DHS GROUNDWATER
CONSULTING SERVICES

WATER USE LICENCE APPLICATION

Geohydrological Assessment

12 October 2022

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DHS GROUNDWATER CONSULTING SERVICES

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Report: DHS-22-192_W1

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Main Authors Resume

Divan Stroebel is a SACNASP registered and active member of the Groundwater Division, the Geological Society of South Africa, hydrogeologist and professional geoscientist with more than 16 years of industry experience. He obtained his B.Sc. (Geology) degree in 2005 and his B.Sc. Honours (Geology) degree in 2006 from Stellenbosch University. From 2007, he worked throughout Africa as an exploration geologist in base metal, iron ore and gold exploration. In 2009 he joined a hydrogeological consultancy and completed additional groundwater modules at the Institute for Groundwater Studies (IGS), University of Free State. He was employed by mining giant, Rio Tinto in 2010 in Guinea as a Geologist, after which he was the Superintendent Geologist at Goldfields' Kloof mine from 2012. He joined AEON at the Nelson Mandela University (NMU) in 2014 as Associate Research Manager for the Karoo Shale Gas Research Programme- focused on Karoo hydrogeology.

Divan's technical experience includes all aspects of mineral exploration, extraction and reserve management as well as hydrogeological assessments, aquifer characterisation, groundwater supply development, groundwater and surface water characterisation and monitoring as well as water quality assessments.

Divan is very active in the hydrogeological community and has attended, presented at and co-organised numerous water-research workshops and conferences. In June 2016, he was appointed as a visiting researcher at Queen's University, Belfast. In China (2017), he successfully completed an international training programme on the Sustainable Development of Water Resources in Arid Regions for Developing Countries.

During his time at AEON, Divan researched the Groundwater Hydrochemistry and Aquifer Connectivity Baseline of the Eastern Cape Karoo. In anticipation of the controversial hydraulic fracturing planned for the Eastern Cape, he has obtained unique experience in the determination of salinity, aquifer yields and groundwater levels of the Karoo's scarce groundwater resources and has published an article in a special publication by the Geological Society of London on fractured aquifers on the topic. https://sp.lyellcollection.org/content/479/1/129

Divan is the founder and owner of DHS Groundwater Consulting Services and leads the team as principal hydrogeologist, overseeing all projects from inception to completion.

Declaration of Consultants Independence

I consider myself bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP);

• At the time of conducting the study and compiling this report I did not have any interest, hidden or otherwise, in the proposed development that this study has reference to, except for financial compensation for work done in a professional capacity;

• Work performed for this study was done in an objective manner. Even if this study results in views and findings that are not favourable to the client/applicant, I will not be affected in any manner by the outcome of any environmental process of which this report may form a part, other than being members of the general public;

• I declare that there are no circumstances that may compromise my objectivity in performing this specialist investigation. I do not necessarily object to or endorse any proposed developments, but aim to present facts, findings and recommendations based on relevant professional experience and scientific data;

• I do not have any influence over decisions made by the governing authorities;

• I undertake to disclose 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 a competent authority to such a relevant authority and the applicant;

• I have the necessary qualifications and guidance from professional experts in conducting specialist reports relevant to this application, including knowledge of the relevant Act, regulations and any guidelines that have relevance to the proposed activity;

• This document and all information contained herein is and will remain the intellectual property of DHS Groundwater Consulting (Pty) Ltd. This document, in its entirety or any portion thereof, may not be altered in any manner or form, for any purpose without the specific and written consent of the specialist investigators.

• All the particulars furnished by me in this document are true and correct.

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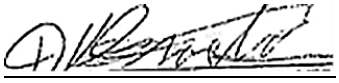

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Executive Summary

Wisteria Boerdery (Pty) Ltd will be using groundwater for the irrigation of citrus orchards and other crops on Land Parcel 50 (Portions 6 and 8), hereafter also referred to as the site. Groundwater will be abstracted from a borehole with volumes exceeding General Authorisation (GA) and therefore the water use needs to be licensed. Wisteria Boerdery (Pty) Ltd therefore appointed DHS Groundwater Consulting Services (Pty) Ltd to conduct a geohydrological assessment as part of the Water Use License Application (WULA).

The most important findings of the assessment are summarised in the following table:

Geohydrological Characteristics	Land Parcel 50
Geology:	Enon and Kirkwood Formations of the Uitenhage Group. The Enon conglomerates are overlain by Kirkwood Formation mudstone and sandstone and both overlain by river gravel terraces. The regional scale Gamtoos fault (trending northwest-southeast) is located to the north of the site.
Aquifer Types:	Hard rock/Secondary fractured aquifers.
Aquifer Classification:	Major Aquifer System
Borehole Yield:	17.44 L/s
Depth to Water Table:	5.20 meters below ground level
Groundwater Quality:	EC, Chloride, Sodium, Sulphate, Iron and Manganese do not comply with the (SANS 241-1:2015, edition 2) drinking water standards. TDS of 2020 mg/l.
Regional Groundwater Use:	Agriculture (Irrigation & stock watering)
Mean Annual Rainfall:	555 mm/a
Recharge:	25 - 37 mm/a (4.5% - 6.7% of MAP)
Groundwater available for abstraction from GRU:	0.055 Mm^3/a

Geohydrological Characteristics	Land Parcel 50
Cumulative sustainable yield from tested borehole(s):	0.550 Mm^3/a
Recommended volume to be applied for:	0.0432 Mm^3/a

Based on the field work, interpretation of available and newly acquired data, the abstraction of groundwater from the site will have an overall "negligible – negative" impact on the investigated geohydrological environment after implementation of appropriate mitigation measures. During the rating and ranking procedure of impacts, all identified impacts could be countered by appropriate mitigation.

Based on the water balance results, it is recommended to apply for an allocation of 0.0432 Mm^3/annum which places the application in Category B (medium scale abstractions 60-100% recharge to the GRU). The tested borehole will be able to supply 100% of the recommended volume applied for.

From a water quality point of view, elevated Electrical Conductivity, Chloride, Sodium, Sulphate, Iron and Manganese exceeding SANS241 drinking water limits were reported in the borehole located within the site. One of the boreholes located outside the site has elevated Iron whilst another has elevated Iron and Manganese. Due to these elevated concentration levels exceeding SANS241 drinking water limits, the water is not fit for human consumption.

It is the assessor's professional opinion that adequate information was available to appropriately assess the impact of groundwater abstraction from the production borehole on the geohydrological environment. Based on the results, it is recommended that the application be approved. It is however imperative that the applicant implements the proposed "Environmental Management & Groundwater Monitoring Program". Production boreholes should be equipped as follow:

- Installation of a 32 mm LDPE observation pipe from the pump depth to the surface, open at the bottom. This allows for a 'window' of access down the borehole which enables manual water level monitoring and can house an electronic water level logger if required.
- Installation of a sampling tap (to monitor water quality).
- Installation of a flow volume meter (to monitor abstraction rates and volumes).
- The appropriate borehole pump must be installed, i.e., not an over-sized pump that is choked with a gate valve. If the monitoring shows that more water can be abstracted, then duty cycles (i.e., the duration of pumping time) may be increased, and not the flow rate.

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List of Abbreviations

Term	Definition
%	Percentage
CDT	Constant Discharge Test
CFU	Colony Forming Unit
DEA	Department of Environmental Affairs
DRO	Diesel Range Organics
DWAF	Department of Water Affairs & Forestry
DWS	Department of Water & Sanitation
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Program
EWR	Ecological Water Requirement
GA	General Authorisation
GMA	Groundwater Management Area
GMU	Groundwater Management Unit
GQM	Groundwater Quality Management
GRDM	Groundwater Resource Directed Measures
GRO	Gasoline Range Organics
GRU	Groundwater Resource Unit
Ha	Hectare
K	Hydraulic Conductivity
km	Kilometre
km^2	Square Kilometre
l/h	litres/hour
l/s	litres/second
LDPE	Low density polyethylene
M	meter
m/d	Meters per day
m^3	Cubic Meters

Term	Definition
m^3/a	Cubic Meters/annum
$m^3/ha/a$	Cubic Meters/hectare/annum
mamsl	meters above mean sea level
mbcl	meters below casing level
mbgl	meters below ground level
ML/d	Mega Litre/day
mm/a	Millimetres/annum
Mm^3/a	Million Cubic Meters/annum
mS/m	Millisiemens per meter
NEMA	National Environmental Management Act
NGA	National Groundwater Archive
nm	not measured
NTU	Nephelometric Turbidity Units
NWA	National Water Act
^oC	Degrees Centigrade
SABS	South African Bureau of Standards
SANAS	South African National Accreditation System
SANS	South African National Standards
SWL	Static water level
T	Transmissivity
TMG	Table Mountain Group
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
WARMS	Water Use Authorization & Registration Management System
WRC	Water Research Commission
WULA	Water Use Licence Application

1 Introduction

Wisteria Boerdery (Pty) Ltd will be using groundwater for the irrigation of citrus orchards and other crops on Land Parcel 50 (Portions 6 and 8), hereafter also referred to as the site. Groundwater will be abstracted from a borehole with volumes exceeding General Authorisation (GA) and therefore the water use needs to be licensed. Wisteria Boerdery (Pty) Ltd therefore appointed DHS Groundwater Consulting Services (Pty) to conduct a geohydrological assessment as part of the Water Use License Application (WULA).

1.1 Site Location

The site is located on Land Parcel 50, located approximately 9.5km north-west of the town of Patensie, within the Eastern Cape Province. It covers an area of approximately 53.24 ha (Map 1, Appendix A).

1.2 Topography and Drainage

The site is located in quaternary catchment L90A within the Mzimvubu to Tsitsikamma Water Management Area (WMA). The site is drained by the Gamtoos River flowing in a south easterly direction. The topography on site can be described as follow:

- The northern portion of the site drains in a southern direction towards the Gamtoos River. The highest point of the water divide being ~300 mamsl.
- The western portion of the site drains in an easternly direction towards the Gamtoos River. The highest point of the water divide being ~135 mamsl.
- Once the drainage has reached the lowest point within the central portion of the site (~60 mamsl), the site drains in a south easterly direction in the Gamtoos River towards the Indian Ocean.

1.3 Climate

The weather is mild without extreme conditions with an average summer temperature of 22.1°C and a winter temperature of 14.02°C. The autumn months of March, April and May receive the lowest average windspeed of 8.83 km/h while the spring months of September, October and November receive the highest average windspeed of 9.88 km/h.

Meteorological data obtained from SamSam Water Climate Tool[1] is presented in Figure 1. Figures of 555 mm for the mean annual precipitation (MAP) and 1654 mm for the mean annual evaporation (MAE) is reported. The MAE exceeds the MAP by an order of magnitude, resulting in a negative moisture index. Rainfall within the study area is bimodal where both summer and winter rainfall occurs, a feature typical of the south-east coastal region of the country.

[1] https://www.worldclim.org/ & Global Aridity Index and Potential Evapotranspiration Climate Database v2

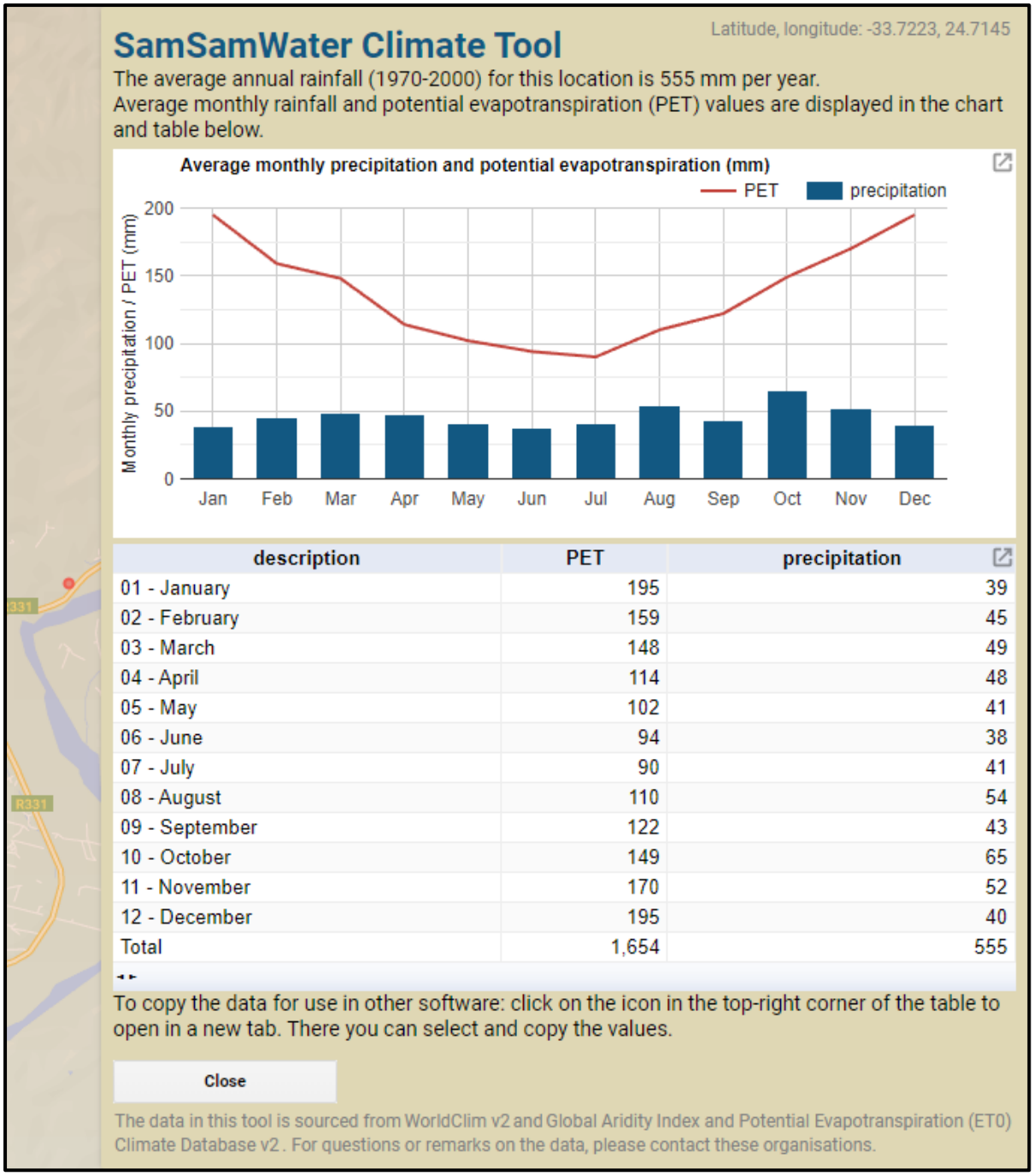

Figure 1. Precipitation and Evapotranspiration within the project area

2 Scope of Work

The objective of this assessment is to:

- Complete a geohydrological characterization of the groundwater in the vicinity of the site;
- Evaluate the proposed production borehole in terms of yield and quality;
- Complete an assessment of the groundwater use in the area by means of a hydrocensus within the Groundwater Resource Unit as a minimum, up to a maximum distance of a 1km radius;
- Perform a Rapid Reserve Determination in support of a Water Use License Application (WULA) in terms of Section 21 of the National Water Act (NWA), 1998 (Act 36 of 1998)[2].
- Evaluate predicted impacts of groundwater abstraction on the receiving geohydrological environment;
- Propose measures to mitigate identified negative impacts;
- Develop a monitoring program as part of an environmental management plan;
- Document the above findings in a format fully compatible with the requirements for a WULA (Appendix 2) which is to be submitted to the Department of Water and Sanitation (DWS).

This report is not intended to be an exhaustive description of the assessment, but rather serves as a specialist geohydrological assessment to evaluate the overall geohydrological character of the site, to inform the impact assessment, and propose mitigation measures where applicable.

3 Methodology

It must be stated that no intrusive groundwater investigations (other than test pumping, groundwater level recording and sampling in existing borehole(s)) were done and reporting is thus based on and limited to observations made during the site visit, test pumping, hydrocensus and the collation of available information. The work completed for the purposes of compiling a geohydrological report comprised the following:

3.1 Desk Study

Undertake a desk study of existing information available from relevant literature, the National Groundwater Archive (NGA)[3], the Water Use Authorization & Registration Management System (WARMS) and published geological and geohydrological maps and reports.

3.2 Site Visit & Hydrocensus

A site visit was conducted to evaluate the geology, geohydrology and potential receptors of possible groundwater impacts (quality and quantity) emanating from groundwater abstraction. A hydrocensus was carried out within the Groundwater Resource Unit as a minimum, up to a maximum distance of a 1km radius to identify legitimate groundwater users, the groundwater potential and quality. Where possible, groundwater levels were also measured to assist in the understanding of groundwater flow within the project area. Water samples were collected from selected boreholes and submitted for analysis of the major ions and trace elements.

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

[3] http://www3.dwa.gov.za/NGANet/Security/WebLoginForm.aspx

3.3 Test Pumping

A seventy-two-hour constant discharge test followed by recovery monitoring was conducted on the proposed production borehole. Test pumping was conducted as per SANS 10299-4:2003 standards[4]. The data was scientifically analysed to calculate the sustainable yield of the tested borehole. Water sample were collected and submitted to an SANAS accredited laboratory for the analysis of the major ions and trace elements.

3.4 Aquifer Vulnerability Assessment

The national scale groundwater vulnerability map, which was developed according to the DRASTIC methodology (DWAF, 2005)[5] and recompiled in 2013 was used to assess the project area in terms of "Aquifer Vulnerability". Aquifer Vulnerability can be defined as *"the likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer".*

3.5 Water Balance & Reserve Determination

The "Reserve" and groundwater available for abstraction was calculated through a "Rapid Reserve Determination" using the "Groundwater Resources Directed Measures" software[6] developed by the former Department of Water Affairs and Forestry (DWAF) as basis.

3.6 Aquifer Characterisation

The aquifer(s) underlying the project area was classified in accordance with "A South African Aquifer System Management Classification"[7] developed by the Water Research Commission and DWAF.

3.7 Impact Assessment

The methodology to determine the significance of the potential impacts of groundwater abstraction was developed in 1995 and has been continually refined to date through the application of it to over 400 Environmental Impact Assessment (EIA) processes. The methodology is broadly consistent to that described in the Environmental Impact Assessment Regulations[8] in terms of the NEMA[9].

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

[5] DWAF, 2005. Groundwater Resources Assessment Project, Phase II (GRAII). Department of Water Affairs and Forestry, Pretoria.

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

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

[8] Environmental Impact Assessment Regulations, 2014 published under Government Notice No. 982 in Government Gazette No. 38282 of 4 December 2014

[9] National Environmental Management Act, 1998 (Act No. 107 of 1998) ("NEMA")

The risk associated with the groundwater abstraction for the property pertains to the operational phase only. Each impact was assessed individually and graded using a numerical system on the following factors:

- Duration
- Extent
- Intensity
- Probability

The values assigned to each factor were used to calculate the significance of each impact. Each individual impact was assessed and re-assessed after the appropriate mitigation was applied.

The "Impact Assessment Methodology" is presented in Appendix C.

3.8 Reporting

A technical report was compiled broadly consistent with applicable sections of the proposed geohydrology template presented in the *"Regulations regarding the Procedural Requirements for Water Use Licence Applications and Appeals.*[10]*".*

4 Regional and Local Geology

Based on the 1:250 000 Geological Series (3324 Port Elizabeth[11]) the site is underlain by the Enon and Kirkwood Formations of the Uitenhage Group (Map 2, Appendix A). The Enon conglomerates are overlain by Kirkwood formation mudstone and sandstone and both overlain by river gravel terraces.

The lithostratigraphy is shown in Table 1.

Table 1. Lithostratigraphy of underlying geology

Group	Formation	Lithology
Uitenhage	Kirkwood (J-Kk)	Reddish & Greenish Mudstone, Sandstone.
	Enon (Je)	Conglomerate, subordinate Sandstone, Mudstone.
Quaternary		Alluvial & Fluvial sheet gravel and sand.

[10] Regulations regarding the Procedural Requirements for Water Use Licence Applications and Appeals. (Gazette No. 40713, GoR. 267, 24 March 2017)

[11] 1:250 000 Geological Map (3324 Port Elizabeth). Geological Survey, 1986.

5 Regional Geohydrology

Both the lithology and structural geology have a major bearing on the groundwater potential of the area. In their pristine state, the consolidated geological units have negligible groundwater potential. It is the secondary structural features that give the units groundwater potential. These secondary structures are usually associated with faults, fractures and weathering which give rise to discrete zones of secondary permeability.

Unless otherwise stated, the published 1:500 000 General Hydrogeological Map[12] and associated explanatory booklet[13] were used as basis to describe the regional geohydrological conditions.

5.1 Aquifer Types and Borehole Yields

The study area is underlain by both a shallow primary alluvial aquifer along the floodplain of the Gamtoos River and a deeper secondary fractured rock aquifer occurring within the conglomerates and sandstone of the Enon- and Kirkwood Formation.

The Uitenhage beds are described as a dense mass of rock with low permeability and limited groundwater potential. A borehole yield analysis indicates that close to 40% of successful boreholes yield less than 0.5 l/s. This does not account for unsuccessful boreholes which were destroyed or backfilled, which makes the success rate even worse.

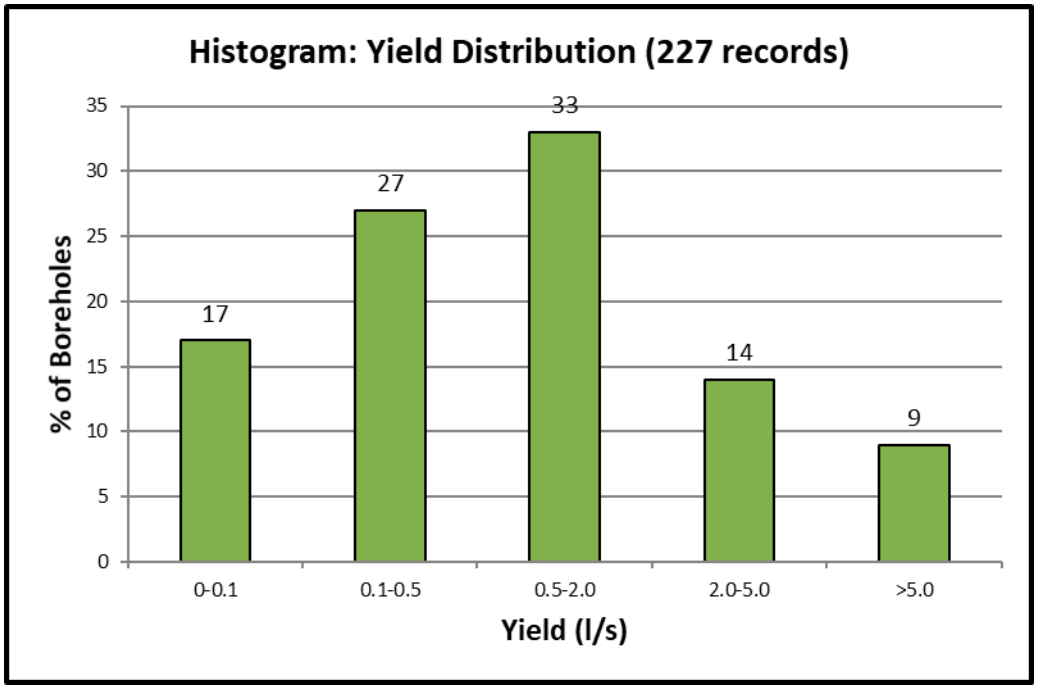


Figure 2. Yield Frequencies of borehole in the Uitenhage Group

Higher borehole yields are not uncommon, with yields of 2-5 l/s and >5 l/s (14% and 9% of borehole yields on record respectively) being reported, but this is not the norm.

[12] 1:500 000 General Hydrogeological Map, Port Elizabeth 3324 (1998)

[13] MEYER, P S (1998). An explanation of the 1:500 000 General Hydrogeological Map Port Elizabeth 3324. Department of Water Affairs and Forestry, Pretoria.

Based on the 1:500 000 Hydrogeological Map, the primary alluvial aquifers within the buried gravel terraces of the Gamtoos River have a yield potential of 0.5-2.0 l/s, while the yield potential of the fractured rock aquifer within the Enon conglomerates and Kirkwood sandstone is reported to be as low as 0 – 0.1 l/s.

5.2 Depth to Groundwater

The static groundwater level generally occurs between 31 and 40m below surface[14].

5.3 Groundwater Recharge and Baseflow

The study area falls within quaternary catchment L90A. The mean annual precipitation and annual recharge figures for the study area is presented in Table 2. Vegter's (1995)[15] recharge and baseflow maps were used to obtain a first estimate of regional recharge and groundwater contribution to rivers and streams (baseflow).

Table 2. Regional Rainfall, Recharge and Baseflow

Mean Annual Precipitation (mm):	555
Annual Recharge (mm):	25 – 37
Percentage Recharge of MAP:	4.5% - 6.7%
Annual Baseflow (mm):	0 – 10
Percentage Baseflow of MAP:	0.0% - 1.8%

5.4 Groundwater Quality

Groundwater with Electrical Conductivity (EC) readings in the range of 150-370 mS/m is common. Sodium, calcium, magnesium, chloride and, occasionally sulphate often exceed maximum permissible drinking water limits (SANS 241-1:2015).

5.5 Aquifer Vulnerability

The national scale Groundwater Vulnerability Map, which was developed according to the DRASTIC methodology (DWAF, 2005) and recompiled in 2013 was used to assess the aquifers underlying the site in terms of "Aquifer Vulnerability". Aquifer Vulnerability can be defined as *"the likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer"*.

The DRASTIC method takes into account the following factors:

- D = depth to groundwater (5)
- R = recharge (4)
- A = aquifer media (3)
- S = soil type (2)

[14] DWA (Department of Water Affairs). (2005.). Groundwater Resource Assessment II

[15] Vegter, J.R. (1995). An explanation of a set of national groundwater maps; WRC Report No. TT 74/95. Water Research Commission, Pretoria.

- T = topography (1)
- I = impact of the vadose zone (5)
- C = conductivity (hydraulic) (3)

The number indicated in parenthesis at the end of each factor description is the weighting or relative importance of that factor.

Aquifer Vulnerability is rated as follows:

Green represents the least vulnerable region that is only vulnerable to conservative pollutants in the long term when continuously discharged or leached
Yellow represents the moderately vulnerable region, which is vulnerable to some pollutants, but only when continuously discharged or leached.
Red represents the most vulnerable aquifer region, which is vulnerable to many pollutants except those strongly absorbed or readily transformed in many pollution scenarios.

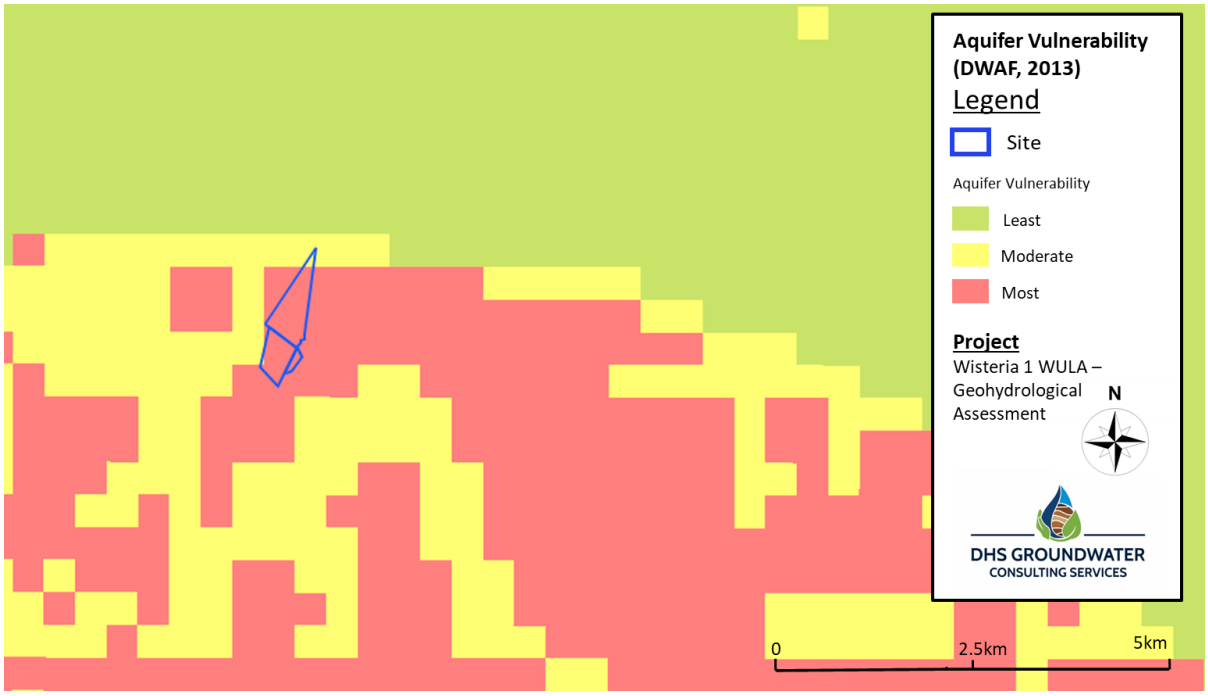


Figure 3. Regional groundwater vulnerability for the study area (DWAF, 2013).

The vulnerability of the aquifers within the project area is rated as “moderately to most vulnerable to pollutants”.

6 Delineation of the Groundwater Resource Unit

A "Geohydrological Response Unit" (GRU), also referred to as a "Groundwater Resource Unit", is defined as a groundwater system that has been delineated or grouped into a single significant water resource based on one or more characteristics that are similar across that unit. Criteria to map a GRU would include:

1. Areas of similar geology;
2. Groundwater elevations generally mimic surface topography, and groundwater flows from higher lying ground towards lower lying springs or valleys (drainage lines), therefore surface water catchment boundaries may be used as surrogate for groundwater divides;
3. Rivers/Streams acting as a constant head boundary;
4. Impermeable dykes/lineaments acting as no-flow boundaries; and lastly
5. Expert judgement and interpretation.

For this study area there are clear drainage features that enable the definition of a more localised aquifer (i.e., a GRU). It is important to note that the Gamtoos River was not used as a boundary. The Gamtoos River can be considered as a gaining river being partially fed from the alluvial aquifer within the floodplain through which it flows. There is also a distinct difference in water quality from the alluvial aquifer (very high salinity) and the deeper fractured aquifer (low salinity) from which the production borehole at the site draws water which strongly suggests that these two systems are not hydraulically linked. The borehole on site was specifically constructed to seal off the alluvial aquifer containing inferior water quality.

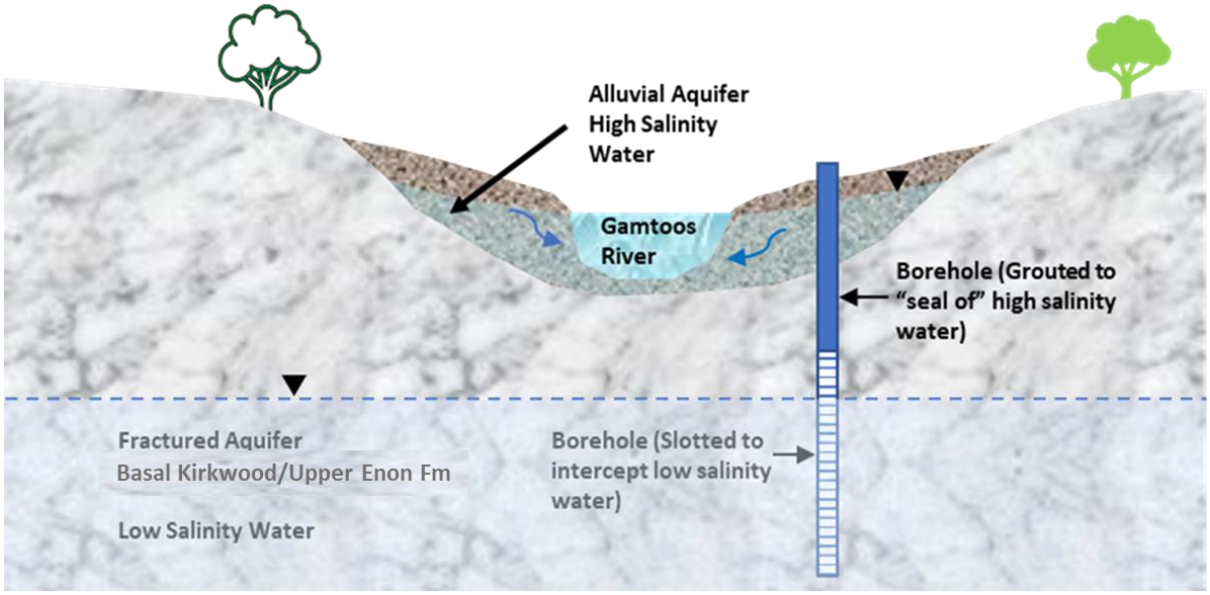


Figure 4. Conceptual model indicating the alluvial aquifer and deeper fractured aquifer

The GRU has been defined as follow:

- The Gamtoos Fault was used as the northern "no-flow" boundary;
- The eastern, western and southern boundaries were defined by topographic highs.

The mapped GRU covers a total area of 530 ha and is indicated in Maps 2 & 3, Appendix 1.

7 Site Specific Assessment

7.1 Existing Groundwater Information

7.1.1 National Groundwater Archive

A desktop hydrocensus was carried out within the GMU as a minimum, but it extended to at least a one-kilometre search radius around the site boundaries. This was done to determine groundwater use in the area. A search of the National Groundwater Archive (NGA), which provides data on borehole positions, groundwater chemistry and yield, when available, was carried out to identify proximal boreholes. These sites are then typically verified in the field and provide background information on the area, should they exist.

Under circumstances where the coordinate accuracy of most of the boreholes enumerated in the NGA is not better than 10 000 m, their positions are at least constrained to the boundaries of the topocadastral farms on which they are located. The associated geohydrological data and information therefore provides only a broad overview of groundwater conditions rather than site-specific information.

A search of the NGA produced zero boreholes within a 1km radius from the site. The search radius was extended to 5km and 7 boreholes were identified. A further 34 dug wells were identified within a 5km radius of the site. A summary of the borehole data contained in the data base is presented in

Table 3. The regional locations of the boreholes were not plotted due to inaccurate and multiple duplicated coordinates.

Borehole yields extracted from the NGA data is slightly lower than the expected yields as given in the Port Elizabeth Hydrogeological Map (section 5.1). This can probably be attributed to the fact that boreholes were not necessarily drilled into the same geological formations and not scientifically sited. The median static water levels are in accordance with published regional data.

Table 3. Summary of data contained in the NGA

BH Id	Latitude	Longitude	Water Use	BH Depth (m)	SWL (mbgl)	Yield (L/s)
3324DA00010	-33.69072	24.73007		136.80	74.00	0.5
3324DB00017	-33.74239	24.74951		174.00	19.00	0.5
EC/L90/0035	-33.74370	24.67114				
EC/L90/0036	-33.74247	24.67223				
EC/L90/0037	-33.74541	24.67206				
EC/L90/0038	-33.74480	24.67343				
EC/L90/0039	-33.74427	24.67229				
			n	2	2	2
			Min	136.8	19	0.5
			Max	174	74	0.5
			Median	155.4	46.5	0.5

7.1.2 Water Use Authorization & Registration Management System (WARMS)

WARMS data (updated 20 September 2022) was acquired for the study area to establish the volume of lawful groundwater use within the GRU. One registered groundwater users were listed within the delineated GRU.

7.2 Hydrocensus

A hydrocensus was conducted from 28 July 2022 to 04 August 2022 to establish groundwater use within the larger project area. The hydrocensus extended to a maximum distance of ~1km from the site boundaries, except where a river or a surface water body exist. The hydrocensus did not extend past such a feature as surface water bodies are usually hydraulically connected to an aquifer, act as a constant-head boundary and a groundwater pollution plume or cone of depression would theoretically not extend past a constant head boundary. Any information pertaining to the abstraction, yield and quality of groundwater was sought.

Apart from the one existing borehole located within the site boundaries, an additional 8 boreholes were identified on neighbouring properties.

A summary of the most important data pertaining to the boreholes are summarised in Table 4. The borehole locations are presented in Map 4 in Appendix 1.

From the hydrocensus data it can be concluded that there is an increasing number of groundwater users within the GRU and where groundwater is abstracted, it is mainly used for agricultural purposes (irrigation watering). High EC values often exceeding the SANS drinking water standards limits the water use for agricultural purposes.

The reported yields obtained from the hydrocensus are not in accordance with the Port Elizabeth Hydrogeological Map. As mentioned above, this could be due to boreholes drilled into different geological formations and/or not scientifically sited.

Apart from limited seasonal fluctuations in groundwater levels (<10%, based on previous experience in similar geology and rainfall), groundwater yields will remain consistent, irrespective of the season. The groundwater information can therefore be gathered indeterminate of the season.

Table 4. Details of boreholes located on neighbouring properties

BH nr	Coordinates Decimal Degrees (WGS84)	Depth (m)	Estimated Yield (l/s)	EC (mS/m)	Static water level (mbgl)	Equipment	Water Use	Property Owner (Cell nr.)
GOBH2	S -33.729187 E 024.715503	200	9.44	55.3	~	Submersible	Irrigation	Grewar Oosthuizen (071 607 6850)
JBBH1	S -33.730708 E 024.707146	118	9.03	45.3	~	Submersible	Domestic/ Irrigation	Jansie Booth (076 834 0760)
GKBH1	S -33.718344 E 024.727013	270	3.47	133	~	Submersible	Irrigation	Graham Kok (072 674 9678)

BH nr	Coordinates Decimal Degrees (WGS84)	Depth (m)	Estimated Yield (l/s)	EC (mS/m)	Static water level (mbgl)	Equipment	Water Use	Property Owner (Cell nr.)
MCBH1	S -33.722297 E 024.717655	208	22.22	250	~	Submersible	Irrigation	Marthinus Colesky (084 508 0277)
JSBH1	S -33.732242 E 024.715064	156	13.89	49.6	~	Submersible	Irrigation	Jakoos Scheepers (082 445 8067)
JSBH2	S -33.727998 E 024.710912	111	2.78	276	~	Submersible (Not operational)	~	Jakoos Scheepers (082 445 8067)
HSBH1	S -33.720214 E 024.713161	150	1.39	36.5	~	Submersible	Irrigation	Hardus Scheepers (082 372 7838)
SVJBH1	S -33.722325 E 024.720284	217	5.56	117	~	Submersible	Irrigation	Skip Van Jaarsveld (082 494 6155)

GOBH2

JBBH1

GKBH1

MCBH1

JSBH1

JSBH2

HSBH1

SVJBH1

Figure 5. Borehole photos on neighbouring properties

7.3 Groundwater Flow Direction

Generally, groundwater elevations mimic surface topography, and groundwater flows from higher lying ground towards lower lying springs or valleys (drainage lines). The general groundwater flow direction will thus be in a south-easterly direction along the Gamtoos River.

7.4 Pumptesting

The production borehole was pumptested during August 2022. The pump test was conducted by Welltek Services and the pumptesting data is attached in Appendix 4.

7.4.1 Description of a Pumptest

The efficient operation and utilization of a borehole require insight into and an awareness of its productivity and that of the groundwater resource from which it draws water. This activity, which is also known as pumptest, provides a means of identifying potential constraints on the performance of a borehole and on the exploitation of the groundwater resource.

The following tests were performed on the borehole: (1) Step-Drawdown Test and (2) Constant Discharge Test.

7.4.1.1 Stepped Discharge Test

The purpose of the step drawdown test is to establish the efficiency of a single borehole and to provide preliminary information on the yield of the borehole (both from a quantitative and qualitative perspective). Often the insights gained from the step-test are used in the design and pumping rate of the constant discharge test.

7.4.1.2 Constant Discharge Test

A constant discharge test is performed to assess the productivity of the aquifer according to its response to the abstraction of water. This test entails pumping the borehole at a single pumping rate which is kept constant for an extended period. The test duration in this instance was 48 hours.

7.4.1.3 Recovery Monitoring

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

7.4.2 Results & Data Interpretation

To estimate optimum pumping rates, pumping schedules and aquifer parameters, the pumptesting data were analysed by means of an Excel based software package developed by Van Tonder et al., (2002)[16]. In the software package, the Flow Characteristic method (FC-method), Cooper-Jacob-, FC Non-Linear- and Barker methods were used to estimate a risk-based sustainable yield for the borehole, as well as aquifer parameters such as transmissivity (T) and the storage coefficient (S).

The pumptesting data for the tested borehole and FC-Solutions is presented in Appendix 4. The calculated sustainable yield for the borehole together with the necessary information to equip the borehole is presented in Table 5.

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

Table 5. Management Recommendations for the tested borehole

Borehole nr.	Coordinates (WGS84)		Depth (m)	Static Water Level (m)	#Dynamic WL (m)	Sustainable Yield (l/h) Pumping 24 hours/day	Proposed depth of pump installation (m)	Volume/day (m^3)
	S	E						
BH1	-33.723964°	024.713136°	55	5.20	9	62784	40	1506.82
							Total Volume (m^3/day)	**1506.82**
							Total Volume (Mm^3/annum)	**0.550**

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

The total volume of water which can be abstracted from the tested borehole (0.550 Mm^3/a) should never exceed the calculated water available for abstraction from the GRU. If the cumulative calculated sustainable yield of the tested borehole exceeds the water available for abstraction from the GRU, borehole yields or duty cycles need to be reduced.

7.5 Groundwater Quality

A groundwater sample was collected for analysis of the major ions and trace elements during pumptesting of the production borehole. Two water samples were also collected from boreholes visited during the hydrocensus (GOBH2 & HSBH1). The laboratory reports are presented in Appendix E.

Water quality results were compared with the SABS drinking water standards (SANS 241-1:2015, edition 2)[17] (Table 6). Water is classified unfit for human consumption if the Standard Limits are exceeded. It must be emphasized that although the water use will mainly be used for irrigation purposes, it was compared to drinking water standards which is more stringent than irrigation standards.

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

Table 6. Water quality results compared to SANS 241-1:2015 (edition 2) drinking water standards

Sample Nr.	BH1	HSBH1	GOBH2	Standard Limits
pH	5,9	6,5	7,2	5.0 - 9.7
EC	310	30	64	170
TDS	2020	192	410	1200
T-Alk	29			~
Cl	302,0	72,0	125,0	300
SO_4	1340,0	25,7	24,6	250
NO_3-N	0,00	0,00	0,34	11
NO_2-N	0,02	0,00	0,00	0,9
NH_4-N	0,78			1,5
F	0,00	0,09	0,21	1,5
Ca	282,00	13,50	5,66	~
Mg	146,00	8,53	10,10	~
Na	220,00	45,00	91,00	200
K	12,50	3,30	2,85	~
Fe	55,20	0,40	0,71	0,3
Mn	7,20	0,02	0,46	0,1
B	0,38			2,4
Cu	0,00	0,00	0,00	2
Pb	0,00	0,00	0,00	0,01
Notes				
Yellow = Acceptable				
Exceeds standard limits				
Blank = Not Analysed				
0 = below detection limit of analytical technique				

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

Within the site boundaries, BH1 has elevated EC, Sodium, Chloride, Sulphate, Iron and Manganese concentrations exceeding the SANS241 drinking water standards, thus rendering the borehole unfit for human consumption.

Boreholes HSBH1 and GOBH2 were sampled outside the site boundaries as part of the hydrocensus. These two boreholes share limited similarities with the borehole within the site as they exhibit elevated concentrations of Iron (HSBH1 and GOBH2) and Manganese (GOBH2). The groundwater within both HSBH1 and GOBH2 is unsuitable for human consumption without prior treatment.

Of the three sampled boreholes, none comply with the SANS241 Drinking Water Standards.

The elevated levels of the constituents are likely contributed to the geological formation present and its chemical composition.

8 Reserve Determination & Water Balance

The sustainable volume of groundwater that can be abstracted from the aquifer(s) underlying the site was determined using data from the GRAII and WARMS datasets[14, 18]. Associated information was collated from governmental and open-source datasets[19, 20]. The reserve is taken into account when calculating the volume of water available for abstraction.

The site falls within quaternary catchment L90A and the default values, except where updated information was available, were used in the assessment in order to develop some guidance on the potential impact of the abstraction on the overall groundwater use in the catchment. It must be stated that the results achieved for the quaternary catchment is not necessarily applicable on the delineated Groundwater Resource Unit (GRU) due to compartmentalisation. Geological lineaments may act as no-flow boundaries while rivers/streams may act as constant head boundaries subdividing the quaternary catchments in smaller GRU's with different exploitation potentials. The results of the GRU should rather be considered when allocating a volume of groundwater for abstraction for this specific project.

8.1 Introduction

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

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

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

where:

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

Under the National Water Act (Act No. 36 of 1998) the water use must be authorised. The water will be abstracted from borehole(s), and used for commercial (agriculture/irrigation) purposes. Under these circumstances, the following (ground) water use is recognised as being relevant to the licence application:

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

[18] Department of Water and Sanitation. Section 21(a) of the National Water Act, Taking Water From A Water Resource. DW760 Report. Accessed: 25 April 2022.

[19] Department of Water and Sanitation. Notice 538 of 2016. National Water Act, 1998 (Act No. 36 of 1998). Revision of General Authorisation for the Taking and Storing of Water.

[20] https://wazimap.co.za/ Census Data.

8.2 Water Demand and Abstraction Classification

The calculated recommended groundwater available for abstraction for the site is 0.78 Mm^3/annum. DWS categorises water use licence applications in three categories (presented in Appendix 2) based on the amount of recharge that is used by the applicant in relation to the specified property:

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

8.3 Assessment on Quaternary Level

The property falls within quaternary catchment L90A and the most salient parameters relevant to this catchment is presented in Table 7.

Table 7. Most salient parameters relevant to catchment L90A.

Area km^2	Protected Area (km^2)[18]	GA (m^3/ha/a)[19]	Recharge (Mm^3/a)[14]	Population[20]	Basic Human Need (Mm^3/a)	EWR Baseflow (Mm^3/a)[5]	Reserve (Mm^3/a)[5]	Current use (Mm^3/a)[18]
515.87	0	275	9.142	13 021	0.119	3.963	4.082	0.036

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

8.3.1 Stress Classification

To provide a quantitative means of defining stress, a groundwater stress index was developed by dividing the volume of groundwater abstracted from a groundwater unit by the estimated recharge to that unit.

Stress Index = Abstraction/Recharge

= 0.036/9.142

= 0.0039

The quaternary catchment is classified as Category A, which indicates “unstressed” levels of stress in terms of abstraction/recharge (Table 8).

Table 8. Guideline for determining the level of stress[21]

Present Status Category	Description	Stress Index (abstraction/recharge)
A	Unstressed or slightly stressed	<0.05
B		0.05 - 0.20
C	Moderately Stressed	0.20 – 0.40
D		0.40 – 0.65
E	Highly Stressed	0.65 – 0.95
F	Critically Stressed	>0.95

8.3.2 Reserve & Water available for allocation

The following table summarizes the reserve and water available for abstraction from the quaternary catchment.

Table 9. A summary of the Reserve for quaternary the catchment L90A.

Quantification of Reserve L90A		
Recharge:		
	Recharge **[Mm³/a]**	9.142
Human Need:		
	Population	13 021
	Basic human need **[l/d/p]**	25
minus	Basic human need total **[Mm³/a]**	0.119
Baseflow:		
	Baseflow **[Mm³/a]**	3.962
	Maint. Low flow **[Mm³/a]**	0
minus	EWR **[Mm³/a]**	3.962
Flow:		
minus	Net Flow **[Mm³/a]**	0
Reserve:		
	Reserve as % recharge	44.65
equals	Groundwater allocation **[Mm³/a]**	**5.06**
	Current abstraction **[Mm³/a]**	**0.036**

From Table 9 it becomes evident that the allocatable portion of the quaternary catchment far exceeds the current abstraction.

[21] Groundwater Resources Directed Measures Manual (WRC Report No TT299/07, April 2007)

8.4 Assessment on Groundwater Resource Unit level

If the calculation is based on the GRU delineated for the project using the Groundwater Resources Assessment Project's (2005) range of recharge and baseflow figures, the following emerges:

Table 10. Water Balance within the Groundwater Resource Unit

Area	Surface Area (ha)	Groundwater Recharge to GRU using recharge figure of 9142580 m^3/a
GRU	530	177.22 **$m^3/a/ha$**
Recharge to GRU		93929.099 **m^3/a** 257 **m^3/day** 3.0 **l/second**
Registered Use (WARMS)		0.0 **m^3/a**
RESERVE	Basic Human Need	739.1 **m^3/a**
	Base Flow (EWR)	3963480 **m^3/a** 76.8 **$m^3/h/a$** 40720.0271 **m^3/a**
Groundwater available for abstraction		52470 **m^3/a** 0.052 **Mm^3/a** 143753 **l/day** 1.7 **l/second**
Application (WULA)		0.0432 **Mm^3/a**
WULA as % of Groundwater available in GRU		82.33 **%**

Based on the water balance results, it is recommended to apply for an allocation of 0.0432 Mm^3/annum which places the application in Category B (medium scale abstractions 60-100% recharge to the GRU) see section 8.2. The tested borehole will be able to supply 100% of the applied for volume.

9 Aquifer Classification

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

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

Based on the available information it can be concluded that aquifer system in the study area can be classified as a "Major Aquifer System". The aquifers are highly productive and even used for Municipal supply.

In order to achieve the Groundwater Quality Management Index a point scoring system, as presented in Table 11 and Table 13 below, was used.

Table 11. Ratings for the Aquifer System Management and Second Variable Classifications:

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

The values in Table 11 are naturally subjective, but is based on the aquifer descriptions given previously. The importance of each aquifer should provide guidance on the protection to be assigned to each area.

The level of protection required of a groundwater system depend, amongst other, on the aquifer system classification class and the fractured extent and connectivity of the aquifers. The assumption is that a higher fracture presence results in a higher aquifer connectivity. An aquifer system management index can be derived with the following equation:

Aquifer System Management Index = Aquifer System Management Class x Fracturing

= 3 x 2 = 6

Table 12. Ratings for the Aquifer System Management Index

Aquifer System Management Index	**Level of Protection**	**Study Area**
<1 1 - 3 3 - 6 6 - 10 >10	Limited Low Level Medium Level High Level Strictly Non-Degradation	6

The ratings for the Aquifer System Management Classification and Second Variable Classification (Fracturing) yield an Aquifer System Management Index of 6 for the study area, indicating that a “high” level of groundwater protection is required in terms of prevailing groundwater flow regime management.

Table 13. Ratings for the Groundwater Quality Management (GQM) Classification System:

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

The vulnerability, or the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer, in terms of the above, is classified as medium (section 0). The level of groundwater protection based on the Groundwater Quality Management Classification:

GQM Index = Aquifer System Management x Aquifer Vulnerability

= 3 X 3 = 9

Table 14. GQM index for the study area

GQM Index	Level of Protection	Study Area
<1	Limited	
1 - 3	Low Level	
3 - 6	Medium Level	
6 - 10	High Level	9
>10	Strictly Non-Degradation	

The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a Groundwater Quality Management Index of 9 for the study area, indicating that a “High” level of groundwater protection is required in terms of groundwater quality management.

In terms of DWS’s overarching water quality management objectives which is (1) protection of human health and (2) the protection of the environment, the significance of this aquifer classification is that if any potential risk exists, measures must be triggered to limit the risk to the environment. In this instance it would be the (1) protection of the “Major Aquifer”, (2) the external groundwater users in the area, and (3) maintain baseflow to the Gamtoos River which drains the subject area.

10 Impact Assessment

The risk associated with groundwater abstraction at the site pertains to the operational phase only. The most significant impacts considered as part of the impact assessment is listed below. Each impact was assessed individually and graded using a numerical system to calculate the significance of each impact. Each individual impact was assessed and re-assessed after the appropriate mitigation was applied. A compressive summary of the assessed impacts, mitigation and significance of each impact is listed in the tables below.

10.1.1 Depletion of the groundwater resource due to over-abstraction

Ref:	1			
Project phase	Operation			
Impact	Depletion of the groundwater resource due to over-abstraction			
Description of impact	Over-abstraction of groundwater from boreholes is likely to lead to depletion of the water levels in the area over time. This can cause damage to the aquifer and might impact on neighbouring and registered groundwater users that are reliant on the same source of water. Reduced baseflow to streams/rivers and groundwater dependent eco systems (wetlands).			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	(1) Yield testing of boreholes as per "SANS 10299-4:2003" standards. Do not exceed calculated sustainable yield of boreholes. (2) Groundwater level monitoring - reduce abstraction in the event of anomolous lowering of groundwater levels. (3) Take "Ecological Water Reserve" into account during waterbalance.			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Medium term	Impact will last between 5 and 10 years	Brief	Impact will not last longer than 1 year
Extent	Local	Extending across the site and to nearby settlements	Very limited	Limited to specific isolated parts of the site
Intensity	Moderate	Natural and/ or social functions and/ or processes are moderately altered	Very low	Natural and/ or social functions and/ or processes are slightly altered
Probability	Probable	The impact has occurred here or elsewhere and could therefore occur	Probable	The impact has occurred here or elsewhere and could therefore occur
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	High	The affected environmental will be able to recover from the impact
Resource irreplaceability	Low	The resource is not damaged irreparably or is not scarce	Low	The resource is not damaged irreparably or is not scarce
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance	After the implementation of mitigation measures, the significance of the impact becomes neglegible.			
Cumulative impacts	Since the impact is negligible negative with mitigation, cumulative impacts to groundwater with other projects are not anticipated.			

10.1.2 Groundwater quality deterioration as a result of over-abstraction

Ref:	2			
Project phase	Operation			
Impact	Groundwater quality deterioration as a result of over-abstraction			
Description of impact	Over-abstraction of groundwater from a borehole can potentially draw poorer water quality from the adjacent geohydrological environment into the borehole. This is likely to affect the groundwater quality in the area in general and might affect the supply in other boreholes within the fractured aquifer. Based on data acquired during the desk study and water quality results from boreholes sampled during the hydrocensus, it can be safely assumed that the water quality in the adjacent aquifers are of similar quality.			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	Groundwater level & quality monitoring - reduce abstraction in the event of anomolous lowering of groundwater levels and/or deteriorating water quality.			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Short term	impact will last between 1 and 5 years	Brief	Impact will not last longer than 1 year
Extent	Limited	Limited to the site and its immediate surroundings	Limited	Limited to the site and its immediate surroundings
Intensity	Moderate	Natural and/ or social functions and/ or processes are moderately altered	Negligible	Natural and/ or social functions and/ or processes are negligibly altered
Probability	Probable	The impact has occurred here or elsewhere and could therefore occur	Unlikely	Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	Low	The resource is not damaged irreparably or is not scarce	Low	The resource is not damaged irreparably or is not scarce
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance	After the implementation of mitigation measures, the significance of the impact becomes neglegible.			
Cumulative impacts	Since the impact is negligible negative with mitigation, cumulative impacts to groundwater with other projects are not anticipated.			

11 Environmental Management & Groundwater Monitoring Program

The main objective of the proposed and discussed mitigation measures, pertaining to the identified impacts, is to maintain and monitor the regional groundwater table and quality to:

- Ensure that Schedule 1 water users within the catchment have adequate water supply to sustain the basic human need.
- Ensure that registered groundwater use within the catchment have adequate water supply.
- Ensure that adequate water is available to maintain groundwater dependent ecosystems (baseflow feeding the rivers/streams draining the subject area and wetlands).

A groundwater monitoring program was developed to reach the resource quality objectives. The on-site production borehole needs to be included in the network and are summarised in Table 15 below.

Table 15. Boreholes to be included in Monitoring Network

Borehole(s)	Objective
BH1	Impact Monitoring

Table 16 below presents the parameters and frequency that should form part of the groundwater monitoring program. It is proposed that the data should be captured into an appropriate electronic database for easy retrieval and submission to the relevant authority as required, and reviewed by a geohydrologist on a bi-annual basis to ensure the source is utilised in a sustainable manner.

Table 16. Proposed Monitoring Requirements

Class	Parameter	Frequency	Motivation
Physical	Static groundwater levels	Monthly	Time dependant data is required to understand the regional groundwater flow dynamics. A lowering in the static water levels may indicate that the aquifer is utilised in an unsustainable way and abstraction rates need to be decreased. Conditions of the Water Use Licence.
	Groundwater abstraction volumes	Monthly	Calculate monthly & annual abstraction volumes. Conditions of the Water Use Licence.
Chemical	Major ions and trace elements.	Bi-annually	Changes in chemical and microbial composition may indicate areas of groundwater contamination and be used as an early warning system to implement management/remedial actions. To determine whether the water is fit for the intended use. Conditions of the Water Use Licence.

12 Conclusion & recommendations

Based on the field work, interpretation of available and newly acquired data, the abstraction of groundwater from the site will have an overall "negligible – negative" impact on the investigated geohydrological environment after implementation of appropriate mitigation measures. During the rating and ranking procedure of impacts, all identified impacts could be countered by appropriate mitigation.

Based on the water balance results, it is recommended to apply for an allocation of 0.0432 Mm^3/annum which places the application in Category B (medium scale abstractions 60-100% recharge to the GRU). The tested borehole will be able to supply in 100% of the recommended volume applied for.

From a water quality point of view, elevated Electrical Conductivity, Chloride, Sodium, Sulphate Iron and Manganese exceeding SANS241 drinking water limits were reported in the borehole within the site. One of the boreholes outside the site has elevated Iron while the other borehole has both elevated Iron and Manganese. Due to these elevated concentration levels exceeding SANS241 drinking water limits, the water is not fit for human consumption.

It is the assessor's professional opinion that adequate information was available to appropriately assess the impact of groundwater abstraction from the production borehole on the geohydrological environment. Based on the results, it is recommended that the application be approved. It is however imperative that the applicant implements the proposed "Environmental Management & Groundwater Monitoring Program". Production boreholes should be equipped as follow:

- Installation of a 32 mm LDPE observation pipe from the pump depth to the surface, open at the bottom. This allows for a 'window' of access down the borehole which enables manual water level monitoring and can house an electronic water level logger if required.
- Installation of a sampling tap (to monitor water quality).
- Installation of a flow volume meter (to monitor abstraction rates and volumes).
- The appropriate borehole pump must be installed, i.e., not an over-sized pump that is choked with a gate valve. If the monitoring shows that more water can be abstracted, then duty cycles (i.e., the duration of pumping time) may be increased, and not the flow rate.

Disclaimer: *The calculated sustainable yield of the borehole(s) is based on data acquired during a short-term constant discharge test. The sustainable yield of a borehole may change for various reasons (lower than average rainfall, increased abstraction within the groundwater resource, mine dewatering, unknown geological boundary conditions, etc.). Continuous groundwater monitoring is critical to provide essential data needed to evaluate changes in the resource over time; as well as the long-term sustainability and status of an aquifer. In the event of anomalous groundwater level behaviour, abstraction rates and pumping cycles should be adapted until pre-operational groundwater levels have been reached.*

13 References

1:250 000 Geological Map (3324 Port Elizabeth). Geological Survey, 1986.

1:500 000 General Hydrogeological Map, Port Elizabeth 3324 (1998)

Department of Water and Sanitation. Notice 538 of 2016. National Water Act, 1998 (Act No. 36 of 1998). Revision of General Authorisation for the Taking and Storing of Water.

Department of Water and Sanitation. Section 21(a) of the National Water Act, Taking Water From A Water Resource. DW760 Report. Accessed: 25 April 2022.

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

Department of Water Affairs and Forestry, 1996. South African Water Quality Guidelines (second edition). Volume 1: Domestic Use.

DWA (Department of Water Affairs). (2005.). Groundwater Resource Assessment II

DWAF, 2005. Groundwater Resources Assessment Project, Phase II (GRAII). Department of Water Affairs and Forestry, Pretoria.

Environmental Impact Assessment Regulations, 2014 published under Government Notice No. 982 in Government Gazette No. 38282 of 4 December 2014.

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

Groundwater Resources Directed Measures Manual (WRC Report No TT299/07, April 2007)

http://www3.dwa.gov.za/NGANet/Security/WebLoginForm.aspx

https://crudata.uea.ac.uk/cru/data/hrg/ - CRU CL 2.0 data-set comprises monthly grids of observed mean climate from 1961-1990, and covering the global land surface at a 10 minute spatial resolution for up to 14 observed and computed agroclimatic parameters.

https://dffeportal.environment.gov.za/ Protected Areas Register (PAR).

https://wazimap.co.za/ Census Data.

https://www.worldclim.org/ & Global Aridity Index and Potential Evapotranspiration Climate Database v2

MEYER, P S (1998). An explanation of the 1:500 000 General Hydrogeological Map Port Elizabeth 3324. Department of Water Affairs and Forestry, Pretoria.

National Environmental Management Act, 1998 (Act No. 107 of 1998) (“NEMA”)

Regulations regarding the Procedural Requirements for Water Use Licence Applications and Appeals. (Gazette No. 40713, GoR. 267, 24 March 2017).

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

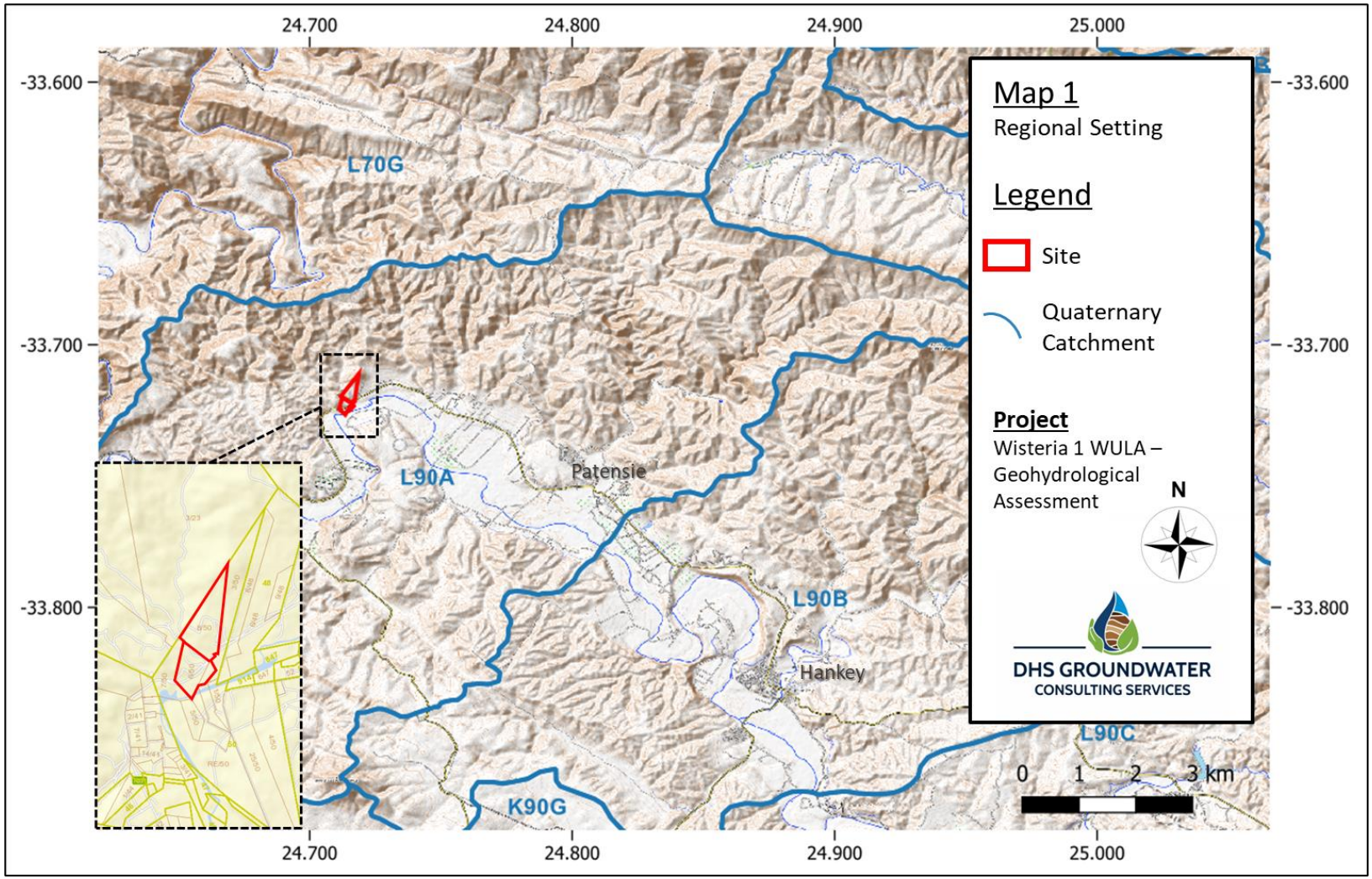
South African National Standard. Development, maintenance and management of groundwater resources. Part 4: Test-pumping of water boreholes (SANS 10299-4:2003, edition 1.1). ISBN 978-0-626-32920-4

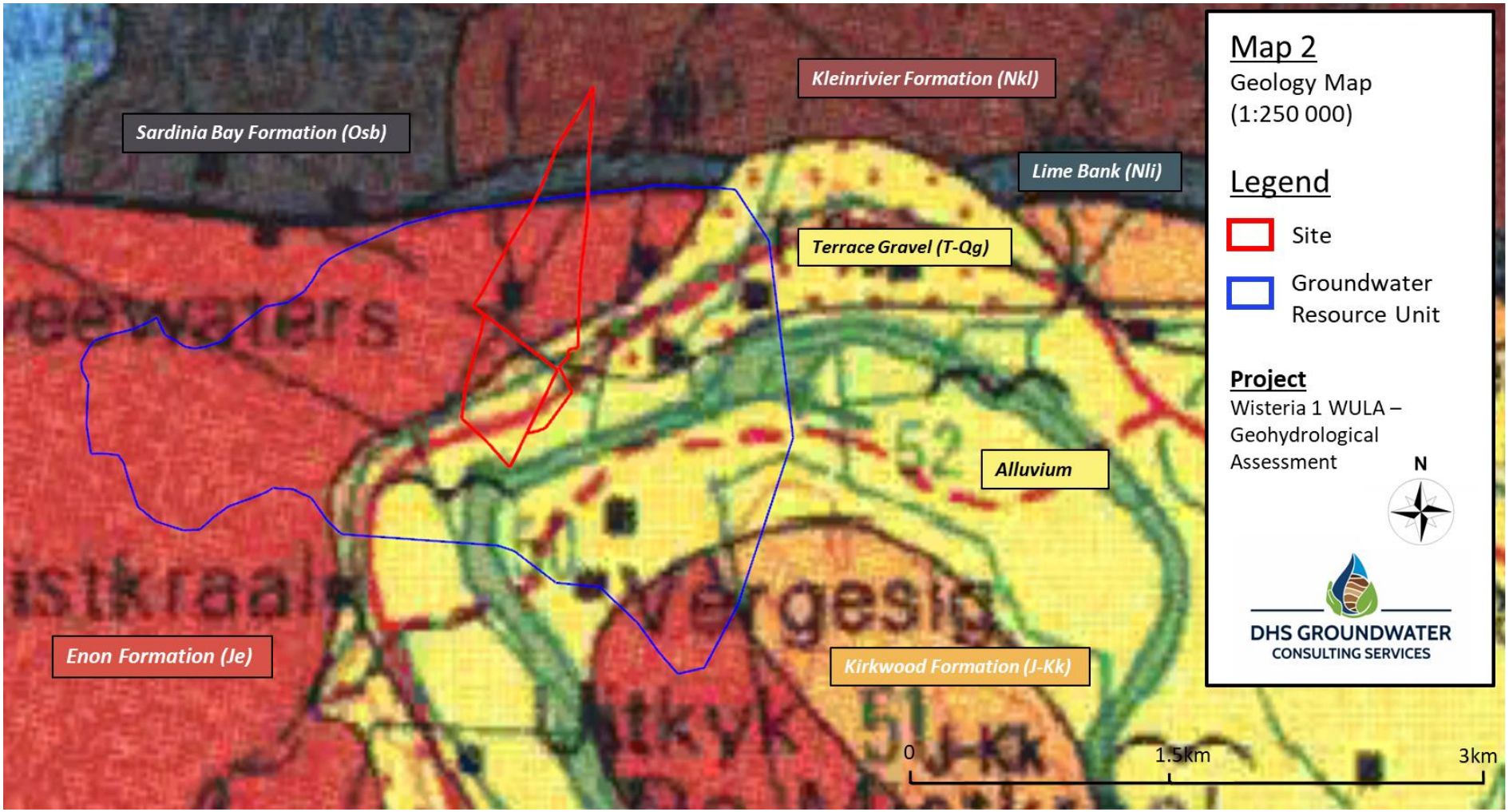
South African National Water Act (Act 36 of 1998)

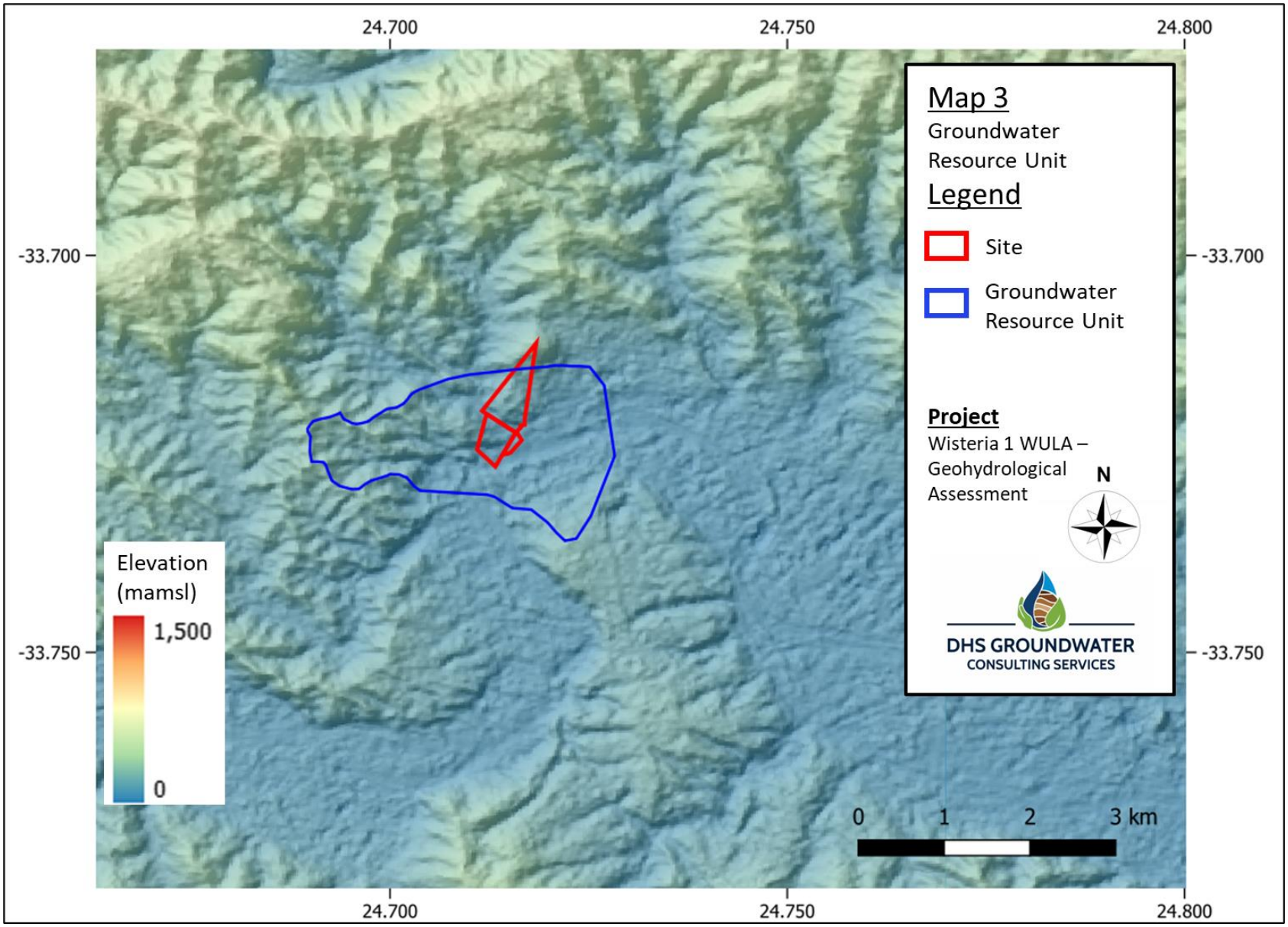
Vegter, J.R. (1995). An explanation of a set of national groundwater maps; WRC Report No. TT 74/95. Water Research Commission, Pretoria

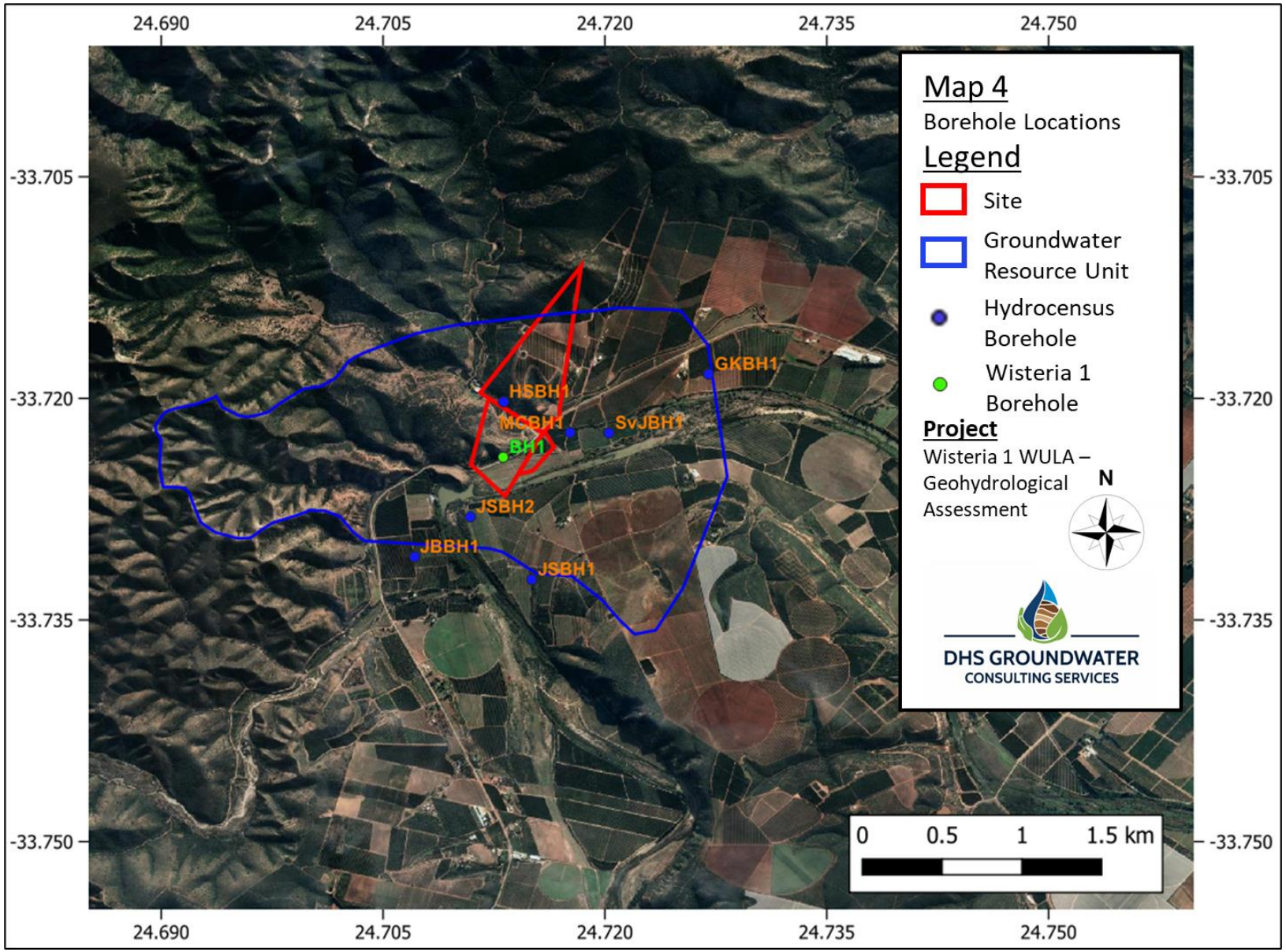
14 Appendices

14.1 Appendix 1: Maps




Kleinrivier Formation (Nkl)
Sardinia Bay Formation (Osb)
Lime Bank (Nli)
Terrace Gravel (T-Qg)
Alluvium
Enon Formation (Je)
Kirkwood Formation (J-Kk)
Map 2
Geology Map
(1:250 000)
Legend
Site
Groundwater Resource Unit
Project
Wisteria 1 WULA – Geohydrological Assessment
N
DHS GROUNDWATER
CONSULTING SERVICES
0
1.5km
3km


24.700
24.750
24.800
-33.700
-33.750
Map 3
Groundwater Resource Unit
Legend
Site
Groundwater Resource Unit
Project
Wisteria 1 WULA – Geohydrological Assessment
N
DHS GROUNDWATER CONSULTING SERVICES
Elevation (mamsl)
1,500
0
0 1 2 3 km


24.690
24.705
24.720
24.735
24.750
-33.705
-33.720
-33.735
-33.750
Map 4
Borehole Locations
Legend
Site
Groundwater Resource Unit
Hydrocensus Borehole
Wisteria 1 Borehole
Project
Wisteria 1 WULA – Geohydrological Assessment
N
DHS GROUNDWATER
CONSULTING SERVICES
HSBH1
MCBH1
BH1
SvJBH1
GKBH1
JSBH2
JBBH1
JSBH1
0
0.5
1
1.5 km

14.2 Appendix 2: DWS Guidelines for Water Use Licence Applications

ANNEXURE B

REQUIREMENTS FOR WATER USE LICENCE APPLICATION: GROUNDWATER ABSTRACTION [S 21 (a)]

The *Initial Regional* assessment is needed to determine the amount of information necessary for each new Water Use licence application for abstraction from groundwater, based on the amount of recharge that is used by the applicant in relation to the specified property.

Categories A, B and C list the information requirements for the licence application, as should be provided by the applicant to the Department of Water Affairs & Forestry.

Regional - Initial

- Size of property ($AREA_{PROP}$)
- Recharge - HP (RE)
- Existing use volume (ABS_{EX})
- New use volume (ABS_{NEW})
- Scale of abstractions (ABS_{SCALE})

CALCULATION

$AREA_{PROP} * RE = RE_{AREA}$ (m^3/a)

$ABS_{EX} + ABS_{NEW} = ABS_{TOTAL}$ (m^3/a)

$ABS_{SCALE} = (ABS_{TOTAL} / RE_{AREA}) * 100$

Please note: The calculation above should be done for each proposed abstraction point (borehole), with the value of "$AREA_{PROP}$" being the area of the relevant aquifer within the property boundaries. The highest value for the relevant property should then be used to calculate the % of recharge as categorized below.

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

The Regional RDM support is info that should be submitted with the request for a Reserve determination. This will not only speed up the process, but also render more confidence to the Reserve determination.

Regional - RDM support

- Delineate resource units (default quaternary, unless geologically different)
- Delineate response units (same as resource unless existing information shows otherwise)
- Drainage (rivers and gauging stations in the resource unit area)
- Climate (average rainfall, reference source)
- Vegter regions (hydrological regions and recharge)
- Geo-hydrology - wq, wl, aquifer tests, main fracture zones – storage, sustainable yield, assurance of supply?
- Aquifer status: Local expert consideration (reference source), natural / impacted (mapping these areas in the resource unit), importance (both socio-economic and strategic), vulnerability, dependent ecosystems, total current use, classification (Parsons and current resource classification system).
- Licensing conditions - wl, wq, level of acceptable degradation?
- Monitoring requirements - according to the Category.
- Site visit necessary to validate all info - regional and applicant

2

Category A

- Volume and purpose of the water required.
- Detail borehole census on the property in question. Information to be collected should include pump depth / borehole depth, depth to water level, yield of the borehole, volume abstracted (daily, weekly, monthly).
- Proximity to surface water discharges (springs, seeps, wetlands streams, rivers, lakes) and groundwater dependant ecosystems.
- Geo-referenced map of the property in question, with boreholes, physical structures (houses, stores, irrigation equipment) and current pollution sources (septic tanks, pit latrines, petrol/diesel tanks, irrigation areas) depicted.
- Monitoring programme - monthly water levels, monthly rainfall.

Category B

- Geology of the area / borehole?
- Volume and purpose of the water required.
- Detail borehole census within a 1km width zone around the property in question as well as on the property itself. Information to be collected should at least include pump installation/ borehole depth, depth to water level, yield of the borehole, volume abstracted (daily, weekly, monthly), water quality (one macro analysis per property).
- Proximity to surface water discharges (springs, seeps, wetlands streams, rivers, lakes) and groundwater dependant ecosystems.
- Geo-referenced map of the property in question, with boreholes, surface water features, physical structures (houses, stores, irrigation equipment) and current pollution sources (septic tanks, pit latrines, petrol/ diesel tanks irrigation areas) depicted.
- Contact details of relevant parties in the hydro census area.
- Potential impacts of potential use on groundwater and surface water quality.
- Monitoring programme - weekly water levels, weekly rainfall, 6 monthly macro analysis and surface water discharges in the 1km width zone.

Category C

- A geo-hydrological report compiled by an acceptable and qualified geo-hydrological consultant. Report should include appropriate maps, tables and figures to support the conclusions and recommendations.
- Detail geology of the area, including structures, maps etc.
- Detail borehole census within at least 1km width zone around the area of recharge as well as on the area itself. Information to be collected for each borehole should at least include pump installation depth, borehole depth, depth of water level, yield of the borehole, depth of water strike(s), volume abstracted (daily, weekly, monthly) and water quality (one macro analysis per property in the zone).
- Aquifer description and characteristics including extent of the aquifer and hydraulic properties (storativity and transmissivity). This would require testing. Drilling might or might not be required. Groundwater piezometric contour map showing flow direction and a depth to water level contour map.

- Effective annual recharge on this property and the safe yield of the aquifer.
- Volume and purpose of the water required and the volume available for abstraction. A water balance that at least cover the aquifer unit in which the property is located should, in other words, is done that includes all gains and losses.
- Contact details of relevant parties in the hydro census area.
- Impact the abstraction will have on existing users and surrounding properties. This should be short- and long-term impact. This might have to be supported by a numerical model.
- Proximity to and potential impact of the abstraction on surface water discharges and groundwater dependant terrestrial ecosystems.
- Potential impact of potential use on groundwater and surface water quality.
- Geo-referenced map of the property in question, with boreholes, surface water features, geological features, physical structures (houses, stores, irrigation equipment) and current pollution sources (septic tanks, pit latrines, petrol/ diesel tanks, irrigation areas) depicted.
- Monitoring programme - weekly water levels, weekly rainfall, 3 monthly macro analysis and surface water discharges and 6 monthly qualities in the 1km width zone.

The Department of Water Affairs and Forestry recommends that the following measures be taken when testing bore holes for sustainable yields and to provide the following information:

- Refer to test procedures in the South African National Standards Code No.: SANS 10299.
- Perform a three (3) hour stepped draw down test to determine the discharge rate of the intended constant rate test OR;
- The constant discharge test should be done at approximately $^{2}/_{3}$ of the blow yield of the bore hole.
- For **HOUSEHOLD** use it as recommended that a 8 hour constant rate test be performed with the draw down and the recovery measured.
- For **IRRIGATION** it as recommended that a 24 constant rate test should be performed while the draw down and the recovery is measured. This test could also be performed for intended **BULK WATER SUPPLY** for a volume of up to 150 000 m^3 per annum.
- For **BULK WATER SUPPLY** in excess of 150 000 m^3 per annum it as recommended that a 72 hour constant rate test should be performed while the draw down and the recovery of the bore hole is measured.
- All data as obtained above should be attached to the relevant Water Use License Application forms, together with an analysis of the data (including draw down curves) and recommendation for the sustainable yield of the borehole(s), by a qualified Geo-hydrologist .

NOTE: The above-recommended requirements may change without prior notice as required by DWAF to effectively manage the respective water resource.

14.3 Appendix 3: Impact Assessment Methodology

METHODOLOGY FOR THE ASSESSMENT OF IMPACTS

The assessment of the predicted significance of impacts for a proposed development is by its nature, inherently uncertain – environmental assessment is thus an imprecise science. To deal with such uncertainty in a comparable manner, a standardised and internationally recognised methodology has been developed. This methodology will be applied in this study to assess the significance of the potential environmental impacts of the proposed development.

For each predicted impact, certain criteria are applied to establish the likely **significance** of the impact, firstly in the case of no mitigation being applied and then with the most effective mitigation measure(s) in place.

These criteria include the **intensity** (size or degree scale), which also includes the **type** of impact, being either a positive or negative impact; the **duration** (temporal scale); and the **extent** (spatial scale). For each predicted impact, the specialist applies professional judgement in ascribing a numerical rating for each of these criteria respectively as per Table 1, Table 2 and Table 3 below. These numerical ratings are used in an equation whereby the **consequence** of the impact can be calculated. Consequence is calculated as follows:

Consequence = type x (intensity + duration + extent)

Depending on the numerical result, the impact's consequence would be defined as either extremely, highly, moderately or slightly detrimental; or neutral; or slightly, moderately, highly or extremely beneficial. These categories are provided in Table 5 and Table 6.

To calculate the significance of an impact, the **probability** (or likelihood) of that impact occurring is also taken into account. The most suitable numerical rating for probability is selected from Table 4 below and applied with the consequence as per the equation below:

Significance = consequence x probability

Depending on the numerical result, the impact would fall into a significance category as negligible, minor, moderate or major, and the type would be either positive or negative. These categories are provided in Table 6.

Once the significance of an impact occurring without mitigation has been calculated, the specialist must also apply their professional judgement to assign ratings for the same impact after the proposed mitigation has been implemented.

The tables on the following pages show the scales used to classify the above variables, and define each of the rating categories.

Table 1 | Definition of Intensity ratings

Rating	Criteria	
	Negative impacts (Type of impact = -1)	**Positive impacts** (Type of impact = +1)
7	Irreparable damage to biophysical and / or social systems. Irreplaceable loss of species.	Noticeable, on-going benefits to which have improved the quality and extent of biophysical and / or social systems, including formal protection.
6	Irreparable damage to biophysical and / or social systems and the contravention of legislated standards.	Great improvement to ecosystem processes and services.
5	Very serious impacts and irreparable damage to components of biophysical and / or social systems.	On-going and widespread positive benefits to biophysical and / or social systems.
4	On-going damage to biophysical and / or social system components and species.	Average to intense positive benefits for biophysical and / or social systems.
3	Damage to biophysical and / or social system components and species.	Average, on-going positive benefits for biophysical and / or social systems.
2	Minor damage to biophysical and / or social system components and species. Likely to recover over time. Ecosystem processes not affected.	Low positive impacts on biophysical and / or social systems.
1	Negligible damage to individual components of biophysical and / or social systems.	Some low-level benefits to degraded biophysical and / or social systems.

*NOTE: Where applicable, the intensity of the impact is related to a relevant standard or threshold, or is based on specialist knowledge and understanding of that particular field.

Table 2 | Definition of Duration ratings

Rating	Criteria
7	**Permanent:** The impact will remain long after the life of the project
6	**Beyond project life**: The impact will remain for some time after the life of the project
5	**Project Life:** The impact will cease after the operational life span of the project
4	**Long term**: 6-15 years
3	**Medium term:** 1-5 years
2	**Short term:** Less than 1 year
1	**Immediate**: Less than 1 month

Table 3 | Definition of Extent ratings

Rating	Criteria
7	**International:** The effect will occur across international borders
6	**National:** Will affect the entire country
5	**Province/ Region:** Will affect the entire province or region
4	**Municipal Area:** Will affect the whole municipal area
3	**Local:** Extending across the site and to nearby settlements
2	**Limited:** Limited to the site and its immediate surroundings
1	**Very limited:** Limited to specific isolated parts of the site

Table 4 | Definition of Probability ratings

Rating	Criteria
7	**Certain/ Definite:** There are sound scientific reasons to expect that the impact will definitely occur
6	**Almost certain/Highly probable:** It is most likely that the impact will occur
5	**Likely:** The impact may occur
4	**Probable:** Has occurred here or elsewhere and could therefore occur
3	**Unlikely:** Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur
2	**Rare/ improbable:** Conceivable, but only in extreme circumstances and/ or has not happened during lifetime of the project but has happened elsewhere. The possibility of the impact manifesting is very low as a result of design, historic experience or implementation of adequate mitigation measures
1	**Highly unlikely/None:** Expected never to happen.

Table 5 | Application of Consequence ratings

Range		Significance rating
-21	-18	Extremely detrimental
-17	-14	Highly detrimental
-13	-10	Moderately detrimental
-9	-6	Slightly detrimental
-5	5	Negligible
6	9	Slightly beneficial
10	13	Moderately beneficial
14	17	Highly beneficial
18	21	Extremely beneficial

Table 6 | Application of significance ratings

Range		Significance rating
-147	-109	Major - negative
-108	-73	Moderate - negative
-72	-36	Minor - negative
-35	-1	Negligible - negative
0	0	Neutral
1	35	Negligible - positive
36	72	Minor - positive
73	108	Moderate - positive
109	147	Major - positive

Despite attempts at providing a completely objective and impartial assessment of the environmental implications of development activities, environmental assessment processes can never escape the subjectivity inherent in attempting to define significance. The determination of the significance of an impact depends on both the context (spatial scale and temporal duration) and intensity of that impact. Since the rationalisation of context and intensity will ultimately be prejudiced by the observer, there can be no wholly objective measure by which to judge the components of significance, let alone how they are integrated into a single comparable measure.

This notwithstanding, in order to facilitate informed decision-making, environmental assessments must endeavour to come to terms with the significance of the potential environmental impacts associated with particular development activities. Recognising this, Geovation has attempted to address potential subjectivity in the current EIA process as follows:

- Being explicit about the difficulty of being completely objective in the determination of significance, as outlined above;
- Developing an explicit methodology for assigning significance to impacts and outlining this methodology in detail. Having an explicit methodology not only forces the specialist to come to terms with the various facets contributing towards the determination of significance, thereby avoiding arbitrary assignment, but also provides the reader with a clear summary of how the specialist derived the assigned significance;
- Wherever possible, differentiating between the likely significance of potential environmental impacts as experienced by the various affected parties; and
- Utilising a team approach and internal review of the assessment to facilitate a more rigorous and defendable system.

Although these measures may not totally eliminate subjectivity, they provide an explicit context within which to review the assessment of impacts.

14.4 Appendix 4: Pumptesting FC Solutions and Data Sheets

Summary — Wisteria 1 - Scott Farm BH1

Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)	Late T (m^2/d)	S	AD used
☑	Basic FC	17.93	9.49	239	151.7	2.20E-03	11.4
☐	Advanced FC						
☐	FC inflection point						
☑	Cooper-Jacob	18.02	11.66		734.1	6.83E-10	11.4
☐	FC Non-Linear						
☑	Barker	16.36	11.27	K_f = 53	S_s =	1.00E-07	11.4
	Average Q_sust (l/s)	17.44	0.93	b = 1.36	Fractal dimension n =	2.22	

Recommended abstraction rate (L/s)		17.44	62784 l/hr	For 24 hrs per day
Hours per day of pumping (L/s)	12	24.67	88812 l/hr	12 hrs per day
Hours per day of pumping (L/s)	10	27.02	97272 l/hr	10 hrs per day
Hours per day of pumping (L/s)	8	30.21	108756 l/hr	8 hrs per day

Amount of water allowed to be abstracted per month	45204.48	m^3
Borehole could satisfy the basic human need of	60273	persons
Is the water suitable for domestic use (Yes/No)	-	

Recommended pump depth below surface (m)	40		
Total Casing length	0		
Blow yield (l/s)	-		
Expected dynamic water level over 24hr pump	9	mbcl	metres below casing level
Critical depth that water level must not exceeded	17	mbcl	
Depth of BH	55	mbcl	
Static Water Level	5.20	mbcl	

Management recommendations

The aquifer consists of a very good fracture network with radial flow present. Transmissivity is in the order of 151.7 to 734.1 m2/day.
An available drawdown of 17 mbcl is recommended.
A dynamic water level of 9 mbcl is anticipated over a 24hr pump schedule at a volume of 17.44 l/s.
The water level should not exceed 17 mbcl, which is referred to as the critical water level.
Consistent drawdown below the critical water level will have a negative impact on the aquifer sustainability and yield.
It is therefore HIGHLY recommended to monitor the water level closely during pumping, to prevent drawdown in excess of 17 mbcl.
A conduit should be installed alongside the pump to allow for the measurement of the water level.
A CALIBRATED FLOW METER SHOULD BE INSTALLED AT THE IMMEDIATE PUMP OUTLET AT THE BOREHOLE TO ENSURE THE RECOMMENDED PUMP VOLUMES ARE NOT EXCEEEDED.

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06/09/2022

Recommended Pump Volumes		
Hours per day pumping	**l/s**	**l/hr**
24	17.44	62 784
22	18.22	65 592
20	19.11	68 796
18	20.14	72 504
16	21.36	76 896
14	22.84	82 219
12	24.67	88 812
10	27.02	97 272
8	30.21	108 756
Pump depth		40 mbcl
Dynamic Water Level (24hr)		9 mbcl
Critical Water Level		17 mbcl

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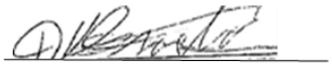

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06/09/2022

Scenic route 565 t/a Welltek Services
Vat nr: 45902 54720
Email: welltekservices@gmail.com

Borehole testing and associated projects

CC Registration nr: 2005/137492/23
18 Highfield Road, EAST LONDON, 5205
Cell: +27 (0)71 031 5086
Fax: +27 (0)86 517 9242

BOREHOLE TEST RECORD

Borehole Number:	**PATENSIE 1**	**Province:**	**EASTERN CAPE**
Alternative Number:		**District:**	**PATENSIE**
Coordinates: Latitude [°S]	**33,723442**	**Town/Village/Farm:**	
Longitude [°E]	**24,713385**	**Rig Type & number:**	
Date & Time Test Started:	**2022/08/09 00:00**	**Operator:**	**RASTA**
Date & Time Test Ended:	**2022/08/15 00:00**	**Supervisor:**	**BISHOP**
Consultant:	**DHS**		

CONSULTANT - DATA PROVIDED / INSTRUCTIONS:		**EXISTING INSTALLATION:**	
Borehole depth [mbgl]:		**Diesel/Electric/Wind/Hand**	**SUBMERSIBLE**
Blow Yield [l/s]:		**Pump Make & Serial no:**	**CRI**
Water Strike Depth(s) [mbgl]:		**Intallation Depth (m)**	
Installation depth [mbgl]:		**Type & Condition - Pump:**	**WORKING**
Estimated Steps [l/s] - Step 1:		**- Column:**	**HDPE**
Step 2:		**- Pump House**	**N/A**
Step 3:		**FIELD MEASUREMENTS:**	
Step 4:		**Depth Before Test [mbcl]:**	
Step 5:		**Depth after Test [mbcl]:**	
Step 6:		**Water Level before Test [mbcl]:**	**5,20**
Step Duration [min]:		**Water Level after Test [mbcl]:**	**5,20**
Step Recovery Duration [Hrs]:		**Casing Depth [mbcl]:**	
Constant Yield [l/s]:		**Casing Height [magl]:**	**0,60**
Constant Duration [Hrs]:		**Casing Diameter [mm]:**	**210,00**
Recovery Duration [Hrs] / Drawdown %:		**TEST PUMP INSTALLATION DETAILS:**	
Lenghth of Layflat Required [m]:		**Pump Used:**	
Frequency of pH and EC Measurements:		**Depth Installed [mbcl]:**	
SAMPLE INSTRUCTIONS:		**Datum Level above Casing [m]:**	**0,00**
		Length of Layflat [m]:	**100,00**

GENERAL ACTIONS:

Supplied new steel cover [Yes/No]:	**NO**	**Slug Test [Yes/No]:**	**N/A**
Welded existing steel cover back on [Y/N]:	**NO**	**Re-install existing pump [Yes/No]:**	**N/A**
Borehole Marking [Yes/No]:	**NO**	**If not, where was it stored?**	**N/A**
Site Cleaning and Finishing [Yes/No]:	**YES**	**Maintenance work [Hrs]:**	**N/A**
Data Reporting and Recording [Yes/No]:	**YES**	**Maintenance Travel [km]:**	**N/A**
Digital Photo Taken? [Yes/No]	**NO**	**List of parts replaced/repaired:**	**N/A**
RETREAT FROM SITE		**Date &Time Sampled:**	**SAMPLE TAKEN BY CONSULTANT**

It is hereby acknowledged that upon leaving the site, all existing equipment is in an acceptable condition.

NAME:	
DESIGNATION:	
SIGNATURE:	
DATE:	

COMMENTS BY ONSITE CREW

BOREHOLE NO:	PATENSIE 1	WATER LEVEL [mbdl]:	5,20	WATER DEPTH [mbgl]:	4,60	AVAILABLE DRAWDOWN [m]:	-5,20

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1			RPM		DISCHARGE RATE 2			RPM		DISCHARGE RATE 3			RPM	
DATE & TIME		2022/08/15 11:00			DATE & TIME		2022/08/15 12:00			DATE & TIME		2022/08/15 13:00		
TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)	TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)	TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)
1	0,11		1		1	0,94		1		1	2,90		1	
2	0,24	8,52	2		2	1,14	15,01	2		2	3,20	20,01	2	
3	0,30		3		3	1,20		3		3	3,46		3	
5	0,35	8,51	5		5	1,37		5		5	3,60		5	
7	0,40		7		7	1,56	15,02	7		7	3,84	20,02	7	
10	0,44		10		10	1,70		10		10	4,00		10	
15	0,48		15		15	1,82		15		15	4,26		15	
20	0,53	8,52	20		20	1,97	15,01	20		20	4,32	20,01	20	
30	0,57		30		30	2,03		30		30	4,50		30	
40	0,66	8,52	40		40	2,10		40		40	4,57		40	
50	0,70		50		50	2,54	15,02	50		50	4,63	20,02	50	
60	0,75		60		60	2,70		60		60	4,70		60	
			70					70					70	
			80					80					80	
			90					90					90	
			100					100					100	
			110					110					110	
			120					120					120	
			150					150					150	
Average Yield (l/s):		8,52	180		Average Yield (l/s):		15,02	180		Average Yield (l/s):		20,02	180	
Drawdown (%):		-14,42	210		Drawdown (%):		-51,92	210		Drawdown (%):		-90,38	210	

DISCHARGE RATE 4			RPM		DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE & TIME		2022/08/15 13:00			DATE & TIME		2022/08/15 13:00			DATE & TIME		2022/08/15 13:00		
TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)	TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)	TIME (min)	DRAWDOWN (m)	YIELD (l/s)	TIME (min)	RECOVERY (m)
1			1		1			1		1			1	1,44
2			2		2			2		2			2	0,56
3			3		3			3		3			3	0,43
5			5		5			5		5			5	0,31
7			7		7			7		7			7	0,26
10			10		10			10		10			10	0,22
15			15		15			15		15			15	0,18
20			20		20			20		20			20	0,16
30			30		30			30		30			30	0,15
40			40		40			40		40			40	0,14
50			50		50			50		50			50	0,13
60			60		60			60		60			60	0,12
			70					70					70	0,10
			80					80					80	0,08
			90					90					90	0,06
			100					100					100	
			110					110					110	
			120					120					120	
			150					150					150	
			180					180					180	
			210					210					210	
			240					240					240	
Average Yield (l/s):		0,00	300		Average Yield (l/s):		0,00	300		Average Yield (l/s):		0,00	300	
Drawdown (%):			360		Drawdown (%):			360		Drawdown (%):			360	

DATUM LEVEL ABOVE GROUND [m]:	0,60	WAS SAND PUMPED ?	NO
STATIC WATER LEVEL AFTER STEPPED DISCHARGE TEST [mbdl]:	5,20	WAS THE WATER CLEAN?	YES

STEPPED DRAWDOWN SUMMARY

STEP	DURATION [min]	DRAWDOWN [m]	DRAWDOWN [%]	AVERAGE YIELD [l/s]	RECOVERY [min]	RECOVERY [m]	RECOVERY [%]	STEP	DURATION [min]	DRAWDOWN [m]	DRAWDOWN [%]	AVERAGE YIELD [l/s]	RECOVERY [min]	RECOVERY [m]	RECOVERY [%]
1	60	0,75	-14,42	8,52				5		0,00		0,00			
2	60	2,70	-51,92	15,02				6		0,00		0,00			
3	60	4,70	-90,38	20,02				7							
4		0,00		0,00				8							
DATE & TIME END:		2022/08/15 14:00						TOTAL:	180,00	4,70	-14,42		0	0,00	0,00

COMMENTS:

ESTABLISHMENT

SITE MOVE FROM:	BOREHOLE	VILLAGE	MOVE TO:	BOREHOLE	VILLAGE	ESTABLISHMENT DATE:	2022/08/09
	0	0		PATENSIE 1	0	DISTANCE BETWEEN BOREHOLES [km]	392,00

BOREHOLE NO:	PATENSIE 1				WATER LEVEL [mbdl]:	5,20				WATER LEVEL [mbgl]:	4,60			
CONSTANT DISCHARGE TEST & RECOVERY														
DISCHARGE BOREHOLE					OBSERVATION HOLE 1			OBSERVATION HOLE 2			OBSERVATION HOLE 3			
TEST STARTED					WATER LEVEL [mbcl]:		N/A	WATER LEVEL [mbcl]:		N/A	WATER LEVEL [mbcl]:		N/A	
DATE & TIME:	2022/08/09 15:00				CASING HEIGHT [m]:		N/A	CASING HEIGHT [m]:		N/A	CASING HEIGHT [m]:		N/A	
TEST COMPLETED					CASING DIAMETER [m]:		N/A	CASING DIAMETER [m]:		N/A	CASING DIAMETER [m]:		N/A	
DATE & TIME:	2022/08/13 15:00				DISTANCE [m]:		N/A	DISTANCE [m]:		N/A	DISTANCE [m]:		N/A	
TIME [min]	DRAWDOWN [m]	YIELD [l/s]	TIME [min]	RECOVERY [m]	TIME: [min]	DRAWDOWN [m]	RECOVERY [m]	TIME: [min]	DRAWDOWN [m]	RECOVERY [m]	TIME: [min]	DRAWDOWN [m]	RECOVERY [m]	
1	1,24		1	1,22	1			1			1			
2	1,40	13,33	2	0,43	2			2			2			
3	1,47		3	0,40	3			3			3			
5	1,60		5	0,32	5			5			5			
7	1,87	13,33	7	0,24	7			7			7			
10	1,94		10	0,18	10			10			10			
15	2,11	13,32	15	0,16	15			15			15			
20	2,28		20	0,15	20			20			20			
30	2,42	13,33	30	0,14	30			30			30			
40	2,58		40	0,13	40			40			40			
60	2,63		60	0,12	60			60			60			
90	2,70		90	0,11	90			90			90			
120	2,82	13,33	120	0,10	120			120			120			
150	2,89		150	0,10	150			150			150			
180	2,94	13,32	180	0,09	180			180			180			
210	3,10		210	0,09	210			210			210			
240	3,21	13,33	240	0,08	240			240			240			
300	3,28		300	0,08	300			300			300			
360	3,34		360	0,07	360			360			360			
420	3,37		420	0,07	420			420			420			
480	3,40	13,33	480	0,06	480			480			480			
540	3,44		540	0,05	540			540			540			
600	3,47		600	0,04	600			600			600			
720	3,50	13,33	720	0,03	720			720			720			
840	3,51		840	0,01	840			840			840			
960	3,54		960	0,00	960			960			960			
1080	3,56		1080		1080			1080			1080			
1200	3,58	13,33	1200		1200			1200			1200			
1320	3,60		1320		1320			1320			1320			
1440	3,61		1440		1440			1440			1440			
1560	3,62	13,32			1560			1560			1560			
1680	3,63				1680			1680			1680			
1800	3,63				1800			1800			1800			
1920	3,64				1920			1920			1920			
2040	3,65	13,32			2040			2040			2040			
2160	3,65				2160			2160			2160			
2280	3,66				2280			2280			2280			
2400	3,66	13,33			2400			2400			2400			
2520	3,66				2520			2520			2520			
2640	3,67				2640			2640			2640			
2760	3,67				2760			2760			2760			
2880	3,67	13,32			2880			2880			2880			
3000	3,68				3000			3000			3000			
3120	3,68				3120			3120			3120			
3240	3,68	13,33			3240			3240			3240			
3360	3,68				3360			3360			3360			
3480	3,68				3480			3480			3480			
3600	3,69				3600			3600			3600			
3720	3,69				3720			3720			3720			
3840	3,69	13,32			3840			3840			3840			
3960	3,70				3960			3960			3960			
4080	3,70				4080			4080			4080			
4200	3,70	13,33			4200			4200			4200			
4320	3,71				4320			4320			4320			
DURATION TOTALS [min]		CDT:	4320		RECOVERY:	1440		OBS 1:	0	OBS 2:	0	OBS 3:	0	
DRAWDOWN / RECOVERY [m]		CDT:	3,71		RECOVERY:	0,00		OBS 1:	0,00	OBS 2:	0,00	OBS 3:	0,00	
DRAWDOWN / RECOVERY [%]		CDT:	-71,35		RECOVERY:	100,00		OBS 1:	0,00	OBS 2:	0,00	OBS 3:	0,00	
AVERAGE YIELD [l/s]		CDT:	13,33		COMMENTS:									
GENERAL ITEMS AND MAINTENANCE														
TRAVELING FOR VERIFICATION [km]:					SAMPLE TRANSPORTATION [km]:					TRANSPORT EXISTING EQUIPMENT [km]:				

14.5 Appendix 5: Laboratory Reports

16 Van der Berg Crescent
Strand, 7140
Tel : 021 853 1490
VAT No : 4200161414
www.bemlab.co.za

bemlab A PathCare Company

sanas Testing Laboratory T0654

CERTIFICATE OF ANALYSIS

Client	: Pathcare Laboratories	Report No	: WT2022-02001	Delivery Date	: 04/04/2022
Address	: N/A	Samples	: 4	Order No/Ref	: 810340524 - 0527
Phone	: N/A	Department	: Water		
Contact	: Sandisiwe Mbula	Sample Type	: Unknown		
Email	: admin@bemlab.co.za, sandisiwe.mbula@bemlab.co.za				

Lab number:	WT22-04189
Sampling Date:	31/03/2022
Sampling Time:	08:00
Sampling temperature upon receipt (°C):	6.7
Sampling ID:	810340527 - Bakland/Christoff

Physical & Aesthetic Determinands	Method ID	Unit	Results	UoM %	SANS241:2015	Compliance Statement
pH (Titrando Method) at 20°C	3777	pH Units	5.9	0.16	≥ 5 to ≤ 9.7	Complies
Carbonate (CO3) as CaCO3 (Titrando)	3777	mg/L	0		Not Applicable	Not Applicable
Bicarbonate (HCO3) as CaCO3 (Titrando)	3777	mg/L	29.1	0.06	Not Applicable	Not Applicable
Alkalinity as CaCO3 (Titrando)	3777	mg/L	29.1		Not Applicable	Not Applicable
Electrical Conductivity (Titrando)	3777	mS/m	310	5.85	≤ 170	Does not comply
Total Dissolved Solids (Calc) *	Calc	mg/L	2020		≤ 1200	Does not comply
Langelier Index *	Calc		-1.9		≥-0.5 to ≤0.5	Undersaturated
Saturation pH (pHs) at 20°C *	Calc	pH Units	7.8		Not Applicable	Not Applicable
Free Chlorine (Cl2) *	3289	mg/L	0.04		≤ 5	Complies
Turbidity	3289	NTU	54.4	3.99	≤ 5	Does not comply
Colour (Apparent - Unfiltered) *	3289	mg/L Pt-Co	253		≤ 15	Does not comply
Colour (True - Filtered) *	3289	mg/L Pt-Co	18		≤ 15	Does not comply

Date Analysed: 05/04/2022 Date Analysis Completed: 14/04/2022 Date Reported: 14/04/2022 Page 10 of 14

DHS GROUNDWATER CONSULTING SERVICES

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sanas Testing Laboratory T0654

CERTIFICATE OF ANALYSIS

Client	: Pathcare Laboratories	Report No	: WT2022-02001	Delivery Date	: 04/04/2022
Address	: N/A	Samples	: 4	Order No/Ref	: 810340524 - 0527
Phone	: N/A	Department	: Water		
Contact	: Sandisiwe Mbula	Sample Type	: Unknown		
Email	: admin@bemlab.co.za, sandisiwe.mbula@bemlab.co.za				

Lab number:	WT22-04189
Sampling Date:	31/03/2022
Sampling Time:	08:00
Sampling temperature upon receipt (°C):	6.7
Sampling ID:	810340527 - Bakland/Christoff

Macro Chemical Determinands	Method ID	Unit	Results	UoM %	SANS241:2015	Compliance Statement
Chloride (Cl) Titrando	3778	mg/L	302	8.00	≤ 300	Does not comply
Ammonia (NH3) as N	4511	mg/L	0.78	6.30	≤ 1.5	Complies
Nitrate (NO3) as N	4511	mg/L	<0.18	2.39	≤ 11	Complies
Total Organic Carbon (TOC) *	3289	mg/L	<5.0		≤ 10	Complies
Nitrite (NO2) as N	4511	mg/L	0.02	1.72	≤ 0.9	Complies
Sodium (Na) Dissolved	3132	mg/L	220	3.39	≤ 200	Does not comply
Calcium (Ca) Dissolved	3132	mg/L	282	2.56	Not Applicable	Not Applicable
Magnesium (Mg) Dissolved	3132	mg/L	146	3.00	Not Applicable	Not Applicable
Potassium (K) Dissolved	3132	mg/L	12.5	7.30	Not Applicable	Not Applicable
Sulphur (S)	3132	mg/L	448	5.11	Not Applicable	Not Applicable
Sulphate (SO4) *	Calc	mg/L	1340	5.11	≤ 500	Does not comply
Phosphorus (P) Total	3132	mg/L	<0.20	4.83	Not Applicable	Not Applicable

Date Analysed: 05/04/2022 Date Analysis Completed: 14/04/2022 Date Reported: 14/04/2022 Page 11 of 14

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CERTIFICATE OF ANALYSIS

Client	: Pathcare Laboratories	Report No	: WT2022-02001	Delivery Date	: 04/04/2022
Address	: N/A	Samples	: 4	Order No/Ref	: 810340524 - 0527
Phone	: N/A	Department	: Water		
Contact	: Sandisiwe Mbula	Sample Type	: Unknown		
Email	: admin@bemlab.co.za, sandisiwe.mbula@bemlab.co.za				

Lab number:	WT22-04189
Sampling Date:	31/03/2022
Sampling Time:	08:00
Sampling temperature upon receipt (°C):	6.7
Sampling ID:	810340527 - Bakland/Christoff

Micro Chemical Determinands	Method ID	Unit	Results	UoM %	SANS241:2015	Compliance Statement
Aluminium (Al) Total	3225	µg/L	22.3	11.45	≤ 300	Complies
Antimony (Sb) Total	3225	µg/L	<6.5	10.82	≤ 20	Complies
Arsenic (As) Total	3225	µg/L	<7.0	7.86	≤ 10	Complies
Barium (Ba) Total	3225	µg/L	120	7.55	≤ 700	Complies
Boron (B) Total	3132	mg/L	0.38	4.37	≤ 2.4	Complies
Cadmium (Cd) Total	3225	µg/L	<1.0	11.05	≤ 3	Complies
Copper (Cu) Total	3132	mg/L	<0.05	4.30	≤ 2	Complies
Chromium (Cr) Total	3225	µg/L	<3.5	5.61	≤ 50	Complies
Iron (Fe) Dissolved	3132	mg/L	52.4	5.65	≤ 2	Does not comply
Iron (Fe) Total	3132	mg/L	55.2	5.65	≤ 2	Does not comply
Lead (Pb) Total	3225	µg/L	<6.0	13.60	≤ 10	Complies
Manganese (Mn) Dissolved	3132	mg/L	6.9	3.99	≤ 0.4	Does not comply
Manganese (Mn) Total	3132	mg/L	7.2	3.99	≤ 0.4	Does not comply
Mercury (Hg) Total *	3225	µg/L	<4.0	21.33	≤ 6	Complies
Nickel (Ni) Total	3225	µg/L	<5.0	7.60	≤ 70	Complies
Selenium (Se) Total	3225	µg/L	<15.0	8.85	≤ 40	Complies
Uranium (U) Total *	3225	µg/L	<12.0	16.69	≤ 30	Complies
Zinc (Zn) Total	3132	mg/L	<0.20	7.70	≤ 5	Complies
General Chemistry	**Method ID**	**Unit**	**Results**	**UoM %**	**SANS241:2015**	**Compliance Statement**
Cyanide (CN) *	3289	mg/L	<0.01		≤ 0.2	Complies
Fluoride (F) *	5534	mg/L	<0.20		≤ 1.5	Complies

Date Analysed: 05/04/2022 Date Analysis Completed: 14/04/2022 Date Reported: 14/04/2022 Page 12 of 14

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T0654

CERTIFICATE OF ANALYSIS

Client	: Pathcare Laboratories	Report No	: WT2022-02001	Delivery Date	: 04/04/2022
Address	: N/A	Samples	: 4	Order No/Ref	: 810340524 - 0527
Phone	: N/A	Department	: Water		
Contact	: Sandisiwe Mbula	Sample Type	: Unknown		
Email	: admin@bemlab.co.za, sandisiwe.mbula@bemlab.co.za				

Lab number:	WT22-04189
Sampling Date:	31/03/2022
Sampling Time:	08:00
Sampling temperature upon receipt (°C):	6.7
Sampling ID:	810340527 - Bakland/Christoff

Comments

WISTERIA PAKHUIS

810340524 - Kanaal
810340525 - Tenk
810340526 - Rivier
810340527 - Bakland/Christoff

Terms and Conditions

Recommendations included with this report are based on the assumption that the samples were representative of the source from which they were taken. To ensure sample integrity - Water samples are only stored for two weeks after release of the report, thereafter they are disposed of and a fresh sample will be required if additional analyses are requested. The information supplied by the client (or lack thereof) may affect the validity of the results. This information includes but is not limited to client details, sample reference, the date and time of sampling, the sampler, and transportation of the sample to the testing laboratory.
Results marked with "Not SANAS Accredited" or "Subcontracted" in this report are not included in the SANAS Schedule of Accreditation for this laboratory. Opinions and interpretations expressed herein are outside the scope of SANAS accreditation. These results relate to the items tested. This test report shall not be reproduced except in full, without written approval of the laboratory. Uncertainty of Measurement and method references available on request.

We hereby consent to the processing of the information supplied herein in terms of the Protection of Personal Information Act (2013) for the purposes of this request. All processing of personal information takes place according to the terms and conditions of the Privacy Policy of Bemlab (Pty) Limited which can be found on our website at www.bemlab.co.za.

Sample condition:

Samples for analysis must be kept cool (<10°C) and reach the laboratory within 24 hours of sampling. Chemical parameters that can be affected by exceeded temperature and sampling times includes: Acidity, Alkalinity, BOD, CO2, Chlorine, Chlorophyll, Cyanide, Chromium VI, Dissolved Oxygen, Odor, pH & Turbidity. The effect on the microorganisms is unknown, treat microbiological results with reserve.

Additional Information including: Testing date & time for all analysis are available on request

**** - Not SANAS Accredited*** ***** - Outstanding*** ****** - Insufficient Sample*** ***# - Subcontracted***

UoM - Uncertainty of Measurement ***Not Detected* = <1 cfu's /mL or <1 MPN/100mL was detected**

(R) - Test parameter has been Repeated to confirm value

Date Analysed: 05/04/2022 Date Analysis Completed: 14/04/2022 Date Reported: 14/04/2022 Page 13 of 14

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CERTIFICATE OF ANALYSIS

Client	: Pathcare Laboratories	Report No	: WT2022-02001	Delivery Date	: 04/04/2022
Address	: N/A	Samples	: 4	Order No/Ref	: 810340524 - 0527
Phone	: N/A	Department	: Water		
Contact	: Sandisiwe Mbula	Sample Type	: Unknown		
Email	: admin@bemlab.co.za, sandisiwe.mbula@bemlab.co.za				

Lab number:	WT22-04189
Sampling Date:	31/03/2022
Sampling Time:	08:00
Sampling temperature upon receipt (°C):	6.7
Sampling ID:	810340527 - Bakland/Christoff

Samples Registered by: Gail Samuels

Shaun Salie

Technical Signatory
(Water Chemistry &
Microbiology)

Date Analysed: 05/04/2022 Date Analysis Completed: 14/04/2022 Date Reported: 14/04/2022 Page 14 of 14

TALBOT
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T0122

[006432/22], [2022/08/10]

Certificate of Analysis

Project details

Customer Details

Company name:	DHS GROUNDWATER CONSULTING SERVICES
Contact address:	9 SCHUBERT ROAD, PORT ELIZABETH, 6070
Contact person:	DIVAN STROEBEL

Sampling Details

Sampled by:	CUSTOMER
Sampled date:	2022/07/28

Sample Details

Sample type(s):	GROUNDWATER SAMPLES
Date received:	2022/08/01
Delivered by:	CUSTOMER - PORT ELIZABETH LAB
Temperature at sample receipt (°C):	3.4

Report Details

Testing commenced:	2022/08/01
Testing completed:	2022/08/10
Report date:	2022/08/10
Our reference:	006432/22

Talbot Laboratories (Pty) Ltd

Analytical Results

Methods	Determinands	Units	020521/22	020522/22
			GOBH1 28.07.2022	GOBH2 28.07.2022
Chemical				
85	Dissolved Calcium	mg Ca/ℓ	15.2	5.66
85	Potassium	mg K/ℓ	7.85	2.85
85	Dissolved Magnesium	mg Mg/ℓ	23	10.1
84	Sodium	mg Na/ℓ	**215**	91
83A	Copper	µg Cu/ℓ	156	1.8
83A	Iron	µg Fe/ℓ	974	705
83A	Manganese	µg Mn/ℓ	93	**464**
83A	Lead	µg Pb/ℓ	5.6	<1
10G	Total Alkalinity	mg $CaCO_3$/ℓ	78	37
16G	Chloride	mg Cl/ℓ	**320**	125
123	Free Chlorine*	mg Cl_2/ℓ	<0.1	<0.1
122	Monochloramine*	mg/ℓ	<3	<3
40A	Colour (True)*	mg Pt-Co/ℓ	<10	<10
2A	Electrical Conductivity at 25°C	mS/m	148	63.6
18G	Fluoride	mg F/ℓ	0.14	0.21
65Gc	Nitrate	mg N/ℓ	0.35	0.34
65Gb	Nitrite	mg N/ℓ	<0.05	<0.05
Calc.	Combined Nitrate + Nitrite (sum of Ratios)*	-	<0.12	<0.12
4	Turbidity	NTU	**17**	**7.9**
1	pH at 25°C	pH units	7.5	7.2
67G	Sulphate	mg SO_4/ℓ	53.1	24.6
Calc.	Total Hardness*	mg $CaCO_3$/ℓ	134	56
Microbiological				
32	*E.coli**	MPN/100mℓ	<1^	<1^
32	Total Coliforms*	MPN/100mℓ	**365^**	<1^
31	Standard Plate Count*	colonies/mℓ	**>1000^**	16^

Refer to the "Notes" section at the end of this report for further explanations.

Where the laboratory reporting limit for a test is higher than the required specification limit, the raw data is reviewed and the detection limit highlighted in bold font if outside of specification.

Specific Observations

Results that appear in bold do not meet the specification limits in Appendix 1 of this report.

Quality Assurance

Technical signatories

Inorganic Chemistry: Sipho Mgabhi

Microbiology: Olivia Magaya

Notes to this report

Limitations

This report shall not be reproduced except in full without prior written approval of the laboratory.
Results in this report relate only to the samples as taken, and the condition received by the laboratory.
Any opinions and interpretations expressed herein are outside the scope of SANAS accreditation.
The decision rule applicable to this laboratory is available on request.
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Uncertainty of measurement

Talbot Laboratories' Uncertainty of Measurement (UoM) values are:

- Identified for relevant tests.
- Calculated as a percentage of the respective results.
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- Available upon request.

Analysis explanatory notes

Tests may be marked as follows:

^	Tests conducted at our Port Elizabeth satellite laboratory.
*	Tests not included in our Schedule of Accreditation and therefore that are not SANAS accredited.
#	Tests that have been sub-contracted to a peer laboratory.
NR	Not required -shown, for example, where the schedule of analysis varied between samples.
σ	Field sampling point on-site results.
a	Testing has deviated from Method.

[006620/22], [2022/08/18]

Certificate of Analysis

Project details

Customer Details

Company name:	DHS GROUNDWATER CONSULTING SERVICES
Contact address:	9 SCHUBERT ROAD, PORT ELIZABETH, 6070
Contact person:	DIVAN STROEBEL

Sampling Details

Sampled by:	CUSTOMER
Sampled date:	2022/08/04

Sample Details

Sample type(s):	GROUNDWATER SAMPLES
Date received:	2022/08/08
Delivered by:	CUSTOMER - PORT ELIZABETH LAB
Temperature at sample receipt (°C):	3.5

Report Details

Testing commenced:	2022/08/08
Testing completed:	2022/08/18
Report date:	2022/08/18
Our reference:	006620/22

Analytical Results

Methods	Determinands	Units	021140/22
			HSBH1 04.08.2022
Chemical			
85	Dissolved Calcium	mg Ca/ℓ	13.5
85	Potassium	mg K/ℓ	3.30
85	Dissolved Magnesium	mg Mg/ℓ	8.53
84	Sodium	mg Na/ℓ	45
83A	Copper	µg Cu/ℓ	1.7
83A	Iron	µg Fe/ℓ	395
83A	Manganese	µg Mn/ℓ	24
83A	Lead	µg Pb/ℓ	1.0
10G	Total Alkalinity	mg $CaCO_3$/ℓ	41
16G	Chloride	mg Cl/ℓ	72
123	Free Chlorine*	mg Cl_2/ℓ	<0.1
122	Monochloramine*	mg/ℓ	<3
40A	Colour (True)*	mg Pt-Co/ℓ	**32**
2A	Electrical Conductivity at 25°C	mS/m	29.7
18G	Fluoride	mg F/ℓ	0.09
65Gc	Nitrate	mg N/ℓ	<0.25
65Gb	Nitrite	mg N/ℓ	<0.05
Calc.	Combined Nitrate + Nitrite (sum of Ratios)*	-	<0.12
4	Turbidity	NTU	4.9
1	pH at 25°C	pH units	6.5
67G	Sulphate	mg SO_4/ℓ	25.7
Calc.	Total Hardness*	mg $CaCO_3$/ℓ	69
Microbiological			
32	*E.coli**	MPN/100mℓ	<1^
32	Total Coliforms*	MPN/100mℓ	<1^
31	Standard Plate Count*	colonies/mℓ	**>1000^**

Refer to the "Notes" section at the end of this report for further explanations.

Where the laboratory reporting limit for a test is higher than the required specification limit, the raw data is reviewed and the detection limit highlighted in bold font if outside of specification.

Specific Observations

Results that appear in bold do not meet the specification limits in Appendix 1 of this report.

Quality Assurance

Technical signatories

Inorganic Chemistry: Sipho Mgabhi

Microbiology: Jocelyn Winchester

Notes to this report

Limitations

This report shall not be reproduced except in full without prior written approval of the laboratory.
Results in this report relate only to the samples as taken, and the condition received by the laboratory.
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