D10: Geohydrological Assessment

Geohydrological Impact Assessment: Carpe Diem North Solar PV Facility, near Carletonville.

Prepared by

GEOSS

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Executive Summary

Legacy Environmental Management Consulting has been appointed by JUWI Renewable Energies (Pty) Ltd to undertake the required scoping and environmental impact assessment (EIA) processes for a proposed solar energy cluster located west of Carletonville in Gauteng Province. As such, GEOSS was approached by Legacy Environmental Management Consulting to complete a geohydrological assessment and hydrocensus for the Carpe Diem North Solar PV Facility (**Map 1**). This geohydrological assessment is necessary to identify potential boreholes and potential areas for groundwater development along with the potential impacts the development may have on the local and regional geohydrological system.

The water requirements for the proposed Carpe Diem North Solar PV Facility are as follows:

- Construction phase 6 120 m^3/a (0.19 L/s)
- Operational phase: 1 800 m^3/a (0.06 L/s).

The proposed site is directly underlain by two main lithologies (rock/soil types):

- Thickly developed dolomites of the Malmani Subgroup (Vma)
- Locally developed areas of thick residual soils and/or other quaternary deposits.

The Carpe Diem North Solar PV Facility and surrounding area is underlain by two aquifers:

- A dolomitic karst aquifer with an average borehole yield potential of more than 5.0 L/s.
- An intergranular and fractured aquifer with an average borehole yield potential of 0.1 – 0.5 L/s.

Based on regional datasets, the groundwater electrical conductivity (EC) typically ranges between 0 and 300 mS/m, with areas southwest of the site reaching EC values of more than 1 000 mS/m. These ranges sourced from the National Groundwater Archive (NGA) and other literature, were generally corroborated by in field observations during a hydrocensus conducted in March of 2024. Chemical analysis of the groundwater according to the DWA (1998) domestic water standards and SANS241-1:2015 drinking water standards indicate that the groundwater in the region is of ideal to good water quality.

Reference has been made to specific scenarios to meet the required peak (construction) water supply of 6 120 m^3/a for the proposed Carpe Diem North Solar PV Facility. The volumes of water required for the development should be readily available according the average borehole yield of the area. Furthermore, the calculated Firm Yield for the groundwater resource units west of the regional Oberholzer Dyke also shows this. Any groundwater use will, however, not be serviceable under a General Authorisation. As such, a Water Use Licence Application will need to be submitted to the Department of Water and Sanitation for any newly constructed boreholes or when a borehole that does not yet have an existing Water Use License is used. This can be guided by a professional with knowledge of the National Water Act ensuring that the water used, during construction and operation of the solar farms, is lawful.

Finally, the following recommendations have been made in this report:

- The groundwater supply can be sourced from either existing boreholes outside of the affected property, newly developed boreholes, or a combination of these options.
- Making use of any groundwater resources in the area will require a Water Use License Application to the Department of Water and Sanitation under Section 40 of the National Water Act, 1998 (Act No. 36 of 1998).
- The legal status of groundwater use at each borehole should be confirmed. This will inform

the need for future water use authorisations.

- In the event that water provider used has an active Water Use License or an Existing Lawful Use, the recommendations and stipulations within the license need to be reviewed and adhered to.
- All boreholes planned for use will require scientific yield and quality testing and analysis, should this not have already been done.
- Groundwater exploration via geological and geophysical methods is recommended for the proposed facility should existing boreholes not be sufficient to meet the demand. Groundwater exploration aims to understand the geological environment which can increase the chance of borehole success by providing more realistic expectations for yields and borehole drill depths.
- Due to the artificially low water table, any new groundwater development will require a significant capital investment in addition to scientific yield testing as part of a Water Use License application.
- Any newly constructed boreholes will require input from a geotechnical professional regarding the potential for sinkhole formation due to water abstraction.
- In the case that multiple projects are constructed simultaneously, adherence to recommended mitigation measures should be strictly followed to prevent over abstraction.
- All proposed impact mitigation measures are to be implemented during the development of the project. These include the use of environmentally safe cleaning agents, the construction of (Battery Energy Storage Systems) BESS facilities 50m from any boreholes along with appropriate bunding and secondary containment, and the recommended precautionary approaches aimed at preventing oil spills and fuel leaks.

From the impact assessment, it is evident that the development will have a very low to low impact on the local geohydrological system as long as the recommended mitigation measures are adhered to. As such, the project should be authorised to continue from a geohydrological perspective on condition of implementation of the prescribed recommendations.

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Abbreviations

BESS	Battey Energy Storage System
BH	Borehole
CGS	Council for Geoscience (Est 1993 formerly the Geological Survey of South Africa)
DD	Decimal degrees
DWAF	Department of Water Affairs and Forestry (Est. 1994 up until May 2009)
DWS	Department of Water and Sanitation (DWS was established from May 2009 until May 2019. It was then made part of the Ministry of Human Settlements, Water and Sanitation (Established in May 2019)
EC	Electrical Conductivity
GA	General Authorisation
GRU	Groundwater Resource Unit
ELU	Existing Lawful Use
ha	hectare
ID	identity
km	kilometre
L/s	litres per second
m	metres
m^3/a	metres cubed per annum
m^3/ha/a	metres cubed per hectare per annum
MAE	Mean Absolute Error
mamsl	maters above mean sea level
MAR	Mean Anual Rainfall
mbgl	metres below ground level
mg/L	milligrams per litre
mm	millimetre
mm/a	millimetres per annum
mS/m	milliSiemens per meter
SANAS	South African National Accreditation System
SANS	South African National Standard
	WGS84 Since the 1st January 1999, the official co-ordinate system for South Africa is based on the World Geodetic System 1984 ellipsoid, commonly known as WGS84.
WMA	Water Management Area
WL	water level
WULA	Water Use Licence Application.

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 [from National Water Act (Act No. 36 of 1998)].
Fractured aquifer:	Fissured and fractured bedrock resulting from decompression and/or tectonic action. Groundwater occurs predominantly within fissures and fractures.
Karst aquifer:	An aquifer typified by a network if interconnected fissures, fractures and conduits emplaced in a relatively low-permeability rock matrix. The groundwater flow generally occurs through an interconnected network of openings whilst the storage occurs in the matrix. This environment is usually found in a limestone or dolomitic terrain.
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.
Intergranular aquifer:	The intergranular aquifer is the primary aquifer and is described as an aquifer in which groundwater is stored within the flows through open pore spaces in the unconsolidated Quaternary deposits.
Sinkhole:	A cavity in the ground, usually formed in a limestone (dolomite) environment. Caused by water erosion usually along preferential pathways to flow

SPECIALIST EXPERTISE – LOUIS JONK

GENERAL

Nationality:	South African
Profession:	Geotechnical Specialist
Specialization:	Soil classification for engineering purposes, groundwater exploration and sampling
Position in firm:	Geotechnical Geologist at GEOSS – South Africa (Pty) Ltd.
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- Soil and rock profiling.
- Material classification and material use determination.
- Supervision of geotechnical contractors.
- Groundwater geophysics and conducting hydrocensus studies.
- Groundwater development - borehole drilling and test pumping supervision and analysis.
- Groundwater monitoring - development and analysis of groundwater level and quality data.
- Groundwater management - sustainable aquifer development and management.
- Groundwater contamination assessments.
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- Groundwater Division of the Geological Society of South Africa
- South African Council for National Scientific Professions (SACNASP) Mem. No. 121278/21
- Palaeontological Society of South Africa (PSSA)

EMPLOYMENT RECORD

Jan 2023 to present	GEOSS South Africa (Pty) Ltd, South Africa
April 2020 to Dec 2022	Council for Geoscience South Africa
April 2018 to March 2020	Iziko Museums of South Africa

SPECIALIST DECLARATION

I, Louis Jonk, as the appointed independent specialist hereby declare that I:

- act/ed as the independent specialist in this application;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct, and
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- have and will not have no vested interest in the proposed activity proceeding;
- have disclosed, to the applicant, EAP and competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- are fully aware of and meet the responsibilities in terms of NEMA, the Environmental Impact Assessment Regulations, 2010 (specifically in terms of regulation 17 of GN No. R. 543) and any specific environmental management Act, and that failure to comply with these requirements may constitute and result in disqualification;
- have provided the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not; and
- am aware that a false declaration is an offence in terms of regulation 71 of GN No. R. 543.

Louis Jonk
GEOSS South Africa (Pty) Ltd.
Pr. Sci. Nat. – 121278/21
13 May 2024

1 Introduction

JUWI Renewable Energies (Pty) Ltd has appointed Legacy Environmental Management Consulting to undertake the required scoping and environmental impact assessment (EIA) processes for a proposed solar energy cluster located west of Carletonville in Gauteng Province. As such, GEOSS was approached by Legacy Environmental Management Consulting to complete a geohydrological assessment and hydrocensus for the Carpe Diem North Solar PV Facility (**Map 1**). This geohydrological assessment is necessary to identify potential boreholes and potential areas for groundwater development along with the potential impacts the development may have on the local and regional geohydrological system.

It is understood that the water will primarily be used across the Solar PV Facility in the construction of roads, hardstand compaction, concrete foundations, cleaning of equipment, and dust suppression on roads. Water consumption during the operational phase will mostly be limited to staff ablutions and cleaning of solar panels. Water use for the facility has been estimated at a cumulative 6 120 m^3/a (0.19 L/s) during the construction phase and 1 800 m^3/a (0.06 L/s) for the operational phase.

This report outlines the work completed to assess the likelihood of using existing sources of groundwater for the project, the potential to develop additional areas for groundwater abstraction, and the potential impacts to the geohydrological environment. Regarding the legal aspect of the proposed groundwater use, **Table 1** lists details that have relevance.

Table 1: General Authorisation limit for Varkenslaagte (5/119), Gauteng.

Property	Varkenslaagte (5/119)
Quaternary Catchment	C23E
Property Size (ha)	257.755
General Authorization (m^3/ha/a)	0.000
General authorization zone	E
General authorization volume (m^3/a)	0.000
Required peak abstraction for the property (m^3/a)	6 120
Is General Authorization exceeded?	Yes

2 Scope of Works

The main objectives of this project are to:

- Complete a geohydrological characterization of the groundwater in the vicinity of the property.
- Determine the sustainable (i.e., long-term and safe) yield of all the boreholes as well as the quality of the groundwater.
- Assess the importance of groundwater (both socio-economically and environmentally) in the area through reviews of historic hydrocensus data.
- Document the above findings in a format compatible with the requirements for a water use license application given additional yield tests of the production

borehole(s) are performed at a later stage.

3 Region setting

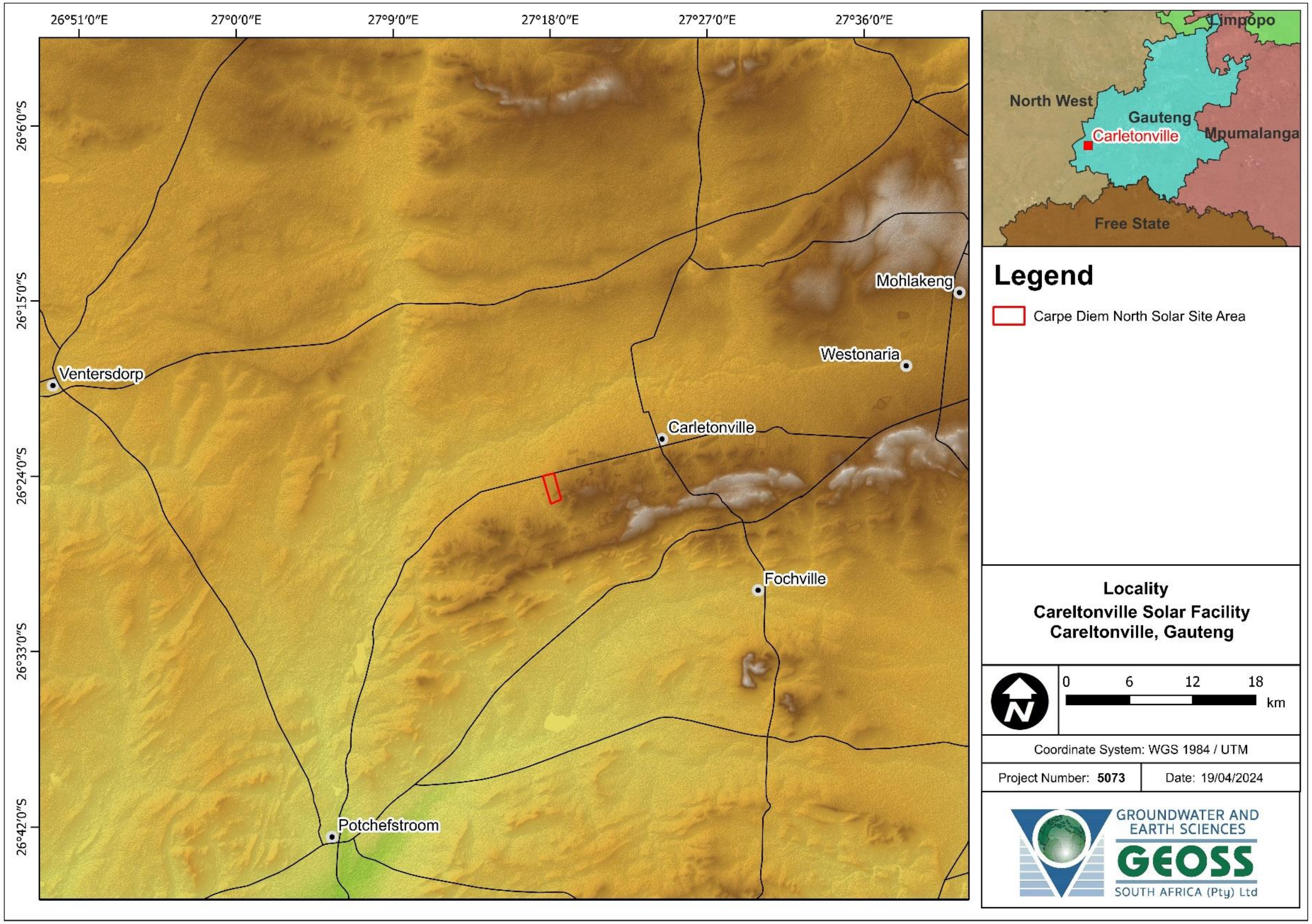
3.1 General

The Carpe Diem North Solar PV Facility is located just to the west of Carletonville, on the outskirts of the town in the Gauteng province. The property earmarked for the development is located within Quaternary Catchment C23E, which forms part of the Upper Vaal Water Management Area. The quaternary catchment is approximately 849.91 km^2 and has a groundwater General Authorisation (GA) of zero (0) m^3/a/ha. The main river closest to the planned Carpe Diem North Solar PV Facility is the Wonderfonteinspruit which is situated approximately 4.2 kilometres directly north of the proposed area, and represents the main drainage feature within the region. Carpe Diem North Solar PV Facility is located at an elevation of 1 593 to 1 527 mamsl, with a general shallow slope of approximately five (5) to six (6) degrees to the north.

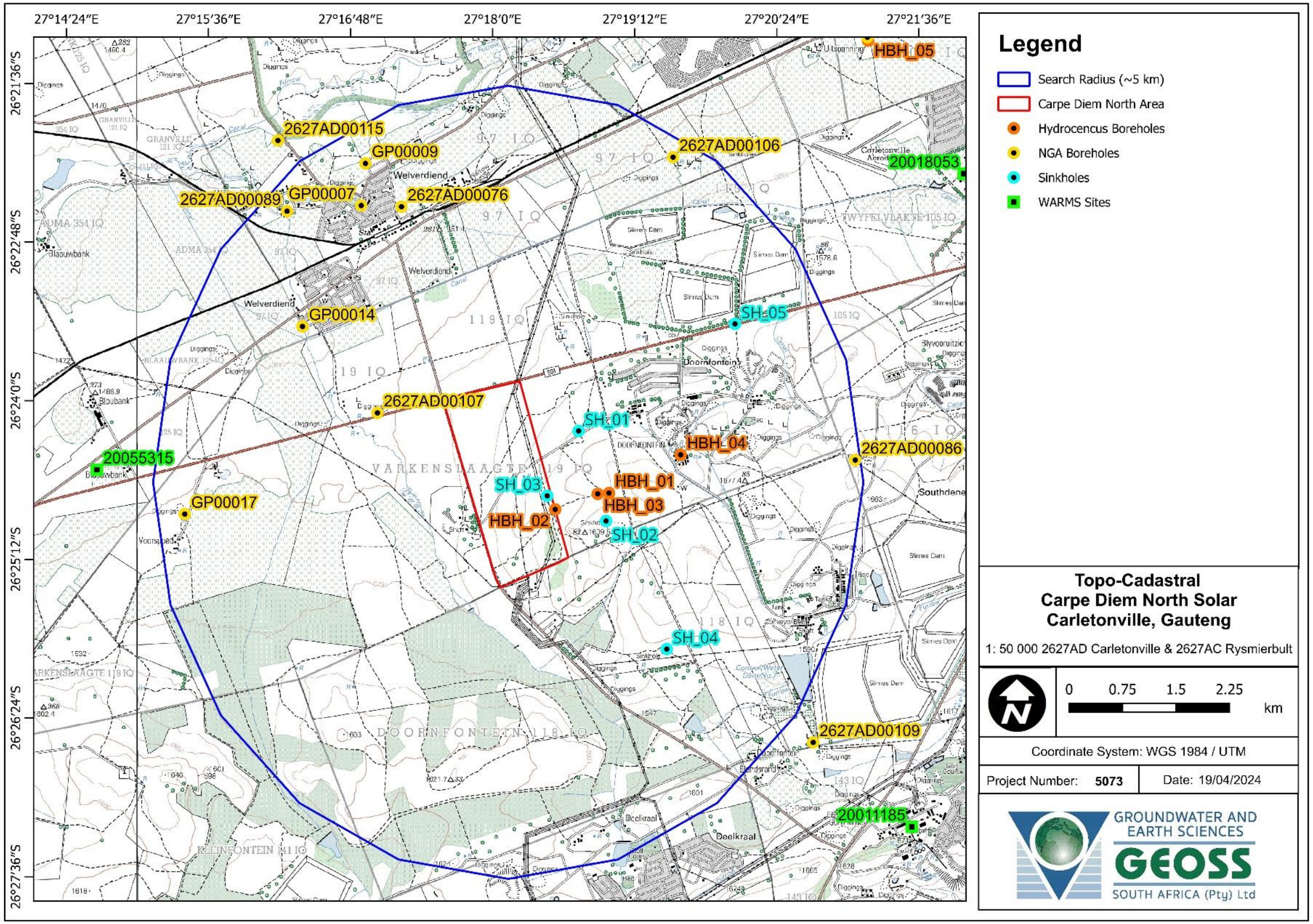
The study area, within a regional context, is shown in **Map 1. Map 2** and **Map 3** show more detailed views of the study site with relevant information (borehole positions on and near the property) superimposed on a 1:50 000 topo-cadastral map and aerial image, respectively.

3.2 Climate

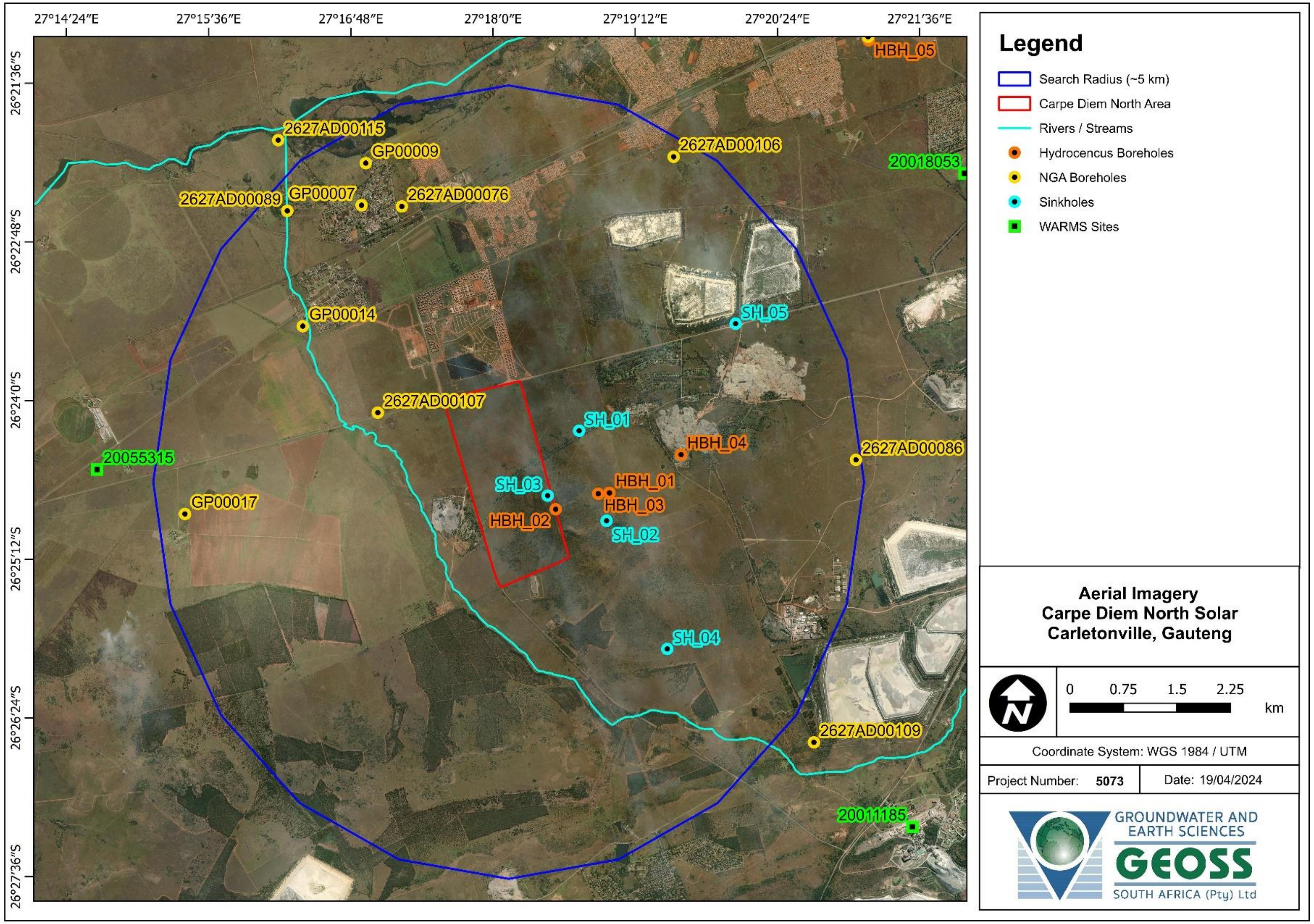
The Carpe Diem North Solar PV Facility and surrounding area experiences a continental climate with hot summers with scattered rains, and cold dry winters. **Figure 1** shows the monthly average range of air temperatures, and **Figure 2** shows the monthly average rainfall and evaporation distribution for the Carpe Diem North PV Facility and surrounding region (Schulze, 2009). The long-term (1950 – 2000) mean annual precipitation for the region is 465 mm/a. The evaporation rates typically exceed the rainfall volumes throughout the year.



Map 1: Location of the study area within a regional setting.



Map 2: The study site with the property boundary with the hydrocensus, NGA and WARMS boreholes superimposed on a 1:50 000 scale topo-cadastral map (Carletonville 2627 AD & Rysmierbult 2627 AC)



Map 3: The study site with the property boundary with the hydrocensus, NGA and WARMS boreholes superimposed on an aerial photograph.

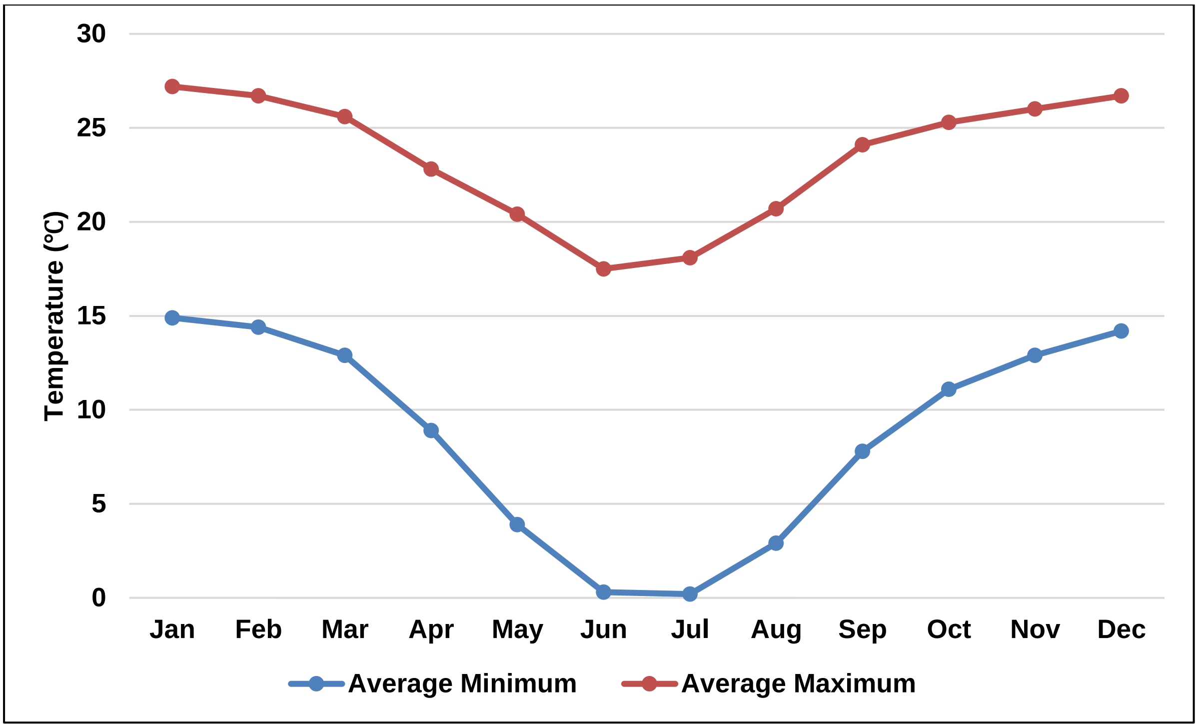


Figure 1: Monthly average air temperature of the Carletonville area (Schulze, 2009).

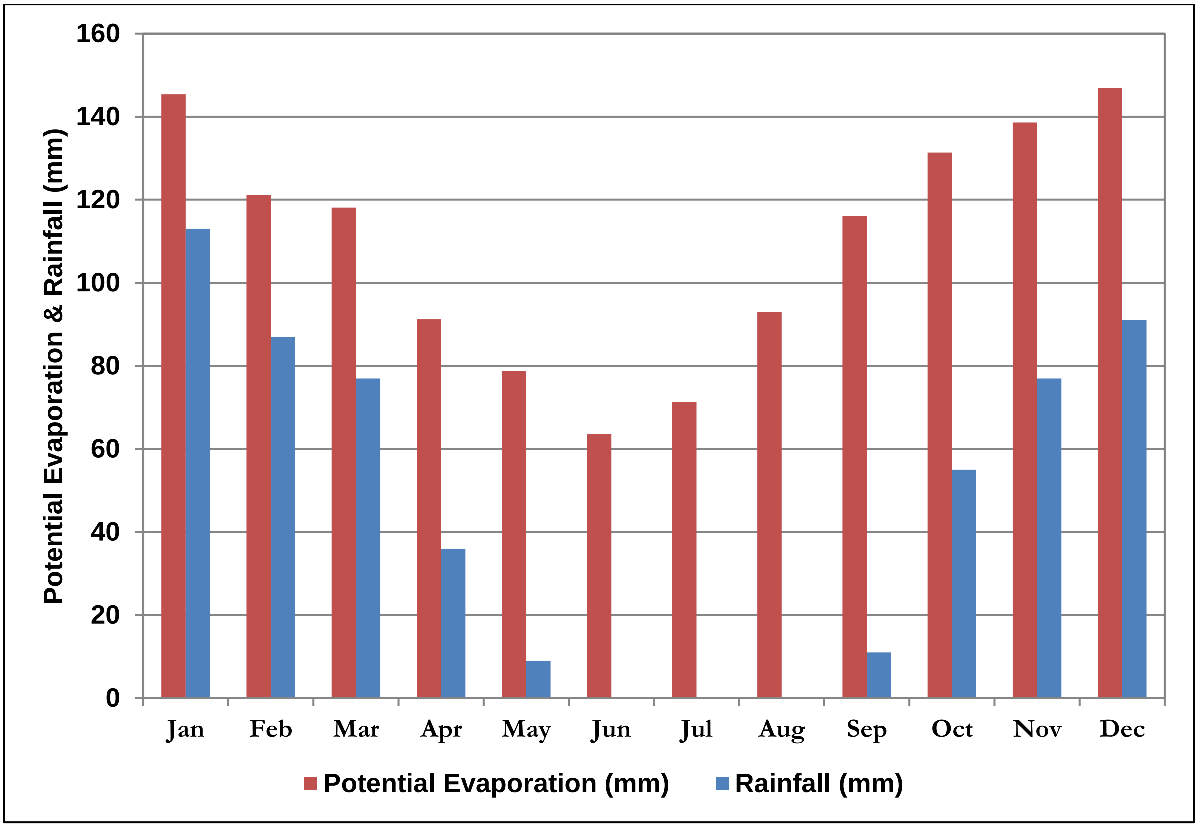


Figure 2: Monthly average rainfall and potential evaporation for the Carletonville area (Schulze, 2009).

4 Regional Geology

The Council for Geoscience (CGS) has mapped the region at 1:250 000 scale (2626 Wes Rand, CGS 1986). The geological setting is shown in **Map 4** and the main geology of the area is listed in **Table 2.**

Table 2: Geological formations within the study area.

Code	Formation	Group	Description
Q25	Quaternary-age sediments		Alluvium
Vdp	Daspoort	Pretoria	Quartzite with minor shale and siltstone
Vst	Strubenkop	Pretoria	Shale, subordinate siltstone, minor quartzite
Vh	Hekpoort	Pretoria	Andesitic lava, subordinate pyroclastic rocks, minor quartzite, shale and conglomerate
Vbo	Boshoek	Pretoria	Arkosic quartzite, subgreywacke, siltstone, shale, conglomerate (in places)
Vti	Timeball Hill	Pretoria	Units of interbedded mudstones and fine-grained sandstones, thick black shales, quartzites, and lavas
Vrh	Rooihoogte	Pretoria	Conglomerate/breccia, shale, quartzite
Voa	Oaktree	Chuniespoort	Thick units of carbonaceous shales, stromalitic dolomites, and locally developed quartzites
Vma	Malmani Subgroup	Chuniespoort	Dolomite, subordinate chert, minor carbonaceous shale, limestone and quartzite.
Vbr	Black Reef	Transvaal Supergroup	Quartzite, subordinate conglomerate and shale

The regional geology around the site is comprised of numerous geological units from the Dominion and West Rand Groups, and the Pretoria and Chuniespoort groups from the Transvaal Supergroup.

The most extensively outcropping units within in the area belong to the Malmani Subgroup of the Transvaal Supergroup. The Neoarchean aged Malmani Subgroup is a thick (up to 2 000 m) succession of dolomites, subordinate chert, carbonaceous shales, limestone and quartzites. Mapped units within the Malmani Subgroup in the study area include the dolomitic Oaktree Formation which lies conformably on the interbedded quartzites, shales and conglomerates of the Black Reef Formation (Van der Neut et al., 2012). The Black Reef Formation in turn, preserves an unconformable contact with the underlying West Rand and Dominion groups (Eriksson et al, 2006; Van der Neut et al., 2012).

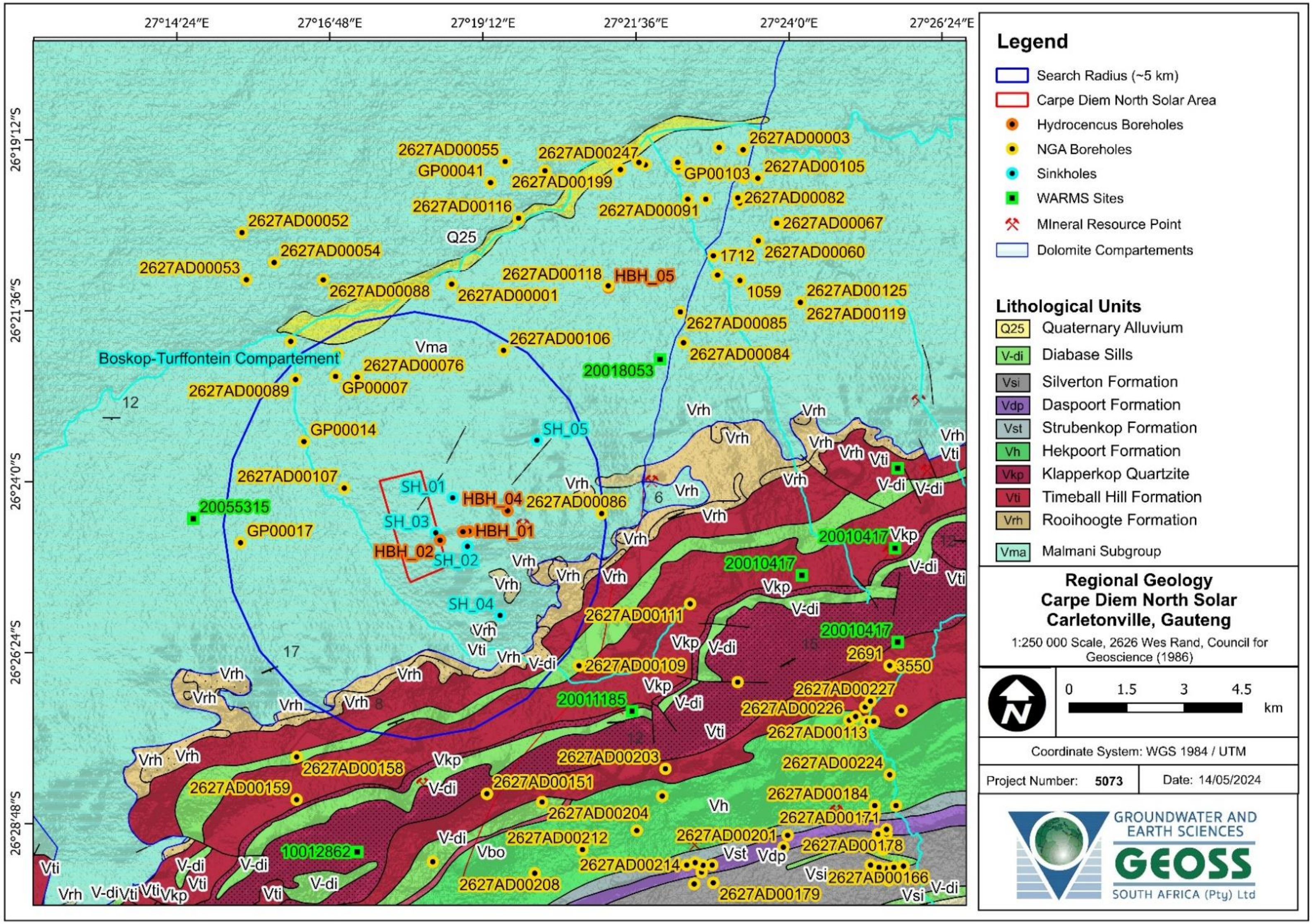
Overlying the Dolomites of the Malmani Subgroup, are the laterally discontinuous conglomeratic units of the Rooihoogte Formation of the Pretoria Group. Due to the undulating contact and variable internal facies relationships, it is believed that the Rooihoogte Formation was deposited within a deeply weathered karstic palaeotopography developed on the carbonates of the Chuniespoort Group (Eriksson et al, 2006; Van der Neut et al., 2012).

Located south of the project area, is a region of elevated topography which exposes nearly the entirety of the Pretoria Group. This includes units of interbedded mudstones, fine-grained sandstones, arkosic quartzite, subgreywacke and siltstones of the Timeball Hill and Boshoek formations, which are overlain by the andesitic lavas and pyroclastic flows of the Hekpoort Formation. The upper part of the Pretoria Group in the area is in turn, defined by interbedded shales and subordinate siltstone, thick quartzite units and interbedded shales and minor quartzite of the Strubenkop, Daspoort, and Silverton formations (Eriksson et al; Van der Neut et al., 2012).

Prominent features within the region are the north to south trending syenite dykes which stratigraphically transect the Transvaal Supergroup and older units. Theses dykes are typically between 6 and 60 meters thick and impervious to groundwater movement (Kleywegt and Enslin, 1973). These syenite dykes form the youngest non-Cenozoic units in the area, dated to 1 310 Ma, and are thought to be related to the intrusion of the Pilanesberg Alkaline Complex (Van Niekerk, 1962). The two dykes closest to the study area are named the Oberholzer and Bank dykes, and respectively define the western and eastern borders of the Oberholzer groundwater compartment (Van der Neut et al., 2012).

Finally, Cenozoic deposits within the area surrounding the proposed development include successions (50 - 100 m in thickness) of residual and transported soils derived from material of the Chuniespoort Group, coarse river alluvium associated with the Wonderfontein spruit to the north of the site, and locally developed ferricrete (Kleywegt and Pike, 1982; Van der Neut et al., 2012).

Structurally, the site lies on the southern limb of an east to west trending mega anticline, with sediments of the Pretoria Group to the south of the site generally dipping southwards at approximately 15 degrees. Furthermore, several northwest-southeast trending strike-slip and dip-slip fault structures are present within the Pretoria group sequence to the south of the proposed development (Council for Geoscience, 1986).



Map 4: Geological setting of Carpe Diem North Solar PV Facility, Carletonville (1:250 000 scale 2626 Wes Rand (CGS, 1987)).

5 Regional Hydrogeology

The aquifer yield and aquifer quality classifications are based on regional datasets, and therefore, only provide an indication of conditions to be expected. As detailed above, the geological setting of the study area is complex, with a multitude of lithologies. This complex geological setting is reflected in the geohydrology of the area. There are both primary porosity and secondary fractured bedrock aquifers within this area, with weathered shale clay layers present in some areas. As such, recharge rates and mechanisms are variable and groundwater flow paths and mechanisms also differ throughout the area. Geology, therefore, plays a major role controlling geohydrological conditions and for this reason, the groundwater response units do not conform to surface water catchment boundaries. In addition, the amount of groundwater inflow and outflow also needs to be taken into account when carrying out water balance equations for the area. The following section outlines some of the key geohydrological characteristics of the area.

5.1 Aquifer yield

The region around the Carpe Diem Solar PV Facility is located within quaternary attachment C23E of the Upper Vaal WMA and is shown to be underlain by two main aquifers according the Department of Water Affairs and Forestry (DWAF) 1:500 000 hydrological map, see **Map 5** (DWAF, 2000). The northern aquifer is classified by the DWAF as a **karst aquifer**, while the southern aquifer is classified as an **intergranular and fractured aquifer**. An intergranular aquifer is an aquifer where groundwater flows in spaces between grains or weathered rock, while a fractured aquifer is one where water flows in joints, fissures, cracks and fractures within the rock. A karstic aquifer is an aquifer where water flows through, and accumulates in cavities leached out of soluble limestone and dolomitic rocks. In the case of the Chuniespoort aquifer, Kleywegt and Enslin (1973) suggested that groundwater is specifically stored within the highly leached zones of the Chuniespoort Group dolomites which can extend between 50 to 200 meters below the water table. The northern karst aquifer is estimated to have a **borehole yield potential of more than 5.0 L/s**, while the southern intergranular and fractured aquifer is estimated to have a **borehole yield potential of 0.1 to 0.5 L/s**.

The karstic aquifer directly underlying the site effectively constitutes the main local hydrogeological aquifer of interest due to the high average borehole yield and proximity to the proposed development site. This aquifer is separated into multiple blocks by north to south trending impermeable syenite dykes which hydrologically isolate the blocks from each other (Kleywegt and Enslin, 1973; Van der Neut et al., 2012; Hobbs et al., 2013). This natural compartmentalisation of the aquifer has enabled the surrounding gold mines in the area to selectively dewater specific blocks in an effort to control groundwater ingress into the deeply developed mines (Van der Neut et al., 2012).

The Oberholzer and Boskop-Turffontein blocks constitutes the groundwater compartments present around the study area (**Map 4**). Of these, the Oberholzer block was previously highly productive in terms of groundwater as evidenced by springs such as the Oberholzer eye, which had a long term mean discharge of 55 ML/d. This eye has subsequently dried up due to extensive dewatering of the Oberholzer block from the late 1950s to present (Hobbs et al., 2013). According to Fleisher (1981), the mean groundwater abstraction for the Oberholzer block due to mining activities is approximately 19 million m^3 per annum (602.5 L/s). It is, however, important to note that compartments are only dewatered to match the amount of water entering the mine workings. The compartments are, as such, never completely dewatered (Van der Neut et al., 2012).

5.2 Aquifer quality

According to regional hydrogeological mapping (DWAF, 2000), the electrical conductivity of the groundwater in the area predominantly ranges between 0 and 300 mS/m, which is considered "**good to marginal**" in terms of drinking water standards. The quality notably degrades to a singular point towards the southwest, with electrical conductivities of 300 to more than 1000 mS/m, which is considered to be of "**marginal to poor**" quality (**Map 6**). Although the average EC values reported by DWA (2000) indicate generally good quality, standard deviations in values of elements such as sulphate, chloride, and nitrate suggest a distinct impact from poorer water sources on the karst aquifer (Hobbs et al., 2013). Furthermore, long term monitoring of the Gerhard Minnebron Eye indicates a continuously degrading water quality over the last four decades (Winder and Stoch, 2010). This deterioration has been directly attributed to long term groundwater pollution due to gold mining further upstream (DWAF, 2005).

Although the regional groundwater quality is currently considered marginal, unplanned or environmentally unsuitable mine closures in future could drastically decrease water quality to dangerous levels (Winder and Stoch, 2010).

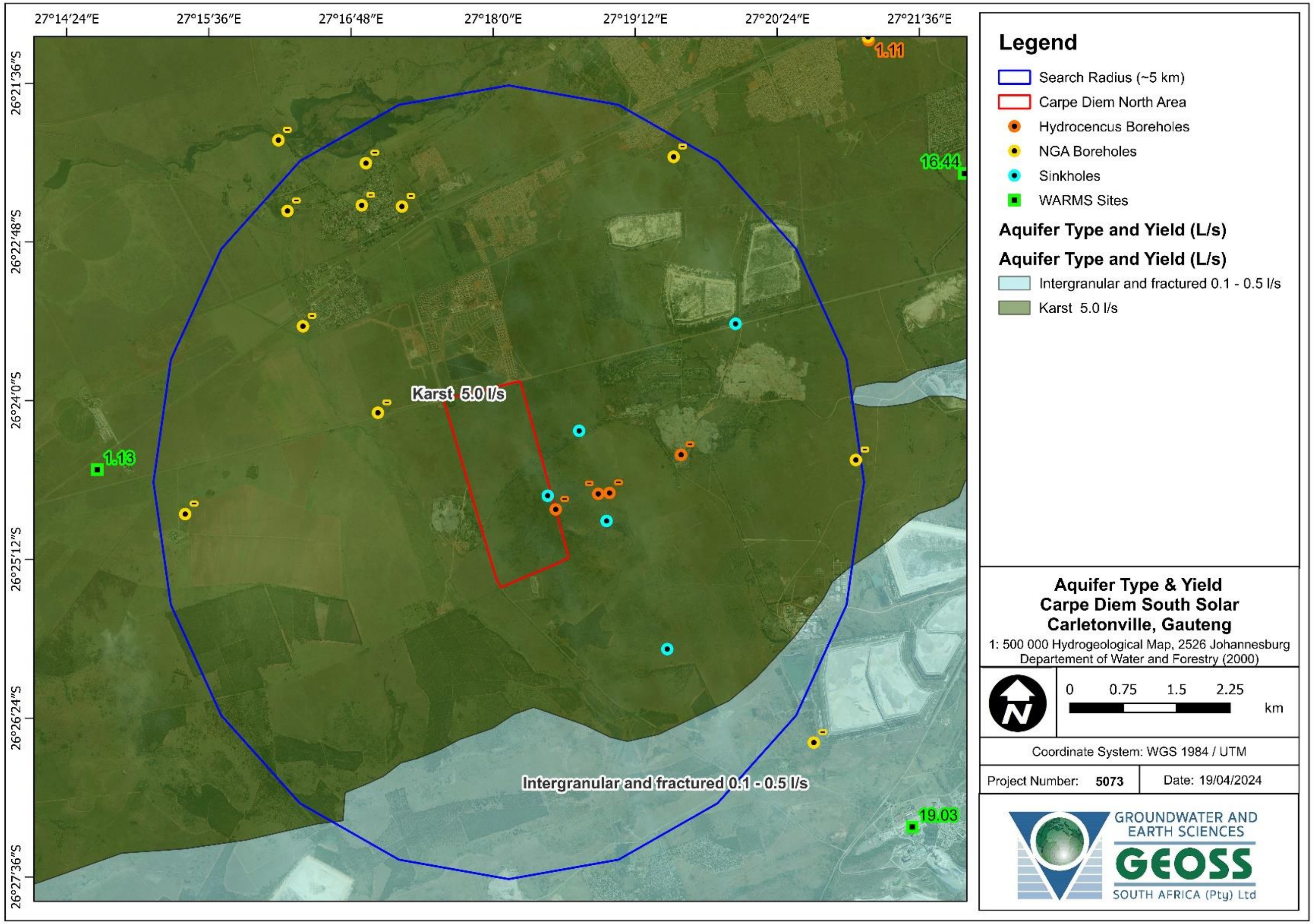
5.3 Aquifer vulnerability

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 farm property has a high vulnerability to surface-based contaminants (**Map 7**). The DRASTIC method takes into account the following factors:

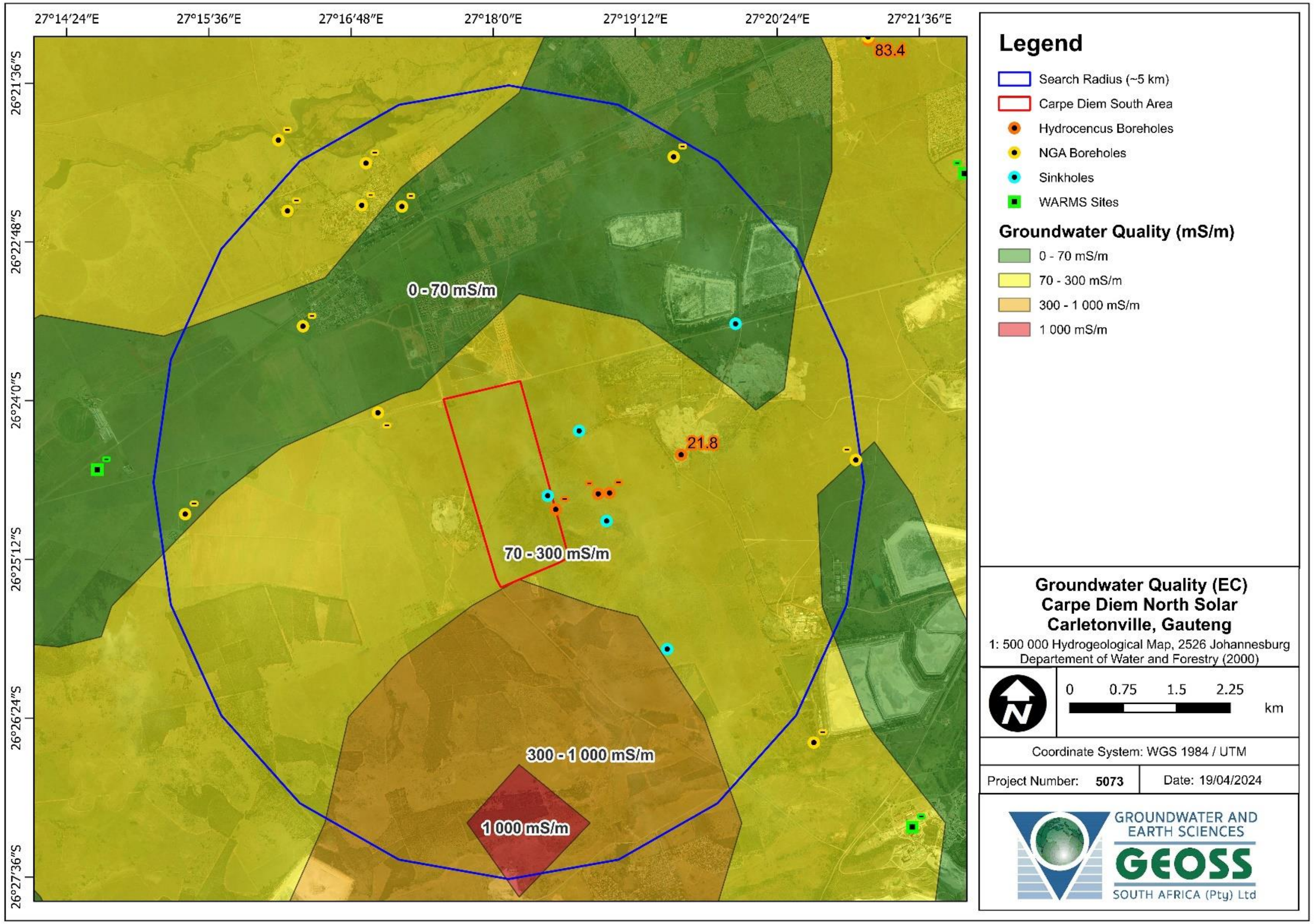
D	=	depth to groundwater	(5)
R	=	recharge	(4)
A	=	aquifer media	(3)
S	=	soil type	(2)
T	=	topography	(1)
I	=	impact of the vadose zone	(5)
C	=	conductivity (hydraulic)	(3)

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

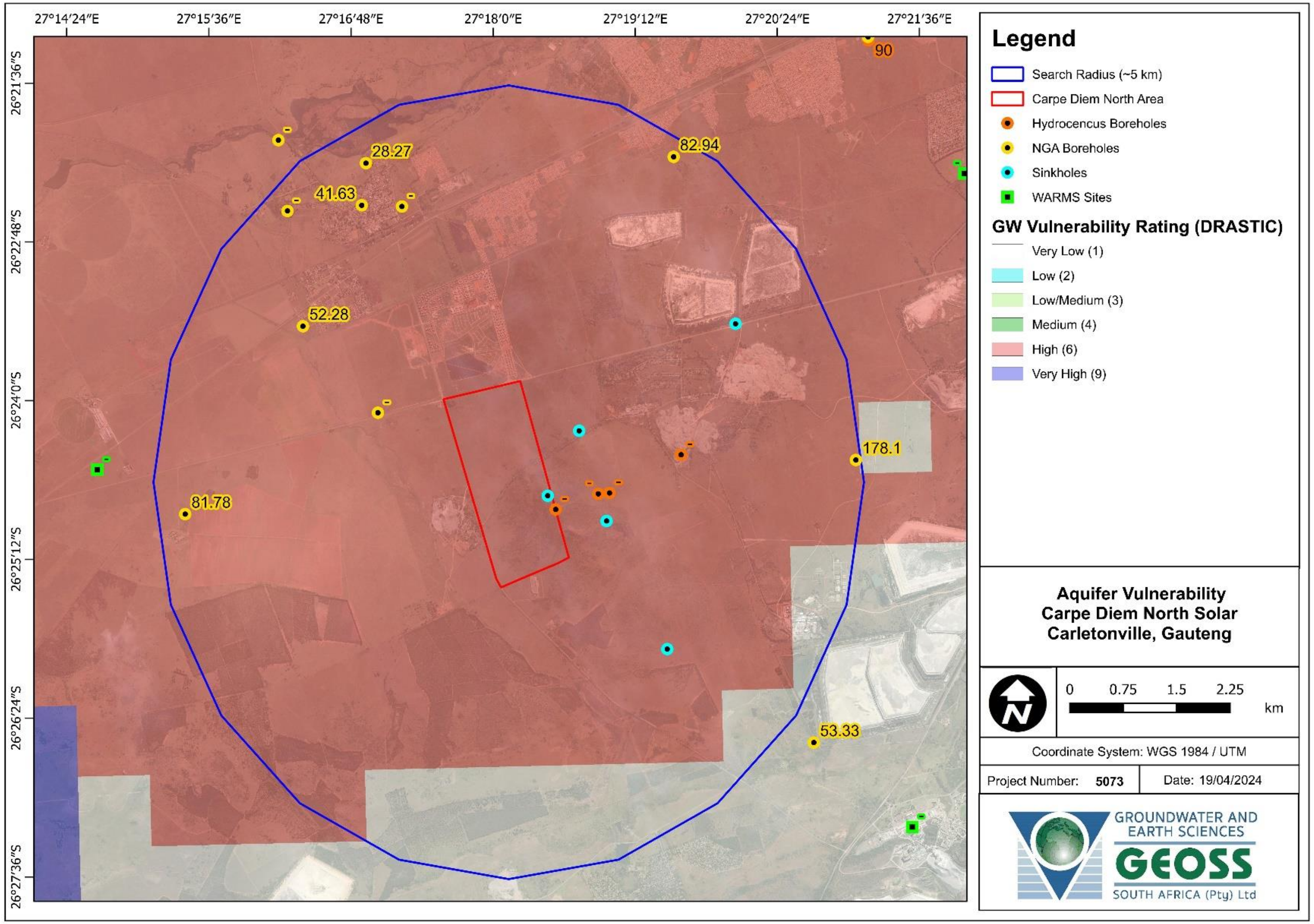
The site overlies an area delineated as "high" and is associated with the underlying geology consisting of a dolomitic karstic aquifer that can allow for easy infiltration and dispersion of pollutants throughout the aquifer. It is, however, important note that the regional water table has been artificially lowered by significant depths. A combination of the attenuation capacity of the overlying soils and a deep water table may offer some protection to contaminants entering the regional karstic aquifer. It is still advisable to monitor groundwater on site for early detection should such a case occur.



Map 5: Regional aquifer yield from the 1:50 000 scale groundwater map (2526_Johannesburg) (DWAF, 2000), of the study site with the property boundary with the hydrocensus, WARMS and NGA boreholes and borehole yields (L/s



Map 6: Regional groundwater quality (EC in mS/m) from (DWAF, 2000), of the study site with the property boundary with the hydrocensus, WARMS and NGA boreholes.



Map 7: Regional groundwater vulnerability for the study area showing the study site with the property boundary with the hydrocensus, WARMS and NGA boreholes and groundwater level depths (mbgl).

6 Volume and purpose of water use

The Carpe Diem North Solar Facility (remainder of Varkenslaagte 5/119) is located within Quaternary Catchment C23E, with the General Authorisation (GA) regarding groundwater abstraction demarcated as 0.00 m^3/ha. As such, although the total area of the farm is 257.75 ha, no groundwater can be abstracted under the General Authorisation. Since any new abstraction volume will exceed the GA limit amount, a groundwater use license will need to be granted by the Department of Water and Sanitation (DWS) if groundwater is to be extracted from the site.

The Carpe Diem North Solar facility has a planned cumulative water usage of 6 120 m^3/a (0.19 L/s) during the construction phase. During this phase, water will be used for construction of roads, hardstand compaction, concrete foundations, cleaning of equipment, and dust suppression on roads. The planned water usage decreases significantly during the operational phase to 1 800 m^3/a (0.06 L/s), and will be mostly used for staff ablutions and cleaning of solar panels.

At the stage of reporting, no boreholes on the property have been identified as the primary production borehole. As such, once a production borehole has been identified, the borehole will need to be correctly yield tested according to the National Standard (SANS 10299-4:2003, Part 4 – Test pumping of water boreholes) and the results used to determine the sustainable (i.e., long-term and safe) yield of the borehole.

7 Site Specific Information

7.1 Existing groundwater information

A desktop assessment was initially carried out within and around the study region (15 km radius) to determine if there were any groundwater users in the area. The NGA database provides data on borehole positions, groundwater chemistry and yield, where available. The NGA indicated there are 123 potential boreholes surrounding the study. A statistical summary of the data captured from the NGA website is given in **Table 3**. A detailed breakdown of the data points for each borehole is given in **Appendix I**. The accuracy of NGA borehole data requires validation prior to use, but does provide an indication of conditions that are to be anticipated for an area. The mean electrical conductivity (EC) measured for these boreholes is 71.2 mS/m, and values ranged between 36.1 – 116.0 mS/m, which falls within the ideal to marginal (0 – 300 mS/m) classification according to DWAF (2002). The depths of the boreholes in the region are shown to range between 10.0 m to 189.8 m, with a mean depth of 42.8 m. Water levels for the boreholes show a maximum depth of 178.1 m, and a minimum depth of 1.5 m with the mean water level at 17.5 m. A groundwater elevation map in meters above mean sea level (mamsl) was produced from the NGA water depth data, hydrocensus data, and water strike depths of geotechnical boreholes in the area (**Map 8**). Finally, blow yield values for several boreholes were recorded and showed a maximum yield of 10.00 L/s, and minimum of 0.10 L/s, and a mean of 0.8 L/s.

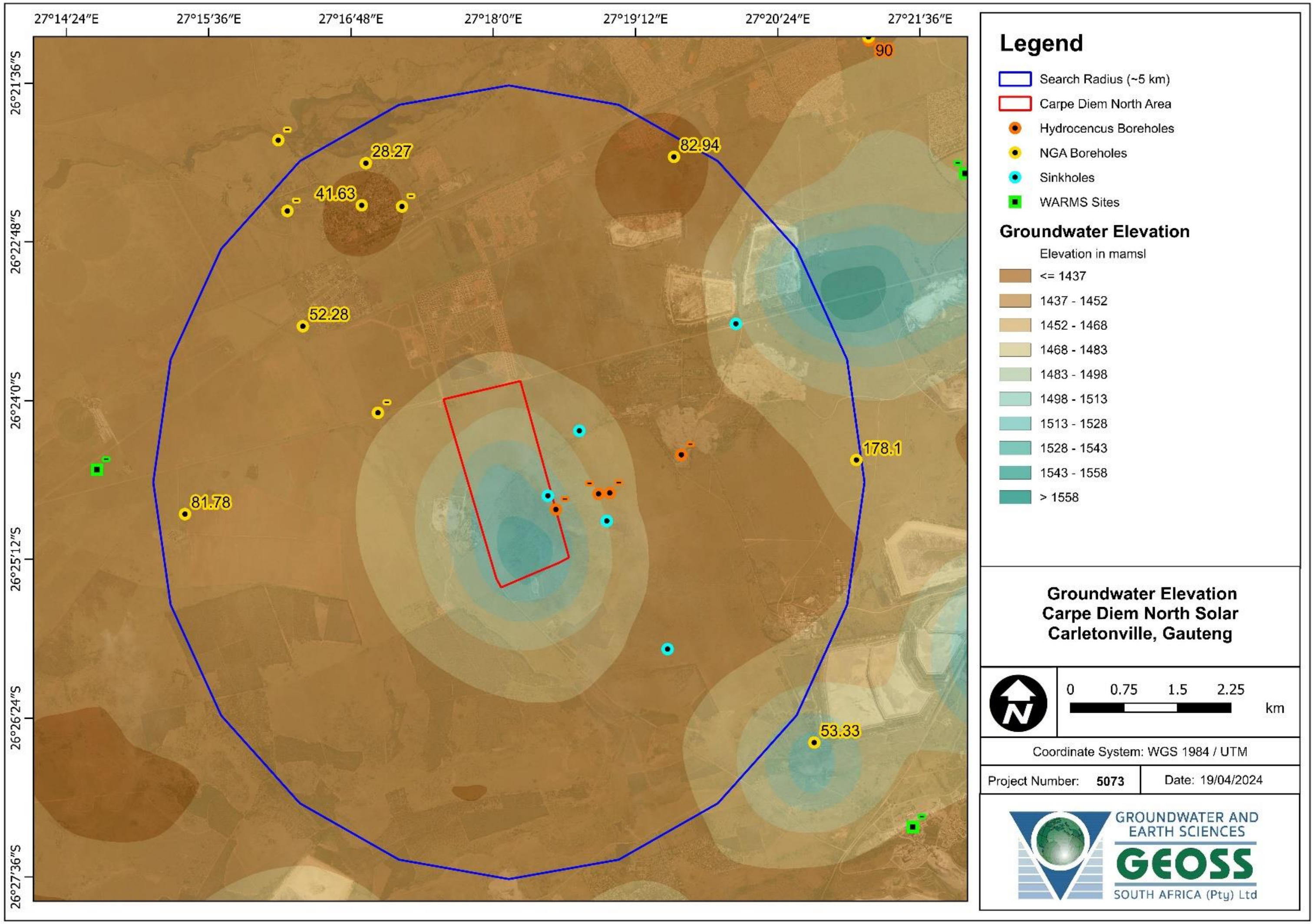
Table 3 Summary of NGA borehole details

Hydrocensus	Water level	pH	EC (mS/m)	Borehole Depth (m)	Total Blow Yield (l/s)
Maximum	178.1	7.8	116.0	189.8	10.0
Mean	17.5	7.3	71.2	42.8	0.8
Minimum	1.5	6.2	36.1	10.0	0.1
Range	176.6	1.6	79.9	179.8	9.9
Standard Deviation	29.9	0.5	22.4	28.4	2.4
Variance	895.6	0.3	503.3	806.6	5.6
n =	51	18	19	84	17

There are 15 registered groundwater abstraction points (WARMS sites) located in a 10 km boundary, which is also indicated on **Map 2** and **Map 3.** Only active and registered groundwater abstraction sites were included. The information for these sites are summarised in **Table 4.**

Table 4: Summary of WARMS borehole details.

WARMS no.	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Registered Volume (m^3/a)
20004870	-26.4661	27.45694	45 288
20010417	-26.4156	27.42775	1 500 000
20010417	-26.4219	27.40336	1 460 000
20010417	-26.4376	27.42844	250 000
20010417	-26.3969	27.42844	60 000
20011185	-26.4537	27.359	600 000
20025562	-26.3658	27.47333	21 535 000
20031369	-26.5171	27.35878	51 465
20031378	-26.5231	27.36356	55 480
20051113	-26.4778	27.47333	23 576 865
20055315	-26.4087	27.2443	35 736
10012862	-26.4866	27.28716	42 624
20011924	-26.5255	27.38022	55 480
20018053	-26.3714	27.36633	518 331



Map 8: Groundwater elevation map of study area

7.2 Hydrocensus

A representative hydrocensus was conducted from the 11th to 15th of March 2024 on the farm portions on which the Carletonville Solar Facility and Carpe Diem Solar Facilities are planned to be constructed as well as the surrounding properties where access was available (i.e., the study area). The hydrocensus boreholes are shown on **Map 2 and Map 3**. During the hydrocensus, data such as borehole depth, water level (WL), total dissolved solids (TDS) and electrical conductivity (EC) was measured. Due to the anomalously deep regional water table, there are very few accessible boreholes which could be measured. The parameters acquired from the tested boreholes are presented in **Table 5**.

Table 5: Public Participation and Hydrocensus borehole details.

Site Name	Latitude (DD, WGS84)	Longitude (DD, WGS84)	WL (mbgl)	Yield (L/s)	EC (mS/m)	Depth (m)	Comment
HBh_04 / SP_01	-26.406821	27.326461	-	-	-	-	Borehole constitutes a historic mineshaft currently being dewatered by the Covalent Water Company (CWC, a subsidiary of Anglo American.
HBh_05	-26.354591	27.3528562	90	1.1	640	100	Yields and borehole depth are based on conversations with owner. The borehole has yet to be correctly yield tested.

7.3 Groundwater Quality

Groundwater samples were collected from borehole HBh_05 as well as from a water outflow of HBh_04 on the neighbouring property. The samples were submitted for inorganic chemical analyses to a SANAS accredited laboratory (Vinlab) in the Western Cape. The certificate of analysis for the sample is presented in **Appendix IV.** The chemistry results obtained for the borehole have been classified according to the SANS241-1: 2015 standards for domestic water (**Table 6**). **Table 8** presents the water chemistry analysis results, colour coded according to the SANS241-1: 2015 drinking water assessment standards. Furthermore, a detailed groundwater quality assessment was performed for the Chuniespoort dolomites which comprise the aquifer underlying the study area as part of the 1:500 000 Hydrogeology Map of Johannesburg (2000). These results are discussed briefly along with results from the hydrocensus boreholes and presented in **Table 7** as a means to approximate the regional groundwater quality that can be expected at the Carpe Diem North Solar PV Site. Results from this historical study were classified according to the DWAF (1998) domestic water assessment standards, as a common point of reference.

Table 6: Classification table for specific limits

Acute Health	Chronic Health	Aesthetic	Operational	Acceptable

The limits and associated risks for domestic water as determined by the South African National Standards (SANS) 241:2015 are as follows, where:

- **Health risks:** parameters falling outside these limits may cause acute or chronic health problems in individuals.
- **Aesthetic risks:** parameters falling outside these limits indicate that water is visually, aromatically or palatably unacceptable.
- **Operational risks:** parameters falling outside these limits may indicate that operational procedures to ensure water quality standards are met may have failed.

The chemistry results obtained have been classified according to the DWAF (1998) standards for domestic water. **Table 7** enables an evaluation of the water quality with regards to the various parameters measured (DWAF, 1998). **Table 9** presents the water chemistry analysis results colour coded according to the DWAF drinking water assessment standards.

Table 7: 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.

Table 8: Production borehole results classified according to SANS241-1:2015

Analyses	HBh_05	HBh_04 / SP_01	SANS 241-1:2015
pH (at 25 ºC)	7.6	7.8	≥5 - ≤9.7 Operational
Conductivity (mS/m) (at 25 ºC)	83.4	21.8	≤170 Aesthetic
Total Dissolved Solids (mg/L)	565.45	147.80	≤1200 Aesthetic
Turbidity (NTU)	0.60	0.56	≤5 Aesthetic ≤1 Operational
Colour (mg/L as Pt)	10.61	10.61	≤15 Aesthetic
Sodium (mg/L as Na)	42	15	≤200 Aesthetic
Potassium (mg/L as K)	3	4	N/A
Magnesium (mg/L as Mg)	43	8	N/A
Calcium (mg/L as Ca)	78	19	N/A
Chloride (mg/L as Cl)	38.72	13.51	≤300 Aesthetic
Sulphate (mg/L as SO_4)	172.18	17.96	≤250 Aesthetic ≤500 Acute Health
Combined Nitrate & Nitrite Nitrogen (as a ratio)	0.29	0.14	≤1 Acute Health
Nitrate Nitrogen (mg/L as N)	2.71	0.71	≤11 Acute Health
Nitrite Nitrogen (mg/L as N)	0.04	0.07	≤0.9 Acute Health
Ammonia Nitrogen (mg/L as N)	0.11	0.11	≤1.5 Aesthetic
Total Alkalinity (mg/L as $CaCO_3$)	238.4	76.4	N/A
Total Hardness (mg/L as $CaCO_3$)	371.3	80.3	N/A
Fluoride (mg/L as F)	0.11	0.11	≤1.5 Chronic Health
Aluminium (mg/L as Al)	0.006	0.008	≤0.3 Operational
Total Chromium (mg/L as Cr)	0.008	0.003	≤0.05 Chronic Health
Manganese (mg/L as Mn)	<0.018	0.003	≤0.1 Aesthetic ≤0.4 Chronic Health
Iron (mg/L as Fe)	0.018	0.007	≤0.3 Aesthetic ≤2 Chronic Health
Nickel (mg/L as Ni)	0.006	0.006	≤0.07 Chronic Health
Copper (mg/L as Cu)	0.009	0.021	≤2 Chronic Health
Zinc (mg/L as Zn)	0.059	0.021	≤5 Aesthetic
Arsenic (mg/L as As)	0.007	0.007	≤0.01 Chronic Health
Selenium (mg/L as Se)	0.007	0.007	≤0.04 Chronic Health
Cadmium (mg/L as Cd)	0.001	0.001	≤0.003 Chronic Health
Antimony (mg/L as Sb)	0.009	0.009	≤0.02 Chronic Health
Mercury (mg/L as Hg)	0.003	0.001	≤0.006 Chronic Health
Lead (mg/L as Pb)	0.006	0.006	≤0.01 Chronic Health
Uranium (mg/L as U)	0.020	0.020	≤0.03 Chronic Health
Cyanide (mg/L as CN^-)	0.007	0.007	≤0.2 Acute Health
Total Organic Carbon (mg/L as C)	1.12	4.53	N/A
Charge balance %	-0.6	1.7	≥-5 - ≤5 Acceptable

Table 9: Classified potential borehole results according to DWAF 1998.

	Statistics drawn from 233 samples					Hydrocensus Boreholes		DWA (1998) Drinking Water Assessment Guide				
Analyses	**Min**	**Mean**	**Max**	**Std**	**CoV**	**HBh_05**	**SP_01**					
								Class 0	**Class I**	**Class II**	**Class III**	**Class IV**
pH	5.8	7.6	9.5	0.4	5%	7.6	7.8	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)	4.4	62.9	397	56	89%	83.4	21.8	<70	70-150	150-370	370-520	>520
Turbidity (NTU)	-	-	-	-	-	0.6	0.56	<0.1	0.1-1	1.0-20	20-50	>50
	mg/L											
Total Dissolved Solids	43.1	443.6	3402	403	91%	565.45	147.8	<450	450-1000	1000-2400	2400-3400	>3400
Sodium (as Na)	1	24.1	299	39	162%	42	15	<100	100-200	200-400	400-1000	>1000
Potassium (as K)	0.1	2.3	39	4.2	183%	3	4	<25	25-50	50-100	100-500	>500
Magnesium (as Mg)	1	35.4	223	31	88%	43	8	<70	70-100	100-200	200-400	>400
Calcium (as Ca)	1	52.7	436	54	102%	78	19	<80	80-150	150-300	>300	
Chloride (as Cl)	1	37.7	900	83	220%	38.72	13.51	<100	100-200	200-600	600-1200	>1200
Sulphate (as SO_4)	1	70.5	2172	233	330%	172.18	17.96	<200	200-400	400-600	600-1000	>1000
Nitrate& Nitrite (as a ratio)	0.1	5.6	122	12.1	216%	0.29	0.14	<6	6.0-10	10.0-20	20-40	>40
Fluoride (as F)	0.1	0.3	2.8	0.4	133%	0.11	0.11	<0.7	0.7-1.0	1.0-1.5	1.5-3.5	>3.5
Manganese (as Mn)	-	-	-	-	-	<0.018	0.003	<0.1	0.1-0.4	0.4-4	4.0-10.0	>10
Iron (as Fe)	-	-	-	-	-	0.018	0.007	<0.5	0.5-1.0	1.0-5.0	5.0-10.0	>10
Copper (as Cu)	-	-	-	-	-	0.009	0.021	<1	1-1.3	1.3-2	2.0-15	>15
Zinc (as Zn)	-	-	-	-	-	0.059	0.021	<20	>20			
Arsenic (as As)	-	-	-	-	-	0.007	0.007	<0.010	0.01-0.05	0.05-0.2	0.2-2.0	>2.0
Cadmium (as Cd)	-	-	-	-	-	0.001	0.001	<0.003	0.003-0.005	0.005-0.020	0.020-0.050	>0.050
Hardness (as $CaCO_3$)	8	177.3	664	94	53%	371.3	80.3	<200	200-300	300-600	>600	
Charge Balance %	-	-	-	-	-	-0.6	1.7	≥-5 - ≤5 Acceptable				

Analysis results from previous assessments undertaken within the Upper Vaal WMA (Hobbs et al., 2013) are presented on a tri-linear diagram known as a Piper diagram along with the results from this project's hydrocensus (**Figure 3**). This diagram indicates the distribution of cations and anions in separate triangles and then a combination of the chemistry in the central diamond. From the figure (central diamond), it is evident that the samples of the Oberholzer Block (catchment C23E) and Turffontein Block (catchment C23G) reflect the Ca-Mg-HCO_3 composition of the dolomitic groundwater. Furthermore, the data from C23E shows a stronger Ca-SO_4 signature, which is typically more associated with polluted mine water, likely due to the leaching/oxidation of newly exposed sulfide-bearing minerals. Samples collected during this project's hydrocensus generally reflect the same chemistry of the Turffontein Block, with only the sample from HBh-04 (SP-01) being more enriched in Na+K-HCO_3 than typical Turffontein block chemistry.

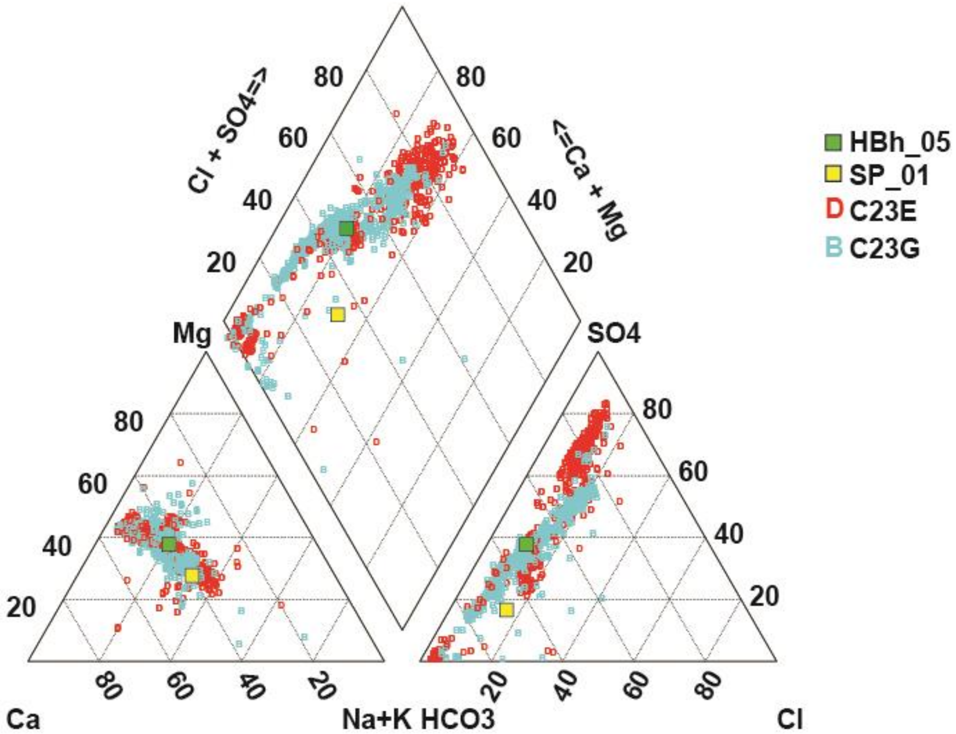


Figure 3 Piper diagram showing representative groundwater chemistry in the region (after Hobbs et al., 2013) along with chemistry from hydrocensus boreholes. Note red symbols denote values from the Oberholzer Block and blue symbols represent values from the Turffontein Block

Stiff Diagrams were used to graphically represent the relative concentrations of the cations (positive ions) and anions (negative ions) (**Figure 4**). 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 presented below, it can be inferred that the general geometries of samples HBh_05 and SP_01 are similar, with the geometry defined by relatively elevated calcium cations and alkalinity. However, the relative concentrations of the ions are quite different between samples, with HBh_05 showing a significantly higher concentrations of ions as opposed to SP_01.

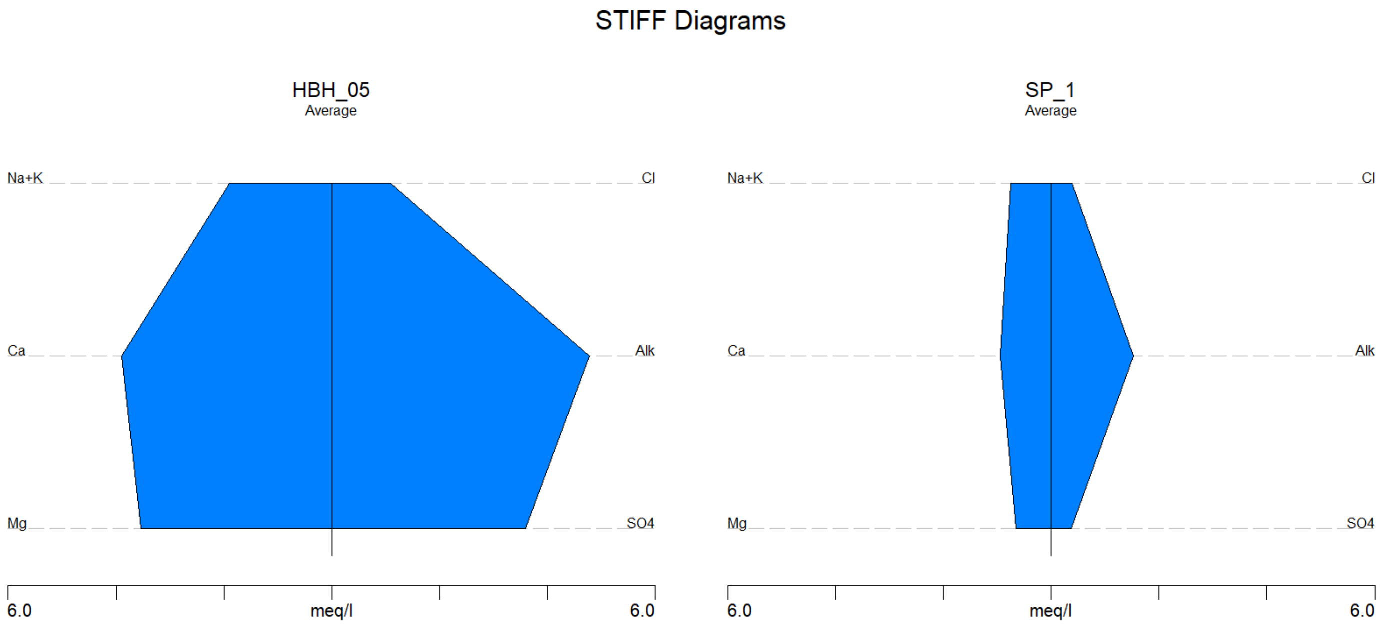


Figure 4: Stiff diagram of the groundwater samples.

From the chemical results presented in **Table 8** and **Table 9**, groundwater from both samples hydrocensus sites (HBh_05 and HBh_04/SP_01) is of good quality for irrigation and potable use and generally reflect the mean parameter values for the Chuniespoort dolomites. The hardness and TDS concentration of HBh_05 is elevated to Class II and Class I, respectively according to the DWAF 1998 domestic water standard. Thus, the water should be treated prior to consumption. The hardness might also have an effect of carbonate precipitation on solar panels should it be used for cleaning purposes. These values compare well with results from Barnard (2000) which indicate that on average, groundwater derived from the Chuniespoort dolomites can be considered of ideal quality. It should, however, be noted that from the maximum values for the parameters analyses, only the pH, potassium, and sodium contents were considered still acceptable without treatment. All other parameters showed maximum potential values that indicated poor to dangerous water quality. Water quality is, therefore, highly variable within this unit.

8 Aquifer Firm Yield Model

To evaluate the sustainable volume of groundwater that can be abstracted from the aquifer for the property, the Aquifer Firm Yield Model (AFYM) was utilised (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 5**.

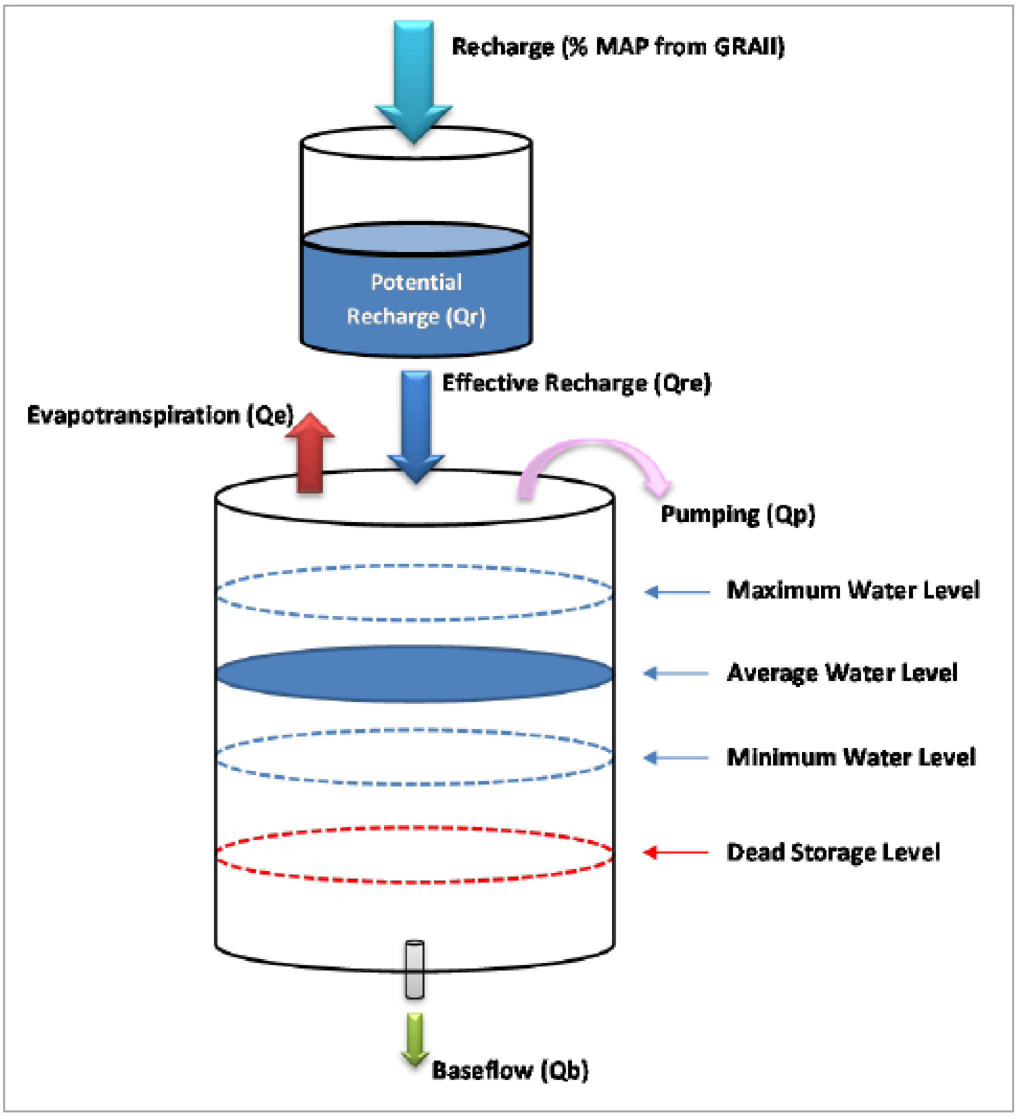


Figure 5: Aquifer Firm Yield lumped box model (WRC, 2012).

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 study (2012) (e.g., recharge threshold and riparian zone (% catchment area)).

Although no production boreholes have been identified at the time of report compilation, any potential boreholes will likely be drilled into the underlying dolomites of the Malmani Subgroup, which represent a high yielding karstic aquifer within catchment C23E. The aquifer in question is recharged through direct vertical recharge within catchment C23E. It is important to note that catchment C23E is bisected by several large dykes which effectively separate the karstic aquifer into several distinct geohydrological blocks. In the case of natural groundwater flow, these blocks are not interconnected and should be treated as completely separate groundwater units. The parameters for Quaternary Catchment C23E, with an area of 849.9 km^2 are presented in **Table 10.**

Table 10: Hydrogeological Parameters for Quaternary Catchment C23E (WRC, 2012).

Parameter	C23E
Groundwater Level (mbgl)	36.4
Max Drawdown (m)	5
Specific Yield	0.033365
Firm Yield (L/s)	485.7
Firm Yield (L/s/km^2)	0.5715
Recharge %	6.2
Recharge Threshold (mm)	53
MAP (mm)	630.6
Hydrological MAR (mm)	25.9
Hydrological MAE (mm)	1675
Baseflow: Default (Mm^3/a)	7.45
ET Model	Linear
ET Extinction Depth (m)	4
Riparian Zone (%)	2.3

The Aquifer Firm Yield Model was run for the catchment C23E and the Aquifer Firm Yield was determined to be 15 327 526 m^3/a (485.70 L/s) with a recharge of 33 228 710 m^3/a. The results of the Aquifer Firm Yield Model for Quaternary Catchment C23E are presented in **Table 11.**

Table 11: Results of the Aquifer Firm Yield Model for Quaternary Catchment C23E

Name	Q (L/s)	Q (m^3/month)	Q (m^3/a)
C23E	485.7	1 258 934.4	15 327 526.32

For this study area, there are geological features that enable the definition of a more localised aquifer (i.e., a groundwater resource unit (GRU)). The potential boreholes surrounding the property as well as any new boreholes that will be drilled on the property are drilled through intergranular sands and gravels of Cenozoic alluvial deposits into the underlying karstic aquifer hosted within the dolomites of the Malmani Subgroup. The Malmani Subgroup within the area represents the southern limb of a large anticlinal structure, which is underlain by the metasediments of the Witwatersrand Group, and outcrop further north of the study site. The Malmani Subgroup is overlain by metasedimentary rocks of the Pretoria Group which outcrop south of the site and have a shallow southerly dip direction.

Still further south, competent quartzitic units of the Pretoria Group formed a regional east-west trending ridge, which defines a regional watershed and the southern extent of catchment C23E. To the north of the site lies the west flowing Wonderfonteinspruit river, which has historically been fed by several groundwater springs further upstream. Finally, the north-south trending Oberholzer dyke acts as vertical impermeable barriers to groundwater flow, effectively compartmentalising the aquifer. As such, the underlying Boskop-Turffontein Dolomite compartment was used as the basis for delineating the extent of the Boskop-Turffontein (BT) GRU.

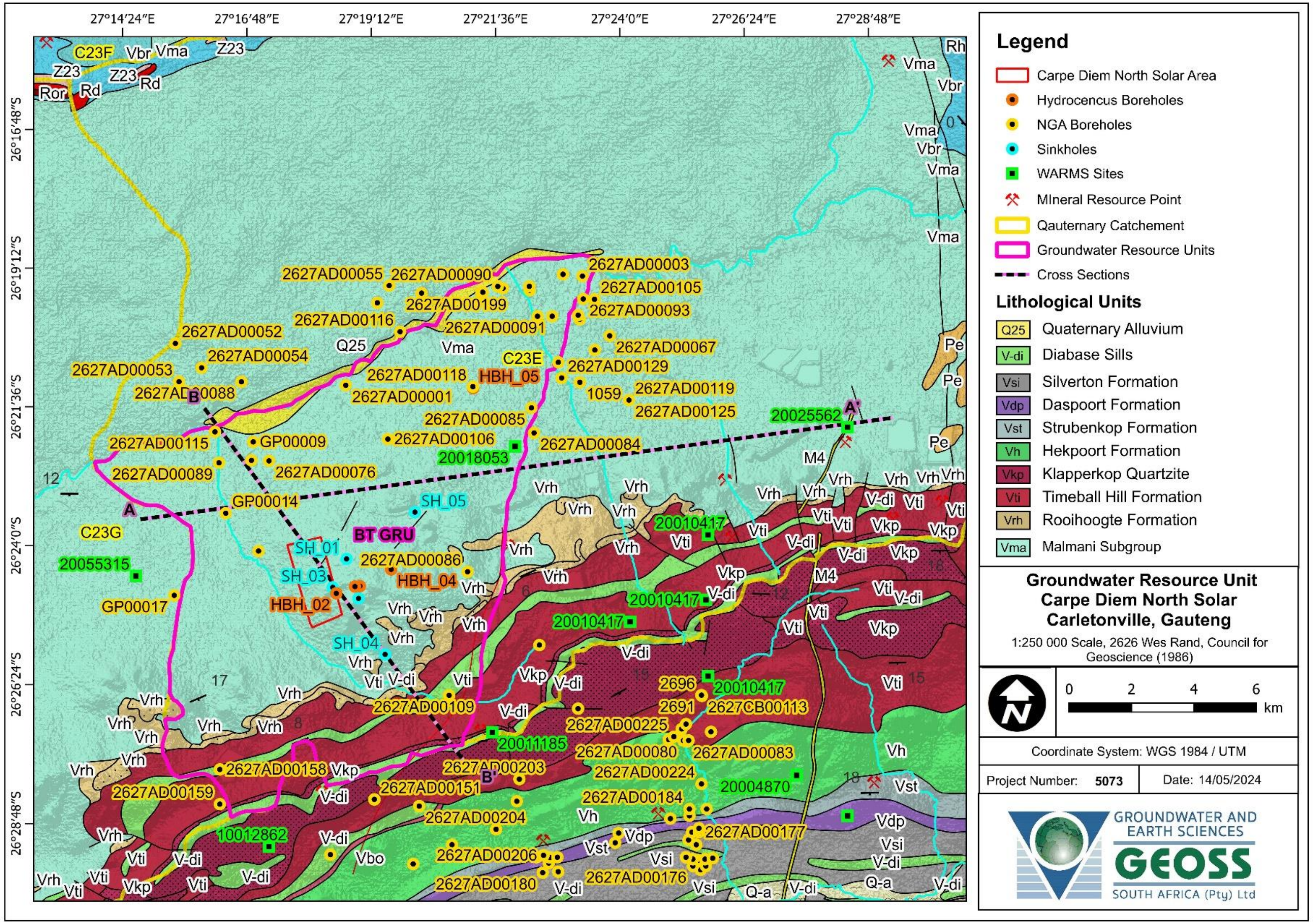
Following this, the southern extent of the BT GRU was delineated using the east-west trending ridge to the south of the site, whilst the northern extent of the GRU is delineated by the Wonderfonteinspruit. The Oberholzer Dyke were used to define the eastern extent of the BT GRU, and the western boundary of Catchment C23E was used to define the western extent of the BT GRU. The GRU is displayed in **Map 9** and **Figure 6** with **Figure 7** depicting schematic cross-sections of the geology.

On the assessment of the geological map, the BT GRU has an extent of approximately 147.8 km^2. Using the GRAII recharge values the direct vertical recharge (minimum recharge volume) is calculated to be 5 779 733.2 m^3/a for the BT GRU and the Firm Yield is calculated to be 2 666 038.3 m^3/a.

Based on the registered WARMS boreholes (database last updated January 2021), the current volume of groundwater abstracted within the BT GRU is 518 331 m^3/a. Note that only registered and active sites were taken into account. Based on these volumes, a volume of 2 147 707.28 m^3/a (2 666 038.3 m^3/a – 518 331.00 m^3/a) is available within the BT GRU.

The additional volume of 6 120.00 m^3/a for which a license is being applied, is much less than the volume of 2 147 707.28 m^3/a available within the firm yield of the BT GRU. Because the firm yield of the BT GRU is in excess of the predicted water demand of the property, the license application volume is considered to be within the sustainable supply volume of the aquifer.

GRU BT (147.8 km^2)	Total recharge = 5 779 733.2 m^3/a
	Total firm yield = 2 666 038.3 m^3/a
	Authorised existing abstraction (from WARMS 2021) = 518 331 m^3/a
	Available groundwater = 2 147 707.28 m^3/a (excluding lateral recharge)
	Requested additional groundwater use = 6 120.00 m^3/a
	Is there sufficient groundwater for this application? YES



Map 9: GRU, property boundaries with the existing, recently drilled, production, hydrocensus, NGA and WARMS boreholes superimposed on the regional geology map

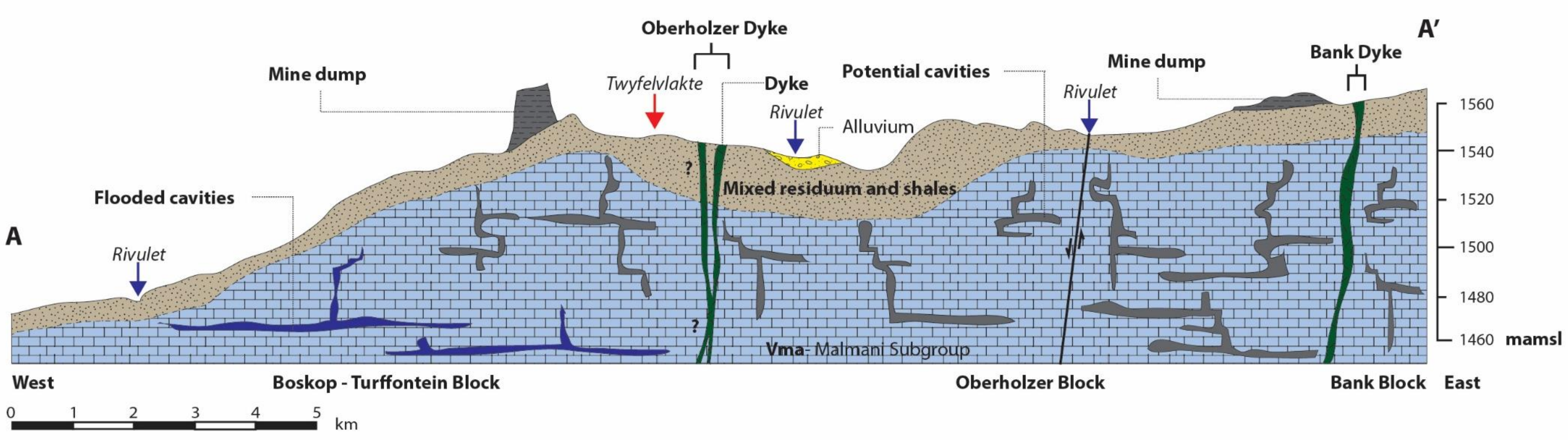


Figure 6: A schematic and conceptual east to west geological cross-section.

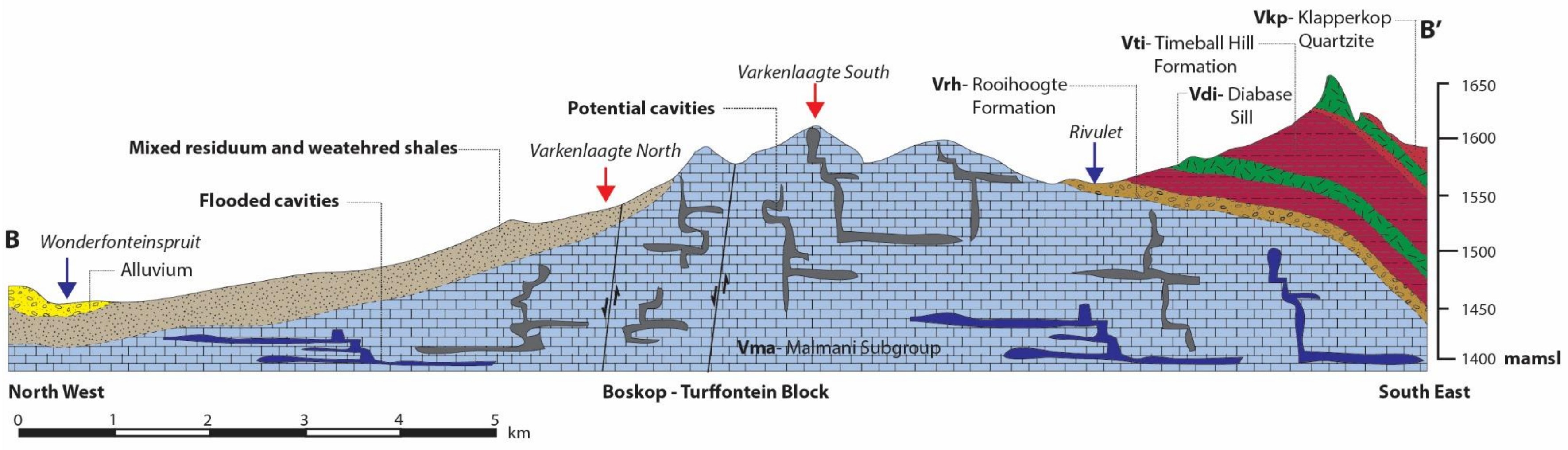


Figure 7: A schematic and conceptual north to-south geological cross-section.

9 Risk Assessment and Matrix

The risk assessment includes identifying and rating the potential risks associated with the groundwater abstraction and use for Carpe Diem North South Solar and any proposed mitigation measures where possible. The groundwater will be used for the irrigation of crops and domestic use.

Each risk is qualitatively assessed based on the information currently available. The risk rating is conducted in accordance with the criteria in **Appendix II.**

The risk assessment relates only to groundwater abstraction and potential contamination through facility activities during the construction and operational phases. These will be discussed separately below.

9.1 Impact on groundwater quality due to accidental oil spillage / fuel leakage

During the construction phase, accidental oil spillages or fuel leakages can detrimentally impact the regional groundwater quality. Considering the regional water table depth and thickness of the overlying Quaternary aged cover, should an accidental oil spill or fuel leakage occur during the construction phase, then the low permeability of the unsaturated zone will provide significant attenuation capacity. As such, the overall impact of this risk is considered as low.

A precautionary approach must, however, be implemented and reasonable measures must be undertaken to prevent oil spillages and fuel leakages from occurring during the construction phase:

1. Vehicles must regularly be serviced and maintained to check and ensure there are no leakages. A designated area should be established at the construction site camp for this purpose.
2. Any engines that stand in one place for an excessive length of time must have drip trays.
3. Diesel fuel storage tanks should be placed above ground on an impermeable concrete surface in a bunded area.
4. Construction vehicles and equipment should also be refuelled on an impermeable surface. A designated area should be established at the construction site camp for this purpose, if off-site refuelling is not possible.
5. If spillages occur, they should be contained and removed as rapidly as possible, with correct disposal procedures of the spilled material, and reported.
6. Proof of disposal (waste disposal slips or waybills) should be obtained and retained on file for auditing purposes.

Potential impact on groundwater quality due to accidental oil spillage / fuel leakage		
Impact	**Description**	
Nature of Impact	Negative	
Type of impact	**Description**	
Direct	Accidental oil spillage / fuel leakage associated with construction can result in contaminated groundwater and surrounding environment.	
Recommended mitigation measures	**Description**	
Impact avoidance/ Prevention/ Mitigation	Vehicles must be regularly serviced and maintained to check and ensure there are no leakages. Any engines that stand in one place for an excessive length of time must have drip trays. Diesel fuel storage tanks, if required, should be placed above ground on an impermeable surface in a bunded area. Vehicles and equipment should also be refuelled on an impermeable surface. A designated area should be established at the construction site camp for this purpose, if off-site refuelling is not possible. If spillages occur, they should be contained and removed as rapidly as possible, with correct disposal procedures of the spilled material, and reported. Proof of disposal (waste disposal slips or waybills) should be obtained and retained on file for auditing purposes	
Impact minimization	Impact can be minimized if an appropriate management plan at the construction camp is implemented with the above-mentioned procedures	
Rehabilitation/ restoration/ repair	Use appropriate and published aquifer scrubbing methods associated with a detailed monitoring program	
Degree to which the impact can be mitigated	High	
Degree to which the impact can be reversed	High	
Degree to which the impact may cause irreplaceable loss of resources	Low	
Assessment of impact	**Rating before mitigation**	**Rating after mitigation**
Extent of impact	Local	Site specific
Duration of impact	Long term >15 years but <30 years	Short term 0 – 5 years (with mitigation)
Intensity of impact	Low	Low
Probability of occurrence	Likely	Improbable
Level of confidence in prediction	Medium	Medium
Significance	Moderate	Low
Confidence	Medium	Medium

9.2 Impact on groundwater quality due to leakages from BESS

The proposed development will require a Battery Energy Storage System (BESS) at the facility. There are usually electrolytes of an environmentally harmful chemical composition that are used within the BESS, especially for Redox Flow BESS (whereas Lithium Ion BESS are solid state containerized systems). With any chemical storage, there is always a risk of contamination to soils and groundwater. It is, therefore, recommended that all BESS's are placed a minimum distance of 50 m from any borehole and placement should include effective bunding and secondary containment structures. With adherence to the proposed mitigation measures, the significance of this impact would be considered very low.

Potential impact on groundwater quality due to leakages from BESS		
Impact	**Description**	
Nature of Impact	Negative	
Type of impact	**Description**	
Direct	Chemical leakages from the BESS may lead to contamination of the groundwater resource	
Recommended mitigation measures	**Description**	
Impact avoidance/ Prevention/ Mitigation	Ensure that all electrolyte or chemicals stored or used on site have secondary containment systems in place with reliable leak detection, annunciation in place. Ensure that all chemicals are handled on concrete bunded surfaces and not on bare soil. Any waste products produced from the BESS systems should be removed and disposed of appropriately. Waste water produced by fire hydrants should not be allowed to runoff into the environment. It is recommended that all BESS's are placed a minimum of 50 m from any borehole.	
Impact minimization	Impact can be minimized if an appropriate management plan for the BESS is implemented with the above-mentioned procedures	
Rehabilitation/ restoration/ repair	Use appropriate and published aquifer scrubbing methods associated with a detailed monitoring program	
Degree to which the impact can be mitigated	High	
Degree to which the impact can be reversed	High	
Degree to which the impact may cause irreplaceable loss of resources	Low	
Assessment of impact	**Rating before mitigation**	**Rating after mitigation**
Extent of impact	Local	Site specific
Duration of impact	Long term >15 years but <30 years	Short term 0 – 5 years (with mitigation)
Intensity of impact	Medium	Low
Probability of occurrence	Likely	Improbable
Level of confidence in prediction	Medium	Medium
Significance	Moderate	Very Low
Confidence	Medium	Medium

9.3 Impact on groundwater quality due to leakages from cleaning of solar panels

For solar panels to function optimally, the solar panels will need to be cleaned. It is understood that cleaning agents may be required for cleaning of solar panels; should this be the case, biodegradable and/or environmentally friendly agents should be used to reduce/minimise the impact of solar panel cleaning on the quality of the regional/local groundwater quality. To ensure that any harmful chemicals are detected, an appropriate groundwater monitoring program should be instated. If harmful chemicals are detected, the services of a specialist subconsultant should be sought to remediate contamination of the groundwater.

Potential impact on groundwater quality due to leakages from cleaning of solar panels		
Impact	**Description**	
Nature of Impact	Negative	
Type of impact	**Description**	
Direct	Chemicals used for washing solar panels may lead to contamination of the groundwater resource	
Recommended mitigation measures	**Description**	
Impact avoidance/ Prevention/ Mitigation	Use environmentally safe cleaning agents that breakdown naturally and do not cause adverse effects.	
Impact minimization	Impact can be minimized if an appropriate management plan for the facility is implemented with the above-mentioned procedures	
Rehabilitation/ restoration/ repair	Use appropriate and published aquifer scrubbing methods associated with a detailed monitoring program	
Degree to which the impact can be mitigated	High	
Degree to which the impact can be reversed	High	
Degree to which the impact may cause irreplaceable loss of resources	Low	
Assessment of impact	**Rating before mitigation**	**Rating after mitigation**
Extent of impact	Local	Site specific
Duration of impact	Long term >15 years but <30 years	Short term 0 – 5 years (with mitigation)
Intensity of impact	Low	Low
Probability of occurrence	Improbable	Improbable
Level of confidence in prediction	Medium	Medium
Significance	Low	Very Low
Confidence	Medium	Medium

9.4 Impact on groundwater resource as a result of over abstraction

Water use for the facility has been estimated at a cumulative 6 120 m^3/a (0.19 L/s) during the construction phase and 1 800 m^3/a (0.06 L/s). for the operational phase for the Carpe Diem North Solar PV Facility. These requirements are well below the average yield potential of single boreholes within the underlying aquifer (>5 L/s). Considering this, it is possible that both the construction and operation requirements of the project can be serviced from a single production borehole.

Considering the average yield of 1.68 L/s derived from the NGA data obtained in the region, a single borehole would be required to meet the Construction Phase water demands for the Carpe Diem North Solar PV Project. Based on information collected from the NGA database (**Appendix I**), there are 124 boreholes in the immediate area of the Carpe Diem North Solar PV project. Furthermore, the current groundwater extraction from mining operations in the region total approximately 836.2 L/s. Therefore, it is believed that the impact of this facility on its own on the groundwater availability is low/insignificant, since there is a much higher volume being currently abstracted. Presently, the boreholes in the area are used for multiple purposes, as the aquifer in the region has been developed for irrigation, domestic, mining, and municipal/industrial water supply purposes. Some of these groundwater users are not registered on the NGA or WARMS databases and, therefore, the actual groundwater abstraction in the region is likely higher than stated above. Although the impact of groundwater abstraction for the Carpe Diem North Solar Facility is considered to be low in comparison to the region, it should be noted that abstraction in the Oberholzer compartment is already higher than the actual recharge of the resource. Considering this, any further abstraction in this compartment, even if it is comparatively little, is ill-advised.

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.

Potential impact on groundwater due to over abstraction		
Impact	**Description**	
Nature of Impact	Negative	
Type of impact	**Description**	
Direct	Over abstraction of the aquifer may results in decrease of water table levels	
Recommended mitigation measures	**Description**	
Impact avoidance/ Prevention/ Mitigation	Adhere to the borehole's safe yield and to monitor water levels and flow. Boreholes must be correctly yield tested according to the National Standard (SANS 10299-4:2003, Part 4 – Test pumping of water boreholes). This includes a Step Test, Constant Discharge Test and recovery monitoring Monitoring information must be assessed regularly (suggested monthly in winter). If the water level drops below 15 meters of drawdown, 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 15-meter drawdown 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 minimization	Impact can be minimized if abstraction adheres to the safe yield values established for the boreholes and water levels are closely monitored.	
Rehabilitation/ restoration/ repair	Stop water abstraction process for the duration in which it takes for the aquifer to recover	
Degree to which the impact can be mitigated	High	
Degree to which the impact can be reversed	High	
Degree to which the impact may cause irreplaceable loss of resources	Low	
Assessment of impact	**Rating before mitigation**	**Rating after mitigation**
Extent of impact	Local	Site specific
Duration of impact	Short term 0 – 5 years	Short term 0 – 5 years (with mitigation)
Intensity of impact	Low	Low
Probability of occurrence	Improbable	Improbable
Level of confidence in prediction	Medium	Medium
Significance	Low	Very Low
Confidence	Medium	Medium

9.5 Geotechnical impact as a result of groundwater abstraction

Considering the presence of dolomitic terrain across the site, drawdown of the water table underlying the site may result in sinkhole formation. Considering the low groundwater abstraction amounts envisioned for the property, the potential environmental significance is considered low with the proposed mitigation methods (**Table 12**). This is, however, wholly conditional on the actual conditions present on-site and a Dolomite Hazard Assessment in line with the **Proposed Method for Dolomite Land Hazard and Risk Assessment in South Africa**" by Buttrick, Van Schalkwyk, Kleywegt and Watermeyer, Volume 43, Number 2, dated 2001.

Table 12: Scoping level Impact table surmising potential impacts and recommended mitigation measures for geotechnical instability due to over abstraction

Potential impact on geotechnical stability due to over abstraction		
Impact	**Description**	
Nature of Impact	Negative	
Type of impact	**Description**	
Indirect	Abstraction of the groundwater can destabilise the geotechnical environment and can result in sinkhole formation.	
Recommended mitigation measures	**Description**	
Impact avoidance/ Prevention/ Mitigation	Adhere to the borehole's safe yield and to monitor water levels and flow. Boreholes must be correctly yield tested according to the National Standard (SANS 10299-4:2003, Part 4 – Test pumping of water boreholes). This includes a Step Test, Constant Discharge Test and recovery monitoring The region should be assessed according to the Proposed Method for Dolomite Land Hazard and Risk Assessment in South Africa" by Buttrick, Van Schalkwyk, Kleywegt and Watermeyer, Volume 43, Number 2, dated 2001 in order to accurately confirm the geotechnical conditions underlying the site.	
Impact minimization	Impact can be minimized if an appropriate assessment as mentioned above are followed and the recommendations therein adhered to.	
Rehabilitation/ restoration/ repair	Refilling and stabilisation of developed sinkholes.	
Degree to which the impact can be mitigated	High	
Assessment of impact	**Rating before mitigation**	**Rating after mitigation**
Duration	Permanent (5)	Permanent (5)
Spatial Extent	Site Specific (1)	Site Specific (1)
Intensity of impact	Very High (10)	Very High (10)
Probability of occurrence	Medium probable (3)	Improbable (1)
Reversibility	Low potential for reversibility (4)	Low potential for reversibility (4)
Irreplaceability	High (4)	High (4)
Cumulative Impact	Medium	Low
Environmental Significance	Moderate (72)	Low (24)

9.6 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 is in the range of 70 -300 mS/m around the proposed Carpe Diem North Solar Facility. The EC of the nearby boreholes does fall within the expected range and is seen as “good quality” for the area.

The water quality surrounding the study area varies only slightly, with regional datasets placing the groundwater quality in the range of 0 -70 mS/m less than1 km to the north of the study area, and 300 – 1 000 mS/m directly south west of the study area. It is important to note that less than 3 km south of the study are the EC values are very high at 1000 mS/m. Although there appears to be a geological structure separation the low quality zone from the study area, care should be taken as to not inadvertently cause a potential plume migration due to over abstraction. Hydrocensus data within the area have also reported low EC values of 21.8 - 83.4 mS/m. Considering the generally low abstraction rate required to fulfil the water requirements of the development, the risk of drawing lower quality groundwater to the site would be low. However, quality monitoring should be conducted to ensure that a deterioration in quality does not occur. The risk assessment is presented in **Table 13.**

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 13: 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 pooper 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 stabilises.	
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	Moderate	Negligible
Confidence	Medium	Medium

9.7 The risk of groundwater abstraction impacting the surface water system

If boreholes are recharged by a river's surface or base flow, continued abstraction or over-abstraction from boreholes could impact the surface water system.

The Carpe Diem North Solar Facility is situated approximately 4.2 kilometres south of the Wonderfonteinspruit. The river has historically been fed by groundwater springs including the Upper Turffontein, Oberholzer and Bank eyes. Some of these springs have subsequently dried up due to the impact of dewatering for the mining operations in the area. Currently, the Wonderfonteinspruit is fed by meteoric water as well as treated water extracted from the mines and disposed at surface in the greater Mooi River catchment further afield (Van Tonder & Schomean, 2021). Finally, considering the generally deeply seated groundwater table in the area, it is unlikely that the Wonderfonteinspruit will be affected by additional abstraction of the comparatively low amounts groundwater required for this project.

Table 14: Risk assessment for the groundwater abstraction impacting a surface water system

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 a non-perennial stream situated approximately 200 m east	
Recommended mitigation measures	**Description**	
Impact avoidance/ prevention	Monitoring information must be assessed regularly (suggested monthly in winter). Installation of a piezometer between the Carpe Diem North Solar Facility and the Wonderfonteinspruit is recommended. This will allow for chemistry and water level testing to assess the surface water and groundwater connectivity. If an impact is observed, abstraction should be decreased at the borehole. 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 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 resource.	
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	Low	Low
Probability of occurrence	Possible	Improbable
Level of confidence in prediction	High	High
Significance	Moderate	Low
Confidence	Medium	Medium

10 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 from one set of test results. Seasonal changes may occur in the chemistry of the borehole's water, which has not been accounted for.
- 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.
- All registered abstraction volumes (that could be obtained from the WARMS January 2021 data) 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.
- Several properties surrounding the developments could not be accessed due to owners being either unwilling or unavailable to grant site access.
- From the hydrocensus conducted in March 2024, it was evident that several groundwater users in the area exist which are not registered on the WARMS database. Groundwater utilisation for these users is, however, typically limited to domestic use.
- Considering the known input of dewatered mine effluent into the northern Wonderfonteinspruit river further upstream, isotopic analysis for the purpose of investigating the interconnectivity between this river and the groundwater system would likely not be able to provide reliable data. As such, no isotopic studies were performed.

11 Groundwater Management

Potential environmental impacts pertaining to local groundwater resources have been considered in this EIA. In order to ensure safe and sustainable management of the groundwater resources in the area, several management inputs will be required. These inputs are, however, not required as part of the EIA phase and will only be required once the final operational conditions of the project are confirmed post environmental authorisation. Phase 1 will be required to determine if the groundwater is of a suitable quality and quantity; and Phase 2 will only be required if the groundwater quality and quantity are confirmed suitable for use. Additional information is provided below.

Phase 1: Determining if the groundwater is of a suitable quality and quantity:

1. Undertake a full laboratory analysis to confirm that the groundwater can be used for potable and domestic purposes, and determine the required treatment. This Geohydrological Assessment has confirmed that the groundwater is generally of good quality in terms of DWS (1998) and SANS241-1: 2015 domestic and drinking water standards.
2. The water quality from HBH_05 is not considered suitable for panel washing as it will result in salts precipitating on the panels. The salts could be removed from the groundwater by thermal distillation (i.e. boiling since salt has a much higher boiling point than water) or by membrane separation (commonly reverse osmosis). The mechanisms that could be used

to remove the salts from the groundwater for panel cleaning will need to be confirmed. This will entail undertaking a financial viability investigation / feasibility study. The water quality from HBH_04 (SP_01), i.e. water from the Covalent Water Company appears to be suitable for panel washing.

3. Undertake necessary tests to confirm if the groundwater is suitable for construction and concrete batching.
4. Conduct scientific yield tests to determine sustainable abstraction volumes from boreholes that are to be utilised.

Phase 2: Once the groundwater quality and quantity are confirmed to be suitable for use, the follow steps are required for sustainable management:

1. Ensure water saving techniques are instated and adhered to.
2. Ensure that proper bunding and secondary containment measures are in place for BESS facilities and are designed by an appropriate competent person.
3. Ensure that environmentally safe cleaning agents that breakdown naturally and do not cause adverse effects are used.
4. In the event that the Carletonville Solar Facility, the Carpe Diem North Solar Facility, and the Carpe Diem North Solar Facility are constructed simultaneously, adherence to the recommended mitigation measures should be strictly followed to prevent over-abstraction.
5. Instate an appropriate monitoring program including monitoring of groundwater quality, water levels (ideally by water level loggers and hand readings using a dip meter), and abstracted volumes. These data should be reported on at the least biannually.

In the event that a new borehole is to be constructed or the use of water from a provider that does not have an existing water use license, the following recommendations are made:

1. Yield test all abstraction boreholes according to SANS 10299-4:2003, Part 4 – Test pumping of water boreholes. This includes a Step Test, Constant Discharge Test and recovery monitoring.
2. Yield test data is to be assessed by an appropriately qualified groundwater specialist to determine the safe abstraction ates of the boreholes
3. The borehole(s) yield assessment in combination with the information presented in this report, can be used for a Water Use License application and can be guided by a professional with knowledge of the National Water Act ensuring that the water used during construction and operation of the solar farms, is lawful.
4. An “observation pipe” needs to be installed (32 mm inner diameter, class 10 as shown in **Appendix V**) from the pump depth to the surface, closed at the bottom and slotted for the bottom 5 – 10 m for the production borehole. This allows for a ‘window’ of access down the borehole which enables manual water level monitoring and can house an electronic water level logger.
5. Continuous monitoring of groundwater levels using a pressure transducer in the borehole is ideal. The water level in the borehole may not drop below the critical water level. If the water level in the borehole drops below the critical water level, abstraction must be immediately reduced by10 %. 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.

6. Water quality monitoring, which includes sampling and analysing groundwater at an accredited laboratory, is important. A quarterly sampling interval is recommended for the first year of monitoring; thereafter, the water quality monitoring should be reviewed and can potentially be reduced to biannually or annually, as seen in **Table 15.**
7. The monitoring data should initially be reviewed quarterly and can then be scaled down to biannually.
8. Installation of a sampling tap at the production borehole (to monitor water quality) is essential.
9. 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.
10. Abstraction volumes must be monitored and recorded by a designated on-site person. Depending on the frequency of use, daily, weekly or monthly abstraction volumes should be recorded.
11. The appropriate borehole pump must be installed, i.e., not an oversized pump that is choked with a gate valve.
12. The borehole and pump should be serviced annually.
13. A geohydrologist should review the above information annually to ensure optimal groundwater abstraction and management.
14. Water levels for boreholes close to the production borehole(s) should be monitored regularly to assess the level of interconnectivity between boreholes.
15. The relevant DWS monitoring officer (as specified in the Water Use License) should also be informed if water levels are dropping to critical level or if any parameters, as specified in **Table 15,** changes by 20%.
16. The groundwater abstraction should be reviewed to ensure sustainability based on the monitoring data obtained.

Table 15: Proposed groundwater monitoring parameters.

Parameter	Frequency
Groundwater Level	Ideally, every 30 minutes with a data logger.
Chemical parameters	
pH (at 25 ºC)	Quarterly (Field Chemistry)
Conductivity (mS/m) (at 25 ºC)	Quarterly (Field Chemistry)
Total Dissolved Solids (mg/L)	Quarterly (Field Chemistry)
Turbidity (NTU)	Quarterly*
Colour (mg/L as Pt)	Quarterly*
Sodium (mg/L as Na)	Quarterly*
Potassium (mg/L as K)	Quarterly*
Magnesium (mg/L as Mg)	Quarterly*
Calcium (mg/L as Ca)	Quarterly*
Chloride (mg/L as Cl)	Quarterly*
Sulphate (mg/L as SO_4)	Quarterly*
Nitrate & Nitrite Nitrogen (mg/L as N)	Quarterly*
Nitrate Nitrogen (mg/L as N)	Quarterly*
Nitrite Nitrogen (mg/L as N)	Quarterly*
Ammonia Nitrogen (mg/L as N)	Quarterly*

Parameter	Frequency
Total Alkalinity (mg/L as $CaCO_3$)	Quarterly*
Total Hardness (mg/L as $CaCO_3$)	Quarterly*
Fluoride (mg/L as F)	Quarterly*
Aluminium (mg/L as Al)	Quarterly*
Total Chromium (mg/L as Cr)	Quarterly*
Manganese (mg/L as Mn)	Quarterly*
Iron (mg/L as Fe)	Quarterly*
Nickel (mg/L as Ni)	Quarterly*
Copper (mg/L as Cu)	Quarterly*
Zinc (mg/L as Zn)	Quarterly*
Arsenic (mg/L as As)	Quarterly*
Selenium (mg/L as Se)	Quarterly*
Cadmium (mg/L as Cd)	Quarterly*
Antimony (mg/L as Sb)	Quarterly*
Mercury (mg/L as Hg)	Quarterly*
Lead (mg/L as Pb)	Quarterly*
Uranium (mg/L as U)	Quarterly*
Cyanide (mg/L as CN^-)	Quarterly*
Total Organic Carbon (mg/L as C)	Quarterly*
E.coli (count per 100 ml)	Quarterly*
Total Coliform Bacteria (count per 100 ml)	Quarterly*
Heterotrophic Plate Count (count per ml)	Quarterly*
**Can be reduced to bi-annually or annually if reviewed and deemed appropriate*	

In the case where groundwater is used from a provider with a current water use license or existing lawful use, the stipulations of the license will have to be reviewed and stipulations therein adhered to.

11.1 Proposed Monitoring Plan:

It is recommended that at several boreholes in the vicinity of each cluster of projects be allocated for monitoring purposes. These can either be existing boreholes, or newly drilled monitoring boreholes as this will allow for monitoring of the groundwater quality and groundwater levels across the affected area. Considering the regionally deep-water levels, drilling new monitoring boreholes may not be feasible and, as such, it is recommended that existing boreholes be monitored near to the study site. The optimum position of the monitoring boreholes should be based on availability of open space surrounding the planned buildable area; however, it is recommended that one borehole be located up-gradient of the affected area to monitor background values and the other two boreholes be down-gradient of the affected area where possible. General monitoring sites are presented in **Table 16,** and are based on existing boreholes in the vicinity of the proposed sites that can potentially be utilised for monitoring purposes. The borehole water level (if present) and the groundwater quality should be monitored on a monthly basis during construction phase and then on a quarterly basis during operational phase, so as to determine seasonal fluctuation. The implementation of the groundwater monitoring programme will be important for assessing any impacts of the Carpe Diem North Solar Facility on groundwater and the environment.

It is recommended that groundwater monitoring be undertaken at the proposed site in accordance with guidelines set out in the publication by DWAF (1998). The various aspects of the monitoring are presented in this section, along with relevant recommendations.

Table 16: General location of proposed monitoring points

Site_ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)
CWCM_01	-26.40649	27.32621
CNM_01	-26.40187	27.28429
CSM_01	-26.44358	27.34568

In the case that new monitoring boreholes are drilled, the drilling should be supervised by a geohydrologist and drill samples should be collected every 1 metre and logged. Additional information should also be collected including the depth of water strikes, associated water strike yields and groundwater quality. This is crucial information for the optimal design of the boreholes. The driller should be supervised to ensure all site requirements are met. A graphical representation of a proposed borehole construction is presented in **Figure 8**; the exact construction will, however, be unique for the borehole. It is not anticipated that multiple aquifers will be present in the bedrock. The inner diameter of the uPVC casing must not be less than 110 mm.

A gravel pack should be installed with an annulus of about 12 mm. The boreholes should be developed with compressed air for at least two hours upon completion along with an airlift test to estimate the yield of the borehole. Each borehole must be protected with a concrete block or a protected manhole if there is traffic in the area. Each borehole also needs a permanent plate glued to the lid containing the details pertaining to the borehole. A bentonite plug of at least 500 mm needs to be installed at the top of the hole to prevent ingress of surface water.

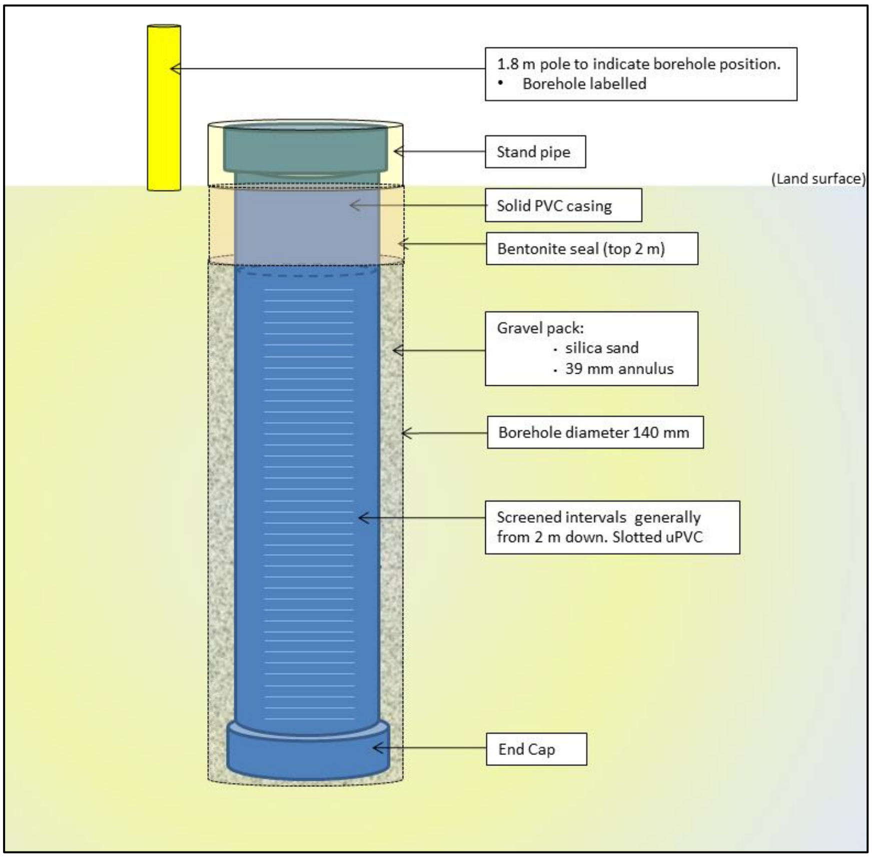


Figure 8 Schematic representation of the proposed general borehole construction.

11.1.1.1 Groundwater Level Monitoring

Groundwater level measurements are recommended for the monitoring boreholes at the study site. A dip meter can be used to measure the water level below the top of the borehole collar/casing height (mbch). The height of the collar/casing height must then also be measured (m). The water level (metres below ground level (mbgl)) can then be calculated by subtracting the collar/casing height from the water level (mbch). The value must be recorded along with the date and time of measurement. An interface meter can be used during monitoring to detect the presence of non-aqueous phase liquids (if present).

11.1.1.2 Groundwater Quality Monitoring

It is preferable to use a low volume sampling pump in most monitoring boreholes. Prior to sampling, the groundwater should be pumped through a flow-through cell until field chemistry parameters have stabilised.

11.1.1.3 Sample Collection, Preservation and Submission

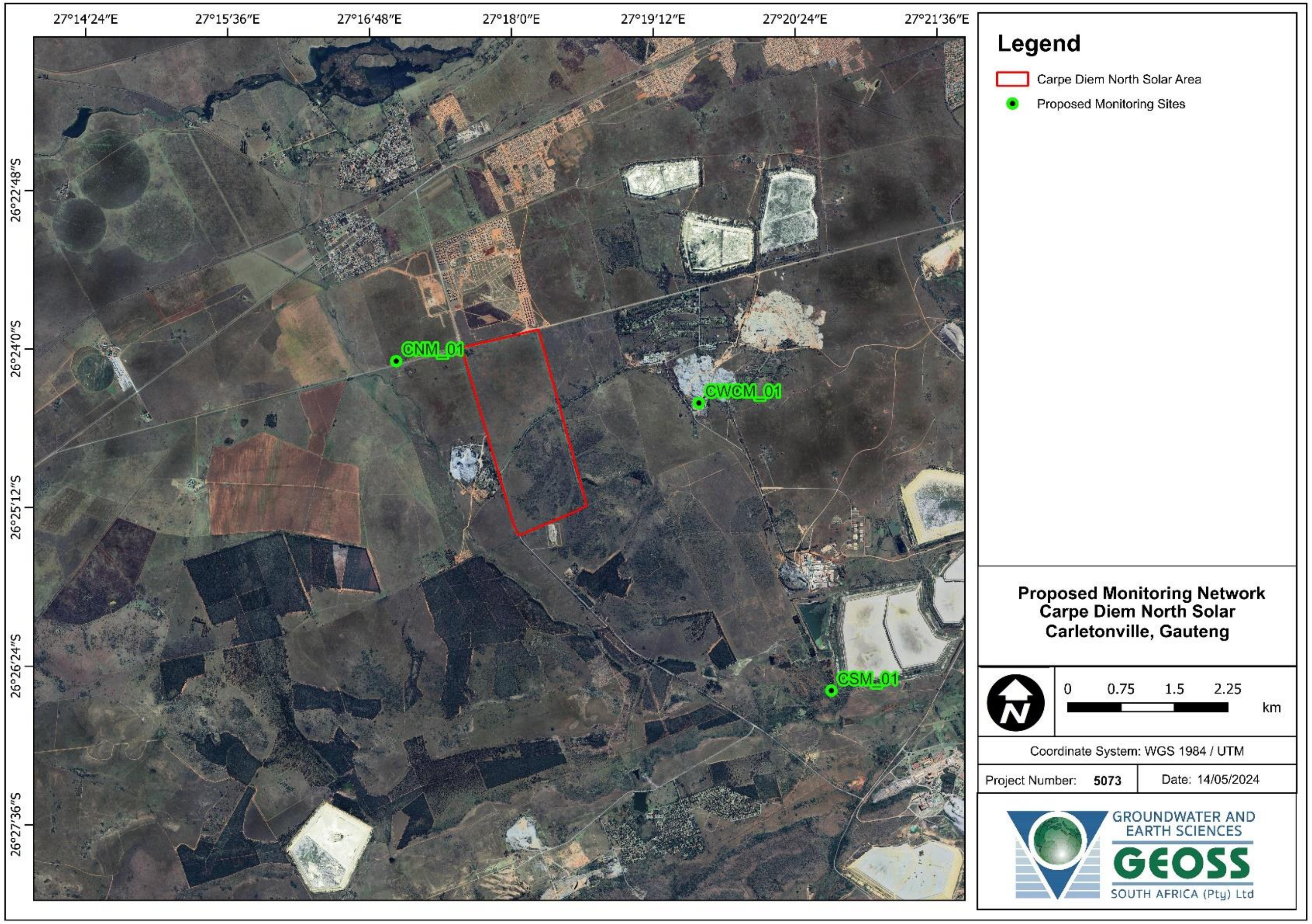
Sample bottles must be labelled with the site name, borehole name and date. At the time of sampling, field chemistry parameters must be measured and recorded. These include electrical conductivity (EC), oxidation reduction potential (ORP), pH, temperature and dissolved oxygen (DO). During sampling, disposable nitrile gloves should be worn to minimise the transfer of any potential contaminants. Nitrile gloves should be dedicated to a sampling location and disposed of after use. Samples must be collected in an appropriate sampling container and preserved in the correct manner prior to submission to an accredited laboratory for the analysis parameters. The sample method and preservation must be discussed with the laboratory prior to sampling.

11.1.1.4 Monitoring Frequency and Parameter Analysis

In order to best understand and monitor the site, it is recommended that monthly water level measurements be taken to determine seasonal fluctuation during the construction period, after which water level measurements can be taken at quarterly intervals during the operational phase. Further to this, water quality measurements should be taken on a quarterly basis during the construction phase, after which water quality measurement can be taken on a bi-annual basis during the operational phase. The recommended sampling parameters are based on a screening philosophy, whereby notable fluctuations in the parameters tested for can be further inspected in detail should the need arise. The monitoring schedule can be reviewed and revised upon the start of the decommissioning phase. **Table 17** indicates the potential parameters for the analysis.

Table 17: Proposed groundwater monitoring parameters and their recommended frequency.

Parameter	K1M_01	K1M_02
Groundwater Level	Monthly (Construction Phase) Quarterly (Operational Phase)	Monthly (Construction Phase) Quarterly (Operational Phase)
pH	Quarterly (Construction Phase) Bi-annually (Operational Phase)	Quarterly (Construction Phase) Bi-annually (Operational Phase)
Electrical conductivity (EC)	Quarterly (Construction Phase) Bi-annually (Operational Phase)	Quarterly (Construction Phase) Bi-annually (Operational Phase)
Phosphates (PO4)	Quarterly (Construction Phase) Bi-annually (Operational Phase)	Quarterly (Construction Phase) Bi-annually (Operational Phase)
Nitrates (NH4)	Quarterly (Construction Phase) Bi-annually (Operational Phase)	Quarterly (Construction Phase) Bi-annually (Operational Phase)
Total Organic Carbon (TOC)	Quarterly (Construction Phase) annually (Operational Phase)	Quarterly (Construction Phase) annually (Operational Phase)
Chemical Oxidation Demand (COD)	Quarterly (Construction Phase) Bi-annually (Operational Phase)	Quarterly (Construction Phase) Bi-annually (Operational Phase)
K	Quarterly (Construction Phase) Bi-annually (Operational Phase)	Quarterly (Construction Phase) Bi-annually (Operational Phase)
Fe	Quarterly (Construction Phase) Bi-annually (Operational Phase)	Quarterly (Construction Phase) Bi-annually (Operational Phase)
Li	Quarterly (Construction Phase) Bi-annually (Operational Phase)	Quarterly (Construction Phase) Bi-annually (Operational Phase)
Mn	Quarterly (Construction Phase) Bi-annually (Operational Phase)	Quarterly (Construction Phase) Bi-annually (Operational Phase)



Map 10: Proposed monitoring network

12 Conclusion and Recommendations

12.1 Statement and Reasoned Opinion

The Geohydrological Assessment conducted for the Carpe Diem North Solar Facility came to the following main conclusions:

- The anticipated demands of this facility (0.06 – 0.19 L/s) are less than the regional yield potential of the underlying aquifer(>5 L/s).
- There are multiple sources and scenarios that could potentially supply the required peak requirement (during the construction phase) of 6 120 m^3/a for the proposed Carpe Diem North Solar PV Facility. It is anticipated that this could be achieved through utilising nearby existing boreholes (pending relevant consent and authorisations), purchasing water from an entity with an existing water use license, or through drilling of new boreholes in the area.
- HBH_05 and HBH_04 (Covalent Water Company hole) are potentially viable sources of groundwater for the development of the Carpe Diem North Solar Facility. The use of this/these borehole/s would/ depend on the operational requirements of the facility, negotiations with the landowners, proximity to the facility and any legal restrictions or stipulations related to existing water use licenses.
- Although drilling of new boreholes is a potential option, the deep regional water levels may represent a significant capital investment cost and all new boreholes will need to be scientifically yield tested according to according to SANS 10299_4-2003 to determine the safe yield of the boreholes. A Water Use License for these new boreholes will then need to be applied for.
- Any newly constructed boreholes will require input from a geotechnical professional regarding the potential for sinkhole formation due to water abstraction.
- The cumulative demands of construction (1.38 L/s) for the Carletonville, Carpe Diem South, and Carpe Diem North solar facilities (if developed simultaneously) are well within the regional yield potential of the underlying aquifer (5.0 L/s).
- The study site has been classified as overlying a high yielding aquifer with a groundwater vulnerability classification of “high”. This is based on regional data and does not consider the attenuation effect of the overlying thick quaternary sediments or the artificially lowered water table.
- Both the potential individual and cumulative impacts from the construction, operation, and decommissioning phases for of the development are considered as Low to Very Low with appropriate mitigation.

Given these conclusions, it is the opinion of the specialist that development of the proposed Carpe Diem North Solar Facility be authorised to proceed given that the proper mitigation measures highlighted within this document are implemented during each phase of the project to mitigate the intensity of the identified impacts.

Also, because the required peak volume can be supported by the Firm Yield calculated for the Turffontein-Boskop GRU, the abstraction of the total volume of 6 120m^3/a can be considered sustainable should the water be sourced from a position west of the Oberholzer Dyke.

12.2 EA Condition Recommendations

From the impact assessment it is evident that the development will have a very low to low impact on the local geohydrological system as long as the recommended mitigation measures are adhered to. As such, the project is authorised to continue from a geohydrological perspective on condition of implementation of the following recommendations:

- In the case that multiple projects are constructed simultaneously, adherence to recommended mitigation measures should be strictly followed to prevent over abstraction.
- Phase two of the monitoring plan is to be discussed and evaluated in the event that groundwater is to be used in the project. The proposed monitoring plan should be followed with a special focus on groundwater level monitoring to ensure that the aquifer is not over abstracted and falls to levels below historic borehole depths.
- All proposed impact mitigation measures are to be implemented during the development of the project. These include the use of environmentally safe cleaning agents, the construction of BESS facilities 50 m from any boreholes along with appropriate bunding and secondary containment, and the recommended precautionary approaches aimed at preventing oil spills and fuel leaks.
- In the event that a new borehole is to be constructed or water provider used that does not have an existing water use license, the recommendations stipulated in Section 11 are to be adhered to.
- In the event that the water provider used has an active Water Use License or an Existing Lawful Use, the recommendations and stipulations within the license need to be reviewed and adhered to.

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Appendix I: NGA Database

ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	WL (mbgl)	EC (mS/m)	pH	Depth (m)	Yield (L/s)
2627AD00180	-26.49415	27.37523	-	-	-	-	-
2627AD00179	-26.49387	27.38023	-	-	-	-	-
2627AD00188	-26.49332	27.42606	-	-	-	-	-
2627AD00176	-26.49221	27.42356	-	65,4	7,7	91,44	-
2627AD00175	-26.49221	27.42773	-	100	7,3	-	-
2627AD00208	-26.49165	27.33356	-	-	-	30	-
2627AD00205	-26.49137	27.37717	8,85	-	-	35	-
2627AD00229	-26.49054	27.42550	4,5	68,9	7,6	-	-
2627AD00181	-26.49026	27.42356	6,33	86,3	7,6	27	-
2627AD00167	-26.49026	27.42745	-	103,8	7,8	25,3	-
2627AD00166	-26.48998	27.42995	1,68	116	7,4	18	-
2627AD00108	-26.48979	27.37757	15,7	-	-	25,7	-
2627AD00214	-26.48971	27.37328	-	-	-	-	-
2627AD00213	-26.48971	27.37995	-	-	-	-	-
2627AD00182	-26.48971	27.42134	6,42	51	7,7	75	-
2627AD00206	-26.48915	27.37550	-	-	-	-	-
2627AD00110	-26.48896	27.30692	6,77	-	-	16,77	-
2627AD00212	-26.48610	27.34606	-	-	-	-	-
2627AD00172	-26.48610	27.42467	6,5	44,3	7,5	40	-
2627AD00201	-26.48554	27.39856	-	-	-	64	-
2627AD00173	-26.48471	27.42217	14,2	81,8	7,8	40	-
2627AD00202	-26.48276	27.39967	-	-	-	76,2	-
2627AD00178	-26.48248	27.42328	9,27	62,3	6,2	-	-
2627AD00177	-26.48248	27.42550	-	76,6	6,3	-	-
2627AD00211	-26.48165	27.36023	-	-	-	-	-
2627AD00171	-26.48137	27.42550	-	36,1	6,8	-	-
2627AD00174	-26.47860	27.41634	25	58,3	6,8	35	-
2627AD00183	-26.47776	27.42245	-	93,9	7,5	40	-
2627AD00184	-26.47582	27.42245	-	91,9	7,5	50	-
2627AD00195	-26.47582	27.42800	3,52	84,1	7,7	10	-
2627AD00204	-26.47498	27.33550	-	-	-	60	-
2627AD00207	-26.47498	27.33550	-	-	-	50	-
2627AD00159	-26.47442	27.27133	1,52	-	-	22,25	0,89
2627AD00159	-26.47442	27.27133	1,52	-	-	22,25	0,89
2627AD00210	-26.47359	27.36689	-	-	-	-	-
2627AD00151	-26.47307	27.32108	30	-	-	108	0,4
2627AD00150	-26.47306	27.32107	12	-	-	23,5	10
2627AD00149	-26.47305	27.32106	20	-	-	114	0,33
2627AD00148	-26.47304	27.32105	12	-	-	19,5	0,33
2627AD00224	-26.46860	27.42634	-	-	-	-	-
2627AD00203	-26.46721	27.36773	-	-	-	60	-
2627AD00158	-26.46443	27.27134	-	-	-	50,29	-
2627AD00158	-26.46443	27.27134	-	-	-	50,29	-

ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	WL (mbgl)	EC (mS/m)	pH	Depth (m)	Yield (L/s)
2627AD00083	-26.45637	27.42161	13,39	-	-	40	-
2627AD00080	-26.45610	27.42050	53,87	-	-	64	-
2627AD00113	-26.45608	27.42219	21,05	-	-	31,05	-
2627AD00226	-26.45582	27.41578	-	-	-	-	-
2627AD00225	-26.45498	27.41745	-	-	-	-	-
2627AD00192	-26.45360	27.42939	20,29	39,4	7,8	100	-
2627AD00228	-26.45276	27.41995	-	-	-	-	-
2627AD00227	-26.45137	27.42134	-	-	-	-	-
2627AD00209	-26.44693	27.38661	-	-	-	-	-
2627CB00115	-26.44324	27.42647	29,26	-	-	52,12	-
2627CB00114	-26.44323	27.42646	18,29	-	-	47,55	3,23
2627CB00113	-26.44319	27.42642	-	-	-	54,56	-
2627CB00112	-26.44318	27.42641	-	-	-	35,05	-
3550	-26.44317	27.42640	7,32	-	-	53,34	2,42
2627CB00107	-26.44315	27.42638	20,12	-	-	33,53	1,1001
2627CB00106	-26.44314	27.42637	-	-	-	52,12	-
2627CB00105	-26.44313	27.42636	-	-	-	11,58	-
2627CB00093	-26.44312	27.42635	-	-	-	51,05	-
2627CB00095	-26.44312	27.42635	3,66	-	-	45,72	0,15
2627CB00104	-26.44312	27.42635	-	-	-	38,1	-
2684	-26.44311	27.42634	-	-	-	50,6	-
2627CB00103	-26.44311	27.42634	10,67	-	-	53,65	1,82
2627CB00102	-26.44310	27.42633	18,29	-	-	27,43	0,22
2627CB00101	-26.44309	27.42632	-	-	-	31,7	0,1001
2627AD00109	-26.44308	27.34514	53,33	-	-	63,33	-
2696	-26.44308	27.42631	18,29	-	-	23,47	0,1
2627CB00094	-26.44307	27.42636	-	-	-	32,92	-
2691	-26.44306	27.42629	11,28	-	-	22,25	1,11
2686	-26.44305	27.42628	-	-	-	59,74	2,4001
2627CB00092	-26.44305	27.42635	-	-	-	45,11	-
2627CB00069	-26.44304	27.42634	15,54	-	-	42,37	2,42
2627AD00111	-26.42860	27.37417	8,17	-	-	18,17	-
GP00017	-26.41430	27.25666	81,78	-	-	110	-
2627AD00086	-26.40748	27.35106	178,1	-	-	189,83	-
2627AD00107	-26.40153	27.28379	-	-	-	-	-
GP00014	-26.39063	27.27324	52,28	-	-	80	-
2627AD00089	-26.37610	27.27106	-	-	-	-	-
2627AD00076	-26.37554	27.28717	-	-	-	17,93	-
GP00007	-26.37539	27.28151	41,63	-	-	100	-
GP00009	-26.37008	27.28210	28,27	-	-	45	-
GP00009	-26.37008	27.28210	28,27	18,9	-	45	-
2627AD00106	-26.36928	27.32541	82,94	-	-	92,94	-
2627AD00084	-26.36749	27.37245	-	-	-	-	-
2627AD00115	-26.36718	27.26978	-	-	-	-	-

ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	WL (mbgl)	EC (mS/m)	pH	Depth (m)	Yield (L/s)
2627AD00085	-26.36026	27.37162	-	-	-	-	-
2627AD00119	-26.35804	27.40300	-	-	-	64,01	-
2627AD00125	-26.35804	27.40300	-	-	-	23,47	-
2627AD00118	-26.35416	27.35277	-	-	-	-	-
2627AD00001	-26.35376	27.31186	-	-	-	46,2	-
1059	-26.35290	27.38720	72,97	-	-	88,13	-
2627AD00088	-26.35276	27.27828	-	-	-	-	-
2627AD00053	-26.35272	27.25821	-	-	-	-	-
2627AD00129	-26.35166	27.38134	-	-	-	25,3	-
2627AD00132	-26.35166	27.38134	-	-	-	50,29	-
2627AD00130	-26.35165	27.38133	-	-	-	27,43	-
2627AD00128	-26.35165	27.38134	-	-	-	24,51	-
2627AD00133	-26.35164	27.38133	-	-	-	33,53	-
2627AD00131	-26.35164	27.38134	-	-	-	28,35	-
2627AD00054	-26.34871	27.26545	-	-	-	-	-
1712	-26.34713	27.38025	21,43	-	-	35,52	-
2627AD00060	-26.34360	27.39200	-	-	-	50	-
2627AD00052	-26.34170	27.25704	-	-	-	-	-
2627AD00067	-26.33950	27.39680	-	-	-	82,45	-
2627AD00116	-26.33832	27.32934	-	-	-	-	-
2627AD00117	-26.33476	27.38714	-	-	-	-	-
2627AD00087	-26.33387	27.37356	20,45	-	-	31,26	-
2627AD00091	-26.33387	27.37828	55,54	-	-	72,75	-
2627AD00082	-26.33355	27.38665	-	-	-	-	-
GP00041	-26.32999	27.32201	52	72,1	-	56	-
2627AD00105	-26.32897	27.39189	31,95	-	-	60,46	-
2627AD00093	-26.32888	27.38828	54,46	-	-	67,43	-
2627AD00200	-26.32720	27.33625	-	-	-	-	-
2627AD00199	-26.32720	27.35550	-	-	-	-	-
2627AD00002	-26.32694	27.35596	36,21	-	-	42,9	-
2627AD00246	-26.32637	27.37105	-	-	-	-	-
2627AD00247	-26.32581	27.36244	-	-	-	-	-
2627AD00090	-26.32527	27.36078	34,2	-	-	48,05	-
GP00103	-26.32524	27.37093	47,55	87,1	6,87	47,55	-
2627AD00055	-26.32503	27.32584	-	-	-	-	-
2627AD00003	-26.32229	27.38803	33,93	-	-	45,16	-
2627AD00059	-26.32177	27.38175	-	-	-	-	-

Appendix II: Risk Assessment Methodology and Criteria

Impact Assessment Methodology

The following methodology has been applied to the prediction and assessment of impacts. Potential impacts have been rated in terms of the direct, indirect, and cumulative nature of the impact:

- **Direct** impacts – are impacts that are caused directly by the activity and generally occur at the same time and at the place of the activity. These impacts are usually associated with the construction, operation or maintenance of an activity and are generally obvious and quantifiable;
- **Indirect** impacts – of an activity are indirect or induced changes that may occur because of the activity. These types of impacts include all the potential impacts that do not manifest immediately when the activity is undertaken, or which occur at a different place because of the activity;
- **Cumulative** impacts – are impacts that result from the incremental impact of the proposed activity on a common resource when added to the impacts of other past, present, or reasonably foreseeable future activities. Cumulative impacts can occur from the collective impacts of individual minor actions over a period of time and can include both direct and indirect impacts.

The significance of each potential impact, with and without the implementation of the proposed mitigation measures, will be assessed based on the following variables (evaluation components):

- Spatial extent – The size of the area that will be affected by the impact;
- Intensity (or Magnitude) – The anticipated severity of the impact;
- Duration – The timeframe during which the impact will be experienced;
- Probability – The probability of the impact occurring;
- Reversibility – The “reversibility” of the environmental impacts of the proposed development after project cessation or decommissioning; and
- Irreplaceability – The “irreplaceability” of natural characteristics in the area that may be impacted upon by the proposed development.

Using the criteria above, the impacts will further be assessed with the use of quantifiable values as described below:

Table 18: Evaluation of criteria, by means of quantitative ratings and descriptions.

Criteria	Description	Quantitative Rating
Duration	Temporary (less than a year)	1
	Short term (1 to 6 years)	2
	Medium term (6 to 15 years)	3
	Long term (the impact will cease after the operational life of the activity)	4
	Permanent (mitigation will not occur in such a way or in such a time span than the impact can be considered transient)	5
Spatial extent	Site specific	1
	Local (less than 2 km from the site);	2
	Regional (within 30 km of the site)	3
	National (beyond Provincial boundaries and within National boundaries)	4
	International / Transboundary (Beyond National boundaries)	5
Intensity Applicable to Negative Impacts (at indicated spatial extent)	None (Biophysical and/or social functions and/or processes will remain unaltered)	0
	Very Low (Biophysical and/or social functions and/or processes might be negligibly altered)	2
	Low (Biophysical and/or social functions and/or processes might be slightly altered)	4
	Medium (Biophysical and/or social functions and/or processes might be notably altered)	6
	High (Biophysical and/or social functions and/or processes might be considerably altered)	8
	Very High (Biophysical and/or social functions and/or processes might be severely altered)	10
Intensity Applicable to Positive Impacts (at indicated spatial extent)	None (Biophysical and/or social functions and/or processes will remain unaltered)	0
	Very Low (Biophysical and/or social functions and/or processes might be negligibly enhanced)	2
	Low (Biophysical and/or social functions and/or processes might be slightly enhanced)	4
	Medium (Biophysical and/or social functions and/or processes might be notably enhanced)	6
	High (Biophysical and/or social functions and/or processes might be considerably enhanced)	8
	Very High (Biophysical and/or social functions and/or processes might be substantially enhanced)	10
Probability	Improbable (5% to no chance of occurring)	1
	Probable (5% - 25% chance of occurring)	2
	Medium Probability (25% - 75% chance of occurring)	3

Criteria	Description	Quantitative Rating
	Highly probable (75% - 95% chance of occurring)	4
	Definite (greater than 95% chance of occurring)	5
Reversibility	No impact	0
	Impact will be reversible	1
	High potential that impact might be reversed	2
	Moderate potential that impact might be reversed	3
	Low potential that impact might be reversed	4
	Impact cannot be reversed	5
Irreplaceability	None	0
	Very low potential for loss of irreplaceable resources	1
	Low potential for loss of irreplaceable resources	2
	Moderate potential for loss of irreplaceable resources	3
	High potential for loss of irreplaceable resources.	4
	Definite loss of irreplaceable resources	5
CUMULATIVE impact	High: The activity is one of several similar pasts, present or future activities in the same geographical area, and might contribute to a very significant combined impact on the natural, cultural, and/or socio-economic resources of local, regional or national concern.	
	Medium: The activity is one of a few similar pasts, present or future activities in the same geographical area, and might have a combined impact of moderate significance on the natural, cultural, and/or socioeconomic resources of local, regional or national concern.	
	Low: The activity is localised and might have a negligible cumulative impact.	
	None: No cumulative impact on the environment.	

Once the evaluation components have been ranked for each impact, the significance of potential impact are assessed (or calculated) using the following formula:

SP (significance points) = (intensity + duration + spatial extent + irreplaceable + reversibility) x probability.

The maximum value is 150 SP (significance points). The unmitigated and mitigated scenarios for each environmental impact should be rated as per the table below (Table 19).

Table 19: Definition of significance ratings (positive and negative)

Significance Points	Environmental Significance	Description
125 – 150	Very high (VH)	An impact of high or very-high significance which could influence a decision about whether to proceed with the proposed project, regardless of available mitigation options. Cumulative Impacts:
100 – 124	High (H)	

Significance Points	Environmental Significance	Description
		The activity is one of several similar pasts, present or future activities in the same geographical area, and might contribute to a very significant combined impact on the natural, cultural, and/or socio-economic resources of local, regional, or national concern.
75 – 99	Moderate-high (MH)	If left unmanaged, an impact of moderate-high significance could influence a decision about whether to proceed with the proposed project. Mitigation options should be re-evaluated.
40 – 74	Moderate (M)	If left unmanaged, an impact of moderate significance could influence a decision about whether to proceed with the proposed project. Cumulative Impacts: The activity is one of a few similar pasts, present or future activities in the same geographical area, and might have a combined impact of moderate significance on the natural, cultural, and/or socio-economic resources of local, regional, or national concern.
<40	Low (L)	An impact of low significance is likely to contribute to positive decisions about whether to proceed with the proposed project. It will have little real effect and is unlikely to have an influence on project design or alternative motivation. Cumulative Impacts: The activity is localised and might have a negligible cumulative impact.
+	Positive impact (+)	A positive impact is likely to result in a positive consequence/ effect and is likely to contribute to positive decisions about whether to proceed with the proposed project.

Appendix III: Supporting Images

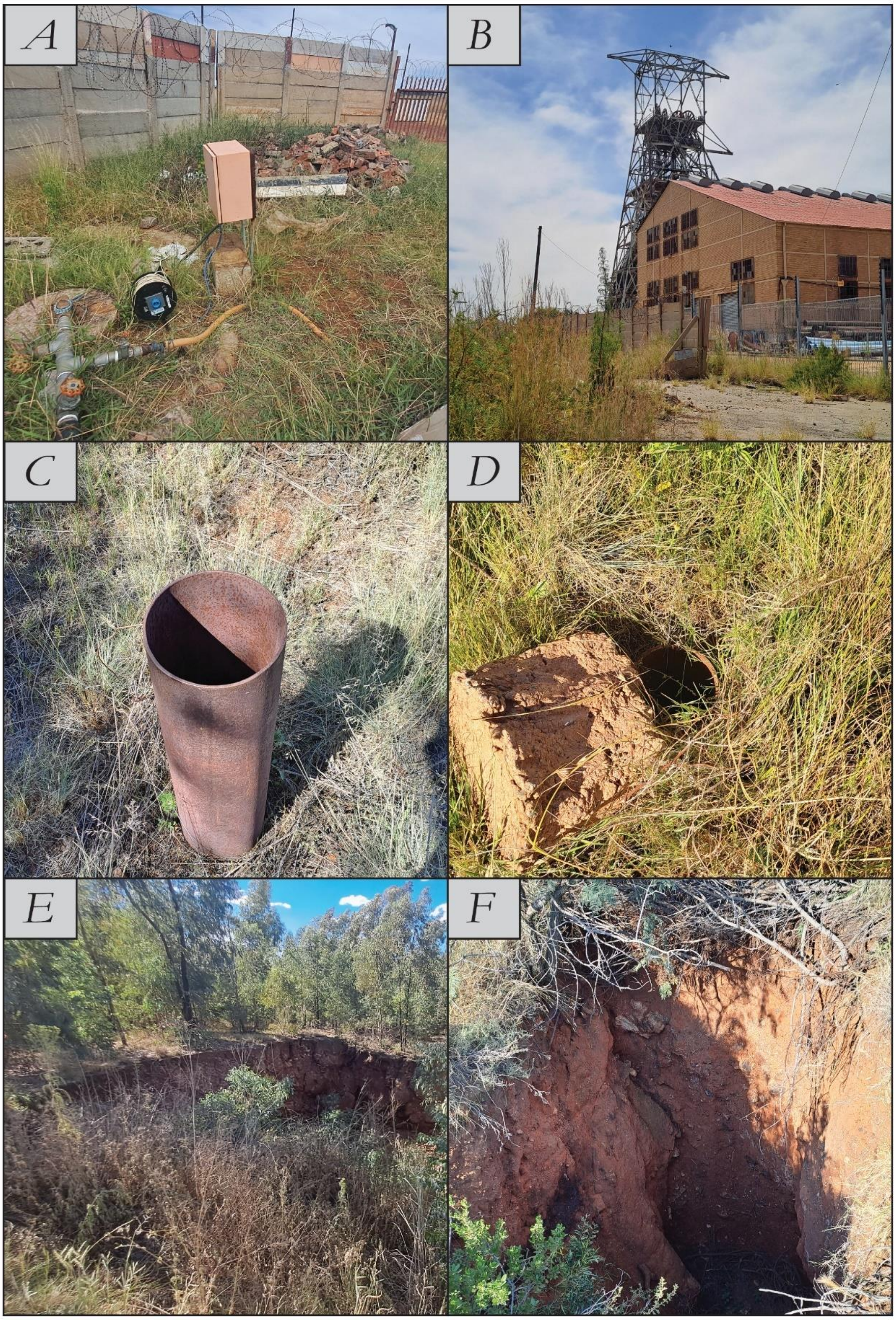

*Figure 9: Photomosaic showing typical materials and features found on site during trial pitting: **A**) Borehole HBH_05 at property north of Carletonville Solar Facility. **B**) Mine shaft east of Carpe Diem North (HBH_04) being dewatered by Covalent Water Company. **C, D**) Dry boreholes east of Carpe Diem North. **E**) Medium sized sinkhole next to road east of Carletonville Solar Facility. **E**) Small sinkhole on Carpe Diem North Solar Facility*

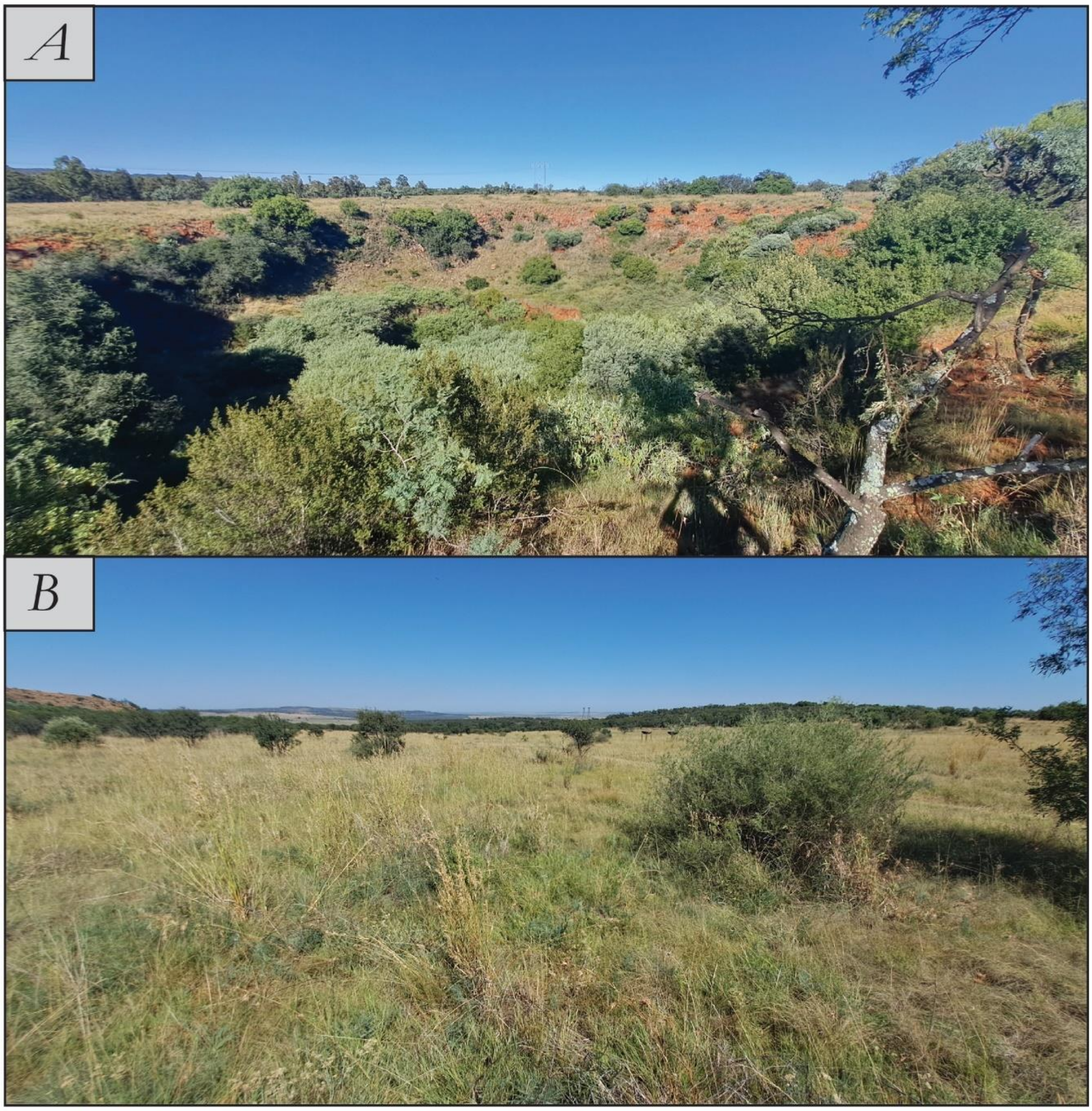

Figure 10: Photomosaic showing typical materials and features found on site during trial pitting: ***A)*** *Large sinkhole on Carpe Diem South Solar property.* ***B)*** *Valley on Carpe Diem North Solar Property likely formed due to faulted structure.*

Appendix IV: Certificate of analyses

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Stellenbosch
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www.vinlab.com
2024-03-25

TEST REPORT

Water

Geoss South Africa (Pty) Ltd

Attn: Alison McDuling

P.O.Box 12412
Die Boord, Stellenbosch
7613
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@VinlabSA

Sample Details					
SampleID	W49166	W49167			
Water Type	Drinking Water	Drinking Water			
Water Source	Borehole	Borehole			
Sample Temperature					
Description	5073_G_SP_1	5073_H_HBH_05			
Batch Number	5073_G_SP_1	5073_H_HBH_05			
PO Number	5073_G_SP_1	5073_H_HBH_05			
Date Received	2024-03-18	2024-03-18			
Condition	Good	Good			

Water - Routine

	Unit	Method	Uncertainty	Limit	Results	Results	Results	Results	Results
pH@25C (Water)		VIN-05-MW01	^^^	>= 5 to <= 9.7	7.78	7.60			
Conductivity@25C (Water)	mS/m	VIN-05-MW02	^	<= 170	21.8	83.4			
Turbidity (Water)*	ntu			<= 5	0.56	0.60			
Total dissolved solids (Water)*	mg/L			<= 1200	147.80	565.45			
Free Chlorine (Water)*	mg/L			<= 5	<0.02	<0.02			
Ammonia (NH4) as N (Water)	mg/L	VIN-05-MW08	8.90%	<= 1.5	<0.15	<0.15			
Nitrate as N (Water)	mg/L	VIN-05-MW08	11.00%	<= 11	<1.00	2.71			
Nitrite as N (Water)	mg/L	VIN-05-MW08	4.50%	<= 0.9	0.07	<0.05			
Chloride (Cl-) - Water	mg/L	VIN-05-MW08	10.12%	<= 300	13.51	38.72			
Sulphates (SO4) - Water	mg/L	VIN-05-MW08	7.56%	<= 500	17.96	172.18			
Fluoride (F) - Water	mg/L	VIN-05-MW08	12.30%	<= 1.5	<0.15	<0.15			
Alkalinity as CaCO3 (Water)*	mg/L				76.40	238.40			
Colour (Water)*	mg/L Pt-Co			<= 15	<15	<15			
Total Organic Carbon (Water)*	mg/L			<=10	4.53	1.12			
Date Tested					2024-03-18	2024-03-18			

Water - Metals

	Unit	Method	Uncertainty	Limit	Results	Results	Results	Results	Results
Calcium (Ca) - Water	mg/L	VIN-05-MW43	14.60%		19	78			

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

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<35 and a negative result (non-detected) indicates a Cq value of >35.

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^ - 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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TEST REPORT

Water

Geoss South Africa (Pty) Ltd

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Magnesium (Mg) - Water	mg/L	VIN-05-MW43	8.49%		8	43			
Sodium (Na) - Water	mg/L	VIN-05-MW43	11.45%	<= 200	15	42			
Potassium (K) - Water	mg/L	VIN-05-MW43	9.42%		4	3			
Zinc (Zn) - Water	mg/L	VIN-05-MW43	19.40%	<= 5	0.021	0.059			
Antimony (Sb) - Water*	µg/L			<=20	<13.0	<13.0			
Arsenic (As) - Water*	µg/L			<= 10	<10.0	<10.0			
Boron (B) Water	µg/L	VIN-05-MW43	11.79%	<= 2400	<10	26			
Cadmium (Cd) Water	µg/L	VIN-05-MW43	12.26%	<= 3	<1	<1			
Chromium (Cr) - Water	µg/L	VIN-05-MW43	13.03%	<= 50	<4	8			
Copper (Cu) - Water	µg/L	VIN-05-MW43	11.57%	<= 2000	21	9			
Iron (Fe) - Water	µg/L	VIN-05-MW43	12.49%	<= 2000	<10	18			
Lead (Pb) - Water	µg/L	VIN-05-MW43	16.32%	<= 10	<8	<8			
Manganese (Mn) - Water	µg/L	VIN-05-MW43	12.44%	<= 400	<4	<4			
Nickel (Ni) - Water	µg/L	VIN-05-MW43	17.38%	<= 70	<8	<8			
Selenium (Se) - Water*	µg/L			<= 40	<10.0	<10.0			
Aluminium (Al) - Water	µg/L	VIN-05-MW43	13.49%	<= 300	8	<8			
Cyanide (CN) - Water*	µg/L			<= 200	<10.0	<10.0			
Mercury (Hg) - Water*	µg/L			<= 6	<1.0	3			
Barium (Ba) Water	µg/L	VIN-05-MW43	14.09%	<= 700	46	<8			
Uranium (U) - Water*	µg/L			<= 30	<28	<28			
Date Tested					2024-03-18	2024-03-18			

Comments
W49166 Ion balance = 6.7%.
W49167 Ion balance = 2.7%.

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^^^ - pH ± 0.1

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TEST REPORT

Water

Geoss South Africa (Pty) Ltd

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AEFourie

Adelize Fourie
Laboratory Manager (Waterlab)
VIN-05-
M01,M02,M03,M04,M05,MO8,M10,M28,
M43, MW01, MW02, MW03, MW04,
MW05, MW06, MW07, MW08/9/10,
MW12, MW13, MW14

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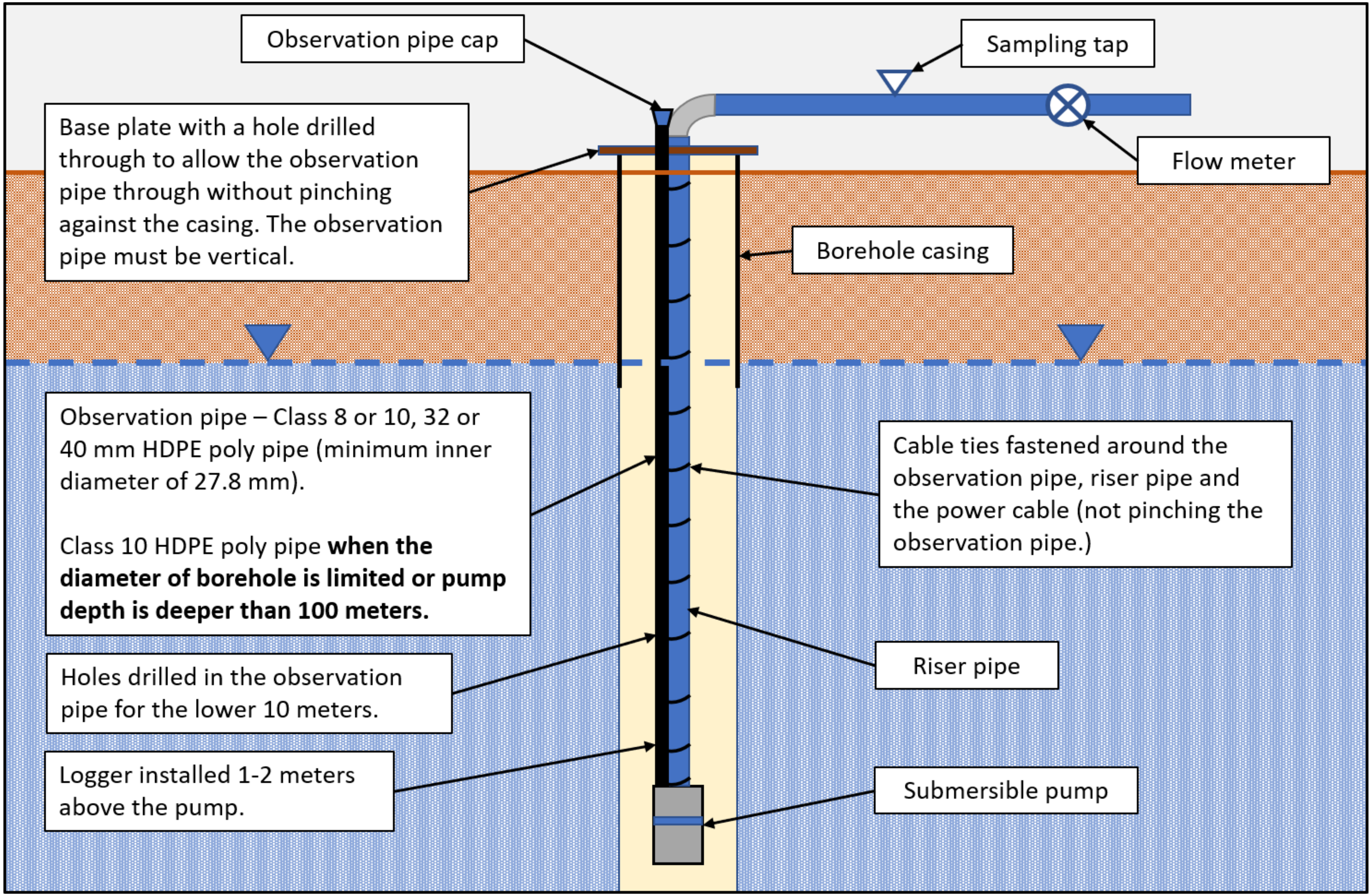
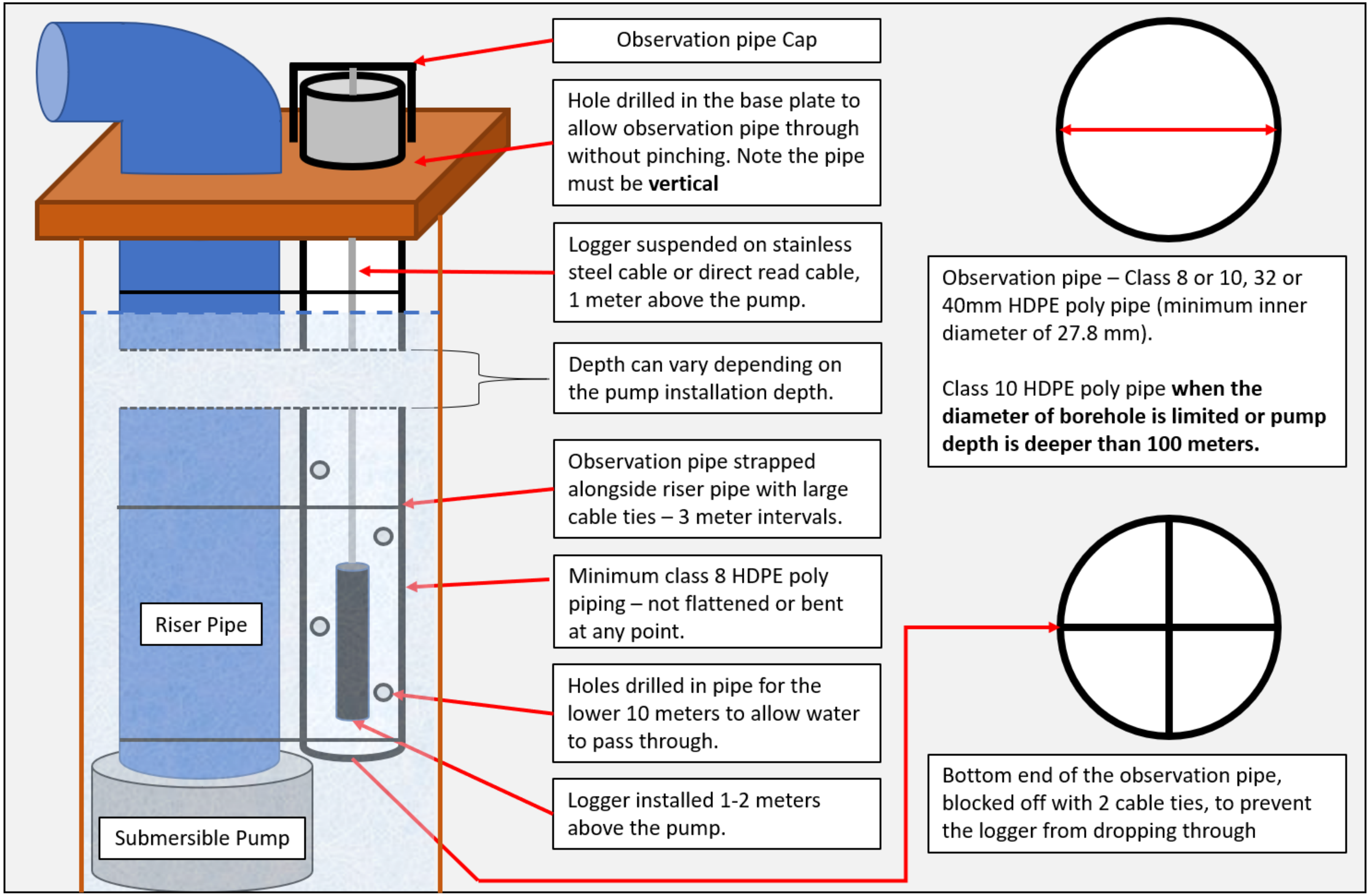
Appendix V: Monitoring infrastructure


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

(last page)