REPORT N^O 47579-R03

WATER ASSESSMENT FOR THE LETSOAI SOLAR FACILITIES: LETSOAI CSP SITE 1

BIOTHERM SOUTH AFRICA (PTY) LTD

CONFIDENTIAL

AUGUST 2016

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Final Split Report
Confidential

Project no: 47579
Date: 31 August 2016

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1 INTRODUCTION

1.1 STUDY

WSP | Parsons Brinckerhoff, Environment & Energy (WSP) was appointed in November 2015 by BioTherm Energy (Pty) Ltd (BioTherm) to undertake a Scoping and Environmental Impact Assessment (S&EIA) Process for a proposed renewable solar energy project located in the Northern Cape Province, near the small town of Aggeneys.

The proposed project site is located on a Farm RE86 in the Northern Cape, with the solar power farm area split into two areas, the Letsoia and Enamandla sites, outlined below:

- **Letsoia**, which consists of two concentrated solar power sites:
  - CSP 1
  - CSP 2
- **Enamandla**, which consists of five photovoltaic solar power sites:
  - Enamandla PV Site 1
  - Enamandla PV Site 2
  - Enamandla PV Site 3
  - Enamandla PV Site 4
  - Enamandla PV Site 5

There are seven individual Water Assessment Reports for the area (one for each of the above); this report primarily addresses **Letsoia CSP Project Site 1**.

1.2 PURPOSE OF THE REPORT

The purpose of this specialist Water Assessment Report is to evaluate the water component as part of the larger S&EIA Study for the proposed Solar Power Letsoia CSP Site 1, including:

- Site description and proposed technology;
- Water requirements (quality and quantity);
- Water resources including groundwater and geology (aquifer characteristics) and surface water and (quality and quantity);
- Quantity and quality requirements and availability;
- Environmental Flow Requirements (EFRs);
- Supply schemes, and the
- Water Service Authority (Sedibeng Water).

In addition, there have already been several options identified for conveyance of the water (pipelines) as well as powerlines, and these will be addressed on a high level basis.

2 SITE DESCRIPTION

2.1 LOCALITY

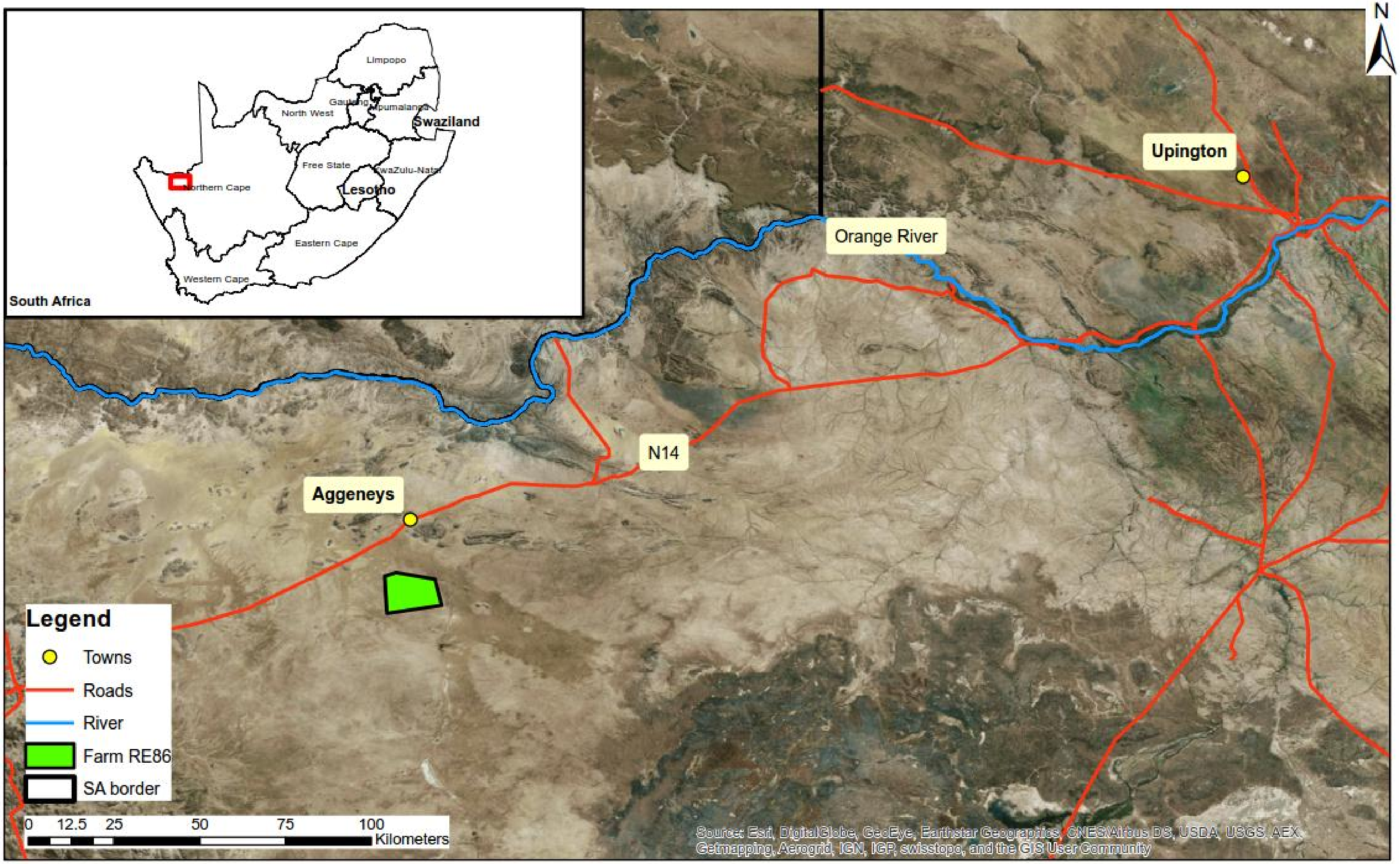
The proposed site is located on Farm RE86 (Hartebeest Vlei Farm) in the Northern Cape Province. The closest town is a small mining village, Aggeneys, which is 15 km north of the site. The main town of Upington is situated approximately 250 km north-east of the site. The Orange River is located 55 km north of the site, approximately 192 km from the Orange River Estuary entering the Atlantic Ocean (**Figure 1**).

The site is located within the Namakwa District Municipality (DM) and the Khai-Ma Local Municipality (LM). The towns located within the Khai-Ma LM are Aggeneys, Pofadder and Pella. The main economic sectors ae agriculture, tourism, community, social and personal services (The Local Government Handbook, accessed 2016).

The town of Aggeneys was established to accommodate the employees of the Black Mountain Mine (BMM) which is located approximately 11 km north of the site. Most municipal services within the town are provided and funded by the Black Mountain Mining Company. The main road of the N14 runs from Upington to Springbok and serves as the primary access route to Aggeneys and neighbouring towns.

The Study area is the Farm RE86, which has an area of 132 km^2, with the proposed Letsoia CSP Project Site 1 taking up 774 ha (7.74 km^2). Although the proposed site covers only part of the farm, the entire farm area was assessed in order to identify any fatal flaws which may result in the inability to use an area within a potential identified site.

WSP conducted a three day site visit in order to assess the water resources and associated availability (such as the presence of rivers, wetlands, groundwater) as well as soils, topography and to observe general conditions of the site as well as the larger area.



Farm RE86
(Lestsoai and Enamandla Sites)
Regional Setting

Data Source: South African Department of Rural Development and Land Reform - Chief Directorate: National Geo-spatial Information	**Project:** BioTherm	**Date:** 29 June 2016	WSP PARSONS BRINCKERHOFF www.wspenvironmental.co.za
	Project No: 47579		
	Drawn by: B Wickham	**Figure 1**	
Projection Geographic - (WGS 84)	**Reviewed by:** K Grimmer		

Figure 1 Farm RE86 (BioTherm Site) Regional Setting

2.2 HYDROLOGY

The Water Resources 2012 (WR2012) Study (Water Research Commission/Department of Water and Sanitation i.e. WRC/DWS, 2012) was used to obtain the hydrological data for the area. This Study modelled South Africa (including Lesotho and Swaziland) on a quaternary basis. Catchments are delineated into primary (e.g. D), secondary (e.g. D8), tertiary (e.g. D82) and quaternary (e.g. D82B), with quaternary catchments considered to be the generally accepted level of analysis or modelling.

South Africa is divided into 19 Water Management Areas (WMAs); the proposed solar power site is situated in the Lower Orange WMA. This WMA makes up the downstream portion of the Orange River Basin, which starts in the Lesotho Highlands headwaters of the Senqu River. The Upper Orange WMA, as well as the Upper, Middle and Lower Vaal WMA's all contribute to the Orange River Basin as a whole. As one moves westward along the Orange River, from the headwaters in Lesotho to the Atlantic Ocean, the drier the climate becomes (lower precipitation and higher evaporation).

The site is situated approximately 55 km south of the Orange River, the longest river in South Africa with the largest catchment area of almost 1 000 000 km^2. The headwaters of the Orange River is the Senqu River in Lesotho, flowing west towards the Atlantic Ocean, where it exits at Alexander Bay.

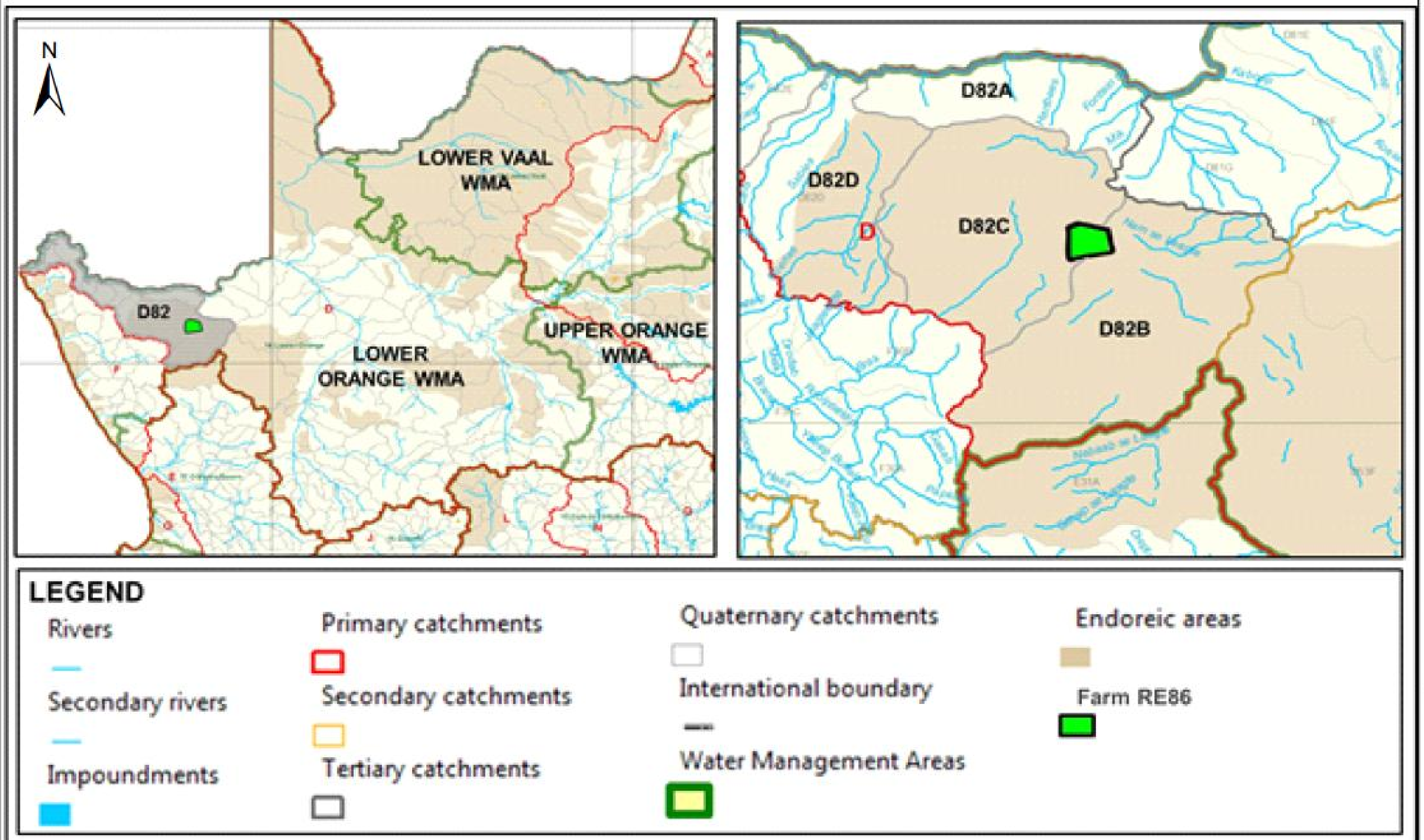
Within the Lower Orange WMA, the proposed site lies within tertiary D82, and overlays parts of the D82B and D82C quaternary catchments (**Figure 2**).

The D82 tertiary hydrological characteristics are shown in **Table 1** below, including catchment area, Mean Annual Precipitation (MAP), Mean Annual Evaporation (MAE) and Mean Annual Runoff (MAR).

Table 1 Tertiary D82: Quaternary Information (proposed site falls within D82B and D82C)

QUATERNARY	CATCHMENT AREA (KM^2)		MAP (mm)	MAE (mm)	MAR (million m^3/a)
	GROSS	NET			
D82A	1 917	1 917	77	2 650	0.28
D82B	4 877	0	80	2 650	0.00
D82C	3 996	0	83	2 650	0.00
D82D	2 967	1 075	111	2 650	0.60
D82E	944	944	100	2 549	0.75
D82F	1 039	1 039	106	2 401	1.00
D82G	594	594	79	2 401	0.19
D82H	822	822	60	2 401	0.09
D82J	1 385	1 385	29	2 401	0.01
D82K	917	917	31	2 201	0.01
D82L	754	619	42	2 401	0.02
TOTAL	**20 212**	**18 185**	**76**	**2 561**	**2.13**

Source: WRC/DWA, 2012



Lower Orange WMA (Left) and Quaternary Catchments (Right)	**Data Source:** WRC *(WR2012)*	**Project:** BioTherm	**Date:** 29 June 2016	WSP PARSONS BRINCKERHOFF
		Project No: 47579		
		Drawn by: B Wickham	**Figure 2**	
	Projection: Geographic - (WGS 84)	**Reviewed by:** K Grimmer		www.wspenvironmental.co.za

Figure 2 Lower Orange WMA (left) and Quaternary Catchments (right)

The MAE largely exceeds the MAP, resulting in very low runoff of the tertiary, reinforcing the arid conditions of the region, resulting in the lack of surface water resources such as wetlands and rivers. Quaternary catchments D82B and D82C, where the Letsoai CSP Project Site 1 is located, are 100% endoreic (**Figure 2**). An endoreic area does not contribute to runoff and thus rainfall on this area is lost and does not contribute to any streamflow. This accounts for the gross and net catchment areas shown in **Table 1** (net area is gross area less the endoreic area).

To accurately represent the quaternary catchment's rainfall, both temporally (record period) and spatially (catchment area), representative raingauges were identified and patched for missing or suspect data. This 'cleaned' data is then used to provide a catchment based rainfall file.

The raingauges identified proximal to the site, and their associated information, are provided in **Table 2**. The summary of the annual rainfall statistics (i.e. monthly maximum, minimum and average) is provided in **Table 3**.

Table 2 Rainfall Stations Information

RAIN GAUGE	MAP (MM)	PERIOD OF RECORD	LATITUDE	LONGITUDE
214 670	199	1920-1989	29.40	17.53
244 405	144	1920-2009	29.15	17.44
277 177	71	1960-1989	28.57	18.06
246 555	94	1947-2009	29.15	18.49

Source: WRC/DWA, 2012

Table 3 Lowest, Highest and Average Monthly Rainfall Values over the Record Period

RAINFALL STATISTIC (MM)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MAXIMUM	41.4	47.1	58.5	34.9	59.0	49.9	63.6	43.6	88.5	52.8	46.7	31.7
MINIMUM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AVERAGE	5.6	4.1	4.2	3.6	6.7	8.1	9.5	10.2	12.6	10.8	11.0	5.4

Source: WRC/DWA, 2012

2.3 GEOLOGY AND HYDROGEOLOGY

HYDROGEOLOGY

The topography of Farm RE86 is predominantly flat, with an average slope of 3.1% declining from the south west towards the north east. The elevation of the property ranges between 835 – 1009 meters above mean sea level (a.m.s.l), and characterised by 2 small mountain tops, which is typical of the area on the northern boundary.

The ranges of hills, mountains and inselbergs in the area display some of the most diverse and complex geology in Southern Africa including some of the richest known concentrations of copper, lead and zinc (Mining Technology, accessed 2016).

According to the original Environmental Management Programmes (EMPRs) the Aggeneys deposits occur in the Precambrian metavolcanic metasedimentary Bushmanland Group which forms part of the Namaqualand Metamorphic Complex. The Bushmanland Group is located within the Namaqualand-Natal Mobile Belt, with and area of approximately 18 000km^2 (RHDHV, 2013).

The project area, including Letsoai CSP Site 1, falls within the northern Aggeneys terrain of the Bushmanland Terrane group. The orebody at Gamsberg is hosted by iron sulphide-rich pelitic rocks and iron formation, and the economic mineralisation comprises sphalerite (zinc) and minor galena (lead).

The area includes deposits of zinc, lead, copper, and silver suitable for mining. A major zinc deposit containing mineral resources of 194Mt has been identified in the nearby Gamsberg inselberg (Mining Technology, accessed 2016). The underlying natural geology is considered to be representative of a poor aquifer, a low-yielding system of poor water quality with a least vulnerability to contamination and the low susceptible to anthropogenic activities.

Regional depth to groundwater is 30–50m bgl. However, from the water level measured from the three boreholes, the water level is between 27.74 m and 79.59m bgl. Due to deep underground mining, it can be expected that the groundwater level will be induced to drop. Average borehole yields are less than 0.5l/s, mean annual recharge is between 1-5mm per annum with the mean annual precipitation of between 20-150mm per annum. Groundwater quality is described as being Type D, dominated by sodium, potassium, chloride and sulphate ions, with dissolved solids typically ranging from 1000–1500mg/l.

2.4 LAND USE

Due to the arid conditions of the area, agricultural landuse within the area is primarily livestock farming including cattle and sheep. The landuse associated with Letsoai CSP Site 1 (Farm RE86) is primarily used for sheep grazing. Furthermore, antelope (Springbok) were spotted several times throughout the farm, which may offer potential hunting activities.

The boreholes driven by windmills supply water to small reservoirs and water tanks throughout the farm to supply water for the sheep.

Mining is prevalent in the surrounding area. Black Mountain Mine, located approximately 20 km from the Letsoia Site, has been in operation for over three decades, and is expected to continue operations until 2019. It is predominantly focussed on the mining of zinc, as well as silver, copper and lead. Due to the high mineral content in the area, the new Gamsberg Mine is under development, located approximately 25 km north-east of the Letsoia Site. The Gamsberg Mine is expected to have a life expectancy of at least 13 years, commencing in 2017, and will therefore be in operation until at least 2030.

There is also domestic settlement in the area; the small nearby town of Aggeneys was originally founded to service the employees of Black Mountain Mine, and continues to grow with the expanding development within the area.

WATER USERS

The DWS WARMS Database was used to identify the water use within the D82 tertiary. Water use within D82B and D82C is associated with livestock watering, water supply services (towns), and mining. The detailed volumes of water use used for irrigation are shown in **Table 4.** All irrigation in the tertiary is supplied via water schemes connected to the Orange River, excluding two areas which are supplied directly from a river/stream. The DWS WARMS database does not indicate any irrigation in D82B or D82C; however, there may be small areas of irrigation on the farms which has not been captured on the WARMS database.

Table 4 Irrigation Water Use within Tertiary D82

QUATERNARY	VOLUME (M^3/A)	AREA (HA)
D82A	36 486 000	1 880.2
D82B	45 000	3
D82F	1 975 500	131.7
D82G	7 474 500	498.3
D82K	0	0
D82L	8 290 990	555.6

QUATERNARY	VOLUME (M^3/A)	AREA (HA)
Total	**54 271 990**	**3068.8**

Source: DWS WARMS Database

There are many water supply schemes along the length of the Orange River, as the water resources around the downstream Orange River are scarce, and therefore are supplied by the Gariep and Vanderkloof Dams, limiting the main water use to be alongside the river. Therefore irrigation along the Orange River is the principal water use. The major schemes connected to the Orange River include (ORASECOM, 2012):

- Douglas Irrigation Scheme (part of the Orange-Vaal Transfer Scheme): The Scheme is located between 400-500 km's away from the site at the downstream end of the Vaal River (its primary water source).
- Middle Orange Irrigation Area (includes irrigation along the riparian zone between Hopetown and Boegoeberg Dam: The area stretches from Hopetown to Boegoeberg Dam. The irrigators are not part of a formalised scheme with a common supply system, but rather abstract water directly from the Orange River individually. The scheme is located 300+ km's away from the site.
- Keimoes Canal Irrigation Area: Keimoes irrigation area consists of various Irrigation Boards, each with its own diversions from the Keimoes Canal which obtains its water from the Orange River. The scheme is located 400+ km's away from the site.
- Namakwaland Irrigation Area: The water for the Namakwaland Irrigation Area is abstracted from the Orange River. Water is released from Vanderkloof Dam to supply users in this area. The scheduled area is about 2 439 ha and too extensive to study in any further depth.
- Vioolsdrift and Noordoewer Irrigation Area (extends into Namiba): The irrigation areas are supplied through a canal system fed by the Vioolsdrift Weir on the Orange River. The scheme is operated by the Vioolsdrift and Noordoewer Joint Water Authority over a vast area.

Table 5 shows volumes of the remainder of water users within the tertiary.

Table 5 Water Users within Tertiary D82 (excluding irrigation)

QUATERNARY	VOLUME (m^3/a)	SECTOR	SOURCE
D82A	12 000	Water supply service	Orange River
	4 000 000	Industry (urban)	Scheme
D82B	20 280	Livestock Watering	Borehole
D82C	16 060 000	Water supply service	Scheme
	3 500	Mining	Borehole
D82G	4 000	Water supply service	Scheme
D82H	35 200	Water supply service	Borehole
D82K	528 000	Industry (urban)	Scheme
	724 100	Industry (urban)	Scheme
	1 800	Mining	Scheme
D82L	2 000 000	Mining	Scheme

Source: DWS WARMS Database

WSP is not in a position to state the availability of water with regards to river/dam resources (i.e. the Orange River and associated dams). For this information, BioTherm would need to approach the DWS, who carry out in-depth studies on the availability of water within the Orange River Catchment in order to provide allocations to water users. Accordingly, Sedibeng Water has an allocation from the DWS and as such, it has been recommended that BioTherm liaise with Sedibeng Water (and/or entities which already have existing allocations).

3 PROPOSED TECHNOLOGY

3.1 DESCRIPTION OF TECHNOLOGY

The proposed Letsoai Site on Farm RE86 has been sub-divided into two areas, both of which will make use of Concentrating Solar Power (CSP), generating 150 MW each. Both the CSP and PV sites are shown in **Table 6** below and **Figure 3**. The electricity produced at the proposed sites will be fed directly onto the National Grid.

Table 6 Potential Solar Power Sites

SITE NAME	SOLAR POWER TECHNOLOGY	AREA (HA)	ENERGY (MW)
Letsoai CSP Project 1	CSP	774	150
Letsoai CSP Project 2	CSP	779	150
Enamandla Project 1	PV	354	75
Enamandla Project 2	PV	491	75
Enamandla Project 3	PV	725	75
Enamandla Project 4	PV	337	75
Enamandla Project 5	PV	325	75

Source: BioTherm

CONCENTRATED SOLAR POWER (CSP)

Concentrated Solar Power (CSP) is a type of technology used to create energy through the use of sunlight, using mirrors/lenses to focus a large area of sunlight onto one space creating a small, concentrated beam of light. This method does not convert the light directly into energy, but rather uses the sun’s radiation to drive turbines in order to generate electricity.

The CSP can either make use of a tower or parabolic trough technology, as explained further below:

- CSP tower technology consists of an array of reflectors/mirrors, known as heliostats, which track the sun and are able to concentrate the sunlight onto a central receiver. This receiver contains a fluid, and is located at the top of a tower. The fluid in the receiver (often sea water) is heated to between 500 – 1000 °C and can then be used as a heat source for energy storage or power generation. Tower technology offers higher efficiency than trough systems because the fluid temperatures are higher. This leads to better thermodynamic operation. CSP tower also aids in better energy storage capability.
- A parabolic trough consists of a reflector that concentrates light onto a tube (i.e. the receiver) which is positioned along the reflector's focal line. This receiver is positioned above the middle of the parabolic mirror, which is filled with heat transfer fluid (HTF). The HTF absorbs the energy which is transported via carrier tubes to the heat transfer vault, where it is used for steam generation in a conventional heat exchanger. The generated steam drives a turbine which in turn generates electricity.

It has been confirmed that BioTherm will be making use of tower technology for the project.

PHOTOVOLTAIC (PV)

Unlike CSP, PV solar power converts light directly into electricity. This technology uses photovoltaic cells which convert light into electric current through the ‘*photovoltaic effect*’. The PV system produces direct current power which fluctuates with the sunlight's intensity. Multiple photovoltaic cells are connected to form a module, and in turn the modules are wired together to form an array. The arrays are connected to a transformer, which is able to convert the power to the desired required voltage, or into alternating current (with desired frequency/phase), in order to accommodate the associated powerline.

3.2 PIPELINES AND PUMPSTATIONS

Currently there is an abstraction point at the Orange River at Pelladrift pumpstation, with the pipeline stretching from the pumpstation to the Horseshoe Reservoir, which provides for 12 Ml/day (12 000 m^3/day), and is currently acting at full capacity. Black Mountain Mine utilizes 85% of the water, while local communities receive the remaining 15%.

The Gamsberg Mine was suggested as an opportunity for BioTherm to collaborate with and tie into the scheme. The infrastructure for the mine will include a new 38km long surface pipeline from the existing Pelladrift Scheme abstraction point on the Orange River to the mine (Mining Technology, accessed 2016). Due to the Gamsberg Mine water requirements, the 12Ml/day pumpstation and pipeline will be upgraded to 24 Ml/day (24 000 m^3/day).

BioTherm initially identified two proposed pipelines for transferring water from the Orange River to the site. Subsequent to discussions with Sedibeng Water and Vedanta Mining, based upon the above upgrades and existing infrastructure, three new pipeline routes have been identified, as shown below:

- ***Option 1***: Installation of a new 28.8 km pipeline from the Solar Farm to the Kokerboom Reservoir to the western side of the Solar Farm (Sedibeng Water will provide the connection point).
- ***Option 2***: Installation of a new 34.1 km pipeline from the Solar Farm to the Kokerboom Reservoir to the eastern side of the Solar Farm (Sedibeng Water will provide the connection point).
- ***Option 3***: Installation of a new 65.6 km pipeline from the Solar Farm along the existing Pella pipeline to the Pella pumpstation located at the Orange River. Should Option 3 be chosen, once constructed by BioTherm, the infrastructure would be transferred to Sedibeng Water for operation and maintenance.

Sedibeng Water has agreed to supply water to the BioTherm site; however, this is subject to BioTherm Energy (Pty) Ltd entering into a service level agreement with Sedibeng Water prior to the commencement of the project. Additionally, BioTherm will be responsible for payment of the applicable connection fees.

Each of the three pipeline options described above will connect to the sub-station option of ***Sub-Station Location 1*** which is just north of CSP Project Site 1.

Pipeline options are shown in **Figure 4**.

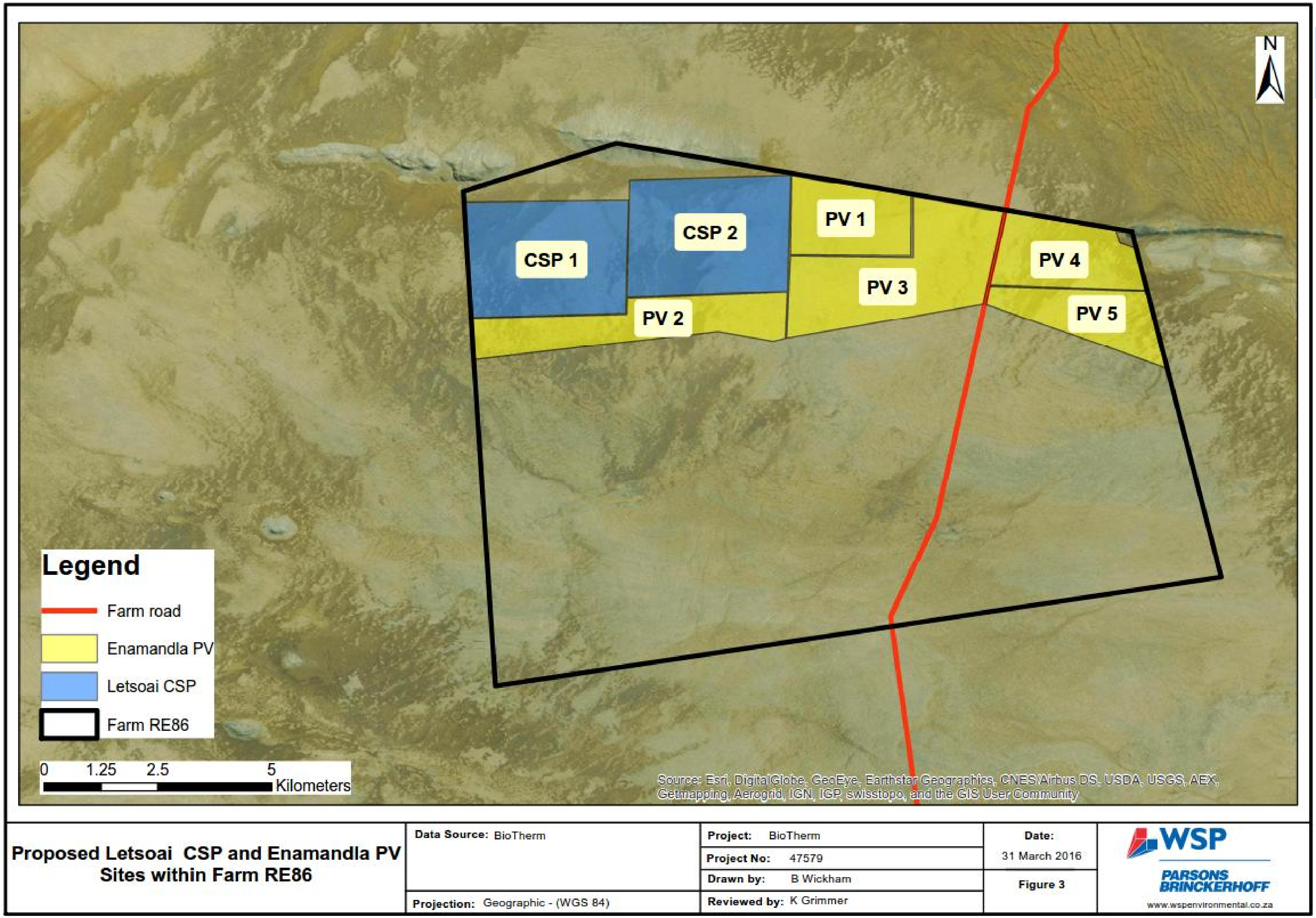


Figure 3 Proposed CSP and PV Sites within Farm RE86

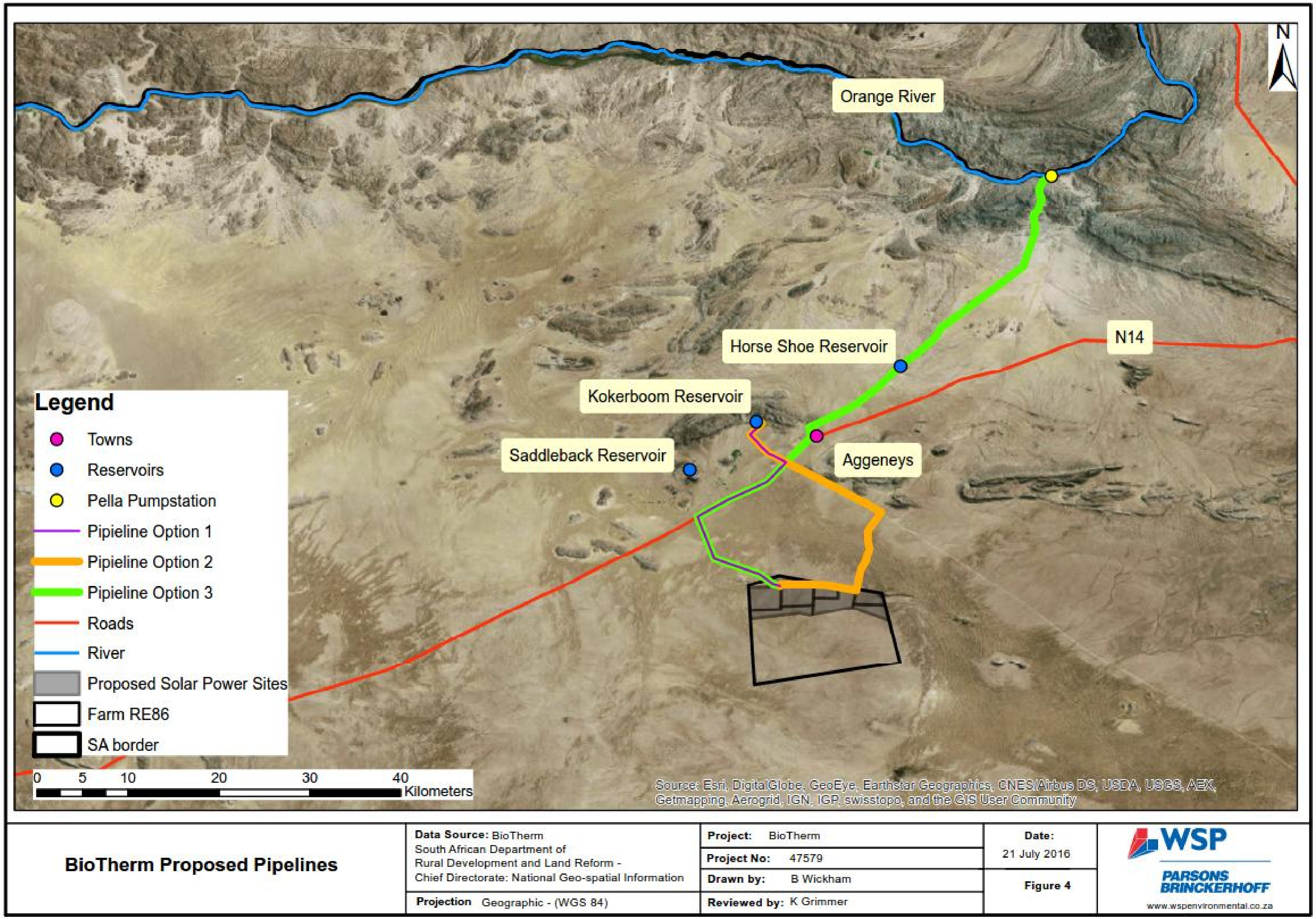


Figure 4 BioTherm Proposed Pipelines

3.3 WATER QUANTITY REQUIREMENTS

The dry cooling option is proposed for the BioTherm project as the water requirements will be less. Water for steam production and cleaning of the mirrors are considered the primary areas of water use associated with the technology. The only other water use associated with the project will include potable use and water required for cleaning of the power plants.

BioTherm has been able to confirm the water requirements for each facility per day, under both the construction and the operational phases. Letsoai CSP Project Site 1 will have a demand of 315 m^3 per day for the Construction Phase, and 550 m^3 per day for the Operational Phase.

Table 7 below shows the total water requirements per phase of the project, for the entire proposed Solar Farm (including the five PV sites and two CSP sites).

Table 7 Solar Farm Water Quantity Requirements

TOTAL WATER DEMAND	CONSTRUCTION PHASE		OPERATIONAL PHASE	
SITE	M^3/DAY	ML/DAY	M^3/DAY	ML/DAY
LETSOAI CSP PROJECT	630	0.630	1100	1.100
ENAMANDLA PV PROJECT	85	0.085	35	0.035
TOTAL	**715**	**0.715**	**1135**	**1.135**

Source: BioTherm

Due to the relatively small requirements of the Solar Farm (as a whole), Sedibeng Water has agreed to supply BioTherm with the water requirements (**Table 7**) via the routes proposed in **Section 3.2** above.

With the new pumpstation and pipeline at the Pella offtake providing 24 000 m^3/day, the Solar Farm site would only be utilizing 3.0% and 4.7% of the available water for the construction and operational phases, respectively. According to the Gamsberg EIA, Gamsberg Mine will require approximately 2 000 m^3/day during their construction phase.

3.4 WATER QUALITY

The water quality for the proposed solar power plant is very important, especially for, *inter alia*, steam generation, cooling, use in the clarifier and in the demineralisation pre-treatment plant. The CSP will require high quality water for heat exchangers, cooling water, steam generation and wash water.

The Department of Water Affairs and Forestry (DWAF, now the DWS) have a set of water quality guidelines which are stipulated specifically for industrial water (Industrial Water Requirements specified by the Department of Water Affairs and Forestry, 1996). These requirements factor in process types considered in defining the guidelines, including cooling, steam production, process water (solvent, diluent and carrier), product water, utilities and wash water.

There are four categories of process water which have been defined according to the degree of water quality requirements for the specific application, shown in **Table 8** below.

Table 8 Industrial Water Use Categorisation

CATEGORY	DESCRIPTION
1	Process that requires high quality water with relative tight to stringent specifications of limits for most or all the relevant water quality constituents. Standard or specialised technology is essential to provide water conforming to the required quality specification. Consequently, cost of in-house treatment to provide such water are a major consideration in the economy of process.
2	Processes that require water of a quality intermediate between the high quality required for Category 1 processes and domestic water quality (Category 3 processes). Specifications for some water quality constituents are somewhat tighter or more stringent than required for domestic water quality. Standard technology is usually sufficient to reach the required water quality criteria. Costs for such additional water treatment begins to be significant in the economy of the process.
3	Processes for which domestic water quality is the baseline minimum standard. Water of this quality may be used in the process without further treatment, or minimum treatment using low to standard technology may be necessary to reach the specifications laid down for a desired water quality. Costs of further significant in-house treatment are not significant in the economy of process.
4	Process that within certain limitations can use water of more or less any quality for their purposes without creating any problems. No additional treatment is usually required and there is therefore no further cost.

Source: DWAF, 1996

These water quality guidelines for industrial use (for each of these abovementioned categories) are shown in **Table 9** below. Due to the nature of the high quality of water required, it has been assumed that the plant will fall under Category 1.

Table 9 DWAF Industrial Water Quality Guidelines (1996)

PARAMETER	UNITS	GUIDELINE VALUES (INDUSTRY)			
		DWAF CATEGORY 1	DWAF CATEGORY 2	DWAF CATEGORY 3	DWAF CATEGORY 4
Total Suspended Solids	mg/ ℓ	<3	<5	<5	<25
Total Organic Carbon	mg/ ℓ	-	-	-	-
Total Dissolved Solids	mg/ ℓ	-	-	-	-
Turbidity	NTU	<100	<200	<450	<1 600
pH	-	7-8	6.5-8	6.5-8	5-10
Conductivity	µS/cm	<150	<300	<700	<2 500
Sodium (as Na)	mg/ ℓ	-	-	-	-
Total Alkalinity as $CaCO_3$	mg/ ℓ	<50	<120	<300	<1 200
Calcium Hardness as $CaCO_3$	mg/ ℓ	-	-	-	-
Total Hardness as $CaCO_3$	mg/ ℓ	<50	<100	<250	<1 000
Dissolved Iron	mg/ ℓ	-	-	-	-
Total Iron	mg/ ℓ	<0.1	<0.2	<0.3	<10
Chloride	mg/ ℓ	<20	<40	<100	<500
Sulphates (as SO_4)	mg/ ℓ	<30	<80	<200	<500
Silica (as SiO_2)	mg/ ℓ	<511	<101	<201	<1501
Manganese	mg/ ℓ	<0.05	<0.1	<0.2	<10
Chemical Oxygen Demand	mg/ ℓ	<10	<15	<30	<75
Copper	mg/ ℓ	-	-	-	-

PARAMETER	UNITS	GUIDELINE VALUES (INDUSTRY)			
Lead	mg/ ℓ	-	-	-	-
Zinc	mg/ ℓ	-	-	-	-

Source: Department of Water Affairs and Forestry, 1996

Table 10 outlines the potential detrimental impacts to industrial related processes associated with the various determinants included in the industrial water quality guideline.

Table 10 Water Quality Impacts on Industrial Process

PROBLEM	PH	EC	TH*	FE	MN	ALK	SO_4	CL	SIO_2	SS	COD
Corrosion	X	X	X	X		X	X	X		X	X
Scaling	X	X	X	X							
Fouling				X	X					X	X
Blockages	X	X	X	X	X	X	X		X	X	X
Abrasion							X			X	
Embrittlement	X	X						X			
Discolouration	X			X	X						
Resin Binding	X	X	X	X	X	X	X		X		
Foaming	X					X					
Sediment	X			X			X				
Gas production	X						X				
Taste/Odour	X	X		X	X			X			
Precipitates	X	X	X	X	X	X	X				
Turbidity	X			X			X			X	X
Colour											X
Biological Growth	X			X	X	X	X			X	X

Source: Department of Water Affairs and Forestry (now DWS)
** TH Total Hardness (mainly Ca2+ and Mg2+)*

Groundwater samples obtained from the site were subjected to analysis; results have been compared to limits as described above; results of the analysis shown in **Section 4.1**.

4 WATER RESOURCE ASSESSMENT

In this Section potential water resources available for the supply of the proposed sites are assessed. This includes options such as groundwater, surface water (local and the Orange River), other supply sources (active mines), as well as the Water Service Provider which would need to be engaged with (Sedibeng Water).

4.1 GROUNDWATER

HYDROCENSUS

The desktop review identified boreholes located on the FarmRE86, as well as in the buffer zone and the immediate area. Sources of available information included aerial imagery (Google Earth Pro, Agricultural Geo-Referenced Information System (AGIS) and the Department of Water and Sanitation's National Ground Water Archive. Maps of the primarily identified boreholes were created to assess further on site.

The boreholes were then able to be verified upon the ground-truthing exercise on site (February, 2016). Additionally, several other boreholes were identified within the area. The criteria for the chosen boreholes for yield testing were based upon the accessibility, structural integrity, condition, and use of the boreholes. Seventeen windmill driven boreholes were identified within the area, located within Farm RE86, as well as a 5km buffer zone from the farm boundary.

No boreholes were available on the Letsoia Site; however, the chosen boreholes for testing are located in close proximity, south of the sites. The three boreholes chosen for testing are Boreholes 133, 145, and 155 (**Figure 5**), details in **Table 11**.

Table 11 Locations of Boreholes

BOREHOLE NO.	LATITUDE (DECIMAL DEGREES)	LONGITUDE (DECIMAL DEGREES)	NOTES / USE
133	-29.431147	18.911828	Working, feeds a reservoir for sheep pen
145	-29.456212	18.925976	Working, feeds a reservoir for sheep pen
155	-29.428145	18.964373	Working, directly connected to JoJo Tank

Source: WSP Site Walkover

The three representative boreholes were analysed for both yield and chemical constituents, as described further below. Two of the sites are located approximately 4km south of the sites (133 and 155); the third (145) approximately 7km south of the site, on the border of Farm RE86. These three boreholes are considered to be representative of the area's aquifer conditions including the Letsoia Site, and therefore indicative of yield and quality of the sites. In order to establish the sustainable yield of the underlying aquifer, pump testing was carried out on the three selected boreholes on Farm RE86.

AQUIFER YIELD TESTING

The aquifer yield testing is usually achieved by conducting a pumping test which involves removing water from a borehole (or well) at variable or constant discharge while measuring displacement/drawdown of the water level against time. The borehole testing was carried out by VSA Leboa Consulting (Pty) Ltd and comprised of the following:

- Step-drawdown test
- Constant discharge rate test

The results obtained both this test are summarised below. The summary information of the boreholes is shown in **Table 12** below (full results in **Appendix A**).

Table 12 Summary of Borehole Results

BOREHOLE NO.	BOREHOLE DEPTH BEFORE INSTALLATION OF TEST PUMP (m)	INSTALLATION DEPTH OF TEST PUMP (m)	WATER LEVEL MEASURED BEFORE STEP TESTS (m)
133	77.28	72.50	41.24
145	137.42	93.80	80.65
155	59.55	51.50	27.74

Source: VSA Leboa Consulting

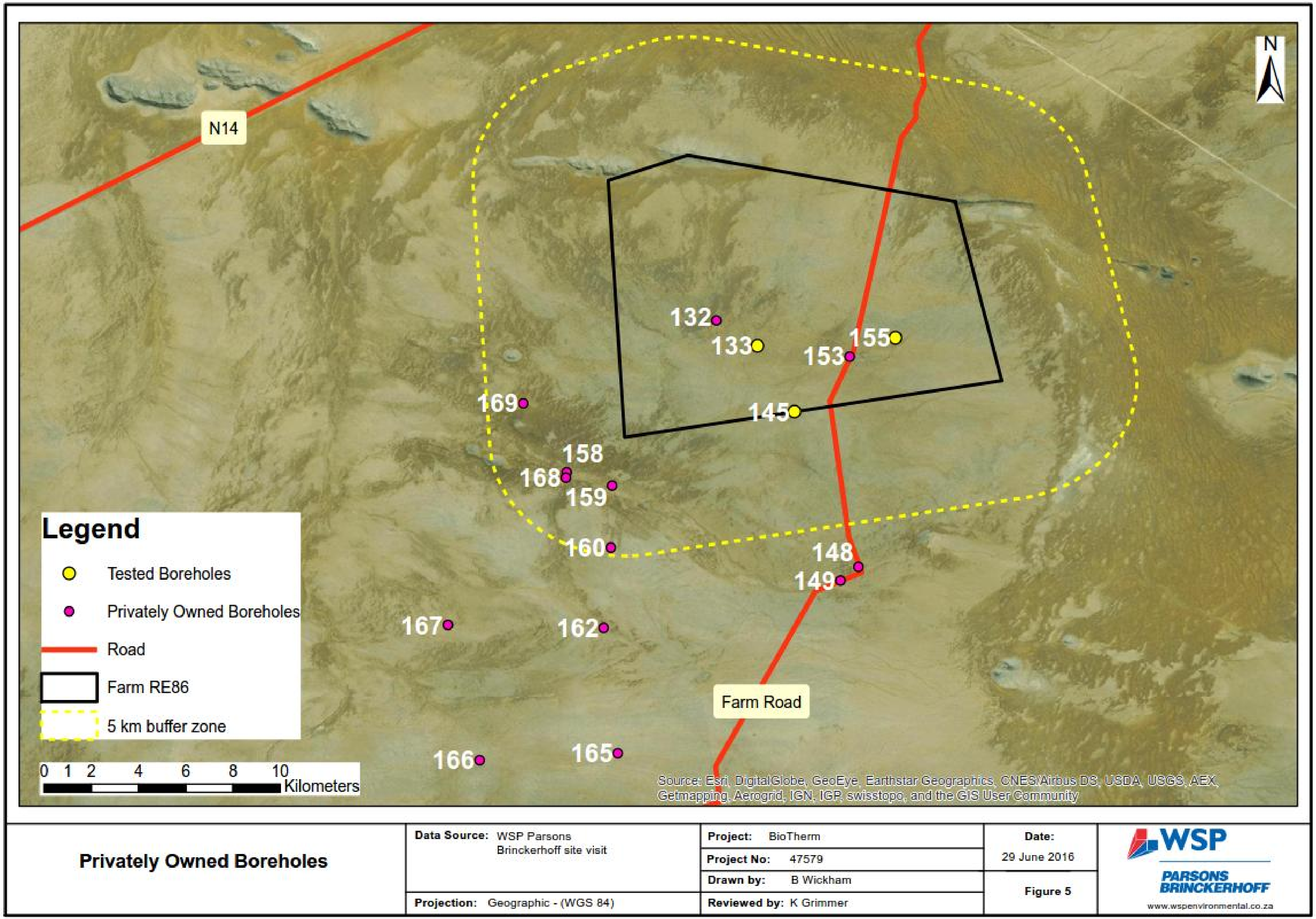


Figure 5 Privately Owned Boreholes

STEP DRAWDOWN TEST

The principle of step-drawdown test is that it is used to determine the rate (*Q*) at which water can be pumped during the constant discharge drawdown test. It is expected that the rate is kept constant at each step but is increased form one step to the next, until the end of the test. During this test, it is preferable to run at least a four step test although a three step test is widely acceptable. It is also important that during the last step the pumping rate should be the highest possible. Each step test is carried out over a duration of one hour (60 minutes).

Three boreholes were identified during the site trip for further testing, including boreholes 133 (BH133), 145 (BH145) and 155 (BH155). Step tests were conducted for boreholes BH133 and BH155. Borehole BH145 was not tested due to limited infrastructure pipe lengths and other equipment, as well as the condition of the boreholes, which are generally old and in poor condition. Therefore, the results for this borehole were inconclusive in terms of yield due to the abovementioned restrictions. Furthermore, the depth of the test pump (93.8m) was unable to reach the depth of the borehole (137.42m), which was by far the deepest borehole of the three. It is therefore noted that this borehole may have a higher yield if tested at a greater depth. The results of the step test are summarised in **Table 13** below.

Table 13 Summary of Field Results of the Step Drawdown Test

Borehole ID	Step No.	Pump Rate		Drawdown (m)	Duration of Step (Minutes)
		ℓ/s	m^3/hr		
BH133	1	0.2	0.72	0.17	60
	2	0.41	1.48	0.56	60
	3	1.054	3.78	3.49	60
	4	3.72	13.39	13.53	7
BH155	1	0.32	1.15	1.87	60
	2	0.605	2.18	0.79	60
	3	1.26	4.54	0.62	60
	4	3.42	12.31	7.44	3

While every effort was made to complete four step tests, none of the boreholes sustained the chosen rate. In BH133, the fourth step failed after seven minutes while BH155 failed just after three minutes at pumping rate above 3 ℓ/s. The determined aquifer parameters (i.e. transmissivity and storativity), based upon the step tests, are shown in **Table 14** below.

Table 14 Summary of analysis results using FC-method

Borehole ID.	Transmissivity (m^2/d)	Storativity [-]
BH133	8.0	0.00082
BH155	6.0	0.00102

CONSTANT DISCHARGE RATE TEST

This test is normally used to determine the long term yield of the borehole especially for community water supply. It can accurately determine the aquifer properties when compared to the step-test because of its duration. The determined parameters from the constant discharge rate test are shown in **Table 15**.

Table 15 Summary of results from the constant discharge rate test

Borehole ID.	Borehole Depth (m)	Static Water Level (m)	Drawdown available (m)	Drawdown achieved (m)	Drawdown achieved (%)	Recovery		Constant Q (ℓ/s)
						%	Hrs	
BH133	77.28	41.24	36.04	12.09	33.55	97.78	8	1.56
BH155	59.55	27.74	31.81	22.26	69.98	91.25	10	1.29

The pumping in each of the boreholes was conducted for duration of eight hours. Due to the short duration, this test is not sufficient to determine the aquifer parameters but can be used as a first estimate for both the sustainable yield and the aquifer parameters. From the table above it can be seen that both BH133 and BH155 were pumped at rates above 1 ℓ/s which is greater than the anticipated average borehole yield (based on the initial desktop assessment) of 0.5ℓ/s.

Though it is ideal that the pumping test should stress the aquifer, these tests were not designed for that purpose due to the level of detail required for the study. However, this can be used as a first estimate and /or to design proper pumping test during the feasibility phase or even during the implementation of the project. Based on the derivative plots, both boreholes show a behavior typical of borehole drilled through a fractured network. Not much information can be deduced from the graph.

After 8 hours of pumping, borehole BH133 and BH155 achieves a drawdown of 12.09m (33.55%) and 22.26m (69.98%), respectively, while the recovery in each borehole can be regarded as slow. From the pumping data, the aquifer parameters determined using the Cooper-Jacob analysis methods within the FC-Method (Van Tonder *et. al.*, 2002) are summarized in **Table 16**.

Table 16 Aquifer Parameters (Cooper-Jacob analysis methods within the FC-Method)

Borehole ID	Borehole Depth (m)	Q (ℓ/s)	Transmissivity (m^2/d)	Storativity [-]	Solution
BH133	77.28	1.56	6.8	0.005	Cooper-Jacob
BH155	59.55	1.29	13.4	0.005	Cooper-Jacob*

** Fit at early time*

The borehole results for BH133 and BH155 were fitted against curves for each method. The transmissivity at BH155 was determined by fitting the curve at both early and late time. The early time shows a transmissivity of 13.4 m^2/d whereas the late time shows transmissivity of 1.2 m^2/d, which are both different from that observed in in BH133.

BOREHOLE SUSTAINABLE YIELD

Reliable sustainable yield can accurately be determined if pumping test results from step-drawdown and constant rate test are available and well documented. For the purpose of this study the sustainable yield was determined using the Flow Characterization (FC) tool developed by the University of the Free State (Van Tonder *et. al.* 2002). Various methods were applied within this tool, and an average was taken of the results. The methods used included the FC method utilizing the Basic FC solution, Cooper-Jacob, FC Non-linear and the Baker solution. In this context, the sustainable yield is defined as the discharge rate that will not cause the water level in the well to drop below a prescribed limit, identified from the nature and thickness of the aquifer (especially water strikes) and the depth of the well. Based on the analytical results, the sustainable yield of each borehole is shown below in **Table 17**.

Table 17 Sustainable yield based on FC Method

Method	Sustainable yield (ℓ /s)	
	Borehole 133	Borehole 155
Basic FC	0.46	0.16
Cooper-Jacob	1.71	3.9*
FC Non-Linear	0.04	0.04
Barker	0.66	0.32
Average Sustainable Yield (ℓ/s)	**0.72**	**1.105**

**Early time fit*

It is clear from this table that the sustainable yield from the borehole will not be sufficient to supply the need for the plant. Based upon the approximate demand of 115 000 m^3/a and 200 000 m^3/a, it can be assumed that should it be cost effective, these boreholes are indicative that the groundwater in the area may be able to supplement, but not meet, the demand of the plant. This would need to be readdressed once the precise requirements of this proposed plant have been determined, as well as the outcomes of the water quality assessment.

GROUNDWATER QUALITY

Subsequent to the borehole testing done by VSA Leboa Consulting, water samples were taken at each of the three boreholes and sent to Capricorn Veterinary Laboratories cc. Here the samples were analysed for various metals and physical properties of the water.

It has been assumed that CSP technology (Letsoia CSP Project Site 1) would qualify as a Category 1 user, based on the assumption that the process will require high quality water. Category 1 specifies '*a process that requires high quality water with relative tight to stringent specifications of limits for most or all the relevant water quality constituents. Standard or specialised technology is essential to provide water conforming to the required quality specification. Consequently, cost of in-house treatment to provide such water are a major consideration in the economy of process*'.

The water quality results have been compared to the water quality guidelines for Industrial Standards as set out by the Department of Water Affairs and Forestry (DWAF, 1996) for Category 1 type industry. In the case where no Industrial Guidelines have been set by the DWS, Domestic Water Quality Guidelines have been used for comparison. In addition, the SANS 241 (potable) guidelines give additional standards for comparison where no Industrial or Domestic Guidelines are available.

The water quality results obtained from the three boreholes tested on site (Boreholes 133, 145 and 155) are shown in **Table 18** Error! Reference source not found.below (full results in **Appendix B**). Exceedances are shown in red; grey text (Mg Hardness as $CaCO_3$) indicates no final conclusion (either due to no specifications and/or restrictions of detection limits).

Table 18 Borehole Results from on-site testing

Determinant	Unit	Domestic	Industrial Category 1	Borehole 133	Borehole 155	Borehole 145
Physical and aggregate properties						
pH at 25°C	pH units	6.0-9.0	7.0-8.0	7.1	7.2	7.1
Conductivity at 25°C	mS/m	0-70	0-15	**185.9**	**149.2**	**404.3**
TDS (calculated)	mg/ ℓ	0-450	0-100	**1208**	**970**	**2386**
Alkalinity						

Determinant	Unit	Domestic	Industrial Category 1	Borehole 133	Borehole 155	Borehole 145
Bicarbonate alkalinity as $CaCO_3$	mg/ ℓ	<50	<50	**208.8**	**239.6**	**215.8**
Carbonate alkalinity as $CaCO_3$	mg/ ℓ			0.0	0.0	0.0
Hardness						
Total hardness as $CaCO_3$	mg/ ℓ	50 -150	<50	**472.67**	**351.55**	**996.07**
Ca hardness as $CaCO_3$*	mg/ ℓ	<150*	-	**339.83**	**256.10**	**659.25**
Mg hardness as $CaCO_3$	mg/ ℓ	-	-	132.84	95.45	336.82
Metals						
Aluminium	mg/ ℓ	0-0.15	-	<0.01	0.01	<0.01
Arsenic	mg/ ℓ	0-10	-	<0.03	< 0.03	<0.03
Calcium	mg/ ℓ	0-32	-	**135.93**	**102.44**	**263.70**
Copper	mg/ ℓ	0-1	-	<0.01	<0.01	<0.01
Iron	mg/ ℓ	0.0-0.1	<0.1	<0.01	<0.01	<0.01
Magnesium	mg/ ℓ	0-30	-	**32.40**	23.28	**82.15**
Manganese	mg/ ℓ	0-0.05	<0.05	<0.01	<0.01	**0.23**
Potassium	mg/ ℓ	0-50	-	14.01	10.74	27.85
Sodium	mg/ ℓ	0-100	-	**203.61**	**181.06**	**471.05**
Inorganic non-metallic constituents						
Chloride as Cl	mg/ ℓ	0-100	<20	**330.1**	**222.6**	**939.4**
Fluoride as F	mg/ ℓ	0-1.0		**3.04**	**3.17**	**2.30**
Ammonium as NH_4-N	mg/ ℓ	0-1.0**		<0.20	0.79	0.20
Nitrate as NO_3-N	mg/ ℓ	0-6	-	**18.66**	**12.70**	**25.56**
Nitrite as NO_2-N	mg/ ℓ		-	<0.01	0.02	0.05
Orthophosphate as PO_4-P	mg/ ℓ	-	-	<0.05	<0.05	<0.05
Sulphate as SO_4	mg/ ℓ	0-200	<30	**143.04**	**111.56**	**333.78**
Silica as Si	mg/ ℓ	<5.0	-	**18.18**	**13.88**	**10.70**

Source: Capricorn Veterinary Laboratories CC (VSA Leboa Consulting)
** No DWS Guidelines (Industrial or Domestic) - SANS 241 (potable) used.*
*** Ammonia*

The following list shows the chemical constituents which are of concern as they are of high concentrations or exceed the specified DWAF Domestic Guidelines limitations (or Industrial/SANS where necessary).

- à **Conductivity** and **TDS** for all three boreholes exceeds the limit by far, which can cause major damage to equipment and structures, interference with industrial processes including scaling, precipitation of salts and inefficient heat exchange. Boreholes 133 and 145 considerably exceed Category 4 standards.
- à **Alkalinity** for all three boreholes is exceeds the target Category 1 Industrial water quality standards, indicating a risk of moderate to significant damage due to scaling or precipitation. Values associated with the boreholes are incorporated into Category 3 Target Water Quality Range.
- à For all 3 boreholes, the **Total Hardness** values are substantially higher than indicated limits. Standards, and fall within the Category 4 target range. The water is classifies as very hard' and the effects of such high values include the formation of scaling on heat exchange surfaces such as hot water pipes and geysers, as well as an increase in the formation of insoluble salts of long chain fatty acids (scum/sludge) which is aesthetically unpleasing. The addition of lime and descaling would be required to avoid and mitigate.

- **Calcium** guidelines are not provided for industrial processes, but they do exceed the levels indicated for domestic use. Calcium levels such as these may cause severe scaling problems but do not present any health risks.
- **Magnesium** levels within Boreholes 133 and 155 are acceptable according to domestic target levels (no industrial levels set). However, Borehole 145 is exceeding the limitations and therefore may present health problems, especially in sensitive users, as well as scaling problems.
- **Sodium** for Boreholes 133 and 155 are slightly higher than domestic targets, and may result in slightly salty water. Borehole 145 will result in a distinctly salty taste but no adverse health effects; however, may be undesirable for sodium-sensitive individuals.
- According to the guidelines, the highest level of acceptable **chloride** (Industry Category 4) is 500mg/ℓ (potable standard at 200 mg/ℓ); borehole 145 has a value almost double this, at 939mg/ℓ. The remaining 2 boreholes are less severe but still have high concentrations of chloride. Negative effects will include damage due to the precipitation and build-up of chloride, interference with the processes and product.
- **Fluoride** levels in all 3 boreholes are above the domestic limit and can cause health risks including tooth damage. The borehole levels are between 1.5-3.5mg/ℓ, which cause mottling and tooth damage in continuous users.
- Using Domestic Guidelines, nitrite levels are low but **nitrate** levels are high; however, no indication is given for industrial use. Levels between 10-20 (Boreholes 133 and 155) can cause health effects in infants; however levels in Borehole 145 are higher and can have adverse effects on adults.
- **Sulphate** levels are exceeding the Domestic Category 1 Guidelines. Boreholes 133 and 155 are acceptable to Domestic Guidelines but Borehole 145 is beyond the limit, causing a an unfavourable taste and a tendency to health effects in sensitive individuals.
- All three boreholes exceed the limitations of the silica accepted Domestic Guidelines, and can lead to moderate to significant scaling, interferences with processes and impairment of product quality.

It is noted that borehole 145 is consistently high in chemical constituents. This may be related to the depth of the borehole/water level. The depth of borehole 145 (137m) is much deeper than the other two boreholes (77m and 59m for boreholes 133 and 155, respectively), which suggests that not only were the yield tests affected by the depth, but it may also have a potential impact upon groundwater quality.

Groundwater quality is described as being Type D, dominated by sodium, potassium, chloride and sulphate ions, with dissolved solids typically ranging from 1000–1500mg/ℓ.

The water quality required, and therefore treatment requirements, will only be able to be properly established once the full and precise requirements are stipulated.

4.2 SURFACE WATER

The WR2012 database (WRC/DWA, 2012), and the Pitman (Rainfall/Runoff) Model were used to assess the surface water resources in the immediate (local) area. The proposed site falls with two quaternaries which are 100% endoreic in nature. Due to the high evaporation and low precipitation associated with the region, the option of onsite surface water harvesting for use on the project was not considered sustainable and therefore not deemed to be a viable option.

There are several water schemes in the Lower Orange WMA, which are fed from the Orange River. As such the Orange River is the surface water resource in the area which is considered the most viable with a high assurance of potential supply (**Section 4.4**).

Figures 6, 7 and **7** show the flows in the Orange River where quaternary catchment D82D converges with the Orange River. These graphs include mean monthly flows, the monthly hydrograph and the annual hydrograph, respectively. The mean monthly flows on the Orange River show a peak month of March, which is not indicative of the typical winter rainfall region. This can be attributed to two factors. Firstly, the flow in the river is largely regulated due to releases from the Gariep and Vanderkloof Dams. In addition, due to the size of the Orange River Catchment, the area will incorporate hydrologically and climatically different catchment characteristics from upstream catchments which will result in changes in typical flows in the lower reaches of the Orange River. The MAR associated with the Orange River at the outlet of D82D is 7 542 million m^3/annum.

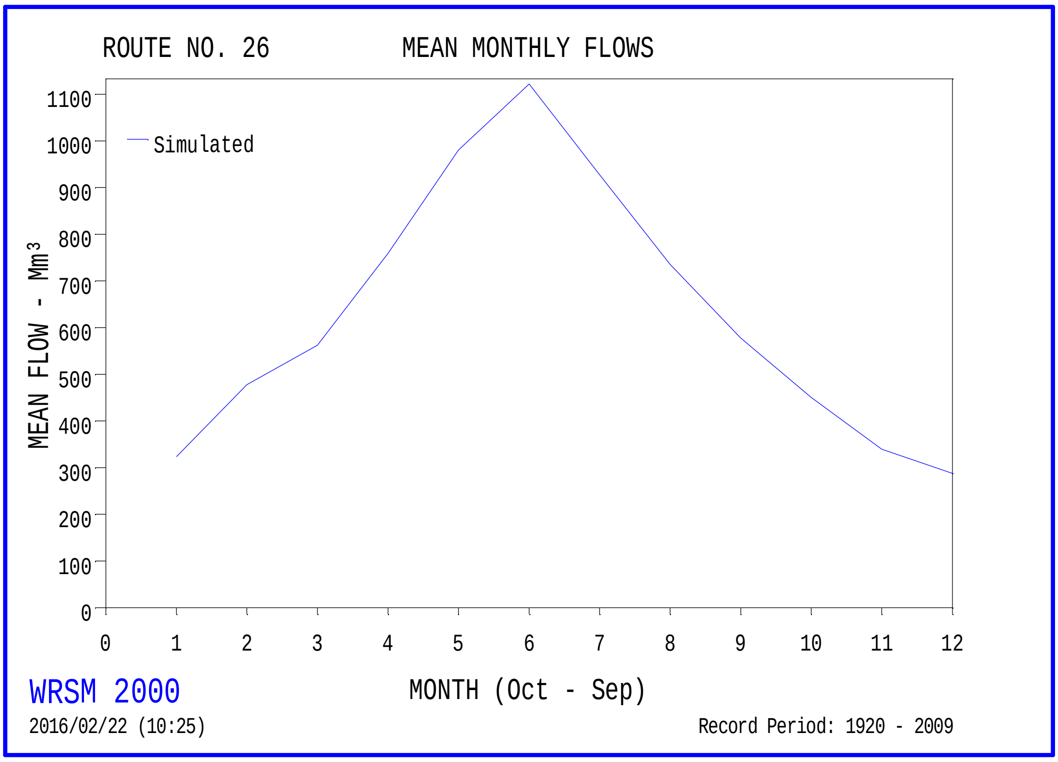


Figure 6 Orange River Mean Monthly Flows (at the confluence of D82D)

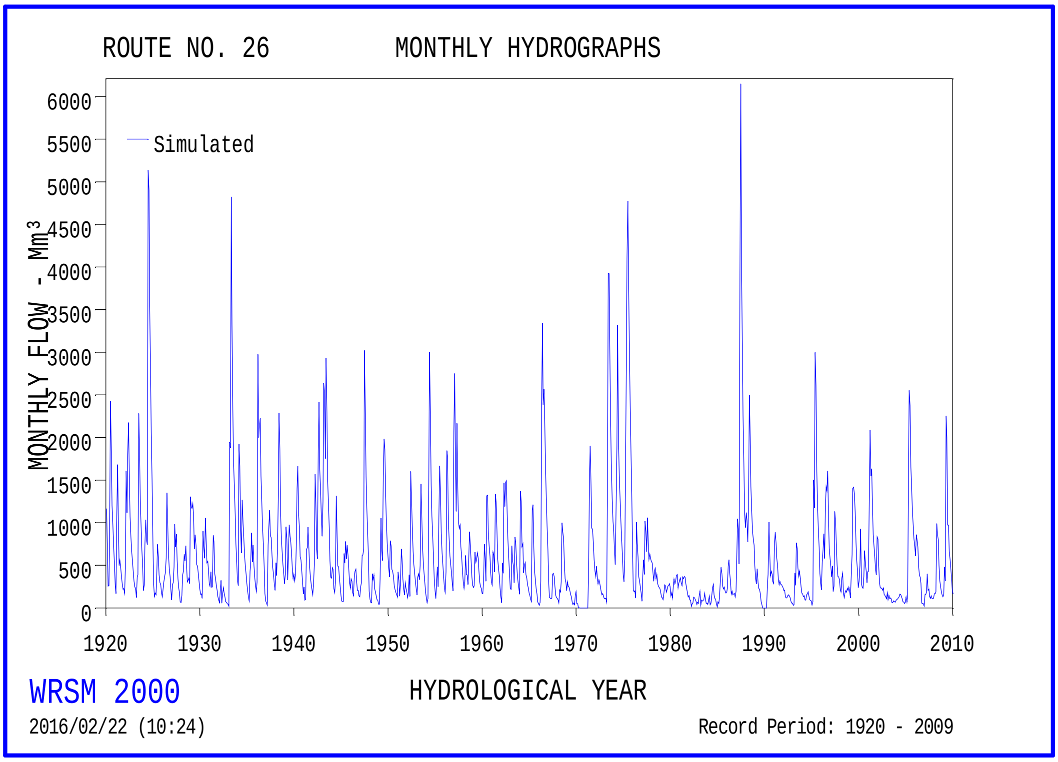


Figure 7 Orange River Monthly Hydrograph (at the confluence of D82D)

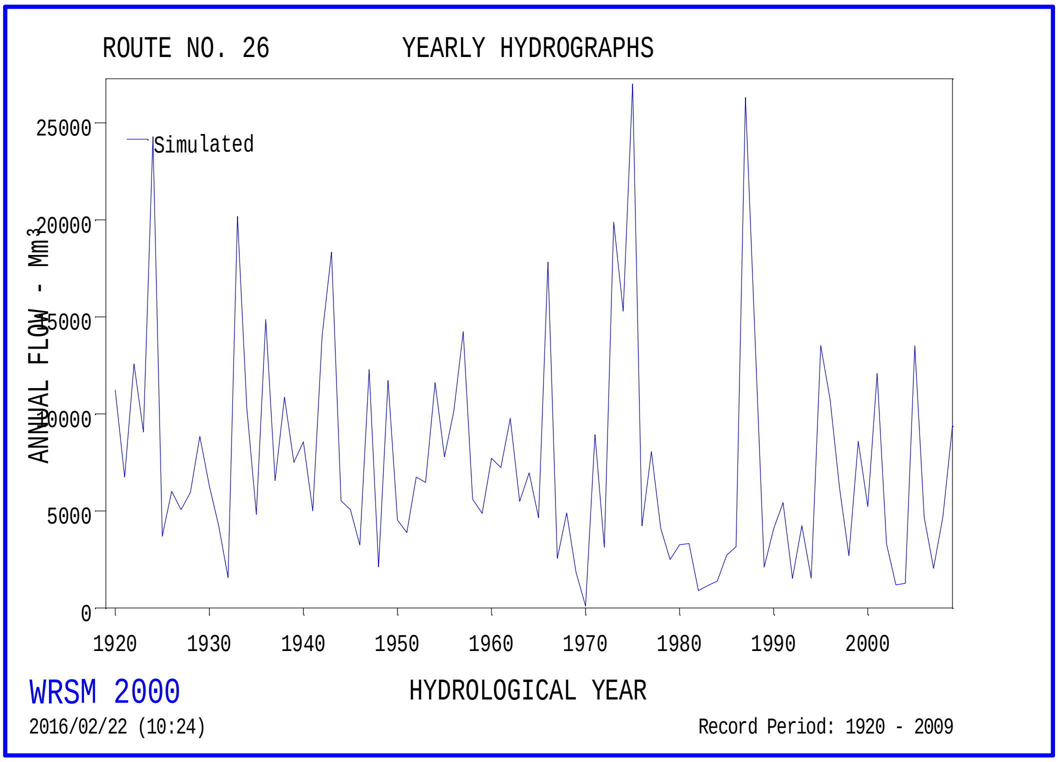


Figure 8 Orange River Annual Hydrograph (at the confluence of D82D)

The only surface water resource which may be an option as a surface water supply source to the project is the Orange River, as no local resources will provide the assurance of supply required by the proposed power plant.

ORANGE RIVER PROJECT

South Africa's two largest dams, Gariep and Vanderkloof Dams, make up the Orange River Project (ORP). The Orange River extends over such a large area that it is used as a primary resource for its entire length of 2 300km (DWS[1], 2016).

The Lesotho Highlands Water Project (LHWP) produces and supplies Lesotho with hydroelectric power as well as providing and transferring water into South Africa - approximately 780million m^3/annum (DWS[2], 2015). The Orange River is crucial to South Africa as it supplies irrigation along the length of the river, including many irrigation Schemes. The ORP dams (Gariep and Vanderkloof Dams) release water all the way down to the Orange River Estuary (some 1 400km downstream from Vanderkloof Dam).

The releases from these dams are over such a great length that it causes the releases to be subject to extremely large losses, (i.e. seepage and evaporation). For this reason a project is in the pipeline for the construction of a new dam (Vioolsdrift Dam) in the lower reaches of the Orange River to decrease these losses and thus create more efficient use of the water resources. Vioolsdrift Dam is currently in the planning stage with the expected commission date around 2022 (DWS, 2015). The dam will be situated on the Orange River approximately 150 km downstream of the site.

Within the first phase (Phase I) of the Lesotho Highlands Development Project, approximately 780million m^3/annum is transferred into South Africa. However, Phase II of the Project has commenced and will see the construction of the new Polihali Dam. The commissioning of this dam (anticipated approximately 2022) may then have the effect of retaining water which otherwise may have been released to South Africa. If so, the ORP may experience shortfalls in water supply. The long term projected stochastic yields of the two dams (i.e. Gariep and Vanderkloof Dams) are shown in **Table 19**.

Table 19 Long Term Yields for the Orange River Project

DAM	Long-Term Stochastic Yield Results with Recurrence Intervals (million m^3/annum)			
	1:20 Year	1:50 Year	1:100 Year	1:200 Year
Gariep and Vanderkloof (ORP)	3 716	3 332	3 084	2 892

Source: DWA, 2015

According to the Reserve Requirement Scenarios and Scheme Yields Study (part of the Development of Reconciliation Strategies for Lark Bulk Water Supply Systems for the Orange River), the current and future demands on the Orange River are as shown below in **Table 20** (DWA, 2015).

Table 20 Long Term Yields for the Orange River Project

DESCRIPTION	YEAR AND REQUIREMENT (MILLION M^3/ANNUM)					
	2014	2020	2025	2030	2035	2040
Irrigation Demands (including net canal losses)						
Upper Orange Irrigation	102	105	108	111	111	111
From Gariep Dam	599	617	635	635	635	635
From Vanderkloof Dam (RSA)	1 403	1 487	1 487	1 487	1 487	1 487
From Vanderkloof Dam (Namibia)	41	46	51	58	58	58
Sub-Total: Irrigation Demands	2 145	2 255	2 282	2 291	2 291	2 291
Domestic/Urban Demands						
Bloemfontein Botshabelo	87	104	122	143	168	194

Upper Orange	12	13	13	14	14	15
From Gariep only	75	76	78	79	81	82
From Vanderkloof Dam (RSA)	64	71	79	82	85	89
From Vanderkloof Dam (Namibia)	17	20	19	18	17	17
Sub-Total: Domestic/Urban Demands	**254**	**284**	**310**	**336**	**365**	**397**
Katse to Vaal Dam	780	780	855	940	1008	1056
Total River and Operating Requirements	1 083	1 083	1 083	1 083	1 083	1 083
Total Orange River Demand	**4 262**	**4 402**	**4 529**	**4 650**	**4 748**	**4 826**

ENVIRONMENTAL FLOW REQUIREMENTS

A comprehensive environmental assessment was conducted by the Orange-Senqu River Commission (ORASECOM) in 2010 for the entire Orange-Senqu Basin (ORASECOM, 2010).

The Study defined six Management Resource Units (MRU), which are analogous to river reaches along the Orange River, and seven Environmental Flow Requirements[1] (EFR) sites (**Figure 9**).

Environmental Flow Requirement studies classify the sites in terms of several characteristics and physical properties at the sites. Natural conditions are taken into account and the objective of implementing these river requirements is to try and maintain as natural a habitat as possible, in order to sustain the natural ecology and integrity of the river.

The proposed solar power plant is situated along the MRU Orange E reach of the Orange River, which is represented by the upstream EFR Site 03 (Augrabies). Downstream of the site is EFR Site 04 (Vioolsdrift) which is situated at the beginning of MRU Orange F, the reach of river which extends towards the estuary.

Of particular importance to the proposed site, is the downstream EFR Site (Site 04) as this EFR needs to be met, both in terms of quantity and quality, and therefore any additional development upstream of Site 04 (including the proposed solar power plant) needs to adhere to specifications which comply with the EFR conditions at Site 04. Characteristics of EFR Sites 03 and 04 are shown in **Table 21** below.

Table 21 EFR Site Information

EFR SITE	EFR 03	EFR 04
EFR Number	03	04
EFR Name	Augrabies	Vioolsdrift
River	Orange River	Orange River
MRU ('River Reach')	MRU Orange E	MRU Orange F
Location in relation to Proposed Solar Power Site	Upstream	Downstream
Location Co-ordinates (Decimal Degrees)	28°25'43.21" S	28°45'18.90" S
	19°59'53.88" E	17°43'01.06" E
Quaternary Catchment	D81B	D82F
Hydrological Gauge	D7H014	D8H013
Natural Mean Annual Runoff (nMAR) (million m^3)	10 513.08	10 335.08

[1] Environmental Flow Requirements (EFRs) and Environmental Water Requirements (EWRs) are used interchangeably in studies.

EFR SITE	EFR 03	EFR 04
Present Day Mean Annual Runoff (million m^3)	4 228.47	3 906.75
Present Day MAR as a percentage of nMAR	40%	38%

Source: ORASECOM, 2010

For both sites, the wettest month is March and the driest is September, despite being a winter rainfall region (ORASECOM, 2010). The MAR has significantly reduced from its natural conditions (i.e. prior to anthropogenic impacts). The Study showed that there have been changes in reference conditions at EFR Sites 03 and 04, largely due to the construction of large dams (i.e. Gariep and Vanderkloof Dams) upstream of the site.

Hydrologically, there are fewer naturally occurring floods. This, combined with the attenuating effect of the dams, results in a lower frequency of high flows or floods along the Orange River. In addition, there are decreased baseflows during the wet season and increased baseflows during dry/drought periods, which is mainly attributed to the irrigation/agricultural practises (return flows) along the Orange River. Water quality has deteriorated from the natural (reference) conditions due to mining and irrigation practices (application of pesticides and nutrients). The upstream dams make releases (for EFR requirements, downstream demands or releases to create buffer storage in the dam) but these releases may not coincide with naturally occurring high flows, which aids in the hydrological changes in the river.

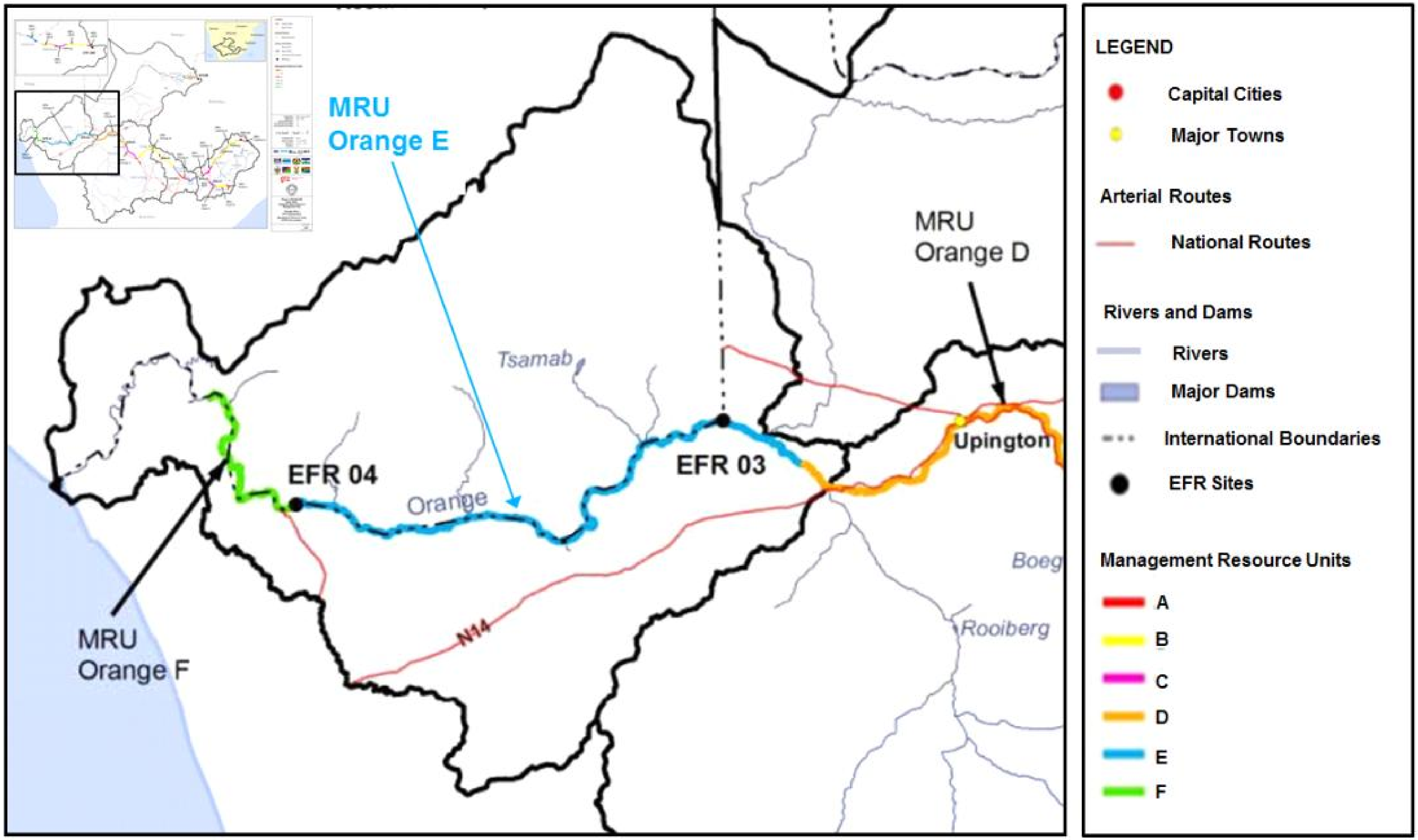
Due to the changes occurring in habitat, there has been a shift in species quantity and type for riparian vegetation, fish, macroinvertebrates and riverine fauna. Sources of these changes include, *inter alia*, flow velocity and volume, water quality, oxygen content of the water, water temperature (related to flow), spawning and/or migration success, natural seasonal variances (cyclic or climate change) as well as releases from upstream dams which are not the same as naturally occurring high flows. There has also been an increase in alien vegetation and alien fish species. In addition there are changes in geomorphology, such as the upstream dams causing a reduction in sedimentation and changes in channels from erosion.

To determine the class (i.e. condition/health/integrity) of a site, an EcoClassification process is undertaken and flow regimes are set in order to maintain specific ecological states. The purpose of the EcoClassification process is to detect and understand the causes and sources of the deviation of the Present Ecological State (PES) from the reference condition. This process will therefore aid in understanding what activities or strategies can be implemented to try and rectify or improve the status.

The state of a river is expressed in terms of the biophysical components of drivers and responses, as follows:

- drivers (hydrology, physico-chemical, geomorphology), and
- biological responses (riparian vegetation, fish and aquatic invertebrates).

Ecological classifications are divided into categories ranging from A to F, with A being pristine and F being severely degraded. The changes in habitat, as mentioned above, are used in classifying the site. A PES is assigned, which is the current state of the river, and a Recommended Ecological Category (REC) is assigned, which is the category aimed at achieving, in order to improve the condition of the ecology of the river. In the 2010 ORASECOM Study, an Alternative Ecological Category (AEC) was also assigned, in the cases where the REC was practically unattainable.



EFR Sites and Management Resource Units (After Orasecom, 2010)	**Data Source:** ORASECOM Environmental Flow Requirements Report (Volume 1), 2010	**Project:** BioTherm **Project No:** 47579 **Drawn by:** B Wickham **Reviewed by:** K Grimmer	**Date:** 29 June 2016 **Figure 9**	WSP PARSONS BRINCKERHOFF www.wspenvironmental.co.za

Figure 9 EFR Sites and Management Resource Units (*after* ORASECOM, 2010)

The Ecological Importance and Sensitivity (EIS) of the site must also be determined, which is based upon riparian and instream components, such as the presence of rare, endangered or endemic species, species sensitive to changes (intolerant), habitat diversity (i.e. pools, rapids etc.), migration activities, as well as the sensitivity and resilience of the system. EFR Site 04 is classified as having a high EIS; this means that it is considered to be unique on a national scale due to biodiversity of habitat species.

The Ecological Categories (EC) and classes of the EFR Sites 03 and 04 are shown in **Table 22** below.

Table 22 Ecological EFR Site Information

Environmental Component	EFR 03 (Augrabies)	EFR 04 (Vioolsdrift)
Ecological Importance and Sensitivity (EIS)	High	High
Ecological Category (EC)	C	D
Present Ecological State (PES)	C	D
Recommended Ecological Category (REC)	B	B
Alternative Ecological Category (AEC) (i.e. ↓)	D	C
Hydrology Ecological Category (EC)	E	D

Source: ORASECOM, 2010

Individual EC's for each environmental component for Sites 03 and 04 are shown in **Table 23** below. Note only Site 04 will be affected by the proposed solar power plant; Site 03 shown for comparative purposes only.

Table 23 Ecological Categories for EFR Site 04 (Vioolsdrift)

EFR Site	Site 03			Site 04		
Environmental Component	PES	REC	AEC	PES	REC	AEC
Hydrology	E	-	-	D	B	-
Physico-chemical	C	C	D	C/D	C/D	D
Geomorphology	C	C	C-	C	C	C
Riparian/Vegetation	B/C	B	C	C	B	C/D
Fish	C	B	D	C	B/C	D
Macro-invertebrates	C	B	D	C	B/C	D
Riverine fauna	C	B	C	C	B/C	C/D

Source: ORASECOM, 2010

The results for EFR Sites 03 (Augrabies) and 04 (Vioolsdrift) are summarised in **Table 24** and **Table 25**, respectively, including maintenance flows, drought flows, high flows as a percentage of the natural MAR (nMAR) and as volumes (both sites are shown for comparative purposes).

Table 24 EFR Results Summary as a Percentage of the Natural MAR for EFR Site 03 (Augrabies)

EFR Site 03 EC	Maintenance Low Flows		Drought Low Flows		High Flows		Long Term Mean	
	% nMAR	million m^3	% nMAR	million m^3	% nMAR	million m^3	% nMAR	million m^3
PES = C	8.4	883.10	2.6	273.34	4.7	494.12	11.9	1251.06
REC = B	17.6	1850.31	3.4	157.37	4.7	494.12	19.2	2018.52

EFR Site 03 EC	Maintenance Low Flows		Drought Low Flows		High Flows		Long Term Mean	
AEC = D	4.1	431.04	2.2	231.29	4.4	462.58	9.0	946.18

Source: ORASECOM, 2010

Table 25 EFR Results Summary as a Percentage of the Natural MAR for EFR Site 04 (Vioolsdrift)

EFR Site 04 EC	Maintenance Low Flows		Drought Low Flows		High Flows		Long Term Mean	
	% nMAR	million m^3	% nMAR	million m^3	% nMAR	million m^3	% nMAR	million m^3
PES=C	6.3	651.11	0.9	35.16	4.2	434.07	8.9	919.82
REC=B/C	10.1	1043.85	1.3	134.36	4.2	434.07	12.2	1260.88
AEC=D	3.1	320.39	0.8	31.25	3.8	392.73	6.9	713.12

Source: ORASECOM, 2010

Major issues which have caused the changes from natural (reference) conditions to the PES for Site 04 are as follows (ORASECOM, 2010):

- decreased frequency of large floods;
- agricultural affects such as changes in return flows and water quality;
- mining activities;
- higher low flows in the dry season (or droughts/dry periods);
- lack of naturally occurring zero flows;
- decreased low flows at other times;
- presence/increase of alien fish species (due to barrier effects of dams) and increase in alien vegetation, and
- decrease in sedimentation load due to the upstream dams, as well as a natural decrease in floods.

The most recent study done by a consortium for the DWS in 2015, has determined the yield of the Orange River system to be 3 325 million m^3/a, which reduces to 3 038million m^3/a when the full EWR releases are supplied.

The reduction in yield due to the implementation of EWRs can vary greatly, dependent upon the class of EWR used, the related assumptions, seasonal variation, to what extent the requirements are implemented and how the system is operated as a whole (for example, if no winter flows are accounted for). Comparing different scenarios set out with different operating rules, the reduction in yield varied from a substantial 1 060 million m^3/a to a lesser 479 million m^3/a (DWA, 2015).

The Study revealed that the Orange River system is only just in balance with the inclusion of EWRs, and any surplus water identified has already been allocated to resource poor farmers along the Orange River, in the amount of 170million m^3/a.

During this Study, the DWS identified the need for detailed water resource management strategies to form part of their Internal Strategic Perspective (ISP) planning initiative, which aims to provide water to meet the demands for the next three to four decades. The final recommendation from the 2015 Reserve Study was that the DWS needs to carry out a Classification Study on the Orange River as soon as possible. It was felt that the existing studies are not sufficiently detailed to make a final decision on the implementation of EWRs on the Orange River. The final EWRs will only be agreed upon and implemented in 2026, with Vioolsdrift Dam in place by 2025.

The Study concluded that going forward, some kind of infrastructure is required to enable the effective implementation of the EWRs (including the Orange River Estuary), and this may be achieved by utilizing the Vioolsdrift Dam, once commissioned. This is required to prevent further deterioration to the environment as well as provide information for planning and development within the Basin going forward (DWA, 2015).

This flexibility and uncertainty in the EWRs provides doubt in the future allocation of water from the Orange River, in terms of quantity and assurance of supply.

It is feasible that the Orange River may be used as a source of water for the BioTherm proposed solar power project, especially due to the fact that it is the only water resource in the area which would provide a high assurance of supply. However, the Reserve Determination Study carried out by DWA in 2015 determined that the ORP is currently in balance, with any surplus water having already been allocated to resource poor farmers (170 million m^3/a).

However, the planned Vioolsdrift Dam, the operating rules of the Gariep and Vanderkloof Dam, as well as the method and classes of Environmental Water Requirements (EWRs) implemented, will significantly impact the availability of water in the Orange River.

Once the quantity of water to commence construction of the solar power plant, as well as what the future demand would be when the plant is in full scale productions, discussions should be held between BioTherm and Sedibeng Water and ORASECOM to determine availability, assurance of supply and water tariffs.

5 WATER SERVICE PROVIDERS

5.1 KHAI-MA LOCAL MUNICIPALITY

As discussed in **Section 2.1**, the proposed site falls within the Khai-Ma LM, which supplies an area of 16 628km^2, with the main offices situated in Pofadder (The Local Government Handbook, accessed 2016).

The Integrated Development Plan (IDP) for 2012-2017 (Khai-Ma LM, 2011) states that considerable attention has been given to the current and potential activities within the municipality's area, such as Black Mountain Mine.

The IDP states that key roles of the local government pertaining to water services include the following:

- Continued improvement of community health service infrastructure by providing clean water, sanitation and waste removal services.
- Maintenance of bulk water infrastructure to aid in the assurance of water supply by maintaining and expanding water purification works and waste water treatment works in line with the growing demands of the supply area.
- Enhance water quality and quantity of water resources (through the National Water Resource Infrastructure Programme), including reducing water losses. This will be done through the development and implementation of water management plans, maintenance, rehabilitation of infrastructure and running water saving awareness campaigns.
- Increasing access to water and sanitation.

According to the IDP, a Water Services Development Plan (WSDP) does exist; however, this required updating at the time (2011). The Bulk Infrastructure Master Plan (Water and Sanitation) is part of the WSDP but a Stormwater Management Plan and a Water Safety Plan were both outstanding. Presently there does not seem to be an updated version of the IDP available.

The Khai-Ma LM is the Water Services Authority (WSA) in the area. However, the Water Service Provider (WSP) is the Pelladrift Water Board (now part of Sedibeng Water).

The Blue Drop Report for the Northern Cape (Part 3, 2014) shows that the Khai-Ma LM holds a Blue Drop Score of **76.53%**, which is an increase of 23.42% from 2012. The breakdown of the Blue Drop Score is shown in **Table 26**.

Table 26 Khai-Ma Local Municipality Blue Drop Scores

Performance Area	Pofadder, Pella, Aggeneys	Onseepkans Melkbosrand	R.K. Onseepkans	Witbank
WSP(s)	Pella WB, Khai-Ma	Khai-Ma LM	Khai-Ma LM	Khai-Ma LM
Water Safety Planning	26.26	13.83	13.83	13.83
Treatment Process Management	8.00	3.60	3.60	3.60
DWQ Compliance	30.00	0.00	7.95	8.75
Management Accountability	7.30	1.95	1.50	1.50
Asset Management	9.03	0.00	0.00	0.00
Use Efficiency, Loss Management	0.00	0.00	0.00	0.00
Bonus Scores	3.20	0.00	0.75	0.75
Penalties	0.00	0.00	0.81	0.59
2014 Blue Drop Score	**83.78%**	**19.38%**	**26.82%**	**19.38%**
2012 Blue Drop Score	56.25%	23.24%	10.61%	6.50%
System Design Capacity (M ℓ/d)	14.0	0.3	0.4	0.3
Operational Capacity (% ito Design)	106%	200%	200%	200%
Average Daily Consumption	1 461	329	796	1 333
Microbiological Compliance	99.7%	81.3%	100.0%	80.0%
Chemical Compliance	99.4%	0.0%	0.0%	0.0%

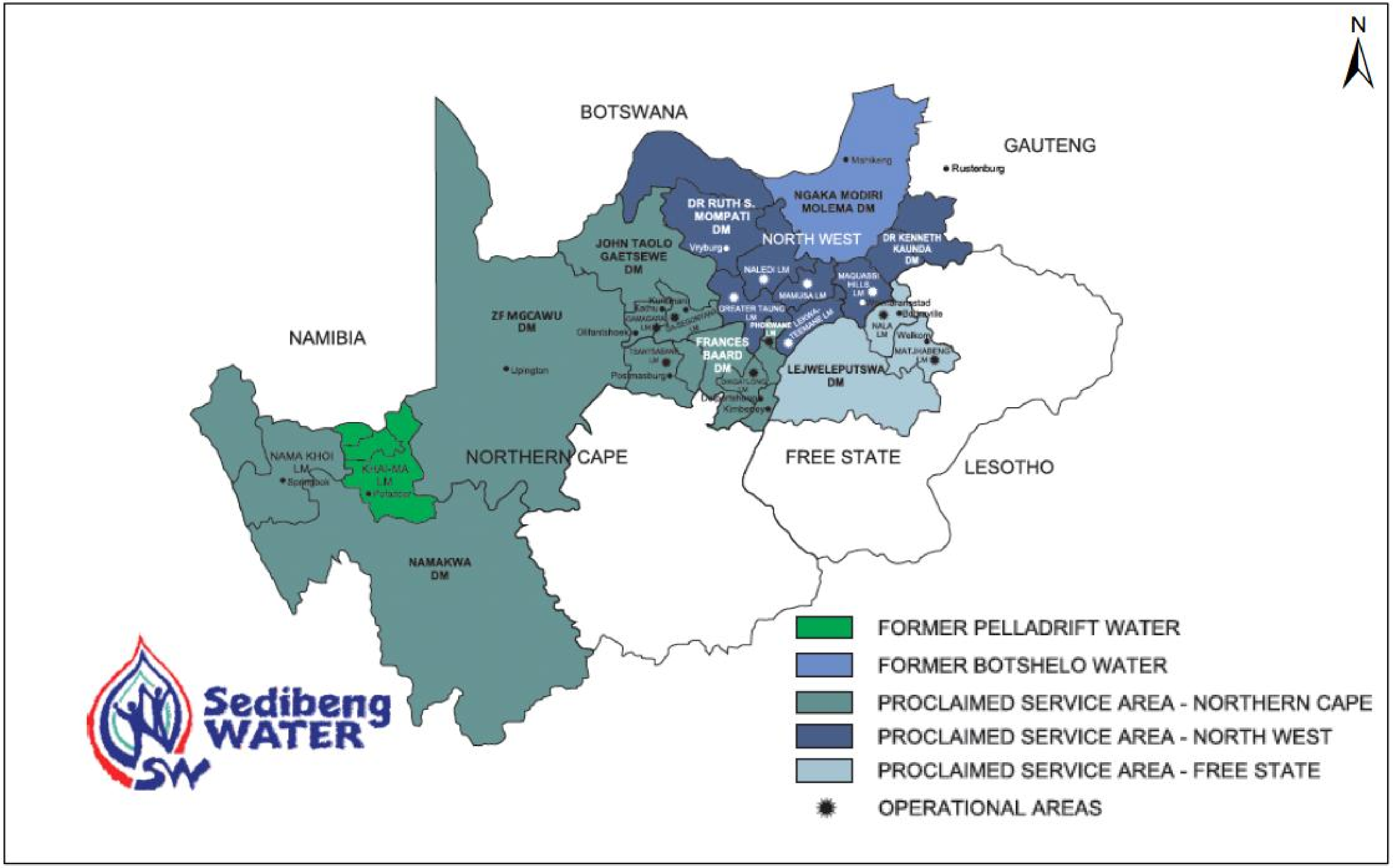
Source: Northern Cape Blue Drop Report, 2014 (Chapter 3)

The water quality in all systems is considered high-risk due to missing or poor results, except for the Pofadder/Aggeneys System which is highly rated in terms of domestic water quality. The DWS believes the lack of understanding of the Blue Drop System within the LM is causing some problems, and the score may easily increase with a better understanding of the system. Based on the results obtained, the DWS has made the poor drinking water quality a matter of urgency to be communicated with the affected consumers.

5.2 SEDIBENG WATER AND THE PELLADRIFT SUPPLY SCHEME

The Pelladrift Water Board was established in 1980, with the primary purpose of acting as the bulk water supplier for the area. The water board operates the Pelladrift Supply Scheme, which abstracts water directly from the Orange River at Pelladrift and provides a sustainable water supply to the Black Mountain Mine (BMM), Aggeneys, Pella, Pofadder and Onseepkans (all located within the Khai-Ma LM) as well as neighbouring farmers (Pelladrift Water Board *Report to Committee*, 2013).

In November 2014, as per DWS directive, the Pelladrift Water Board was incorporated into Sedibeng Water. Pelladrift Water was then disestablished and the area of supply was incorporated into that of Sedibeng Water's area of supply (Sedibeng Water Annual Report 2013-2014). Sedibeng Water covers three provinces, namely the Free State, the North West and the Northern Cape Provinces, with Pelladrift still operating within the supply (**Figure 10**).



Sedibeng Water: Area of Supply (Showing the Pelladrift Supply Area)	**Data Source:** Sedibeng Water	**Project:** BioTherm	**Date:** 29 June 2016	WSP PARSONS BRINCKERHOFF www.wspenvironmental.co.za
		Project No: 47579		
		Drawn by: B Wickham	**Figure 10**	
		Reviewed by: K Grimmer		

Figure 10 Sedibeng Water: Area of Supply (showing the Pelladrift supply area)

The improvement of the Blue Drop Score for the Khai-Ma LM has been entirely attributed to the role of Pelladrift Water Board for the Pofadder/Aggeneys Supply System (Northern Cape Blue Drop Report, 2014).

The Pelladrift Water Supply Scheme consists of the following components (Sedibeng Water, 2011 and 2015):

- Raw Water Pump Station at Pelladrift (135ℓ/s);
- Raw Water Rising Main;
- Clear Water Rising Main from Pelladrift WTP to Horseshoe Reservoir to Saddleback Reservoir (~23km);
- Potable Water Rising Main;
- Rising Main from Pelladrift WTP to Pofadder Booster Pump Station;
- Rising Main from Pofadder Booster Pump Station to a Municipal Reservoir in Pofadder;
- Pelladrift Water Treatment Plant 12Mℓ/d;
- Booster Pumpstation (135ℓ/s at 80 bar);
- Horseshoe (Balancing) Reservoir;
- Saddleback Reservoir;
- Off-take off the Rising Main at Pella Village;
- Kokerboom Reservoir;
- Meters and telemetry, and
- Clarifier.

Pelladrift water treatment plant does not have a filtration system for the distribution of the final water. However, there is a pressurised filtration unit which is used for potable water. The existing clarifier, which is cleaned once a year, removes the flock which is formed. The upgrade anticipated for the Gamsberg Mine includes the construction of a filtration system to reduce the turbidity levels, which are between 1-5 NTU (Nephelometric Turbidity Units) (Sedibeng Water, 2011).

The Pelladrift treatment plant has a capacity of 12Mℓ per day and since it is currently operating at full capacity, it will not have spare capacity to support the proposed BioTherm Solar Power Project. This scheme was able to meet its demands in the 2014/15 financial year producing a total of 4.6 million m^3 within that time. The Black Mountain Mine and the Aggeneys township collectively consume approximately 85% of the water supplied by the Pelladrift Scheme (Sedibeng Water Board Annual Report, 2015). The Pelladrift Scheme is earmarked for an upgrade from 12 Mℓ per day to 24 Mℓ per day, as explained in **Section 3.2**. With the Black Mountain Mine nearing the end of its lifespan, the upgrades due to the new Gamsberg Mine, as well as infrastructure development by BioTherm themselves, water will be available for supply for the Solar Farm and able to be conveyed via one of the Options discussed in **Section 3.2**.

An annual maintenance plan for the scheme exists, which includes planned maintenance (daily, weekly, monthly and annual inspections), in addition to unplanned maintenance as and when required. During 2014/2015 planned maintenance was carried out, such as services of equipment (e.g. pumps, actuator, telemetry system), cleaning (e.g. reservoirs, clarifier) and analyses (e.g. oil and vibration analyses of pumps). Unplanned repairs and replacements included, inter alia, valves, burst pipes, faulty meters, and the telemetry system. There was no refurbishment done in the 2014/15 financial year; however, the plant and pipeline have been earmarked for upgrades (Sedibeng Water Annual Report 2014/2015).

At this time, the system was already operating at its maximum capacity and a recommendation was made for the construction of a new pipeline from the Orange River at Pelladrift via Aggeneys. This study recognised the need for upgrade to increase Pelladrift's supply capacity, and suggested it be made part of the infrastructure which would be required by the anticipated Gamsberg Mine.

Volumes of water supplied are shown in **Table 27**, which includes the supply to a total of approximately 8 500 people (Pelladrift WB, 2013).

Table 27 Water Supply of Pelladrift Water Board in 2013

ABSTRACTION	VOLUME (M^3)
Black Mountain Mine	3 672 199
Khai Ma LM	530 990
Farmers	27 417
Total	**4 230 606**

Source: Pelladrift Water Board, 2013

An updated total from Sedibeng Water shows a total volume of 4.6 million m^3/a to be allocated to the Pelladrift Water Supply Scheme (Sedibeng Water, 2015).

Aggeneys and the associated mines receive their water from the Orange River via the Pelladrift pump station. The water is first purified at the treatment plant mainly to remove the sediment which would cause problems in a long pipeline. It is then conveyed to Aggeneys and also to the town of Pofadder through the 50 km long pipeline. Almost 8 million m^3 of water are used annually at the mine and although this volume is relatively small relative to the resources of the Orange River, it represents a high priority demand (DWS[2], 2016).

The water quality results for the Pelladrift Water Scheme are shown in **Table 28** below (Sedibeng Water, 2015).

Table 28 Pelladrift Water Quality Results based upon SANS 241

Determinant	Unit	Risk	Standard Limit	Compliance
Physical and Aesthetic Determinants				
pH (at 25 °C)	pH Units	Operational	≥ 5.0 ≤ 9.7	100
Turbidity	NTU	Operational	≥ 1	0
		Aesthetic	≤ 5	100
Conductivity (at 25 °C)	mS/m	Aesthetic	≤ 170	-
Microbiological safety requirements				
Heterotrophic Plate Count	count/100mℓ	Operational	≤ 1000	100
Total Coliforms	count/100mℓ	Operational	≤ 10	100
E. coli	count/100mℓ	Acute Health	Not detected	100
Chemical Determinants				
Acid soluble iron	µg/ℓ Fe	Operational	≤ 2 000	-
		Aesthetic	≤ 300	-
Acid soluble aluminium	µg/ℓ Al	Operational	≤ 300	-

Source: Sedibeng Annual Report 2014 -2015 (2011)

Should Sedibeng Water have the resources and motivation to supply the proposed project with the associated water demand, BioTherm would not require authorisation, which is an additional benefit.

5.3 BLACK MOUNTAIN MINE

The existing Black Mountain Mine (operated by Black Mountain Mining (Pty) Ltd) and is a joint venture between Sesa Sterlite (74%) and Vedanta Resources (26%). It is located approximately 14km east of the town of Aggeneys, which was founded to support the labourers of the mine. The mine has been operating since 1979 (RHDHV, 2013). The mine uses both potable and processed water for the mining operations with almost all of its supply coming from the Orange River (Pelladrift Water Supply Scheme).

There are two sewerage plants which are operated in conjunction with the mine, one for the mine itself, and one servicing the nearby township. Both plants use oxidation ponds to treat the effluent, and the resultant treated water is used for irrigation of Lucerne (from the mine plant) and a golf course (from the township plant) (RHDHV, 2013).

The mine is finite and the resource (ore deposits) will deplete with the mine's lifespan. Therefore, in the long term, the Pelladrift Supply Scheme will need to become self-sustainable and an exit strategy will need to be developed in collaboration with the Department of Water Affairs (DWAF Q&A, 2007). With the Mine currently being the main consumer of water from the scheme, the Pelladrift Supply Scheme should have additional capacity once this mine is decommissioned in 2019.

Within the mining areas, there is very little water available from an underground resource, and most of the water which is pumped from underground originates from backfill drainage. As such the Orange River is the main source of water for the mine (RHDHV, 2013). The current infrastructure and available water are fully utilised and therefore this mine does not offer an option of water supply for the proposed solar power plant.

5.4 GAMSBERG MINE

Black Mountain Mining will operate the new Gamsberg Mine Project which is one of the world's biggest undeveloped zinc ore deposits, estimated to contain 194 million tonnes of zinc ore resources. The Gamsberg Mine will be a part of the larger Gamsberg-Skorpion Integrated Project, which includes the development of an open-pit zinc mine, a concentrator plant (and associated infrastructure), as well as the conversion of the Skorpion zinc refinery in Namibia. This includes an addition to the existing Skorpion mine refinery in Namibia, which will enable the production of high-grade zinc from Gamsberg's zinc sulphide ore.

The 24 month construction period of the mine commenced in July 2015; the first production from the mine expected by 2017. The mine is projected to have a life expectancy of 13 years (with the potential to extend), and therefore will only be decommissioned after 2030. The project will create approximately 1 500 temporary jobs during the construction phase, and thereafter 500 permanent jobs.

The power requirement of the Gamsberg Project will be 40MVA, and will be provided via the Aggeneys substation, located approximately 15km from the mine site, through a new 28km-long power line. The Project has a water demand of 13mℓ/d and will be supplied by a 38km surface pipeline which will be constructed from the existing Pelladrift Scheme abstraction point on the Orange River to the mine (Mining Technology, accessed 2016).

The following associated infrastructures will be put in place along with mine and concentrator (Vedanta Zinc International, accessed 2016):

- Tailings dam, waste rock dump, stockpiles and a landfill site;
- Evaporation dams;
- Offices, workshops and construction workers contractor's camp;

- Powerlines from the Aggeneys substation to Gamsberg, approximately 15 km;
- Pipelines from the Pella Pump Station to Gamsberg, approximately 60 km;
- Access Roads from the N14 to Gamsberg, approximately 10 km of road network, and
- Sewage treatment facilities.

Due to the planned infrastructure development for the Gamsberg Mine, it may be a viable option for the proposed BioTherm Solar Plant to tie into this through association between the Pelladrift Water Board and Black Mountain Mining (Pty) Ltd. This would include both water reticulation (infrastructure such as pipelines) as well as water provisions to secure future supply for the associated demand of the Biotherm Project.

6 CONCLUSIONS AND RECOMMENDATIONS

CSP Project Site 1 and the other six sites will be supplied from the same source, via the pipelines, pumpstations and sub-stations (power) as described in **Section 3.2**. Recommendations on the supply source are detailed below.

6.1 GROUNDWATER

Supplementary water supply is potentially available through groundwater abstraction; however this will be based upon the exact site locations and plant (or borehole) demand. Due to the sparse population of the area, there is little regional competition for the groundwater which makes this a viable option.

The water quality may require treatment prior to use in the BioTherm operations. As noted in **Section 4.1**, the groundwater quality seems to be highly variable and would therefore be technology specific and will need to be further investigated in terms of quality and associated treatment requirements.

6.2 SURFACE WATER

Local surface water resources are not a viable option for the project, due to the regional climate (and the absence of perennial rivers. Even in periods of rainfall, the assurance of supply would be too low to be considered a sustainable option.

The only surface water resource which would be a viable option is the Orange River. The Orange River would be able to supply water at a high assurance of supply, which is necessary for a plant such as this. However, the availably of water and assurance of supply will be affected by the EWR requirement, once it has been finalised.

A water use licence application in terms of Section 21(a), “taking water from a resource” will be required to legally abstract water from the river.

6.3 MUNICIPALITY / WATER SERVICE PROVIDER

The Pelladrift Supply Scheme, which provides (amongst others) the town of Aggeneys and the Black Mountain Mine, is currently operating at its capacity and therefore there is no spare capacity for allocation through this source. The Pelladrift Supply Scheme abstracts water from the Orange River, and despite the possible available resource, the infrastructure associated with the supply scheme (e.g. treatment plant) is preventing any additional water to be allocated through this source.

However, the planned infrastructure expansions and upgrades will result in a capacity increase from 12 000 m^3/day to 24 000m^3/day, and therefore significantly change the water availability.

It is advised that BioTherm engage in discussions with Sedibeng as the Water Service Provider for the area, as well as Vedanta Mining to tie in with both systems in order to maximise infrastructure use and minimise costs.

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Appendix A

WATER QUANTITY (BOREHOLE) RESULTS

BH NO:	**BH 133**
DATE:	2016/03/02
LONGITUDE:	18.911828
LATITUDE:	-29.431147
CASING DEPTH:	
BH DEPTH:	77.28m
STATIC WATER LEVEL:	40.56m
BH DIAMETER:	165mm
CASING HEIGHT:	
CONCRETE PLINTH:	0.25m
CONCRETE FLOOR:	

BOREHOLE NO : BH 133 | **STEP TEST & RECOVERY** | **VSA Leboa Consulting**

ALT.BH. NO :
ALT.BH. NO :________________________
VILLAGE NAME : AGGENEYS
ALT. VILLAGE NAME : FARM RE/86
BOREHOLE DEPTH (Before installation of test pump) : 77.28m
DATUM LEVEL ABOVE CASING 0.68m
WATER LEVEL (Measured at datum point before Steps) 41.24m
CONTRACTOR : VSA LEBOA
INSTALLATION DEPTH OF TESTPUMP: 72.50m
FOREMAN : GIFT
Latitude: **Longitude:**
Date : 2016/03/02 Time : 15:25

DISCHARGE RATE 1				**DISCHARGE RATE 2**				**DISCHARGE RATE 3**				**RECOVERY**		
TIME (min)	**ACTUAL TIME**	**Water level (m)**	**YIELD (l/s)**	**TIME (min)**	**ACTUAL TIME**	**Water level (m)**	**YIELD (l/s)**	**TIME (min)**	**ACTUAL TIME**	**Water leve (m)**	**YIELD (l/s)**	**TIME (min)**	**ACTUAL TIME**	**RECOVERY (m)**
1	15:26	42.45		**1**	16:26	42.98		**1**	17:26	44.02		**1**	18:36	57.47
2	15:27	42.5		**2**	16:27	43	0.31	**2**	17:27	44.24		**2**	18:37	53.36
3	15:28	42.49		**3**	16:28	43.18	0.44	**3**	17:28	44.42	0.86	**3**	18:38	48.74
5	15:30	42.4		**5**	16:30	43.22		**5**	17:30	44.82	1.1	**5**	18:40	45.78
7	15:32	42.33		**7**	16:32	42.27		**7**	17:32	45.64		**7**	18:42	45.27
10	15:35	42.16	0.2	**10**	16:35	43.3	0.43	**10**	17:35	46.05	1.1	**10**	18:45	44.42
15	15:40	42.34		**15**	16:40	43.3		**15**	17:40	46.57		**15**	18:50	43.76
20	15:45	42.46	0.2	**20**	16:45	43.34	0.44	**20**	17:45	46.72		**20**	18:55	43.24
30	15:55	42.46	0.2	**30**	16:55	43.37		**30**	17:55	46.93	1.11	**30**	19:05	42.95
40	16:05	42.51		**40**	17:05	43.43	0.44	**40**	18:05	47.18		**40**	19:15	42.67
50	16:15	42.56	0.2	**50**	17:15	43.49	0.44	**50**	18:15	47.36	1.1	**60**	19:35	42.34
60	16:25	42.62		**60**	17:25	43.54		**60**	18:25	47.51		**90**	20:05	42.08
70				**70**				**70**				**120**	20:35	42.02
80				**80**				**80**				**150**	21:05	41.8
90				**90**				**90**				**180**	21:35	41.71

DISCHARGE RATE 4			
TIME (min)	ACTUAL TIME	**Water level** (m)	YIELD (l/s)
1	18:26	51.66	
2	18:27	54.79	
3	18:28	56.17	3.56
5	18:30	59.21	3.81
7	18:32	65.19	3.81
	18:33	71.36	
		pump suction	1.96
	18:34	pump suction	1.92
	18:35	pump suction	1.9

BOREHOLE NO : BH 133 | **CONSTANT RATE DISCHARGE TEST** | ***VSA Leboa Consulting***

ALT. BH. NO.:
VILLAGE NAME: AGGENEYS
ALT. BH. NO.:
ALT.VILLAGE NAME : **FARM RE/86**
BOREHOLE DEPTH (BEFORE INSTALLATION OF TESTPUMP): 77.28m
Datum Level Above Casing : 0.68m
WATER LEVEL (Measured at datum point before the Constant) 41.24m
CONTRACTOR : VSA LEBOA
INSTALLATION DEPTH OF TESTPUMP : 72.50m
FOREMAN : GIFT
Date started: 2016/03/03 Time started: 06:45
Latitude: **Longitude:**
Drawdown still outstanding when constant rate was started: 41.15
OBSERVATION HOLE | OBSERVATION HOLE | Water level (m)
TOTAL DURATION OF TEST : (Pump time + Recovery): min
Bh NO': | Bh NO':
*** NOTE Distance between discharge and observation holes in (m) >**
Distance: | Distance:

TIME (min)	ACTUAL TIME (Hour : Min)	**Water level (m)**	YIELD (l/s)	TIME (min)	ACTUAL TIME (Hour : Min)	RECOVERY (m)	Water level: TIME (min)	Water leve (m)	Water level: TIME (min)	Water leve (m)	Water level: TIME (min)	
1	06:46	43.22		1	14:46	51.74	1		1		1	
2	06:47	43.96		2	14:47	50.55	2		2		2	
3	06:48	44.21	0.95	3	14:48	49.92	3		3		3	
5	06:50	44.99	1.6	5	14:50	49.31	5		5		5	
7	06:52	45.68	1.63	7	14:52	49.11	7		7		7	
10	06:55	47.36		10	14:55	48.68	10		10		10	
15	07:00	47.58	1.62	15	15:00	47.97	15		15		15	
20	07:05	47.87		20	15:05	47.48	20		20		20	
30	07:15	48.24	1.63	30	15:15	46.74	30		30		30	
40	07:25	48.69		40	15:25	46.09	40		40		40	
60	07:45	49.21	1.63	60	15:45	45.36	60		60		60	
90	08:15	49.72		90	16:15	44.55	90		90		90	
120	08:45	50.25	1.62	120	16:45	43.31	120		120		120	
150	09:15	50.6		150	17:15	43.06	150		150		150	
180	09:45	50.95	1.63	180	17:45	42.9	180		180		180	
210	10:15	51.81	1.63	210	18:15	42.79	210		210		210	
240	10:45	52.26		240	18:45	42.66	240		240		240	
300	11:45	52.89	1.63	300	19:45	42.52	300		300		300	
360	12:45	52.2		360	20:45	42.39	360		360		360	
420	13:45	52.79	1.63	420	21:45	42.24	420		420		420	
480	14:45	53.33		480	22:45	42.08	480		480		480	

BH NO:	BH 145
DATE:	2016/03/09
LONGITUDE:	18.925976
LATITUDE:	-29.456212
CASING DEPTH:	
BH DEPTH:	137.42m
STATIC WATER LEVEL:	79.59m
BH DIAMETER:	155mm
CASING HEIGHT:	
CONCRETE PLINTH:	0.49m
CONCRETE FLOOR:	

BOREHOLE NO : BH 145	**STEP TEST & RECOVERY**	**VSA Leboa Consulting**
ALT.BH. NO :		VILLAGE NAME : AGGENEYS
ALT.BH. NO :_______________________		ALT. VILLAGE NAME : FARM RE/86
BOREHOLE DEPTH (Before installation of test pump) :	137.42m	DATUM LEVEL ABOVE CASING : 0.61m
WATER LEVEL (Measured at datum point before Steps)	80.65m	CONTRACTOR : VSA LEBOA
INSTALLATION DEPTH OF TESTPUMP:	93.80m	FOREMAN : PAUL
Latitude:	**Longitude:**	**Date : 2016/03/08 Time : 13:55**

DISCHARGE RATE 1				**DISCHARGE RATE 2**				**DISCHARGE RATE 3**				**RECOVERY**		
TIME (min)	ACTUAL TIME	**Water level** (m)	YIELD (l/s)	TIME (min)	ACTUAL TIME	**Water level** (m)	YIELD (l/s)	TIME (min)	ACTUAL TIME	**Water level** (m)	YIELD (l/s)	TIME (min)	ACTUAL TIME	RECOVERY (m)
1	13:56	83.85		**1**				**1**				**1**	14:17	80.1
2	13:57	85.19		**2**				**2**				**2**	14:18	80.09
3	13:58	85.86		**3**				**3**				**3**	14:19	80.08
5	14:00	86.56		**5**				**5**				**5**	14:21	80.06
7	14:02	88.17		**7**				**7**				**7**	14:23	80.05
10	14:05	90.76		**10**				**10**				**10**	14:26	80.13
15	14:10	92.47	0.15	**15**				**15**				**15**	14:31	80.17
	14:12	pump suction	0.06	**20**				**20**				**20**	14:36	80.2
	14:14	pump suction	0.04	**30**				**30**				**30**	14:46	80.24
	14:16	pump suction	0.03	**40**				**40**				**40**	14:56	80.27
				50				**50**				**60**	15:16	80.29
				60				**60**				**90**		
				70				**70**				**120**		
				80				**80**				**150**		
				90				**90**				**180**		
				100				**100**				**210**		
				110				**110**				**240**		
				120				**120**				**300**		

BH NO:	BH 155
DATE:	2016/03/05
LONGITUDE:	18.964373
LATITUDE:	-29.428145
CASING DEPTH:	9.40m
BH DEPTH:	59.55m
STATIC WATER LEVEL:	26.90m
BH DIAMETER:	165mm
CASING HEIGHT:	
CONCRETE PLINTH:	0.40m
CONCRETE FLOOR:	

BOREHOLE NO : BH 155	**STEP TEST & RECOVERY**	**VSA Leboa Consulting**
ALT.BH. NO :		VILLAGE NAME : AGGENEYS
ALT.BH. NO :_______________________		ALT. VILLAGE NAME : FARM RE/86
BOREHOLE DEPTH (Before installation of test pump) :	59.55m	DATUM LEVEL ABOVE CASING : 0.60m
WATER LEVEL (Measured at datum point before Steps)	27.74m	CONTRACTOR : VSA LEBOA
INSTALLATION DEPTH OF TESTPUMP:	51.50m	FOREMAN : GIFT
Latitude: **Longitude:**		**Date : 2016/03/04** **Time : 15:05**

DISCHARGE RATE 1				**DISCHARGE RATE 2**				**DISCHARGE RATE 3**				**RECOVERY**		
TIME	ACTUAL	**Water level**	YIELD	TIME	ACTUAL	**Water level**	YIELD	TIME	ACTUAL	**Water level**	YIELD	TIME	ACTUAL	RECOVERY
(min)	TIME	(m)	(l/s)	(min)	TIME	(m)	(l/s)	(min)	TIME	(m)	(l/s)	(min)	TIME	(m)
1	15:06	28.2		**1**	16:06	30.22		**1**	17:06	31.34		**1**	18:11	44.08
2	15:07	28.42		**2**	16:07	30.34		**2**	17:07	31.37		**2**	18:12	39.62
3	15:08	28.43		**3**	16:08	30.4	0.6	**3**	17:08	31.48	1	**3**	18:13	35.76
5	15:10	28.54		**5**	16:10	30.57		**5**	17:10	31.62	1.25	**5**	18:15	31.1
7	15:12	28.76		**7**	16:12	30.67	0.61	**7**	17:12	31.81		**7**	18:17	30.84
10	15:15	29	0.32	**10**	16:15	30.72		**10**	17:15	31.93	1.26	**10**	18:20	30.64
15	15:20	29.39		**15**	16:20	30.84	0.6	**15**	17:20	31.93	1.26	**15**	18:25	30.44
20	15:25	29.59	0.32	**20**	16:25	30.86	0.6	**20**	17:25	31.93	1.26	**20**	18:30	30.33
30	15:35	29.76		**30**	16:35	30.91		**30**	17:35	31.94	1.26	**30**	18:40	30.15
40	15:45	29.81	0.32	**40**	16:45	30.93	0.61	**40**	17:45	31.94	1.26	**40**	18:50	30
50	15:55	30		**50**	16:55	30.98	0.61	**50**	17:55	31.95	1.25	**60**	19:10	29.88
60	16:05	30.07		**60**	17:05	31.01		**60**	18:05	31.96	1.26	**90**	19:40	29.72
70				**70**				**70**				**120**	20:10	29.65
80				**80**				**80**				**150**	20:40	29.6
90				**90**				**90**				**180**	21:10	29.51
100				**100**				**100**				**210**		
110				**110**				**110**				**240**		
120				**120**				**120**				**300**		

DISCHARGE RATE 4			
TIME	ACTUAL	**Water level**	YIELD
(min)	TIME	(m)	(l/s)
1	18:06	42.53	
2	18:07	49.62	
3	18:08	49.97	3.42
		50.8	3.42
	18:09	pump suction	1.78
		pump suction	1.75
	18:10	pump suction	1.7
80			
90			
100			
110			
120			

CONSTANT RATE DISCHARGE TEST

VSA Leboa Consulting

BOREHOLE NO : BH 155

ALT. BH. NO.:

ALT. BH. NO.:

VILLAGE NAME: AGGENEYS

ALT.VILLAGE NAME : **FARM RE/86**

BOREHOLE DEPTH (BEFORE INSTALLATION OF TESTPUMP): 59.55m

Datum Level Above Casing : 0.60m

WATER LEVEL (Measured at datum point before the Constant) 27.74m

CONTRACTOR : VSA LEBOA

INSTALLATION DEPTH OF TESTPUMP : 51.50m

FOREMAN : GIFT

Date started: 2016/03/04 | Time started: 21:30 | **Latitude:** | **Longitude:**

Drawdown still outstanding when constant rate was started: 29.46m

TOTAL DURATION OF TEST : (Pump time + Recovery): min

*** NOTE Distance between discharge and observation holes in (m) >**

							OBSERVATION HOLE 1		OBSERVATION HOLE 2		Water level
							Bh NO':		Bh NO':		(m)
							Distance:		Distance:		
TIME	ACTUAL	**Water level**	YIELD	TIME	ACTUAL	RECOVERY	Water level:		Water level:		Water level:
(min)	TIME	**(m)**	(l/s)	(min)	TIME	(m)	TIME	Water level	TIME	Water level	TIME
	(Hour : Min)				(Hour : Min)		(min)	(m)	(min)	(m)	(min)
1	21:31	30.82		1	03:01	47.28	1		1		1
2	21:32	31.35		2	03:02	44.91	2		2		2
3	21:33	31.59	1.4	3	03:03	43.44	3		3		3
5	21:35	31.7		5	03:05	42.5	5		5		5
7	21:37	31.96	1.41	7	03:07	40.43	7		7		7
10	21:40	32.1	1.4	10	03:10	38.66	10		10		10
15	21:45	32.4		15	03:15	34.62	15		15		15
20	21:50	32.88	1.4	20	03:20	31.92	20		20		20
30	22:00	33.27		30	03:30	31.64	30		30		30
40	22:10	38.2	1.4	40	03:40	31.55	40		40		40
60	22:30	38.69		60	04:00	31.43	60		60		60
90	23:00	39.56		90	04:30	31.29	90		90		90
120	23:30	40.21	1.4	120	05:00	31.12	120		120		120
150	00:00	42.1	1.39	150	05:30	31	150		150		150
180	00:30	44.98		180	06:00	30.9	180		180		180
210	01:00	46.64	1.39	210	06:30	30.84	210		210		210
240	01:30	48.84		240	07:00	30.74	240		240		240
300	02:30	50	1.4	300	08:00	30.6	300		300		300
	02:55	50.8	0.99	360	09:00	30.53	360		360		360
	02:58	pump suction	0.99	420	10:00	30.46	420		420		420
	03:00	pump suction	0.98	480	11:00	30.4	480		480		480
				540			540		540		540
				600			600		600		600
				720			720		720		720

Appendix B

WATER QUALITY (BOREHOLE) RESULTS

CAPRICORN VETERINARY LABORATORIES cc

VETERINARY PRECISE ANALYTICAL & DIAGNOSTIC LABORATORY SERVICES

215 Marshall Street, Flora Park, Polokwane, South Africa, 0699
P.O. Box 115; Bendorpark, 0713
Tel: +27(15) 297-6666
Fax: +27(15) 297-3929
E-mail: info@caprivet.co.za

LABORATORY TEST REPORT

WATER CHEMISTRY:

Your reference:	**PR12/112**
Our reference:	**16/03/952**
Enquiries:	**015 297-6666**
Date:	**2016/03/15**

Sender/ Client:	VSA Leboa Consulting	**Owner:**	Ref sender
Person sent:	Rabelani	**Sample origin:**	On site – Springbok
Postal:	P.O. Box 222 Polokwane 0700	**Postal:**	Ref sender Ref sender Ref sender
Tel:	015 289-8847	**Tel:**	Ref sender
Fax:	086 685 7724	**Fax:**	Ref sender
E-mail:	vsaleboanels@mweb.co.za	**E-mail:**	Ref sender

Water

1. Samples received:
3 x ground water sample(s) as indicated in Table 1.

1.1 Date sample(s) received:	2016/03/10
1.2 Time sample(s) received:	16h25
1.3 Date test(s) started:	2016/03/11
1.4 Date report completed:	2016/03/15

2. Required test(s):
2.1 Water chemistry

3. Test method
The sample(s) were tested in accordance with:

3.1 Refer to Table 1

4. Sample and condition/…

4. Sample and condition :

4.1 Date of sampling: 2016/03/03 – 2016/03/08

4.2 Date sample submitted: 2016/03/10

4.3 Temp. upon sample reception: 24.0℃

4.4 Sample defects noted: Prolonged sample submission period

5. Sub contractor:

5.1 None

6. Results:

<u>Table 1:</u>

Refer to 2.1

Determinand	Test Method Reference	Unit	1-16/952	2-16/952	3-16/952
			Place: Springbok Albertus Roux farm Re/86 Date: 03-03-2016 Time: 15H40	Place: Farm RE/86 Albertus Roux BH No: 155 Date: 05/03/2016 Time: 03H55	B/H - 145 Place: Springbok Date: 08-03-2016 Time: 14H10
Physical and aggregate properties					
pH @ 25℃	CH-METH-001	pH units	7.1	7.2	7.1
Conductivity @25℃	CH-METH-002	mS/m	185.9	149.2	404.4
*Total dissolved solids (calculated)	CH-METH-038	mg/l	1208	970	2386
Alkalinity					
*Bicarbonate alkalinity as $CaCO_3$	CH-METH-054	mg/l	208.8	239.6	215.8
*Carbonate alkalinity as $CaCO_3$		mg/l	0.0	0.0	0.0
Hardness:					
*Total hardness as $CaCO_3$	CH-METH-039	mg/l	472.67	351.55	996.07
*Ca hardness as $CaCO_3$		mg/l	339.83	256.10	659.25
*Mg hardness as $CaCO_3$		mg/l	132.84	95.45	336.82
Metals					
Aluminium as Al	CH-METH-020	mg/l	<0.01	0.01	<0.01
Arsenic as As	CH-METH-020	mg/l	<0.03	<0.03	<0.03
Calcium as Ca	CH-METH-020	mg/l	135.93	102.44	263.70
Copper as Cu	CH-METH-020	mg/l	<0.01	<0.01	<0.01
Iron as Fe	CH-METH-020	mg/l	<0.01	<0.01	<0.01
Magnesium as Mg	CH-METH-020	mg/l	32.40	23.28	82.15
Manganese as Mn	CH-METH-020	mg/l	<0.01	<0.01	0.23
Potassium as K	CH-METH-020	mg/l	14.01	10.74	27.85
Sodium as Na	CH-METH-020	mg/l	203.61	181.06	471.05
Inorganic non-metallic constituents					
Chloride as Cl	CH-METH-050	mg/l	330.1	222.6	939.4
Fluoride as F	CH-METH-013	mg/l	3.04	3.17	2.30
Nitrogen					
*Ammonium as NH_4-N	CH-METH-031	mg/l	<0.20	0.79	0.20
Nitrate as NO_3-N	CH-METH-050	mg/l	18.66	12.70	25.56
*Nitrite as NO_2-N	CH-METH-011	mg/l	<0.01	0.02	0.05
Phosphorus					
Ortophosphate as PO_4-P	CH-METH-032	mg/l	<0.05	<0.05	<0.05
Sulphur					
Sulphate as SO_4	CH-METH-050	mg/l	143.04	111.56	333.78
Silica					
*Silica as Si	CH-METH-020	mg/l	18.18	13.88	10.70

Key:
* - Not a SANAS accredited method

Disclaimer: Comments and interpretations expressed herein are not within the scope of SANAS accreditation.

7. Comments:
7.1 The sample(s) have deviated from the norm, in which the maximum preservation period allowed for certain chemical determinands has been exceeded prior to sample submission. The prolonged sample submission period may have a definite impact with regard to the outcome of the test results.

8. Interpretations:
8.1 None

M. Andrin
(Technical Manager)

(END OF REPORT)