Water Use Licence Application: Geohydrological Assessment: Erf 3865, Hagley, near Kuils River, Western Cape.

Prepared by

GEOSS

28 August 2024

GROUNDWATER AND EARTH SCIENCES

GEOSS

SOUTH AFRICA (Pty) Ltd

Executive Summary

André-Pierre Gouws from PHS Consulting has appointed GEOSS South Africa (Pty) Ltd on behalf of Lotus South Africa Manufacturing (Pty) Ltd to compile a geohydrological assessment for Erf 3865 in Hagley, near Kuils River, Western Cape and a Water Use License Application (WULA) for the proposed groundwater use. Erf 3865 in Hagley is located within quaternary catchment G22E which is approximately 270.68 km^2 in extent and has a groundwater General Authorisation (GA) of 400 m^3/a/ha. The proposed combined volume to be abstracted from the production borehole is 2 560.0 m^3/a, 0.003% of the borehole sustainable yield 91 517. 04 m^3/a. This abstraction is within the quaternary catchment GA and borehole sustainable yield. However, due to the close proximity of the proposed production borehole to a wetland, the borehole does fall within the regulatory distance and a licence may be needed due to Section 21 (c) (impeding or diverting of the flow of water within a watercourse) and 21 (i) (the altering of the bed, banks, course, or characteristics of a watercourse) of the National Water Act (DWAF, 1998). The floodplain wetland is associated to the Kuils River and located 466 m to the west of the western border of the property. The proximity to the floodplain wetland may thus require the licensing of the production borehole with the Department of Water and Sanitation (DWS).

The property falls in an area mainly associated with Quaternary calcareous dune sand. The area is underlain by the Tygerberg Formation of the Malmesbury Group, signified by greywacke and mud rock. The Tygerberg Formation has been intersected at depths of ~48 m in the borehole on site with the intersected fractures hosting the groundwater exploited on the site. The regional maps indicate yields of 0.1 – 0.5 L/s for the intergranular aquifer. The regional groundwater quality map indicates that electrical conductivity ranges between 70 – 300 mS/m.

The production borehole was correctly yield tested (according to SANS 10299_4-2003) and the results have been used to determine the boreholes' sustainable (i.e., long-term and safe) yield. The tested yield of the borehole is much higher than the indicated regional yields of the aquifer and is 2.9 L/s for 24 hours per day. Concerning quality, the electrical conductivity of the borehole was 136.5 mS/m which falls within the regional water quality range.

A groundwater requirement and supply analysis for the site is provided below:

GROUNDWATER REQUIREMENT

The current groundwater requirement for Lotus South Africa Manufacturing (Pty) Ltd is 2 560.0 m^3/a.

GROUNDWATER SUPPLY

From the yield test, if the borehole is pumped at the recommended rate and schedule, a yield of 91 517. 04 m^3/a can be obtained. Because the proposed application volume is within the sustainable yield of the borehole and can be supported by the Firm Yield calculated for the Groundwater Resource Unit (GRU) and the Groundwater Reserve for catchment G22E, the abstraction of the total volume of 2 560.0 m^3/a can be considered within the local aquifer`s capacity. Continued monitoring is required to ensure its sustainable use.

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Table of Contents

List of Tables

List of Figures

List of Maps

Abbreviations

AD	Available Drawdown
AFYM	Aquifer Firm Yield Model
BH	Borehole
BOCMA	Breede-Olifants Catchment Management Agency
CDT	Constant Discharge Test
CGS	Council for Geoscience
DD	Decimal degrees
DWA	Department of Water Affairs,
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
FC	Flow Characteristic
GA	General Authorisation
GRU	Groundwater Resource Unit
ha	hectare
HBH	Hydrocensus borehole
ID	Identity of borehole
km	kilometre
L/s	litres per second
L/day	litres per day
m	metres
m^3/a	metres cubed per annum
MAE	Mean Annual Evapotranspiration
magl	metres above ground level
mamsl	meters above mean sea level
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
mbgl	metres below ground level
$m^3/ha/a$	metres cubed per hectare per annum
mg/L	milligrams per litre
mm	millimetre
mm/a	millimetres per annum
mS/m	milliSiemens per meter
nd	not detected
NGA	National Groundwater Archive
RWL	Rest Water Level
SANAS	South African National Accreditation System
SANS	South African National Standard
TDS	total dissolved solids
WARMS	Water Authorisation Registration Management System
WGS84	World Geodetic System 1984
WULA	Water Use Licence Application
WRC	Water Research Commission

Glossary of Terms

aquifer	A geological formation, which has structures or textures that hold water or permit appreciable water movement through them [from National Water Act (Act No. 36 of 1998)].
borehole	Includes a well, excavation, or any other artificially constructed or improved groundwater cavity which can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and information on water in an aquifer; or recharging an aquifer.
electrical conductivity	the ability of groundwater to conduct electrical current, due to the presence of charged ionic species in solution (Freeze and Cherry, 1979).
evapotranspiration	The loss of water from a land area through transpiration of plants and evaporation from the soil and surface water bodies.
fault	A zone of displacement in rock formations resulting from forces of tension or compression in the earth's crust.
flow paths	The subsurface course a water molecule or solute would follow in a given groundwater velocity field.
fractured aquifer	Fissured and fractured bedrock resulting from decompression and/or tectonic action. Groundwater occurs predominantly within fissures and fractures.
groundwater	Water found in the subsurface in the saturated zone below the water table or piezometric surface i.e., the water table marks the upper surface of groundwater systems.
groundwater resource unit	groundwater resource unit: A groundwater body that has been delineated or grouped into a single significant water resource based on one or more characteristics that are similar across that unit.
groundwater vulnerability	The vulnerability of groundwater to contaminants generated by human activities taking into account the inherent geological, hydrological, hydrogeological characteristics of an aquifer.
intergranular aquifer	An aquifer in which groundwater is stored in and flows through open pore spaces in the unconsolidated Quaternary deposits.
Regulated area of a wetland	is the use of water for section 21 (c) and (i) water uses within 500 m radius from the boundary of any wetland.
riparian zone	Area of land directly adjacent to a stream or river, influenced by stream-induced or related processes.
sustainable yield	The maximum rate of withdrawal that they can be sustained by an aquifer without causing an unacceptable decline in the hydraulic head or deterioration in water quality in the aquifer.
wetland	Land which is transitional between terrestrial and aquatic systems were the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.

1 Introduction

André-Pierre Gouws from PHS Consulting requested that GEOSS South Africa (Pty) Ltd compile a geohydrological assessment for Erf 3865 in Hagley, near Kuils River, Western Cape applying for a Water Use Licence Application (WULA) with Breede Olifants Catchment Management Area (BOCMA). The WULA application is for

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

The geohydrological assessment is a requirement to submit a WULA application and will focus on Section 21 (a), where groundwater will and be abstracted from one production borehole (AB_BH1) for use on Erf 3865 in Hagley. A summary of the production borehole on the property is shown in **Table 1**.

Table 1: Details of the borehole on Erf 3865 in Hagley.

Borehole	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Borehole Depth (m)
AB_BH1	-33.95713	18.67164	84.0

The borehole was correctly yield tested according to the National Standard (SANS 10299-4:2003, Part 4 – Test pumping of water boreholes). The yield testing was undertaken by GEOSS South Africa from the 6th to 9th of November 2023. The groundwater is intended for agricultural and domestic use (potable and non-potable) on the property. Regarding the legal aspect of the proposed groundwater use, **Table 2** lists details that have relevance:

Table 2: General Authorisation limit for Erf 3865 in Hagley.

Property	Erf 3865
Quaternary Catchment	G22E
Property Size (ha)	6.65
General Authorization (m^3/ha/a)	400
General authorization zone	F
General authorization volume (m^3/a)	2 660.0
Required abstraction for the property (m^3/a)	2 560.0
Is General Authorization exceeded?	**No**

The calculation in **Table 2** indicates that the proposed volume does not exceed the general authorised volume for the property. However, due to the close proximity of the proposed production borehole to a wetland, the borehole does fall within the regulatory distance and a licence may be needed due to section 21 (c) (impeding or diverting of the flow of water within a watercourse) and 21 (i) (the altering of the bed, banks, course, or characteristics of a watercourse) of the National Water Act (NWA) (DWAF, 1998). The floodplain wetland is associated with the Kuils River and located 466 m to the west of the western border of the property, and 790 m from the production borehole, AB_BH1. The proximity to the floodplain wetland may therefore require the licensing of the production borehole with the Department of Water and Sanitation (DWS). It is a requirement from DWS that a geohydrological report must accompany the groundwater portion of the licence application. The application will be submitted to the regional DWS office and should a Water Use Licence (WUL) be granted, the management of the WUL will fall under the authority of the Berg Olifants Catchment Agency (BOCMA).

2 Scope of Work

The scope of work is to provide groundwater specialist services, including the tasks outlined below:

- Review of available literature and other specialist studies pertaining to the study site;
- Complete a geohydrological characterization of the groundwater in the vicinity of the property;
- Determine the sustainable (i.e., long-term and safe) yield of the borehole as well as the quality of the groundwater;
- Complete an assessment of the importance of groundwater (both socio-economically and environmentally) in the area by means of a hydrocensus; and
- Provide recommendations and mitigation measures to minimize risk and impacts from proposed groundwater abstraction;
- Document the above findings in a format fully compatible with the requirements for a Water Use License application (which is to be submitted to the DWS).

The assessment has been conducted in accordance with accepted best practice principles.

3 Regional Setting

3.1 General

The study is completed for Erf 3865 in Hagley, near Kuils River, Western Cape. The property is situated 150 m to the south of the M12 (Stellenbosch Arterial Road), Hagley, Wembley Park. The surrounding area is mainly residential, however, the Blackheath industrial area is located 1.2 km towards the east. Directly towards the west of the site, the Kuils River drains the area from the north to the south.

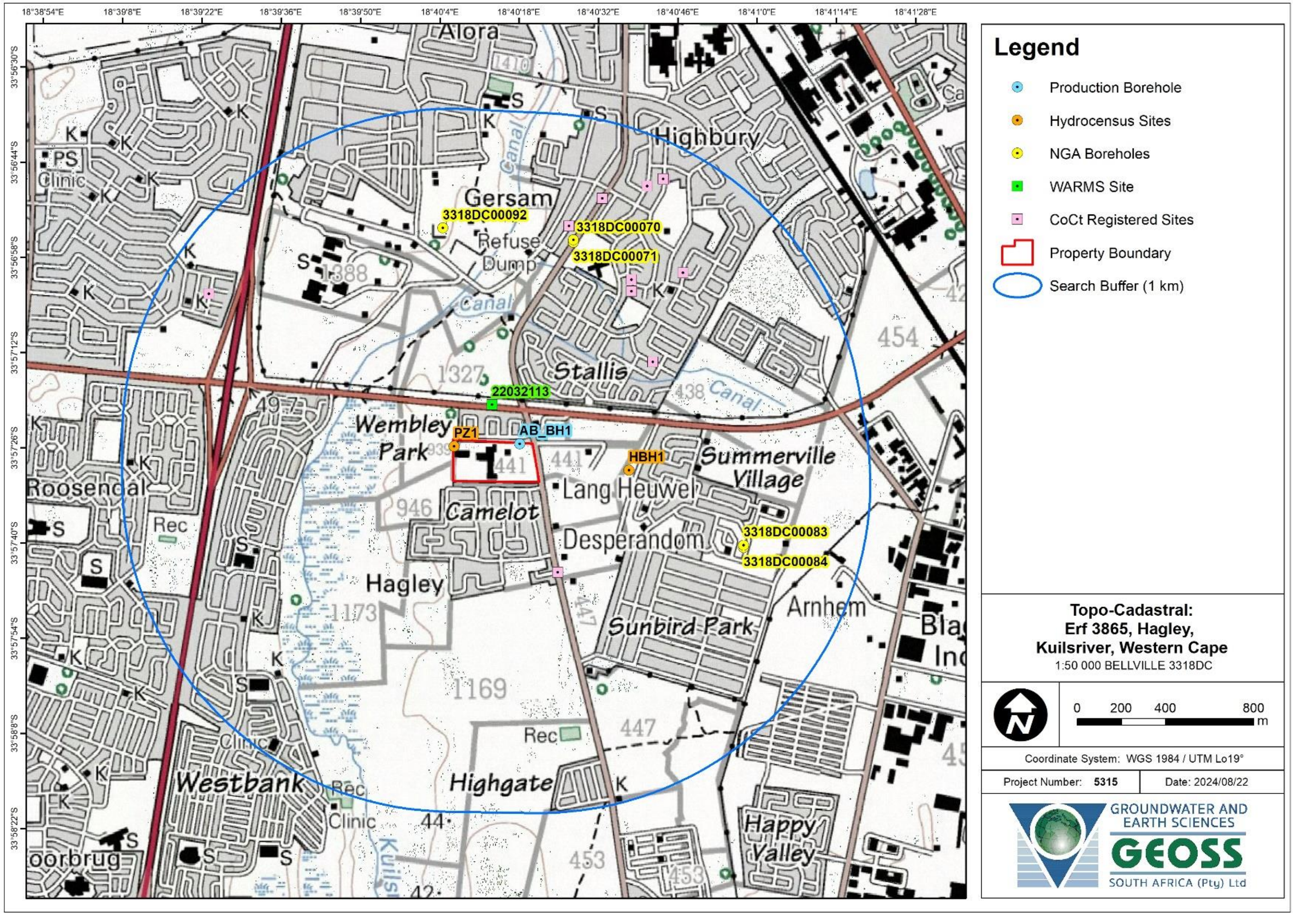
Erf 3865 in Hagley is located within quaternary catchment G22E which is approximately 270.68 km^2 in extent and has a groundwater General Authorisation (GA) of 400 m^3/a/ha. The property is located within the Kuils River District Municipality and falls under the Breede-Olifants Catchment Management Area which is responsible for managing the water resources.

The study area, within a regional context, is shown on **Map 1, Map 2** and **Map 3** to show more detailed views of the study site with relevant information superimposed on a 1:50 000 topo-cadastral map and aerial image, respectively.

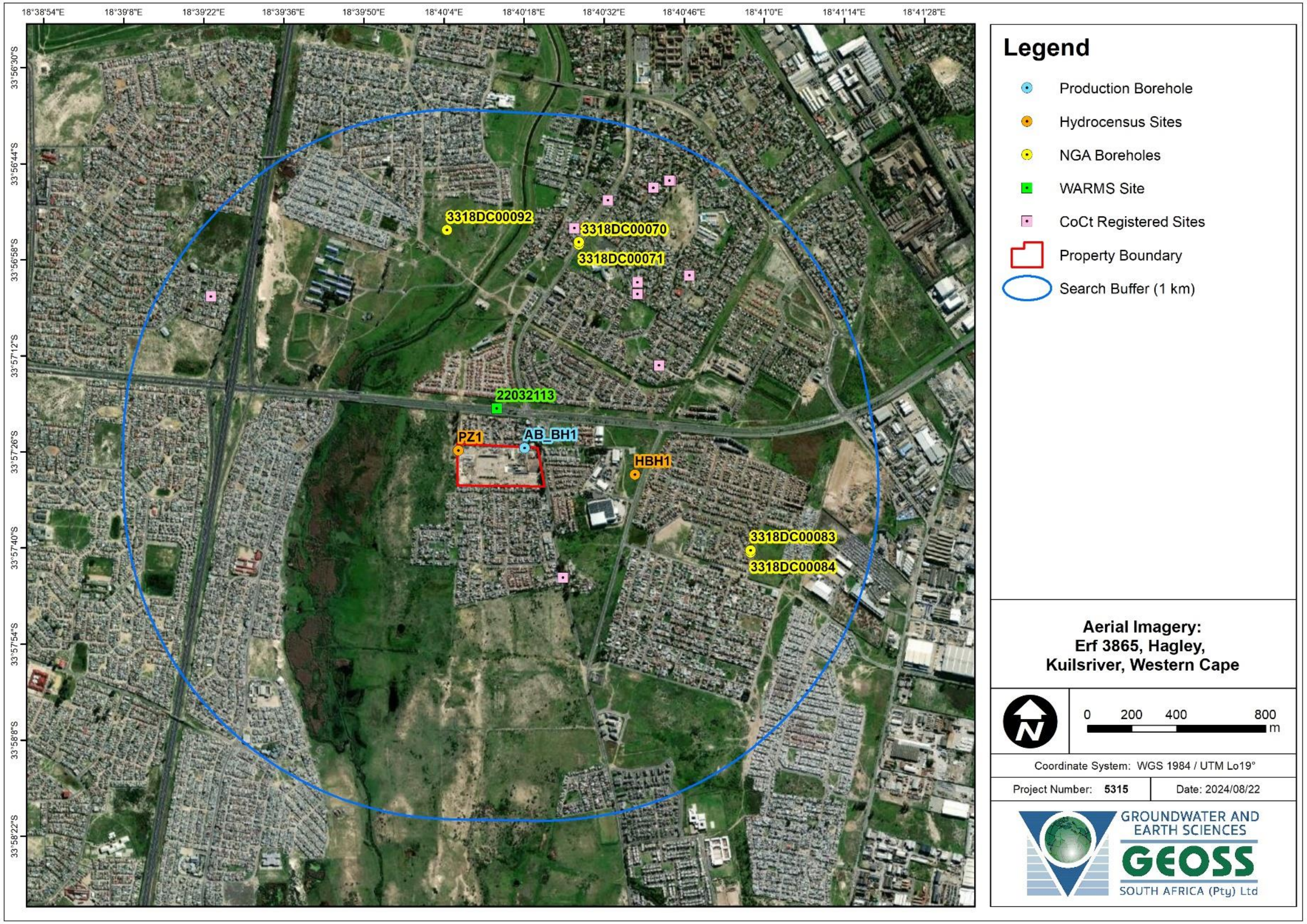
3.2 Drainage

The area drains towards the south to feed the Kuils River with the conditions on the site likely draining in a westerly direction. This area is known to be extremely flat lying with civil construction affecting the topography significantly in addition to the granite of the Stellenbosch Pluton forming hills locally. As the sea is approached towards the west, the topography flattens out and the gradient becomes virtually zero. This, however, coincides with thick sandy overburden associated to the Sandveld Formation and drainage is likely facilitated within this sandy overburden along a hydrostatic gradient.

Map 1: Locality of Erf 3865 in Hagley within a regional setting.



Map 2: The study site with the property boundary with the production, hydrocensus, NGA, WARMS and COCT boreholes superimposed on a 1:50 000 scale topo-cadastral map (3318 DC_Bellville).



Map 3: The study site with the property boundary with the production hydrocensus, NGA, WARMS and COCT boreholes, superimposed on a satellite image.

3.3 Climate

The area experiences a Mediterranean climate with cold, wet winters and hot, dry summers. **Figure 1** shows the monthly average air temperature distribution and **Figure 2** shows the monthly median rainfall and evaporation distribution for the area (Schulze, 2009).

The average annual temperature for the study area is 16.5°C, with the average minimum temperature and average maximum temperature being 11.2°C and 21.8°C, respectively. The long-term (1950 – 2000) mean annual evaporation value of 1152.0 mm/a for the study area exceeds the long-term (1950 – 2000) mean annual precipitation value of 457.0 mm/a for the same area. This suggests that, on an annual basis, more water is lost through evaporation than gained through precipitation. The rainfall is greater than evaporation in the winter months (May to August). Peak groundwater recharge will occur during the cooler, wet winter months.

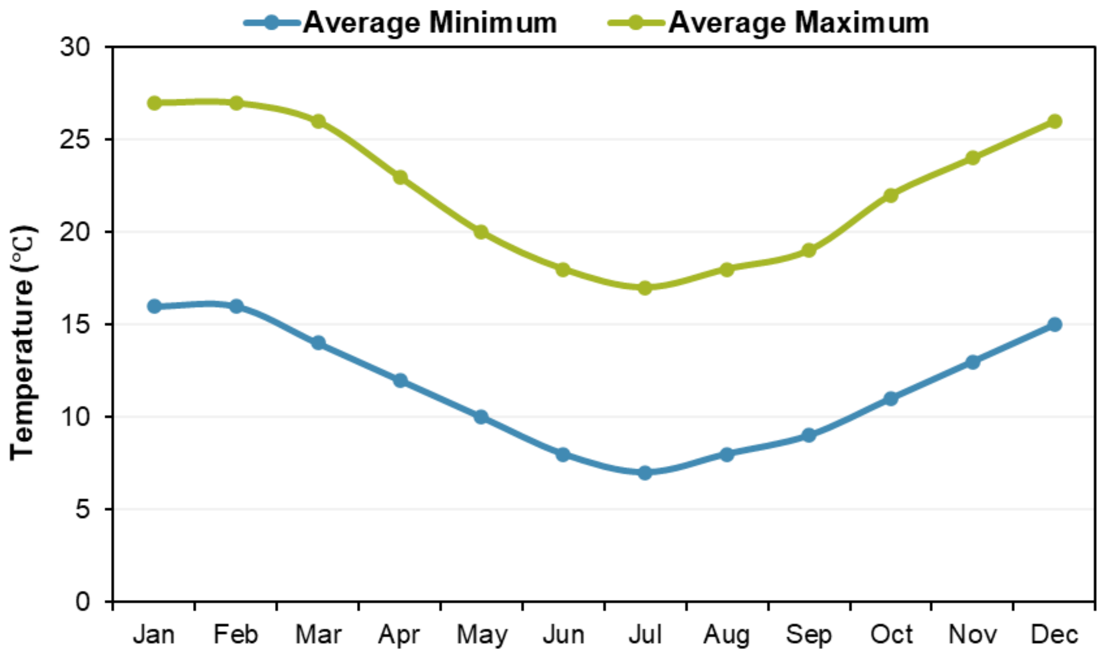


Figure 1: Monthly average minimum and maximum air temperatures for the study area (Schulze, 2009).

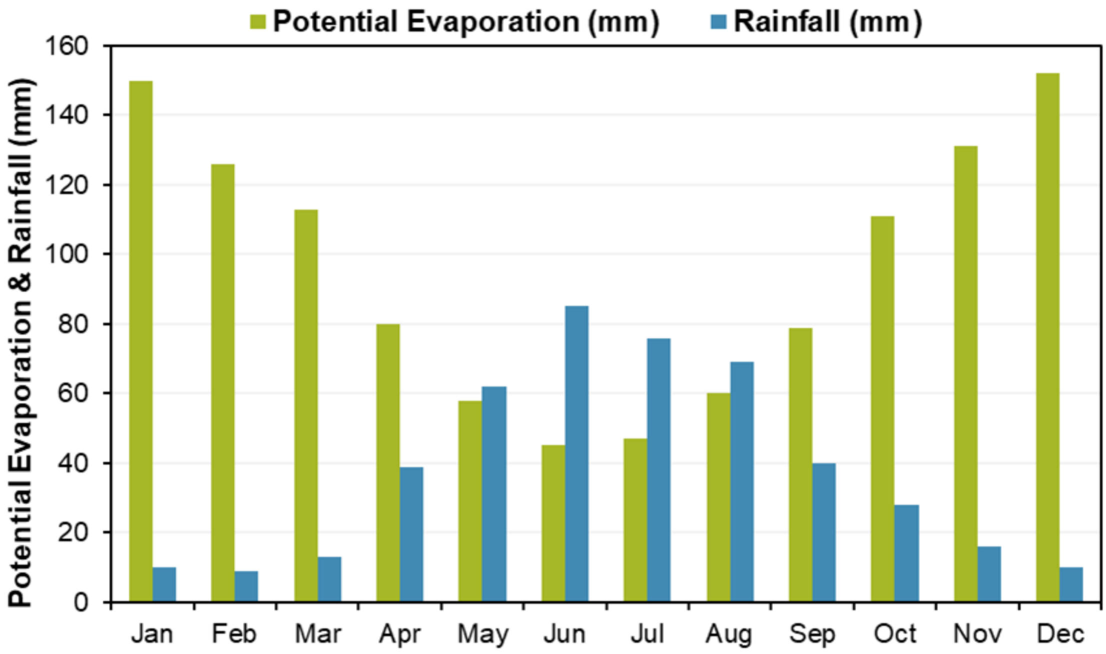


Figure 2: Monthly average rainfall and evaporation distribution for the study area (Schulze, 2009).

4 Geology

4.1 Regional Geology

The Council for Geoscience (CGS) has mapped the area at 1:250 000 scale (3318 Cape Town). The geological setting is shown in **Map 4** and the main lithostratigraphic groups of the area are listed in **Table 3**.

Table 3: Geological formations within the study area

Code	Formation/Pluton	Group/Suite	Lithology
Qwi	Witsand	n/a – Quaternary Age	Unconsolidated calcareous dune sand
Q	Springfontein		
C	Igneous intrusion		Granodiorite
N-Єkh	Kuilsriver Batholith	Cape Granite Suite	Coarse-grained porphyritic granite
Nt	Tygerberg Formation	Malmesbury Group	Quartzose greywacke and mud rock

The property falls in an area mainly associated with Quaternary calcareous dune sand. The area is underlain by the Tygerberg Formation of the Malmesbury Group, signified by greywacke and mud rock. In the area, there are also intrusions of the Kuils River Batholith granites of the Cape Granite Suite towards the north and east of the property. Towards the east of the property, a small granodiorite intrusion has been mapped as outcropping at the surface, this likely associated to a possible southwest – northeast trending fault structure. The Tygerberg Formation has been intersected at depths ~48 m in the borehole on site with intersected fractures hosting the groundwater exploited on the site. **Figure 3** indicates a conceptual model of the geology of the area.

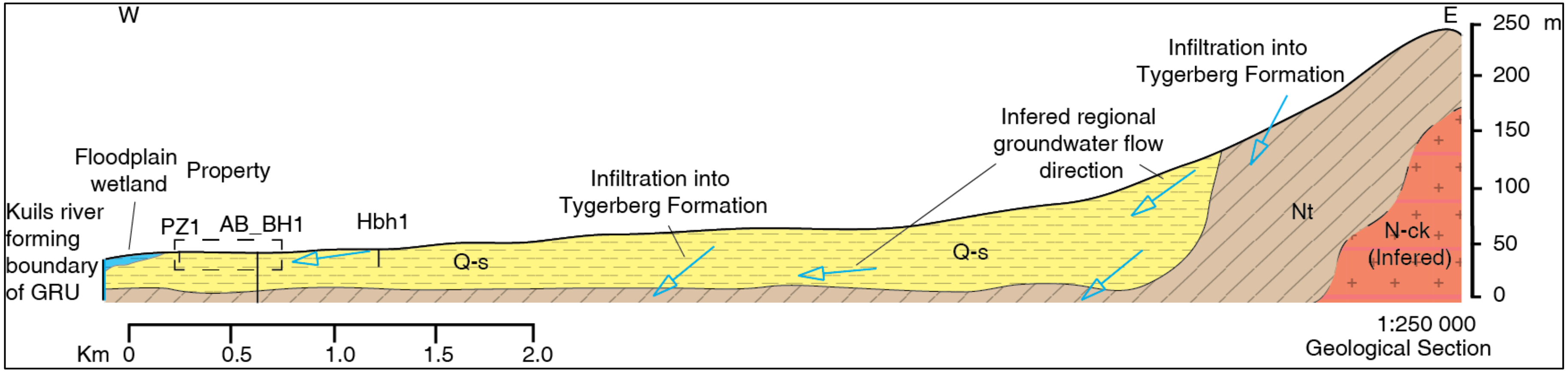
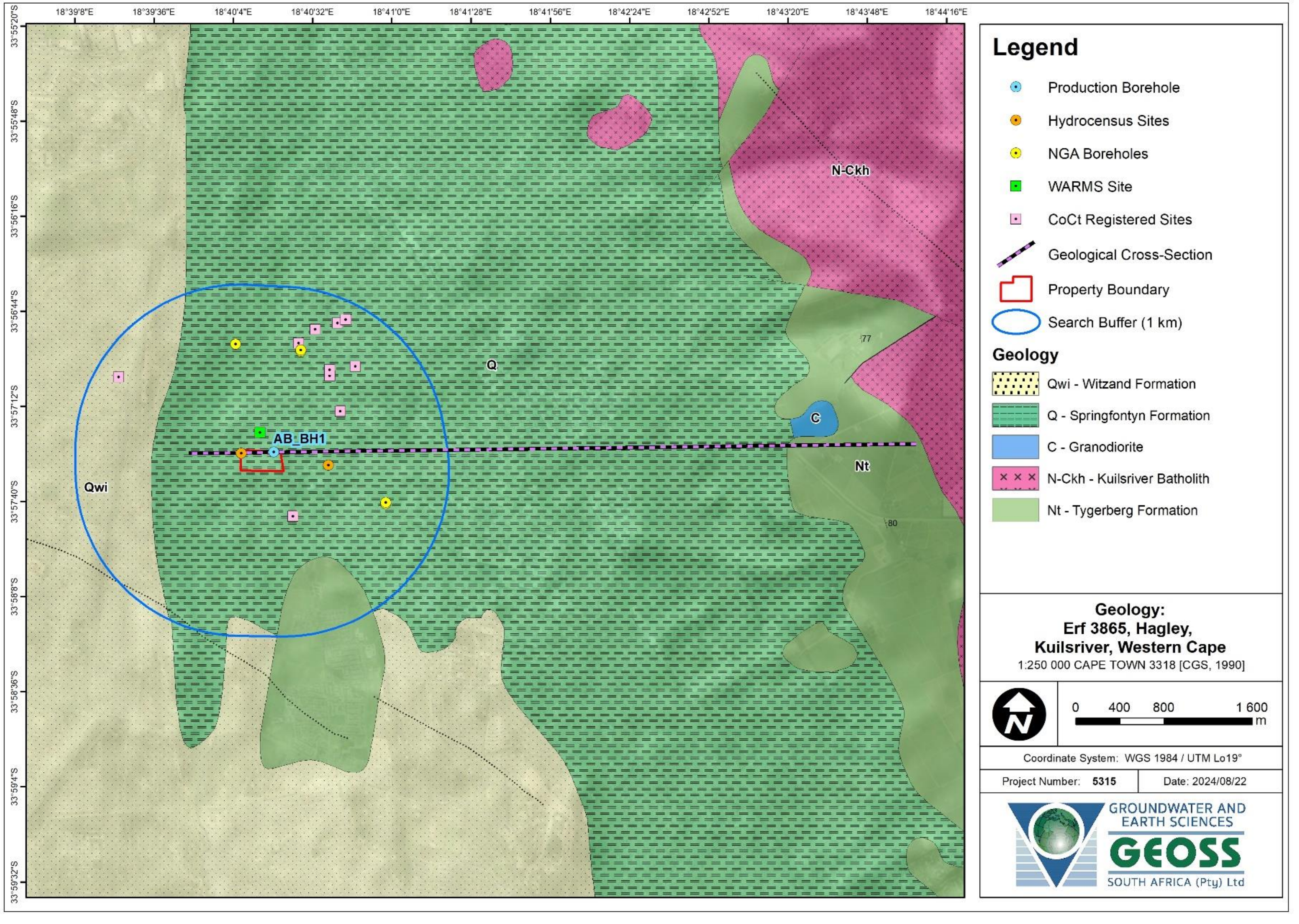


Figure 3: Cross-section of the study site and surrounds (1:250 000 scale 3318 Cape Town).



Map 4: Geological setting of the study site and the hydrocensus, NGA, WARMS and COCT boreholes with the geological cross section line included (1:250 000 scale 3318 Cape Town)

5 Regional Hydrogeology

The aquifer yield and quality classifications are based on regional datasets, and therefore, only indicate conditions to be expected. The presence and characteristics of groundwater in the study area are mainly influenced by the rate and volume of groundwater recharge, as well as the geological formations that act as storage and flow pathways for groundwater.

5.1 Aquifer Yield

The regional aquifer directly underlying the property is classified by the Department of Water Affairs and Forestry (DWAF, 1999) as an intergranular aquifer with an average yield potential of 0.1 – 0.5 L/s (**Map 5**). An intergranular aquifer is where groundwater flows in openings and void spaces between sand grains or weathered rock. A fractured or secondary aquifer describes an aquifer in which groundwater flows through fractures or fault structures.

The production borehole is drilled into the fractured aquifer, the Malmesbury Group shale bedrock and has a sustainable yield of 2.9 L/s, higher than that of the regional classification (see **Section 9**).

5.2 Aquifer Quality

Electrical conductivity (EC) measures the groundwater's ability to conduct electricity which is directly related to the concentration of ions in the water. This parameter is used as an indication of the quality of the groundwater. The groundwater map as illustrated in **Map 6**, indicates that groundwater quality beneath the site is classified as “marginal” with an associated electrical conductivity (EC) of 70 – 300 mS/m. There is an area to the north of the site that has been indicated as having “poor” water quality, based on EC values within the range of 300 – 1 000 mS/m, while a good water quality area is identified towards the southwest of the site (DWAF, 2005). The groundwater quality from the production borehole on site was classified as having poor quality for potable use (see **Section 9.2**).

5.3 Aquifer Vulnerability Classification

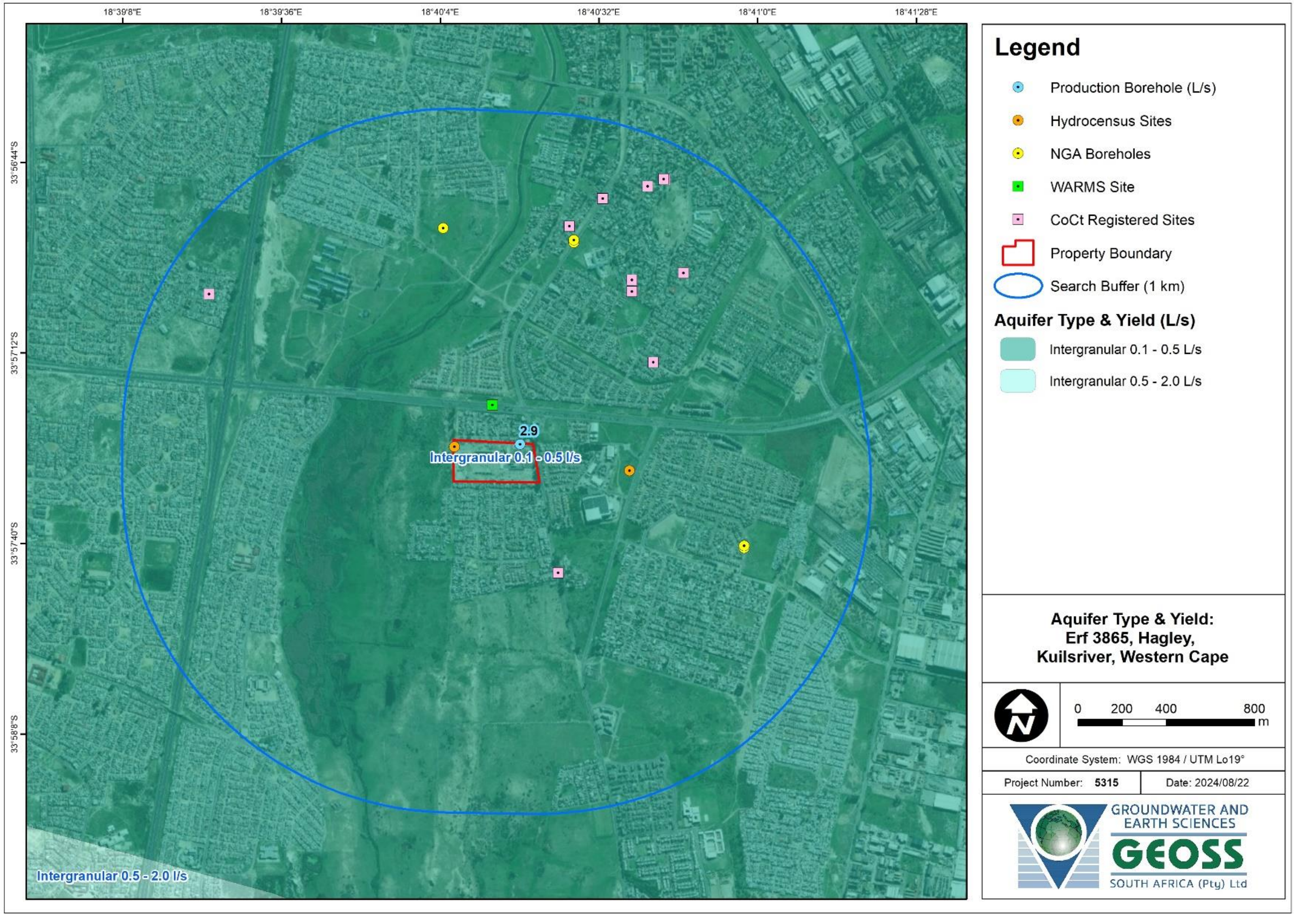
The national scale groundwater vulnerability map for South Africa (Conrad and Munch, 2007) which was developed according to the DRASTIC methodology (Aller et al, 1987), shows that groundwater under the property has a high vulnerability to surface-based contaminants (**Map 7**). The DRASTIC method takes into account the following factors:

D	=	depth to groundwater	(5)
R	=	recharge	(4)
A	=	aquifer media	(3)
S	=	soil type	(2)
T	=	topography	(1)
I	=	impact of the vadose zone	(5)
C	=	conductivity (hydraulic)	(3)

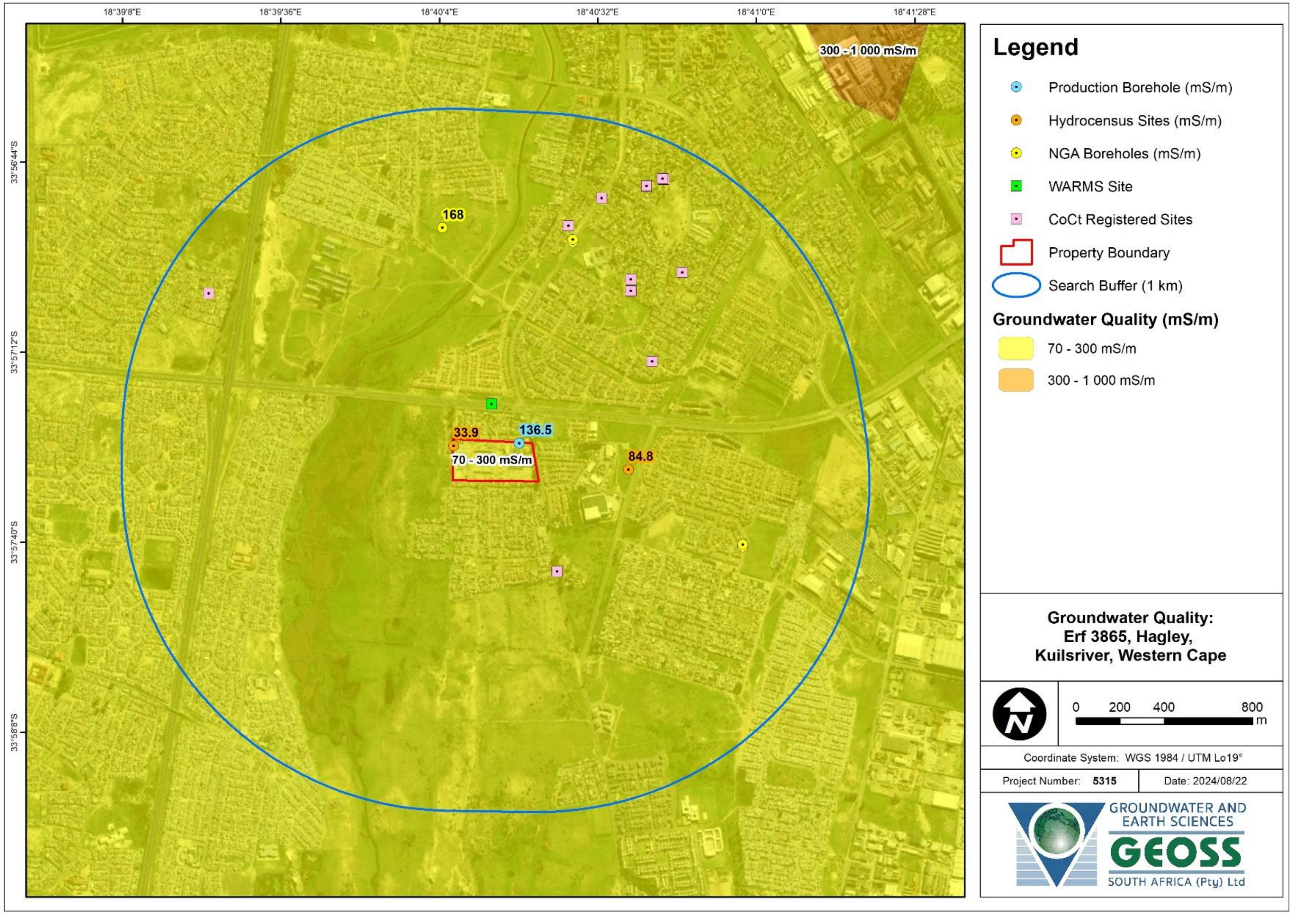
The number indicated in parenthesis at the end of each factor description is the weighting or relative importance of that factor.

The "high" rating is likely associated with the alluvium intergranular (unconsolidated) conditions associated to the sandy overburden. The borehole AB_BH1 has been reported as drilled into the underlying fractured shale bedrock (~48 mbgl) and has a steel casing until 84 mbgl, the steel casing acts as a barrier, preventing interaction between surface water and groundwater resources. The borehole is perforated around water-bearing zones between 48 – 78 mbgl. . In this area, the geological map as well as local knowledge of the area indicate that the shale bedrock is usually overlain by a clay layer. The driller report (**Appendix I**) indicates a weathered clay-rich layer overlying the shale bedrock. This clay layer is likely to provide sufficient protection against point and non-point sources of contamination, and the vulnerability rating of the underlying fractured aquifer would likely be low. The alluvial aquifers are susceptible to contamination. This application is for industrial use and safety measures should be set to ensure that contaminants such as fuel do not contaminate the water found in the shallow primary aquifer. Dip trays under vehicles would assist, as would not parking on open, uncovered ground.

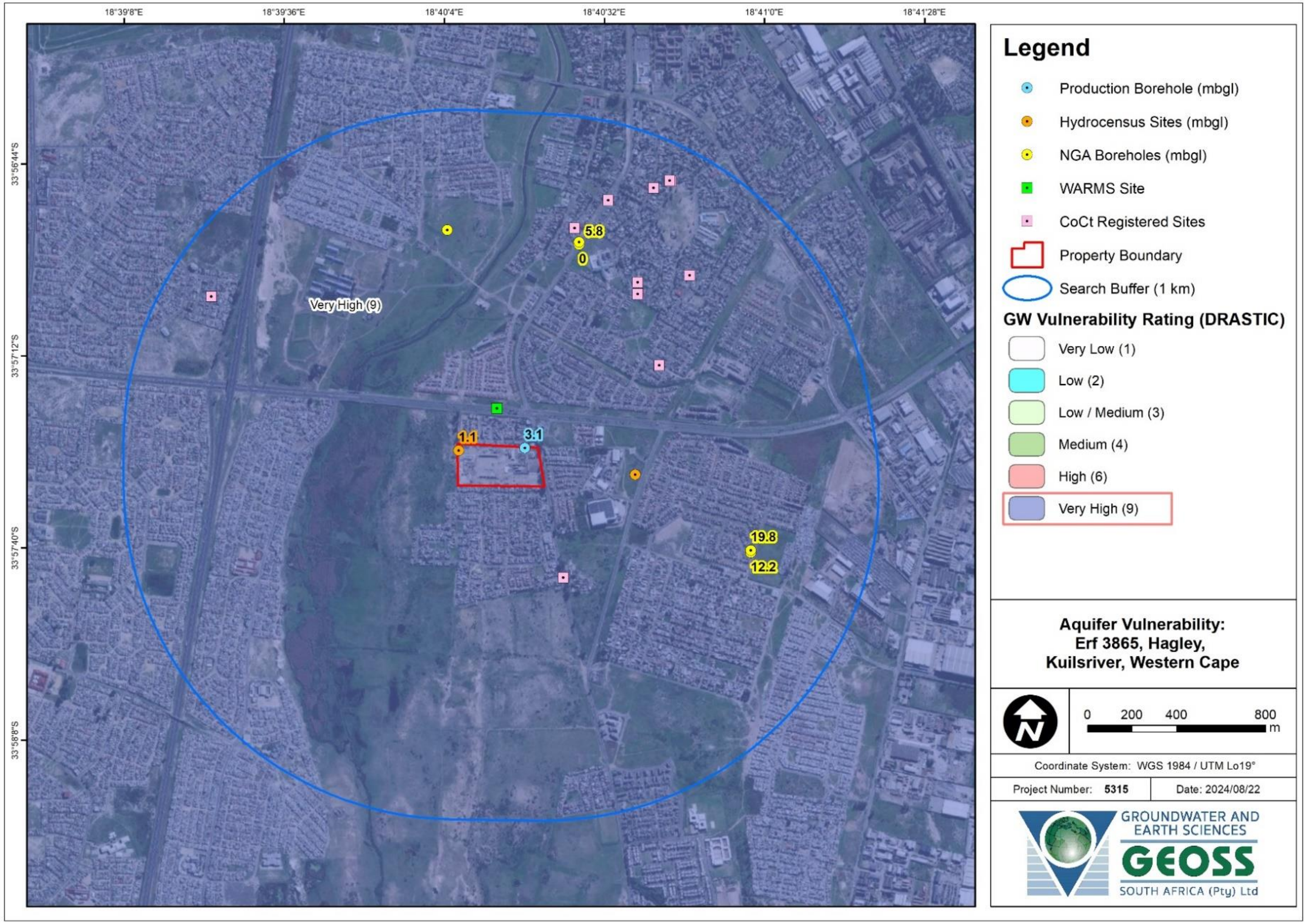
Care should be taken to ensure that the borehole is correctly sealed so that no contaminant can enter the lower aquifer through the borehole. A solid and secure cover must also cover the production borehole to prevent contaminants from reaching the groundwater.



Map 5: Regional aquifer yield (L/s) (DWAF, 2002).



Map 6: Regional groundwater quality (EC in mS/m) from DWAF (2002).



Map 7: Vulnerability rating (DWAF, 2005) and groundwater depths (mbgl).

6 Volume, Purpose, Treatment and Storage of Water Uses

Erf 3865 in Hagley, near Blackheath, Western Cape is located within quaternary catchment G22E, and thus the General Authorisation (GA) regarding groundwater abstraction is 400 m^3/ha/annum and is capped at 40 000 m^3/a per property. The total area of the property is 6.65 ha and a total of 2 660.0 m^3/a can be abstracted under the GA. The proposed volume to be abstracted is 2 560.0 m^3/a which is within the GA limit amount.

The abstracted groundwater will be used for irrigation on the property. A landscaping plan has been included in **Appendix II** indicating areas where irrigation will be focused. Water abstracted from the borehole will be stored in storage tanks where it will be diluted with supplementary municipal water (70% borehole water and 30% groundwater dilution factor) in order to manage the concentration of certain elements in the water considered as detrimental to the irrigation plan. No water treatment will be done on site. The area irrigated will cover around 2 815 m^2 (0.28 ha) by means of optimally spaced sprinklers to consider water saving in addition to seasonal adjustment of irrigation schedules. A water management plan for the property is provided in **Table 4**. It should be noted that the applicant does not plan on reducing their dependency on municipal water, they will use both municipal water and groundwater on the site.

Currently, there are two storage tanks (JoJo tanks) on-site with a total storage capacity of 40 000 L (40 m^3). These are covered storage devices which have no risk of evaporation and generally no safety risk, moreover the volume stored is less than the GA, DWS does not typically have to authorise storage within JoJo tanks falling inside the GA limits.

Table 4: Water management plan for Erf 3865, Hagley, near Kuils River.

<table>
<tr><th rowspan="3">Months</th><th colspan="3">Requirement (m³)</th><th colspan="3">Supply (m³)</th></tr>
<tr><th>Domestic</th><th>Agricultural</th><th rowspan="2">Total Current Requirement (m³/a)</th><th>Groundwater supply (m³)</th><th rowspan="2">Municipal supply (m³)</th><th rowspan="2">Total Supply (m³/a)</th></tr>
<tr><th>Municipal</th><th>Landscape Irrigation (0.281 ha, 2 815 m² Irrigation system)</th><th>AB_BH1</th></tr>
<tr><td>January</td><td>171.9</td><td>401.0</td><td>572.9</td><td>401.0</td><td>171.9</td><td>572.9</td></tr>
<tr><td>February</td><td>139.0</td><td>330.0</td><td>469.0</td><td>330.0</td><td>139.0</td><td>469.0</td></tr>
<tr><td>March</td><td>121.0</td><td>285.0</td><td>406.0</td><td>285.0</td><td>121.0</td><td>406.0</td></tr>
<tr><td>April</td><td>67.0</td><td>157.0</td><td>224.0</td><td>157.0</td><td>67.0</td><td>224.0</td></tr>
<tr><td>May</td><td>51.0</td><td>119.0</td><td>170.0</td><td>119.0</td><td>51.0</td><td>170.0</td></tr>
<tr><td>June</td><td>32.0</td><td>74.0</td><td>106.0</td><td>74.0</td><td>32.0</td><td>106.0</td></tr>
<tr><td>July</td><td>33.0</td><td>77.0</td><td>110.0</td><td>77.0</td><td>33.0</td><td>110.0</td></tr>
<tr><td>August</td><td>33.0</td><td>77.0</td><td>110.0</td><td>77.0</td><td>33.0</td><td>110.0</td></tr>
<tr><td>September</td><td>50.0</td><td>116.0</td><td>166.0</td><td>116.0</td><td>50.0</td><td>166.0</td></tr>
<tr><td>October</td><td>89.0</td><td>209.0</td><td>298.0</td><td>209.0</td><td>89.0</td><td>298.0</td></tr>
<tr><td>November</td><td>134.0</td><td>314.0</td><td>448.0</td><td>314.0</td><td>134.0</td><td>448.0</td></tr>
<tr><td>December</td><td>172.0</td><td>401.0</td><td>573.0</td><td>401.0</td><td>172.0</td><td>573.0</td></tr>
<tr><td>Total (m³/a)</td><td>1 092.9</td><td>2 560.0</td><td>3 652.9</td><td>2 560.0</td><td>1 092.9</td><td>3 652.9</td></tr>
</table>

7 Site Specific Information

7.1 Desktop Assessment (Existing Groundwater Information)

To determine whether any groundwater users in the area may be affected by activities on site, a database search was conducted using a 1.5-km radius around the property boundary. This portion of the study was completed by studying and inquiring about existing databases that contain groundwater information. A search was conducted on several databases, namely the National Groundwater Archive (NGA), Water Use Authorisation and Registration Management System (WARMS), City of Cape Town (COCT) registered groundwater users as well as the internal GEOSS database. These resources provide data on borehole positions, groundwater chemistry, and yield, when available. Based on the desktop assessment of the various databases, it is evident that there is a low reliance on groundwater in the area surrounding the proposed site.

7.1.1 National Groundwater Archive (NGA) Database

A desktop hydrological study was carried out in July 2024 using a 1.5-km search radius from the centre of the property to determine if there are any groundwater users in the area. This part of the study was completed by studying and inquiring about existing databases that contain groundwater information and did not include any field work. 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.

The NGA indicated that there are five (5) boreholes located within the 1.5-km search area of the property. Therefore, very little data could be obtained for the NGA boreholes from the NGA database which shows that for the study area, there are few groundwater users. Of the available information, the depth of the boreholes range from 6.4 m to 74.4 m and the water levels are between 5.8 mbgl and 19.8 mbgl. This indicating that water users have targeted both the shallow primary aquifer as well as the deeper fractured aquifer. The NGA sites are shown in **Map 2** and **Map 3** and the NGA information is summarised in **Table 5**. The geological logs indicated in the table note granitic bedrock intersected in all but one borehole. The geological map indicates a low likelihood of granitic bedrock at this location as few granitic outcrops are located within a 5-km radius, however there is a possibility of granitic intrusive bodies under cover, as Quaternary cover is present in the surrounding area. The production borehole on site (AB_BH1) has been indicated to intersect shale bedrock (**Appendix I: Driller Report**).

Table 5: Summary of NGA borehole details within a 1.5 km radius of the property

NGA ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Water Level (mbgl)	Depth (m)	EC (mS/m)	Estimated Geology	Logged by entrant and date
3318DC00084	-33.9614	18.6826	12.2	51.5	-	0 - 2 Boulders | 2 - 18 Clay | 18 - 51.5 Granite	Driller 1937

NGA ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Water Level (mbgl)	Depth (m)	EC (mS/m)	Estimated Geology	Logged by entrant and date
3318DC00083	-33.9613	18.6826	19.8	74.7	-	0 - 74.7 Granite	Driller 1935
3318DC00071	-33.9489	18.6743	0.0	54.6	-	0 - 5 Clay | 5 - 30 Granite | 30 - 42 Shale | 42 - 54.6 Granite	Driller 1932
3318DC00070	-33.9488	18.6743	5.8	65.5	-	0 - 65.5 Granite	Driller 1932
3318DC00092	-33.9483	18.6679	-	6.4	168	0 - 6.4 Sand	Driller 1990

7.1.2 Water Use Authorisation and Registration Management System (WARMS) Database

From the WARMS database, there is one (1) registered groundwater abstraction point located within the 1.5-km search radius from the property boundary (**Table 6**) indicated on **Map 2** and **Map 3**. This site is registered as an industry (urban) classification of water use and the lawfulness of this abstraction point needs to still be determined. The volume applied for to abstract is 45 000.0 m³/a.

Table 6: Summary of active and registered WARMS borehole details (1.5 km search).

WARMS no.	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Registered Volume (m³/a)
22032113	-33.9555	18.6703	45 000.0

7.1.3 City of Cape Town (COCT) Database

From the COCT database, there are 12 registered groundwater abstraction points located within the 1.5-km search radius from the property boundary (**Table 6**) indicated on **Map 2** and **Map 3**. This database only provides an address with no additional information.

Table 7: Summary of active and registered COCT borehole details (1.5 km search).

Registered property
87 Old Nooiensfontein Road, 7580
29 Carlier Street, Highbury Park, 7580
6 Risedale Close, Highbury, 7580
4 Risedale Road, Highbury
34 Groenvlei Road, Highbury ,7530
6 Beveland Street, Highbury,7580
29 Jonkman Street, Kuils River, 7580
130 Old Nooiensfontein ,Gersham
10 Bellhome Street, Highbury, 7580
38 Excelsior Street, Highbury
49 Excelsior Street, Kuils River, 7580
25 De Villiers Street, Belhar

7.2 Hydrocensus

A hydrocensus was conducted on the 7th of July 2024 within a 1.5 km radius of the property boundary. This involved identifying boreholes and landowners/groundwater users in the area. During the hydrocensus, any information about groundwater abstraction, yield, and quality was requested.

After a complete hydrocensus, it was established that minimal groundwater abstraction is taking place in the immediate area. One (1) borehole was identified during the hydrocensus, in addition to the existing borehole on site and the boreholes listed in the desktop section. This borehole has been reported to be around 6 metres deep and has been analysed for field chemistry parameters. The EC was measured at 84.8 mS/m, indicating 'ideal' water quality in the area. This EC value is in line with the NGA database boreholes. The hydrocensus borehole details are summarised in **Table 8**.

The area surrounding the site is either dependent on municipal water or surface water. It was noted during the hydrocensus that multiple sites listed on the regional datasets such as the NGA, WARMS and COCT do not actually exist. There is a low reliance of groundwater in the area.

The borehole log of the existing borehole on site (AB_BH1) indicated that the area is underlain by approximately 22 m of Springfontein Formation sandy loam followed by weathered clay-rich Tygerberg Formation between depths 22 – 46 m. This, in turn, is underlain by phyllites of the Tygerberg Formation intersected to the final depth of drilling (84 m).

Table 8: Hydrocensus Site Descriptions (31 July 2024).

Site ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Water Level (mbgl)	Depth (m)	Yield (L/s)	EC (mS/m)	TDS (mg/L)	pH	Comments	Image
HBH1	-33.9582	18.6770	-	6.0	-	84.8	574.9	8.2	Well 6m deep. Sampled from tanks. SANS analysis done	
PZ1	-33.9572	18.6684	1.1	1.3	-	33.9	229.8	8.1	Log: 0 - 0.11 overburden | 0.11 - 0.49 grey sandy overburden | 0.49 - 0.62 grey clay | 0.62 - 1.3 grey to white sand with increased water saturation with depth : Installed 40 mm uPVC perforated every 10 mm from 1.3 - 0.56 mbgl, solid from 0.56 to 0.335 magl. Casing length = 1.57 m while the hole is 1.3 m deep	
AB_BH1	-33.9571	18.6716	3.1	84.0	2.9	136.5	925.5	7.1	Borehole has no observation pipe or sampling tap, thus sampled (for SANS) from tanks at intake from borehole	

8 Piezometer Installation

During the site visit conducted on the 7th of July, the installation of one (1) piezometer via the augering of a hole was conducted. Information pertaining to this site is summarised in **Table 9**. The piezometer was installed to determine the shallow groundwater depth, likely associated to the floodplain wetland along the Kuils River. The water intersected was then sampled in order to compare the signature to that sampled from the borehole. Augering also provided an indication of soil types. The position of the piezometer was chosen to provide information as close as possible to the floodplain wetland, situated towards the west of the property boundary. Typically, the holes are hand dug using an auger kit to a maximum depth of 5 m or until water is reached, whichever comes first. The site visit, occurred during a particularly wet winter with multiple rain events, providing surface runoff to the area augered during the site visit. Water was intersected around 1.06 mbgl and auguring was not possible past 1.3 mbgl due to the hole collapsing under the hydrated state.

Piezometer installation involves installing a 50 mm PVC pipe as deep as possible below the groundwater level. The PVC pipe is slotted (i.e., screened) to allow groundwater to flow into the pipe. The general construction of such a screened piezometer can be seen in **Figure 4**.

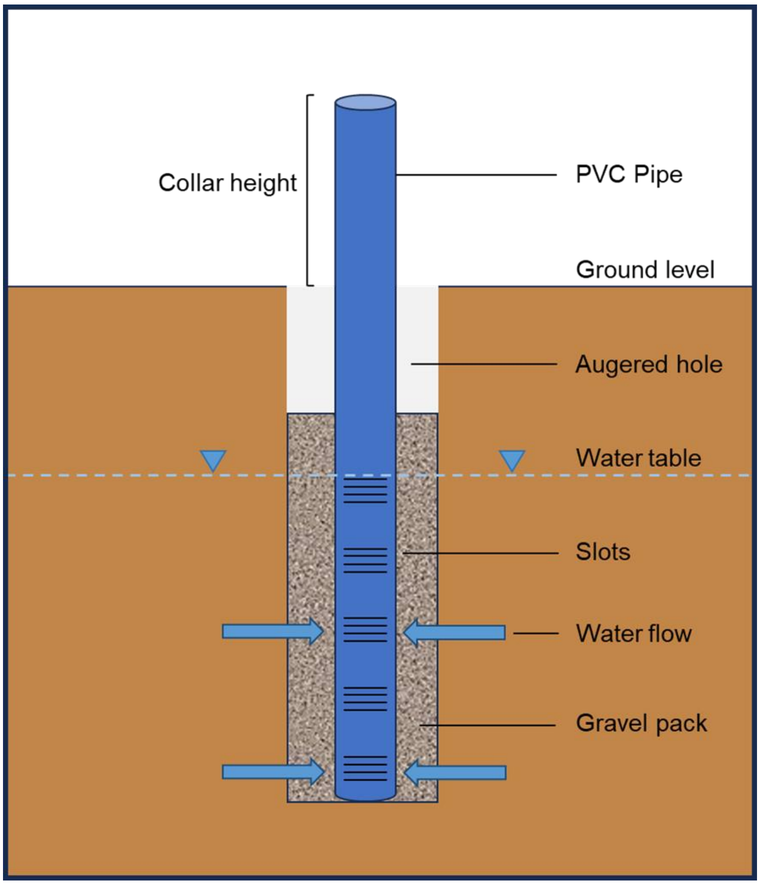


Figure 4: Typical piezometer installation.

The formations intersected during auguring were logged with the generalised soil profile intersected summarised in **Table 10**. The piezometer intersected water at a depth of 1.06 mbgl. The location of the piezometer is illustrated in **Map 3**.

Table 9: Summary of piezometers.

Site_ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Depth (m)	CH (m)	Elevation (mamsl)	WL (mbgl)
PZ1	-33.9572	18.6684	1.3	0.34	44	1.06

Following the augering, piezometer installation and site walkover; the following generalised soil profile typifies this site and is summarised in **Table 10**.

The site is dominated in the shallow subsurface (<1.3 mbgl) by a beige silty fine sand with a loose consistency with minor clay inclusions at depths 0.49 – 0.62 mbgl. Auguring could not reach deeper depths due to the hole collapsing in the hydrated shallow subsurface conditions. Although this profile does not provide sufficient information regarding a clay layer that may impact on transmissivity, infiltration and the spread of potential contaminants the geology intersected during the drilling of borehole AB_BH1 may provide a better indication. Between depths of 23 – 47 m the borehole was indicated to intersect clay and weathered shale material. This layer overlies the bedrock and will have a significant impact in the time it takes to infiltrate the bedrock surrounding the site.

The site is mainly covered by paving and screeded surfaces with small gardens mostly located where services and cabling also gets channelled through. Therefore no further site observations or further auguring could be performed to define the profile across the site.

Table 10: Generalised soil profile.

Unit	Depth (mbgl)	Description	Image
Unit 1	0.00 to ± 0.11	Damp, very loose, dark brown organic material rich overburden, likely compost from neighbouring gardens.	-
Unit 2	0.11 to ± 0.49	Slightly moist to loose, grey, fine to medium- grained sand.	
Unit 3	0.49 to ± 0.62	Slightly moist grey to beige clay.	
Unit 4	0.62 to ± 1.3	Grey to white loose, fine to medium grained sand with increased water saturation with depth.	

9 Borehole Yield Testing

9.1 Methodology

The yield testing was undertaken by GEOSS SA from 6th to the 9th of November 2023 and carried out according to the National Standard (SANS 10299-4:2003, Part 4 – Test pumping of water boreholes). This included a Step Test, Constant Discharge Test (CDT) and recovery monitoring of the borehole. For the Step Test, a borehole is pumped at a constant rate for one-hour intervals and the flow rates are incrementally increased for each step. This test is followed by a Constant Discharge Test where the borehole is pumped at a constant rate for an extended period of time, followed by recovery monitoring. The water level drawdown is monitored at pre-determined intervals during these tests (drawdown refers to the difference in water level from the rest water level (RWL) measured before commencement of the yield test). Raw data and measurements taken during the yield tests are presented in **Appendix III**.

The yield test data was analysed using the Excel-based FC program developed by the IGS (Institute for Groundwater Studies) in Bloemfontein. The sustainable yield of the borehole was calculated based upon long-term extrapolations of the CDT data according to (1) the Cooper-Jacob approximation of the Theis solution for confined aquifers, (2) the Barker Generalised Radial Flow Model (GRF) for hydraulic tests in fractured rock and (3) the Flow Characteristic (FC) method(s) using first and second derivative calculations. Boundary conditions are accounted for in multiplication factors to the rate of drawdown (derivatives), according to each of the above three methods. These three methods are briefly described below.

1. The Cooper-Jacob approximation of the Theis solution for confined aquifers was designed for porous media aquifers, where infinite acting radial flow (IARF) was observed during the pumping of a borehole. The application of this method to fractured aquifers was discussed by Meier et al. (1998), concluding that T estimates using the Cooper-Jacob analysis gave an effective T for the fracture zone. The Cooper-Jacob analysis (and more accurately, the Theis method) is therefore viable for analysing pumping test data for fractured aquifers where IARF is observed. The parameters are then used to predict theoretical long-term drawdowns.
2. The Barker GRF Model (Barker, 1988) uses fracture hydraulic conductivity, fracture storativity, and flow domain to predict drawdown due to abstraction in a borehole in a fractured medium. By changing these values, a curve of drawdown predictions can be made to fit real-world data and therefore predict theoretical long-term drawdowns.
3. The FC methods are the Basic FC, the FC Inflection Point, and the FC Non-Linear. The Basic FC and the FC Inflection Point methods make use of the derivatives of the drawdown data to predict theoretical long-term drawdowns and the scale-back factors are applied to selected available drawdowns. The FC Non-Linear method uses the Step Test data curve fitting to predict theoretical long-term drawdowns. Due to the short nature of the Step Test, this method is usually not included if the other methods of analysis differ from it.

In all three methods, the available drawdown was carefully selected to ensure that the flow regime described by the analytical solution is not extrapolated beyond its applicable depth, which may easily result in an overuse of the resource. For AB_BH1 this was 50 m (54 mbgl), based on the first fracture intersected in the borehole. A two-year extrapolation time without recharge to the aquifer was selected as per the recommendations within the FC method program.

Water samples were collected at the end of the yield test and submitted for inorganic chemical analyses.

9.1.1 Yield Testing at AB_BH1

The yield testing was conducted between the 6th and the 9th of November 2023. The borehole was measured to a depth of 84 meters below ground level (mbgl). The test pump was installed at a depth of 78.12 mbgl, with the observation pipe ending at 75.32 mbgl. A 7.5 kW submersible pump was used to conduct the testing. The size of the pump was limited by the 135 mm steel casing installed in the borehole. The rest water level (RWL) at the start of the test was 3.08 mbgl.

During the step test, the water level was drawn down 17.08 meters below the rest water level (20.16 mbgl) during the 4th step at a rate of 4.8 L/s (17 280 L/hour, pump max). **Figure 5** shows the time-series drawdown for the Step Test.

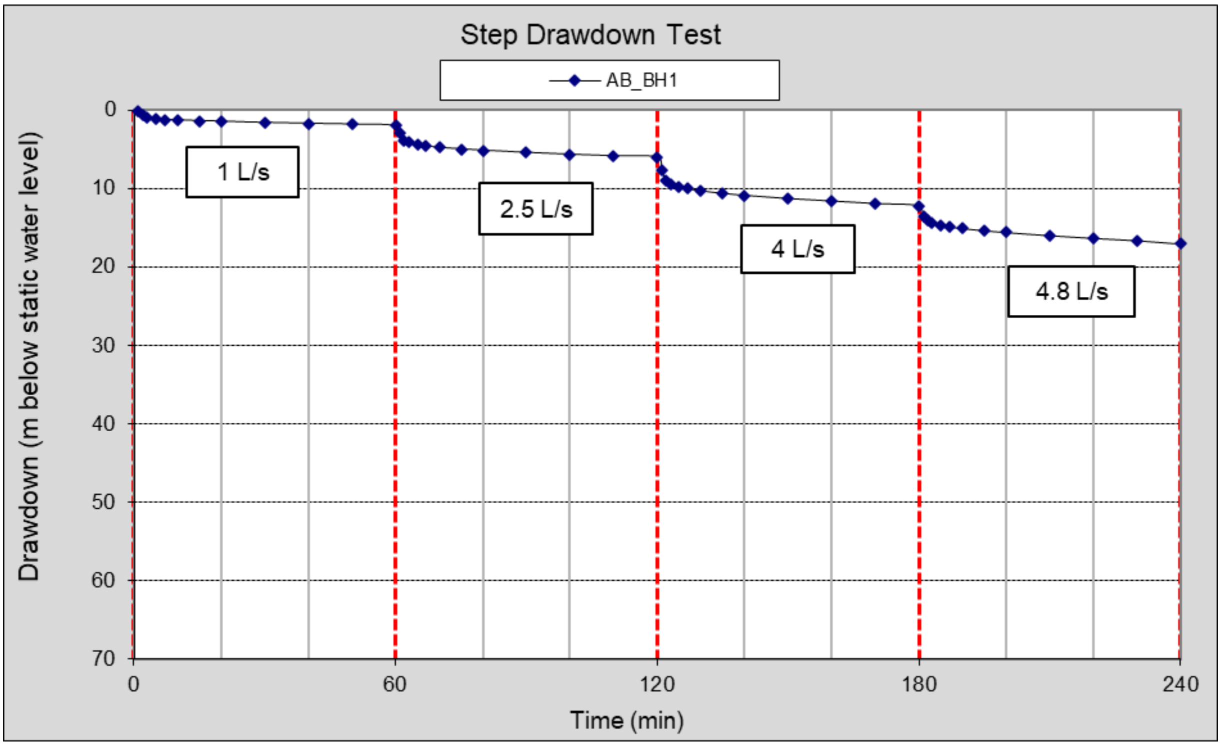


Figure 5: Step Test drawdown data for AB_BH1.

The water level was left to recover overnight. Before starting the CDT, the water level recovered to 3.97 mbgl. Based on the results of the Step Test, the planned 24-hour CDT was conducted at a rate of 4.6 L/s (16 560 L/hour). At the end of the 24-hour period, the water level had drawn down 23.6 meters below the rest water level (27.57 mbgl).

The semi-log plot of the drawdown from the CDT is presented in **Figure 6**. The available drawdown (AD) is indicated with the horizontal red line at 50 m.

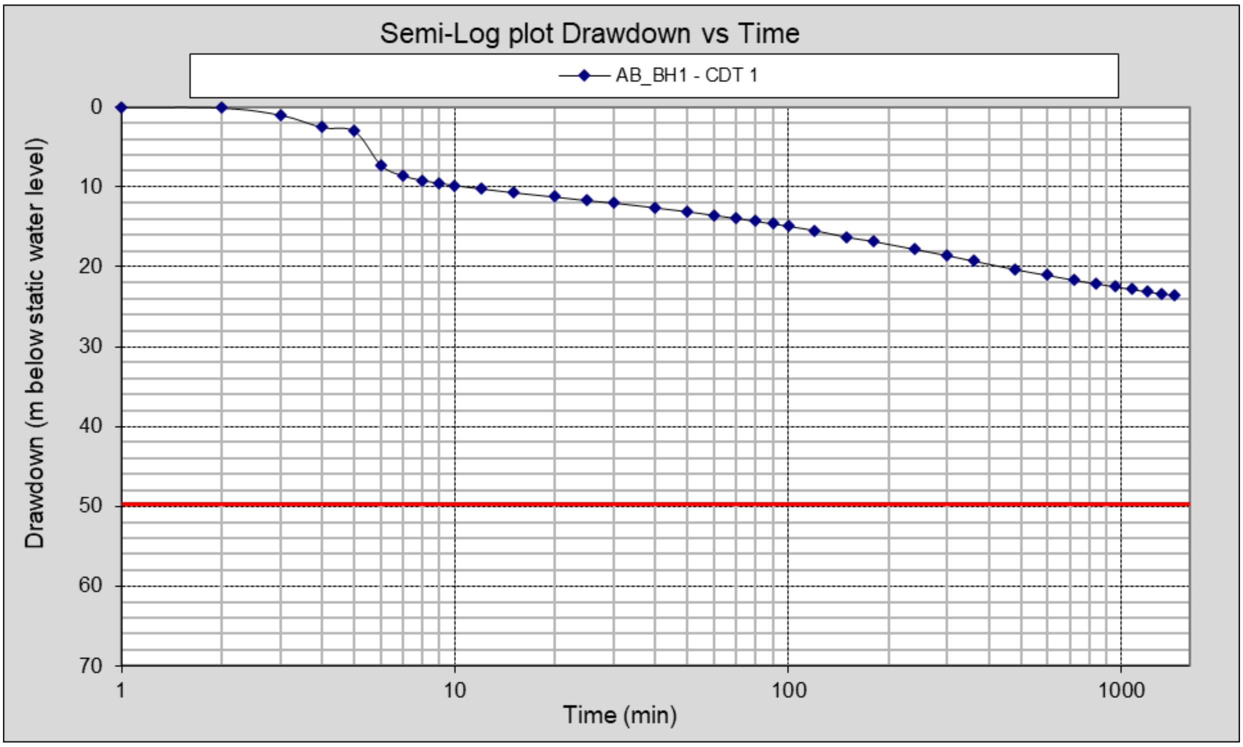


Figure 6: Semi-Log Plot of drawdown during the CDT of AB_BH1 (4.6 L/s).

The recovery of the water level was monitored after the CDT and is presented in **Figure 7**. The recovery was moderate, reaching 95.8% in 24 hours. Monitoring will be essential to determine the long-term recovery of the borehole.

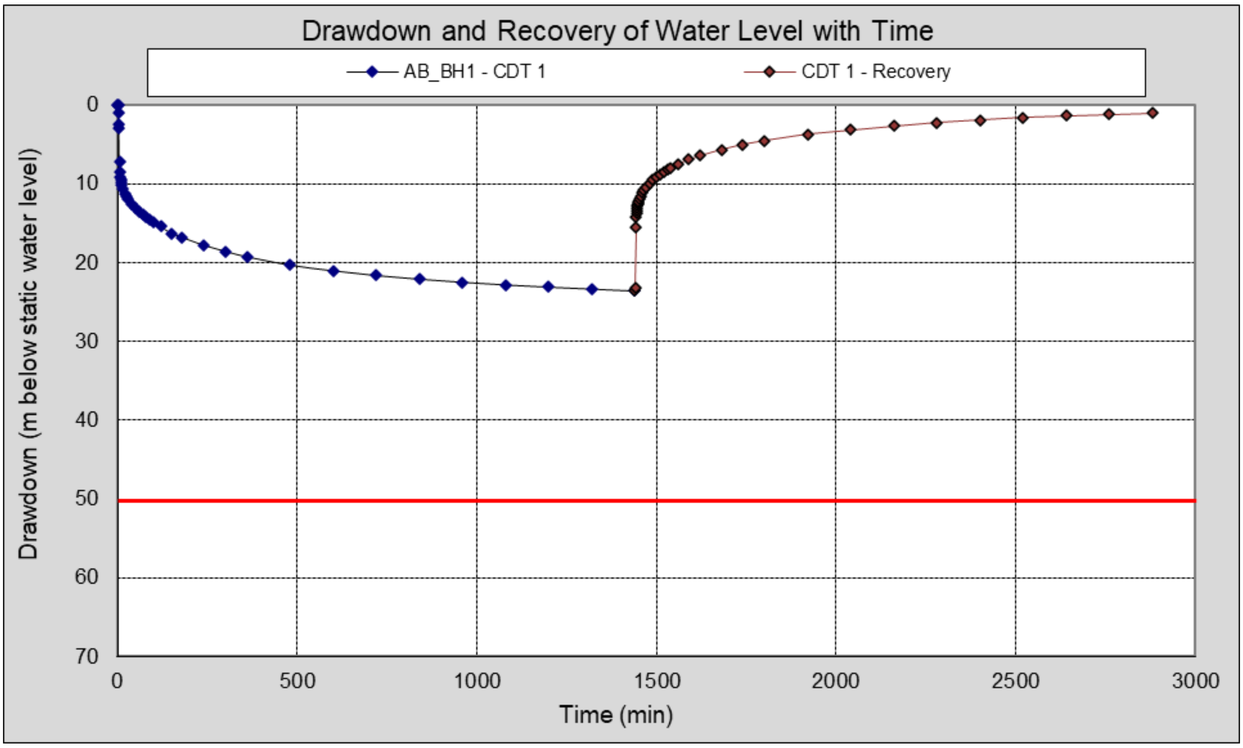


Figure 7: Time-series drawdown and recovery for AB_BH1 (2.9 L/s).

Several methods were used to assess the yield test data as presented in **Table 11**. It is recommended that the borehole can be abstracted from at a rate of up to 2.9 L/s (10 440 L/hour) for up to 24 hours per day. The assessments were based on an available drawdown (AD) of 50 meters below the RWL of the CDT which equates to 54 mbgl.

Table 11: Yield Determination – AB_BH1

AB_BH1			
Method	**Sustainable Yield (L/s)**	**Late *T (m^2/d)**	****AD used (m)**
Basic FC	3.5	11.3	50.0
Cooper-Jacob	2.8	11.4	50.0
FC Non-Linear	2.4	19	50.0
Barker	2.9		50.0
Average Q_sust (L/s)	2.9		
Recommended Abstraction			
Abstraction Rate (L/s)	Abstraction Duration (hours)		Recovery Duration (hours)
2.9	24		0

*AD- Available Drawdown
* T – Transmissivity

No boreholes were monitored during the testing of AB_BH1. Transmissivity was calculated through the Theis method using the drawdown response in AB_BH1. The transmissivity of the system was calculated at 11.4 m^2/d. A storativity value of $5x10^{-4}$ was used for the radius of influence calculation based on an average expected value of confined aquifers as report by (Todd, 1980). Based on the aquifer parameters the radius of influence was calculated for the recommended sustainable yield of the borehole. A drawdown of up to 6.3 meters can be expected 1 kilometre away from AB_BH1 at the recommended sustainable rate (2.9 L/s for 24 hours per day) after 2 years of abstraction without recharge (**Figure 8)**. Importantly the client aims to abstract 0.003 % of the total sustainable yield and thus the drawdown expected under these conditions are expected to be much less. It must be noted that the Cooper-Jacob modelling of radius of influence is based on a homogenous, confined aquifer and therefore does not account for the heterogeneity associated with secondary aquifers (fractured rock). Thus, the radius of influence model will only provide an indication of how abstraction at AB_BH1 will impact the water level in the fracture network. This suggests that the cone of depression will not expand equivalently in all directions surrounding the borehole, but will rather propagate along the fracture network within the secondary aquifer.

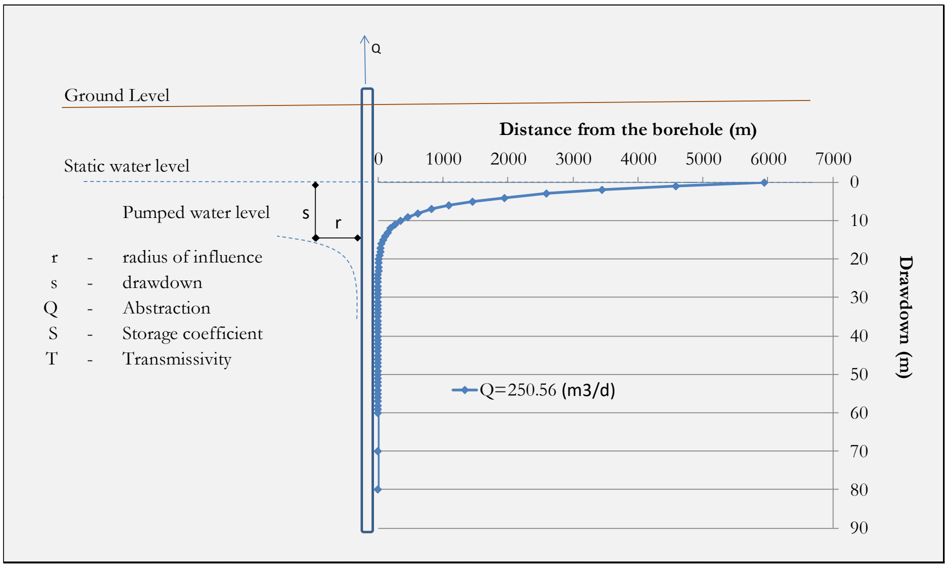


Figure 8: Radius of influence for AB_BH1 at the recommended sustainable yield (2.9 L/s).

9.1.2 Summary of Sustainable Yield of the Borehole AB_BH1

Based on the information obtained from the yield test, the abstraction recommendation for the borehole is presented in **Table 12**. The yield testing was conducted with a Step Test, Constant Discharge Test and Recovery Test and while this data can be analysed to estimate sustainable yields, additional drilling in the area may result in long term cumulative impacts. Optimisation of the resource is also likely through making small changes to the abstraction rate, should the dynamic water level's drawdown be less or more than expected as per **Table 12**. Both of these points are best managed through long-term monitoring data.

For borehole AB_BH1 it is recommended that abstraction can occur at a rate of up to 2.9 L/s for 24 hours per day. A pump suitable to deliver the recommended rate should be installed at a depth of 52 mbgl. It is anticipated that abstraction at the recommended rate will cause the water level to drop to a depth of approximately 30 mbgl – this is referred to as the dynamic water level. During abstraction, a maximum level cut off switch should be installed to 50 mbgl to ensure the groundwater level does not drop to the pump inlet.

Through long term water level monitoring data, the abstraction volumes can be optimised by adjusting the abstraction rate if required. It is recommended that the borehole is equipped with a variable frequency drive. This enables adjustments to the flow rate to be made if required, as determined by the hydrogeological analysis of water level and flow rate monitoring data.

Table 12: Borehole Abstraction Recommendations

Borehole Details				
Borehole Name	Latitude (DD)	Longitude (DD)	Borehole Depth (m)	Inner Diameter (mm)
AB_BH1	-33.95713	18.67164	84.0	135
Abstraction Recommendations				
Borehole Name	Abstraction rate (L/s)	Abstraction Duration (hrs)	Recovery Duration (hrs)	Possible Volume Abstracted (L/d)
AB_BH1	2.9	24	0	250 560
Pump Installation Details				
Borehole Name	Pump Installation Depth (mbgl)	Critical Water Level (mbgl)	Dynamic Water Level (mbgl)*	Rest Water Level (mbgl)
AB_BH1	52	50	30	3.08

* Typical water level expected during long-term production

9.2 Water Quality Analysis

9.2.1 Groundwater Quality Analysis

Groundwater samples were collected from boreholes AB_BH1 (November 2023 and in July 2024), HBH1 and PZ1. The samples were submitted for inorganic and microbiological chemical analysis to a SANAS-accredited laboratory (Vinlab) in the Western Cape. The certificate of analysis for the samples is presented in **Appendix IV.** The chemistry results obtained for the boreholes have been classified according to the SANS241-1: 2015 standards for drinking water in addition to the DWAF (1998) domestic water assessment standards, as a common point of reference.

SANS241-1:2015: Drinking water standards

The chemistry results for these sites have been classified according to the SANS241-1: 2015 standards for domestic water (**Table 13**). **Table 14** presents the water chemistry analysis results, colour coded according to the SANS241-1: 2015 drinking water assessment standards.

Table 13: Classification table for the specific limits.

Limit Classification	Limit Definition	Colour Code in Table
Acceptable	Parameters falling inside these limits indicate that all water quality standards have been met.	**White**
Operational	Parameters falling outside these limits may indicate that operational procedures to ensure water quality standards are met may have failed.	**Purple**
Aesthetic	Parameters falling outside these limits indicate that water is visually, aromatically or palatably unacceptable.	**Yellow**
Chronic Health	Parameters falling outside these limits may cause chronic health problems in individuals.	**Orange**
Acute Health	Parameters falling outside these limits may cause acute health problems in individuals.	**Red**

The chemical analysis results presented in **Table 14** indicate that certain parameters exceeded the acceptable/operational limits of the SANS241-1:2015 standard:

- AB_BH1-31 July 2024 – Turbidity, Chloride, Manganese, Iron
- HBH1 – Turbidity, Colour
- PZ1 – Turbidity, Colour, Aluminium, Iron, Faecal coliforms, Total Coliforms, Charge Balance

Table 14: Water quality results classified according to the SANS241-1:2015

Analyses	AB _ BH1 10 Nov 2023	AB_BH1 31 Jul 2024	HBH1 31 Jul 2024	PZ1 31 Jul 2024	SANS 241-1:2015
pH (at 25 ºC)	7.1	7.1	8.2	8.1	≥5 - ≤9.7 Operational
Conductivity (mS/m) (at 25 ºC)	136.1	136.5	84.8	33.9	≤170 Aesthetic
Total Dissolved Solids (mg/L)	922.76	925.47	574.94	229.84	≤1200 Aesthetic
Turbidity (NTU)	22.50	27.00	2.10	410.00	≤5 Aesthetic ≤1 Operational
Colour (mg/L as Pt)	<15	<15	19.00	15.00	≤15 Aesthetic
Sodium (mg/L as Na)	177	176	54	28	≤200 Aesthetic
Potassium (mg/L as K)	3	5	14	21	N/A
Magnesium (mg/L as Mg)	29	30	16	3	N/A
Calcium (mg/L as Ca)	50	50	93	37	N/A
Chloride (mg/L as Cl)	328.15	315.64	89.21	<10.00	≤300 Aesthetic
Sulphate (mg/L as SO_4)	7.66	7.36	85.65	7.12	≤250 Aesthetic ≤500 Acute Health
Combined Nitrate & Nitrite Nitrogen (as a ratio)	0.068	0.068	0.93	0.17	≤1 Acute Health
Nitrate Nitrogen (mg/L as N)	<1.00	<1.00	9.78	1.41	≤11 Acute Health
Nitrite Nitrogen (mg/L as N)	<0.05	<0.05	<0.05	<0.05	≤0.9 Acute Health
Ammonia Nitrogen (mg/L as N)	0.19	0.22	<0.15	<0.15	≤1.5 Aesthetic
Total Alkalinity (mg/L as $CaCO_3$)	173.2	166.9	183.4	158.2	N/A
Total Hardness (mg/L as $CaCO_3$)	243.9	248.0	298.1	104.8	N/A
Fluoride (mg/L as F)	<0.15	0.40	<0.15	<0.15	≤1.5 Chronic Health
Aluminium (mg/L as Al)	<0.008	<0.008	0.010	2.666	≤0.3 Operational
Total Chromium (mg/L as Cr)	<0.004	<0.004	<0.004	0.004	≤0.05 Chronic Health
Manganese (mg/L as Mn)	0.114	0.113	<0.018	0.032	≤0.1 Aesthetic ≤0.4 Chronic Health
Iron (mg/L as Fe)	1.935	3.219	0.150	1.428	≤0.3 Aesthetic ≤2 Chronic Health
Nickel (mg/L as Ni)	<0.008	<0.008	<0.008	<0.008	≤0.07 Chronic Health
Copper (mg/L as Cu)	0.010	<0.002	<0.002	0.003	≤2 Chronic Health
Zinc (mg/L as Zn)	<0.008	<0.008	<0.008	0.029	≤5 Aesthetic
Arsenic (mg/L as As)	<0.010	<0.010	<0.010	<0.010	≤0.01 Chronic Health
Selenium (mg/L as Se)	<0.008	<0.008	<0.008	<0.008	≤0.04 Chronic Health
Cadmium (mg/L as Cd)	0.001	<0.001	<0.001	<0.001	≤0.003 Chronic Health
Antimony (mg/L as Sb)	<0.013	<0.013	<0.013	<0.013	≤0.02 Chronic Health
Mercury (mg/L as Hg)	<0.001	<0.001	<0.001	0.003	≤0.006 Chronic Health
Lead (mg/L as Pb)	0.009	<0.008	<0.008	<0.008	≤0.01 Chronic Health
Uranium (mg/L as U)	<0.028	<0.028	<0.028	<0.028	≤0.03 Chronic Health
Cyanide (mg/L as CN^-)	<0.01	<0.01	<0.01	0.020	≤0.2 Acute Health
Total Organic Carbon (mg/L as C)	0.54	10.30	10.30	19.35	N/A
Charge balance %	1.5	3.7	3.7	6.2	≥-5 - ≤5 Acceptable

DWA (1998): Drinking Water Assessment Guide

The parameters that were obtained have also been classified according to the DWAF (1998) standards for domestic water. **Table 15** enables an evaluation of the water quality with regard to the various parameters measured (DWAF, 1998). **Table 14** presents the water chemistry analysis results colour-coded according to the DWAF drinking water assessment standards.

Table 15: Classification table for the groundwater results (DWAF, 1998).

Blue	**Class 0**	**Ideal water quality** - suitable for lifetime use.
Green	**Class I**	**Good water quality** - suitable for use, rare instances of negative effects.
Yellow	**Class II**	**Marginal water quality** - conditionally acceptable. Negative effects may occur.
Red	**Class III**	**Poor water quality** - unsuitable for use without treatment. Chronic effects may occur.
Purple	**Class IV**	**Dangerous water quality** - totally unsuitable for use. Acute effects may occur.

The following parameters were found to be elevated (i.e., marginal or above) based on the guidelines presented in DWAF (1998):

- AB_BH1-31 July 2024 – Turbidity, Chloride, Iron
- HBH1 – Turbidity
- PZ1 – Turbidity, Iron, Faecal coliforms, Total Coliforms

Table 16: Classified water quality results according to DWAF 1998.

Sample Marked :	AB_BH1 10 Nov 2023	AB_BH1 31Jul 2024	HBH1 31Jul 2024	PZ1 31Jul 2024	DWA (1998) Drinking Water Assessment Guide				
					Class 0	Class I	Class II	Class III	Class IV
pH	7.1	7.1	8.2	8.1	5-9.5	4.5-5 & 9.5-10	4-4.5 & 10-10.5	3-4 & 10.5-11	< 3 & >11
Conductivity (mS/m)	136.1	136.5	84.8	33.9	<70	70-150	150-370	370-520	>520
Turbidity (NTU)	22.50	27.00	2.10	410.00	<0.1	0.1-1	1.0-20	20-50	>50
Total Dissolved Solids	922.76	925.47	574.94	229.84	<450	450-1000	1000-2400	2400-3400	>3400
Sodium (as Na)	177	176	54	28	<100	100-200	200-400	400-1000	>1000
Potassium (as K)	3	5	14	21	<25	25-50	50-100	100-500	>500
Magnesium (as Mg)	29	30	16	3	<70	70-100	100-200	200-400	>400
Calcium (as Ca)	50	50	93	37	<80	80-150	150-300	>300	
Chloride (as Cl)	328.15	315.64	89.21	<10.00	<100	100-200	200-600	600-1200	>1200
Sulphate (as SO_4)	7.66	7.36	85.65	7.12	<200	200-400	400-600	600-1000	>1000
Nitrate& Nitrite (as a ration)	0.068	0.068	0.93	0.17	<6	6.0-10	10.0-20	20-40	>40
Fluoride (as F)	<0.15	0.40	<0.15	<0.15	<0.7	0.7-1.0	1.0-1.5	1.5-3.5	>3.5
Manganese (as Mn)	0.114	0.113	<0.018	0.032	<0.1	0.1-0.4	0.4-4	4.0-10.0	>10
Iron (as Fe)	1.935	3.219	0.150	1.428	<0.5	0.5-1.0	1.0-5.0	5.0-10.0	>10
Copper (as Cu)	0.010	<0.002	<0.002	0.003	<1	1-1.3	1.3-2	2.0-15	>15
Zinc (as Zn)	<0.008	<0.008	<0.008	0.029	<20	>20			
Arsenic (as As)	<0.010	<0.010	<0.010	<0.010	<0.010	0.01-0.05	0.05-0.2	0.2-2.0	>2.0
Cadmium (as Cd)	0.001	<0.001	<0.001	<0.001	<0.003	0.003-0.005	0.005-0.020	0.020-0.050	>0.050
Hardness (as $CaCO_3$)	243.900	248.00	298.10	104.80	<200	200-300	300-600	>600	
Faecal coliforms	0	nd	0	500	0	0-1	1.0-10	10-100	>100
Total coliforms	0	nd	0	700	0	0-10	10-100	100-1000	>1000
Charge Balance %	1.5	3.7	3.7	6.2	≥-5 - ≤5 Acceptable				

The laboratory analyses of the water samples indicate that the groundwater from AB_BH1 does not currently conform to the acceptable drinking water standards as defined by SANS241-:2015 due to elevated turbidity measured. Additionally, elevated manganese and chloride concentrations exceed the aesthetic limit indicating that water is visually, aromatically or palatably unacceptable. Elevated iron concentrations above the chronic health limits would likely lead to iron biofouling if the borehole is not managed optimally. This will result in the clogging of the borehole as well as abstraction infrastructure. Should the water be used for irrigation, crop selection should take into account the elevated chloride concentration. It should be noted that the borehole could not be sampled after pumping has been conducted to purge the hole and thus the water sample may have elevated iron due to buildup in the water column of the borehole. The borehole chemistry results vary significantly in comparison to PZ1 where surface water on the site was analysed.

The water analysed from PZ1 does not currently conform to the acceptable drinking water standards as defined by SANS241-:2015 due to faecal coliforms and total coliforms being present above acceptable limits according to DWAF (1998). Additionally, classification according to SANS241-1:2015 indicated turbidity and iron concentrations above aesthetic limits while elevated aluminium concentrations are above operational limits and the charge balance is outside the acceptable range. All of these limits are likely exceeded due to the increased surface runoff during the winter, draining surface contaminant sources towards this point which is located within a storm drainage culvert area. Notably, the pH and electrical conductivity values are measured to vary significantly between AB_BH1 and PZ1.

Results for HBH1 are acceptable according to SANS241-1:2015 with turbidity classified as being above operational limits and the colour above aesthetic limits. Groundwater from HBH1 may be used for potable use following simple treatment and filtration. There is a larger correlation between HBH1 and PZ1 as both these compared to AB_BH1 in terms of pH and EC values. This is likely indicative of a surface water signature at these sites as compared to a deeper fractured aquifer signature recorded at AB_BH1.

A number of chemical diagrams have been plotted for the groundwater sample and these are useful for chemical characterisation of the water and illustrate the similarities and differences in the water types.

Stiff Diagrams are used to graphically represent the relative concentrations of the cations (positive ions) and anions (negative ions) (**Figure 9).** By comparing the concentrations of cations and anions to each other, specific salts present in the water can be identified. Based on the Stiff plots it can be inferred that the general chemical signature of borehole AB_BH1 has remained the same over time and may be defined as Na-HCO_3+CO_3 type water. This is expected of groundwater hosted in the greywacke and phyllites of the Tygerberg formation.

The Stiff diagrams for HBH1 and PZ1 may be described as being closer in comparative shape as they are to the shape of AB_BH1. Both HBH1 and PZ1 have calcium as the dominant cation and carbonates as the dominant anion with the other ions present in varying ratios. HBH1 has an increased sulphate signature whereas in PZ1 it is relatively depleted.

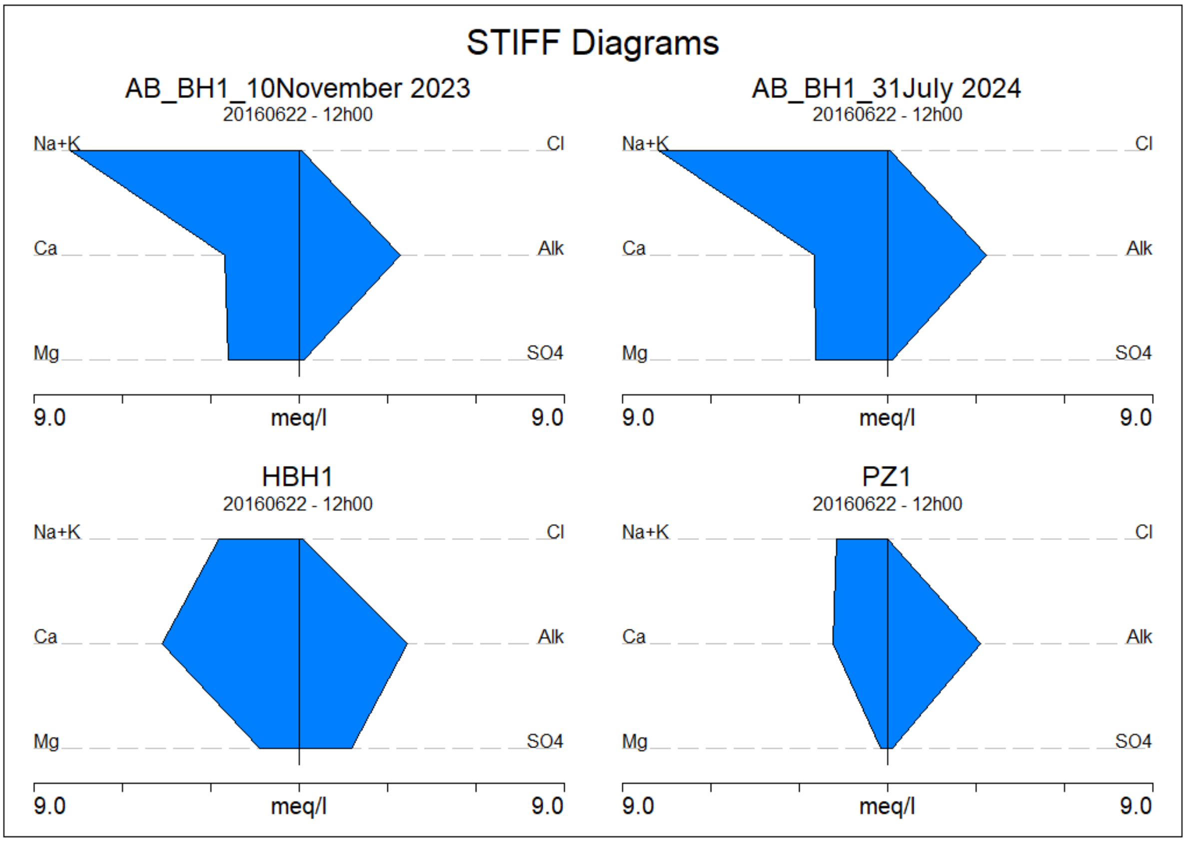


Figure 9: Stiff diagram of the groundwater sample.

A Piper diagram displays the distribution of cations and anions in separate triangles and a combination of their chemistry in a central diamond. A piper diagram developed from the analysed water samples collected during the field investigation is displayed in **Figure 10.** From the figure (central diamond), it is evident that the samples from AB_BH1 plots in almost exactly the same position for the two samples over time. The samples may be classified as a sodium bicarbonate type water. The sample for PZ1 plots further towards a mixed type water with a stronger calcium and lower total alkalinity affinity as compared to the samples of AB_BH1.

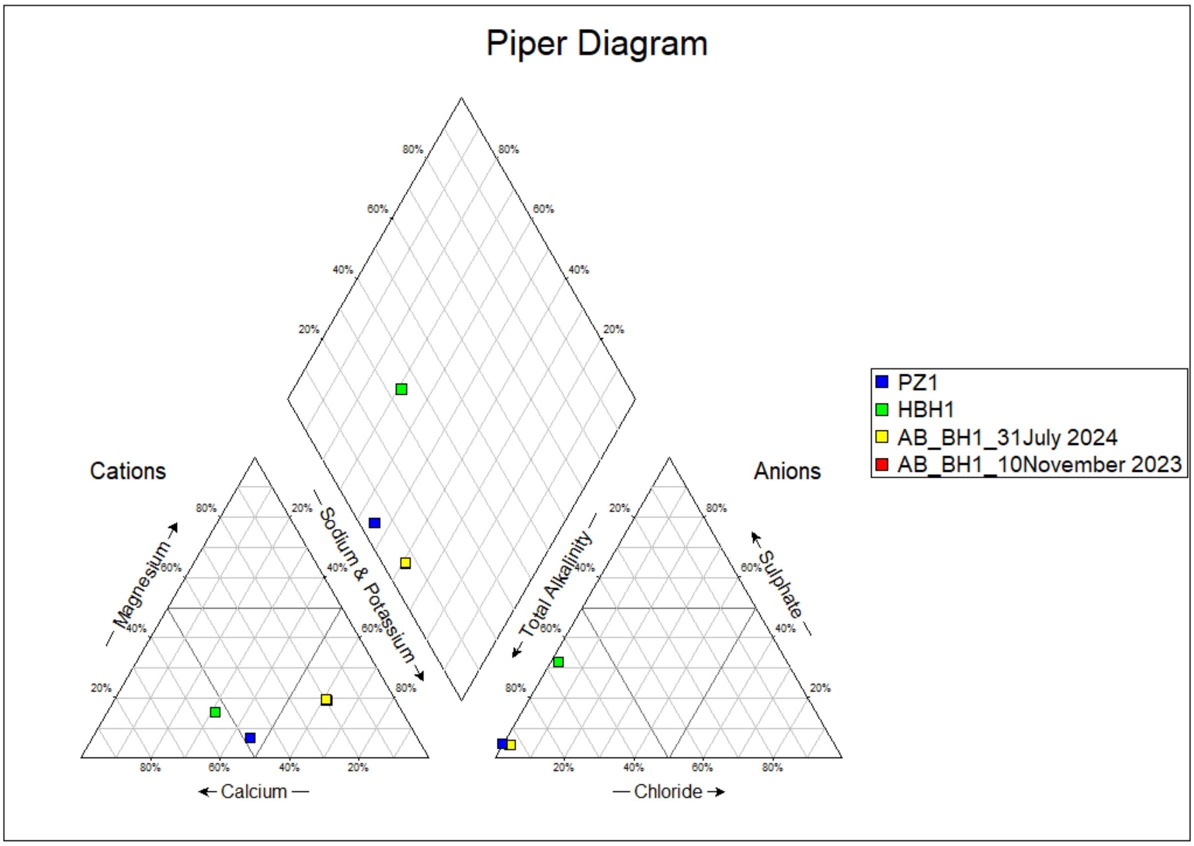


Figure 10: Piper diagram of the groundwater sample

The Sodium Adsorption Ratio (SAR) of the groundwater is plotted in **Figure 11**. AB_BH1 and HBH1 plots as S1/C3, thus classified as low risk in terms of sodium adsorption and high risk in terms of salinity hazard. The sample from PZ1 plots as S1/C2, thus classified as low risk in terms of sodium adsorption and medium risk in terms of salinity hazard This graph is typically applicable to irrigation, however, is dependent on soil texture and crop type.

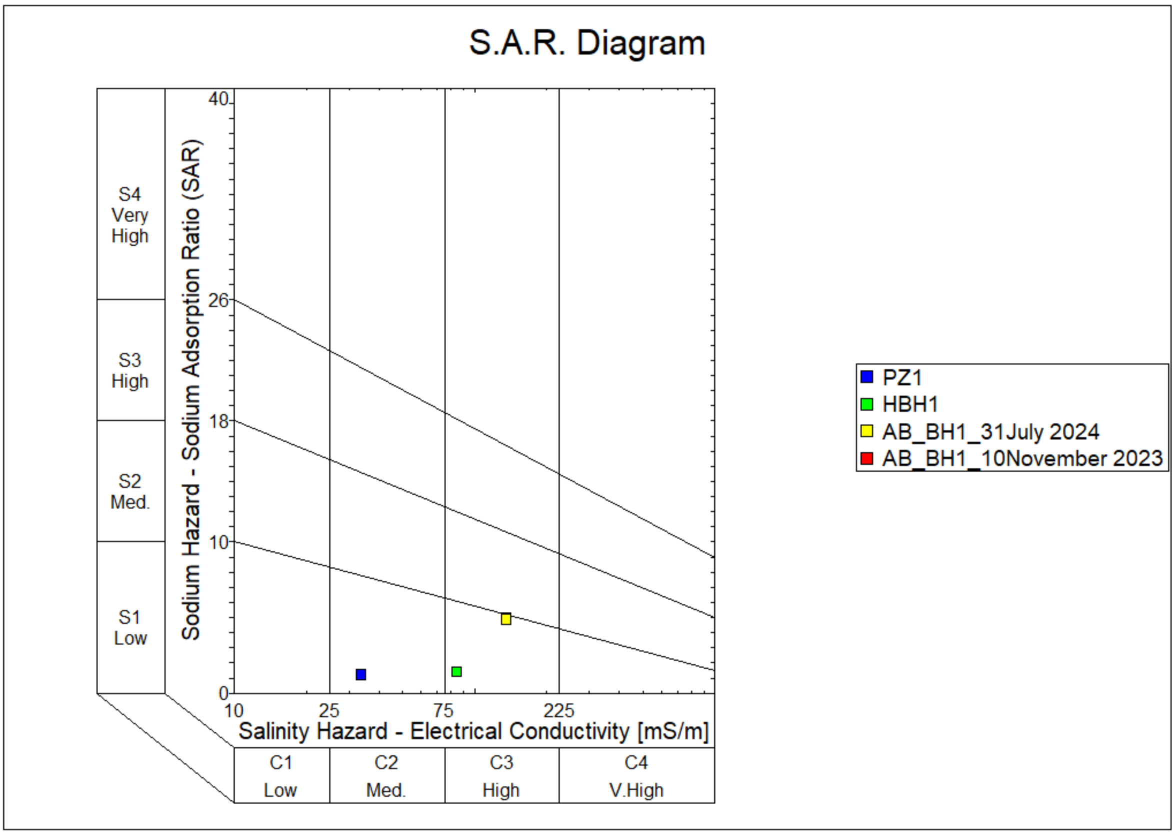


Figure 11: SAR diagram of the groundwater sample

10 Surface Water – Groundwater Isotope Analysis

A groundwater isotope sample was collected from AB_BH1, in addition to the collection of a surface water sample PZ1. The samples were submitted for isotope analyses to a SANAS accredited laboratory (iThemba) in the Western Cape. The certificate of analysis for the sample is presented in **Appendix IV**.

The groundwater stable isotope compositions can be used to infer the source of groundwater recharge as well as groundwater and surface water connectivity. Groundwater can be recharged by surface waters; in which case the stable isotope composition of the groundwater should reflect that of the surface water body. Evaporation from open water and exchange with rock minerals are two common processes which cause deviations from the meteoric water line. As a result, stable isotope ratios are useful in providing a “signature” or “fingerprint” to particular water types (Clark and Fritz, 2013; Gat, 2010).

Each catchment is characterized by its own local meteoric water line (LMWL) and can be determined through long-term isotope measurements of rainfall. During the duration of this study, long-term isotope data for rainfall could not be collected and therefore the global meteoric water line (GMWL), which was originally developed by Craig (1961) after which it was updated by Araguas - Araguas et al. (2000), and Western Cape Meteoric Water Line (WCMWL) established by Diamond and Harris (1997) was used for analysis purposes. Comparisons of the groundwater, surface water and rain water to the WCMWL are presented in **Figure 12.**

In **Figure 12** the borehole is indicated by a black square while the piezometer is indicated by an orange triangle. There is a clear difference between the surface water (PZ1) and groundwater (AB_BH1) samples isotopic signatures.

The isotopic data collected from groundwater illustrates a depletion in heavier isotopes in comparison to the more light isotopes rich surface water sample. The surface water sample may be described as having an evaporative signature typical of coastal regions where lighter isotopes are removed during evaporation, relatively enriching the remaining water in heavy isotopes. Furthermore, when sampling the surface water during a particularly wet winter, plenty of surface runoff may have collected in the site sampled leading to the evaporation signature being enhanced. The groundwater sample bears a signature typically seen in winter during cooler conditions where the ratio of light to heavy isotopes indicate a relative light isotope enrichment. Lighter isotopes would more readily be infiltrating to the bedrock during cooler winter months as less chance for light isotope loss due to evaporation is present. This likely indicates the relative high rate of groundwater recharge during the wet winter months to the fractures intersected by the borehole.

The isotopic data collected on site indicates that there is no clear comparison between the surface water and the groundwater intersected in the borehole. This interpretation can be further supported by the chemical signatures described in above sections where it is apparent that the samples from AB_BH1 and PZ1 does not compare in terms of pH, ec and general water trend exhibited in the chemical characterisation diagrams. Long term isotope and chemistry analysis during different seasons is required to provide a clearer, more in depth understanding of the water resources in the area. Furthermore comparing the water levels between the piezometer and the borehole would shed further light on the correlation between the two locations.

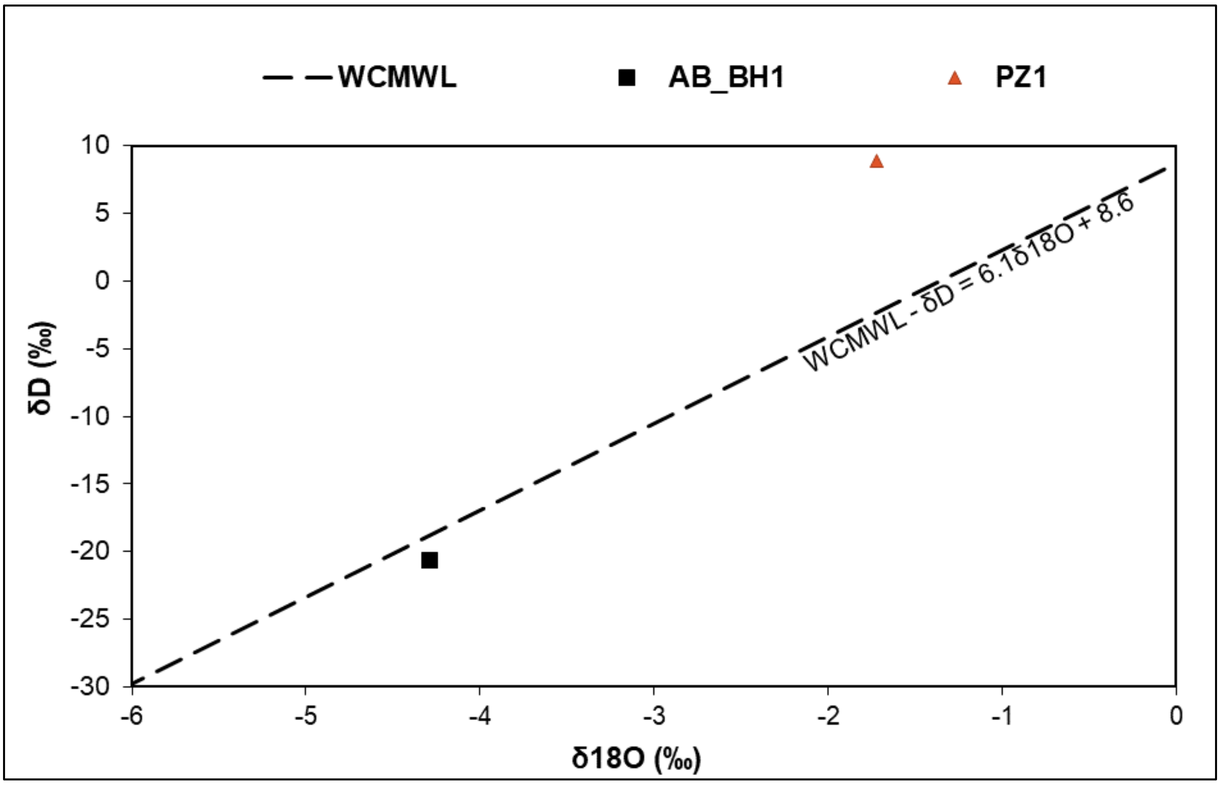


Figure 12: Stable isotope analysis results.

11 Aquifer Firm Yield Model

11.1 Quaternary Catchment (G22E)

To evaluate the sustainable volume of groundwater that can be abstracted from the aquifer for the property, the Aquifer Firm Yield Model (AFYM) was utilized (WRC, 2012). The model uses a single-cell "Box Model" approach and uses a critical management water level, below which aquifer storage levels cannot be drawn down, to provide estimates of aquifer firm and assured yields.

The "Box Model" approach is schematically presented in **Figure 13**.

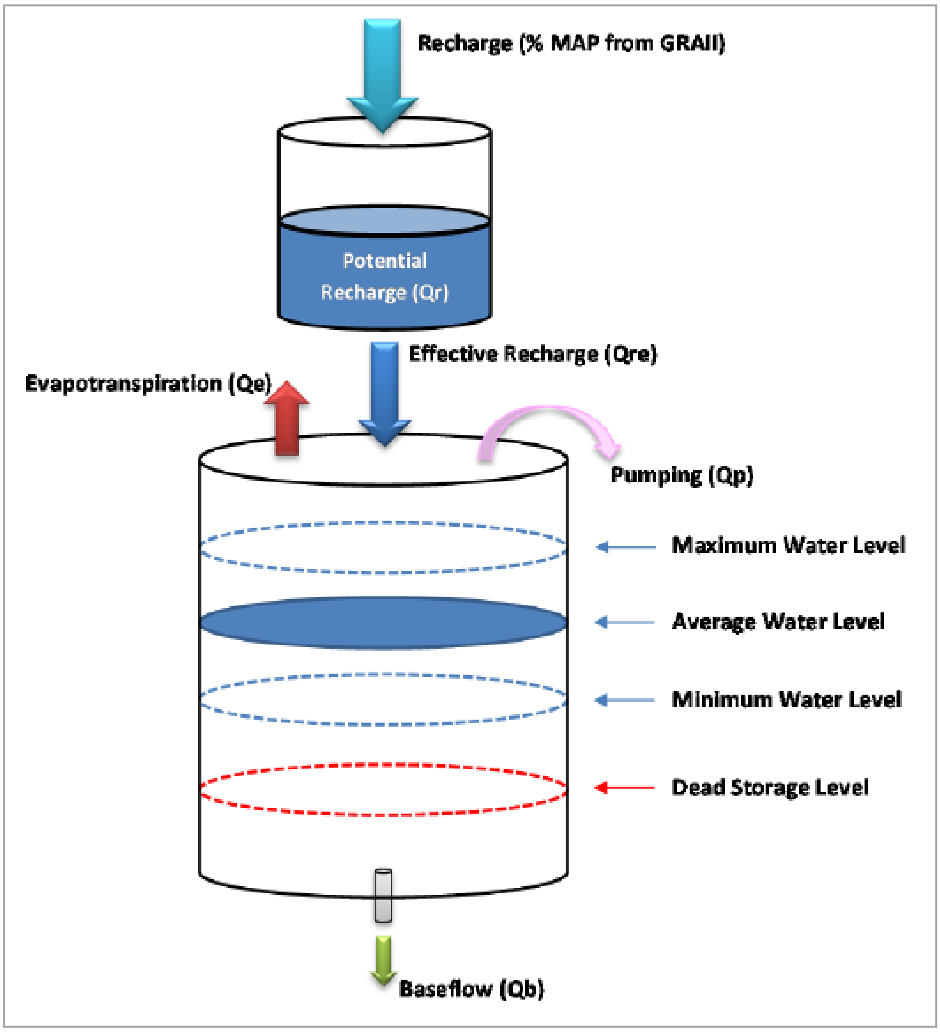


Figure 13: Aquifer Firm Yield lumped box model (WRC, 2012).

An evaluation was completed using the Aquifer Firm Yield model (WRC, 2012). The input parameters used for the catchment are the default values presented in WRC (2012). These are taken from datasets like WR2005 (e.g., rainfall data) (Middleton and Bailey, 2008) and GRAII (e.g., specific yield and recharge (%MAP)) (DWAF, 2005), and others generated during the WRC (2012) (e.g., recharge threshold and riparian zone (% catchment area)), presented in **Table 17**.

Table 17: Hydrogeological Parameters for Quaternary catchment G22E (WRC, 2012).

Parameter	G22E
Area (km^2)	270.7
Groundwater Level (mbgl)	7.6
Max Drawdown (m)	5
Specific Yield	0.002962
Firm Yield (L/s)	161.2
Firm Yield (L/s/km^2)	0.5955
Recharge %	8.7
Recharge Threshold (mm)	48
MAP (mm)	571.6
Hydrological MAR (mm)	76.8
Hydrological MAE (mm)	1410
Baseflow: Default (Mm^3/a)	7.45
ET Model	Linear
ET Extinction Depth (m)	4
Riparian Zone (%)	3.3

The Aquifer Firm Yield Model (AFYM) was run for the catchment G22E and the Firm Yield was determined to be 5 087 085 m^3/a (172.5 L/s) with a recharge of 417 830.4 m^3/a. The results of the Aquifer Firm Yield Model for quaternary catchment G22E are presented in **Table 18**.

Table 18: Results of the Aquifer Firm Yield Model for Quaternary Catchment G22E.

Name	Q (L/s)	Q (m^3/month)	Q (m^3/a)
G22E	161.2	417 830.4	5 087 085.00

11.2 Groundwater Resource Unit (GRU)

For this study area, there are geological features that enable the definition of a more localized aquifer (i.e., a groundwater resource unit (GRU)). The GRU is complex and was delineated using the Kuils River to the west, the Bottelary river to the north until the river intersects the bounding contact between intruded Kuilsriver Batholith granite towards the east and the host Tygerberg Formation. The main contact between the host Tygerberg Formation and the intrusive Kuilsriver Batholith granite can be traced towards the south and this contact mapped on the geological map has been used as the eastern boundary of the GRU. Where this contact intersects the Eerste river towards the south the boundary has been chosen to follow the trace of the river until it joins with the Kuils River in the south. The GRU is displayed in **Map 8** and **Figure 3** depicts a schematic cross-section of the geology underpinning the site and hydrogeological characteristics associated to the area. The parameters for quaternary catchment G22E are presented in **Table 17**.

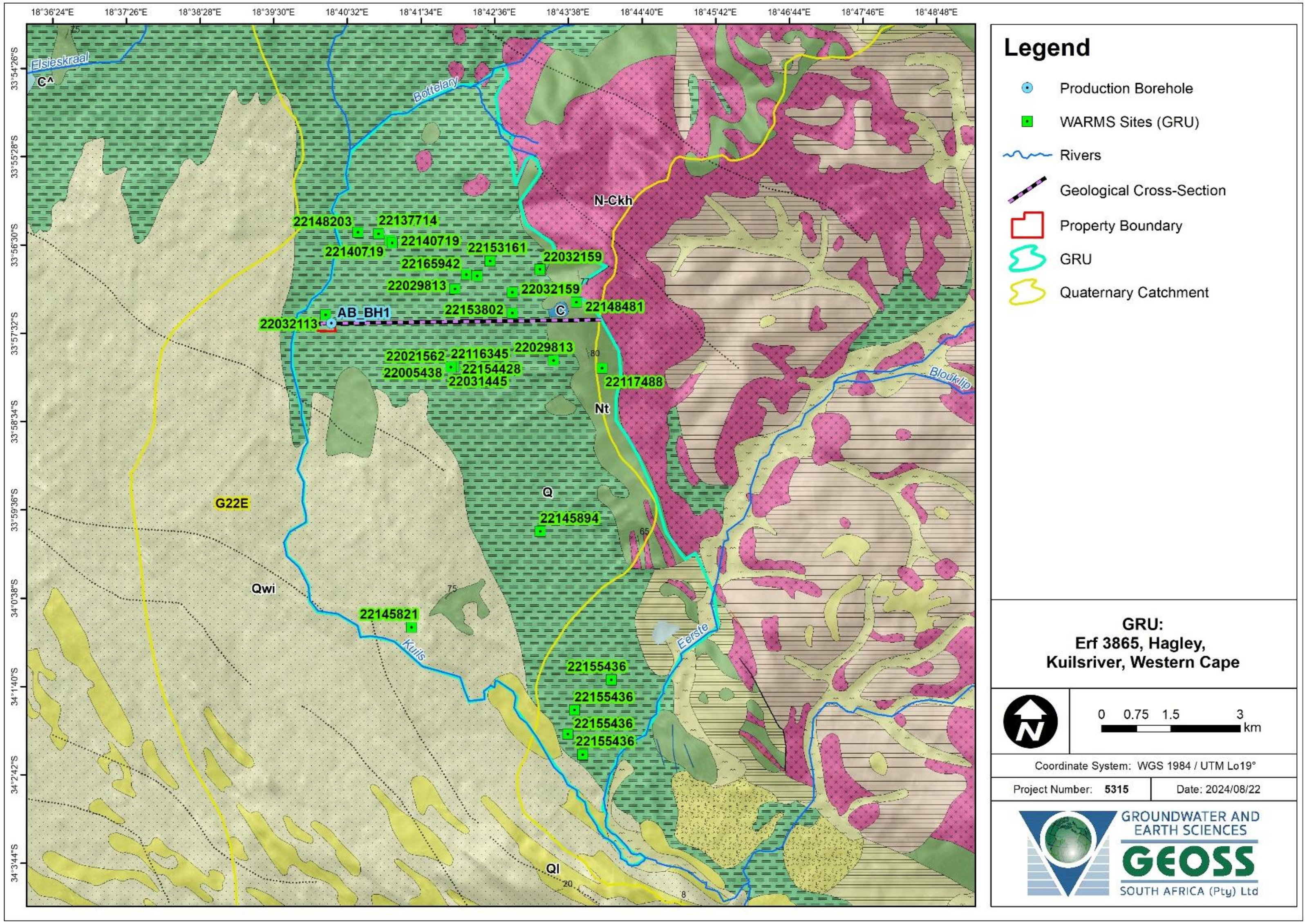
On the assessment of the geological map, the GRU (within quaternary catchment G22E) has an extent of 84.2 km^2. Using the GRAII recharge values the direct vertical recharge (minimum recharge volume) is calculated to be 4 187 198.6 m^3/a for the GRU. The firm yield of the GRU is calculated to be

1 582 314.6 m^3/a which is estimated to be approximately 37.79% of recharge. It is important to note that a conservative approach was used to calculate the recharge and firm yield volumes as it is based on vertical recharge in a fractured aquifer however, lateral recharge is also important, thus the recharge may be higher.

Based on the active, registered, verified, and lawful registered WARMS boreholes (database last updated May 2023, included in **Table 23**, **Appendix VII**, the current volume of groundwater abstracted within the GRU is 297 843.9 m^3/a (**Map 8**). These groundwater users use the groundwater for agricultural and industrial use. Based on these calculations, a volume of 1 284 470.7 m^3/a is available within the GRU (1 582 314.6 m^3/a – 297 843.9 m^3/a). The additional volume of 2 560.0 m^3/a for which a licence is being applied, is less than the volume available within the firm yield of the GRU.

Because the firm yield of the GRU is in excess of the predicted water demand of the proposed activities on Erf 3865 in Hagley, near Kuils River, the licence application volume is considered to be within the sustainable supply volume of the aquifer. Please refer to the summary below:

GRU (84.2 km^2)	Total recharge = 418 7198.6 m^3/a Total firm yield = 1 582 314.6 m^3/a Authorised existing abstraction (from WARMS 2023) = 297 843.9 m^3/a Available groundwater = 1 284 470.7 m^3/a Requested additional groundwater use = 2 560.0 m^3/a Is there sufficient groundwater for this application? **Yes**



Map 8: GRU, property boundaries with the existing production borehole and WARMS boreholes superimposed on the regional geology map (1:250 000 scale 3318 Cape Town).

12 Risk Assessment and Matrix

The risk assessment includes identifying and rating the potential risks associated with the groundwater abstraction on Erf nr 3865, Hagley, near Kuilsriver, Western Cape, and any proposed mitigation measures where possible. The groundwater will be used for agricultural use. Each risk is qualitatively assessed based on the current information. The risk rating is done according to the criteria in **Appendix V**. The risk assessment relates only to groundwater abstraction as proposed on site. There are three potential impacts associated with groundwater abstraction:

- The risk of depletion of the groundwater due to over-abstraction
- The risk of groundwater quality deterioration as a result of over-abstraction
- The risk of groundwater abstraction impacting the surface water system

These will be discussed separately below.

12.1 Depletion of the Groundwater Resource as a Result of Over-Abstraction

Over-abstraction of groundwater from a borehole is likely to lead to depletion of the water levels in the area over time. This can cause damage to the aquifer and so also damage groundwater dependant ecosystems and impact neighbouring groundwater users. It is essential that the borehole are well managed and are not over-abstracted to ensure an impact on the neighbouring properties does not occur. The production borehole AB_BH1 was correctly yield tested according to SANS 10299_4-2003, and the maximum sustainable yield was determined to be 91 517.04 m^3/a. The yield calculated is conservative and the proposed volume of groundwater abstracted is within the sustainable yield (0.003% of sustainable yield proposed for abstraction); therefore, if abstraction is kept to the recommended rate, over-abstraction is unlikely to occur. The risk assessment is presented in **Table 19**.

Groundwater water level monitoring is recommended to ensure that groundwater abstraction is sustainable. The monitoring will also indicate if the groundwater resource is impacted and if mitigation measures can be instituted before long-term impacts occur. Mitigation for over-abstraction would be a reduction in abstraction.

Table 19: Risk assessment for the depletion of the groundwater resource as a result of over-abstraction.

Potential impact due to the depletion of groundwater resources as a result of over-abstraction.	
Impact	Description
Nature of impact	Negative
Type of impact	Description
Direct	Over-abstraction from the borehole would drop the regional groundwater level over an extended period of time.
Recommended mitigation measures	Description
Impact avoidance/ prevention	Groundwater abstraction volumes must be monitored. Water levels must be monitored and should not drop below the critical water level (**Table 12**).

	If critical water levels or a change in water quality is observed, the relevant compliance officer will be notified and relevant mitigation will be discussed with them to obtain the best way forward . Monitoring information must be assessed regularly (suggested to be monthly in summer). If the water level drops below the critical water level for the respective boreholes, abstraction will immediately be reduced by 10 %. Monitoring will persist and after 30 days, if the water level in the borehole does not recover to above the critical water level, abstraction will be reduced by a further 10 %. This process will continue until the water level in the borehole is stable. A groundwater management plan needs to be implemented.	
Impact minimisation	Reduce abstraction either by adjusting the abstraction rate or duration of abstraction.	
Rehabilitation/ restoration/ repair	Groundwater levels will be restored should abstraction be decreased or stopped.	
The degree to which the impact can be mitigated	The impact is completely mitigated.	
The degree to which the impact can be reversed	The impact is completely reversible.	
The degree to which the impact may cause irreplaceable loss of resources	The impact is highly unlikely to cause any irreplaceable loss of resources.	
Assessment of impact	Rating before mitigation	Rating after mitigation
Extent of impact	Local	Site-specific
Duration of impact	Long term >15 years but less than <30	Short-term 0 – 5 years
Intensity of impact	Medium	Low
Probability of occurrence	Possible	Improbable
Level of confidence in prediction	Medium	High
Significance	Low	Very low
Confidence	Medium	Medium

12.2 Groundwater Quality Deterioration as a Result of Over-Abstraction:

Over-abstraction of groundwater from a borehole can potentially draw poorer water quality from the nearby 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 same aquifer. As indicated by the regional datasets the groundwater quality directly underlying the site is in the range of 70 -300 m S/m. The production borehole on site recorded EC values around 136.0 mS/m during two sampling events in 2023 and 2024, falling within the regional classification, values signifying a marginal groundwater quality.

Few known datapoints associated to the aquifer intersected are available to define any reasonable spatial trends relating to the regional groundwater quality. The possibility of having poor quality water nearby does exist. Thus, this risk is valid and care should be taken to ensure that the proposed production boreholes do not draw poor quality to the site. It could be inferred that the poorer surrounding groundwater quality is being drawn to the site due to increased groundwater use in the area. Hence the abstraction must be kept to the recommended rate, the risk would be low, but quality monitoring should be done to ensure that deterioration in quality does not occur. The risk assessment is presented in **Table 20**.

Groundwater quality monitoring is recommended to ensure that groundwater abstraction is sustainable. The monitoring will also indicate if the groundwater resource is impacted and if mitigation measures can be instituted before long-term impacts occur. Mitigation for over-abstraction would be a reduction in abstraction.

Table 20: Risk assessment for the groundwater quality deterioration as a result of over-abstraction.

Potential impact on groundwater quality deterioration as a result of over-abstraction		
Impact	Description	
Nature of Impact	Negative	
Type of impact	Description	
Direct	The over-abstraction of the groundwater could result in the water table being lowered in the area, thus drawing in proper water quality from surrounding areas toward the farm.	
Recommended mitigation measures	Description	
Impact avoidance/ prevention	Groundwater abstraction volumes must be monitored. Water levels must be monitored. Monitoring information must be assessed regularly (suggest monthly in summer). If an increase of 25 % in electrical conductivity is observed, abstraction will immediately be reduced by 10 %. Monitoring will persist and after 30 days, if the water quality of the borehole does not recover, abstraction will be reduced by a further 10 %. This process will continue until the water quality stabilizes.	
Impact minimisation	Reduce abstraction either by adjusting the abstraction rate or duration of abstraction.	
Rehabilitation/ restoration/ repair	Groundwater levels will be restored should abstraction be decreased or stopped.	
The degree to which the impact can be mitigated	The impact can be mitigated through monitoring of the quality.	
The degree to which the impact can be reversed	The impact is partly reversible	
The degree to which the impact may cause irreplaceable loss of resources	The impact is highly unlikely to cause any irreplaceable loss of resources.	
Assessment of impact	Rating before mitigation	Rating after mitigation
Extent of impact	Local	Site-specific
Duration of impact	Long term >15 years but less than <30	Short-term 0 – 5 years
Intensity of impact	Medium	Low
Probability of occurrence	Possible	Improbable
Level of confidence in prediction	High	High
Significance	Low	Negligible
Confidence	Medium	Medium

12.3 Groundwater Abstraction Impacting the Surface Water System

The borehole AB_BH1 is drilled into the underlying fractured shale bedrock (~48 mbgl) and has a steel casing until 84 mbgl, the steel casing is perforated around water bearing zones between 48 – 78 mbgl. Therefore, the likelihood of this borehole impacting on the surface water environment is low due to the casing seated into bedrock. Additionally, during the yield testing, no constant head boundaries were observed which would indicate surface water recharge conditions to the groundwater abstraction site. Moreover isotope and chemical analysis of surface water (PZ1) and the production borehole (AB_BH1) has indicated no definitive signatures correlating the samples to each other. The Kuils River is situated towards the west around 466 m from the property western border and around 790 m from the production borehole AB_BH1 which is the only surface water body that could likely be impacted on.

The risk assessment is presented in **Table 21**. It is important that the quality and quantity of the groundwater needs to be monitored to ensure the safety of the water supply to the immediate users and the surrounding groundwater users.

Table 21: Risk assessment for the groundwater abstraction impacting a surface water system; wetland

Potential impact on surface water systems as a result of over-abstraction		
Impact	Description	
Nature of Impact	Negative	
Type of impact	Description	
Direct	Impacting the baseflow of the Kuils River situated approximately 790 m to the west of the production borehole AB_BH1	
Recommended mitigation measures	Description	
Impact avoidance/ prevention	Monitoring information must be assessed regularly. It is recommended that isotopic data and local rainfall data is collected over an extended period. This will allow for isotope, chemistry and water level testing to assess the surface water and groundwater connectivity. If an impact is observed, abstraction should be decreased at the boreholes. If continued interaction is observed and baseflow reduction is confirmed, abstraction should be reduced further or ceased altogether.	
Impact minimisation	Reduce abstraction either by adjusting the abstraction rate or duration of abstraction. If the connection to baseflow is confirmed, then abstraction from the borehole should be ceased if a decrease in abstraction does not elevate the impact.	
Rehabilitation/ restoration/ repair	Baseflow levels will be restored should abstraction be decreased or stopped.	
The degree to which the impact can be mitigated	The impact can be mitigated through monitoring the water levels in designated wells.	
The degree to which the impact can be reversed	The impact is reversible	
The degree to which the impact may cause irreplaceable loss of resources	The impact is highly unlikely to cause any irreplaceable loss of resources.	
Assessment of impact	Rating before mitigation	Rating after mitigation
Extent of impact	Local	Site-specific
Duration of impact	Long term >15 years but less than <30	Short-term 0 – 5 years
Intensity of impact	Medium	Low
Probability of occurrence	Improbable	Improbable
Level of confidence in prediction	High	High
Significance	Low	Low
Confidence	Medium	Medium

13 Groundwater Management Plan

To facilitate monitoring and informed management of a borehole, it is highly recommended that boreholes be equipped with the following monitoring infrastructure and equipment (diagram included in **Appendix VI**):

- Installation of a 32 mm (inner diameter, class 10) observation pipe from the pump depth to the surface, closed at the bottom and slotted for the bottom 5 – 10 m.
- Installation of an electronic water level logger (for automated water level monitoring).
- Installation of a sampling tap (to monitor water quality).
- Installation of a flow volume meter (to monitor abstraction rates and volumes).

A qualified hydrogeologist should analyse this monitoring data to ensure long-term sustainable use of the borehole. Legal compliance about the use of groundwater also needs to be addressed with the Department of Water and Sanitation.

The management of the groundwater abstraction includes the following recommendations:

1. Continuous monitoring of groundwater levels using a pressure transducer in the borehole is ideal. This is however an expensive endeavour and should the department approve of weekly monitoring by means of a dip meter it may be considered as a cost-effective alternative. The water level in the borehole may not drop below the critical water level (**Table 12**). If the water level in the borehole drops below the critical water level, abstraction must be immediately reduced by 10 %. Monitoring must continue and after 30 days, if the water level in the borehole does not recover to above the critical water level, abstraction must be reduced by a further 10 %. This process must continue until the water level in the borehole is stable.
2. Water quality monitoring, which includes sampling and analysing groundwater at an accredited laboratory, is important. A sampling interval of bi-annual is recommended for the first year of monitoring; after that, the water quality monitoring should be reviewed and can potentially be reduced to annually, as seen in **Table 22**.
3. To address the potential for iron to clog the borehole and abstraction infrastructure, it is recommended to maintain a constant and continuous pumping schedule as much as possible. As a daily volume of less than 250 560 L/d is required, it is recommended to decrease the pumping rate and not the pumping duration. By pumping continuously instead of on a stop-start schedule, iron oxidation in the borehole is minimized, decreasing the amount of iron precipitation inside the boreholes and pumps.
4. The monitoring data should be reviewed quarterly at first and can then be scaled down bi-annually.
5. Installation of a sampling tap at the production borehole (to monitor water quality) is essential.
6. Installation of a flow volume meter at the production borehole (to monitor abstraction rates and volumes) is also important. External flow (e.g., mag-flow) meters are recommended.
7. Abstraction volumes must be monitored and recorded by a designated on-site person. Depending on the frequency of use, daily, weekly, or monthly abstraction should be recorded.
8. The appropriate borehole pump must be installed, i.e., not an oversized pump that is choked with a gate valve. If the monitoring shows that more water can be abstracted, then the duration of pumping time can be increased (not the flow rate).
9. The borehole and pump may be cleaned if iron clogging has occurred and the borehole efficiency has dropped.

10. A geohydrologist should review the above information annually to ensure optimal groundwater abstraction and management.

The groundwater abstraction should be reviewed to ensure sustainability based on the monitoring data obtained.

Table 22: Proposed groundwater monitoring parameters.

Parameter	Frequency
Groundwater Level	Ideally, every 30 minutes with a data logger. Alternatively weekly with a hand dip meter, taking only static water levels.
Chemical parameters and frequency (Year 1)	
pH (at 25 ºC)	Biannually (Field Chemistry)
Conductivity (mS/m) (at 25 ºC)	Biannually (Field Chemistry)
Total Dissolved Solids (mg/L)	Biannually (Field Chemistry)
Sodium (mg/L as Na)	Biannually*
Potassium (mg/L as K)	Biannually*
Magnesium (mg/L as Mg)	Biannually*
Calcium (mg/L as Ca)	Biannually*
Chloride (mg/L as Cl)	Biannually*
Sulphate (mg/L as SO4)	Biannually*
Nitrate & Nitrite Nitrogen (mg/L as N)	Biannually*
Nitrate Nitrogen (mg/L as N)	Biannually*
Nitrite Nitrogen (mg/L as N)	Biannually*
Total Alkalinity (mg/L as CaCO3)	Biannually*
Total Hardness (mg/L as CaCO3)	Biannually*
Fluoride (mg/L as F)	Biannually*
Aluminium (mg/L as Al)	Biannually*
Total Chromium (mg/L as Cr)	Biannually*
Manganese (mg/L as Mn)	Biannually*
Iron (mg/L as Fe)	Biannually*
Nickel (mg/L as Ni)	Biannually*
Copper (mg/L as Cu)	Biannually*
Zinc (mg/L as Zn)	Biannually*
Arsenic (mg/L as As)	Biannually*
Selenium (mg/L as Se)	Biannually*
Cadmium (mg/L as Cd)	Biannually*
Lead (mg/L as Pb)	Biannually*
Uranium (mg/L as U)	Biannually*
Total Organic Carbon (mg/L as C)	Biannually*
Total Coliform Bacteria (count per 100 ml)	Biannually*
*Can be reduced to annually if reviewed and deemed appropriate	

14 Discussion and Conclusion

Groundwater use is planned on Erf nr 3865, Hagley, near Kuils Rriver, Western Cape. The borehole registration is underway with the Local Municipality, Kuils River District Municipality, and the company appointed GEOSS South Africa (Pty) Ltd to conduct a geohydrological assessment for the proposed activity, Section 21 (a) – taking water from a water resource. The proposed application volume (2 560.0 m^3/a) is agricultural use on the site in order to irrigate the gardens on site.

From the desktop study and hydrocensus, it is evident that there are groundwater users within the study area. The main purpose for the groundwater abstraction in the area is for agricultural and industrial use.

The production borehole on site have been drilled in 2023 and was subsequently correctly yield tested according to the National Standard (SANS 10299-4:2003, Part 4 – Test pumping of water boreholes). The application volume, 2 560.0 m^3/a is within the sustainable yield (0.003 % of the sustainable yield of 91 517.04 m^3/a) of the aquifer. The borehole is drilled into the fractured Malmesbury Group aquifer (shales of the Tygerberg Formation). The groundwater is of marginal quality (EC > 70 mS/m) and will be blended with municipal water before being used on the property. In this area, the geology intersected in drillholes usually have a clay layer on top of shales, as logged in the drill log of AB_BH1. This clay layer is likely to provide sufficient protection against point and non-point sources of contamination and the vulnerability rating of the underlying fractured aquifer would likely be low. Additionally, the borehole has been cased off by means of steel casing until the end of borehole depth with the steel casing perforated around water bearing zones between 48 – 78 mbgl. It is recommended that the general Groundwater Management guideline outlined in **Section 13** of this report be included in the licence conditions of the WULA.

The Aquifer Firm Yield Model indicates that there is proficient available groundwater left in the catchment, i.e. the quaternary catchment G22E may still allocate additional groundwater abstraction when taking into account the application volume together with the registered, active, verified, and lawful groundwater users.

15 Assumptions and Limitations

During this study, certain assumptions limited the accuracy of the data acquired and the outcome of this report.

- The groundwater quality was conducted in November 2023 and July 2024, both during winter months. Seasonal changes may occur in the chemistry of the borehole's water, which has not been accounted for.
- Sampling at AB_BH1 during July 2024 was conducted at the storage tank inlet next to the borehole due to no sampling tap available which may impact on the chemistry results reported.
- Sampling at HBH1 was conducted in a storage tank next to the borehole due to no sampling tap available which may impact on the chemistry results reported.
- The coordinates of the NGA boreholes are sometimes found to be inaccurate. Hence, it was difficult to incorporate the NGA data accurately into the field hydrocensus.
- There are very few complete groundwater point-source data sets available from the NGA, i.e. which include geology, time-series water levels, water quality, and where relevant, pump rates and periods for the hydrocensus. Additionally the geological logs reported do not correlate well with the geological map, indicating possible incorrect geological logs.
- The borehole AB_BH1, although it correlates well with the geological map has not been logged by a geologist and therefore uncertainty regarding the strata intersected is still noted.
- All active, registered, verified, and lawful abstraction volumes (that could be obtained from the WARMS May 2023) were taken into account when calculating the available volumes within the firm yield of the GRU. This database is updated continuously; however, access to the latest data is limited and not easily accessible. Also, it should be noted that not all groundwater abstraction is suitably registered and documented and this study could only take into account what has been registered and active.
- No details to the site neighbours were provided by the client and therefore no upfront contact could be established to conduct a holistic hydrocensus. Thus, very little additional data on the aquifer could be obtained apart from what was collected for the proposed production borehole or what could be obtained from the NGA database.
- The Aquifer Firm Yield model does not incorporate lateral groundwater flow as the model is a linear Model.

16 Recommendations

The following recommendations can be made:

- The proposed production borehole may be used for the applied application stipulated in this document.
- The general Groundwater Management guideline outlined in **Section 13** of this report should be integrated into the license conditions of the Water Use License Application (WULA).

17 References

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18 Appendix I: Driller Report

GERRITSEN DRILLING SA

BOREHOLES, PUMPS, YIELD TESTING & ACCESSORIES

CC REG 2008/032582/23 VAT REG 4580245159

P.O Box 1263, Durbanville, 7551
021 976 0039
pierre@gdsa-wc.co.za
www.gdsa-wc.co.za

DRILLING REPORT

BOREHOLE: BH 1

SITE: Ackermans DC

Delft

CLIENT : Isipani Construction

COMMENCEMENT DATE: 17-10-2023

COMPLETION DATE: 20-10-2023

SITE COMPLETION DATE: 21-10-2023

DEPTH: 84m

BLOWYIELD: Approx. 18 000 L/H

Borehole Water Association of Southern Africa

GERRITSEN DRILLING SA

BOREHOLES, PUMPS, YIELD TESTING & ACCESSORIES

CC REG 2008/032582/23 VAT REG 4580245159

DRILLING METHOD:

0-23m : 254mm Air Percussion Drilling

23-47m : 203mm Air Percussion Drilling

47-84m : 165mm Air Percussion Drilling

CASINGS:

0-24m : 219mm OD Steel Casing

0-48m : 177mm OD Steel Casing

0-48m : 139mm OD Steel Casing Solid

48-78m : 139mm OD Steel Casing Perforated 1mm Slots

78-84m : 139mm OD Steel Casing Solid

FILTERPACK:

41 x Filterpack

cidb
Construction Industry Development Board

RATED BY BEE EMPOWERED

Borehole Water Association
of Southern Africa

GERRITSEN DRILLING SA

BOREHOLES, PUMPS, YIELD TESTING & ACCESSORIES

CC REG 2008/032582/23 VAT REG 4580245159

FORMATION:

0-23m : Sand

23-47m : Clay & Weathered Shale

47-84m : Shale Bedrock

WATER STRIKES:

54m : 2 400 L/H

59m : 12 000 L/H

70m : 16 000 L/H

77m : 18 000 L/H

COMMENTS:

Borehole should be tested to determine the correct size pump and installation depth.

DRILLING SUPERVISOR: S.Swart

DRILLING MANAGER: PA Gerritsen

cidb Construction Industry Development Board

RATED BY BEE EMPOWERED

Borehole Water Association of Southern Africa

19 Appendix II: Irrigation Plan


LEGEND:
Existing tree to be retained
New tree
BS = Buddleja saligna
CS = Celtis sinensis
LS = Liquidambar styraciflua
PS = Populus simonii
SG = Syzygium guineense
Euphorbia "Firesticks"
Arctotis hybrid - red or orange flowers
Asystasia gangetica
Carissa "Green Carpet"
Dietes grandiflora and Chasmanthe aethiopica
Plectranthus neochilus
Rhoicissus digitata
Tecoma capensis - red
ENTRY GATEHOUSE 01
EXIT GATEHOUSE 02
NOTE:
ACKERMANS DC WAREHOUSE
PLANTING PLAN
20.11.2023
1:200 @ A0
ADCW-PP
IXIA
LANDSCAPE ARCHITECTS CC

20 Appendix III*:* Scientific Yield Testing

GROUNDWATER AND EARTH SCIENCES
GEOSS
SOUTH AFRICA (Pty) Ltd

Unit 12, Technostell
9 Quantum Street, Technopark,
Stellenbosch, 7600
PO Box 12412, Die Boord,
7613, South Africa
Tel: +27 (0)21 880 1079
Fax: +27 (0) 86 605 1121
www.geoss.co.za

Borehole Yield Test Results

Project Name	Ackermans Blackheath
Project Number	5315_A
Borehole Name	AB_BH1

Site Details		
Province	Western Cape	
Area	Blackheath	
Farm/Site Name	Ackermans development	
Rig operator	Lusanda/Nunens	
Pump type	7.5 KW	
Coordinate system	-33.95713	Lat
	18.67164	Long
BoreholeStatus	Newly drilled	
Borehole depth	84	m
Borehole diameter (OD,ID)	135 ID	mm
Dummy pump test	*4	
Casing depth	78	m
Casing height	0.49	m
Datum level above ground	0.98	m
Test pump depth	78.12	m
Observation pipe depth	75.32	m
Logger depth	75.32	m
Available Drawdown	71.26	m
Water level before the test	3.49	mbch
Rest water level before step test	4.06	mbdl
	3.08	mbgl
Rest water level before CDT	4.95	mbdl
	3.97	mbgl
Outlet distance	Stormwater	m
Water sample type	Sans 241	
Comment	Completed	

Test date		
06-Nov-23	-	09-Nov-23

Step test details					
Date	**Step**	**Length**	**Flow rate**		**Comments**
06-Nov-23	1	1 h	1.0	l/s	Completed
06-Nov-23	2	1 h	2.5	l/s	Completed
06-Nov-23	3	1 h	4.0	l/s	Completed
06-Nov-23	4	1 h	4.8	l/s	Completed

Constant discharge test details				
Start Date	**Length**	**Flow rate**		**Comments**
07-Nov-23	24	4.6	l/s	Completed

Recovery details	
Start Date	**Data Capture**
08-Nov-23	Solinst logger

Monitoring boreholes			
Borehole:	**RWL**	**Distance from:**	**AB_BH1**

GEOSS SOUTH AFRICA (PTY) LTD • REG NO 2018/636989/07

DIRECTORS: JE CONRAD, DL BARROW

Step Test	06-Nov-23		5315_A	AB_BH1
Time	14:00		RWL (mbgl)	3.08
Ackermans Blackheath				
Step 1			**Step 2**	
1	l/s		2.5	l/s
Time interval (min)	Water level drawdown (m)		Time interval (min)	Water level drawdown (m)
1	0.16		61	2.96
2	0.72		62	3.86
3	1.05		63	4.17
5	1.20		65	4.46
7	1.23		67	4.60
10	1.30		70	4.80
15	1.41		75	4.99
20	1.49		80	5.16
30	1.64		90	5.44
40	1.75		100	5.68
50	1.85		110	5.87
60	2.04		120	6.03
Step 3			**Step 4**	
4	l/s		4.8	l/s
121	7.61		181	13.52
122	9.02		182	14.15
123	9.44		183	14.43
125	9.82		185	14.72
127	10.06		187	14.91
130	10.32		190	15.12
135	10.64		195	15.39
140	10.89		200	15.62
150	11.29		210	16.01
160	11.62		220	16.36
170	11.93		230	16.66
180	12.22		240	17.08

Constant Discharge Test (CDT) - Raw data			
Ackermans Blackheath			
5315_A	AB_BH1	07-Nov-23	
Time:	06:59	RWL (mbgl)	3.97
	Abstraction rate (L/s)	4.6	
Test Duration: 24 hours			
Hours	Time interval (min)	Water level drawdown (m)	
	0	0.00	
	1	0.00	
	2	0.07	
	3	0.97	
	4	2.51	
	5	3.01	
	6	7.26	
	7	8.57	
	8	9.15	
	9	9.51	
	10	9.78	
	12	10.20	
	15	10.68	
	20	11.22	
	25	11.67	
	30	11.98	
	40	12.58	
	50	13.07	
1	60	13.52	
	70	13.92	
	80	14.27	
	90	14.59	
	100	14.89	
2	120	15.42	
	150	16.26	
3	180	16.79	
4	240	17.78	
5	300	18.55	
6	360	19.25	
8	480	20.31	
10	600	21.04	
12	720	21.63	
14	840	22.10	
16	960	22.49	
18	1080	22.82	
20	1200	23.11	
22	1320	23.35	
24	1440	23.60	

Post CDT Recovery		
Ackermans Blackheath		
5315_A	AB_BH1	08-Nov-23
Hours	Time interval (min)	Water level drawdown (m)
	0	23.60
	1	23.23
	2	15.48
	3	14.29
	4	13.73
	5	13.35
	6	13.06
	7	12.82
	8	12.60
	9	12.42
	10	12.26
	12	11.99
	15	11.64
	20	11.16
	25	10.79
	30	10.46
	40	9.93
	50	9.49
1	60	9.11
	70	8.77
	80	8.46
	90	8.19
	100	7.93
2	120	7.48
	150	6.91
3	180	6.43
4	240	5.66
5	300	5.05
6	360	4.54
8	480	3.73
10	600	3.12
12	720	2.64
14	840	2.24
16	960	1.91
18	1080	1.63
20	1200	1.38
22	1320	1.18
24	1440	0.99

21 Appendix IV: Certificate of Analysis

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Your partner in quality water analysis

Distillery Road
Stellenbosch
Tel 021-8828866/7
info@vinlab.com
www.vinlab.com
2023-11-14

TEST REPORT

Water

Geoss South Africa (Pty) Ltd

Attn: Alison McDuling

P.O.Box 12412
Die Boord, Stellenbosch
7613
+27218801079

@VinlabSA

Sample Details						
SampleID	W44219					
Water Type	Drinking Water					
Water Source	Borehole					
Sample Temperature						
Description	5315_A_AB_BH1					
Batch Number	5315_A_AB_BH1					
PO Number	5315_A_AB_BH1					
Date Received	2023-11-10					
Condition	Good					

Water - Routine	Unit	Method	Uncertainty	Limit	Results	Results	Results	Results	Results
pH@25C (Water)		VIN-05-MW01	^^^	>= 5 to <= 9.7	7.11				
Conductivity@25C (Water)	mS/m	VIN-05-MW02	^	<= 170	136.1				
Turbidity (Water)*	ntu			<= 5	22.5				
Total dissolved solids (Water)*	mg/L			<= 1200	922.76				
Free Chlorine (Water)*	mg/L			<= 5	<0.02				
Ammonia (NH4) as N (Water)	mg/L	VIN-05-MW08	8.90%	<= 1.5	0.19				
Nitrate as N (Water)	mg/L	VIN-05-MW08	11.00%	<= 11	<1.00				
Nitrite as N (Water)	mg/L	VIN-05-MW08	4.50%	<= 0.9	<0.05				
Chloride (Cl-) - Water	mg/L	VIN-05-MW08	10.12%	<= 300	328.15				
Sulphates (SO4) - Water	mg/L	VIN-05-MW08	7.56%	<= 500	7.66				
Fluoride (F) - Water	mg/L	VIN-05-MW08	12.30%	<= 1.5	<0.15				
Alkalinity as CaCO3 (Water)*	mg/L				173.20				
Colour (Water)*	mg/L Pt-Co			<= 15	<15				
Total Organic Carbon (Water)*	mg/L			<=10	0.54				
Date Tested					2023-11-10				

Water - Metals	Unit	Method	Uncertainty	Limit	Results	Results	Results	Results	Results
Calcium (Ca) - Water	mg/L	VIN-05-MW43	14.60%		50				

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Test results relate only to the items tested as received. This Document shall not be reproduced without the written approval of Vinlab (Pty) Ltd.Opinions and interpretations expressed herein are outside
the scope of SANAS accreditation. Results for methods VIN-05-MW12, 13 and 14, are based on Cq values, a positive result (detected) indicates a Cq value
<35 and a negative result (non-detected) indicates a Cq value of >35.

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Vinlab is not liable to any client for any loss or damages suffered which could, directly or remotely, be linked to our services. Alcohol results are obtained using the most appropriate or a combination of one of the following methods: Py= pycnometer; W=winescan; A=alcolyzer. W = Winescan. Micro results: Enumeration of yeast: WL nutrient, 3 days unless otherwise specified, 30°C. Samples that have had prior microbiological spoilage or treatment for spoilage should always be sterile filtered at bottling. SO2 additions less than 10 days may depress the growth of microbes in culture although they are viable/active in the wine. Some microbes, especially lactobacilli, may not grow in culture even where viable/potentially active in the wine.

^ - Conductivity <1000mS/m = ±1mS/m , >1000mS/m = ±8mS/m
^^ - COD, LR = ±16mg/L, MR = ±48mg/L, HR = ±477mg/L
^^^ - pH ± 0.1

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Doc No V47695 | VIN 09-01 30-11-2022 | Page: 1 of 3 | Visit Vinlab H20

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TEST REPORT

Water

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Magnesium (Mg) - Water	mg/L	VIN-05-MW43	8.49%		29					
Sodium (Na) - Water	mg/L	VIN-05-MW43	11.45%	<= 200	177					
Potassium (K) - Water	mg/L	VIN-05-MW43	9.42%		3					
Zinc (Zn) - Water	mg/L	VIN-05-MW43	19.40%	<= 5	<0.008					
Antimony (Sb) - Water*	µg/L			<=20	<13.0					
Arsenic (As) - Water*	µg/L			<= 10	<10.0					
Boron (B) Water	µg/L	VIN-05-MW43	11.79%	<= 2400	54					
Cadmium (Cd) Water	µg/L	VIN-05-MW43	12.26%	<= 3	1					
Chromium (Cr) - Water	µg/L	VIN-05-MW43	13.03%	<= 50	<4					
Copper (Cu) - Water	µg/L	VIN-05-MW43	11.57%	<= 2000	10					
Iron (Fe) - Water	µg/L	VIN-05-MW43	12.49%	<= 2000	1935					
Lead (Pb) - Water	µg/L	VIN-05-MW43	16.32%	<= 10	9					
Manganese (Mn) - Water	µg/L	VIN-05-MW43	12.44%	<= 400	114					
Nickel (Ni) - Water	µg/L	VIN-05-MW43	17.38%	<= 70	<8					
Selenium (Se) - Water*	µg/L			<= 40	<10.0					
Aluminium (Al) - Water	µg/L	VIN-05-MW43	13.49%	<= 300	<8					
Cyanide (CN) - Water*	µg/L			<= 200	<10.0					
Mercury (Hg) - Water*	µg/L			<= 6	<1.0					
Barium (Ba) Water	µg/L	VIN-05-MW43	14.09%	<= 700	78					
Uranium (U) - Water*	µg/L			<= 30	<28					
Date Tested					2023-11-13					

Comments

W44219
Ion balance = 1.5%

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^ - Conductivity <1000mS/m = ±1mS/m , >1000mS/m = ±8mS/m
^^ - COD, LR = ±16mg/L, MR = ±48mg/L, HR = ±477mg/L
^^^ - pH ± 0.1

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Caitlyn McCartney
Laboratory Manager - RP
VIN-05-
M01,M02,M03,M04,M05,M09,M10,M28,
M40,MW07, MW09, MW10, MW12,
MW13, MW14, VIN-05-M42, M44, M45,
MW31, MW02, MW03, MW04, MW39,
MW43, M48, M49, M50, M51, M52, M53,
M54, M55, M46, M56, M57, M58, M68

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* - Conductivity <1000mS/m = ±1mS/m , >1000mS/m = ±lmS/m
** - COD, LR = ±16mg/L, MR = ±48mg/L, HR = ±477mg/L
*** - pH ± 0.1

sanas
Testing Laboratory
T0885

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2024-08-05

TEST REPORT

Water

Geoss South Africa (Pty) Ltd
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Sample Details					
SampleID	W54161	W54162	W54163		
Water Type	Drinking Water	Drinking Water	Drinking Water		
Water Source	Borehole		Borehole		
Sample Temperature					
Description	AB_BH1	PZ1	HBH1		
Batch Number	AB_BH1	PZ1	HBH1		
PO Number	5315_B	5315_B	5315_B		
Date Received	2024-08-01	2024-08-01	2024-08-01		
Condition	Good	Good	Good		

Water - Routine

	Unit	Method	Uncertainty	Limit	Results	Results	Results	Results	Results
pH@25C (Water)		VIN-05-MW01	^^^	>= 5 to <= 9.7	7.10	8.06	8.22		
Conductivity@25C (Water)	mS/m	VIN-05-MW02	^	<= 170	136.5	33.9	84.8		
Turbidity (Water)*	ntu			<= 5	27.0	410.00	2.10		
Total dissolved solids (Water)*	mg/L			<= 1200	925.47	229.84	574.94		
Free Chlorine (Water)*	mg/L			<= 5	0.02	<0.02	<0.02		
Ammonia (NH4) as N (Water)	mg/L	VIN-05-MW08	8.90%	<= 1.5	0.22	<0.15	<0.15		
Nitrate as N (Water)	mg/L	VIN-05-MW08	11.00%	<= 11	<1.00	1.41	9.78		
Nitrite as N (Water)	mg/L	VIN-05-MW08	4.50%	<= 0.9	<0.05	<0.05	<0.05		
Chloride (Cl-) - Water	mg/L	VIN-05-MW08	10.12%	<= 300	315.64	<10.00	89.21		
Sulphates (SO4) - Water	mg/L	VIN-05-MW08	7.56%	<= 500	7.36	7.12	85.65		
Fluoride (F) - Water	mg/L	VIN-05-MW08	12.30%	<= 1.5	0.40	<0.15	<0.15		
Alkalinity as CaCO3 (Water)*	mg/L				166.90	158.20	183.40		
Colour (Water)*	mg/L Pt-Co			<= 15	<15	15	19		
Total Organic Carbon (Water)*	mg/L			<=10	6.18	19.35	10.3		
Date Tested					2024-08-01	2024-08-01	2024-08-01		

Water - Metals

	Unit	Method	Uncertainty	Limit	Results	Results	Results	Results	Results
Calcium (Ca) - Water	mg/L	VIN-05-MW43	14.60%		50	37	93		
Magnesium (Mg) - Water	mg/L	VIN-05-MW43	8.49%		30	3	16		
Sodium (Na) - Water	mg/L	VIN-05-MW43	11.45%	<= 200	176	28	54		
Potassium (K) - Water	mg/L	VIN-05-MW43	9.42%		5	21	14		

Please click here for SANS241-1:2015 drinking water limits

*** Not SANAS Accredited. Results marked "Not SANAS Accredited" in this report are not included in the SANAS Scope of Accreditation for Vinlab.**

^ - Conductivity <1000mS/m = ±1mS/m , >1000mS/m = ±9mS/m
^^ - COD, LR = ±16mg/L, MR = ±48mg/L, HR = ±477mg/L
^^^ - pH ± 0.1

Distillery Road
Stellenbosch
Tel 021-8828866/7
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2024-08-05

TEST REPORT

Water

Geoss South Africa (Pty) Ltd

Attn: Alison McDuling

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Die Boord, Stellenbosch
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Zinc (Zn) - Water	mg/L	VIN-05-MW43	19.40%	<= 5	<0.008	0.029	<0.008		
Antimony (Sb) - Water*	µg/L			<=20	<13.0	<13.0	<13.0		
Arsenic (As) - Water*	µg/L			<= 10	<10.0	<10.0	<10.0		
Boron (B) Water	µg/L	VIN-05-MW43	11.79%	<= 2400	40	<10	101		
Cadmium (Cd) Water	µg/L	VIN-05-MW43	12.26%	<= 3	<1	<1	<1		
Chromium (Cr) - Water	µg/L	VIN-05-MW43	13.03%	<= 50	<4	4	<4		
Copper (Cu) - Water	µg/L	VIN-05-MW43	11.57%	<= 2000	<2	3	<2		
Iron (Fe) - Water	µg/L	VIN-05-MW43	12.49%	<= 2000	3219	1428	150		
Lead (Pb) - Water	µg/L	VIN-05-MW43	16.32%	<= 10	<8	<8	<8		
Manganese (Mn) - Water	µg/L	VIN-05-MW43	12.44%	<= 400	113	32	<4		
Nickel (Ni) - Water	µg/L	VIN-05-MW43	17.38%	<= 70	<8	<8	<8		
Selenium (Se) - Water*	µg/L			<= 40	<10.0	<10.0	<10.0		
Aluminium (Al) - Water	µg/L	VIN-05-MW43	13.49%	<= 300	<8	2666	10		
Cyanide (CN) - Water*	µg/L			<= 200	<10.0	20.0	<10.0		
Mercury (Hg) - Water*	µg/L			<= 6	<1.0	3	<1.0		
Barium (Ba) Water	µg/L	VIN-05-MW43	14.09%	<= 700	72	30	28		
Uranium (U) - Water*	µg/L			<= 30	<28	<28	<28		
Date Tested					2024-08-01	2024-08-01	2024-08-01		

Water - Micro

	Unit	Method	Uncertainty	Limits	Results	Results	Results	Results	Results
Total Coliforms (Water)	cfu/100mL	VIN-05-MW09		<= 10	nd	700			
E-Coli (Water)	cfu/100mL	VIN-05-MW09		not detected	nd	500			
Heterotrophic plate count*	cfu/mL			<= 1000	nd	1300			
Date Tested					2024-08-01	2024-08-01			

Comments

W54161
Ion balance = 3.7%

W54162
Ion balance = 6.2%

W54163
Ion balance = 3.7%

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*** Not SANAS Accredited. Results marked "Not SANAS Accredited" in this report are not included in the SANAS Scope of Accreditation for Vinlab.**

* - Conductivity <1000mS/m = ±1mS/m , >1000mS/m = ±9mS/m
** - COD, LR = ±16mg/L, MR = ±48mg/L, HR = ±477mg/L
*** - pH ± 0.1

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2024-08-05

Your partner in quality water analysis

TEST REPORT

Water

Geoss South Africa (Pty) Ltd

Attn: Alison McDuling

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Adelize Fourie
Laboratory Manager (Waterlab)
VIN-05-
M01,M02,M03,M04,M05,M08,M10,M28,
M43, MW01, MW02, MW03, MW04,
MW05, MW06, MW07, MW08/9/10,
MW12, MW13, MW14

Please click here for SANS241-1:2015 drinking water limits

Test results relate only to the items tested as received. This Document shall not be reproduced without the written approval of Vinlab (Pty) Ltd.Opinions and interpretations expressed herein are outside the scope of SANAS accreditation. Results for methods VIN-05-MW12, 13 and 14, are based on Cq values, a positive result (detected) indicates a Cq value <35 and a negative result (non-detected) indicates a Cq value of >35.

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Vinlab is not liable to any client for any loss or damages suffered which could, directly or remotely, be linked to our services Alcohol results are obtained using the most appropriate or a combination of one of the following methods: Py= pycnometer; W=winescan; Al=alcolyzer. W = Winescan. Micro results: Enumeration of yeast: WL nutrient, 3 days unless otherwise specified, 30°C. Samples that have had prior microbiological spoilage or treatment for spoilage should always be sterile filtered at bottling. SO2 additions less than 10 days may depress the growth of microbes in culture although they are viable/active in the wine. Some microbes, especially lactobacilli, may not grow in culture even where viable/potentially active in the wine.

* - Conductivity <1000mS/m = ±1mS/m , >1000mS/m = ±9mS/m
** - COD, LR = ±16mg/L, MR = ±46mg/L, HR = ±477mg/L
*** - pH ± 0.1

Doc No V54793 | VIN 09-01 07-05-2024 | Page: 3 of 3 | Visit Vinlab H20

Testing Laboratory T0324

Environmental Isotope Laboratory

Postal address: Private Bag 11, Wits, 2050, South Africa.
Physical Address: Empire Road (between Jan Smuts Avenue and Yale Road)
Tel ++27 11 351 7000/1 (switchboard/secretary), Fax ++27 11 351 7053

Report

Reference: GEOS081

Date: 6th August 2024

Environmental isotope analysis on two (2) water samples

submitted by Ms Alison McDuling

GEOSS South Africa (Pty) Ltd

Ref: 2023_10--5315_B

— —

M.J. Butler, M. Mabitsela

confidential

1. General

Two water samples were submitted by Ms A. McDuling of GEOSS South Africa (Pty) Ltd for D/H ($^2H/^1H$) and $^{18}O/^{16}O$ analysis. The samples were received on the 5th of August 2024.

2. Stable Isotope Analysis

Water D/H ($^2H/^1H$) and $^{18}O/^{16}O$ ratios were analysed in the laboratory of the Environmental Isotope Laboratory (EIL) of iThemba LABS, Johannesburg.

The equipment used for stable isotope analysis consists of a Los Gatos Research (LGR) Liquid Water Isotope Analyser. Laboratory standards, calibrated against international reference materials, are analysed with each batch of samples. The analytical precision is estimated at 0.5‰ for O and 1.5‰ for H.

Analytical results are presented in the common delta-notation:

$$\delta^{18}O(‰) = \left[\frac{(^{18}O/^{16}O)_{sample}}{(^{18}O/^{16}O)_{standard}} - 1 \right] \times 1000$$

which applies to D/H ($^2H/^1H$), accordingly. These delta values are expressed as per mil deviation relative to a known standard, in this case standard mean ocean water (SMOW) for $\delta^{18}O$ and δD.

3. Results

The analytical results are presented in Table 1 and illustrated in Figure 1.

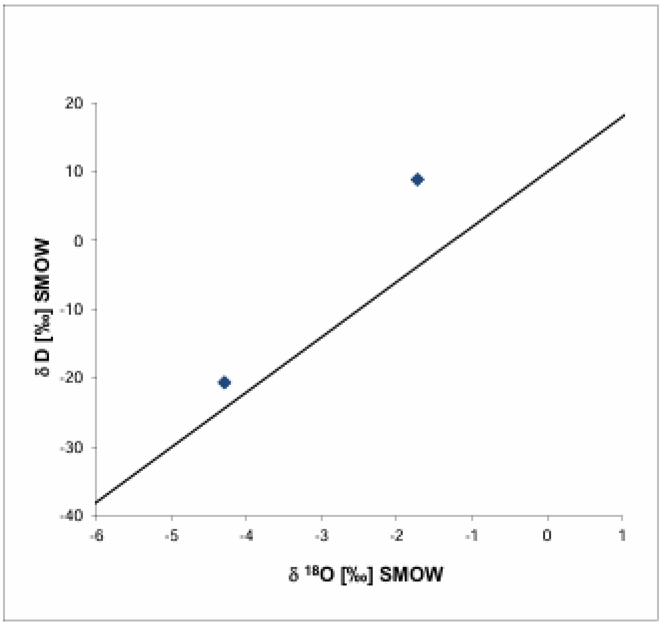


Figure 1: Stable isotope data relative to Global Meteoric Water Line (Craig, 1961).

The stable isotope analyses for the sample data could be well reproduced within the expected analytical error limits. Figure 1 shows these data in a $\delta^{18}O$ vs. δD space relative to the Global Meteoric Water Line (GMWL, Craig, 1961).

4. References

Craig, H. (1961). Isotopic variations in meteoric waters. *Science*, **133**, 1702–1703.

Table 1: Analytical Results

		Deuterium	Oxygen-18
Lab No	**Field Name**	**δD‰ SMOW**	**δ^{18}O‰ SMOW**
GEOS 831	1. AB_BH1	-20.6	-4.29
GEOS 832	2. PZ1	+8.9	-1.72

Table 2: Stable isotope aliquot determinations

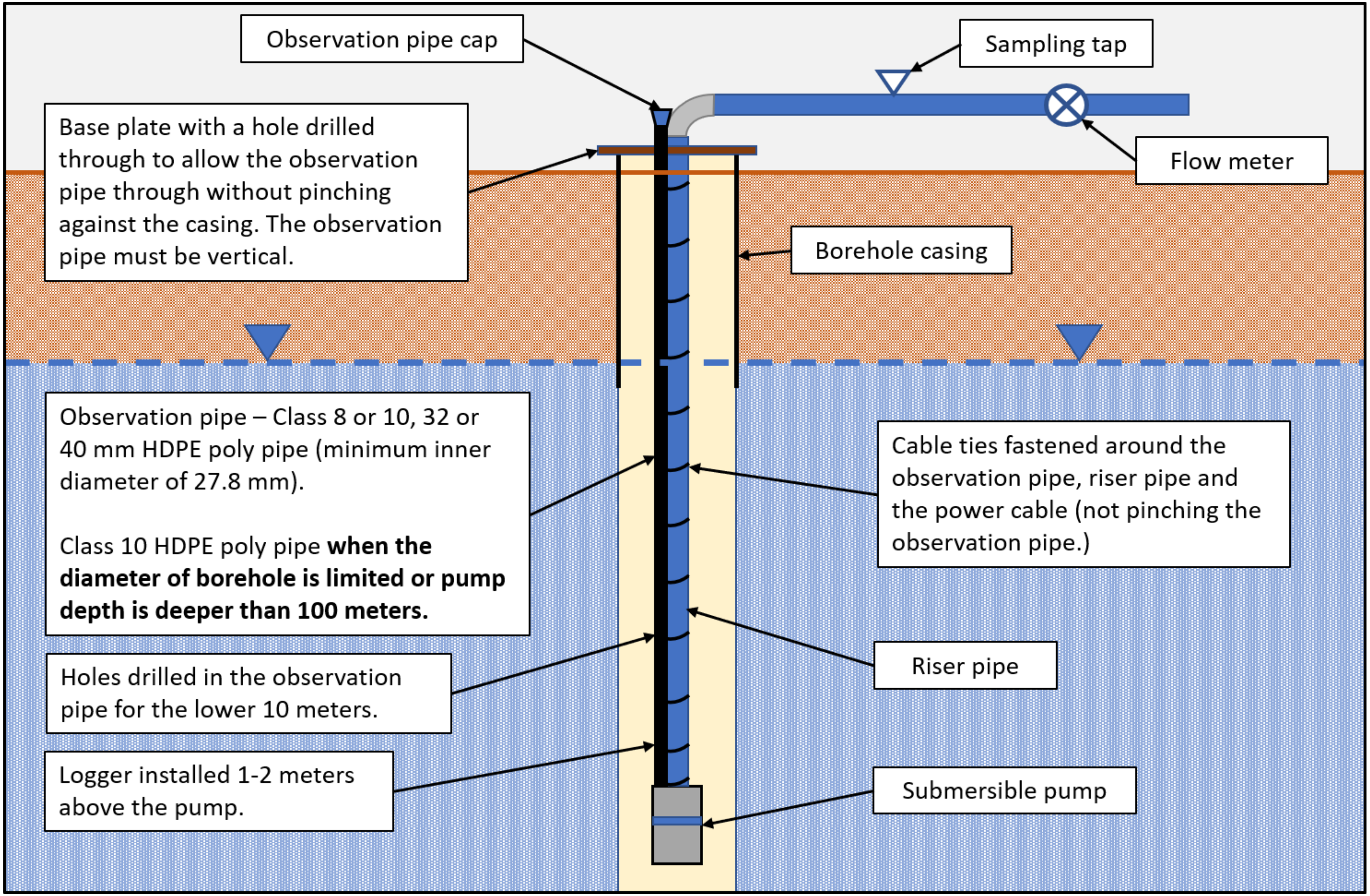
		Deuterium			Oxygen-18		
Lab No.	Field Name:	analysis	Batch	**δD‰ SMOW**	analysis	Batch	**δ^{18}O‰ SMOW**
GEOS 831	1. AB_BH1	a	2024/08/05	-20.9	a	2024/08/05	-4.28
		b		-20.3	b		-4.30
			avg.:	**-20.6**		**avg.:**	**-4.29**
			diff.:	*0.6*		*diff.:*	*0.02*
GEOS 832	2. PZ1	a	2024/08/05	8.5	a	2024/08/05	-1.76
		b		9.2	b		-1.69
			avg.:	**8.9**		**avg.:**	**-1.72**
			diff.:	*0.7*		*diff.:*	*0.07*

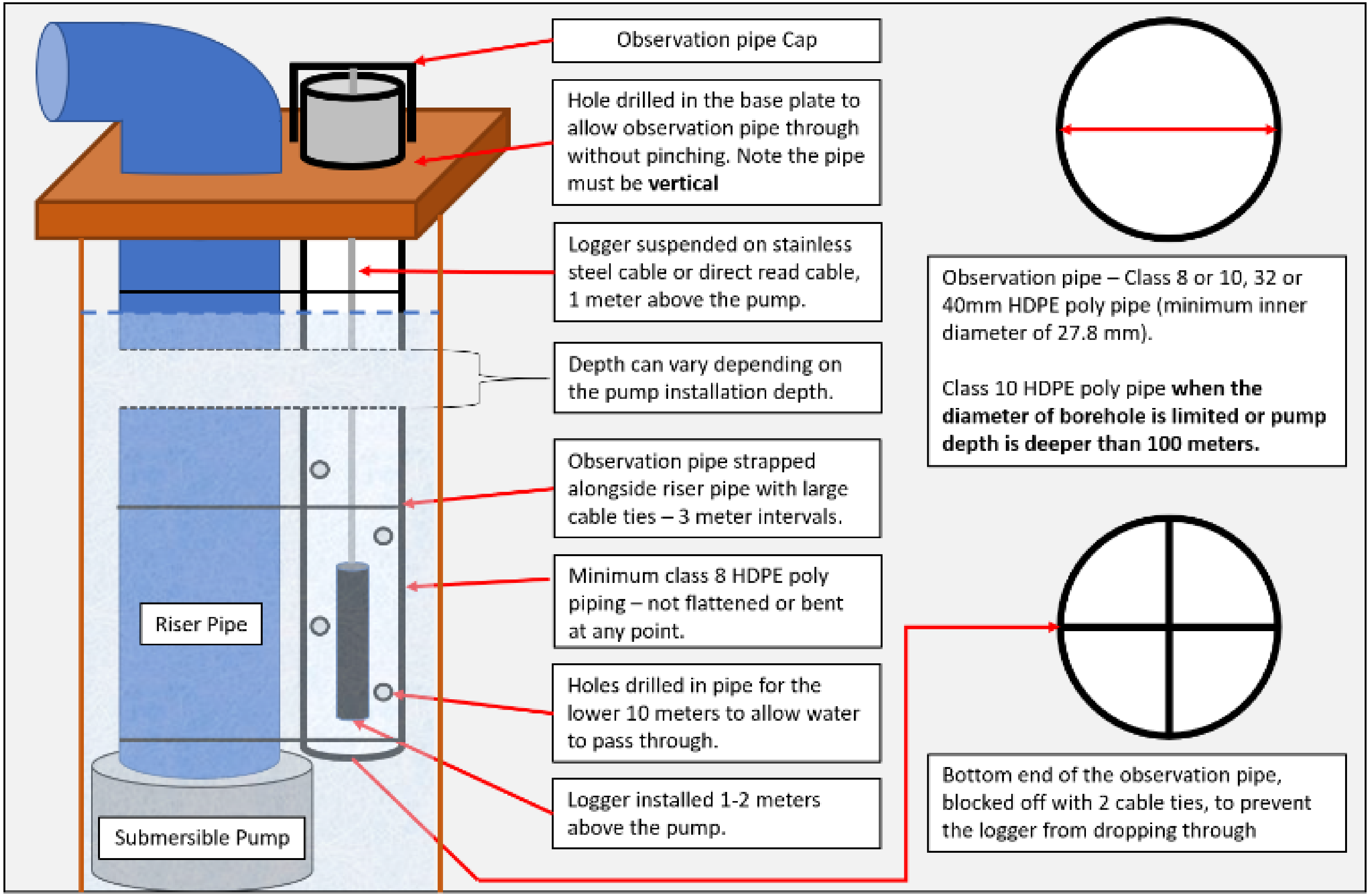
22 Appendix V: Risk Rating Criteria

Nature of impact	**Description**
Positive	Impacts would benefit the receiving environment (including people).
Negative	Impacts would harm the receiving environment (including people).
Type of impact	**Description**
Direct	Impacts that result directly from the causal activity, usually at the same time and in the same space as that activity
Indirect	Secondary impacts may result from direct impacts, generally occurring later in time and may manifest elsewhere in space (e.g. downstream)
Induced	Impacts that may happen as a consequence of the Project (e.g., migration of people along newly created access routes)
Cumulative	Impacts that add to or magnify existing or reasonably foreseeable future impacts on the same receiving environment or specific resource
Extent Rating	**Description**
Site specific	Impact (and implications) limited to the project site.
Local	Impact extends only as far as the activity, limited to the site and its immediate surroundings, and local assets/ resources.
Regional	Impact extends to a regional scale, and affects provincial resources, e.g. District or Province; Western Cape
National	Impact extends to a national scale, and affects national resources; South Africa.
International	Impact extends across national borders, and affects global resources.
Duration Rating	**Description**
Short term	0 - 5 years
Medium term	5 - 15 years
Long term	Where the impact will cease after the operational life of the activity, either because of natural processes or by human intervention. Generally >15 years but <30 years
Permanent	Where the impact will, for all intents and purposes, endure in perpetuity. That is, it would be regarded as ‘irreversible’
Intensity Rating	**Description**
Low	Where the impact affects the environment in such a way that a small or negligible proportion of resources and/or beneficiaries would be affected. Receptors in the receiving environment are not threatened or vulnerable, and affected communities have negligible or very low dependence on affected resources for livelihoods, health and safety.
Medium	Where a sizeable proportion of resources and/ or of beneficiaries would be affected, and natural, cultural and social functions and processes would continue, albeit in a modified way. Receptors in the receiving environment are moderately threatened or vulnerable, and/ or affected communities have some dependence on affected resources for livelihoods, health and safety, affected resources could be substituted.
High	Where most/ a major proportion of resources and/ or beneficiaries would be affected, and natural, cultural and social functions or processes are altered to the extent that they would temporarily or permanently cease. Receptors in the receiving environment are highly threatened or vulnerable (i.e. close to environmental or legal thresholds, standards or targets), and affected communities are highly dependent on affected resources for livelihoods, health and safety, and/ or resources are

	considered to be irreplaceable (if lost they could not be substituted, and/ or their loss would undermine achieving targets, standards).
Probability Rating	**Description**
Improbable	Where the possibility of the impact materializing is very low, but it could occur e.g. in unplanned / upset conditions
Possible	Where there is a possibility that the impact will occur during normal operations.
Probable	Where the impact is expected to occur during normal operations
Definite	Where the impact will undoubtedly occur.
Confidence Rating	**Description**
High	High confidence in predictions.
Medium	Some uncertainty in predictions e.g. due to information gaps, constraints on study
Low	Little confidence in predictions e.g. due to constraints on study, information gaps, inherent uncertainties
Significance Rating	**Description**
Negligible	Where the receiving environment (including people) would not be materially affected by the proposed activity(ies). *There would be no need for mitigation*.
Very Low	Where there would be minimal effect on the environment or human wellbeing, and impacts would be well within environmental quality standards or targets, or legal requirements. *There would be no need for mitigation*.
Low	Where there would be little material effect on the environment or human wellbeing, and impacts would be well within environmental quality standards or targets, or legal requirements. *Minor mitigation measures may be required.*
Moderate	Where the activity (ies) would have a material effect on the receiving environment (including people), legal requirements would still be met but thresholds of potential concern with regard to environmental quality may be crossed. *Mitigation measures – avoidance, minimization and rehabilitation/ restoration, and in some cases offsets/ compensation - would be needed to reduce the impact significance.*
High	Where there would be major effects on the receiving environment to the extent where environmental quality standards or targets may be jeopardized, legal requirements may not be met, and the health, safety, livelihoods and/or wellbeing of affected people could be jeopardized. *Mitigation measures – preferably avoidance/ impact prevention, minimization, rehabilitation/ restoration, and offsets/ compensation – are essential to reduce the impact significance substantially.*
Very High	Where there would be severe or substantial effects on the receiving environment to the extent where environmental quality standards or targets would be undermined/ exceeded, there would be non-compliance with legal requirements or commitments, and the health, safety, livelihoods and/or wellbeing of affected people would be jeopardized. *Mitigation measures – avoidance or prevention of impacts as a priority would be required, since impacts are unacceptable. Additional measures to minimize, rehabilitate/ restore, and offset/ compensate for residual impacts would be – are essential to reduce the impact significance substantially*

23 Appendix VI: Monitoring Infrastructure


Observation pipe cap
Sampling tap
Base plate with a hole drilled through to allow the observation pipe through without pinching against the casing. The observation pipe must be vertical.
Flow meter
Borehole casing
Observation pipe – Class 8 or 10, 32 or 40 mm HDPE poly pipe (minimum inner diameter of 27.8 mm).
Class 10 HDPE poly pipe **when the diameter of borehole is limited or pump depth is deeper than 100 meters.**
Cable ties fastened around the observation pipe, riser pipe and the power cable (not pinching the observation pipe.)
Holes drilled in the observation pipe for the lower 10 meters.
Riser pipe
Logger installed 1-2 meters above the pump.
Submersible pump


Observation pipe Cap
Hole drilled in the base plate to allow observation pipe through without pinching. Note the pipe must be **vertical**
Logger suspended on stainless steel cable or direct read cable, 1 meter above the pump.
Depth can vary depending on the pump installation depth.
Observation pipe strapped alongside riser pipe with large cable ties – 3 meter intervals.
Minimum class 8 HDPE poly piping – not flattened or bent at any point.
Holes drilled in pipe for the lower 10 meters to allow water to pass through.
Logger installed 1-2 meters above the pump.
Riser Pipe
Submersible Pump
Observation pipe – Class 8 or 10, 32 or 40mm HDPE poly pipe (minimum inner diameter of 27.8 mm).
Class 10 HDPE poly pipe **when the diameter of borehole is limited or pump depth is deeper than 100 meters.**
Bottom end of the observation pipe, blocked off with 2 cable ties, to prevent the logger from dropping through

24 Appendix VII: WARMS Groundwater Users Within the GRU

Table 23: Summary of active and registered WARMS borehole details within the GRU.

WARMS no.	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Register Status	WU Sector	Resource Type	Registered Volume (m3/a)
22029813	-33.9646	18.7236	LAWFUL	INDUSTRY (NON-URBAN)	BOREHOLE	200.0
22029813	-33.9506	18.7006	LAWFUL	AGRICULTURE: IRRIGATION	BOREHOLE	20000.0
22032159	-33.9513	18.7140	LAWFUL	AGRICULTURE: IRRIGATION	BOREHOLE	36000.0
22032159	-33.9467	18.7205	LAWFUL	AGRICULTURE: IRRIGATION	BOREHOLE	4000.0
22117488	-33.9661	18.7349	LAWFUL	INDUSTRY (NON-URBAN)	BOREHOLE	10000.0
22137714	-33.9397	18.6828	LAWFUL	INDUSTRY (URBAN)	BOREHOLE	180.0
22140719	-33.9410	18.6853	LAWFUL	INDUSTRY (URBAN)	BOREHOLE	1218.0
22140719	-33.9415	18.6859	LAWFUL	INDUSTRY (URBAN)	BOREHOLE	1218.0
22145821	-34.0165	18.6901	LAWFUL	INDUSTRY (URBAN)	BOREHOLE	9461.0
22145894	-33.9979	18.7203	LAWFUL	WATER SUPPLY SERVICE	BOREHOLE	27594.0
22148203	-33.9394	18.6779	LAWFUL	INDUSTRY (URBAN)	BOREHOLE	28470.0
22148481	-33.9532	18.7290	LAWFUL	AGRICULTURE: IRRIGATION	BOREHOLE	5000.0
22153161	-33.9451	18.7088	LAWFUL	AGRICULTURE: IRRIGATION	BOREHOLE	21565.0
22153802	-33.9553	18.7139	LAWFUL	AGRICULTURE: IRRIGATION	BOREHOLE	14000.0
22154428	-33.9657	18.7002	LAWFUL	AGRICULTURE: IRRIGATION	BOREHOLE	32250.0
22155436	-34.0327	18.7282	LAWFUL	AGRICULTURE: IRRIGATION	BOREHOLE	15100.0
22155436	-34.0374	18.7267	LAWFUL	AGRICULTURE: IRRIGATION	BOREHOLE	15107.0
22155436	-34.0414	18.7302	LAWFUL	AGRICULTURE: IRRIGATION	BOREHOLE	15100.0
22155436	-34.0268	18.7369	LAWFUL	AGRICULTURE: IRRIGATION	BOREHOLE	15100.0
22165942	-33.9477	18.7032	LAWFUL	AGRICULTURE: IRRIGATION	BOREHOLE	3140.5
22165942	-33.9480	18.7057	LAWFUL	AGRICULTURE: IRRIGATION	BOREHOLE	3140.5
22005438	-33.9658	18.6996	LAWFUL	INDUSTRY (URBAN)	BOREHOLE	20000.0
Total Lawful Sites:						**297 843.9**

WARMS no.	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Register Status	WU Sector	Resource Type	Registered Volume (m3/a)
22021562	-33.9658	18.6996	LAWFULNESS STILL TO BE DETERMINED	INDUSTRY (URBAN)	BOREHOLE	30000.0
22031445	-33.9658	18.6996	LAWFULNESS STILL TO BE DETERMINED	WATER SUPPLY SERVICE	BOREHOLE	2611.0
22032113	-33.9555	18.6703	LAWFULNESS STILL TO BE DETERMINED	INDUSTRY (URBAN)	BOREHOLE	45000.0
22098695	-33.9658	18.6996	LAWFULNESS STILL TO BE DETERMINED	AGRICULTURE: IRRIGATION	BOREHOLE	3650.0
22116345	-33.9658	18.6996	LAWFULNESS STILL TO BE DETERMINED	AGRICULTURE: WATERING LIVESTOCK	BOREHOLE	4500.0
22116345	-33.9658	18.6996	LAWFULNESS STILL TO BE DETERMINED	AGRICULTURE: IRRIGATION	BOREHOLE	30000.0
Total:						**413 604.9**

(Last Page)