Report: Hydrogeological Investigation in support of for the Proposed Beta Solar Power Plant Water Use License Application

GROUNDWATER AND
GEOCHEMISTRY
CONSULTING

geostratum

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Glossary

Aquifer: A geological formation which has structures or textures that hold water or permit appreciable water movement through them. Appreciable water is usually taken to be enough water to supply a well.
Borehole: Includes a well, excavation or any artificially constructed or improved underground cavity which can be used for the purpose of - (a) intercepting, collecting or storing water in or removing water from an aquifer; (b) observing and collecting data and information on water in an aquifer; or (c) recharging an aquifer.
Catchment: The area from which any rainfall will drain into the watercourse or watercourses or part of a watercourse, through surface flow to a common point or common points.
Catchment Management Agency: A statutory body established by the Minister of DWAF responsible for the management of water resources within a defined water management area.
Contamination: The addition of potentially harmful substances to, in this case, groundwater, or an increase in naturally occurring substances to unnatural levels.
Discharge: Water which leaves the aquifer to become surface water, soil water, seawater or atmospheric water vapour.
Discharge area: The area or zone where ground water emerges from the aquifer naturally or artificially. Natural outflow may be into a stream, lake, spring, wetland, etc. Artificial outflow may occur via pumping wells.
Down gradient: Direction toward lesser hydraulic head.
Geohydrology: The scientific study of water that occurs in rocks, specifically aquifers.
Geology: The scientific study of the origin, history, structure and composition of the earth.
Groundwater management: Organised control of activities which may affect aquifers. Typically, this would include controlling pollution and the amount of groundwater abstracted from boreholes. Monitoring and geohydrological assessments are necessary if the management is scientifically based.
Permeability: The capacity of rock or soil to transmit water. The permeability results from the spaces in a rock and the degree to which they are connected to each other. In some aquifers the spaces were formed when the rock was deposited (primary aquifers), in other rocks the spaces were dissolved (e.g., dolomites) or cracked (e.g., faulted sandstone) into the rock after it was formed (secondary aquifers).
pH: A measure of the acidity or alkalinity of the solution (concentration of hydrogen ions)
Potable water: Water, which is safe for human consumption.
Primary aquifer: Aquifers in which the water moves through the spaces that were formed at the same time as the geological formation was formed, for instance intergranular porosity in sand (e.g., alluvial deposits).
Recharge: Water that adds to groundwater stored in an aquifer, e.g. – the small proportion of rainfall that seeps through the ground surface and flows through the unsaturated soil until it reaches the water table.
Recharge areas: Areas of land that allow groundwater to be replenished through infiltration or seepage from precipitation or surface runoff.
Saturated zone: The subsurface zone below the water table where all spaces are filled with water. Aquifers are located in this zone.
Secondary aquifer: Aquifers in which the water moves through spaces that were formed after the geological formation was formed, such as fractures in hard rock.
Surface water: Bodies of water, snow, or ice on the surface of the earth (such as lakes, streams, ponds, wetlands, etc.).
Sustainability: The use of resources and the environment by people to meet their present needs in a way which will not compromise the ability of future generations to meet their needs.
Unconfined aquifer: An aquifer which is not restricted by any confining layer above it. Its upper boundary is the water table, which is free to rise and fall. The water level in a well tapping an unconfined aquifer is at atmospheric pressure and does not rise above the level of the water table within the aquifer. An unconfined aquifer is often near to the earth's surface and not protected by low permeability layers, causing it to be easily recharged as well as contaminated.

Unsaturated zone: An area, usually between the land surface and the water table, where the openings or pores in the soil contain both air and water.
Up gradient: Direction toward greater hydraulic head than point of origin or point of interest.
Water level (groundwater): The level at which groundwater rests in an aquifer, borehole or point of discharge.
Water Management Areas: An area established as a management unit in the national water resource strategy within which a catchment management agency will conduct the protection, use, development, conservation, management and control of water resources.
Water table: The top of an unconfined aquifer where water pressure is equal to atmospheric pressure. The water table depth fluctuates with climate conditions on the land surface above and is usually gently curved and follows a subdued version of the land surface topography.
Wetland: Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.

1 INTRODUCTION

Geostratum (Pty) Ltd (Geostratum) was appointed by Environamic on behalf of Subsolar to carry out a Hydrogeological investigation in support of Water Use License Application for the new proposed Beta Solar Power Plant (Beta SPP). The project area is located approximately 16 km east-southeast of the town of Hertzogville, in the Free State Province of South Africa.

2 SCOPE OF WORK

The following components were accepted by the Client as the scope of work:

- Geological and hydrogeological desktop review.
- Hydrocensus survey within a 2 km radius of the proposed facility.
- Pump testing of the proposed production borehole.
- Groundwater sampling and chemical analyses.
- Groundwater reserve determination
- Groundwater impact assessment and mitigation measures.

3 METHODOLOGY

3.1 Desktop Study

Geostratum assessed available geological and hydrogeological data prior to the commencement of the field work. Existing groundwater data was also reviewed and assessed during the desktop study. The following data sources were consulted during the study:

- 1:250 000 Geological Map – 2824 Kimberley
- 1:500 000 Hydrogeological Map – 2722 Kimberley
- Groundwater Resource Directed Measures (GRDM, 2013) obtained from the Department of Water and Sanitation (DWS).
- Registered water user database (WARMS) database
- NGA database, boreholes from the National Groundwater Database.

3.2 Hydrocensus

Geostratum conducted a hydrocensus survey on the 8th of July 2022 within a 2 km radius of the proposed abstraction borehole.

The following information was recorded:

- GPS co-ordinates and elevation of existing boreholes.
- Water levels of the boreholes, where accessible.
- Estimated abstraction volumes, where provided.
- Any other information regarding the water reliability or quality.
- Identifying surface water bodies and usage; and
- Determine groundwater usage and identify groundwater users.

3.3 Aquifer Testing

The borehole under consideration for water use authorisation (BetaSPP-BH4) was subjected to aquifer testing.

The borehole was aquifer tested by means of a mobile pump test unit and involved at 24-hour Constant Discharge test that was followed by recovery monitoring. During the pumping phase, the borehole is pumped at a constant rate for the duration of the test, during which the response of the water level due to pumping was monitored and measured using a handheld dip meter. At the cessation of the constant discharge pumping test the measurement of the recovering groundwater levels was conducted until groundwater level were within 95% of the pre-pumping conditions.

The aquifer test data was analysed with Aqtesolv v4.5 software and the Cooper Jacob method was used to determine the transmissivity of the aquifer. The transmissivity is defined as the measurement of the ease with which water will pass through the earth's material, expressed as the product of the average hydraulic conductivity and thickness of the saturated portion of an aquifer. It therefore indicated the ease at which water moves through the subsurface and is used to calculate rates of groundwater movement.

3.4 Groundwater Sampling and Quality Testing

Groundwater samples were collected from the proposed abstraction borehole (BetaSPP-BH4) and from another hydrocensus borehole (BetaSPP-BH1) on the 8th of July 2022. The samples were submitted to the IGS Laboratory Services at the University of the Free State, which is a SANAS-accredited laboratory for analysis services. The groundwater quality results were used to determine the preliminary groundwater condition. The samples were collected according to the following publications:

- ISO 5667-1: 2006 Part 1: Guidance on the design of sampling programs and sampling techniques.

- ISO 5667-3: 2003 Part 3: Guidance on preservation and handling of samples.
- ISO 5667-11: 2009 Part 11: Guidance on sampling of groundwater.
- DWAF Best Practice Guidelines Series G3: General Guidelines for Water Monitoring Systems.

3.5 Groundwater Reserve Determination

A groundwater reserve determination was completed to assess the status of the groundwater resource unit and to determine the scale of abstraction that can safely be abstracted in relation to the groundwater recharge. The groundwater reserve determination considers the following parameters:

- Area of sub-catchment delineation for the site.
- Effective recharge from rainfall and specific geology conditions.
- Basic Human Needs for the site.
- Groundwater contribution to surface water (baseflow).
- Existing abstraction; and
- Surplus if any available for abstraction.

4 PHYSIOLOGICAL DESCRIPTION

4.1 Locality of the site

The project site is located on a portion of the cadastral farm Talana 1241, which is located approximately 16 km east-southeast of the town of Hertzogville, in the Free State Province of South Africa (Figure 4-1).

4.2 Elevation and Drainage

The topography of the project site is flat with the only noticeable change in topography being a small hill at the north-western corner of the site and a portion of the foot slope of a hill located to the south of the site. The elevation of the project site ranges from ±1344 mamsl at its northern boundary roughly near the centre of the site to ±1374 mamsl at the top of the hill at the north-western corner of the site (Figure 4-2).

Coinciding with the topography, surface drainage across the central portion of the site is directed towards the north, while at its western boundary drainage is directed to the west.

Figure 4-1: Locality Map

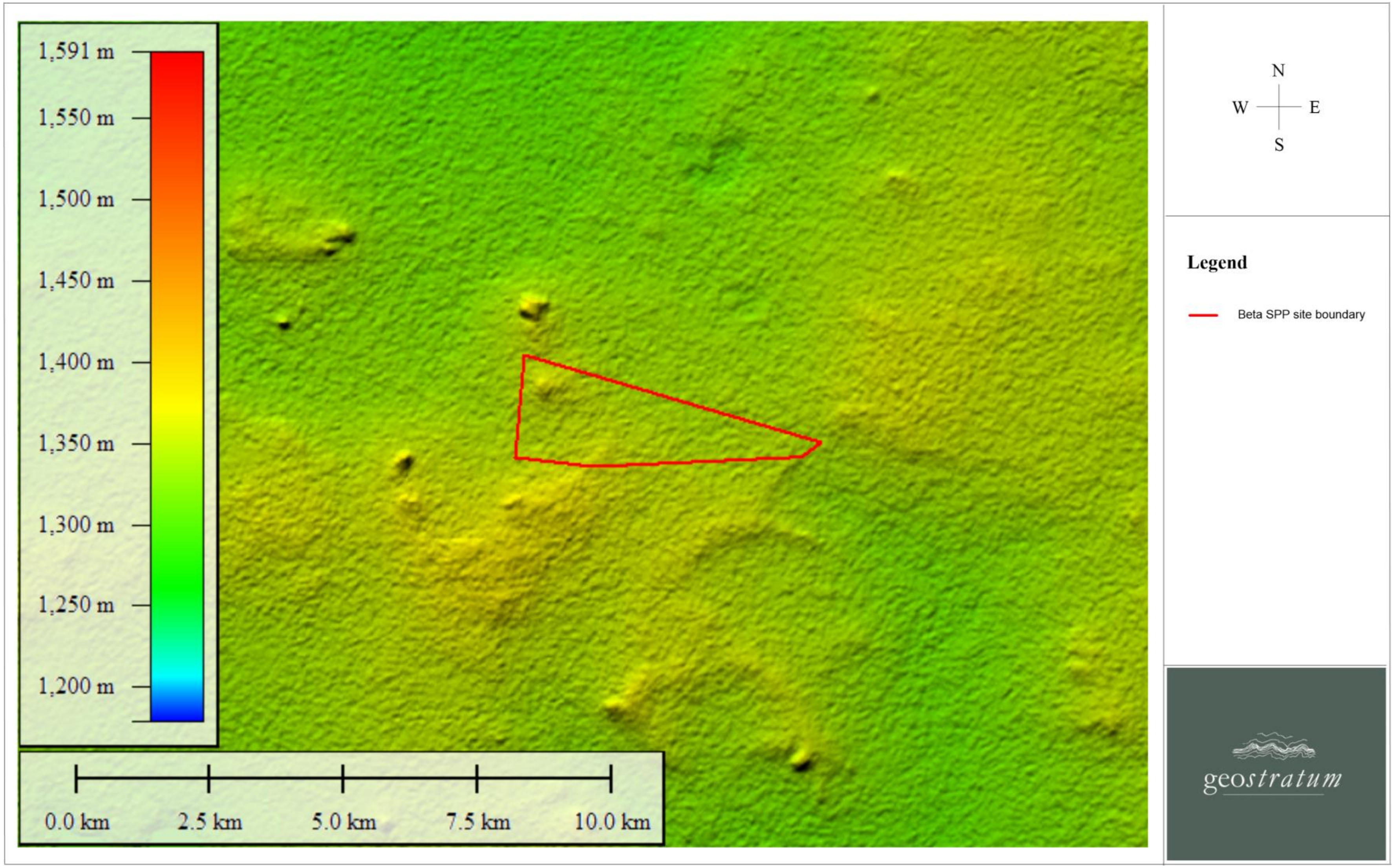

Figure 4-2: Elevation Map

4.3 Local Geology

According to the 1:250 000 Geological Map – 2824 Kimberley, the project site is underlain entirely by dolerite of Jurassic age. The dolerite has intruded into shales, siltstones and sandstones of the Tierberg Formation, which forms part of the Ecca Group of the Karoo Supergroup (Figure 4-3).

4.4 Local Hydrogeology

According to the 1:500 000 Hydrogeological Map – 2722 Kimberley, the local hydrogeology of the area is characterised by low-yielding intergranular and fractured aquifers, with median borehole yields of 0.0-0.1 l/s. The groundwater quality in the area is fairly good, with typical electrical conductivity values of 70 to 300 mS/m.

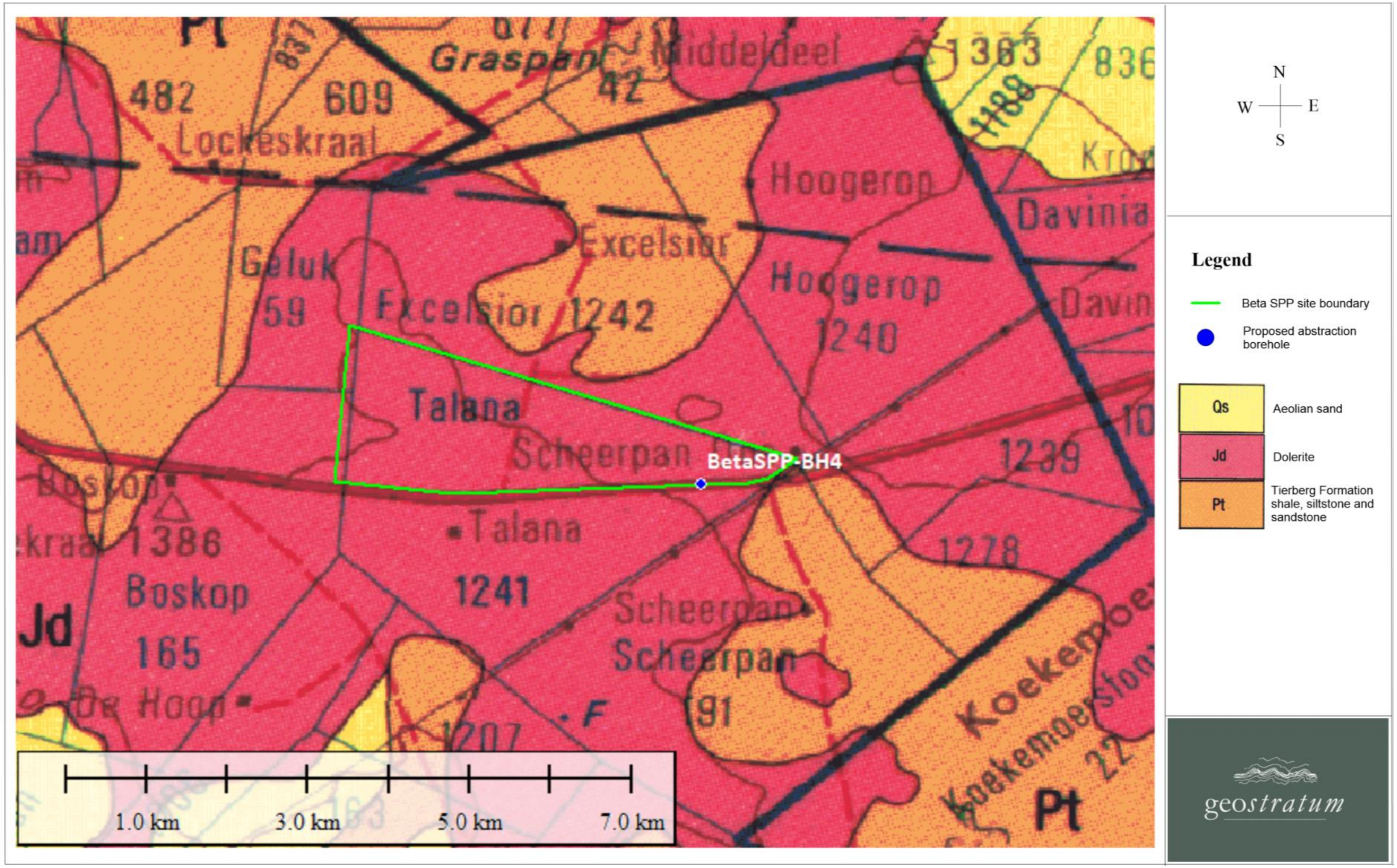

Figure 4-3: Geological Map – 2824 Kimberley

5 HYDROCENSUS

During the hydrocensus, five boreholes (excluding the proposed abstraction borehole) were identified. Information regarding the boreholes identified during the hydrocensus are presented in Table 5-1 and Table 5-2. Their locations are presented in Figure 5-1.

In addition to the hydrocensus, a WARMS database search was compiled for registered groundwater users within the sub-catchment in order to identify additional boreholes. The WARMS reports DW760 FREE STATE OFFICE QA Data Report 2019/10/28 and DW760 LOWER VAAL - NORTHERN CAPE KIMBERLEY OFFICE QA Data Report 2019/10/28 were consulted. According to the reports, there are no registered boreholes within the sub-catchment containing the project site.

5.1 Groundwater Levels and Yields

The static water levels (SWL) in the area are shallow and range from 1.58 to 3.76 meters below ground level (mbgl), with an average depth of about 2.44 mbgl.

The yields of the hydrocensus boreholes are unknown (owner could not provide an estimate).

5.2 Groundwater Use within the Sub-catchment

Groundwater abstraction rates of the hydrocensus boreholes in the sub-catchment are estimated to be ± 2.5 m^3/day since these boreholes are equipped with windpumps. These estimates may be considered an over-estimation of actual abstraction. Locally groundwater is used for agricultural (livestock watering) purposes.

The detailed groundwater reserve determination is discussed in Section 9 of the report.

Table 5-1: Proposed abstraction borehole

BH nr.	Lat	Long	Date drilled	Depth (m)	Collar height (m)	Static water level (mbgl)	Equipment	Estimated Yield (l/s)	User application	Abstraction (m³/day)	Field pH	Field EC (µS)	Field Temp (ºC)	Comments
Hansie Labuschagne - 0827896233														
BetaSPP-BH4	-28.175250	25.684637	Unknown	13 - 15	0.10	2.12	Windpump	Unknown	Agriculture (Livestock)	±2.5	7.01	1058.0	16.9	Sample sent for Lab analysis. Strongest yielding Borehole. BH closest to prospective solar farm.

Table 5-2: Hydrocensus summary

BH nr.	Lat	Long	Date drilled	Depth (m)	Collar height (m)	Static water level (mbgl)	Equipment	Estimated Yield (l/s)	User application	Abstraction (m³/day)	Field pH	Field EC (µS)	Field Temp (ºC)	Comments
Hansie Labuschagne - 0827896233														
BetaSPP-BH1	-28.175837	25.662188	Unknown	Unknown	0.28	2.25	Windpump	Unknown	Agriculture (Livestock)	±2.5	7.27	1246.0	5.2	Sample sent for Lab analysis. Close to prospective solar farm
BetaSPP-BH2	-28.175630	25.662665	Unknown	Unknown	0.60	1.73	Windpump	Unknown	Agriculture (Livestock)	±2.5	7.25	1295.0	10.3	Close to prospective solar farm
BetaSPP-BH3	-28.171595	25.673195	Unknown	30 - 36	0.05	1.58	Windpump	Unknown	Agriculture (Livestock)	±2.5	~	~	~	Deepest borehole approximately 30m to 36m. Weak yield. Windpump currently disconnected. No space for bailer for Field pH and EC
BetaSPP-BH5	-28.163906	25.676945	Within last 3 years	Unknown	0.55	3.76	Submersible	Unknown	Agriculture (Livestock)	±2.5	7.37	788.0	19.0	Solar powered submersible pump
BetaSPP-BH6	-28.164191	25.676777	Unknown	Unknown	0.36	3.18	Windpump	Unknown	Agriculture (Livestock)	±2.5	7.3	821.0	18.9	

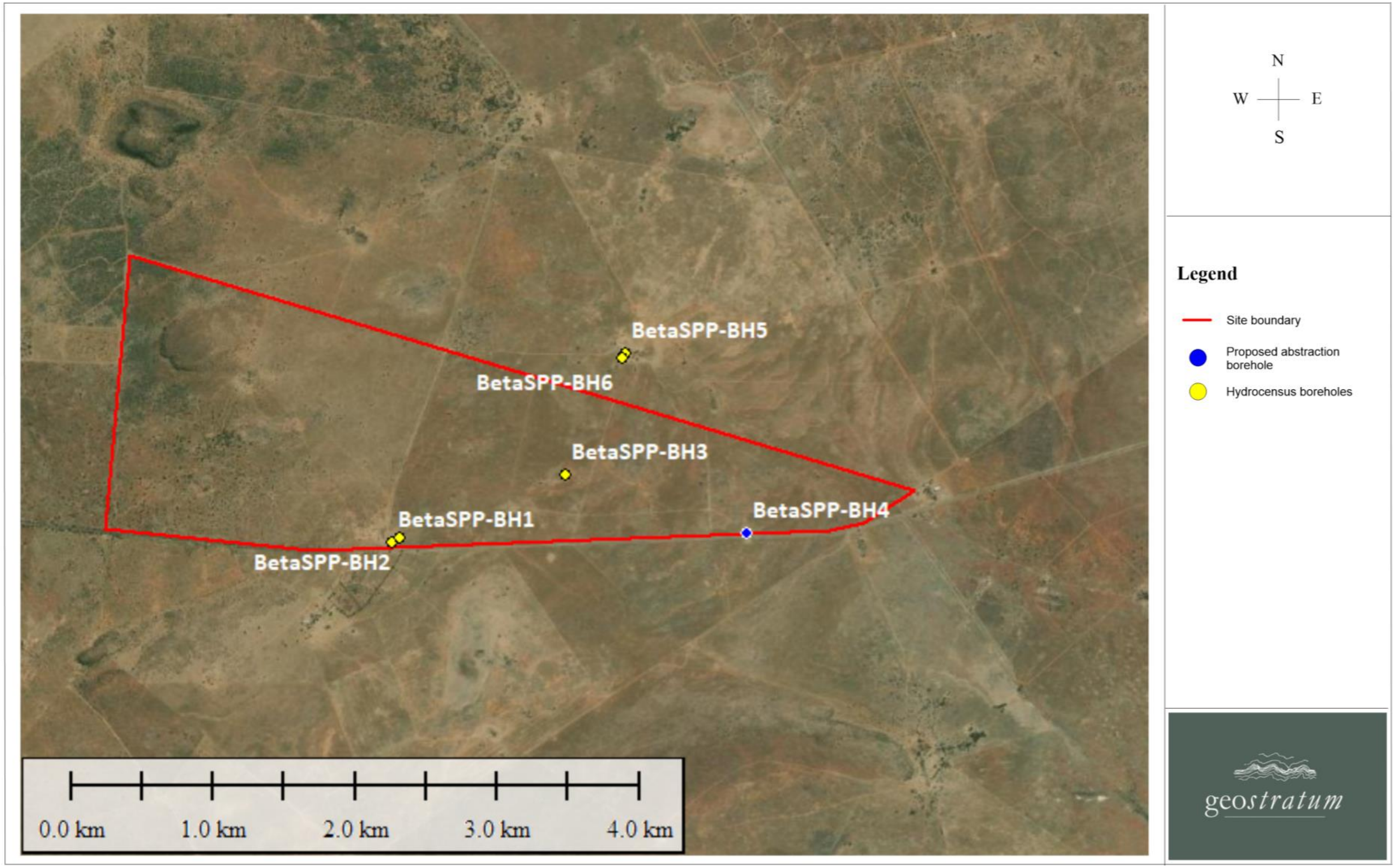

Figure 5-1: Spatial distribution of hydrocensus boreholes

6 AQUIFER TESTING

A constant discharge pumping test and recovery test was conducted on one (1) existing borehole on site, namely BetaSPP-BH4 (Table 6-1). The location of BetaSPP-BH4 with respect to the project area is shown in Figure 5-1.

Table 6-1: Aquifer pump test programme for BetaSPP-BH4

Borehole ID			BetaSPP-BH4
Coordinates	Latitude	[-]	-28.175250°S
	Longitude	[-]	25.684637°E
Static Water Level		[mbgl]	2.13
Pump System Information	Pump Inlet	[mbgl]	20
	Electronic Flow Meter	[-]	n/a
Constant Discharge Test	Available Drawdown[1]	[m]	17.87
	Duration	[min]	1440
	Yield	[l/s]	2.8
	Maximum Drawdown	[m]	9.27
Recovery Test	Duration	[min]	12
	Recovery Amount	[%]	100

Note/s:

- mbgl - metres below ground level
- mamsl - metres above mean sea level
- m – metres
- l/s - Litres per second
- min – minutes
- % - present

[1]Available drawdown is the difference between pump inlet and static water level

The drawdown and recovery curves from the constant discharge pumping test and recovery monitoring are provided in Figure 6-1. The aim of the test is to determine if the borehole will be suitable to deliver the proposed water demand for the solar power facility.

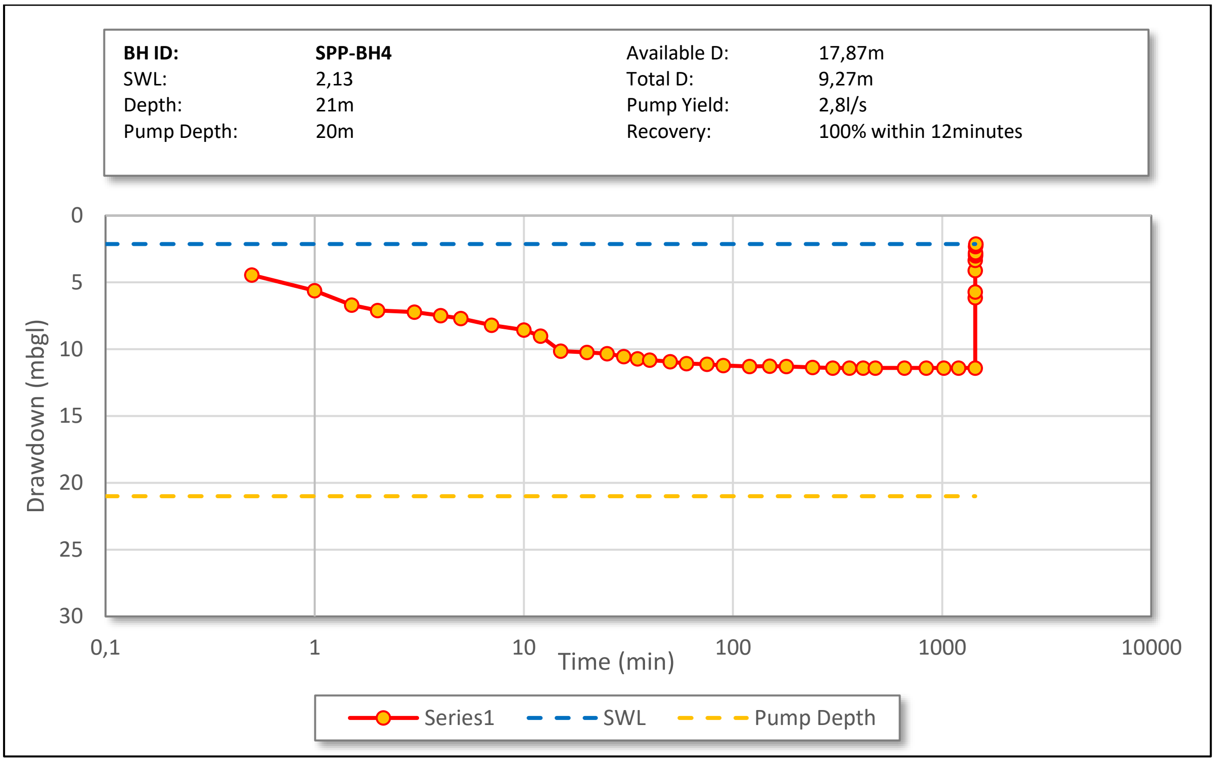

Figure 6-1: Drawdown vs time for borehole BetaSPP-BH4

6.1 Sustainable Abstraction Rate

The sustainable abstraction rate of borehole BetaSPP-BH4 has been calculated from analytical methods, using the constant rate test data. The following criteria have been used in defining the sustainable yield:

- Sustainable yield calculation was based on an 18-hour abstraction schedule.
- No groundwater recharge was accounted for in the analytical calculations to allow for a more conservative approach.

The sustainable abstraction calculations contain the following limitations:

- Little information is available in terms of groundwater boundaries, including aquifer limits, low permeable barriers and recharge flux boundaries. These boundaries will impact on the medium to long-term groundwater drawdown response.
- No borehole and/or formation skin effects were taken into account. These skin effects could result in turbulent flow and increase drawdown.

Drawdown and abstraction rate (Q) were determined using the Cooper-Jacob equation:

$$s = \frac{2.3Q}{4\pi T} Log \frac{2.25Tt}{r^2 S}$$

Where:

- s - Drawdown [m].
- Q - Yield [m3/d]
- T - Transmissivity [m2/d]
- t - Time [d]
- r - Radius [m]; and
- S - Storativity [unit less]

Table 6-2 summarises the estimated safe sustainable abstraction rate for BetaSPP-BH4 for an 18-hour daily pump rate. The safe sustainable yield calculated for the borehole is 2.0 l/s for 18 hours per day.

Table 6-2: Safe sustainable abstraction for BetaSPP-BH4

Borehole ID			BetaSPP-BH4
Pump Inlet Depth		[mbgl]	20
Sustainable Abstraction Rate	[18-hour Daily Pump Schedule]	[l/s]	2.0
		[l/day]	129 600
		[m^3/day]	129.6

Note/s:

- mbgl - metres below ground level
- l/s - litres per second
- l/day - litres per day
- m^3/day - cubic meters per day

The safe sustainable yield calculated with the Cooper-Jacob equation is lower than the abstraction rate during the constant discharge pump test. As a rule of thumb, the proposed safe sustainable yield should not exceed the abstraction rate used during the constant discharge test.

7 GROUNDWATER QUALITY

Groundwater samples were collected from boreholes BetaSPP-BH1 and BetaSPP-BH4 on the 8th of July 2022. The sample was submitted to a SANAS-accredited laboratory, the IGS Laboratory Services of the University of the Free State based in Bloemfontein, South Africa. A summary of the groundwater quality results and comparison against the SANS: 241 (2015) Drinking Water Standards are presented in Table 7-1. The laboratory certificates are attached in Appendix B.

Table 7-1: Water Quality Compared to Drinking Water Standards

Parameters	Unit	SANS: 241 (2015) Drinking Water Standards	08/07/2022	08/07/2022
			BetaSPP-BH1	BetaSPP-BH4
pH at 25 °C	pH units	> 5 - < 9.7	6.64	6.78
Electrical Conductivity as EC at 25 °C	mS/m	*170*	129.41	108.22
Total dissolved solids (TDS)	mg/l	*1200*	851.87	663.64
Total Alkalinity as $CaCO_3$	mg/l	*NS*	339.4	362.87
Chloride as Cl	mg/l	*300*	98.02	56.42
Sulphate as SO_4	mg/l	*250*	139.88	69.13
Nitrate (NO_3) as N	mg/l	*11*	6.11	2.09
Fluoride (F)	mg/l	*1.5*	0.40	0.57
Calcium (Ca)	mg/l	*100*	136.27	68.16
Magnesium (Mg)	mg/l	*70*	76.05	37.76
Sodium (Na)	mg/l	*200*	30.41	47.66
Potassium (K)	mg/l	*50*	7.12	21.07
Aluminium (Al)	mg/l	*0.3*	<0.01	<0.01
Arsenic (As)	mg/l	*0.01*	0.016	<0.01
Barium (Ba)	mg/l	*0.7*	0.083	0.091
Cadmium (Cd)	mg/l	*0.003*	<0.005	<0.005
Cobalt (Co)	mg/l	*0.5*	<0.020	<0.020
Chromium (Cr)	mg/l	*0.05*	<0.010	<0.010
Copper (Cu)	mg/l	*2*	<0.010	<0.010
Iron (Fe)	mg/l	*2*	0.455	0.200
Manganese (Mn)	mg/l	*0.4*	0.028	0.016
Nickel (Ni)	mg/l	*0.07*	<0.005	<0.005
Lead (Pb)	mg/l	*0.01*	<0.017	<0.017
Selenium (Se)	mg/l	*0.04*	<0.005	<0.005
Vanadium (V)	mg/l	*NS*	<0.010	<0.010
Zinc (Zn)	mg/l	*5*	0.271	0.710
Total hardness as $CaCO_3$	mg/l	*NS*	653.43	325.70
Calcium Hardness	mg/l	*NS*	340.25	170.20
Magnesium Hardness	mg/l	*NS*	313.18	155.50
Notes:	*NS -*	*No Standard*		
	BDL -	*Below Detection Limit*		
	mS/m -	*Millisiemens per meter*		
	mg/l -	*Milligram per litre*		
	ug/L -	*Microgram per litre*		

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meq -	*Milliequavalent*
x -	*parameter exceeds standard*

The quality of the samples collected can be described as near-neutral (pH: ±7.0), saline (TDS: 450-1000 mg/l) and very hard (Total hardness: 300-700 mg $CaCO_3$/l). As seen in Table 7-1, the concentrations of calcium, magnesium and arsenic in sample BetaSPP-BH1 slightly exceeds the SANS: 241 (2015) standards. None of the chemical parameters of BetaSPP-BH4 exceed the SANS: 241 (2015) standards. Consequently, the overall water quality from BetaSPP-BH4 is better than that of BetaSPP-BH1. The results indicate that the water from the proposed production borehole (BetaSPP-BH4) is unaffected by pollution, of overall good quality, fit for human consumption and suitable for use for the purposes of the power plant.

A Piper diagram (Figure 7-1) was created using WISH version 3.02 software to characterize the water analysed.

A Piper diagram is utilized to characterize water types in a graphical manner and to distinguish any specific water types presented by the samples.

The Piper diagram was quartered to simplify this process. The position of the water samples on the plot is based on the ratio of the various constituents measured in equivalence and is not an indication of the absolute water quality or the suitability thereof for domestic consumption.

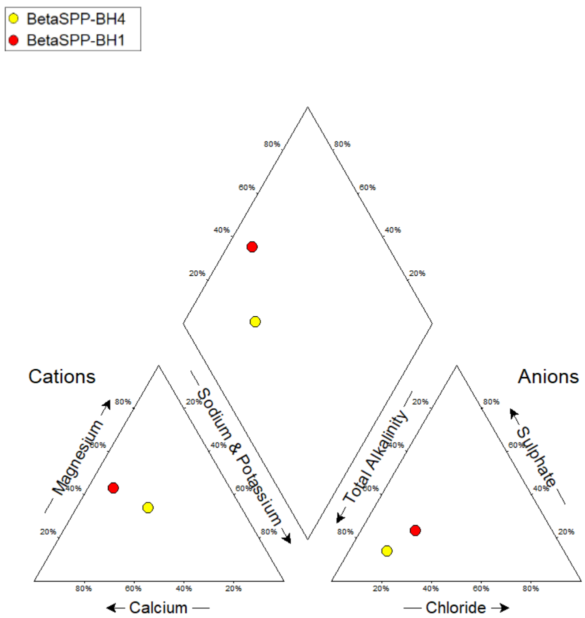

Figure 7-1: Piper diagram

Based on the Piper Diagram it can be concluded that the water quality from the two boreholes fall within the Calcium-Magnesium Bicarbonate type.

8 WATER DEMAND

The water demand of the proposed solar facility during its construction and operation is presented below. The water demand of the facility can be regarded as the proposed groundwater abstraction volumes.

8.1 Construction Phase

The water demand during the construction phase of the facility (lasting 15 months) is given in Table 8-1. The water demands were provided by Subsolar and drinking water use is excluded since potable will be provided by bottled water.

Table 8-1: Water demand during the construction phase

Facility	Water demand	
	[m^3/annum]	[m^3/day]
Beta SPP	29 298.4	80.3

8.2 Operation Phase

The water demand during the operation phase of the facility (lasting 20 years) is given in Table 8-2. The abstraction volumes were provided by Subsolar and drinking water use is excluded since potable will be provided by bottled water.

Table 8-2: Water demand during the operation phase

Facility	Water demand	
	[m^3/annum]	[m^3/day]
Beta SPP	4 092	11.2

8.3 Available Water Supply

As discussed in Section 6.1 above, the safe sustainable yield of the proposed abstraction borehole is approximately 129.6 m^3/day for an 18-hour daily pumping schedule. The water demand for the project facility equals:

- 80.3 m^3/day during construction (15 months)
- 11.2 m^3/day during operation (20 years)

Thus, the capacity of the proposed abstraction borehole exceeds the water demand of both the construction and operation phases and therefore the borehole may be considered as a suitable source of water supply during the construction and operation of the facility.

9 GROUNDWATER RESERVE DETERMINATION

9.1 Quaternary Catchment

Data from the relevant hydrogeological databases including the Groundwater Resource Directed Measures (GRDM) was obtained from the Department of Water and Sanitation. The project site is situated on the boundary between quaternary catchments C91C and C91B, however, the proposed abstraction borehole is located within quaternary catchment C91C. Information regarding catchment C91C is presented in Table 9-1.

Table 9-1: Summarised Quaternary Catchment Information (GRDM, 2013)

Quaternary Catchment ID		C91C
Total Area	[km^2]	3133.2
Mean Annual Precipitation	[mm/a]	430.4
Recharge	[mm/a]	4.2
Current Use	[m^3/d]	19897.92
Groundwater Contribution to Baseflow	[mm/a]	0.0
Population	[count]	24396

Note/s:

- km^2 - squared kilometer
- mm/a - millimeter per annum
- Mm^3/a - mega cubic meter per annum

9.2 Sub-catchment Delineation

In order to delineate a sub-catchment for the site within the quaternary catchment, Global Mapper was used. The programme provides a method to describe the physical characteristics of a surface. Using a digital elevation model as input, it is possible to delineate a drainage system and then quantify the characteristics of that system. The tools in the extension let you determine, for any location in a grid, the upslope area contributing to that point and the down slope path water would follow. This data is important during impact assessment. The delineated sub-catchment is presented in Figure 9-1.

The size of the sub-catchment equals 49.6 km^2.

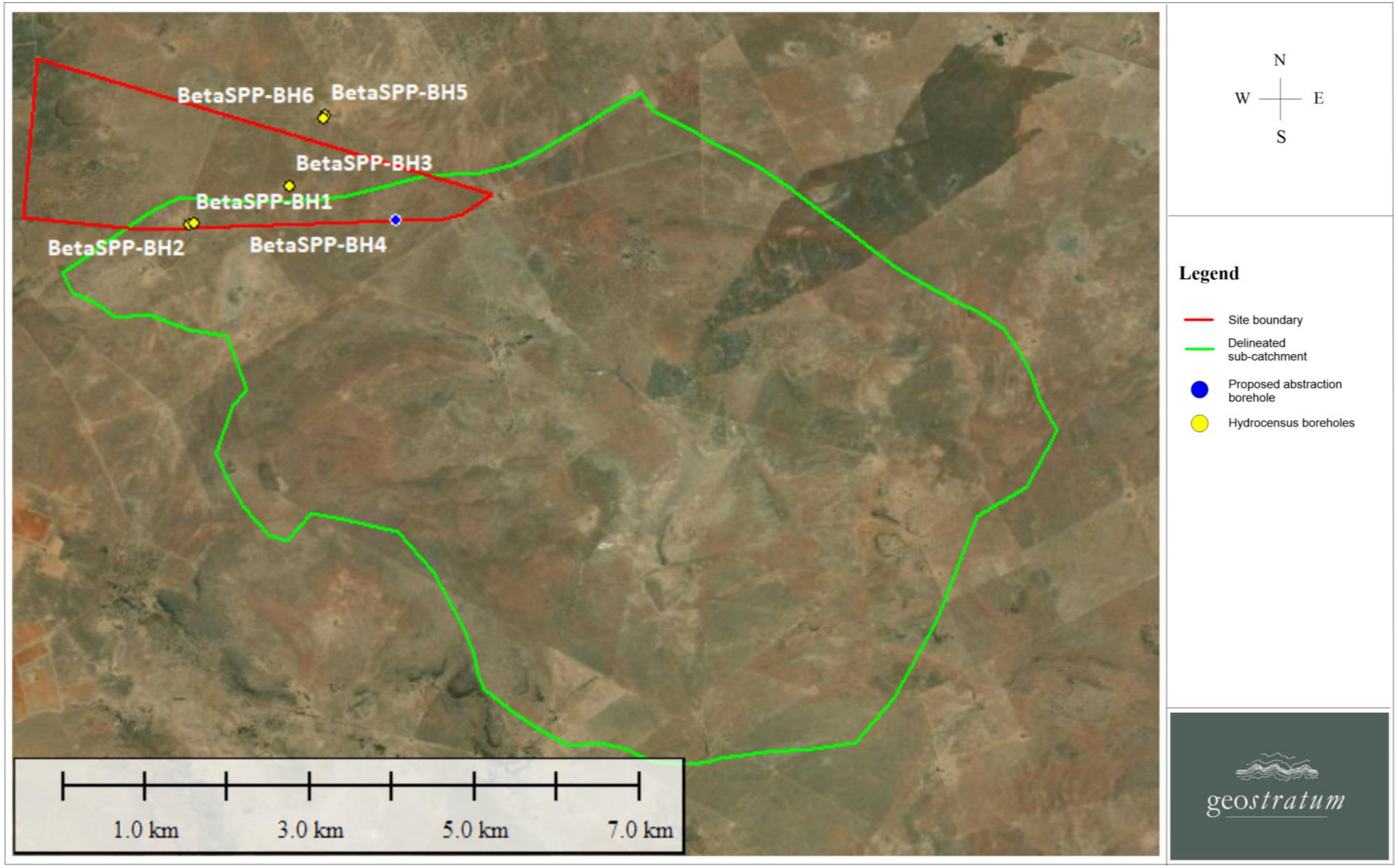

Figure 9-1: Delineated sub-catchment and identified boreholes

9.3 Groundwater Balance

A groundwater balance was calculated for the sub-catchment to determine the available groundwater for abstraction. The details regarding the water balance are given below.

9.3.1 Groundwater Recharge

Based on the literature review, a conservative average recharge of the geology is estimated between 1% and 2% of the annual rainfall.

1% of 430.4 mm/a = **4.3 mm/annum**

GRDM (2013) = **4.2 mm/annum**

9.3.2 Current Abstraction

Only two of the boreholes identified during the hydrocensus are located within the sub-catchment (and quaternary catchment) that contains the proposed abstraction borehole. The total abstraction from these boreholes amounts to about **5 m^3/day**.

No additional registered groundwater users were located within the sub-catchment delineated for the project site. This is based on data made available by the Water Registration Management System (WARMS).

9.3.3 Basic Human Need

The basic human needs are set by the Water Services Act (Act No. 108 of 1997) at 25 l per person per day. The reserve is calculated by multiplying the number of people living within the confines of a source unit by 25 l/day (0.025 m3/d). According to GRDM (2013), approximately 24 396 people live in the C91C quaternary catchment with an area of 3133.2 km^2. Therefore, on average 7.8 people can be found within any 1 km^2 in this quaternary catchment.

Basic human need in sub-catchment = **9.7 m^3/day**

9.3.4 Proposed Abstraction

The proposed abstraction volume by the Subsolar during the construction phase is approximately **80.3 m^3/day**. During the operation phase, the proposed abstraction volume is approximately **11.2 m^3/day**.

9.3.5 Groundwater Contribution to Baseflow

Baseflow is the low flow in a river during dry or fair-weather conditions, but not necessarily all contributes by groundwater, baseflow includes contributions from delayed interflow and groundwater discharge. The baseflow of groundwater into surface water bodies in the compartment is negligible (GRDM, 2013). This is expected since there are no perennial rivers passing through the sub-catchment.

9.4 Groundwater Balance

Groundwater balances were calculated for the sub-catchment during both the construction and operation phases and are presented in the sections below.

9.4.1 Construction Phase

Table 9-2 presents the water balance calculation completed for the duration of the construction phase which is set to last 15 months.

Table 9-2: Water balance calculation during the construction phase

Sub-catchment	Reserve Determination
Size	49.6 km^2
Groundwater Recharge	4.3 mm/a (0.0043 m/a) = 0.0043 m/a x 49 600 000 m^2 = 213 280 m^3/a = 584.33 m^3/day
Existing abstraction	GRDM: 314.99 m^3/day WARMS: 0 m^3/day Hydrocensus boreholes in sub-catchment: 5 m^3/day
Basic Human Need	9.7 m^3/day
Groundwater Contribution to Baseflow	0 m^3/day
Proposed Abstraction	80.3 m^3/day
Total use	409.95 m^3/day
Surplus amount	174.38 m^3/day
Scale of abstraction	70% of recharge (Class B medium-scale abstraction)

From the sub-catchment preliminary water balance calculation, medium-scale abstraction (Class B) is calculated for the 15-month duration of the construction phase.

9.4.2 Operation Phase

Table 9-3 presents the water balance calculation completed for the duration of the operation phase which is scheduled to last 20 years.

Table 9-3: Water balance calculation during the operation phase

Sub-catchment	Reserve Determination
Size	49.6 km^2
Groundwater Recharge	4.3 mm/a (0.0043 m/a) = 0.0043 m/a x 49 600 000 m^2 = 213 280 m^3/a = 584.33 m^3/day
Existing abstraction	GRDM: 314.99 m^3/day WARMS: 0 m^3/day Hydrocensus boreholes in sub-catchment: 5 m^3/day
Basic Human Need	9.7 m^3/day
Groundwater Contribution to Baseflow	0 m^3/day
Proposed Abstraction	11.2 m^3/day
Total use	340.85 m^3/day
Surplus amount	243.48 m^3/day
Scale of abstraction	58% of recharge (Class A small-scale abstraction, <60% of recharge)

From the preliminary sub-catchment water balance calculation, small-scale abstraction (Class A) is calculated for the 20-year duration of the operation phase.

9.5 Groundwater Quantity

The recent status of a groundwater resource unit can be assessed in terms of sustainable use, observed ecological impacts or water stress. Since no information about ecological impacts of groundwater abstraction is available, the concept of water stress was applied for the classification process.

The concept of stressed water resources is addressed by the National Water Act but is not defined. Part 8 of the Act gives some guidance by providing the following qualitative examples of 'water stress':

- Where demands for water are approaching or exceed the available supply.
- Where water quality problems are imminent or already exist; or
- Where water resource quality is under threat.

To provide a quantitative means of defining stress, a groundwater stress index was developed by dividing the volume of groundwater abstracted from a groundwater unit by the estimated recharge to that unit (Parsons and Wentzel, 2007). However, this concept does not take into cognisance of the impact of other land use practices on groundwater and surface water resources. It is therefore proposed to modify the stress index by taking the groundwater contribution to baseflow into account. The modified stress index reads then:

$$Stress\ Index = \frac{Groundwater\ Abstraction}{Recharge - Baseflow}$$

The stress-index and classes described in Table 9-4 and Table 9-5, are a guide for determining the level of stress of a groundwater resource unit, based on abstraction, baseflow and recharge (modified after Parsons and Wentzel, 2007). The tables are populated with the values pertaining to the construction phase – as an example. The stress index and class for the operation phase is presented Section 9.5.2 below.

Table 9-4: Stress Index Calculations

Sub- Compartment Total Abstraction (Including proposed abstraction)	**[m³/d]**	409.95
Sub- Compartment Baseflow	**[m³/d]**	0
Sub-Catchment Recharge	**[m³/d]**	584.33
Stress Index	**[-]**	0.70

Note/s:

- m^3/d - cubic metres per day

Table 9-5: Guide for determining the level of stress of a groundwater resource unit

Present Status Category	Description	Stress Index
A	Unstressed or low level of stress	<0.05
B		0.05 – 0.2
C	Moderate levels of stress	0.2 – 0.5
D		**0.5 – 0.75**
E	Stressed	0.75 – 0.95
F	Critically stressed	>0.95

9.5.1 Construction Phase

During the construction of the project facility, the existing abstraction together with the proposed abstraction of 80.3 m^3/day will have a moderate level of stress impact (category D) on the groundwater resource unit (Table 9-5).

Therefore, according to the sub-catchment water balance calculation, groundwater may be used as a viable source of water for the construction of the solar power facility. The resource will however require monitoring and management.

9.5.2 Operation Phase

During the operation of the project facility, the existing abstraction together with the proposed abstraction of 11.3 m^3/day yielded a stress index of 0.58 – and therefore will have a moderate level of stress impact (category D) on the groundwater resource unit.

Therefore, according to the sub-catchment water balance calculation, groundwater may be used as a viable source of water for the operation of the solar power facility. The resource will however require monitoring and management.

10 GROUNDWATER IMPACT ASESSMENT

10.1 Impact Assessment Methodology

The impact assessment methodology assists in evaluating the overall effect of the proposed operations on the underlying aquifer. Determining of the significance of an environmental impact on an environmental parameter is determined through a systematic analysis.

10.1.1 Determination of Significance of Impact

Significance is determined through a synthesis of impact characteristics which include context and intensity of an impact. Context refers to the geographical scale (i.e., site, local, national or global), whereas intensity is defined by the severity of the impact e.g., the magnitude of deviation from background conditions, the size of the area affected, the duration of the impact and the overall probability of occurrence. Significance is calculated as shown in Table 10-1.

Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The total number of points scored for each impact indicates the level of significance of the impact.

10.1.2 Impact Rating System

The impact assessment must take account of the nature, scale and duration of effects on the environment and whether such effects are positive (beneficial) or negative (detrimental). Each issue/impact is also assessed according to the various project stages, as follows:

- Construction
- Operation

Where necessary, the proposal for mitigation or optimisation of an impact should be detailed. A brief discussion of the impact and the rationale behind the assessment of its significance has also been included.

10.1.3 Rating System Used to Classify Impacts

The rating system is applied to the potential impact on the receiving environment and includes an objective evaluation of the possible mitigation of the impact. Impacts have been consolidated into one (1) rating. In assessing the significance of each issue, the following criteria (including an allocated point system is used:

Table 10-1: Rating of impact criteria

ENVIRONMENTAL PARAMETER		
A brief description of the environmental aspect likely to be affected by the proposed activity (e.g., Surface Water).		
ISSUE / IMPACT / ENVIRONMENTAL EFFECT / NATURE		
Include a brief description of the impact of environmental parameter being assessed in the context of the project. This criterion includes a brief written statement of the environmental aspect being impacted upon by a particular action or activity (e.g., oil spill in surface water).		
EXTENT (E)		
This is defined as the area over which the impact will be expressed. Typically, the severity and significance of an impact have different scales and as such bracketing ranges are often required. This is often useful during the detailed assessment of a project in terms of further defining the determined.		
1	Site	The impact will only affect the site
2	Local/district	Will affect the local area or district
3	Province/region	Will affect the entire province or region
4	International and National	Will affect the entire country
PROBABILITY (P)		
This describes the chance of occurrence of an impact		
1	Unlikely	The chance of the impact occurring is extremely low (Less than a 25% chance of occurrence).
2	Possible	The impact may occur (Between a 25% to 50% chance of occurrence).
3	Probable	The impact will likely occur (Between a 50% to 75% chance of occurrence).
4	Definite	Impact will certainly occur (Greater than a 75% chance of occurrence).
REVERSIBILITY (R)		
This describes the degree to which an impact on an environmental parameter can be successfully reversed upon completion of the proposed activity.		
1	Completely reversible	The impact is reversible with implementation of minor mitigation measures
2	Partly reversible	The impact is partly reversible but more intense mitigation measures are required.
3	Barely reversible	The impact is unlikely to be reversed even with intense mitigation measures.
4	Irreversible	The impact is irreversible, and no mitigation measures exist.

IRREPLACEABLE LOSS OF RESOURCES (L)		
This describes the degree to which resources will be irreplaceably lost as a result of a proposed activity.		
1	No loss of resource.	The impact will not result in the loss of any resources.
2	Marginal loss of resource	The impact will result in marginal loss of resources.
3	Significant loss of resources	The impact will result in significant loss of resources.
4	Complete loss of resources	The impact is result in a complete loss of all resources.
DURATION (D)		
This describes the duration of the impacts on the environmental parameter. Duration indicates the lifetime of the impact as a result of the proposed activity.		
1	Short term	The impact and its effects will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (0 – 1 years), or the impact and its effects will last for the period of a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years).
2	Medium term	The impact and its effects will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years).
3	Long term	The impact and its effects will continue or last for the entire operational life of the development but will be mitigated by direct human action or by natural processes thereafter (10 – 50 years).
4	Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered transient (Indefinite).
INTENSITY / MAGNITUDE (I / M)		
Describes the severity of an impact (i.e., whether the impact has the ability to alter the functionality or quality of a system permanently or temporarily).		
1	Low	Impact affects the quality, use and integrity of the system/component in a way that is barely perceptible.
2	Medium	Impact alters the quality, use and integrity of the system/component but system/ component still continues to function in a moderately modified way and maintains general integrity (some impact on integrity).

3	High	Impact affects the continued viability of the system/component, and the quality, use, integrity and functionality of the system or component is severely impaired and may temporarily cease. High costs of rehabilitation and remediation.
4	Very high	Impact affects the continued viability of the system/component, and the quality, use, integrity and functionality of the system or component permanently ceases and is irreversibly impaired (system collapse). Rehabilitation and remediation often impossible. If possible, rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation.
SIGNIFICANCE (S)		
Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. This describes the significance of the impact on the environmental parameter. The calculation of the significance of an impact uses the following formula: **Significance = (Extent + probability + reversibility + irreplaceability + duration) x magnitude/intensity.** The summation of the different criteria will produce a non-weighted value. By multiplying this value with the magnitude/intensity, the resultant value acquires a weighted characteristic which can be measured and assigned a significance rating.		
Points	Impact Significance Rating	Description
5 to 23	Negative Low impact	The anticipated impact will have negligible negative effects and will require little to no mitigation.
5 to 23	Positive Low impact	The anticipated impact will have minor positive effects.
24 to 42	Negative Medium impact	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.
24 to 42	Positive Medium impact	The anticipated impact will have moderate positive effects.
43 to 61	Negative High impact	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.
43 to 61	Positive High impact	The anticipated impact will have significant positive effects.
62 to 80	Negative Very high impact	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws".
62 to 80	Positive Very high impact	The anticipated impact will have highly significant positive effects.

10.2 Potential Groundwater Impacts

The potential groundwater impacts from the proposed solar project, direct and indirect, are summarised in Table 10-2 below. The potential impacts contribute to the following major aspects:

- Potential changes in groundwater quality.
- Aquifer destruction / over abstractions of groundwater.
- Potential leakage / overflow from potential conservancy tanks

Table 10-2: Summary of potential groundwater impacts with respect to the proposed solar project

Major aspect	Key Environmental Issues/Potential Issues
Changes in groundwater quality	Spillage of fuels, lubricants and other chemicals from construction equipment, vehicles and temporary workshop areas will be a likely source of pollution during the constructional phase. Groundwater quality can also be influenced due to the contamination from different wastewater sources that could be constructed on site during the operational phase of the project. Wastewater contains a variety of contaminants for example micropollutants (such as microplastics, pharmaceuticals and endocrine disrupting chemicals which are present in low concentrations) or macropollutants (such as Petroleum Hydrocarbons (PHCs)). If any battery energy storage systems (BESS) are installed these would be a source of pollution as the batteries store a hazardous substance. There are a number of possible contamination sources identified. The sources of contamination are mostly originating from sources on surface, but the wastewater systems and any BESS installed underground would serve as a contaminate source within the subsurface. If any of the above mentioned contaminates reach the groundwater resource this could have adverse impacts on the aquifer and groundwater users.
Aquifer destruction /over abstractions of groundwater	The sustainable use of the groundwater is important to avoid water being pumped from the aquifer faster than it is being replenished. Over abstraction of the aquifer could result is decreasing water tables, empty wells, higher pumping costs and ultimately the destruction of the groundwater resource. It is therefore crucial to adhere to the sustainable safe yield and abstraction programs to ensure the aquifer is not overstressed.
Potential leakage / overflow from the conservancy tanks	In the event that large amounts of wastewater are continuously spilled on the surface, the wastewater would firstly infiltrate into the subsurface and thereafter it would systematically move through the unsaturated zone. The infiltrating wastewater would move down until the interface with the bedrock is encountered thereafter the following could occur: 1. The wastewater could collect on the less permeable rock interface (assuming there are no fractures) creating a perched aquifer system. Once larger volumes of wastewater collect the wastewater will start to move laterally along the bedrock towards the west as the lithology dip angle of around 6° to 8°to west. 2. If the wastewater collecting on the less permeable rock interface encounters fractures the wastewater would move, via fracture flow, down through the fractures where it could eventually reach the underlying groundwater.

10.3 Overall Impact Rating

Table 10-3 presents the rating and mitigation measures for potential groundwater impacts during construction and operation of the solar facility. It is recommended that the provided mitigation measures be included in the environmental management programme of the project.

Table 10-3: Rating of impacts and mitigations

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Construction Phase																				
Groundwater quality impacts due to spillage on surface	Spillage of fuels, lubricants and other chemicals from construction equipment, vehicles and temporary workshop areas will be a likely source of pollution if these pollutants can reach the groundwater.	1	2	1	2	1	2	14	-	Low	It is expected that without mitigation a low negative impact can be expected. Mitigation will include: -Bunded areas to store chemicals and/or fuel; and -Clean-up of spills as soon as they occur. By implementing these mitigations, the groundwater quality would likely not be negatively influenced.	1	1	1	2	1	2	12	-	Low
Aquifer destruction /over abstractions of groundwater	Over abstraction of the aquifer could result is decreasing water tables, empty wells, higher pumping costs and ultimately the destruction of the groundwater resource. The proposed water demand is significantly less than the actual capacity of the borehole. The groundwater reserve determined for the sub-catchment indicates that sufficient recharge occur in the catchment in order to ensure a sustainable abstraction program. However, the resource must be monitored and managed.	2	2	3	2	3	2	24	-	Medium	It is expected that without mitigation a medium risk can be expected. Mitigation will include: -Developing a sustainable abstracting programme from the aquifer testing results and calculated sustainable yield. -Groundwater level monitoring should be conducted, and data should be interpreted by a hydrogeologist. -All boreholes intended to be used for water supply will be licenced. The significance of the impact after mitigation is likely to decrease.	2	1	2	2	3	2	20	-	Low
Operation Phase																				

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Potential leakage / overflow from the conservancy tanks	In the event that large amounts of wastewater are continuously spilled on the surface, the wastewater would firstly infiltrate into the subsurface and thereafter it would systematically move through the unsaturated zone. The infiltrating wastewater would move down until the interface with the bedrock is encountered. Temporal Conservancy Tanks will be installed on site will cater for a minimum of 60% of wastewater produced for sanitary use (6 850 m3/a). The rest of the wastewater will be disposed on a daily basis with the use of mobile ablution facilities. The placement of the conservancy tank should be down gradient of any production borehole to (at least 200m from the boreholes) to ensure that potential leakages / overflow from the tanks does not negatively affect the groundwater quality.	1	1	2	3	2	2	22	-	Low	It is expected that without mitigation a low risk can be expected. Mitigation will include: -Ensure adequate lining and drainage systems are installed. -Ensure surface water runoff is contained and treated before disposal	1	1	2	2	1	2	18	-	Low

11 PROPOSED MONITORING PLAN

11.1 Groundwater Levels

It is recommended that the groundwater level of the abstraction borehole (BetaSPP-BH4) be monitored continuously by means of an electronic logger. The water levels of boreholes BetaSPP-BH1, BetaSPP-BH2 and BetaSPP-BH3 should be monitored quarterly in order to monitor the impact of the proposed abstraction over time (Table 11-1 and Figure 11-1). Comparison between the static and dynamic levels should be done over time in order to ensure the sustainability of the groundwater unit.

The water level data should be interpreted by a Hydrogeologist on an annual basis.

11.2 Groundwater quality

Water quality monitoring should be done biannually for boreholes BetaSPP-BH4, BetaSPP-BH1, BetaSPP-BH2 and BetaSPP-BH3. Analyses should include the parameters listed in Table 11-2.

Table 11-1: Groundwater monitoring plan

Monitor location	Latitude	Longitude	Water level monitoring	Quality monitoring
BetaSPP-BH4	-28.175250°S	25.684637°E	Continuously	Biannually
BetaSPP-BH1	-28.175837°S	25.662188°E	Quarterly	Biannually
BetaSPP-BH2	-28.175630°S	25.662665°E	Quarterly	Biannually
BetaSPP-BH3	-28.171595°S	25.673195°E	Quarterly	Biannually

Table 11-2: Parameters to be analysed during quality monitoring

Chemical Parameters	
pH at 22oC (pH units)	Calcium, Ca
Conductivity mS/m @ 25°C	Magnesium, Mg
Total dissolved solids (TDS)	Sodium, Na
Total Alkalinity as CaCO3	Potassium, K
Total Hardness as CaCO3	Iron, Fe
Chloride, Cl	Aluminium, Al
Sulphate, SO4	Manganese, Mn
Fluoride, F	Bacteria , E-coli , Total Coliforms and Faecal Coliforms
Nitrate as N	
Nitrate as NO3	
Ammonia (NH3) as N	
Nickel, Ni	
Zinc, Zn	

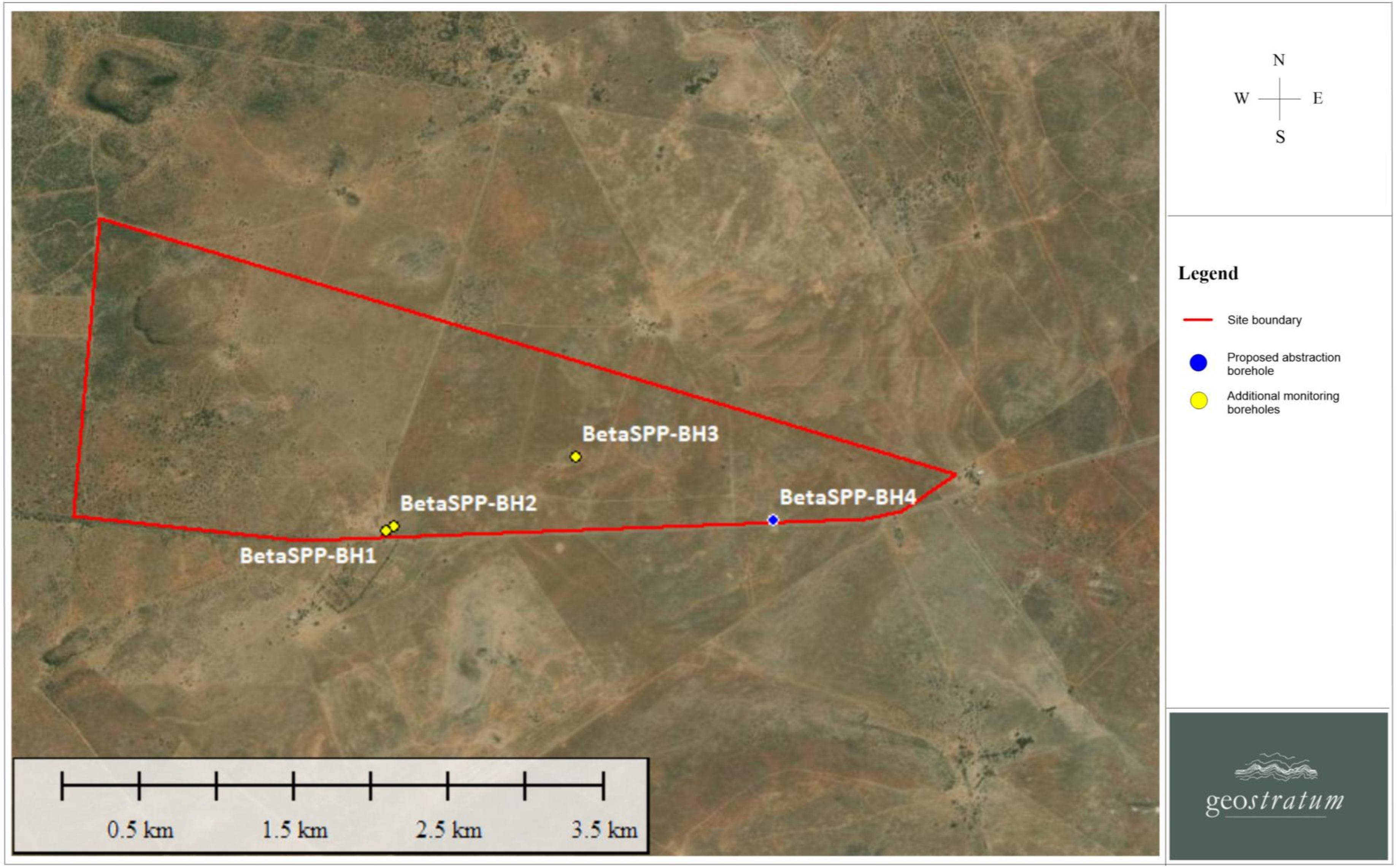

Figure 11-1: Monitoring locations

12 CONCLUSION

Geostratum (Pty) Ltd (Geostratum) was appointed by Environamics on behalf of Subsolar to carry out a Hydrogeological Study for the new proposed Beta Solar Power Plant. The project area is located approximately 16 km east-southeast of the town of Hertzogville, in the Free State Province of South Africa.

The main findings of the study are listed below:

- The 1:250 000 Geological Map – 2824 Kimberley indicates that the project site is underlain by dolerite of Jurassic age that has intruded into shales, siltstones and sandstones of the Tierberg Formation, which forms part of the Ecca Group of the Karoo Supergroup.
- The 1:500 000 Hydrogeological Map – 2722 Kimberley indicates that the local hydrogeology of the area is characterised by low-yielding intergranular and fractured aquifers, with median borehole yields of 0.0-0.1 l/s.
- During the hydrocensus, five boreholes were identified within a 3 km radius of the borehole under consideration for water use authorisation. However, only two of these are located within the quaternary catchment containing the proposed abstraction borehole.
- The static water levels (SWL) in the area are shallow and range from 1.58 to 3.76 mbgl, with an average depth of about 2.44 mbgl.
- Groundwater abstraction rates in the area range from 0.4 to 4566 m^3/day. Locally groundwater is used primarily for irrigation as well as for domestic purposes and livestock watering.
- The aquifer test conducted on the proposed production borehole (BetaSPP-BH4) indicated that a sustainable yield of 129.6 m^3/day (or 2 l/s) for an 18-hour daily pump schedule is appropriate.
- Based on the provided water demand of the solar power facility, the capacity of the proposed abstraction borehole exceeds the demand of the construction and operation phase of the project.
- The quality of the water from the proposed abstraction borehole (BetaSPP-BH4) is good, fit for human consumption and suitable for use by the power plant. The concentration of all the chemical constituents analysed are below the thresholds of the SANS: 241 (2015) Drinking Water Standards.
- From the sub-catchment water balance calculation, medium-scale abstraction (Class B) is calculated when the proposed abstraction is included for the duration of the construction phase, and small-scale abstraction (Class A) is calculated for the duration of the operation

phase. The total abstraction will have a moderate level of stress impact on the groundwater resource unit during both phases. Therefore, the resource will require monitoring and management.

The following recommendations are listed in the study:

- The rate of groundwater abstraction recommend in this report should be adhered to.
- The groundwater level of the abstraction borehole (BetaSPP-BH4) be monitored continuously by means of an electronic logger.
- The water levels of boreholes BetaSPP-BH1, BetaSPP-BH2 and BetaSPP-BH3 should be monitored quarterly in order to monitor the impact of the proposed abstraction over time.
- The water level data should be interpreted by a Hydrogeologist on an annual basis.
- Water quality monitoring should be done biannually for boreholes BetaSPP-BH4, BetaSPP-BH1, BetaSPP-BH2 and BetaSPP-BH3.

13 REFERENCES

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Appendix A

Description	Photo
Beta BH1	
Beta BH2	
Beta BH4	

Beta BH6	
Beta BH5	

Appendix B

Water Quality Certificate

Institute for Groundwater Studies
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SEC 7.8 F1
Revision 19

sanas Testing Laboratory T0695

Test Report **Case no: 2022 - 511** Page 2 of 2

Determinand	Units	Methods used	BH1	BH4
Date received:	08/07/2022		Client sample name: $$	
			Lab number:	
			511-1	511-2
			value	value
Chemical report:				
pH	pH units	Chem-TM01	6.64	6.78
Electrical conductivity	mS/m	Chem-TM02	129.41	108.22
Calcium as Ca	mg/L	Chem-TM19	136.27	68.16
Magnesium as Mg	mg/L	Chem-TM19	76.05	37.76
Sodium as Na	mg/L	Chem-TM19	30.41	47.66
Potassium as K	mg/L	Chem-TM19	7.12	21.07
Alkalinity #	mg/L	Chem-TM05	339.40	362.87
Fluoride as F	mg/L	Chem-TM13	0.40	0.57
Chloride as Cl	mg/L	Chem-TM06	98.02	56.42
Nitrate as N #	mg/L	Chem-TM09	6.11	2.09
Sulphate as SO_4	mg/L	Chem-TM19	139.88	69.13
Calcium Hardness	mg/L	Chem-TM20	340.25	170.20
Magnesium Hardness	mg/L	Chem-TM20	313.18	155.50
Total Hardness as $CaCO_3$	mg/L	Chem-TM20	653.43	325.70
Total Dissolved Solids	mg/L	Chem-TM20	851.87	663.64
Aluminium as Al	mg/L	Chem-TM19	<0.010	<0.010
Arsenic as As	mg/L	Chem-TM19	0.016	<0.010
Barium as Ba	mg/L	Chem-TM19	0.083	0.091
Cadmium as Cd	mg/L	Chem-TM19	<0.005	<0.005
Cobalt as Co	mg/L	Chem-TM19	<0.020	<0.020
Chromium as Cr	mg/L	Chem-TM19	<0.010	<0.010
Copper as Cu	mg/L	Chem-TM19	<0.010	<0.010
Iron as Fe	mg/L	Chem-TM19	0.455	0.200
Manganese as Mn	mg/L	Chem-TM19	0.028	0.018
Nickel as Ni	mg/L	Chem-TM19	<0.005	<0.005
Lead as Pb	mg/L	Chem-TM19	<0.017	0.014
Selenium as Se	mg/L	Chem-TM19	<0.005	<0.005
Vanadium as V	mg/L	Chem-TM19	<0.010	<0.010
Zinc as Zn	mg/L	Chem-TM19	0.271	0.710

Comments:

Results marked with (#) in this report, are not included in the SANAS Schedule of Accreditation for this laboratory.

Bacteriological results obtained from samples older than the prescribed 24 hours may deviate.

Data marked with blue dollar signs ($$) is provided by the customer.

MPN = cfu

(BAC-TM02) - no growth reported as <1

Ammendment reason: N/A

Signature: ______________________

Dr L Deysel (Technical signatory / Technical manager) (All Methods)

END OF REPORT