). Borehole diameter and pump limitations defined the maximum pumping rate.

Based on the drawdown characteristics and recovery data for this test, the borehole can safely yield the test rate of 18 684 L/hr (18.68 m^3/hr). The borehole has historically been used at a total volume of approximately 12 000 litres per hour (143 408 L/day) (CM Eclectic Pty Ltd, June 2024).

GWA recommends an abstraction rate of 18 684 L/hr (18.68 m^3/hr), with borehole abstraction limited to 12 hours of pumping per day. Based on the aquifer test data assessment the borehole can safely yield 27.11 m^3/hr (650.59 m^3/day), but the abstraction of this volume is limited by the casing diameter. The calculations indicate that the borehole has a possible maximum yield of 151.8 m^3/hr (3642 m^3/day), but this could not be accurately determined due to the casing diameter limitations. The current use and recommended safe abstraction rate are approximately a tenth of the maximum volume determined.

Based on the constant discharge test data for the Corobrik Lawley 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 494 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 47 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.

The closest boreholes to the Corobrik Lawley BH are:

- borehole Law 2 approximately 1.3 km to the southwest (Garden and domestic use); and
- borehole Law 3 approximately 2.1 km to the southwest (Garden and domestic use);
- borehole C2N0849 approximately 1.1 km to the northwest (not in use – groundwater monitoring).

These boreholes are thus far outside the potential radius of influence of the Corobrik Lawley borehole.

Potential impacts:

Based on the results of the site investigations, groundwater abstraction, discharges from sewage systems, discharges from landfill site, industrial waste spills / discharges, and herbicides and pesticides from farming activities, plus hydrocarbon pollution are all potential impacts to the local groundwater environment. 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.

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 494 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 47 m (FC-method calculator).

The closest production borehole to the Corobrik Lawley borehole is borehole Law 2, at Tolstoy Farm of Mahatma Gandhi Museum, 1.3 km away. All production boreholes are thus outside the potential radius of influence, of a production borehole at the Corobrik Lawley borehole.

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, landfill site discharge and contaminated storm water runoff posing the greatest risk to the groundwater quality.

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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 markets.

Corobrik operates factories around South Africa, of which Corobrik Lawley is one of them. The Corobrik Lawley Factory is one of several properties of Corobrik (Pty) Ltd. It is an established quarrying and brick manufacturing operation that has been in operation since the early 1940's while the current factory has been in operation since 1981. The Corobrik Lawley Factory operations are situated on Portion 1 and 2 of the Farm Syferfontein 293 IQ, Portion 88 of the Farm Roodepoort 302 IQ and the Remaining Extent of Portion 47 (a Portion of Portion 2) of the Farm Roodepoort 302 IQ.

Corobrik Lawley is situated along Walter Road, approximately 3 kilometres (km) southwest of Lenasia and approximately 7 km west of the N1 national road (Figure 1). Corobrik Lawley is between Lenasia and Lenasia South area, with Ennerdale approximately 5 km to the south. Corobrik Lawley is within the borders of Johannesburg Metropolitan Municipality, Gauteng Province.

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 Lawley to assist with an assessment of the groundwater characteristics and provide recommendations regarding the use of one borehole on the Corobrik Lawley property. This document presents the geological and hydrogeological conditions associated with the Corobrik Lawley area and focusses on:

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

1.1 GROUNDWATER STUDY OBJECTIVES

The groundwater assessment will focus on the following objectives:

- Define the aquifers underlying the Corobrik Lawley 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 Lawley 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.

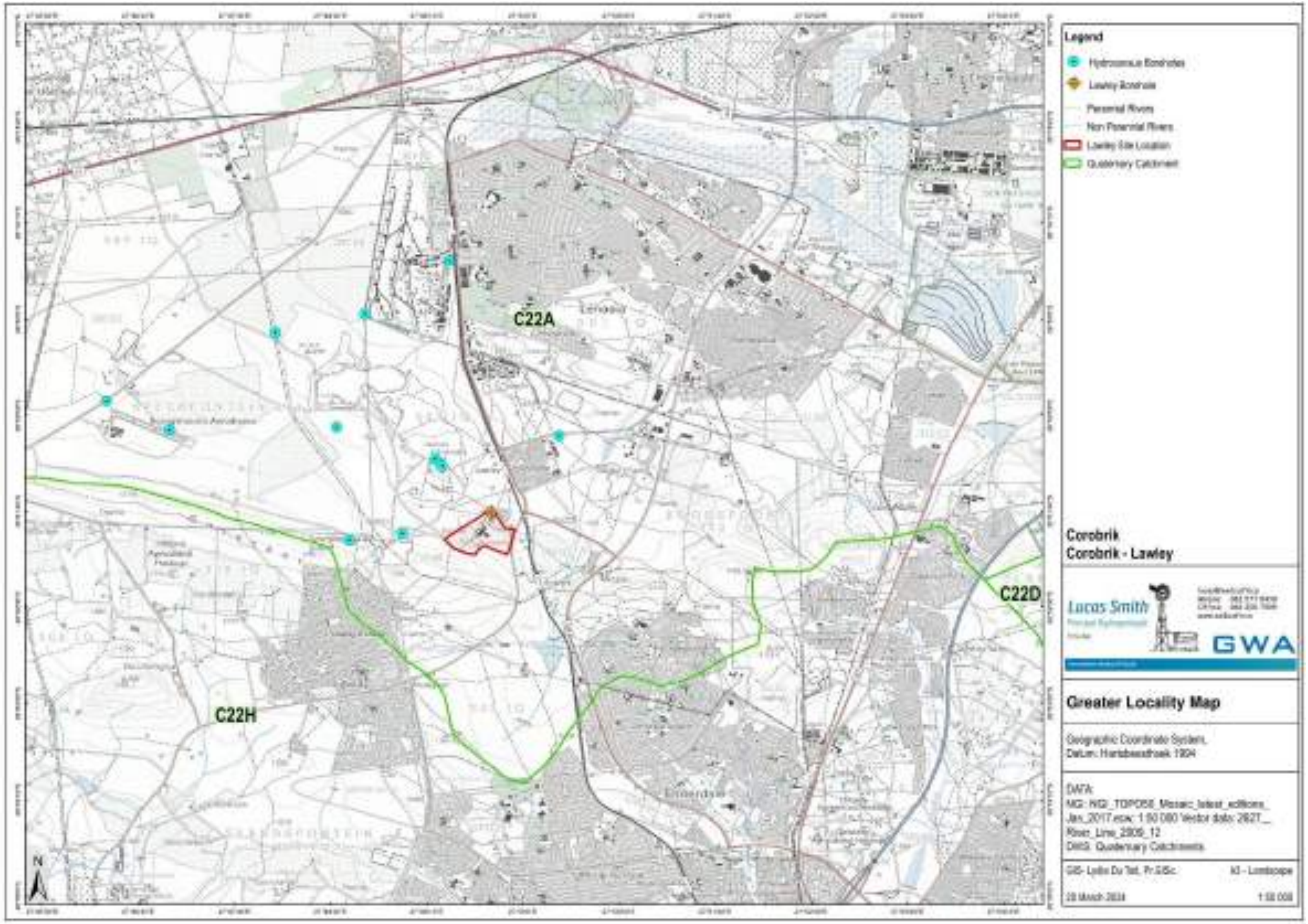

Figure 1. Greater locality map

1.3 Groundwater Assessment Team

The following hydrogeologist is involved in the Corobrik Lawley 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 Lawley.
- 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.
- Appendix B: Water Laboratory Certificates.

2 Corobrik Lawley

The following site description and infrastructure definition was taken from:

- ***North Arrow Consulting and Advisory Services (Pty) Ltd report dated 15 November 2017 (Baseline Geohydrology Assessment Report for Corobrik (Pty) Ltd, Lawley Extension 1 Quarry and Factory Operation located near Johannesburg, Gauteng Province).***
- ***CM Eclectic (Pty) Limited, June 2024. Corobrik Lawley Factory Site-Wide Water Balance Report.***

A description of the extent of the operation, mining method, project life and infrastructure requirements are given below.

2.1 Site Process Description Summary

Lawley Factory mines and processes various raw earth materials and is supported by run of mine stockpiles, offices, sewage treatment works, brick making plant and workshops. Clay is bench mined by a back-actor from the six quarries belonging to the Lawley operations and transported to stockpiles on site. Current quarrying operations are carried out on an annual basis for approximately four months a year, during the dry winter months. Rehabilitation of the worked-out sections of the quarries is carried out concurrently during the quarrying period by a mining contractor. The quarries are mined for Henly, Redshale, Smactite, Sandy Kaolin, Red Kaolin and Topface clays, and have been named Quarry 1 up to Quarry 6 (refer to Figure 2).

Figure 2. Lawley borehole and quarry localities

The clays are drawn by front end loader from the different stockpiles and pre-blended by volume before being fed into the brick making plant. The pre-blended clays pass through crushers all along the mechanical preparation process, further mixing, and enhancement of the mix takes place. The brick making process also involves the use of coal dust, which is mixed with the clayey soils. Water is added to the material when it passes through the mixers 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 and proceed to a tunnel dryer for final controlled drying to the desired moisture content. The bricks are then fired in the tunnel kilns. Before the bricks are packed, they pass through a de-hacking process, where they are dipped into water at the dipping station. Once dipped, the bricks are carried by forklift, to the stock bins, ready for dispatch to the customers.

2.2 Mining Method

The mining operation consists of opencast quarrying involving load and haul operations using an excavator and trucks. No blasting activity takes place at the Corobrik Lawley as the clay is soft enough to allow for free dig. The depth of quarrying is approximately 20 meters (m) below surface. The raw materials are selectively extracted from benches from the quarries by excavator. The clays are loaded onto dump trucks and transported to a prepared stockpiling area at the factory site where the materials are layered into ROM stockpiles in a controlled manner for later use in brick manufacturing.

Quarrying operations are carried out on an annual basis for approximately 4 months a year during the dry winter months. The duration of the mining period varies from between 3 to 6 months depending on the raw material volumes required for the annual clay brick production of the following calendar year. Rehabilitation of the worked-out sections of the quarries is carried out concurrently with the quarrying operations. This entails the separate stripping of topsoil and subsoil (overburden) from the intended mining area, reprofiling (shaping) of worked-out quarry slopes, backfilling of stripped subsoil into the reprofiled areas, spreading of stripped seed-bearing topsoil over reprofiled and backfilled areas (prepared areas) and profiling (smoothing) of placed topsoil. Waste/spoil brick from the factory is also used as rehabilitation material.

2.3 Project Life Description

The factory produces approximately 70 million bricks per year. In 2008 the life of the quarry operations was estimated at approximately 40 years.

The Lawley property is approximately 336 hectares (ha) in extent of which only 18 ha is quarried.

2.4 Site Infrastructure

The north- and eastern sections of the Corobrik Lawley property are adjacent to the Lenasia Drive/Johannesburg-Vereeniging Railway Line. An informal settlement is situated to the east. A small industrial establishment (Anchorville) is situated to the north.

The operations include:

- Brick-making factory (with associated infrastructure for brick-manufacturing by means of a gas-fired kilns);
- Clay ROM and coal stockpiles areas;
- 6 quarries;
- Brick laydown areas; and
- Haul roads and other disturbed areas.

2.4.1 Workshops, Administration and Other Buildings

The buildings on the site consist of:

- Truck weighbridge;
- Administration office block;
- Security complex;
- Tuckshop;
- Ablutions;
- Mechanical and engineering workshops;
- Substations;
- Vehicle wash bay;
- Sewage plant; and
- Old hostel accommodation blocks.

2.4.2 Brickmaking Factory and Crushing Plant

The tertiary crushing plant receives ROM material from a stockpile for crushing and grinding to the right level of clay consistency and moisture content before it enters the brick making process in the factory consisting of brick forming machines, kilns (to fire/burn the bricks to the required temperature) and to the drying, strip batching and Potassium Carbonate (K_2CO_3) dipping tank sections. Water used in the factory is obtained from a reservoir fed from one borehole on the property (Lawley BH). In the entire process, very little water is used in the brick-making process other than the introduction of moisture into the ROM stockpile (with 11% moisture content) to raise it up to 19% moisture content between the primary and secondary mixture sections. All this moisture is removed as part of the brick burning process. In essence, the factory does not produce residue water, except for reject paste which is recycled back to the brick making process or disposed to the quarry to form part of the rehabilitation together with reject bricks.

2.4.3 Solid Waste Management Facilities

Industrial waste disposal

There is no industrial waste produced on site as part of the quarrying, nor brick-manufacturing processes. Only waste bricks are produced which are backfilled into the worked-out sections of the quarries as part of the rehabilitation process.

Domestic Waste

Domestic waste is disposed of in terms of the applicable environmental standards, meaning there is no disposal of domestic waste on site.

Main Residue Disposal Facilities

The quarries produce an operational residue namely overburden waste soil/rock. No tailings or slimes are produced. Approximately 1039 tons per month of 28CV coal (lignite) is imported from Witbank to be blended with the clay to assist in the brick-firing process.

Waste Rock Dumps

Overburden waste rock dumps are created next to the quarries during mining and are used to backfill the pits as part of operational rehabilitation. These dumps consist of inert rock material.

2.4.4 Water Management Facilities

2.4.4.1 Sewage Treatment Plant

The factory has a sewage treatment plant which handles waste from all site ablutions. The biological treatment process is fully automated, which greatly simplifies the plant operational control and reduces the total operating costs. The comprises of a septic tank (removes and decomposes settleable solids), two rotating bio disc units (remove the residual organic matter), a humus tank (settles solids) and a chlorine contact channel (disinfection of harmful bacteria).

Semi-purified water (effluent) from the treatment plant is discharged to the nearby wetland. This water is regularly tested. Non-degradable or digestible sewage sludge is disposed of at a licensed waste site, using a licensed waste management service provider.

2.4.4.2 Storm Water Drainage and Handling

Because of precipitation, the resultant surface water run-off around the site is collected through the appropriate design of roads, pavements and construction of berms to direct water to the nearby wetland/stream.

2.5 Water Circuit

Water sources at Corobrik Lawley are:

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

Water losses are through the following:

- Water evaporation from the quarry dams 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 sewer system.

The following are key notes in terms of water used at Corobrik Lawley (CM Eclectic Pty Ltd):

- For dust suppression on the roads and in the quarry area – water from the quarries is used.
- There is one existing borehole which is used for the crushing plant, brick making plant / process, and for the domestic water requirements.

3 Environmental Setting

Corobrik Lawley is remotely located on the northern foot of the east-west striking quarzitic ridge, with clusters of indigenous and alien vegetation scattered across the area. Agricultural land, plus other quarrying and brick making activities are found to the west. The Ennerdale Landfill Site is located along the eastern boundary of the Corobrik Lawley property. The Corobrik Lawley site-topography has a gentle slope towards the north, with the surface elevation ranging from approximately 1629 mamsl (metres above mean sea level) in the Corobrik Lawley Plant area, to 1615 mamsl in the north, near the Quarries 2, 3 and 4 (Figure 2).

3.1 Climate

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.

The climate is considered warm and temperate. According to the Köppen-Geiger classification, the prevailing climate in this region is categorized as Cwb. The average annual temperature is 16.1°C in Lenasia. Annually, approximately 794 millimetres (mm) of precipitation is received (Figure 3) (www.en.climate-data.org).

With an average of 19.9°C, December and January are the warmest months (Table 1). July is the coldest month, with temperatures averaging 9.6°C (www.en.climate-data.org).

The mean annual precipitation (MAP) for quaternary catchment C22A is 695 mm according to the WR2012 database. The mean annual evaporation (MAE) (S-pan evaporation) is 1650 mm (WR2012 database).

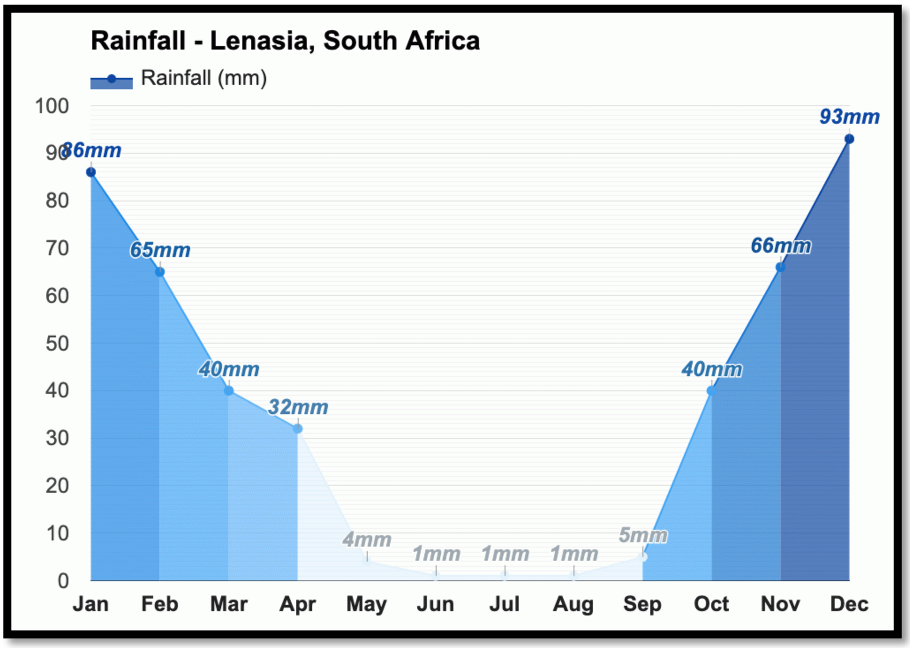

Figure 3. Average precipitation for the Lenasia area (www.weather-atlas.com)

Table 1. Average precipitation data for Irene (www.en.climate-data.org)

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Avg. Temp (°C)	19.9	19.6	18.3	15.6	12.7	9.9	9.6	12.9	16.7	18.6	19.1	19.9
Precipitation (mm)	138	123	97	47	20	8	4	10	22	76	102	147

3.2 GEOLOGY

According to published geological maps (Geology Map 2626 West Rand), the property is underlain by dolomite and chert of the Chuniespoort Group, Transvaal Supergroup, with formations of the Karoo, Transvaal and Ventersdorp Supergroups occurring in the area (Figure 4).

The units of the Transvaal Supergroup include the Pretoria Group and the Chuniespoort Group. The Transvaal Supergroup comprise mainly shale, quartzite, banded ironstone, tillite and intercalated lava flows. The Transvaal Supergroup overlies the Ventersdorp Supergroup, with the Ventersdorp formations consisting mainly andesitic lavas and related volcanic pyroclastics. The Ventersdorp formations are found in the Soweto area.

The Transvaal Supergroup, Chuniespoort Group formations are of specific interest to this study. The Black Reef quartzite, which is present at the base of the Transvaal Supergroup, outcrops north of the project area, north of the N12 national road. Of the Transvaal Supergroup Formations, the Chuniespoort Group are of most significance, as the Lawley quarries are located on Malmani dolomite. The dolomite varies in thickness regionally from around 200 m to 1500 m.

According to Parsons (1991), the two lower formations of the Malmani Subgroup is present in this area, namely the Oaktree and Monte Christo Formations. The Oaktree Formation consists of chert-poor homogenous dark-grey dolomite with interbeds of shale and numerous columnar stromatolites. The Oaktree Formation is conformably overlain on the Black Reef Formation with a transitional zone of carbonaceous, calcareous, argillaceous and arenaceous sediments. The Monte Christo Formation lies conformably on the Oaktree Formation and consists of alternating chert-rich and chert-poor dolomite. This formation consists of interlayered crystalline coarse-grained dolomite, calcareous shale and fine-grained white dolomite.

The dolomite forms a significant aquifer regionally. Dissolution of the dolomite encourages deep zones of weathering. The residues of the weathering are present as brown clays and wad, chert rubble and boulders. The depth of weathering can vary significantly with pinnacles of fresh dolomite often adjacent to deeply weathered zones. The depth of weathering is controlled by the presence of fractures and fissures in the dolomite along which water can infiltrate. In addition, cavities often form in fresh, unweathered dolomite where dissolution has taken place along faults and fractures to depth. These cavities can be filled with water, which provides hydrostatic pressure and keeps the cavities stable. If the cavities are dewatered, the stability is removed and the probability of sinkhole development increases. Information indicates that the base of the weathered dolomites is highly irregular, with an average depth of 200 m (Jones and Wagener, 2013).

South of Corobrik Lawley, formations of the Pretoria Group outcrop, including ferruginous shale and quartzite of the Timeball Hill Formation, Hekpoort lavas, as well as shale outcrops of the Strubenkop and Silverton Formations.

Some Karoo sediments have remained as inliers above the dolomite, delineated as the Vryheid Formation in Figure 4.

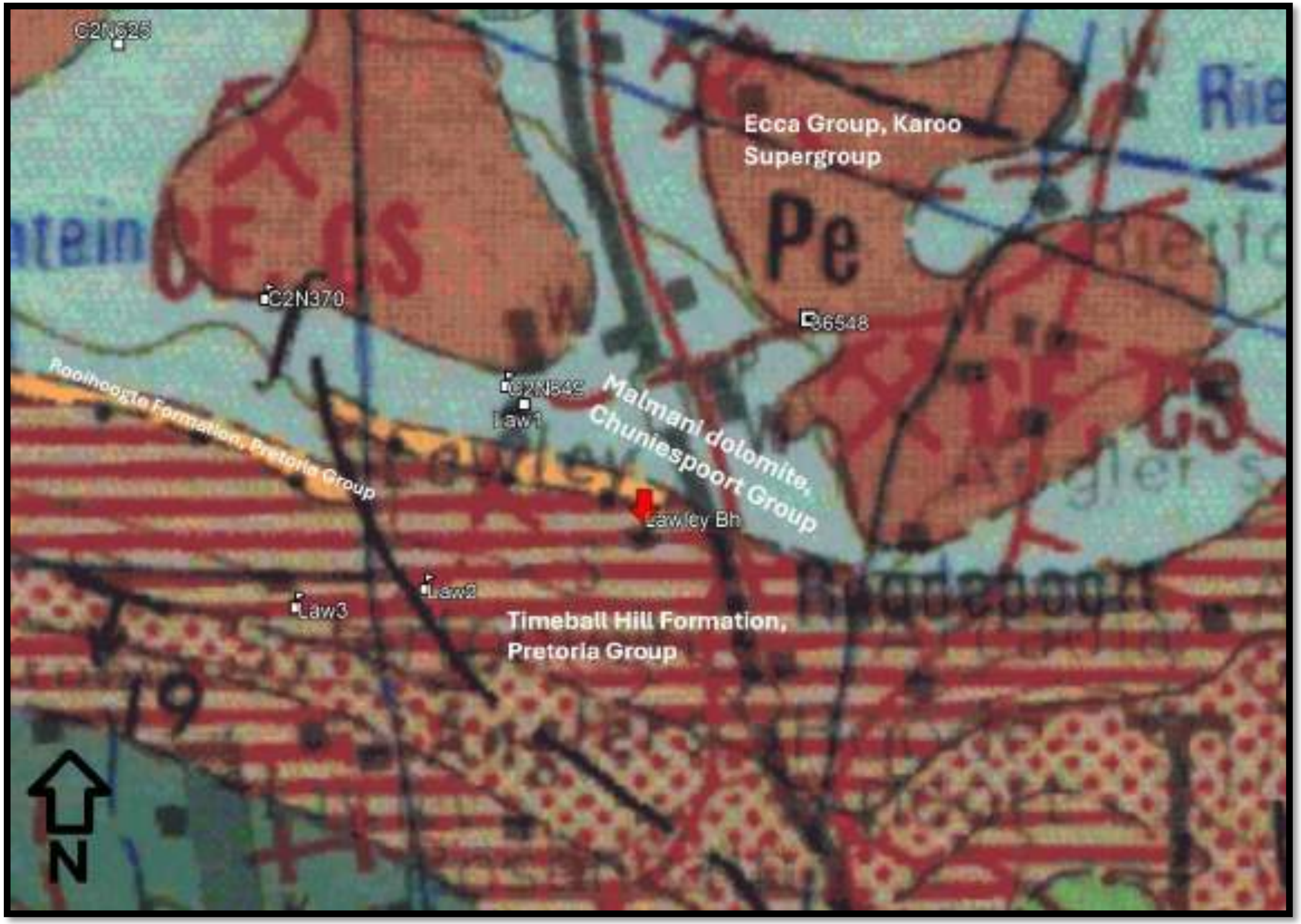

Figure 4. Geology map (2626 West Rand)

3.2.1 Structural Geology

The structural geology forms an important component of the hydrogeological setting of the project and is complex in this region. The information presented here is based on work completed by Dr Marius van Biljon (Jones & Wagnener, 2013).

The structural geology governs aquifer development and regional groundwater flow patterns. The region is characterised by several folds. This structure affects the deeper geological setting and the underground mining areas and is distorted by several north-south trending folds. The result is a regional geological structure interpreted as domes and cusps (basins). Within the dome structures, prominently deeply weathered grykes form from the dolomite surface. A gryke is a deep narrow slot filled with dolomite wad. Dolomitic aquifers are also typically formed within the dome structures. The cusp structures for the most efficient groundwater conduits at the intersections of the synclinal fold axes. Some of the cusp structures resulted in post-Transvaal age faults, which are younger in geological age than the dolomite.

In addition to the regional post-Transvaal faults, regional diabase (dolerite) dykes have intruded into some of the north-easterly striking faults. Many of these faults penetrated the full Transvaal sequence as well as the underlying Ventersdorp and Witwatersrand Supergroups. These dykes have subdivided the dolomite in watertight compartments. A number of these dolomitic compartments are present in the project area, including the Gemsbokfontein, Zuurbekom and Upper Klip River compartments.

Corobrik Lawley is in the eastern section of the Gemsbokfontein Compartment. The eastern boundary of the Gemsbokfontein Compartment is formed by the Klip River Dyke, located near the eastern boundary of the Corobrik Lawley property, near Walter Road. The northern boundary is formed by the Panvlakte Dyke, which transects the southern section of the military base on the outskirts of Lenasia.

Prior to mining, groundwater levels in the dolomitic compartments varied due to the impermeable nature of the compartment forming dykes. Mining activities have however punctured these dykes in places.

3.3 Surface Drainage

The Corobrik Lawley property is in the C22A quaternary catchment, and forms part of the Vaal Water Management Area (WMA 5) (Figure 1). Locally, the study area is drained by a tributary of the Klip River. Surface drainage in the Corobrik Lawley area (locally) flows in an easterly direction.

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 C22A quaternary catchment covers an area of approximately 548 km^2 and includes most of the Johannesburg CBD, Florida, Soweto and Lenasia 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.

The dolomitic (karst) aquifer is considered the most significant in the project area. The following is a summary of the main geological units and 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. 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 diabase dykes;
- Weathered and fractured diabase dykes; and
- Basins of deep weathering in the sandstone and shale.

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 (milli-Siemens per meter).

4.2 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 the Corobrik Lawley area is associated with the Gemsbokfontein dolomitic compartment. 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 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.

4.3 Groundwater Levels – Dolomite Monitoring Stations

Groundwater in the dolomite 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 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).

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 Lawley area. The NGA database indicates that several groundwater (dolomite) monitoring boreholes are in the Corobrik Lawley area, in the Gemsbokfontein, Zuurbekom and Upper Klip River Compartments. Groundwater level data for 6 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 monitoring data presented in Figure 5 to Figure 10 presents groundwater level responses across three different dolomitic compartments in the Corobrik Lawley area, i.e.:

- Borehole C2N0509 – Zuurbekom dolomitic compartment;
- Borehole C2N0331 – Gemsbokfontein dolomitic compartment;
- Borehole C2N0370 – Gemsbokfontein dolomitic compartment;
- Borehole C2N0371 – Gemsbokfontein dolomitic compartment;
- Borehole C2N0625 – Gemsbokfontein dolomitic compartment; and
- Borehole C2N0849 – Gemsbokfontein dolomitic compartment.

The closest monitoring borehole to the Corobrik Lawley BH, is borehole C2N0849 (Figure 11), located approximately 1.2 km northwest of the Corobrik Lawley BH, at the farmhouse. The rest of the DWS monitoring boreholes are to the north and the west, approximately 1.5 km to 6 km from the Corobrik Lawley BH.

The dolomite monitoring data / borehole information presented in Figure 5 to Figure 10 indicates:

- Based on the available data the rest groundwater levels are on a similar elevation, across the two dolomitic compartments – between the Gemsbokfontein compartment and the Zuurbekom compartment (borehole C2N0509). The elevation in the Zuurbekom compartment borehole (C2N0509) is 1556,71 mamsl (latest 2024 reading) versus the groundwater elevations in the Gemsbokfontein that varies between 1554.65 mamsl and 1557.26 mamsl.
    - C2N0509 1556,71 mamsl
    - C2N0331 1557,26 mamsl
    - C2N0370 1556,18 mamsl
    - C2N0371 1555,50 mamsl
    - C2N0625 1554,65 mamsl
    - C2N0849 1555,21 mamsl
- The 6 dolomite monitoring boreholes have long-term water level data and indicate a water table depth between 28.29 m and 93.5 metres below surface. The 6 boreholes are in 2 different dolomitic compartments and at different elevations above sea level.
    - Considering a water level below surface:
        - C2N0509 – 28,29 m below surface
        - C2N0331 – 85.74 m below surface
        - C2N0370 – 74.82 m below surface
        - C2N0371 – 93.5 m below surface
        - C2N0625 – 55.35 m below surface
        - C2N0849 – 68.79 m below surface

- With the long-term monitoring data, plus the recent levels, it is not possible to identify dewatering impacts. Based on the water level data in the 6 boreholes (Figure 5 to Figure 10), they respond in a similar way over time, except for borehole C2N0331 located west of the Baragwanath Aerodrome, along the main dirt road (see Figure 6).
- The groundwater level data for 5 of the 6 boreholes start on a high elevation in the 1986 / 1987 period, followed by a low in 1992, followed by another rise and peak in 2000 to 2002, another low during 2010, and then a sharp rise during 2022.
- The most significant step in the water levels, in the 6 boreholes was over the period 1992 to 2001, where the levels rose by:
  - C2N0509 6.45 m
  - C2N0331 no response
  - C2N0370 7.43 m
  - C2N0371 13.6 m
  - C2N0625 7.69 m
  - C2N0849 7.62 m
- 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.

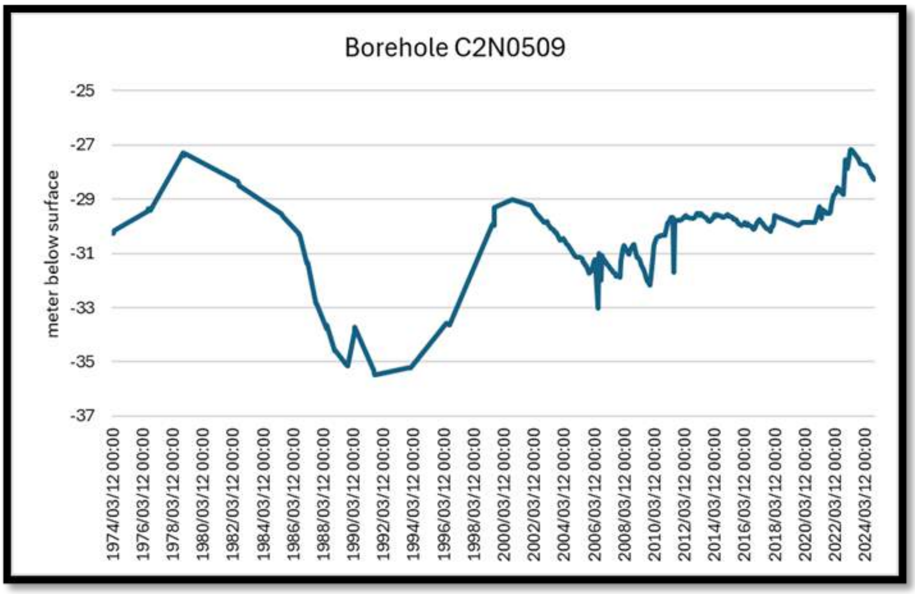

Figure 5. Time series groundwater levels – borehole C2N0509 (Zuurbekom)

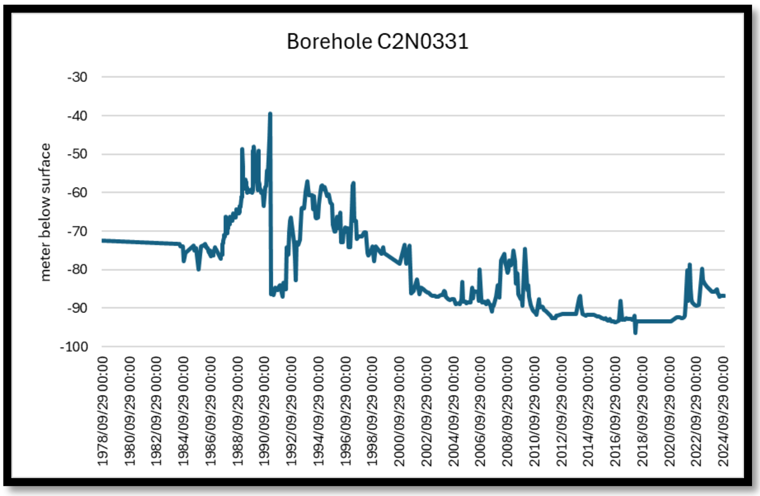

Figure 6. Time series groundwater levels – borehole C2N0331 (Gemsbokfontein)

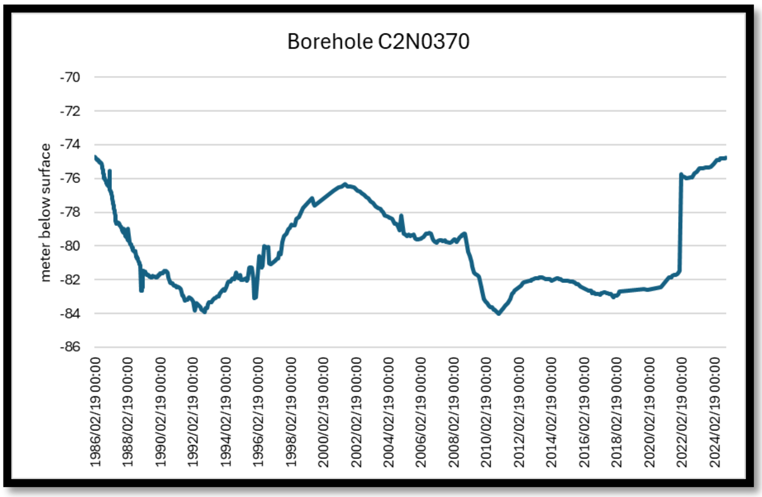

Figure 7. Time series groundwater levels – borehole C2N0370 (Gemsbokfontein)

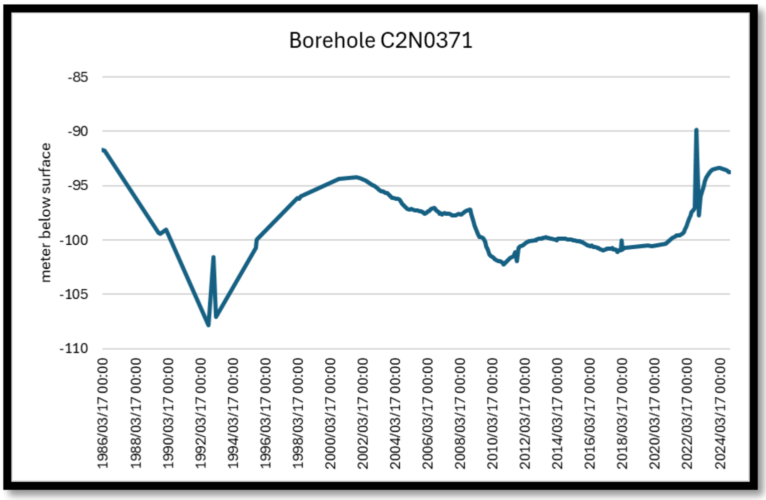

Figure 8. Time series groundwater levels – borehole C2N0371 (Gemsbokfontein)

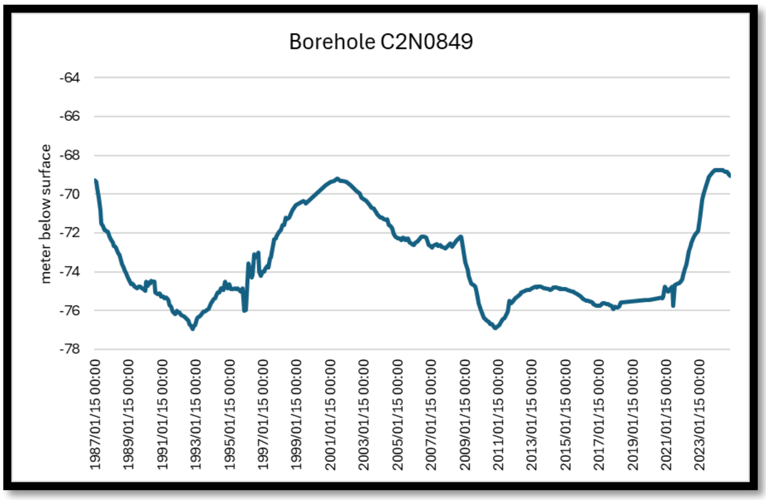

Figure 9. Time series groundwater levels – borehole C2N0849 (Gemsbokfontein)

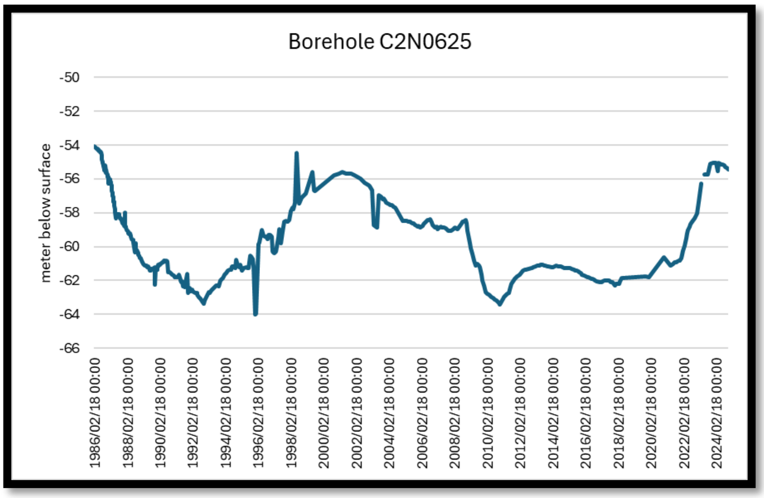

Figure 10. Time series groundwater levels – borehole C2N0625 (Gemsbokfontein)

4.4 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 vary between 7% and 15% of the mean annual precipitation. Hobbs (2004) estimate a recharge value of 11 to 14% for the dolomite in the Tshwane area.

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 recharge was estimated as 15% of a mean annual rainfall.

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. Recharge from leaking sewer systems unfortunately contributes to aquifer contamination impacts.

4.5 Groundwater Quality

Hobbs (2004) described the groundwater quality of the dolomitic aquifers 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 Lawley study area during February 2024. The survey included Corobrik Lawley and neighbouring properties and concentrated on identifying existing boreholes to enhance the knowledge of the groundwater systems and current groundwater use.

Corobrik Lawley is on the northern foot of the east-west striking quarzitic ridge, with agricultural land and other quarrying and brick making activities to the west. The Ennerdale Landfill Site is located along the eastern boundary of the Corobrik Lawley property. Corobrik Lawley is situated approximately 3 km southwest of Lenasia and approximately 7 km west of the N1 national road (Figure 1). Corobrik Lawley is between Lenasia and Lenasia South area, with Ennerdale approximately 5 km to the south. Most of the greater area has access to municipal connections.

A tributary of the Klip River is approximately 1.5 km to the east.

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 2. All coordinates were taken with a hand-held Garmin GPS (Global Positioning System) (WGS84).

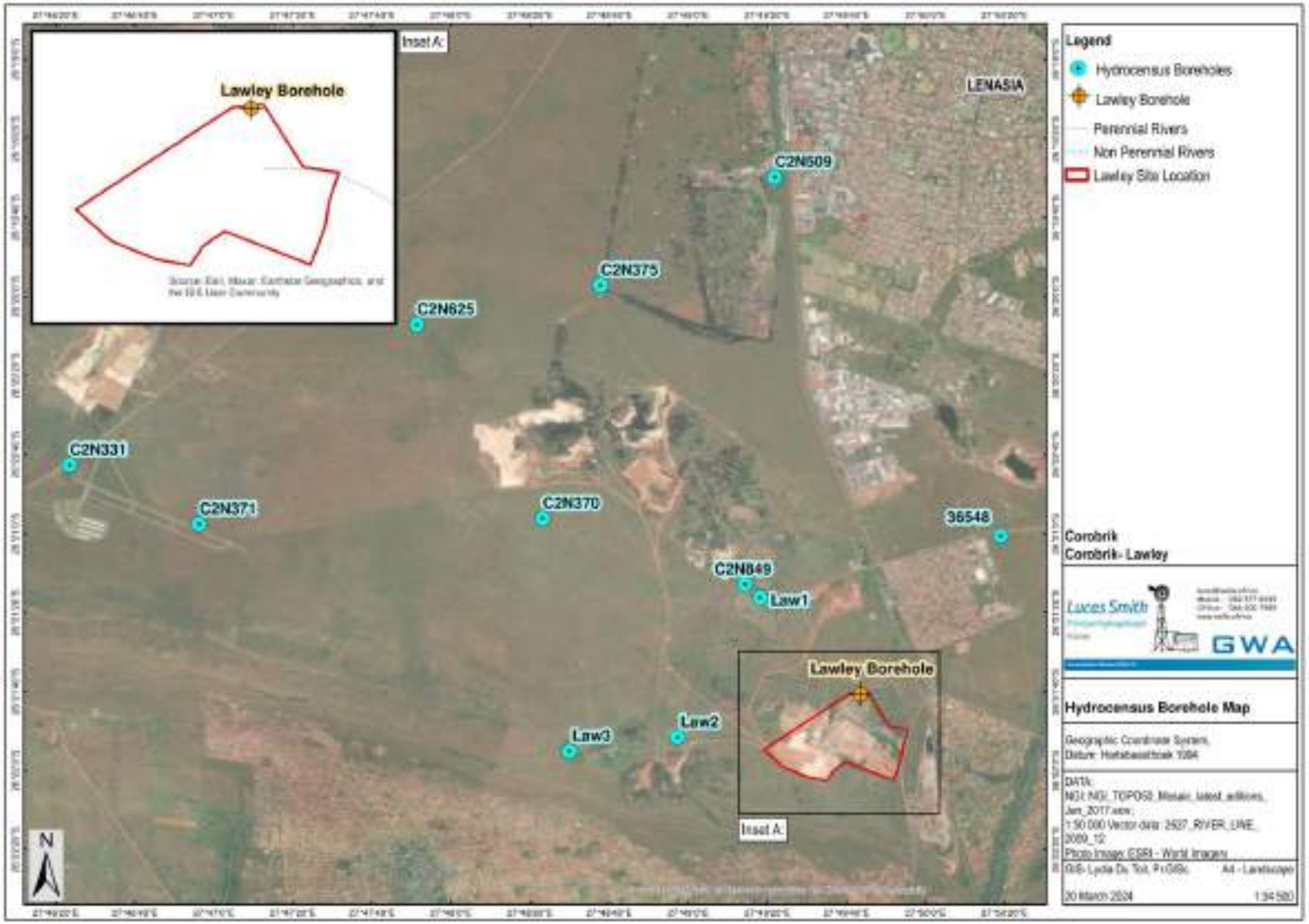

Figure 11. Hydrocensus borehole locality map

Table 2. Hydrocensus summary

Site ID	Lat (WGS84)	Long	Elev (mamsl)	Water depth (mbgl)	Collar height (m)	Water elevation (mamsl)	BH depth (m)	Yield (L/hr)
Lawley BH	26°21'40.61"S	27°49'43.47"E	1629	71,45	0,01	1557,56	148	18000
Law1	26°21'16.26"S	27°49'18.11"E	1625	blocked	--	--	--	--
Law2	26°21'51.57"S	27°48'57.23"E	1656	23,70	-0,12	1632,18	--	--
Law3	26°21'55.12"S	27°48'29.88"E	1681	26,95	0,04	1654,09	--	--
36548	26°21'00.63"S	27°50'18.99"E	1593	blocked	--	--	--	--
C2N0849	26°21'12.86"S	27°49'14.36"E	1624	68,60	0,29	1555,69	--	--
C2N0370	26°20'56.21"S	27°48'23.07"E	1632	75,10	0,32	1557,22	--	--
C2N0371	26°20'57.66"S	27°46'56.29"E	1649	93,31	0,31	1556,00		
C2N0331	26°20'42.66"S	27°46'23.49"E	1644	85,86	0,29	1558,43		
C2N0375	26°19'57.17"S	27°48'37.74"E	1597	blocked	--	--	--	--
C2N0625	26°20'07.12"S	27°47'51.34"E	1611	55,00	0,30	1556,30		
C2N0509	26°19'29.81"S	27°49'21.84"E	1585	27,71	0,54	1557,83		

Site ID	Casing diameter (mm)	Sampled	Pump type	Use	Note
Lawley BH	145	yes	submersible	Corobrik	Only source of water to Lawley. In palisade fence
Law1	165	no	none	not in use	Near farmhouse. Collapsed?
Law2	165	no	submersible	Domestic, Gardens	Tolstoy Farm of Mahatma Gandhi. In small manhole
Law3	150	no	submersible	Domestic, Gardens	BH at back of property
36548	165	no	none	not in use	filled by rocks
C2N0849	50	yes	none	monitoring	Old monitor BH
C2N0370	340	no	none	monitoring	large cavity around casing
C2N0371	165	no	none	monitoring	BH at Airfield end of landing strip. Priv BH nearby
C2N0331	155	no	none	monitoring	Next to main dirt road near Baragwanath Airfield
C2N0375	165	no	none	not in use	On fence corner of military base. Filled by rocks
C2N0625	260	no	none	not in use	Old production BH / Monitoring BH / 2nd BH nearby
C2N0509	165	yes	none	monitoring	On military base grounds

During the February 2024 hydrocensus 12 boreholes were identified (Table 2), with the closest borehole approximately 1-kilometre from the Corobrik Lawley BH – borehole Law1. This borehole is not in use and possibly collapsed. The closest production / private borehole is borehole Law2, at the Tolstoy Farm of Mahatma Gandhi Museum, approximately 1.4 km to the southwest (Figure 11).

Only 3 of the 12 boreholes are equipped and in use, including the Corobrik Lawley BH. The remaining boreholes are old, open boreholes, mostly used for monitoring purposes by the DWS (Table 2).

Three (3) groundwater samples were collected during the 2024 hydrocensus (Table 3 and see Section 5.1.1). Groundwater level measurements were possible from 9 of the 12 boreholes; the rest are blocked (Table 2). 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 2).

The m bgl measurement was subtracted from the borehole's surface elevation to define the groundwater table elevation in metres above mean sea level, for all borehole measurements.

The local groundwater level below surface varied between a maximum depth of 93.31 m bgl (borehole C2N0371), and a minimum of 23.70 m bgl for borehole Law2 (Table 2). If the groundwater levels are viewed as an elevation above sea level, then the highest groundwater elevations can be found at borehole Law3 (1654.09 mamsl). This private borehole along the foot of the east-west striking ridge, plus the neighbouring borehole at Tolstoy Farm of Mahatma Gandhi present the highest groundwater elevations, as measured during the 2024 hydrocensus. The lowest water table elevation is at borehole C2N0849 in the north (approximately 1555.69 mamsl).

The correlation between topography and groundwater elevation is very good (approximately 94%), 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.

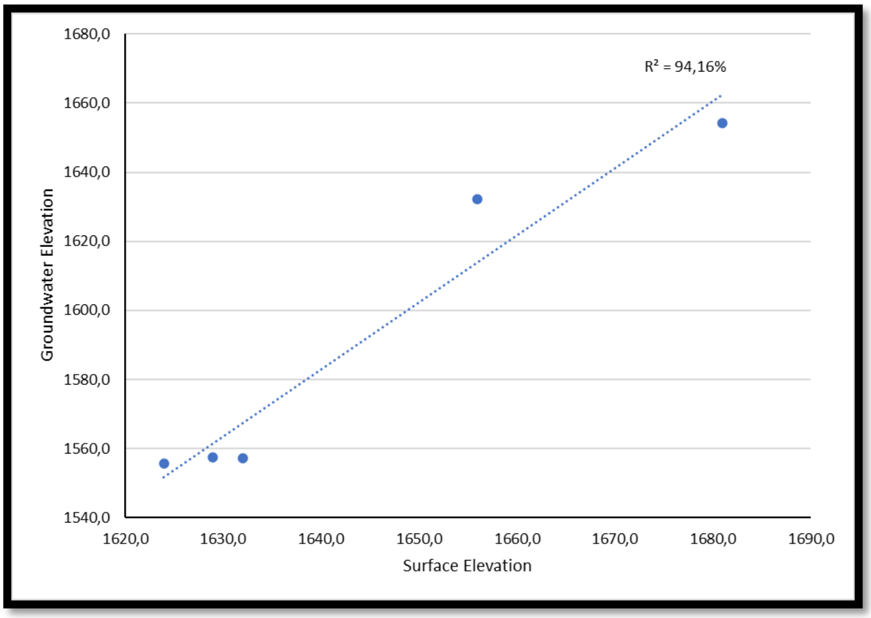

Figure 12. Correlation between surface and groundwater elevations

Thus, on a localised scale the groundwater flow is towards the north. The 12 boreholes identified are in 2 different dolomitic compartments, i.e., Gemsbokfontein and Zuurbekom. The groundwater elevations appear to be similar across the two dolomitic compartments.

5.1.1 Groundwater Quality Results

Three (3) groundwater samples were collected during the Corobrik Lawley hydrocensus (Table 3). 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 3).

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 3. 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 3):

- Aesthetic / Operational effects:
  - Iron – The speciation of iron is related to the pH and Eh of water. An elevated iron concentration (exceeding the chronic health limits) was recorded for borehole C2N0849 (0.84 mg/L), with the SANS limit set at 0.3 mg/L (Table 3). The concentration of dissolved iron in water is also dependent on the occurrence of other heavy metals or could be related to the local Karoo and dolomite geology or corrosion of the installed steel casing.

    Borehole C2N0849 is downstream from Corobrik Lawley, near the farmhouse. The borehole is open, and the sampled water was very dirty. The total iron concentrations were below the detection limit for the other two sampled sites.
  - Manganese – Manganese is a relatively abundant element, constituting approximately 0.1% of the earth's crust. Borehole C2N0849 measured a manganese concentration above the operational limit (0.36 mg/L) (Table 3). The operational limit is set at 0.1 mg/L and the health impact limit is set at 0.4 mg/L. Manganese tends to precipitate out of solution to form a black hydrated oxide which is responsible for staining problems.

    The manganese concentration could be related to the local Karoo and dolomite geology. The manganese concentrations were below detection limit or the SANS aesthetic limit for the other two sampled sites.
  - Ammonium – The ammonium concentration for borehole C2N0849 exceeds the aesthetic limits for drinking water (49.9 mg/L) with the aesthetic limit set at 1.5 mg/L. The chemistry of ammonia is very complex, especially where transition metals are present in water, and while ammonia itself is of relatively low toxicity, this is not necessarily the case for some of its organometallic complexes. Taste and odour complaints are likely to occur if the ammonia concentration exceeds 1.5 mg/L. High

concentrations of ammonia can also give rise to nitrite, which is potentially toxic, especially to infants.

- Total Hardness – an elevated total hardness level was measured for boreholes C2N0849 and C2N0509 (298 and 257 mg/L respectively). 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 boreholes C2N0849 and C2N0509 (125 and 15.5 mg/L respectively). The Turbidity value guideline limit is 1. Both boreholes are open and not in use and silt and organic matter was possibly disturbed during the sampling.

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 4). 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.

Based on the DWS classification system (Table 4) the sampled water is categorized as:

- Corobrik Lawley BH – Class 0 water (water of ideal quality).
- Borehole C2N0509 – Class 3 water (water is unsuitable for use) due to the Turbidity; and then Class 1 (water of good quality) due to the Total Hardness.
- Borehole C2N0849 – Class 3 water (water is unsuitable for use) due to the Turbidity value and Ammonium concentration. Thereafter, Class 1 due to the Iron and Manganese concentrations and Total Hardness.

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.

Table 3. Hydrocensus Water Quality Data

	DWS Drinking Water Guideline Limits					ANS241:2015 Drinking Water Standard Limits		Lawley BH	C2N0509	C2N0849
	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		8,12	8,39	8,14
Electrical Conductivity	*<70*	70-150	150-370	370-520	>520	Aesthetic ≤170		19,3	47,8	**127**
TDS	*<450*	450-1000	1000-2400	2400-3400	>3400	Aesthetic ≤1200		136	304	**731**
Turbidity	*0 - 1*	1 - 5	5 - 10	>10		Operational ≤ 1	Aesthetic ≤ 5	0,208	**15,5**	**124**
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				14,2	49,7	59,8
Copper	*<1*	1-1,3	1,3-2	2-15	>15		Chronic health ≤2	-0,002	-0,002	-0,002
Iron	*<0,5*	0,5-1	1-5	5-10	>10	Aesthetic ≤0,3	Chronic health ≤2	-0,004	-0,004	**0,844**
Magnesium	*<70*	70-100	100-200	200-400	>400			12,4	32,3	36
Manganese	*<0,1*	0,1-0,4	0,4-4	4-10	>10	Aesthetic ≤0,1	Chronic health ≤0,4	-0,001	-0,001	**0,36**
Nickel							Chronic health ≤0.07	-0,002	-0,002	-0,002
Zinc	*0 - 5*	5 - 10	10 - 50	50 - 700	>700	Aesthetic ≤5		0,016	-0,002	-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			0,787	0,875	17,6
Sodium	*<100*	100-200	200-400	400-1000	>1000	Aesthetic ≤200		9,95	10,9	58,6
Chloride	*<100*	100-200	200-600	600-1200	>1200	Aesthetic ≤300		2,29	11,1	28
Fluoride	*<0,7*	0,7-1	1-1,5	1,5-3,5	>3,5		Chronic health ≤1,5	-0,263	-0,263	0,428
Ammonium (NH_4) as N	*0 - 1*	1 - 2	2 - 10	>10		Aesthetic ≤1,5		0,408	0,136	**49,9**
Nitrate	*<6*	6 - 10	10 - 20	20-40	>40		Acute health ≤11	1,23	4,49	0,359
Total oxidised nitrogen as N								1,23	4,49	0,359
Sulphate	*<200*	200-400	400-600	600-1000	>1000	Aesthetic ≤250	Acute health ≤500	12,7	31,1	1,61
Total Alkalinity								83,2	201	649

	DWS Drinking Water Guideline Limits					ANS241:2015 Drinking Water Standard Limits		Lawley BH	C2N0509	C2N0849
	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		86	**257**	**298**
Total organic carbon							Chronic health ≤10	4,38	5,67	8,47
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							-0,05	1,15	0,7
Total Coliform Bacteria		***0 - 5***	5 - 100	>100		≤ 10		-1	-1	--
E. coli							Not detected	-1	-1	--
							DWS Classification	**0**	**3**	**3**

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 4. 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

5.2 Aquifer Testing

Groundwater Abstract (Pty) Ltd was appointed by Corobrik Lawley to conduct an aquifer test on the Corobrik Lawley 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 Lawley BH has historically been used as the main water supply source to the Lawley operations.

The aquifer testing was conducted from 28 November 2024. A summary of the test programme is given in Table 5. 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 Lawley 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 2.74 L/s (9 864 L/hr) on step 1, to 5.92 L/s (21 300 L/hr) on step 4. Full drawdown was not achieved during the step test with only 4.5% of the available drawdown (28 m) used. The maximum rate of the test was limited by the small diameter of the borehole – 145 mm diameter. The data is presented in Figure 13. Step drawdown test included:

- Step 1 – 2.74 L/s, with 33 cm drawdown at the end of the step.
- Step 2 – 4.21 L/s, with 75 cm drawdown at the end of the step.
- Step 3 – 5.54 L/s, with 1.12 m drawdown at the end of the step.
- Step 4 – 5.92 L/s, with 1.3 m drawdown at the end of the step. Full drawdown was not achieved due to the high yield of the borehole / aquifer.
- Recovery – 100% in 5 minutes.

The step test data indicates a gradual but minimal drawdown curve for the 4 steps. The maximum drawdown, at a pumping rate of 21 300 L/hr was 1.3 meter. No flow boundaries were visible, considering a change of only 1 meter.

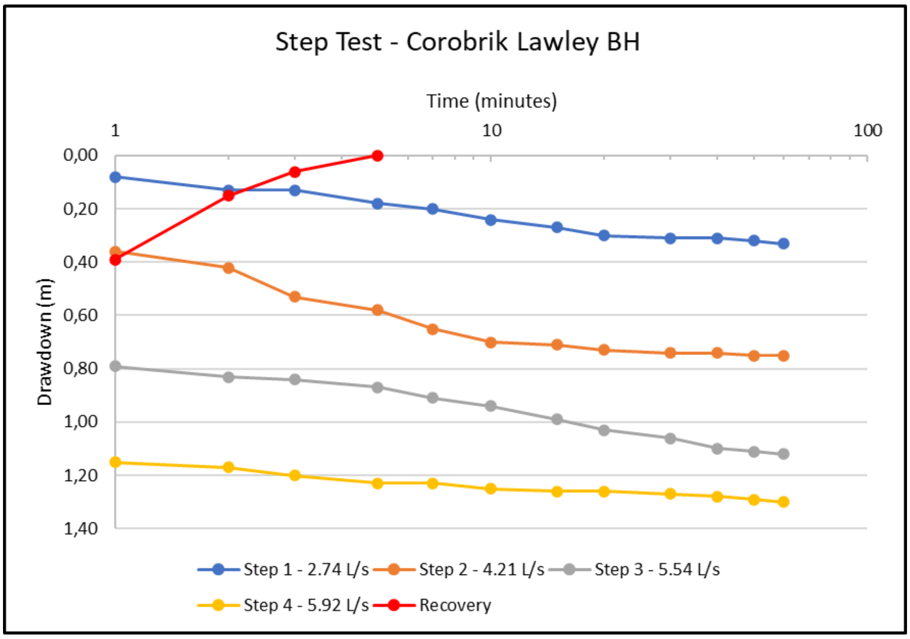

Figure 13. Step test data

The constant discharge test was run at 18 684 L/hr (5.2 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 (18 684 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 0.92 m drawdown, at 5.2 L/s (18 684 L/hr). Minimal drawdown was achieved over the duration of the 24-hour test with only 3% of the available drawdown was used.

The water table recovered 100% in 7 minutes. The pump was set at 100 m below surface during the aquifer test, with a borehole depth of 148 m.

Based on the drawdown characteristics and recovery data for this test, the borehole can safely yield the test rate of 18 684 L/hr (18.68 m^3/hr). The borehole has historically been used at a total volume of approximately 12 000 litres per hour (143 408 L/day) (CM Eclectic Pty Ltd, June 2024).

GWA recommends an abstraction rate of 18 684 L/hr (18.68 m^3/hr), with borehole abstraction limited to 12 hours of pumping per day. Based on the aquifer test data assessment the borehole can safely yield 27.11 m^3/hr (650.59 m^3/day), but the abstraction of this volume is limited by the casing diameter. The calculations indicate that the borehole has a possible maximum yield of 151.8 m^3/hr (3642 m^3/day), but this could not be accurately determined due to the casing diameter limitations. The current use and recommended safe abstraction rate are approximately a tenth of the maximum volume determined. Please note that the borehole / aquifer can yield much more compared to the recommended rate of 18 684 L/hr (18.68 m^3/hr).

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

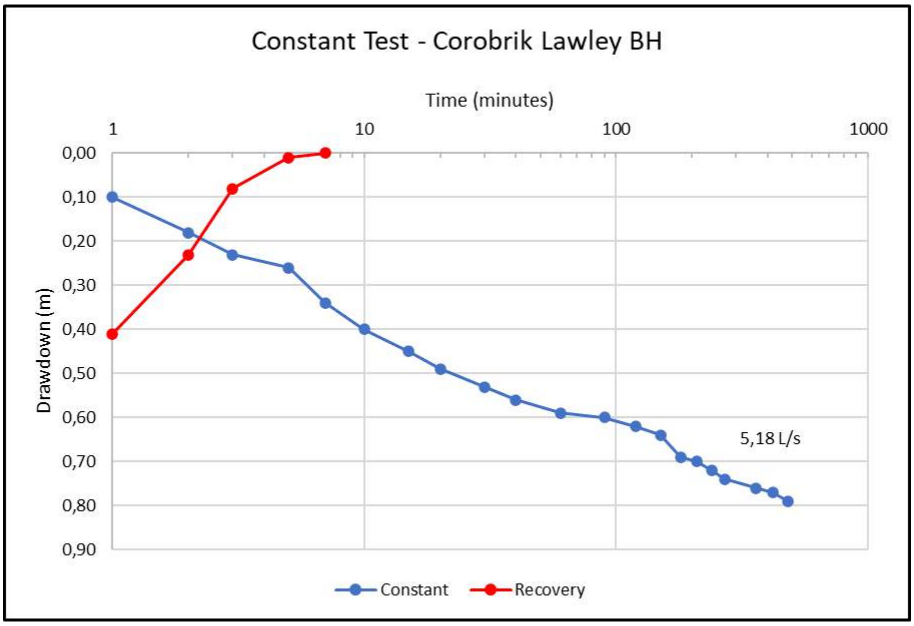

Figure 14. Constant discharge test data

Table 5. Aquifer test information

BH	Test date	BH depth	Rest water level	Available drawdown	Step test max yield	Step test duration	Step test recovery
	28 November 2024	148 m	71.45 mbgl	28.55 m	5.92 L/s	60 minutes x 4	100% in 5 min
	Constant discharge test rate	**Constant test duration**	**Constant test recovery**	**T**	**Recommended abstraction rate**		
	5.2 L/s	24 hours	100% in 7 min	303 m^2/day	18.68 m^3/hour (18 684 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 Lawley 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 494 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 47 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 Lawley 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 Lawley 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 18 684 L/hr.
- The aquifer is infinite, homogeneous, and isotropic.

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

- borehole Law 2 approximately 1.3 km to the southwest (Garden and domestic use); and
- borehole Law 3 approximately 2.1 km to the southwest (Garden and domestic use);
- borehole C2N0849 approximately 1.1 km to the northwest (not in use – groundwater monitoring).

These boreholes are thus far outside the potential radius of influence of the Corobrik Lawley borehole.

GWA recommends that boreholes Law 2, Law 3 and C2N0849 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 Lawley 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 if the data supports such a request.

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 Lawley 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 the Lawley Plant plus domestic and irrigation use, discharges from sewage systems, discharges from landfill site, industrial waste spills / discharges, and herbicides and pesticides from farming activities, plus hydrocarbon pollution are all potential impacts to the local groundwater environment. 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 494 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 47 m (FC-method calculator).

The closest production borehole to the Corobrik Lawley borehole is borehole Law 2, at Tolstoy Farm of Mahatma Gandhi Museum (Figure 11), 1.3 km away. All production boreholes are outside the potential radius of influence, of a production borehole at the Corobrik Lawley borehole.

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, landfill site discharge and contaminated storm water runoff posing the greatest risk to the groundwater quality.

The following is concluded:

Table 6. Potential impacts summary

Potential impact	1. Contamination of the borehole water with seepage from local, private sewer systems, landfill site discharge, industrial discharges and contaminated storm water. 2. Poor water quality associated with leachate from material stockpiles, or the coal stockpile areas. 3. Over utilization of the aquifer system intercepted by the various boreholes, including the Corobrik Lawley borehole and the associated dolomite stability issues.
Mitigation	1. A groundwater monitoring programme must be in place to monitor groundwater level and water qualities, to assess what impact the Corobrik Lawley 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 Anchorville industrial zone to the north (downstream), and the landfill site to the east, 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 Lawley borehole;
  - Borehole Law 2 at Tolstoy Farm of Mahatma Gandhi Museum;
  - Borehole Law 3 at the property of Mr Louis;
  - Borehole C2N0849 at the farmhouse to the north;
  - Borehole C2N0370; and
  - Borehole C2N0625.
- 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 to 1 m with a maximum of 3 m and does not exceed the capacity of the borehole.
- Ensure that sufficient information is available on all private boreholes around the Corobrik Lawley 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 7. Additional, new monitoring boreholes are not recommended at this stage. If negative groundwater impacts are observed, then the monitoring programme must be expanded.

Table 7. Proposed groundwater monitoring positions

Borehole	Latitude (WGS84)	Longitude	Groundwater level	Groundwater quality
Lawley BH	26°21'40.61"S	27°49'43.47"E	Yes	Quarterly
Borehole Law 2	26°21'51.57"S	27°48'57.23"E	Yes	Quarterly
Borehole Law 3	26°21'55.12"S	27°48'29.88"E	Yes	Quarterly
Borehole C2N0849	26°21'12.86"S	27°49'14.36"E	Yes	Quarterly
Borehole C2N0370	26°20'56.21"S	27°48'23.07"E	Yes	Bi-annual
Borehole C2N0625	26°20'07.12"S	27°47'51.34"E	Yes	Bi-annual

The spectrum of metals, salts and microbiology listed in Table 3 is recommended for the groundwater quality analysis.

9.2 Monitoring Requirements

The monitoring requirements are presented in Table 7.

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 was appointed by Corobrik Lawley to assist with an assessment of the groundwater characteristics and provide recommendations regarding the use of one borehole on the Corobrik Lawley property.

Lawley Factory mines and processes various raw earth materials and is supported by run of mine stockpiles, offices, sewage treatment works, brick making plant and workshops. Quarrying operations are carried out on an annual basis for approximately four months a year, during the dry winter months.

The factory has a sewage treatment plant which handles waste from all site ablutions. Semi-purified water (effluent) from the treatment plant is discharged to the nearby wetland. This water is regularly tested. Non-degradable or digestible sewage sludge is disposed of at a licensed waste site, using a licensed waste management service provider.

The Lawley property is approximately 336 hectares in extent of which only 18 ha is quarried. In 2008 the life of the quarry operations was estimated at approximately 40 years.

Water sources at Corobrik Lawley are:

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

The following are key notes in terms of water used at Corobrik Lawley (CM Eclectic Pty Ltd):

- For dust suppression on the roads and in the quarry area – water from the quarries is used.
- There is one existing borehole which is used for the crushing plant, brick making plant / process, and for the domestic water requirements.

Environmental setting:

Corobrik Lawley is remotely located on the northern foot of the east-west striking quarzitic ridge. Agricultural land, plus other quarrying and brick making activities are found to the west. The Ennerdale Landfill Site is located along the eastern boundary of the Corobrik Lawley property. The Corobrik Lawley site-topography has a gentle slope towards the north.

The mean annual precipitation for quaternary catchment C22A is 695 mm according to the WR2012 database. The mean annual evaporation (S-pan evaporation) is 1650 mm (WR2012 database).

The Corobrik Lawley property is in the C22A quaternary catchment, and forms part of the Vaal Water Management Area (WMA 5). Locally, the study area is drained by a tributary of the Klip River. Surface drainage in the Corobrik Lawley area (locally) flows in an easterly direction.

According to published geological maps (Geology Map 2626 West Rand), the property is underlain by dolomite and chert of the Chuniespoort Group, Transvaal Supergroup, with formations of the Karoo, Transvaal and Ventersdorp Supergroups occurring in the area.

South of Corobrik Lawley, formations of the Pretoria Group outcrop, including ferruginous shale and quartzite of the Timeball Hill Formation, Hekpoort lavas, as well as shale outcrops of the Strubenkop and Silverton Formations.

Some Karoo sediments have remained as inliers above the dolomite, delineated as the Vryheid Formation.

The dolomite is divided into units or compartments, by intrusive dykes and other geological structures, which form barriers to the flow of groundwater. Based on the delineation of the compartments the Corobrik Lawley area is associated with the Gemsbokfontein dolomitic compartment.

The NGA database indicates that several groundwater (dolomite) monitoring boreholes are in the Corobrik Lawley area, in the Gemsbokfontein, Zuurbekom and Upper Klip River Compartments. Groundwater level data for 6 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 closest monitoring borehole to the Corobrik Lawley BH, is borehole C2N0849, located approximately 1.2 km northwest of the Corobrik Lawley BH, at the farmhouse. The rest of the DWS monitoring boreholes are to the north and the west, approximately 1.5 km to 6 km from the Corobrik Lawley BH.

The dolomite monitoring data / borehole information indicates:

- Based on the available data the rest groundwater levels are on a similar elevation, across the two dolomitic compartments – between the Gemsbokfontein compartment and the Zuurbekom compartment (borehole C2N0509). The elevation in the Zuurbekom compartment borehole (C2N0509) is 1556,71 mamsl (latest 2024 reading) versus the groundwater elevations in the Gemsbokfontein that varies between 1554.65 mamsl and 1557.26 mamsl.
- Based on the water level data in the 6 boreholes, they respond in a similar way over time, except for borehole C2N0331 located west of the Baragwanath Aerodrome, along the main dirt road.
- The groundwater level data for 5 of the 6 boreholes start on a high elevation in the 1986 / 1987 period, followed by a low in 1992, followed by another rise and peak in 2000 to 2002, another low during 2010, and then a sharp rise during 2022.

<u>Site assessments:</u>

A hydrocensus was conducted across the Corobrik Lawley study area during February 2024. The survey included Corobrik Lawley 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 12 boreholes were identified, with the closest borehole approximately 1-kilometre from the Corobrik Lawley BH – borehole Law1. This borehole is not in use and possibly collapsed. The closest production / private borehole is borehole Law2, at the Tolstoy Farm of Mahatma Gandhi Museum, approximately 1.4 km to the southwest.

Only 3 of the 12 boreholes are equipped and in use, including the Corobrik Lawley BH. The remaining boreholes are old, open boreholes, mostly used for monitoring purposes by the DWS.

Groundwater level measurements were possible from 9 of the 12 boreholes; the rest are blocked. The local groundwater level below surface varied between a maximum depth of 93.31 m bgl (borehole C2N0371), and a minimum of 23.70 m bgl for borehole Law2. If the groundwater levels are viewed as an elevation above sea level, then the highest groundwater elevations can be found at borehole Law3 (1654.09 mamsl). This private borehole along the foot of the east-west striking ridge, plus the neighbouring borehole at Tolstoy Farm of Mahatma Gandhi present the highest groundwater elevations, as measured during the 2024 hydrocensus. The lowest water table elevation is at borehole C2N0849 in the north (approximately 1555.69 mamsl).

The correlation between topography and groundwater elevation is very good (approximately 94%). 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.

Thus, on a localised scale the groundwater flow is towards the north. The 12 boreholes identified are in 2 different dolomitic compartments, i.e., Gemsbokfontein and Zuurbekom. The groundwater elevations appear to be similar across the two dolomitic compartments.

Three groundwater samples were collected during the Corobrik Lawley hydrocensus. The water sampled from the three boreholes is of acceptable quality, based on the parameters used in the laboratory analysis. No health impact exceedances were noted, based on the health drinking water guideline limits. The following conclusions were drawn:

- Aesthetic / Operational effects:
  - Iron – An elevated iron concentration (exceeding the chronic health limits) was recorded for borehole C2N0849 (0.84 mg/L), with the SANS limit set at 0.3 mg/L. Borehole C2N0849 is downstream from Corobrik Lawley, near the farmhouse. The borehole is open, and the sampled water was very dirty. The total iron concentrations were below the detection limit for the other two sampled sites.
  - Manganese – Borehole C2N0849 measured a manganese concentration above the operational limit (0.36 mg/L). The operational limit is set at 0.1 mg/L and the health impact limit is set at 0.4 mg/L. The manganese concentration could be related to the local Karoo and dolomite geology. The manganese concentrations were below detection limit or the SANS aesthetic limit for the other two sampled sites.
  - Ammonium – The ammonium concentration for borehole C2N0849 exceeds the aesthetic limits for drinking water (49.9 mg/L) with the aesthetic limit set at 1.5 mg/L.
  - Total Hardness – an elevated total hardness level was measured for boreholes C2N0849 and C2N0509 (298 and 257 mg/L respectively). Water hardness is influenced by the presence of calcium and magnesium salts.
  - Turbidity – The turbidity value exceeded the aesthetic / operational limits for boreholes C2N0849 and C2N0509 (125 and 15.5 mg/L respectively). The Turbidity value guideline limit is 1. Both boreholes are open and not in use and silt and organic matter was possibly disturbed during the sampling.

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

- Corobrik Lawley BH – Class 0 water (water of ideal quality).
- Borehole C2N0509 – Class 3 water (water is unsuitable for use) due to the Turbidity; and then Class 1 (water of good quality) due to the Total Hardness.
- Borehole C2N0849 – Class 3 water (water is unsuitable for use) due to the Turbidity value and Ammonium concentration. Thereafter, Class 1 due to the Iron and Manganese concentrations and Total Hardness.

Groundwater Abstract (Pty) Ltd was appointed by Corobrik Lawley to conduct an aquifer test on the Corobrik Lawley BH, to assess the aquifer response to pumping, plus to determine basic aquifer parameters. The aquifer testing was conducted from 28 November 2024.

The step test data indicates that the borehole can yield much more water compared to the selected constant abstraction rate (18 684 L/hr). Borehole diameter and pump limitations defined the maximum pumping rate.

Based on the drawdown characteristics and recovery data for this test, the borehole can safely yield the test rate of 18 684 L/hr (18.68 m^3/hr). The borehole has historically been used at a total volume of approximately 12 000 litres per hour (143 408 L/day) (CM Eclectic Pty Ltd, June 2024).

GWA recommends an abstraction rate of 18 684 L/hr (18.68 m^3/hr), with borehole abstraction limited to 12 hours of pumping per day. Based on the aquifer test data assessment the borehole can safely yield 27.11 m^3/hr (650.59 m^3/day), but the abstraction of this volume is limited by the casing diameter. The calculations indicate that the borehole has a possible maximum yield of 151.8 m^3/hr (3642 m^3/day), but this could not be accurately determined due to the casing diameter limitations. The current use and recommended safe abstraction rate are approximately a tenth of the maximum volume determined.

Based on the constant discharge test data for the Corobrik Lawley 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 494 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 47 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.

The closest boreholes to the Corobrik Lawley BH are:

- borehole Law 2 approximately 1.3 km to the southwest (Garden and domestic use); and
- borehole Law 3 approximately 2.1 km to the southwest (Garden and domestic use);
- borehole C2N0849 approximately 1.1 km to the northwest (not in use – groundwater monitoring).

These boreholes are thus far outside the potential radius of influence of the Corobrik Lawley borehole.

Potential impacts:

Based on the results of the site investigations, groundwater abstraction, discharges from sewage systems, discharges from landfill site, industrial waste spills / discharges, and herbicides and pesticides from farming activities, plus hydrocarbon pollution are all potential impacts to the local groundwater environment. 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.

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 494 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 47 m (FC-method calculator).

The closest production borehole to the Corobrik Lawley borehole is borehole Law 2, at Tolstoy Farm of Mahatma Gandhi Museum, 1.3 km away. All production boreholes are thus outside the potential radius of influence, of a production borehole at the Corobrik Lawley borehole.

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, landfill site discharge and contaminated storm water runoff posing the greatest risk to the groundwater quality.

11 REFERENCES

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- www.weather-atlas.com.
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Appendix A

Consultant CV

Curriculum Vitae

Lucas Andries Smith (Pr. Sci.Nat)

Independent Hydrogeological Consultant

Principal Hydrogeologist

Based in:
Rietfontein
Tshwane

Mobile phone – 082 577 8439

lucas@wellsafrica.com

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.

Appendix B

Laboratory Certificates

leaders in environmental monitoring
address: 89 Regency drive, R21 Corporate Park, Centurion
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web: www.aquatico.co.za
office: 012 450 3800 • fax: 012 450 3851

828 20TH AVENUE
RIETFONTEIN
PRETORIA

ATTENTION: GROUNDWATER ABSTRACT PTY LTD GWA

1 MARCH 2024

CONCISE WATER QUALITY EVALUATION
(TEST REPORT 177622)

WATER QUALITY RESULTS

A water sample was submitted to Aquatico Laboratories on **23 February 2024** for testing the quality for intended use as domestic water. The water quality test results are displayed on the attached Test Report. Water quality is compared to the SANS 241-1:2015 Drinking Water Standard (SABS, 2015).

The water quality of the sample called '**CZN 509**' can be described as neutral (pH 6.0 - 8.5), non-saline (TDS < 450 mg/l) and hard (total hardness 200 - 300 $CaCO_3$) with no *E. coli* and no total coliforms detected.

Compliance with the 'SANS 241-1:2015 Drinking Water Standard (SABS, 2015)' guidelines is as follows:

Chronic health Risk:	All compliant
Acute health Risk:	All compliant
Operational (non-health):	Turbidity 15.5 NTU (> 1.00 NTU)
Aesthetic (non-health):	Turbidity 15.5 NTU (> 5.00 NTU)

In terms of the classification system of the 'Quality of Domestic water supplies' (WRC, 1998) the quality is classified as follows:

Drinking:	Class 2 - Marginal	due to Turbidity
Bathing:	Class 2 - Marginal	due to Total hardness
Washing:	Class 2 - Marginal	due to Total hardness
Food Preparation:	Class 2 - Marginal	due to Turbidity, Total hardness
Aesthetic:	Class 2 - Marginal	due to Turbidity

According to the Langelier Saturation Index, marked scale formation is expected.

Based on the assessment of variables analysed in comparison to 'SANS 241-1:2015 Drinking Water Standard (SABS, 2015)' and 'Quality of Domestic water supplies' (WRC, 1998), the tested water sample is **Conditionally Fit** for use as potable water and domestic use.

Treatment for intended use: **Recommended**
Variables requiring treatment: Turbidity

Turbidity is the light scattering ability of water and is indicative of the suspended particles in the water. A turbidity of 1 – 20mg/L may affect the appearance, taste and colour of the water.

Please contact us for any further enquiries
Electronically generated report
Noluthando Ngema

aquatico Scientific (Pty). Ltd.
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Appendix A.

DATA TABLE				
CLIENT NAME	Groundwater Abstract Pty Ltd GWA	DATE COMPILED	2024-03-01	
ASSESSMENT SET	SANS 241-1:2015 Drinking Water Standard (SABS, 2015)	COMPILED BY	Noluthando Ngema	
				*Value exceeds the assessment set
VARIABLE	UNITS	ASSESSMENT SET	SAMPLE NAME : CZN 509	POSSIBLE HEALTH EFFECTS
pH @ 25°C	pH	Range 5.0 - 9.7	8.39	No health effects
Electrical conductivity (EC) @ 25°C	mS/m	170	47.8	No effects
Total dissolved solids (TDS)	mg/l	1200	304	
Total Alkalinity	mg $CaCO_3$/l	-	201	
Chloride (Cl)	mg/l	300	11.1	No health effects
Sulphate (SO_4)	mg/l	500	31.1	No effects
Nitrate (NO_3) as N	mg/l	11	4.49	Negligible effects
Total oxidised nitrogen as N	mg/l	-	4.49	
Ammonium (NH_4) as N	mg/l	1.5	0.136	
Fluoride (F)	mg/l	1.5	<0.466	
Calcium (Ca)	mg/l	-	49.7	No health effects
Magnesium (Mg)	mg/l	-	32.3	No health effects
Sodium (Na)	mg/l	200	10.9	Negligible effects
Potassium (K)	mg/l	-	0.875	No health effects
Aluminium (Al)	mg/l	0.3	<0.005	
Iron (Fe)	mg/l	0.3	<0.009	
Manganese (Mn)	mg/l	0.1	<0.001	
Chromium (Cr)	mg/l	0.05	<0.007	
Copper (Cu)	mg/l	2	<0.005	
Nickel (Ni)	mg/l	0.07	<0.005	
Zinc (Zn)	mg/l	5	<0.005	
Cadmium (Cd)	mg/l	0.003	<0.005	
Lead (Pb)	mg/l	0.01	<0.009	
E.coli	CFU/100 ml	0	0	
Total coliform	CFU/100 ml	10	0	
Turbidity	NTU	1	15.5	Disinfection may be compromised, possibility of secondary health effects if bacteria is present
Total hardness	mg $CaCO_3$/l	-	257	Insignificant effects
Total organic carbon (TOC)	mg/l	10	5.67	
Langelier Saturation Index	LSI	-	1.15	

Test Report

Client: Groundwater Abstract Pty Ltd GWA
Address: 828 20th Avenue , Rietfontein, Pretoria, 0084
Report no: 177622
Project: Lawley

Date of report: 29 February 2024
Date accepted: 23 February 2024
Date completed: 29 February 2024
Date received: 23 February 2024

					Uncertainty of measure-ment %	SANS 241-1:2015	
Lab no:							41669
Date sampled:							21-Feb-24
Aquatico sampled:							No
Sample type:							Water
Locality description:							CZN 509
		Analyses	**Unit**	**Method**			
A	AQL	pH @ 25°C	pH	ALM 20	4.23	5 - 9.7	8.39
A	AQL	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	9.52	< 170	47.8
A	AQL	Total dissolved solids (TDS)	mg/l	ALM 26		< 1200	304
A	AQL	Total Alkalinity	mg $CaCO_3$/l	ALM 01	10.41		201
A	AQL	Chloride (Cl)	mg/l	ALM 02	11.39	< 300	11.1
A	AQL	Sulphate (SO_4)	mg/l	ALM 03	8.45	< 500	31.1
A	AQL	Nitrate (NO_3) as N	mg/l	ALM 06	9.85	< 11	4.49
A	AQL	Total oxidised nitrogen as N	mg/l	ALM 06	9.85		4.49
A	AQL	Ammonium (NH_4) as N	mg/l	ALM 05	8.59	< 1.5	0.136
A	AQL	Fluoride (F)	mg/l	ALM 08	10.11	< 1.5	<0.263
A	AQL	Calcium (Ca)	mg/l	ALM 30	7.65		49.7
A	AQL	Magnesium (Mg)	mg/l	ALM 30	7.65		32.3
A	AQL	Sodium (Na)	mg/l	ALM 30	6.94	< 200	10.9
A	AQL	Potassium (K)	mg/l	ALM 30	10.47		0.875
A	AQL	Aluminium (Al)	mg/l	ALM 31	8.59	< 0.3	<0.002
A	AQL	Iron (Fe)	mg/l	ALM 31	7.97	< 0.3	<0.004
A	AQL	Manganese (Mn)	mg/l	ALM 31	8	< 0.1	<0.001
A	AQL	Chromium (Cr)	mg/l	ALM 31	7.61	< 0.05	<0.003
A	AQL	Copper (Cu)	mg/l	ALM 31	4.55	< 2	<0.002
A	AQL	Nickel (Ni)	mg/l	ALM 31	7.56	< 0.07	<0.002
A	AQL	Zinc (Zn)	mg/l	ALM 31	9.31	< 5	<0.002
A	AQL	Cadmium (Cd)	mg/l	ALM 31	7.89	< 0.003	<0.002
A	AQL	Lead (Pb)	mg/l	ALM 31	8.85	< 0.01	<0.004
A	AQL	E.coli	CFU/100ml	ALM 40	7.74	0	<1
A	AQL	Total coliform	CFU/100ml	ALM 40	7.76	< 10	<1

A = Accredited N = Non accredited Sub = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report ; Results relate only to the items received and tested ; Results reported against the limit of detection; Results marked 'Non SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory; Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation; The report shall not be reproduced except in full without approval of the laboratory

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Client: Groundwater Abstract Pty Ltd GWA
Address: 828 20th Avenue , Rietfontein, Pretoria, 0084
Report no: 177622
Project: Lawley

Date of report: 29 February 2024
Date accepted: 23 February 2024
Date completed: 29 February 2024
Date received: 23 February 2024

					Uncertainty of measure-ment %	SANS 241-1:2015	
Lab no:							41669
Date sampled:							21-Feb-24
Aquatico sampled:							No
Sample type:							Water
Locality description:							CZN 509
		Analyses	**Unit**	**Method**			
A	AQL	Turbidity	NTU	ALM 21	5.9	< 1	15.5
A	AQL	Total hardness	mg $CaCO_3$/l	ALM 26			257
A	AQL	Total organic carbon (TOC)	mg/l	ALM 63	6.46	< 10	5.67
A	AQL	Langelier Saturation Index	LSI	ALM 26			1.15

A = Accredited N = Non accredited Sub = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report ; Results relate only to the items received and tested ; Results reported against the limit of detection; Results marked 'Non SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory; Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation; The report shall not be reproduced except in full without approval of the laboratory

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828 20TH AVENUE
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PRETORIA

ATTENTION: GROUNDWATER ABSTRACT PTY LTD GWA

1 MARCH 2024

CONCISE WATER QUALITY EVALUATION
(TEST REPORT 177623)

WATER QUALITY RESULTS

A water sample was submitted to Aquatico Laboratories on **23 February 2024** for testing the quality for intended use as domestic water. The water quality test results are displayed on the attached Test Report. Water quality is compared to the SANS 241-1:2015 Drinking Water Standard (SABS, 2015).

The water quality of the sample called '**Lawley BH**' can be described as neutral (pH 6.0 - 8.5), non-saline (TDS < 450 mg/l) and moderately soft (total hardness 50 - 100 $CaCO_3$) with no *E. coli* and no total coliforms detected.

Compliance with the 'SANS 241-1:2015 Drinking Water Standard (SABS, 2015)' guidelines is as follows:

Chronic health Risk:	All compliant
Acute health Risk:	All compliant
Operational (non-health):	All compliant
Aesthetic (non-health):	All compliant

In terms of the classification system of the 'Quality of Domestic water supplies' (WRC, 1998) the quality is classified as follows:

Drinking:	Class 1 - Good
Bathing:	Class 1 - Good
Washing:	Class 1 - Good
Food Preparation:	Class 1 - Good
Aesthetic:	Class 1 - Good

According to the Langelier Saturation Index, slight corrosion is possible but the water is non-scale forming.

Based on the assessment of variables analysed in comparison to 'SANS 241-1:2015 Drinking Water Standard (SABS, 2015)' and 'Quality of Domestic water supplies' (WRC, 1998), the tested water sample is **Fit** for use as potable water and domestic use.

Treatment for intended use: **none required**
Variables requiring treatment: None

Please contact us for any further enquiries
Electronically generated report
Noluthando Ngema

Appendix A.

DATA TABLE				
CLIENT NAME	Groundwater Abstract Pty Ltd GWA		DATE COMPILED	2024-03-01
ASSESSMENT SET	SANS 241-1:2015 Drinking Water Standard (SABS, 2015)		COMPILED BY	Noluthando Ngema
				*Value exceeds the assessment set
VARIABLE	UNITS	ASSESSMENT SET	SAMPLE NAME : Lawley BH	POSSIBLE HEALTH EFFECTS
pH @ 25°C	pH	Range 5.0 - 9.7	8.12	No health effects
Electrical conductivity (EC) @ 25°C	mS/m	170	19.3	No effects
Total dissolved solids (TDS)	mg/l	1200	136	
Total Alkalinity	mg $CaCO_3$/l	-	83.2	
Chloride (Cl)	mg/l	300	2.29	No health effects
Sulphate (SO_4)	mg/l	500	12.7	No effects
Nitrate (NO_3) as N	mg/l	11	1.23	Negligible effects
Total oxidised nitrogen as N	mg/l	-	1.23	
Ammonium (NH_4) as N	mg/l	1.5	0.408	
Fluoride (F)	mg/l	1.5	<0.466	
Calcium (Ca)	mg/l	-	14.2	No health effects
Magnesium (Mg)	mg/l	-	12.4	No health effects
Sodium (Na)	mg/l	200	9.95	Negligible effects
Potassium (K)	mg/l	-	0.787	No health effects
Aluminium (Al)	mg/l	0.3	<0.005	
Iron (Fe)	mg/l	0.3	<0.009	
Manganese (Mn)	mg/l	0.1	<0.001	
Chromium (Cr)	mg/l	0.05	<0.007	
Copper (Cu)	mg/l	2	<0.005	
Nickel (Ni)	mg/l	0.07	<0.005	
Zinc (Zn)	mg/l	5	0.016	No effects
Cadmium (Cd)	mg/l	0.003	<0.005	
Lead (Pb)	mg/l	0.01	<0.009	
E.coli	CFU/100 ml	0	0	
Total coliform	CFU/100 ml	10	0	
Turbidity	NTU	1	0.208	
Total hardness	mg $CaCO_3$/l	-	86	No effects
Total organic carbon (TOC)	mg/l	10	4.38	
Langelier Saturation Index	LSI	-	-0.05	

directors: R. Erdmann (CEO) • P.J. Naudé • T.B. Sefolo • L.E. Kolobe
company registration number: 2006/028605/07. vat no: 4360195723.

Client:	Groundwater Abstract Pty Ltd GWA	**Date of report:**	29 February 2024
Address:	828 20th Avenue , Rietfontein, Pretoria, 0084	**Date accepted:**	23 February 2024
Report no:	177623	**Date completed:**	29 February 2024
Project:	Lawley	**Date received:**	23 February 2024

Lab no:					Uncertainty of measure-ment %	SANS 241-1:2015	41670
Date sampled:							21-Feb-24
Aquatico sampled:							No
Sample type:							Water
Locality description:							Lawley BH
		Analyses	**Unit**	**Method**			
A	AQL	pH @ 25°C	pH	ALM 20	4.23	5 - 9.7	8.12
A	AQL	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	9.52	< 170	19.3
A	AQL	Total dissolved solids (TDS)	mg/l	ALM 26		< 1200	136
A	AQL	Total Alkalinity	mg $CaCO_3$/l	ALM 01	10.41		83.2
A	AQL	Chloride (Cl)	mg/l	ALM 02	11.39	< 300	2.29
A	AQL	Sulphate (SO_4)	mg/l	ALM 03	8.45	< 500	12.7
A	AQL	Nitrate (NO_3) as N	mg/l	ALM 06	9.85	< 11	1.23
A	AQL	Total oxidised nitrogen as N	mg/l	ALM 06	9.85		1.23
A	AQL	Ammonium (NH_4) as N	mg/l	ALM 05	8.59	< 1.5	0.408
A	AQL	Fluoride (F)	mg/l	ALM 08	10.11	< 1.5	<0.263
A	AQL	Calcium (Ca)	mg/l	ALM 30	7.65		14.2
A	AQL	Magnesium (Mg)	mg/l	ALM 30	7.65		12.4
A	AQL	Sodium (Na)	mg/l	ALM 30	6.94	< 200	9.95
A	AQL	Potassium (K)	mg/l	ALM 30	10.47		0.787
A	AQL	Aluminium (Al)	mg/l	ALM 31	8.59	< 0.3	<0.002
A	AQL	Iron (Fe)	mg/l	ALM 31	7.97	< 0.3	<0.004
A	AQL	Manganese (Mn)	mg/l	ALM 31	8	< 0.1	<0.001
A	AQL	Chromium (Cr)	mg/l	ALM 31	7.61	< 0.05	<0.003
A	AQL	Copper (Cu)	mg/l	ALM 31	4.55	< 2	<0.002
A	AQL	Nickel (Ni)	mg/l	ALM 31	7.56	< 0.07	<0.002
A	AQL	Zinc (Zn)	mg/l	ALM 31	9.31	< 5	0.016
A	AQL	Cadmium (Cd)	mg/l	ALM 31	7.89	< 0.003	<0.002
A	AQL	Lead (Pb)	mg/l	ALM 31	8.85	< 0.01	<0.004
A	AQL	E.coli	CFU/100ml	ALM 40	7.74	0	<1
A	AQL	Total coliform	CFU/100ml	ALM 40	7.76	< 10	<1

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Client: Groundwater Abstract Pty Ltd GWA
Address: 828 20th Avenue , Rietfontein, Pretoria, 0084
Report no: 177623
Project: Lawley

Date of report: 29 February 2024
Date accepted: 23 February 2024
Date completed: 29 February 2024
Date received: 23 February 2024

					Uncertainty of measure-ment %	SANS 241-1:2015	
Lab no:							41670
Date sampled:							21-Feb-24
Aquatico sampled:							No
Sample type:							Water
Locality description:							Lawley BH
		Analyses	**Unit**	**Method**			
A	AQL	Turbidity	NTU	ALM 21	5.9	< 1	0.208
A	AQL	Total hardness	mg $CaCO_3$/l	ALM 26			86
A	AQL	Total organic carbon (TOC)	mg/l	ALM 63	6.46	< 10	4.38
A	AQL	Langelier Saturation Index	LSI	ALM 26			-0.05

A = Accredited N = Non accredited Sub = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report ; Results relate only to the items received and tested ; Results reported against the limit of detection; Results marked 'Non SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory; Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation; The report shall not be reproduced except in full without approval of the laboratory

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828 20TH AVENUES
RIETFONTEIN
PRETORIA

ATTENTION: GROUNDWATER ABSTRACT PTY LTD GWA

4 MARCH 2024

CONCISE WATER QUALITY EVALUATION
(TEST REPORT 177624)

WATER QUALITY RESULTS

A water sample was submitted to Aquatico Laboratories on **23 February 2024** for testing the quality for intended use as domestic water. The water quality test results are displayed on the attached Test Report. Water quality is compared to the SANS 241-1:2015 Drinking Water Standard (SABS, 2015).

The water quality of the sample called '**CZN08U**' can be described as neutral (pH 6.0 - 8.5), saline (TDS 450 - 1000 mg/l) and hard (total hardness 200 - 300 $CaCO_3$) with no *E. coli* and no total coliforms detected.

Compliance with the 'SANS 241-1:2015 Drinking Water Standard (SABS, 2015)' guidelines is as follows:

Chronic health Risk:	All compliant
Acute health Risk:	All compliant
Operational (non-health):	Turbidity 124 NTU (> 1.00 NTU)
Aesthetic (non-health):	Ammonium (NH_4) as N 49.9 mg/l (> 1.50 mg/l), Iron (Fe) 0.844 mg/l (> 0.300 mg/l) Manganese (Mn) 0.360 mg/l (> 0.100 mg/l), Turbidity 124 NTU (> 5.00 NTU)

In terms of the classification system of the 'Quality of Domestic water supplies' (WRC, 1998) the quality is classified as follows:

Drinking:	Class 4 - Unacceptable	due to Turbidity
Bathing:	Class 3 - Poor	due to Turbidity
Washing:	Class 3 - Poor	due to Turbidity
Food Preparation:	Class 4 - Unacceptable	due to Turbidity
Aesthetic:	Class 4 - Unacceptable	due to Turbidity

According to the Langelier Saturation Index, scale formation is likely to occur.

Based on the assessment of variables analysed in comparison to 'SANS 241-1:2015 Drinking Water Standard (SABS, 2015)' and 'Quality of Domestic water supplies' (WRC, 1998), the tested water sample is **Not Fit** for use as potable water and domestic use.

Treatment for intended use: **Essential**
Variables requiring treatment: Turbidity, Ammonium (NH_4) as N, Iron (Fe), Manganese (Mn)

Turbidity is the light scattering ability of water and is indicative of the suspended particles in the water. A turbidity of 1 – 20mg/L may affect the appearance, taste and colour of the water.

Ammonium has an aesthetic effect on drinking water. Taste and odour problems as well as decreased disinfection efficiency is expected at high concentrations.

The major effects of the presence of **Iron (Fe)** in domestic water are a metallic taste and staining of clothing and bathroom fixtures. Health effects may occur at extremely high concentrations.

Water containing **Manganese (Mn)** at concentrations of 0.4 – 1.0 mg/L gives the water a pale brown colour and metallic taste. Brown or black staining of laundry and fixtures can also be observed.

Please contact us for any further enquiries
Electronically generated report
Preasha Naidoo

aquatico Scientific (Pty). Ltd.
leaders in environmental monitoring
address: 89 Regency drive, R21 Corporate Park, Centurion
postal: P.O. Box 905008, Garsfontein, 0042
web: www.aquatico.co.za
office: 012 450 3800 • fax: 012 450 3851

Appendix A.

DATA TABLE				
CLIENT NAME	Groundwater Abstract Pty Ltd GWA	DATE COMPILED	2024-03-04	
ASSESSMENT SET	SANS 241-1:2015 Drinking Water Standard (SABS, 2015)	COMPILED BY	Preasha Naidoo	
				*Value exceeds the assessment set
VARIABLE	UNITS	ASSESSMENT SET	SAMPLE NAME : CZN08U	POSSIBLE HEALTH EFFECTS
pH @ 25°C	pH	Range 5.0 - 9.7	8.14	No health effects
Electrical conductivity (EC) @ 25°C	mS/m	170	127	Insignificant effect on sensitive users
Total dissolved solids (TDS)	mg/l	1200	731	
Total Alkalinity	mg $CaCO_3$/l	-	649	
Chloride (Cl)	mg/l	300	28.0	No health effects
Sulphate (SO_4)	mg/l	500	1.61	No effects
Nitrate (NO_3) as N	mg/l	11	<0.459	
Total oxidised nitrogen as N	mg/l	-	<0.459	
Ammonium (NH_4) as N	mg/l	1.5	49.9	
Fluoride (F)	mg/l	1.5	<0.466	
Calcium (Ca)	mg/l	-	59.8	No health effects
Magnesium (Mg)	mg/l	-	36.0	No health effects
Sodium (Na)	mg/l	200	58.6	Negligible effects
Potassium (K)	mg/l	-	17.6	No health effects
Aluminium (Al)	mg/l	0.3	<0.005	
Iron (Fe)	mg/l	0.3	0.844	Insignificant effects
Manganese (Mn)	mg/l	0.1	0.360	Insignificant effects
Chromium (Cr)	mg/l	0.05	<0.007	
Copper (Cu)	mg/l	2	<0.005	
Nickel (Ni)	mg/l	0.07	<0.005	
Zinc (Zn)	mg/l	5	<0.005	
Cadmium (Cd)	mg/l	0.003	<0.005	
Lead (Pb)	mg/l	0.01	<0.009	
Turbidity	NTU	1	124	Disinfection compromised, serious secondary health effects common if bacteria is present
Total hardness	mg $CaCO_3$/l	-	298	Insignificant effects
Total organic carbon (TOC)	mg/l	10	8.47	
Langelier Saturation Index	LSI	-	0.70	

Test Report

Client:	Groundwater Abstract Pty Ltd GWA	**Date of report:**	01 March 2024
Address:	828 20th Avenue , Rietfontein, Pretoria, 0084	**Date accepted:**	23 February 2024
Report no:	177624	**Date completed:**	01 March 2024
Project:	Lawley	**Date received:**	23 February 2024

					Uncertainty of measure-ment %	SANS 241-1:2015	
Lab no:							41671
Date sampled:							21-Feb-24
Aquatico sampled:							No
Sample type:							Water
Locality description:							CZN08U
		Analyses	**Unit**	**Method**			
A	AQL	pH @ 25°C	pH	ALM 20	4.23	5 - 9.7	8.14
A	AQL	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	9.52	< 170	127
A	AQL	Total dissolved solids (TDS)	mg/l	ALM 26		< 1200	731
A	AQL	Total Alkalinity	mg $CaCO_3$/l	ALM 01	10.41		649
A	AQL	Chloride (Cl)	mg/l	ALM 02	11.39	< 300	28.0
A	AQL	Sulphate (SO_4)	mg/l	ALM 03	8.45	< 500	1.61
A	AQL	Nitrate (NO_3) as N	mg/l	ALM 06	9.85	< 11	0.359
A	AQL	Total oxidised nitrogen as N	mg/l	ALM 06	9.85		0.359
A	AQL	Ammonium (NH_4) as N	mg/l	ALM 05	8.59	< 1.5	49.9
A	AQL	Fluoride (F)	mg/l	ALM 08	10.11	< 1.5	0.428
A	AQL	Calcium (Ca)	mg/l	ALM 30	7.65		59.8
A	AQL	Magnesium (Mg)	mg/l	ALM 30	7.65		36.0
A	AQL	Sodium (Na)	mg/l	ALM 30	6.94	< 200	58.6
A	AQL	Potassium (K)	mg/l	ALM 30	10.47		17.6
A	AQL	Aluminium (Al)	mg/l	ALM 31	8.59	< 0.3	<0.002
A	AQL	Iron (Fe)	mg/l	ALM 31	7.97	< 0.3	0.844
A	AQL	Manganese (Mn)	mg/l	ALM 31	8	< 0.1	0.360
A	AQL	Chromium (Cr)	mg/l	ALM 31	7.61	< 0.05	<0.003
A	AQL	Copper (Cu)	mg/l	ALM 31	4.55	< 2	<0.002
A	AQL	Nickel (Ni)	mg/l	ALM 31	7.56	< 0.07	<0.002
A	AQL	Zinc (Zn)	mg/l	ALM 31	9.31	< 5	<0.002
A	AQL	Cadmium (Cd)	mg/l	ALM 31	7.89	< 0.003	<0.002
A	AQL	Lead (Pb)	mg/l	ALM 31	8.85	< 0.01	<0.004
A	AQL	Turbidity	NTU	ALM 21	5.9	< 1	124
A	AQL	Total hardness	mg $CaCO_3$/l	ALM 26			298

A = Accredited N = Non accredited Sub = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report ; Results relate only to the items received and tested ; Results reported against the limit of detection; Results marked 'Non SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory; Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation; The report shall not be reproduced except in full without approval of the laboratory

aquatico
Laboratories (Pty). Ltd.

Client: Groundwater Abstract Pty Ltd GWA
Address: 828 20th Avenue , Rietfontein, Pretoria, 0084
Report no: 177624
Project: Lawley

Date of report: 01 March 2024
Date accepted: 23 February 2024
Date completed: 01 March 2024
Date received: 23 February 2024

					Uncertainty of measure-ment %	SANS 241-1:2015	
Lab no:							41671
Date sampled:							21-Feb-24
Aquatico sampled:							No
Sample type:							Water
Locality description:							CZN08U
		Analyses	**Unit**	**Method**			
A	AQL	Total organic carbon (TOC)	mg/l	ALM 63	6.46	< 10	8.47
A	AQL	Langelier Saturation Index	LSI	ALM 26			0.70

A = Accredited N = Non accredited Sub = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report ; Results relate only to the items received and tested ; Results reported against the limit of detection; Results marked 'Non SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory; Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation; The report shall not be reproduced except in full without approval of the laboratory

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