Water Use Licence Application for the Abstraction of Groundwater at Kamiebees Farm 368/1, Northern Cape

Technical Motivation Report

Report Prepared for

SJR Boerdery CC

Report Number 552583/1

Report Prepared by

srk consulting

February 2020

Water Use Licence Application for the Abstraction of Groundwater at Kamiebees Farm 368/1, Northern Cape

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February 2020

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Profile and Expertise of EAPs

SRK Consulting (South Africa) (Pty) Ltd (SRK) was appointed by SJR Boerdery CC (SJR Boerdery) to conduct the Water Use Licence Application (WULA) process required in terms of the National Water Act 36 of 1998 (NWA) for additional groundwater abstraction at Kamiebees Farm 368/1 in the Northern Cape.

SRK Consulting comprises over 1 400 professional staff worldwide, offering expertise in a wide range of environmental and engineering disciplines. SRK's Cape Town environmental department has a distinguished track record of managing WULA processes and has been practicing in the Western Cape since 1979. SRK has rigorous quality assurance standards and is ISO 9001 accredited.

The qualifications and experience of the key individual practitioners responsible for this project are detailed below.

Project Director and Reviewer: Christopher Dalgliesh, BBusSc (Hons); MPhil (EnvSci)

Certified with the Interim Board for Environmental Assessment Practitioners South Africa (CEAPSA)

Chris Dalgliesh is an SRK Director and Principal Environmental Consultant with over 33 years' experience, primarily in Southern Africa, West Africa, South America, the middle East and Asia. Chris has worked on a wide range of projects, notably in the natural resources, Oil & Gas, waste, infrastructure and industrial sectors. He has directed and managed numerous Environmental and Social Impact Assessments (ESIAs), in accordance with international standards (e.g. IFC). He regularly provides high level review of ESIAs, frequently directs Environmental and Social Due Diligence studies and monitors project on behalf of financial institutions, and also has a depth of experience in Strategic Environmental Assessment (SEA) and Resource Economics. He holds a BBusSci (Hons) and M Phil (Env) and is a Registered Environmental Assessment Practitioner.

Project Reviewer: Amy Hill (Hons)

Amy Hill is an Environmental Consultant at SRK Consulting and has 4 years of experience in the biodiversity and ecology sector. She is experienced in managing a number of Basic Assessment and Water Use Authorisation processes and has contributed to numerous Environmental Impact Assessment processes, notably in the commercial and industrial sectors. Amy has drafted Environmental Management Plans (EMPs), performed Environmental Control Officer (ECO) duties and coordinated stakeholder engagement processes. She holds a BSc (Hons) in Biodiversity and Ecology from the University of Stellenbosch.

Project Manager: Annalisa Vicente, BSc Hons (Environmental and Water Science)

Annalisa Vicente is a Hydrogeologist and Groundwater Modeller at SRK Consulting (South Africa) (Pty) Ltd. She specialises in 3-Dimensional Numerical Groundwater Modelling. She is therefore proficient in the characterization of groundwater, its occurrence, movement and hydrochemistry, elements needed for conceptual model and subsequent numerical model development. Projects themes include groundwater contamination investigations, groundwater supply, remediation and environmental risk assessments.

Statement of SRK Independence

Neither SRK Consulting (South Africa) (Pty) Ltd (SRK) nor any of the authors of this Report have any material present or contingent interest in the outcome of this Report, nor do they have any pecuniary or other interest that could be reasonably regarded as being capable of affecting their independence or that of SRK. SRK has no beneficial interest in the outcome of the assessment which is capable of affecting its independence.

Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (South Africa) (Pty) Ltd (SRK) by SJR Boerdery CC. The opinions in this Report are provided in response to a specific request from SJR Boerdery CC to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

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List of Abbreviations

c.	*circa* (approximately)
DWS	Department of Water and Sanitation
DWAF:	Department of Water Affairs and Forestry
EAP	Environmental Assessment Practitioner
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
e-WULAAS	Electronic Water Use Application and Authorisation System
GA	General Authorisation
KL /a	Kilolitres per annum
KL /d	Kilolitresper day
KL /h	Kilolitres per hour
KL /m	Kilolitres per month
mamsl	metres above mean sea level
mbgl	metres below ground level
µg/L	micro-grams per litre
mg/L	milligrams per litre
mS/m:	milli Siemens per metre
NGA	National Groundwater Archive
NWA	National Water Act 36 of 1998
S	Storativity
SANS	South African National Standards
SANAS	The South African National Accreditation System
SRK	SRK Consulting (South Africa) (Pty) Ltd
T	Transmissivity
WUA	Water Use Authorisation
WULA	Water Use Licence Application

Glossary

Aquifer:	A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to store and transmit water; and to yield economical quantities of water to boreholes or springs. An aquifer is the storage medium from which groundwater is abstracted.
Baseline	Information gathered at the beginning of a study which describes the environment prior to development of a project, and against which predicted changes (impacts) are measured.
Construction phase	The stage of project development comprising site preparation as well as all construction activities associated with the development.
Electrical conductivity (EC):	Electrical conductivity is a measure of how well a material accommodates the transport of electric charge. The more salts dissolved in the water, the higher the EC value. It is used to estimate the amount of total dissolved salts, or the total amount of dissolved ions in the water.
Environmental Authorisation	The authorisation by a competent authority of a listed activity or specified activity in terms of National Environmental Management Act.
Environmental Impact Assessment	A process of evaluating the environmental and socio-economic consequences of a proposed course of action or project
Environmental Management Measures	Requirements or specifications for environmental management, as presented in the Environmental Management Plan, some of which are based on the mitigation measures identified in the EIA Report (in this case the EIA).
Environmental Management Programme	A description of the means for achieving environmental objectives and targets during all stages of a specific proposed activity.
Formation:	A body of rock identified by lithic characteristics and stratigraphic position. Different formations have different geohydrological properties.
Fracture:	Any break in a rock including cracks, joints and faults. Fractures can form the main conduits for groundwater flow. They can also form pathways for the movement of contamination.
Fractured-rock (Secondary) aquifer:	An aquifer in which groundwater moves through secondary openings and interstices, which developed after the rocks were formed. Approximately 90% of aquifers in South Africa are secondary in nature.
Groundwater:	Water found in the subsurface in the saturated zone below the water table. Groundwater is a source of water and is an integral part of the hydrological system.
Hydrogeology:	In South Africa, the term geohydrology and hydrogeology are used interchangeably. In theory hydrogeology is the study of geology from the perspective of its role and influence in hydrology, while geohydrology is the study of hydrology from the perspective of the influence on geology.
Impact	A change to the existing environment, either adverse or beneficial, that is directly or indirectly due to the development of the project and its associated activities.
Mitigation Measures	Actions identified to manage (avoid, minimise or optimise) potential environmental impacts which may result from the development.
Quaternary:	The Quaternary Period is a geologic time period that includes the most recent 2.6 million years, including the present day.

1 Introduction

1.1 Introduction and background

SJR Boerdery owns the Kamiebees Farm 368 Portion 1 (368/1), which is located c.85 km southeast of Springbok, Northern Cape (see Figure 1-1). The farm currently uses borehole water for irrigation, livestock watering and domestic purposes, sourced from three boreholes equipped with windpumps. SJR Boerdery (owner – Mr Johnnie van Niekerk) intends to supplement his livestock feed (for 300 sheep, 80 springboks and 20 Oryx) with Prickly Pear plants (*Upuntia Ficus Indica*), as the plant is cost-effective, uses minimal water and is a good source of protein. SJR Boerdery proposes to extend the prickly pear plot by 10 hectares (ha) (20 ha in total) by 2026 to harvest *c*.15 tons per annum. Water requirements are comparatively low (a prickly pear requires approximately three litres per week) equating to *c.*18 700 kilolitres per annum (KL/a). This requires a Water Use Licence Application (WULA) for additional groundwater abstraction from existing boreholes based on the recommended sustainable yields.

SRK Consulting (South Africa) (Pty) Ltd (SRK) was appointed by SJR Boerdery CC (SJR Boerdery) to conduct the WULA process for additional groundwater abstraction for irrigation, livestock watering and domestic purposes. A WUL is required from the Department of Water and Sanitation (DWS) for an activity (water use) listed and triggered in terms of Section 21 (a) of the National Water Act 36 of 1998 (NWA) - *taking water from a resource*. In addition, SRK was also appointed to compile a hydrogeological report in support of a WULA.

Applicant details are provided in Table 1-1.

Table 1-1: Water use and applicant details

Project applicant:	Kamiebees Farm 368 Portion 1 (368/1)
Catchment:	F30A
Volume of water to be abstracted:	28 382 m^3 /annum
Contact person:	Johnnie Van Niekerk
Email:	johnnievn0920@gmail.com

A hydrogeological study conducted by SRK (SRK Report 55283, February 2020) has recommended a daily abstraction volume to avoid impacts on the aquifer and nearby groundwater users. Furthermore, the study has concluded that groundwater is not suitable for human consumption unless treated.

1.2 Purpose of the Report

This Technical Report has been prepared in support of the application for a WUA for the NWA Section 21(a) water use. It is intended to provide the competent authority, the DWS, with the relevant information required to consider the WUA application.

This report:

- Describes the water use;
- Assesses ground water impacts of the water use; and
- Outlines the proponent’s NWA Section 27 Motivation for the water use.

The following guideline was taken into account in the compilation of this report:

- DWS Electronic Water Use Application and Authorisation System (e-WULAAS) (July 2017).

1.3 Structure of this Report

This report discusses: the motive for applying for a WULA, presents the project description, presents the regulatory framework, describes the groundwater resources, analyses the potential impacts and mitigation measures, outlines the proponent's motivation and summarises the key findings, conclusions and recommendations. To provide technical input to inform the WULA.

The report is structured in the following sections:

Section 1: Introduction

Provides an introduction and background to the proposed water use and applicant as well as outlines the purpose of this document.

Section 2: Regulatory Framework

Provides a brief summary and interpretation of the relevant legislation and describes the water uses associated with the project.

Section 3: Project Description

Briefly describes the groundwater resources and groundwater users that may potentially be affected by the project.

Section 4: Description of Groundwater Resources

Describes the methodologies employed and information used to conduct the hydrogeological investigation and impact assessment.

Section 5: Assessment of Potential Geohydrological Impacts

Describes and assesses the potential impacts of the water use utilising SRK's impact assessment methodology.

Section 6: Stakeholder Engagement

Describes stakeholder engagement to be undertaken for the WULA.

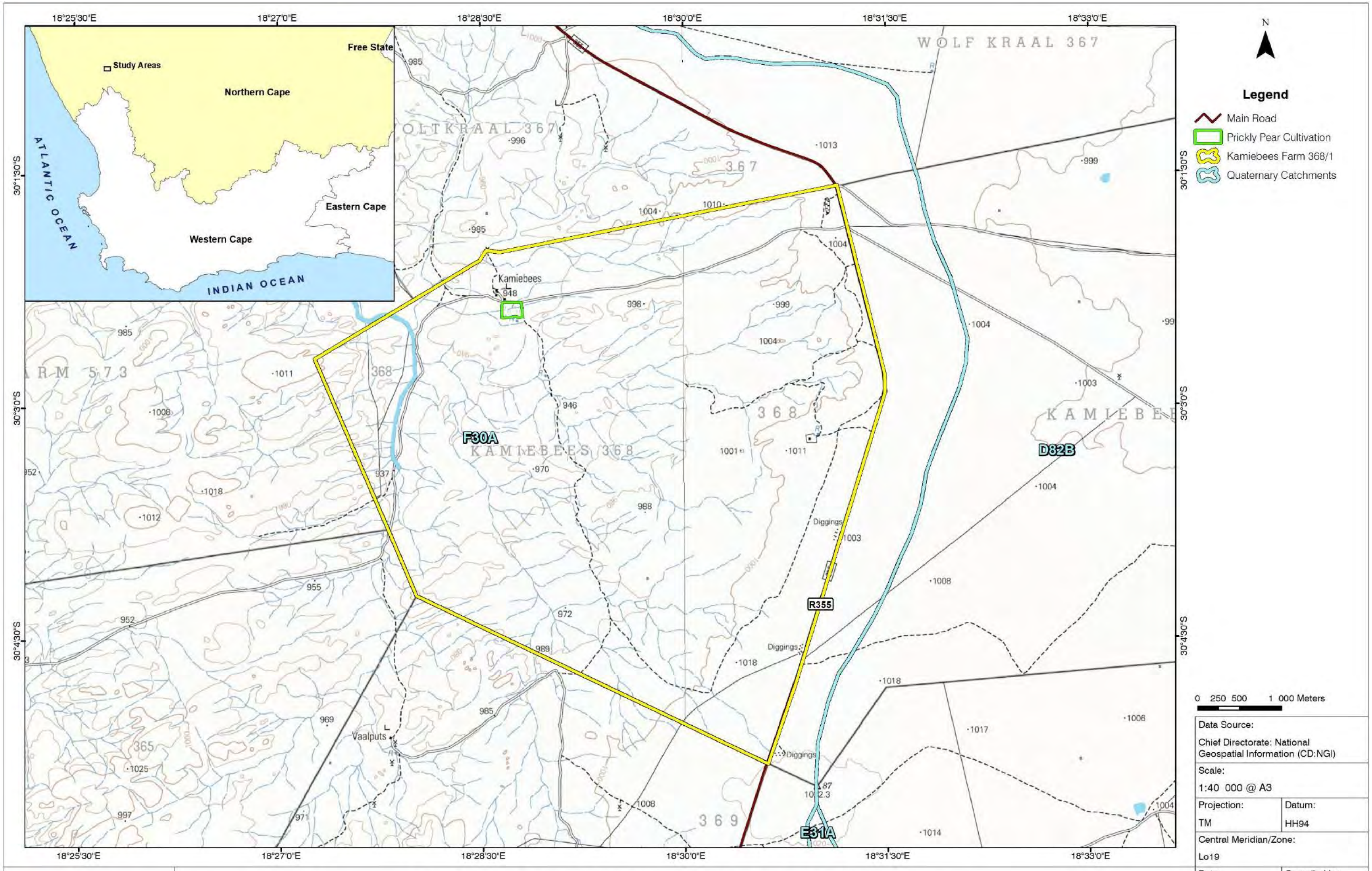
Section 7: Motivation in terms of Section 27 of the NWA

Outlines the proponent's motivation for the water use in terms of Section 27 of NWA.

Section 8: Conclusions and Recommendations

Summarises the key findings and provides conclusions and recommendations regarding the authorisation of the water use.

This report adheres to the contents for minimum information requirements to be submitted for water use technical geohydrology reports as set out in the DWS *Regulations Regarding the Procedural Requirements for Water Use Licence Applications and Appeals* (DWS, 2017).



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KAMIEBEES FARM 368/1 HYDROGEOLOGICAL ASSESSMENT

SITE LOCALITY

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Figure 1-1: Site locality

2 Regulatory Framework

2.1 National Water Act 36 of 1998

Water use in South Africa is governed by the NWA (the Act). The competent authority is the DWS. The NWA recognises that water is a scarce and unevenly distributed national resource in South Africa. Its provisions are aimed at achieving sustainable and equitable use of water to the benefit of all users and to ensure protection of the aquatic ecosystems associated with South Africa's water resources. The provisions of the Act are aimed at discouraging pollution and wastage of water resources.

In terms of the Act, a land user, occupier or owner of land where an activity that causes or has the potential to cause pollution of a water resource has a duty to take measures to prevent pollution from occurring. If these measures are not taken, the responsible authority may do whatever is necessary to prevent the pollution or remedy its effects, and to recover all reasonable costs from the responsible party.

Section 21 of the NWA specifies a number of water uses, including section 21 (a) "*taking water from a water resource".* This water use requires authorisation in terms of Section 22 (1) of the Act (i.e. licencing), unless they are listed in Schedule 1 of the NWA, are an existing lawful use, fall under a General Authorisation (GA) or if the responsible authority waives the need for a licence.

2.1.1 Water Use Licence Application and Appeals Regulation, 2017

The WULA and Appeals Regulation (Regulation 267, which came into effect on 24 March 2017), promulgated in terms of the NWA, prescribe the procedure and requirements for WULAs as contemplated in Section 41 of the NWA; as well as an appeal in terms of Section 41(6) of the NWA.

More specifically, the Regulations provide clarity on:

- Authority decision making timeframes;
- Pre-application requirements;
- Consolidation of multiple WULAs;
- Technical Report content requirements;
- Financial surety following issuing of WUA; and
- Procedure for public participation in terms of S41(4) of NWA.

The SJR Boerdery is obliged to undertake a WULA process in accordance with the procedure stipulated in Regulation 267 under NWA.

2.1.2 General Authorisation in terms of Section 39 of the NWA

2.1.2.1 General Authorisation for Water Uses as defined in Section 21(a)

Government Notice (GN) 538 of 2016, promulgated in terms of Section 39 of NWA, specifies the requirements for GA in terms of Sections 21(a) of NWA, and defines the volume limits of groundwater that may be abstracted in terms of a GA. Any exceedances of these limits will require licensing.

In terms of GN 538, the maximum volume of water that may be taken from groundwater resources within drainage region F30A is 0 m^2 per hectare per year.

The proposed abstraction volumes (*c.*51 KL/d or *c.*18 700 KL/a) exceeds this limit and, as such, SJR Boerdery is required to apply for a WUL for groundwater abstraction at the site.

3 Project Description

3.1 Description of Project Area

The Kamiebees Farm 368/1 is located *c.*85 km south east of Springbok and *c.*16 km north of Vaalputs, Northern Cape (-30.030852°S, 18.519925°E). The farm is located on the R355 Regional Route, where most of the area consists of farming (mainly livestock) and unoccupied municipal land.

Locally, the higher lying topographic regions are to the east of the Kamiebees Farm and slope in a north-westerly direction (Figure 2 3). The highest elevation on the farm is *c.*1 050 mamsl and the lowest elevation is *c.*920 mamsl. The average elevation is *c.*970 mamsl. The farm contains three non-perennial rivers which flow towards the Gasabrivier located on the north-west farm boundary. Regionally, surface and groundwater flows drain towards the Atlantic Ocean via the Buffels River (Department of Water and Sanitation, 2016).

The study area has a Mediterranean climate with cool wet winters (May to September) and hot dry summers (October to April). The quaternary catchment's (F30A) average rainfall is 162 mm/a (DWAF, 2005). Most of the rainfall (albeit minimal) occurs within the winter months where maximum rainfall is recorded in June (37 mm) and minimum rainfall is recorded in January (0 mm) (Weather and Climate, 2019).

3.2 Description of Project

The farm currently uses borehole water for irrigation, livestock watering and domestic purposes, sourced from three boreholes equipped with windpumps. SJR Boerdery intends to supplement the existing livestock feed (for 300 sheep, 80 springboks and 20 Oryx) with Prickly Pear plants. SJR Boerdery proposes to extend the prickly pear plot by 10 hectares (ha) (20 ha in total) by 2026 to harvest *c.*15 tons per annum, requiring an additional *c.*13 000 kilolitres (KL)annual groundwater demand, i.e. a total demand of *c.*18 700 KL/a.

3.3 Project Infrastructure

3.3.1 Existing Production Boreholes

The four boreholes located on Kamiebees Farm 368/1 (Figure 3-2) consisted of three active boreholes (KB-BH1, KB-BH2 and KB-BH3) which pump groundwater to a central reservoir, supplying water to the farmstead, livestock and prickly pear orchard. Water levels are relatively shallow at *c.*10 mbgl Boreholes KB-BH2 and KB-BH3 are within 10 m of each other, whereas borehole KB-BH4 is located near the farmstead and is currently not in use as it is too low-yielding due to the drought. The three active boreholes are equipped with windpumps containing 60 mm Jooste cylinders capable of yielding a maximum of 770 litres per hour (L/h) (Jooste Cylinder & Pump Co, 2019). It is assumed that the wind is of sufficient strength to drive the windpumps approximately 25% of the time, thus the estimated average abstraction rate is *c.*0.053 L/s per borehole, which equates to an average abstraction rate of *c.*1 700 KL/a per borehole. The three active boreholes are targeted for additional groundwater abstraction of the proposed WULA, prompting aquifer testing to determine the aquifer response and estimate the safe yields. All three boreholes are located on the same lineament (fault or fracture), implying that they abstract water from the same source. All borehole measurements and information gathered during the SRK hydrocensus (11 October 2019) is summarised in Table 3-1. In addition, pictures of the boreholes are presented in Figure 3-1.

The existing boreholes and associated infrastructure can accommodate the proposed increase in the groundwater abstraction (18 800 KL/a) and no new boreholes are required.

Table 3-1: Hydrocensus summary

Borehole ID	Farm Name	Latitude S	Longitude E	Owner	BH Depth (mbgl)	Casing Type/ Diameter (mm)	Water Level (mbgl)	Collar Height (magl)	Elevation (mamsl)	Yield (l/s)	EC (mS/m)	pH	**Temp ˚C**
KB_BH1	Kamiebees	-30.03883	18.47695	Johnnie Van Niekerk	54.30	170	12.75	0.33	947	0.05	238	8.57	25.4
KB_BH2		-30.03740	18.47665		30.20	170	10.82	0.26	945	0.05	161	8.22	26.4
KB_BH3		-30.03748	18.47665		17.25	170	10.45	0.28	945	0.05	156	8.32	25.6
KB_BH4		-30.05273	18.516459		+100	150	37.69	0.05	949	N/A	94	8.09	25.7

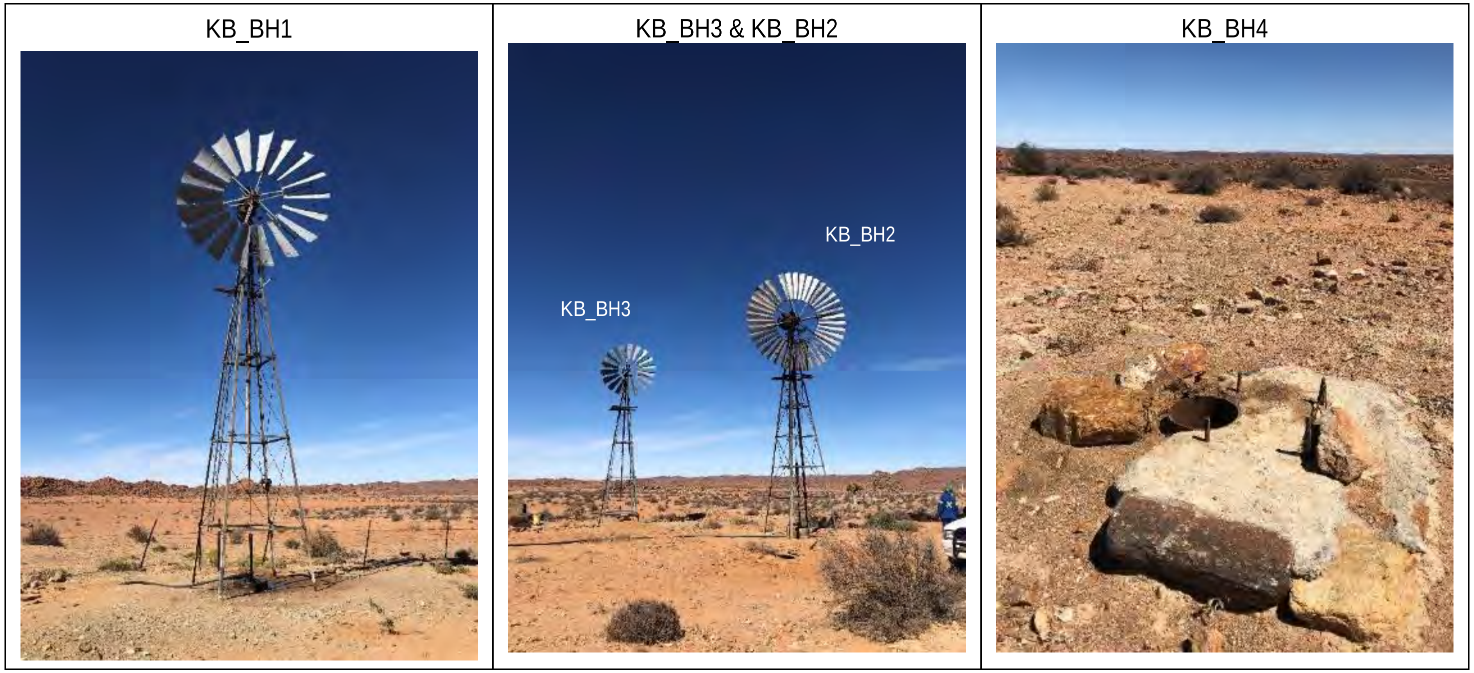

Figure 3-1: Borehole pictures

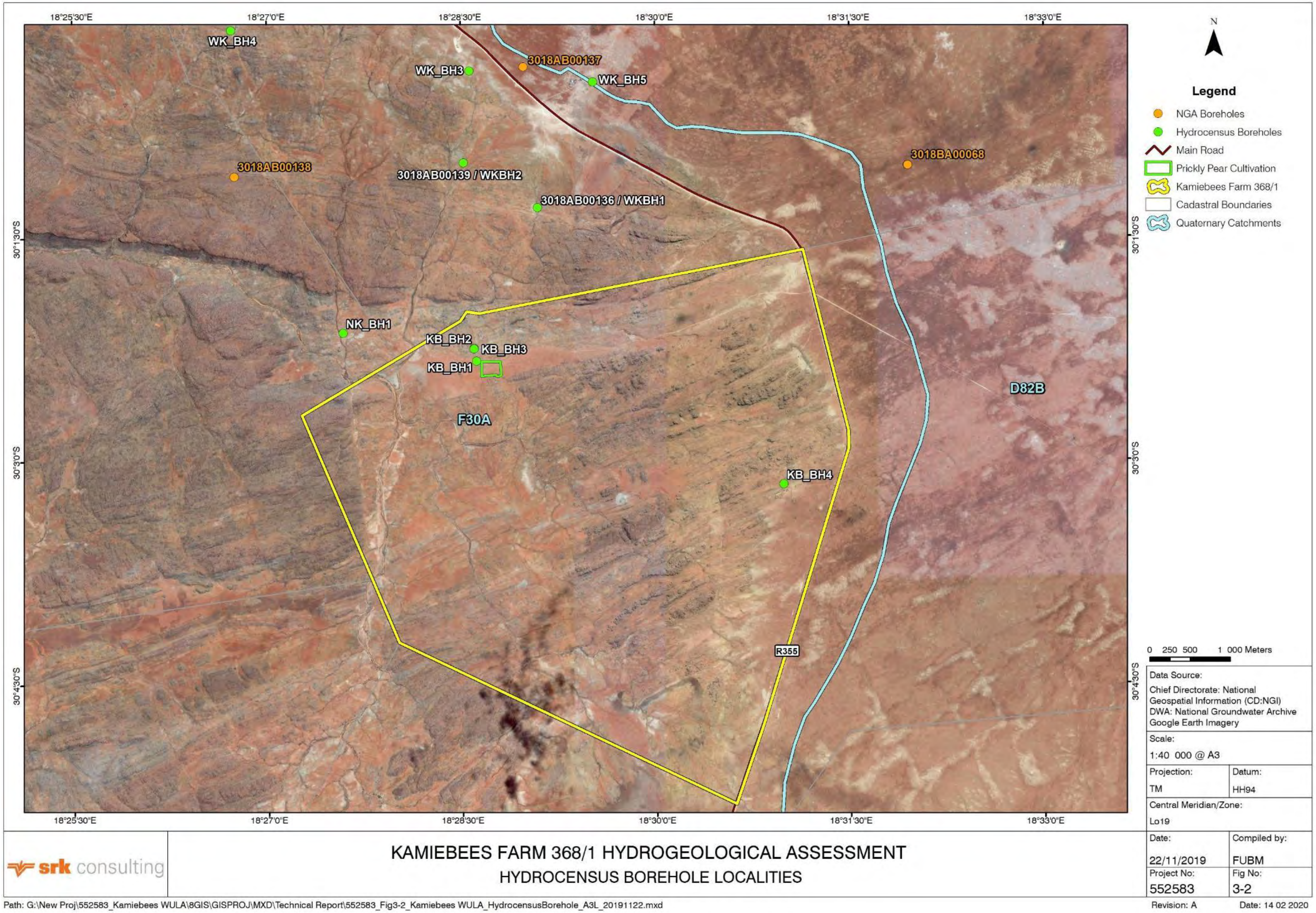

Figure 3-2: **Hydrocensus borehole localities**

4 Description of Groundwater Resources

A hydrogeological study was undertaken to determine the feasibility of additional groundwater abstraction. Secondary data was gathered to determine prevailing groundwater conditions, whereas current groundwater conditions were assessed by conducting aquifer yield tests (13-24 September 2019) and a hydrocensus (11 October 2019). The assessment of the yield test and hydrocensus are included in the hydrogeological study (*Hydrogeological Assessment of the Kamiebees Farm 368/1 ~* SRK, 2019) (seethe Hydrogeological Report). Descriptions of the groundwater resource in the study area are summarised in the proceeding sub-chapters.

4.1 Geology

The quaternary catchment F30A is classified as part of the Namaqualand East Groundwater Resource Unit (GRU). The Namaqualand East is underlain by rocks of the Nama and Vanrhynsdorp Groups, which is characterised as Metamorphic Terrane. The Namaqualand East typically contains Mokolian metasediments and metavolcanics consisting of gneisses, schists, amphibolite, metaquartzite, andesite, quartz porphyry, Intrusive granites, granodiorite, tonalite, mafic and ultramafic's. In addition, tertiary and quaternary fluvial and coastal deposits are often present (DWS, 2016).

The Kamiebees Farm is primarily underlain by Lekkerdrink Gneiss of the Little Namaqualand Suite and Grey Migmatitic Biotite Gneiss of the Kamiesberg Group. The southern section of the farm is underlain by Burtons Puts Granite, which form part of the younger Spektakel Suite (Council of Geoscience, 2010). A brief description of the site geology is presented in Table 4-1 and a representation of the geology is displayed in Figure 4-1.

Table 4-1: Stratigraphy and lithology of the area surrounding the site

Map Code	Formation/ Intrusive	Group/ Suite	Lithology
Nbur	Burtons Puts Granite	Spektakel Suite	Foliated to strongly foliated, orange-brown weathering, megacrystic granite with minor biotite and garnet.
Mkp	Grey migmatitic biotite gneiss	Kamiesberg Group	Grey-weathering, heterogenous, banded, migmatitic gneisses: includes rocks types such as migmatitic banded grey gneiss, semi-pelitic, calc-silicate and quartz-rich gneisses, mafic bands and granitoid lenses and dykes.
Nlek	Lekkerdrink Gneiss	Little Namaqualand Suite	Red-brown weathering, strongly foliated biotite augen and streaky gneiss with minor garnet, augen consist of aggregates of quartz and K-feldspar surrounded by biotite streaks. In-situ charnockitised gneiss typically brown with hypersthene replacing biotite.

Note: Source – 1:250 000 Geological Series Sheet 3018 Loeriesfontein.

Several northwest-southeast striking faults have been mapped at the middle and western parts of Kamiebees Farm (Figure 4-1). The three targeted boreholes are all located on a single fault line, which intercepts the grey migmatitic biotite gneiss Formation.

4.2 Hydraulic Conductivity

The hydraulic conductivity (K) is based on the transmissivity (T) values calculated from analysis of borehole pump test data by dividing T (m^2/d) by the saturation thickness (m), as well as using published values for similar aquifer types. The derived K values are summarised as follows:

- K for fractured granite and gneiss: 43 to 2.2×10^{-4} m/d (Freeze and Cherry, 1979);
- K for unfractured granite and gneiss: 6.5×10^{-5} to 8.6×10^{-10} m/d (Freeze and Cherry, 1979);

- K fractured-rock aquifers of F30A: 0.09 m/d (based on DWAF, 2005 GRA-2 data and the average T values from the aquifer tests. Transmissivity polygon for the 17.5 m^2/d, i.e. 17.5 m^2/d divided by GRA2 aquifer thickness of 188 m);
- K fractured-rock aquifer at KB-BH1: *c.*0.16 m/d (based on dividing the average pumping test derived T-value of *c.*6.67 m^2/d by the *c.*41.6 m saturation depth of the borehole, i.e. 6.67÷41.6);
- K fractured-rock aquifer at KB-BH2: *c.*2.55 m/d (based on dividing the average pumping test derived T-value of c.17.5 m^2/d by the c.6.8 m saturation depth of the borehole, i.e. 17.5÷6.8); and
- K fractured-rock aquifer at KB-BH3: *c.*0.97 m/d (based on dividing the average pumping test derived T-value of c.18.8 m^2/d by the *c.*19.4 m saturation depth of the borehole, i.e. 18.8÷19.4).

Aquifer parameters, derived from yield testing at boreholes KB-BH1, KB-BH2 and KB-BH3 indicate T values between 6.67 and 18.81 m^2/d.

A specific yield (S_y) of 0.0059 and storativity of 0.000049 is reported in the GRA-2 (DWAF, 2005) for the fractured-rock aquifers of F30A. Various pumping test data analysis methods yielded S_y values as follows:

- KB-BH1 range from 0.00020 to 0.00044, with an average of 0.00028;
- KB-BH2 range from 0.00017 to 0.00044, with an average of 0.00019; and
- KB-BH3 range from 0.00017 to 0.00044, with an average of 0.00018.

4.3 Groundwater Levels

Water levels derived from the aquifer tests indicate that groundwater levels range between 10 – 13 mbgl on the Kamiebees Farm. The neighbouring Nama-Khoi Municipal abandoned borehole (NK-BH1) displays a water level of 8.53 mbgl, no water levels could be taken on the Wolfkraal Farm, as all boreholes were equipped with windpumps preventing access. The Wolfkraal Farm owner (Mr Karel Louw), however, communicated that water levels range between 18 – 60 mbgl. These water levels vastly vary, and the reliability of this information is uncertain.

The groundwater flow at the site and its surrounds is inferred to be in a westerly direction (Figure 4-2) and regionally north-westwards towards the Buffels River.

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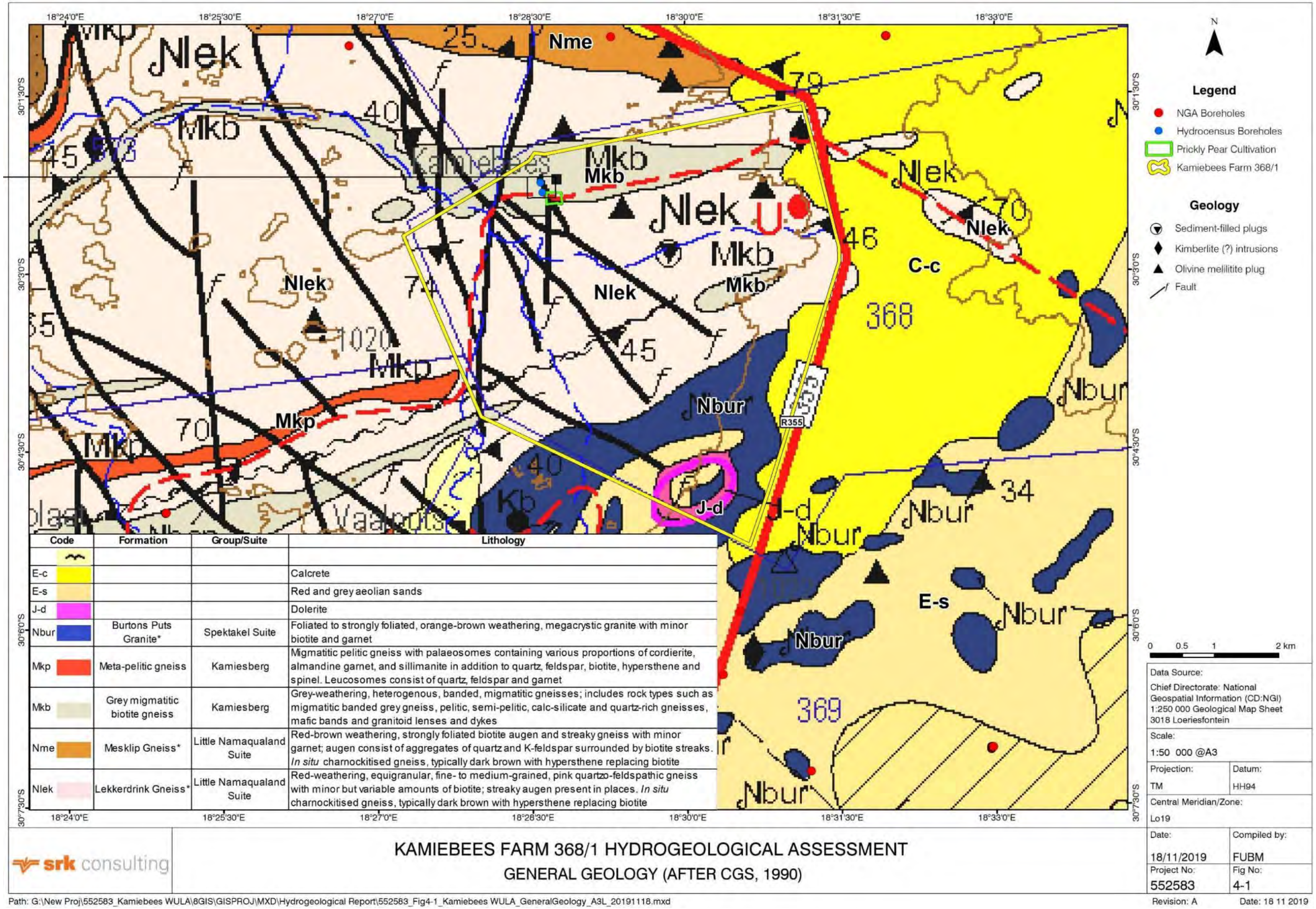
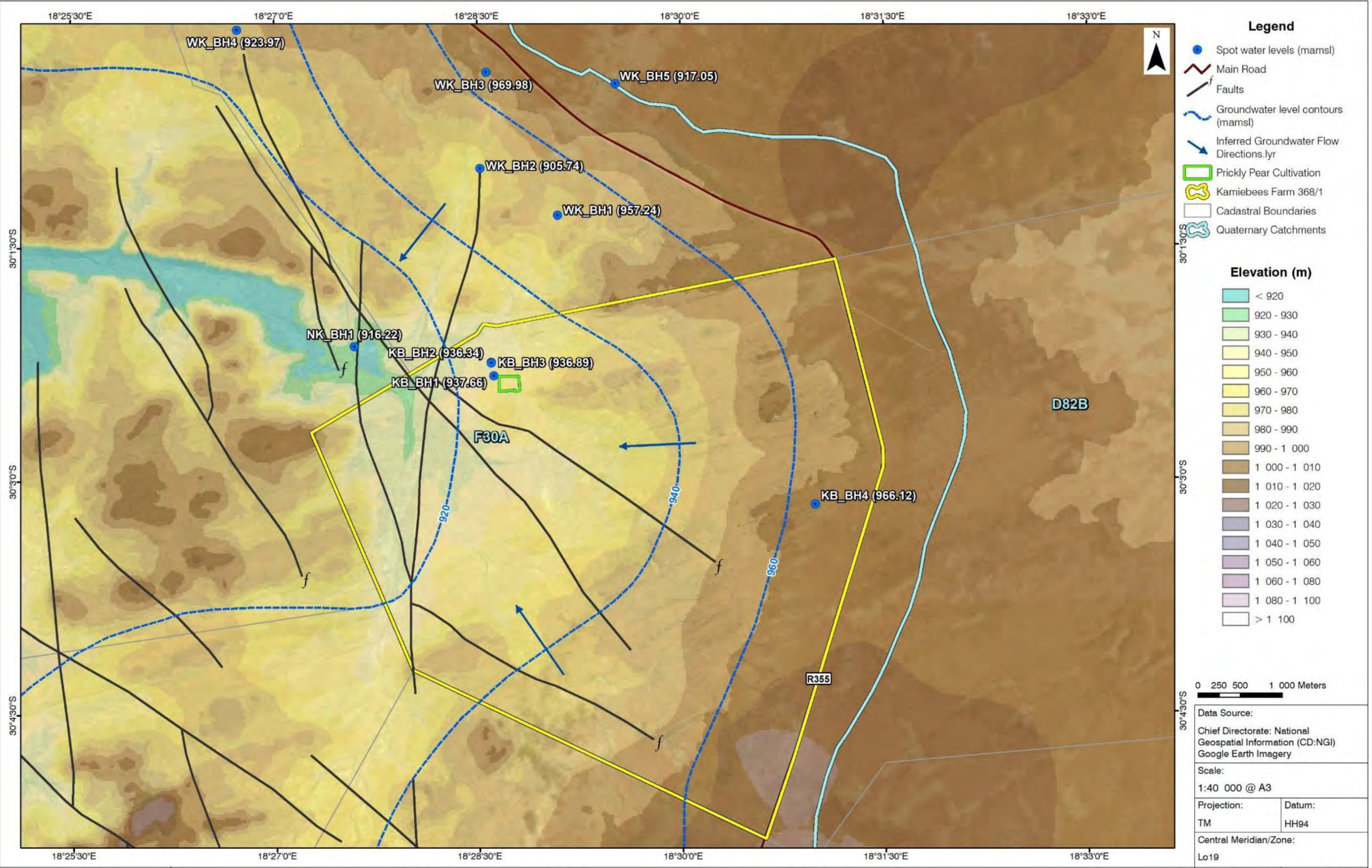


Code	Formation	Group/Suite	Lithology
E-c			Calcrete
E-s			Red and grey aeolian sands
J-d			Dolerite
Nbur	Burtons Puts Granite*	Spektakel Suite	Foliated to strongly foliated, orange-brown weathering, megacrystic granite with minor biotite and garnet
Mkp	Meta-pelitic gneiss	Kamiesberg	Migmatitic pelitic gneiss with palaeosomes containing various proportions of cordierite, almandine garnet, and sillimanite in addition to quartz, feldspar, biotite, hypersthene and spinel. Leucosomes consist of quartz, feldspar and garnet
Mkb	Grey migmatitic biotite gneiss	Kamiesberg	Grey-weathering, heterogenous, banded, migmatitic gneisses; includes rock types such as migmatitic banded grey gneiss, pelitic, semi-pelitic, calc-silicate and quartz-rich gneisses, mafic bands and granitoid lenses and dykes
Nme	Mesklip Gneiss*	Little Namaqualand Suite	Red-brown weathering, strongly foliated biotite augen and streaky gneiss with minor garnet; augen consist of aggregates of quartz and K-feldspar surrounded by biotite streaks. *In situ* charnockitised gneiss, typically dark brown with hypersthene replacing biotite
Nlek	Lekkerdrink Gneiss*	Little Namaqualand Suite	Red-weathering, equigranular, fine- to medium-grained, pink quartzo-feldspathic gneiss with minor but variable amounts of biotite; streaky augen present in places. *In situ* charnockitised gneiss, typically dark brown with hypersthene replacing biotite

Figure 4-1: General geology



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Central Meridian/Zone: Lo19	
Date: 22/11/2019	Compiled by: FUBM
Project No: 552583	Fig No: 4-2

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KAMIEBEES FARM 368/1 HYDROGEOLOGICAL ASSESSMENT

SPOT WATER LEVELS AND INFERRED GROUNDWATER FLOW DIRECTION

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Figure 4-2: Spot water levels and inferred groundwater flow direction

4.4 Groundwater Quality

Water samples were collected for the three boreholes that underwent yield testing (KB-BH1, KB-BH2 and KB-BH3). Water quality analyses of the samples collected are summarised and compared to the *South African National Standard for Drinking Water (SANS 241:2015)* in Table 4-2.

Chemical and microbial concentration values exceeding the SANS 241:2015 acute and chronic health[1] risk related drinking limit are shown in bold red and those exceeding aesthetic[2] and operational[3] limits in bold. Values indicated with <-symbol are below the laboratory's method detection limits. The laboratory reports are included in The Hydrogeology Assessment Report.

The water quality of boreholes KB-BH2 and KB-BH3 is similar in chemistry (little variation) which is expected as they are only 10 m apart. Borehole KB-BH1 displays slightly higher concentrations with poorer water quality. All boreholes exceed the SANS 241-2015 human health risk drinking limits for fluoride and sulfate concentrations. In addition, water at borehole KB-BH1 displayed above human health risk limits for nitrate and nitrite concentrations whilst at KB-BH2 and KB-BH3 manganese at both and iron at the latter, also exceed health related limits. From an aesthetic and operational risks, EC, TDS, chloride and sodium exceeds the limits

To render the water from these three boreholes fit for human drinking, it will have to be treated to reduce the exceedances to acceptable levels. Commonly used treatment options to reduce iron and manganese include oxidation (aeration, chlorination or ozonation), coagulation followed by settlement and filtration. To reduce sulphate, fluoride, sodium, chloride, TDS and EC (salinity) levels, the only treatment options desalination. pH balancing (stabilisation) might also be required[4] as will disinfection.

The pH values for all the boreholes visited during the hydrocensus range between 7.76 to 8.57. Therefore, the groundwater in the study area is neutral to alkaline in nature.

Table 4-2: Summary of groundwater quality indicators of the tested water boreholes at Kamiebees

Determinand	Units	KB-BH1	KB-BH2	KB-BH3	"SANS 241-1:2015 RECOMMENDED LIMITS & RISKS"
Ammonia	mg N/L	0.18	0.23	0.26	Aesthetic: ≤1.5
Chloride	mg Cl/L	831	585	628	Aesthetic: ≤ 300
Colour*	mg Pt-Co/L	<1	<1	<1	Aesthetic: ≤15
Dissolved Aluminium	µg Al/L	2.55	2.84	2.60	Operational: ≤300
Dissolved Antimony	µg Sb/L	0.43	0.45	0.39	Chronic Health: ≤20
Dissolved Arsenic	µg As/L	0.44	0.68	0.12	Chronic Health: ≤10
Dissolved Barium	µg Ba/L	35	64	67	Chronic Health: ≤700
Dissolved Boron	µg B/L	714	500	519	Chronic Health: ≤2 400
Dissolved Cadmium	µg Cd/L	0.02	0.06	0.04	Chronic Health: ≤3
Dissolved Calcium	mg Ca/L	235	128	134	Not specified

[1] Acute human health risk - Determinand that poses an immediate unacceptable human health risk if ingested if present at concentration values exceeding the numerical limits specified in the SANS 241-2015.

Chronic human health risk - Determinant that poses an unacceptable human health risk if ingested over an extended period if present at concentration values exceeding the numerical limits specified in the SANS 241-2015.

[2] Aesthetic risk - Determinand that taints water with respect to taste, odour or colour and that does not pose an unacceptable human health risk if present at concentration values exceeding the numerical limits specified in the SANS 241-2015.

[3] Operational risk - Determinand that is essential for assessing the efficient operation of treatment systems and risks to infrastructure.

[4] Dissolved Iron and other trace-metal analysis were done on a filtered (0.45 micron) and preserved (1% Ultrapure nitric acid) sample. Iron and manganese concentrations may vary over time and the form of iron and manganese may be affected by chlorination. Pilot testing will increase the chance that any iron problems are detected before long term use of the water.

Determinand	Units	KB-BH1	KB-BH2	KB-BH3	"SANS 241-1:2015 RECOMMENDED LIMITS & RISKS"
Total Chromium	µg Cr/L	41.00	39.00	41.00	Chronic Health: ≤50
Dissolved Copper	µg Cu/L	0.98	1.07	1.06	Chronic Health: ≤2 000
Dissolved Iron	µg Fe/L	9.46	7.16	4.98	"Chronic Health: ≤2 000
Dissolved Lead	µg Pb/L	0.04	0.07	0.04	Chronic Health: ≤10
Dissolved Magnesium	mg Mg/L	102	65	66	Not specified
Dissolved Manganese	µg Mn/L	4.39	516.00	830.00	"Chronic Health: ≤ 400 Aesthetic: ≤100
Dissolved Mercury	µg Hg/L	0.94	0.10	0.09	Chronic Health: ≤6
Dissolved Nickel	µg Ni/L	1.21	0.72	0.58	Chronic Health: ≤70
Dissolved Selenium	µg Se/L	5.28	1.67	1.55	Chronic Health: ≤40
Dissolved Uranium	µg U/L	8.53	10.90	10.90	Chronic Health: ≤30
Dissolved Zinc	µg Zn/L	7.38	23.00	17.80	Aesthetic: ≤5 000
Electrical Conductivity at 25°C	mS/m	364	302	302	Aesthetic: ≤170
Fluoride	mg F/L	2.68	3.63	3.56	Chronic Health: ≤1.5
Nitrate	mg N/L	15.80	2.83	3.38	Acute Health: ≤11
Nitrite	mg N/L	<0.01	0.03	0.08	Acute Health: ≤0.9
Combined Nitrate + Nitrite (sum of Ratios)*		1.40	0.29	0.40	Acute Health: ≤1
pH at 25°C	pH units	7.40	7.40	7.40	Operational: ≥5.0 ≤9.7
Potassium	mg K/L	11.00	7.92	7.92	Not specified
Sodium	mg Na/L	504	498	498	Aesthetic: ≤200
Sulphate	mg SO_4/L	599	566	561	Aesthetic: ≤250 "Acute Health: ≤ 500
Total Alkalinity	mg $CaCO_3$/L	251	288	287	Not specified
Total Dissolved Solids at 180°C	mg/L	2 428	1 916	1 910	Aesthetic: ≤1 200
Total Iron	µg Fe/L	422	243	5 001	Aesthetic: ≤300 "Chronic Health: ≤2 000
Dissolved Manganese	µg Mn/L	4.39	516.00	830.00	Aesthetic: ≤100 "Chronic Health: ≤400
Turbidity	NTU	1.20	0.80	47.00	"Operational: ≤1 Aesthetic: ≤5"
E.coli	counts/100mL	0	0	0	Acute Health: 0
Faecal Coliforms	counts/100mL	0	0	0	Acute Health: 0
Total Coliforms	counts/100mL	0	0	3	Operational: ≤10

Exceeds health related SANS 241-2015 long-term drinking limits

Exceeds non-health related SANS 241-2015 long-term drinking limits, i.e. aesthetic and operational limits

Values indicated with <-symbol are below the laboratory analytical method's detection limit

NS = Not Specified

ND = Not Determined

Table 4-3: Summary of groundwater corrosivity/scaling indicators of the tested water boreholes at Kamiebees

Index	KB-BH1	KB-BH2	KB-BH3	Tendency
Langelier Index	0.14	-0.05	-0.03	Negative = Corroding tendency Positive = Scaling tendency
Ryznar Index	7.1	7.5	7.5	< 6.5 = Scale-forming tendency > 6.5 = Corrosive tendency
Larson-Skold Index for Mild Steel	3.6	2.5	2.6	< 0.8 = non-corrosive 0.8 - 1.2 = slightly corrosive > 1.2 = highly corrosive - increasing with rates

4.5 Groundwater Recharge

The F30A quaternary catchment has a low mean annual potential recharge of 0.16 mm/a (DWAF, 2005), which equates to 0.1% of the mean annual precipitation (MAP). The total recharge of the catchment according to the DWS' EWR report (DWS, 2016) is *c*.1.24 million kilolitres per annum (MKL/a), which equates to a mean recharge potential of 0.64 mm/a or 6.4 KL/ha/a.

4.6 Groundwater Modelling

Groundwater modelling was not deemed necessary due to the low yielding nature of the boreholes under consideration and the low groundwater demand of the applicant.

4.7 Groundwater Availability Assessment

The site is located in Quaternary Catchment F30A, which is *c*.43% dependent on groundwater. This catchment receives a relatively low mean annual precipitation of 162 mm/a (DWS, 2016) with a mean groundwater recharge of 1.24 MKL/a, or *c*.6.4 KL/ha/a (DWAF, 2016), which equates to a mean recharge of *c*.19 300 KL/a for the 3 012 ha Kamiebees Farm. The Drought Index is low at 3.84 years and groundwater baseflow contribution is zero (DWAF, 2005). The potential groundwater stored in the catchment's aquifers is *c*.91 872 MKL, or 471 KL/ha. Based on this storage potential, likely storage of the aquifers at the 3 012 ha Kamiebees Farm is *c*.1 418 650 KL

The catchment does not have any associated ecological water requirements but reserves 0.0026 MKL for Basic Human Needs (BHN) and 0.0026 MKL as a groundwater reserve. The catchment has a reported 0.696 MKL/a allocatable groundwater (DWS, 2016). The catchment's General Authorisation (GA) volume for taking groundwater is listed as 0 KL/hectare/annum (DWS, 2016).

The catchment is predominantly dependent on groundwater. Domestic use and small-scale livestock watering do not require licensing or registration as they are listed as a Schedule 1 authorisation. However, higher volume water use such as prickly pear irrigation, as proposed by the SJR Boerdery requires a WUL. The current groundwater abstraction at the Kamiebees Farm is *c*.5 000 KL/a, sourced from the three boreholes equipped with windpumps. This volume is used to irrigate 10 ha's of Prickly Pear crop, comprising of 3 ha mature crop and 7 ha of crop that will mature within two to three years. The 10 ha of mature crop will consume *c*.9 300 KL/a. The Kamiebees Farm is proposing to expand their Prickly Pear plot by a further 10 ha in about six to eight years', enquiring authorisation to abstract a maximum of 18 800 KL/a from the three boreholes. The recommended maximum safe tested yield for the three Kamiebees Farm boreholes is 28 382 KL/a, which equates to *c.*2% of the farm's potential aquifer storage. This requested volume is significantly lower than the recommended maximum safe yield (i.e. *c.*10 000 KL/a lower) of the three boreholes.

The groundwater information published for F30A by the DWAF (2005) and the DWS (2016) is summarised in Table 4-4.

Table 4-4: Summary of groundwater information for Quaternary Catchment F30A

Information Piece	Unit	Amount
Extent	ha	165 320
Potential Aquifer Storage	KL/catchment	91 871 900
	KL/ha	471
Mean Recharge to Groundwater	M KL/a	1.24
	KL/ha/a	2
Drought Index5	Years	3.84
Mean Groundwater River Baseflow Contribution	KL/a	0
Estimated Groundwater Abstraction (2003)	KL /a	241 247
Utilisable Groundwater Exploitation Potential	KL /a	1 068 185
Harvest Potential (Vegter, 1995)	KL /a	10 251 600
Catchment groundwater dependency (DWS, 2016)	%	43.41
Allocable groundwater (DWS, 2016)	M KL /a	0.696
Groundwater reserve (DWS, 2016)	M KL /a	0.0026
Mean Annual Precipitation (MAP)	mm	162

The safe yields of the Kamiebees boreholes were calculated using the aquifer transmissivity, storativity as well concurrent borehole abstractions. For example, the safe yield calculations of KB-BH1 accounts for the simultaneous abstraction of boreholes KB-BH2 and KB-BH3. A summary of the analyses results with recommended safe yields are presented in Table 4-5.

The safe yields for the following boreholes are:

- KB-BH1: 0.40 L/s
- KB-BH2: 0.20 L/s
- KB-BH3: 0.30 L/s

This equates to a total of 77.8 kilolitres per day or 28 382 KL per annum Table 4-5(). Comparing these yields to the groundwater availability in the quaternary catchment, it is apparent that the yield amounts to:

- Approximately >1 % of the groundwater potentially stored in the aquifers of the catchment;
- Approximately.4.7 % of the Mean Annual Groundwater Recharge; and
- Approximately.6.3 % of the Utilisable Groundwater Exploitation Potential

Table 4-5: Summary of recommended safe borehole yields

Borehole No.	Borehole depth	Rest Water Level	Pump Intake	Available Drawdow n	Pump Sensor Depth*	Maximum Yield		Maximum Abstraction Limit		
	mbgl	mbc	mbgl	m	mbc	L/s	KL/h	KL/d	KL/m	KL/a
KB-BH1	54.3	12.41	50.0	47.0	45.0	0.40	1.440	34.6	1 051	12 614
KB-BH2	17.3	10.16	15.0	4.5	13.5	0.20	0.720	17.3	526	6 307
KB-BH3	30.2	10.56	27.0	16.0	25.0	0.30	1.080	25.9	788	9 461
Total						0.90	3.240	77.8	2 365	28 382

Note: Source – Aquifer test (AB Pumps, 2019)

[5] The Drought Index or Di is used to assess the number of years required to bridge cycles of negligible or no aquifer recharge from rainfall, where groundwater abstracted will almost entirely be removed from aquifer storage.

4.8 Nearby Groundwater Users

The nearest groundwater user within a 4 km radius from the Kamiebees Farm is the northern neighbouring Wolfkraal Farm, owned by Karel Louw. Wolfkraal Farm has five boreholes, which consist of four active windpump equipped boreholes (WK-BH1, WK-BH2, WK-BH3 and WK-BH4) that supply drinking water to the livestock and domestic water to the farmhouse. The remaining borehole (WK-BH5) intermittently pumps water once every two weeks and serves as a supplementary borehole for the farmhouse (according to Mr Karel Louw). The farm is solely dependent on groundwater for livestock (sheep and chickens) watering and domestic purposes based on hydrocensus observations.

Water level measurements were unobtainable from the Wolfkraal Farm as they were all equipped, therefore all water level and borehole depth data were attained from Mr Karel Louw, which stated that water levels range between *c.*18 – 60 mbgl, with an average of *c.*50 mbgl. These water levels are deep and vary vastly making water supply and reliability uncertain. Furthermore, all windpump equipped boreholes depths range from 25 - 60 mbgl, with the exception of borehole WK-BH5, which is 100 mbgl deep (Mr Karel Louw, 2019). Borehole yields for Wolfkraal are inferred from Kamiebees yields as *c.*0.053 L/s per borehole. which are classified as low yields. A summary of Wolfkraal borehole information is presented in the hydrogeological report.

In addition, one borehole (NK-BH1) was located on the neighbouring Nama Khoi Municipal land. This borehole was abandoned due its low yields and destroyed infrastructure. The borehole is *c.*55 m deep and has a water level of *c.*8.5 mbgl.

5 Assessment of Potential Geohydrological Impacts

5.1 Impact Rating Methodology

The impacts associated with the water use were identified and assessed using the methodology in Appendix D of the Hydrogeological Assessment Report. This was done to determine the significance of each impact, both with and without the assumed implementation of mitigation measures.

The significance of an impact is defined as a combination of the consequence of the impact and the probability that the impact will occur. Ratings were allocated in terms of extent; intensity and duration for each of the identified impacts. The scores associated with these ratings were then used to determine the consequence rating of the impact. The probability classification of the impact was determined. Finally, the significance of the impact was ascertained by comparing the consequence rating to the probability classification.

The determined impact significance has the following implications:

- **Insignificant:** the potential impact is negligible and will not have an influence on the decision regarding the proposed activity/development.
- **Very Low:** the potential impact is very small and should not have any meaningful influence on the decision regarding the proposed activity/development.
- **Low:** the potential impact may not have any meaningful influence on the decision regarding the proposed activity/development.
- **Medium:** the potential impact should influence the decision regarding the proposed activity/development.
- **High:** the potential impact will affect the decision regarding the proposed activity/development.
- **Very High:** The proposed activity should only be approved under special circumstances.

In addition, impacts were considered in terms of their status, i.e. whether the impact would have an adverse (negative) or beneficial (positive) effect, and the degree of confidence with which the assessment was made was noted as being either: low, medium or high.

5.2 Impact Assessment

The following impact on groundwater has been identified and assessed:

- Reduced groundwater yields available to surrounding groundwater users during operations.

5.2.1 Impacts on Groundwater Quantity

The only concern that has been identified that could potentially impact the groundwater yield is abstraction of more than 77.8 KL/d (28 400 KL/a) of groundwater from the site's three boreholes resulting in drawdown in the local fractured-rock aquifer and which could risk the boreholes running temporarily dry.

Abstraction from boreholes normally results in a water level decline in the abstraction borehole and local surrounding area. As these three boreholes (KB-BH1, KB-BH2 and KB-BH3) are located on a single fault zone, this presents a higher impact should over abstraction and mutual interference occur. For example, boreholes KB-BH2 and KB-BH3, which have fairly shallow depths of 17.3 and 30.2 mbgl, respectively, might run dry should the groundwater table drops to these depths. The extent of the drawdown is dependent on the aquifer's hydraulic conductivity, storage and recharge. Due to the low hydraulic conductivity, the zone of drawdown at the site is likely to be limited and extending along the fault zone in a southeast-northwest direction. As the yield recommended for these boreholes are much lower than the maximum pump yields obtained during the step tests and CDT, coupled with the observed limited drawdown during testing, a reported drought index of *c*.3.84 years (8 years were conservatively allowed in the tests analysis) and very high aquifer storage potential, the significance of impact of abstraction is expected to be **low**.

Best practise to reduce impact is to apply a 12 hour a day pumping schedule at a rate of 0.8 L/s for KB-BH1; 0.4 L/s for KB-BH2 and 0.6 L/s for KB-BH3. This will allow the borehole sufficient time (12 h/d) to recover after each day's abstraction schedule. Such reduced pumping hours will allow the water level to recover and will reduce the significance of the impact to **very low**. See impact rating in Table 5-1and the impact assessment methodology in Appendix D of the Hydrogeological Assessment Report.

Table 5-1: Impact rating assessment groundwater quantity – Operational Phase

<table>
<tr><th>Mitigation</th><th>Impact no.</th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without</td><td>1</td><td>Local
1</td><td>Low
1</td><td>Long-term
3</td><td>Low
5</td><td>Possible</td><td>LOW</td><td>–</td><td>High</td></tr>
<tr><td colspan="10">Essential mitigation measures:
• Limit abstraction to ≤77.8 KL/d
• Install a low-level cut-off switch to prevent the water level from dropping below 45 mbgl; 13.5 mbgl and 25 mbgl for boreholes KB-BH1, KB-BH2 and KB-BH3 respectively (if solar or electrical submersible pumps are used.)
• Implement and adhere to water saving procedures and methodologies, e.g. drip irrigation, covering reservoir to reduce evaporation, etc.
Best practice measures:
• Abstract groundwater volumes necessary for the proposed activity, i.e.c.18 700 KL/a or c.51 KL/d;
• Abstract groundwater for only 12 hours per day, or shorter to allow the borehole sufficient time to recover daily. Alternatively, use solar or windpumps.
• Abstract the required groundwater volume over 12-hour period per day based on the following rates:
o KB_BH1: 0.26 L/s;
o KB_BH2: 0.13 L/s; and
o KB_BH3: 0.20 L/s
• Implement a groundwater monitoring system to monitor groundwater quality, volumes abstracted and water levels.
Natural mitigation:
• Very low groundwater abstraction, regular recharge (drought index of 3.8 years) and storage potential of the aquifers naturally mitigate the negative effects of abstraction on the aquifers of this area.</td></tr>
<tr><td>With</td><td>1</td><td>Local
1</td><td>Low
1</td><td>Long-term
3</td><td>Low
5</td><td>Improbable</td><td>VERY LOW</td><td>–</td><td>High</td></tr>
</table>

6 Stakeholder Engagement

The aim of stakeholder engagement is to ensure that stakeholders have adequate opportunity to provide input into the WULA process and raise their comments and concerns. More specifically, the objectives of stakeholder engagement are to:

- Identify stakeholders and inform them about the water use;
- Afford stakeholders the opportunity to identify relevant issues and concerns; and
- Provide stakeholders with the opportunity to review documentation and assist in identifying mitigation and management options to address potential environmental issues.

6.1 Stakeholder Engagement Activities

Stakeholder engagement on this WUA application will include the following activities:

- Advertise the WULA in the local press, indicating where this report can be accessed and inviting comments on the report and water use;
- Place a site notice at the facility;
- Notify neighbouring properties informing neighbours of the WULA, where this report can be accessed and inviting comments on the report and water use;
- Inform the local councillor of the WULA, where this report can be accessed and inviting comments on the report and water use; and
- Notify relevant organs of state (Department of Environmental Affairs, DWS, Kamiesberg Municipality and Nama Khoi Municipality) of the WUA application, where this report can be accessed and inviting comments on the report and water use.

The advertisement and correspondence will direct stakeholders to the report on SRK's website www.srk.co.za (via the 'Library' and 'Public Documents' links) and inform stakeholders of a 60 day comment period between 14 February 2020 and 17 April 2020. Stakeholder correspondence and the advertisement will be appended to the Final Technical Report to be submitted to the DWS. Issues raised, as well as responses from the proponent, EAP and/or hydrogeologist will also be summarised and included in the Final Technical Report.

7 Motivation in Terms of Section 27 of the NWA

Motivation in terms of Section 27 of the NWA for the water use associated with the project is provided in Table 7-1 below.

Table 7-1: Motivation in terms of Section 27 of the NWA

NWA S 27(1)	Aspect / Factor	Motivation
(a)	Existing lawful water use	The proposed water use is not expected to have a detrimental impact on other existing water users (see Section 5.2).
(b)	Need to redress the results of past racial and gender discrimination	Small scale water use for domestic and agricultural purposes is not intended to redress racial and gender discrimination.
(c)	Efficient and beneficial use of water in the public interest	This water use will increase Kamiebees Farm's, viability as a farming unit and increase employment opportunities
(d)(i)	Socio-economic impact of the water use or uses if authorised	The water use will increase employment opportunities for farm labours.
(d)(ii)	Socio-economic impact of the failure to authorise the water use or uses	The opportunity to reduce the use of potable water for irrigation, livestock watering and domestic purposes will be lost, and the benefit of using this water for other socially beneficial uses, e.g. increased employment of farm labourers, will be forgone.
(e)	Any catchment management strategy applicable to the relevant water resource	As the impact of the water use is assessed to be *very low*, it is unlikely that the water use would conflict with the catchment management strategy.
(f)	Likely effect of the water use to be authorised on the water resource and on other water users	It is highly unlikely that the abstraction of groundwater from the Kamiebees Farm would reduce groundwater yields at the Wolfkraal Farm, or any other farms. This is because the Wolfkraal boreholes are located on different lineaments (faults) and are spatially separated by solid, low permeable geological formations from the Kamiebees Farm boreholes. It is predicted that reported groundwater drawdown on Wofkraal would be attributed to the severe drought currently being experienced in the area.
(g)	The class and resource quality objectives of the water resource	The water use will not affect the class and resource quality objectives of water resources.
(h)	The investments already made and to be made by the water user in respect of the water use	Kamiebees Farm has already installed three boreholes, a reservoir and windpumps in order to abstract groundwater and use it for irrigation, livestock watering and domestic purposes. Investment has already been made by the applicant in terms of consultant fees for the WULA process (including associated specialist studies). Funding has also been allocated for the expansion of the prickly pear farm and associated infrastructure.
(i)	The strategic importance of the water use to be authorised	This is not a strategic water use.
(j)	The quality of the water in the water resource which may be required for the Reserve and for meeting international obligations.	Provided that mitigation measures stipulated above are implemented, the water use will not affect the water quality within the Reserve.

NWA S 27(1)	Aspect / Factor	Motivation
(k)	The probable duration of any undertaking for which the water use is to be authorised.	The lifespan of the proposed water use is unknown, but it is envisaged that it will take place over the long-term.

8 Conclusions and Recommendations

Based on the data and information discussed in this report, the following can be concluded regarding the geohydrology and water borehole use at Kamiebees Farm 368/1 site:

- All three targeted boreholes were yield tested and the data analysed to determine their safe yields. The safe yields for boreholes KB-BH1, KB-BH2 and KB-BH3 are 0.4 L/s, 0.2 L/s and 0.3 L/s, respectively. This equates to a total of 77.8 KL of groundwater per day or 28 382 KL per annum, which are considered as conservatively low abstraction rates. Furthermore, SJR Boerdery plans on abstracting a groundwater volume of *c.*51 KL/d or *c.*18 700 KL/a, which is significantly lower (35% lower) than the recommended safe yield of the three boreholes; and
- Data gathered on the hydrogeology of the area and the localities of surrounding boreholes, imply that it is highly unlikely that the abstraction of groundwater from the Kamiebees Farm would negatively impact groundwater yields at Wolfkraal Farm or any other farms in the surrounding area. This statement is made on the basis that Wolfkraal's boreholes are located on different lineaments (faults) and are spatially separated by impenetrable, solid geological formations from the Kamiebees Farm boreholes. It is postulated that reported groundwater drawdown at Wolfkraal could be attributed to the severe drought being experienced in the region.

The proposed impact of groundwater abstraction is 'low' and with the implementation of essential mitigation measures, reduces to 'very low'. Therefore, there is no obvious reason why abstracting groundwater at a rate of *c.*51 KL/d or *c.*18 700 KL/a to support the proposed activity should not be authorised provided the recommendations in this report are implemented and adhered to.

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional environmental practices.

9 References

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Appendices

Appendix A: Hydrogeological Assessment Report

Hydrogeological Assessment at Farm Kamiebees 368/1, Northern Cape

Hydrogeological Assessment Report

Report Prepared for

SJR Boerdery CC

Report Number 552583/1

Report Prepared by

srk consulting

February 2020

Hydrogeological Assessment at Farm Kamiebees 368/1, Northern Cape

Hydrogeological Assessment Report

SJR Boerdery CC

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Statement of SRK Independence

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List of Abbreviations

c.	*circa* (approximately)
CC	Close Corporation
CDT	Constant Discharge Test
DWS	Department of Water and Sanitation
DWAF:	Department of Water Affairs and Forestry
EAP	Environmental Assessment Practitioner
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
e-WULAAS	Electronic Water Use Application and Authorisation System
GA	General Authorisation
GN	Government Notice
GRU	Groundwater Resource Unit
ha	hectare
hr	hour
L/s:	litres per second
MAP	Mean Annual Precipitation
KL /a	Kilolitres per annum
KL /d	Kilolitresper day
KL /h	Kilolitres per hour
KL /m	Kilolitres per month
mamsl	metres above mean sea level
mbc	metres below collar
mbgl	metres below ground level
µg/L	micro-grams per litre
mg/L	milligrams per litre
mS/m:	milli Siemens per metre
NGA	National Groundwater Archive
NWA	National Water Act 36 of 1998
S	Storativity
SANS	South African National Standards
SANAS	The South African National Accreditation System
SRK	SRK Consulting (South Africa) (Pty) Ltd
T	Transmissivity
WUA	Water Use Authorisation
WUL	Water Use Licence

Glossary

Aquifer:	A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to store and transmit water; and to yield economical quantities of water to boreholes or springs. An aquifer is the storage medium from which groundwater is abstracted.
Aspect	An action, event, product or service, occurring as a component or result of an activity, which interacts with the existing environment (or which results in impacts to it)
Baseline	Information gathered at the beginning of a study which describes the environment prior to development of a project, and against which predicted changes (impacts) are measured.
Construction phase	The stage of project development comprising site preparation as well as all construction activities associated with the development.
Design phase	The stage during which detailed layout and development plans are prepared, including the drafting of contract documents for construction.
Drought Index	The Drought Index or Di is used to assess the number of years required to bridge cycles of negligible or no aquifer recharge from rainfall, where groundwater abstracted will almost entirely be removed from aquifer storage.
Electrical conductivity (EC):	Electrical conductivity is a measure of how well a material accommodates the transport of electric charge. The more salts dissolved in the water, the higher the EC value. It is used to estimate the amount of total dissolved salts, or the total amount of dissolved ions in the water.
Ephemeral	A water body that does not flow or contain water year-round, in response to seasonal rainfall and run-off.
Environment	The external circumstances, conditions and influences that surround and affect the existence and development of an individual, organism or group. These circumstances include biophysical, social, economic, historical and cultural aspects.
Environmental Authorisation	The authorisation by a competent authority of a listed activity or specified activity in terms of National Environmental Management Act.
Environmental Impact Assessment	A process of evaluating the environmental and socio-economic consequences of a proposed course of action or project
Environmental Management Measures	Requirements or specifications for environmental management, as presented in theEnvironmental Management Plan, some of which are based on the mitigation measures identified in the EIA Report (in this case the EIA).
Environmental Management Programme	A description of the means for achieving environmental objectives and targets during all stages of a specific proposed activity.
Formation:	A body of rock identified by lithic characteristics and stratigraphic position. Different formations have different geohydrological properties.
Fracture:	Any break in a rock including cracks, joints and faults. Fractures can form the main conduits for groundwater flow. They can also form pathways for the movement of contamination.
Fractured-rock (Secondary) aquifer:	An aquifer in which groundwater moves through secondary openings and interstices, which developed after the rocks were formed. Approximately 90% of aquifers in South Africa are secondary in nature.

Groundwater:	Water found in the subsurface in the saturated zone below the water table. Groundwater is a source of water and is an integral part of the hydrological system.
Hydrogeology:	In South Africa, the term geohydrology and hydrogeology are used interchangeably. In theory hydrogeology is the study of geology from the perspective of its role and influence in hydrology, while geohydrology is the study of hydrology from the perspective of the influence on geology.
Impact	A change to the existing environment, either adverse or beneficial, that is directly or indirectly due to the development of the project and its associated activities.
Method Statement	A mandatory written submission by the contractor to the ECO setting out the plant, materials, labour and method the contractor proposes using to carry out an activity.
Mitigation Measures	Actions identified to manage (avoid, minimise or optimise) potential environmental impacts which may result from the development.
Phase	A defined period during the life of the project, e.g. the construction and operations phases.
Operational Phase	The stage of the works following the Construction Phase, during which the development will function or be used as anticipated in the Environmental Authorisation.
Product Water	Water from the desalination process which has undergone final treatment to meet the required water quality standards for the end use.
Quaternary:	The Quaternary Period is a geologic time period that includes the most recent 2.6 million years, including the present day.
Storativity:	The volume of water released from storage per unit of aquifer storage area per unit change in head.
Transmissivity:	Transmissivity is the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It is expressed as the product of the average hydraulic conductivity and thickness of the saturated portion of an aquifer.

1 Introduction and Scope

1.1 Appointment

SRK Consulting (South Africa) (Pty) Ltd (SRK) was appointed by SJR Boerdery CC (SJR Boerdery) to conduct the Water Use Licence Application (WULA) process for additional groundwater abstraction for irrigation, livestock watering and domestic purposes. A WUL is required from the Department of Water and Sanitation (DWS) for an activity (water use) listed and triggered in terms of Section 21 (a) of the National Water Act 36 of 1998 (NWA) - *taking water from a resource*. In addition, SRK was also appointed to compile a technical report in support of a WULA.

1.2 Background

SJR Boerdery owns the Kamiebees Farm 368 Portion 1 (368/1), which is located *c*.85 km south east of Springbok, Northern Cape. The farm currently uses borehole water for irrigation, livestock watering and domestic purposes, sourced from three boreholes equipped with windpumps. SJR Boerdery (owner – Mr Johnnie van Niekerk) intends to supplement his livestock feed (for 300 sheep, 80 springboks and 20 Oryx) with Prickly Pear plants (*Upuntia Ficus Indica*), as the plant is cost-effective, uses minimal water and is a good source of protein. SJR Boerdery proposes to extend the prickly pear plot by 10 hectares (ha) (20 ha in total) by 2026 to harvest *c*.15 tons per annum. Water requirements are comparatively low (a prickly pear requires approximately three litres per week) equating to *c.*18 700 kilolitres per annum (KL/a). This requires a WULA for additional groundwater abstraction from existing boreholes based on the recommended sustainable yields.

1.3 Structure of this Report

This report provides the motivation for applying for a WULA, discusses the hydrogeology of the site and surroundings, presents the results of the aquifer yield testing, recommends sustainable yields and evaluates potential impacts of potential groundwater abstraction. The report also provides key recommendations associated with groundwater management/potential abstraction for the Kamiebees Farm 368/1 based on the hydrogeological assessment.

The report is structured in the following sections:

Section 1: Introduction and Scope

Provides an introduction and background of the proposed project and outlines the purpose of this document applicable to the hydrogeological study. In addition, it describes the scope of work proposed to the client to conduct the hydrogeological investigation and impact assessment.

Section 2: Geographical Settings

Provides a brief description of the site locality, climate, topography and drainage.

Section 3: Scope of Work

Describes a narrative description of a project's work requirements.

Section 4: Methodology for the Hydrogeological Assessment

Describes the methodologies employed and information used to conduct the hydrogeological investigation and impact assessment.

Section 4: Prevailing Groundwater Conditions

Describes the prevailing groundwater conditions and geology at the site that informed the impact assessment.

Section 6: Aquifer Characterisation

Describes the classification, vulnerability and protection classification of the site aquifers.

Section 7: Groundwater Modelling

Not included in the project scope.

Section 8: Assessment of Potential Geohydrological Impacts

Describes and assesses the significance of potential hydrogeological impacts according the SRK's methodology.

Section 9: Groundwater Monitoring System

Describes the groundwater monitoring system required to effectively monitor potential impacts.

Section 10: Groundwater Environmental Management Programme

Describes the groundwater management procedures required to mitigate potential impacts of groundwater contamination associated with the proposed site activities.

Section 11: Post-closure Management Plan

Describes the post-closure management strategies to remediate environmental impacts and water resources.

Section 12: Conclusions and Recommendations

Provides a summary of the hydrogeological assessment results, describes the significance of the impact during operation, proposed recommendations and outlines essential mitigation measures to implement if authorisation for a WUL is granted.

This report adheres to the contents for minimum information requirements to be submitted for water use technical geohydrology reports as set out in the DWS *Regulations Regarding the Procedural Requirements for Water Use Licence Applications and Appeals* (DWS, 2017).

2 Geographical Setting

2.1 Site Locality

The Kami bees Farm 368/1 is located *c.*85 km southeast of Springbok and *c.*14 km north of Vaalputs in the Northern Cape at Latitude S 30.030852° and Longitude E 18.519925°. The farm is *c.*3 000 ha in extent and about the R355 Regional Route (see Figure 2-2).

2.2 Topography and Drainage

Kamiebees Farm 368/1 lies within the F30A quaternary catchment, which covers an area of *c.*165 320 ha (DWAF, 2005).

Regionally, the higher lying topographic regions are to the west of the catchment and slope (averaged at 0.9%) in a north-east direction. The highest elevation in the catchment is *c.*1 200 metres above mean sea level (mamsl) in the west and the lowest elevation is *c.*640 mamsl in the north.

Locally, the higher lying topographic regions are to the east of the Kamiebees Farm and slope in a north-west direction (Figure 2-3). The highest elevation on the farm is *c.*1 050 mamsl and the lowest elevation is *c*.920 mamsl. The average elevation is *c*.970 mamsl. Stormwater runoff at the farm drains towards the Gasabrivier located to the north-west of the farm boundary. Regionally, surface and groundwater flows towards the Atlantic Ocean via the Buffelsrivier (DWS, 2016).

The groundwater flow direction is inferred from spot water levels which range from 916 - 966 mamsl over the study area and 10 - 13 meters below ground level (mbgl) on the Kamiebees Farm. The inferred groundwater flow mimics the topography and flows in a westward direction towards the Gasabrivier (Figure 5-3).

2.3 Climate

The study area has a Mediterranean climate with cool wet winters (May to September) and hot dry summers (October to April). The quaternary catchment's (F30A) average rainfall is 162 mm/a (DWAF, 2005). Most of the rainfall occurs within the winter months where maximum rainfall is recorded in June (37 mm) and minimum rainfall is recorded in January (0 mm) (Weather and Climate, 2019).

Inferred temperatures and evaporation rates were taken from the Springbok and O'Kiep weather stations, as these were the closest weather stations for which data could be obtained. The Springbok weather station shows that the average daily temperatures range from 16.0°C in July to 28.3°C in February. The region is coldest during July reaching a low of 3.8°C on average during the night and is the highest in January and February with an average daily temperature of 28°C. Evaporation follows the same trends, with the lowest evaporation rate of 144.3 mm/month occurring in July and the highest (403.6 mm/ month) occurring in January.

The long-term monthly distribution of average monthly rainfall, temperatures and evaporation rate are displayed in

Table 2-1 and Figure 2-1.

Table 2-1: Summary of mean monthly climate indicators

Indicator	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	2.6	7.1	10.1	15.34	25.1	37.9	27.9	31.4	15.1	12.9	7.7	6.2
Temperature (ºC)	28	28	27	24	20	17	16	18	20	23	25	27
Evaporation (mm)	403.6	326.6	305.6	221.0	172.7	152.0	144.3	176.6	227.4	305.9	364	393.4

Note: Source – Rainfall Data: Springbok Weather Station 0214670 (Midgley et al., 1994)

– Evaporation Data: O'kiep Weather Station 0214636 (Midgley et al., 1994)

– Rainfall Data: Springbok Weather Station 0214670 (Midgley et al., 1994)

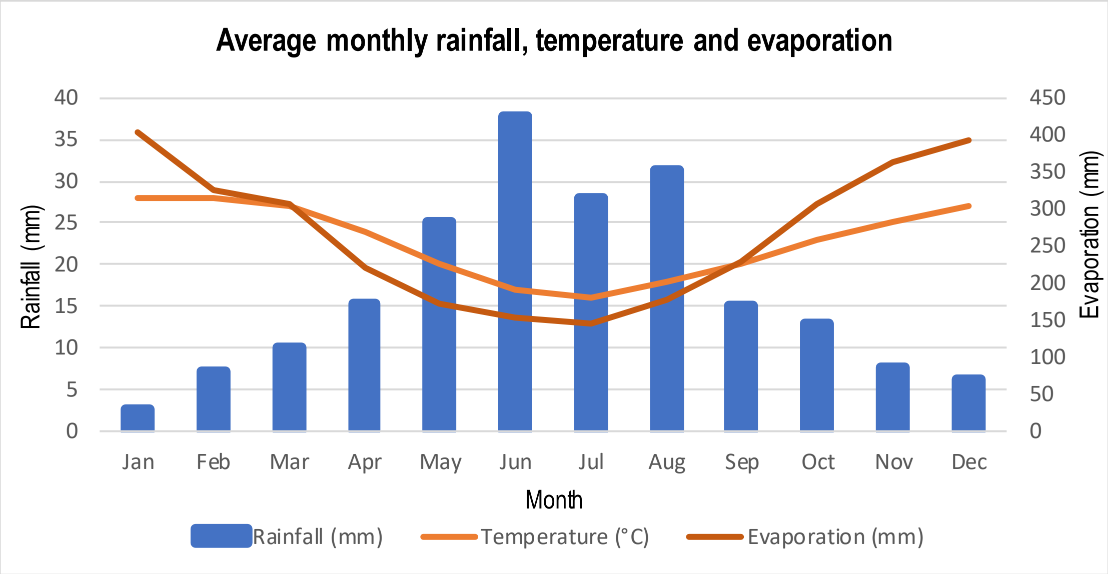


Figure 2-1: Average monthly rainfall, temperature and evaporation

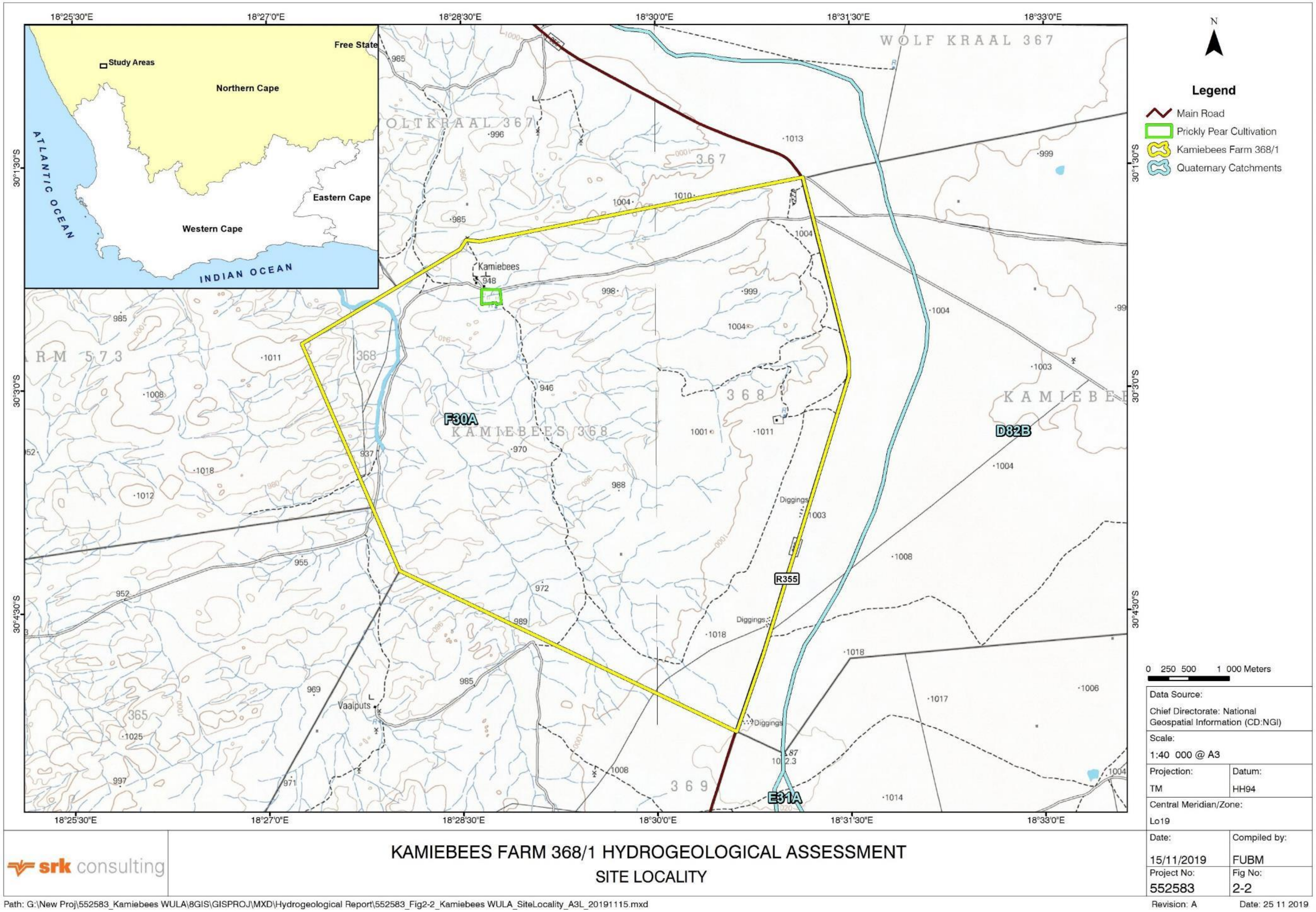


Figure 2-2: Site locality

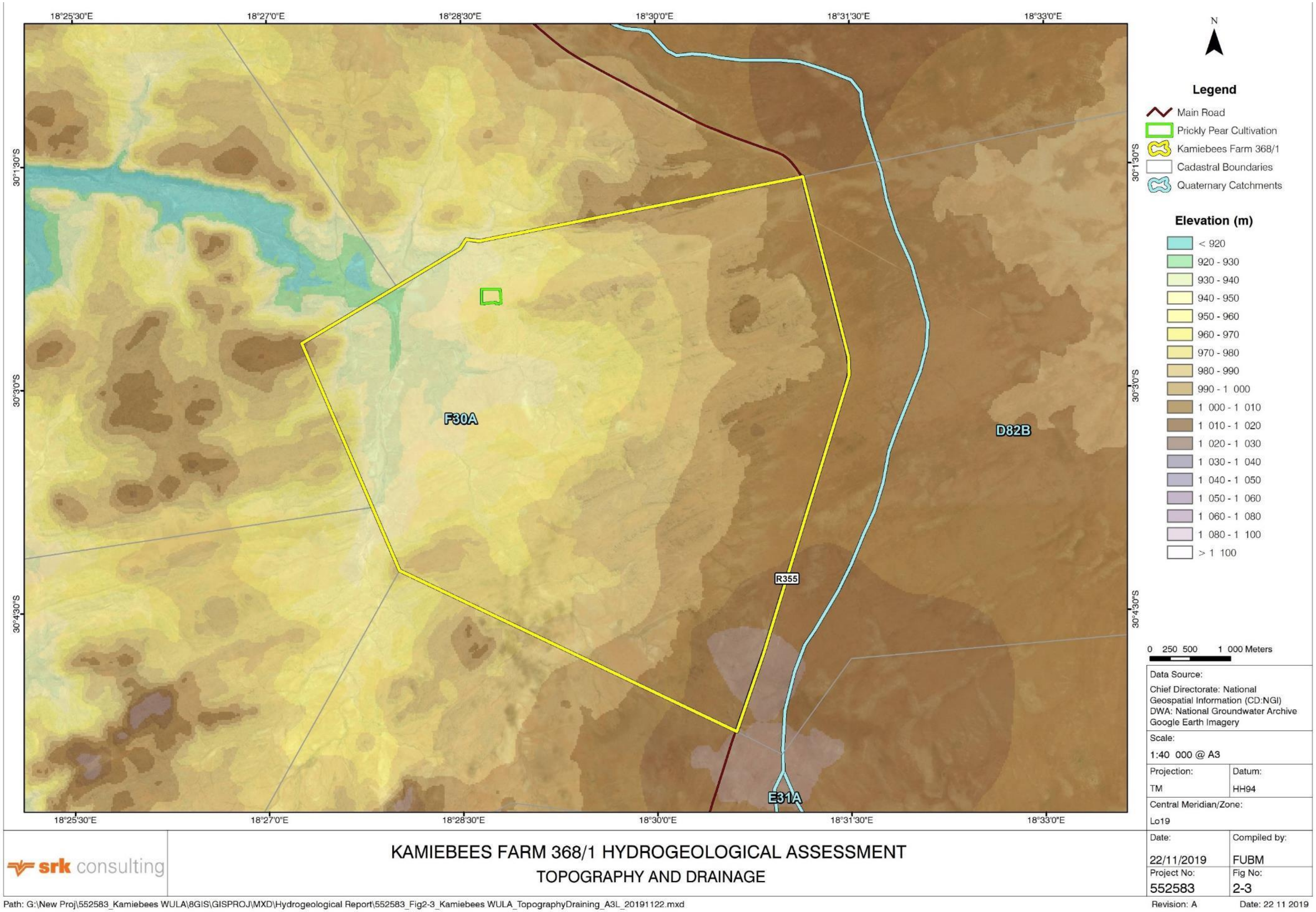


Figure 2-3: Topography and drainage

3 Scope of Work

The scope of work for this investigation included the following:

- Collect data, including latest data from the DWS National Groundwater Archive (NGA), published geological and hydrogeological maps, reports and databases that may be available for the area;
- Visit the site and conduct a hydrocensus of boreholes on the client's property, as well as boreholes on neighbouring properties;
- Analyse the pumping test data and water quality analysis results, and determine the sustainable and optimum pumping rate for each borehole;
- Assess the potential impact of abstraction on the aquifer and other water users;
- Compile a hydrogeological impact report for inclusion with the WULA; and
- Conduct a WULA process as specified in Government Notice 267 of 24 March 2017 published in terms of the National Water Act 36 of 1998 (NWA), including:
  - A pre-application meeting with the Department of Water and Sanitation (DWS) in Upington;
  - Submit the prerequisite application form;
  - Conduct a site inspection with the DWS case officer;
  - Compile the WULA, including NWA Section 27 Motivation and supplementary application forms;
  - Conduct stakeholder engagement on the WULA, including:
    - Erecting a notice on the property boundary;
    - Notifying neighbouring property owners and occupiers, the municipal councillor, and organs of state; and
    - Placing an advert in one local newspaper;
  - Compile a stakeholder engagement report, including issues and responses summary; and
  - Submit the WULA on behalf of the client to the DWS.

4 Methodology for the Hydrogeological Assessment

4.1 Desk Study

For the hydrogeological desktop study of the site and neighbouring properties, the following reports and information were collated and assessed:

- The DWS NGA;
- The DWS (2016) Groundwater Ecological Water Requirements Report;
- DWAF's 2005 National Groundwater Resource Assessment Phase 2 database and reports;
- The DWAF's 2002 1:500 000 Geological Map Sheet 3018 Loeriesfontien;
- The DWAF's May 2001 report "An Explanation of the 1:500 000 General Hydrogeological Map Springbok 2916; and
- Rainfall data received from "Surface water resources of South Africa 1990. Water Research Commission Report No 298/3.1/94".

4.2 Hydrocensus

A hydrocensus was conducted on 11 October 2019. The aim of the hydrocensus was to obtain information regarding groundwater levels, groundwater quality (EC, pH and temperature), existing groundwater use, borehole construction, borehole localities, land use and identify potential impact receptors.

A total of 10 boreholes were surveyed within a 4 km radius of the site (Figure 4-1).Four are located on the Kamiebees Farm, five are positioned on the neighbouring Wolfkraal Farm (Owned by Mr Karel Louw) and one on the neighbouring Nama Khoi Municipal land. All borehole measurements and information gathered during this hydrocensus are summarised in Table 4-1. In addition, borehole descriptions are presented in Table 4-2.

The four boreholes located on Kamiebees Farm 368/1 consisted of three active boreholes (KB-BH1, KB-BH2 and KB-BH3) which pump groundwater to a central reservoir, supplying water to the farmstead, livestock and prickly pear orchard. Water levels are relatively shallow at *c.*10 mbgl Boreholes KB-BH2 and KB-BH3 are within 10 m of each other, whereas borehole KB-BH4 is located near the farmstead and is currently not in use as it is too low-yielding due to the drought. The three active boreholes are equipped with windpumps containing 60 mm Jooste cylinders capable of yielding a maximum of 770 litres per hour (L/h) (Jooste Cylinder & Pump Co, 2019). It is assumed that the wind is of sufficient strength to drive the windpumps approximately 25% of the time, thus the estimated average abstraction rate is *c.*0.053 L/s per borehole, which equates to an average abstraction rate of *c*.1 700 KL/a per borehole.

The five boreholes located on the neighbouring Wolfkraal Farm consist of four active windpump equipped boreholes (WK-BH1, WK-BH2, WK-BH3 and WK-BH4) that supply drinking water to livestock and water for domestic use to the farmstead. Borehole WK-BH5 intermittently pumps water once every two weeks and serves as a supplementary borehole for the farmstead (pers. comm, Mr Karel Louw). Abstraction rates for Wolfkraal are inferred as *c*.0.053 L/s per borehole. Water level measurements were unobtainable from the Wolfkraal Farm as no access could be gained through the windpump baseplates. Therefore, all water level and borehole depth data were attained from Mr Karel Louw who stated that water levels are average *c*.50 mbgl.

The borehole (NK-BH1) located on the neighbouring Nama Khoi Municipal land was naturally destroyed and thus abandoned.

Water quality measurements taken on-site include pH, EC and temperature. The groundwater at five boreholes (KB-BH2, KB-BH3, KB-BH4, WK-BH2 and WK BH3) meet drinking water standards (<270 mS/m), whereas boreholes KB-BH1, NK-BH1, WK-BH1, WK-BH4 and WK-BH5 display high EC values indicative of brackish water (Table 4-1). Although, some of the boreholes are classified as having a brackish water type, it is still suitable for its intended agricultural use.

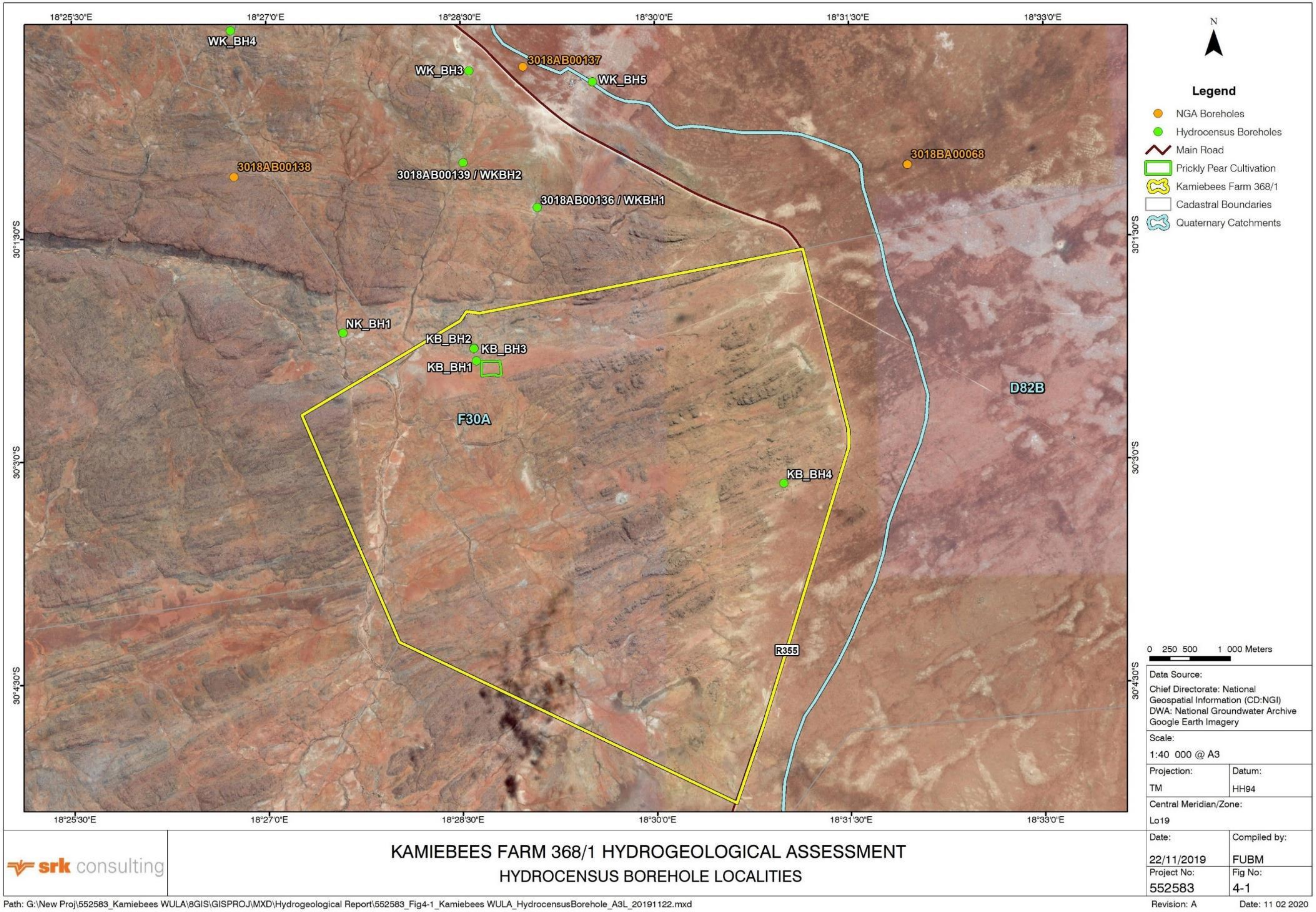


Figure 4-1: Hydrocensus borehole localities

Table 4-1: Hydrocensus summary

Borehole ID	Farm Name	Latitude S	Longitude E	Owner	BH Depth (mbgl)	Casing Type/ Diameter (mm)	Water Level (mbgl)	Collar Height (magl)	Elevation (mamsl)	Yield (l/s)	EC (mS/m)	pH	Temp ˚C
KB-BH1	Kamiebees	-30.03883	18.47695	Mr Johnnie Van Niekerk	54.30	170	12.75	0.33	947	0.05	316	8.57	25.4
KB-BH2		-30.03740	18.47665		30.20	170	10.82	0.26	945	0.05	266	8.22	26.4
KB-BH3		-30.03748	18.47665		17.25	170	10.45	0.28	945	0.05	262	8.32	25.6
KB_BH4		-30.05273	18.516459		+100	150	37.69	0.05	949	N/A	222	8.09	25.7
NK-BH1	Municipal Land	-30.03565	18.459786	Nama Khoi Municipality	55	125	8.53	0.2	879	N/A	655	8.23	22.4
WK-BH1	Wolfkraal	-30.02167	18.484865	Mr Karel Louw	*c.*114	150	*c.*18	0.2	936	0.05	525	7.76	26.9
WK-BH2		-30.01661	18.475348		*c.*72	150	*c.*50	0.2	934	0.05	259	8.29	26.6
WK-BH3		-30.00634	18.476138		*c.*30	150	*c.*30	0.2	964	0.05	249	8.30	25.5
WK-BH4		-30.00172	18.445488		*c.*60	150	*c.*30	0.2	952	0.05	397	7.95	21.4
WK-BH5		-30.00761	18.492038		100	150	86	0.25	972	0.05	301	8.30	28.5

Table 4-2: Hydrocensus borehole descriptions

Borehole ID	Description
KB-BH1	Working windpump with 60mm Jooste cylinder. Pumped to central reservoir used for prickly pear, livestock watering and domestic water supply at homestead.
KB-BH2	Working windpump with 60mm Jooste cylinder. Pumped to central reservoir used for prickly pear, livestock watering and domestic water supply at homestead
KB-BH3	Working windpump with 60mm Jooste cylinder. Pumped to central reservoir used for prickly pear, livestock watering and domestic water supply at homestead
KB-BH4	Near farm homestead and previously used for domestic water supply. Currently too low yielding to be used due to the drought.
NK-BH1	Old disused borehole with windpump of which the pipes and rods have been removed.
WK-BH1	Working windpump Used for livestock (sheep).
WK-BH2	Working windpump. Used for livestock (sheep).
WK-BH3	Working windpump. Supplies water to the farm's homestead
WK-BH4	Working windpump. Used for livestock (sheep).
WK-BH5	Used as a back-up water supply to the homestead. Equipped with electric submersible pump used once every two weeks.

Borehole KB-BH1

Boreholes KB-BH2 & KB-BH3

Borehole KB-BH4

Borehole WK-BH1

Borehole WK-BH2

Borehole WK-BH3

Borehole WK-BH4

Borehole WK-BH5

Borehole NK-BH1

srk consulting	**Hydrogeological Study for Kamiebees Farm 368/1, Northern Cape** HYDROCENSUS PICTURES	Project No. 552583/1

Figure 4-2: Hydrocensus pictures

4.3 Geophysical Survey and Results

Geophysical surveys were not required as the client plans on abstracting groundwater from existing boreholes.

4.4 Siting and Drilling of Boreholes

Drilling of a borehole was not required by the client as they plan to use existing boreholes.

4.5 Aquifer Yield Testing

The three boreholes proposed for licensed abstraction at Kamiebees Farm, KB-BH1, -BH2 and -BH3 (see Figure 4-1 for locality and Figure 4-3 for photographs, were yield tested by AB Pumps from the 13 to 24 September 2019. Yield testing was carried out in accordance with SANS 10299 by employing a positive displacement screw-type pump connected to a diesel engine with gearbox. Discharge was 50 m downstream of each borehole and away from the norhwest - southeast striking fault zone on which these boreholes have been drilled.

Summaries of the yield test results are given in Table 4-3 (step tests) and Table 4-4 (CDTs). The test pumping data sheets received from AB Pumps, together with existing pump details and graphs illustrating water level behaviour during testing, are included in Appendix A.

Calibration tests were conducted on all three boreholes to stress the borehole and determine suitable step test rates. Step tests were conducted on all three boreholes (KB_BH1, KB_BH2 and KB_BH3) using five by 60 min discharge steps with each consecutive step conducted at a higher discharge rate. Constant Discharge Tests (CDT) were conducted for a period of 48 hours, to gain an understanding of the “sustainable yield of each borehole. As one borehole underwent yield testing, the water level at the other two boreholes was monitored to determine the effects of mutual interference during abstraction.

KB-BH1 underwent a calibration test with discharge steps ranging from 1.5 to 5 L/s. The steps tests were conducted at 1, 2, 3.5 and 5 L/s. The drawdown at the end of the last step was 38.62 m. The EC values were constantly below 391 mS/m for the duration of the step tests (). After water level recovery, borehole KB-BH1 was pumped for 48 h at a constant discharge rate of 3 L/s. The borehole reached a final drawdown of *c.*21.56 m by the end of the 48 h CDT (Table 4-4) and took a period of 48 h to recover to a drawdown of 2.21 m (90% recovery).

KB-BH2 underwent five steps during the step test that started at 0.5 L/s and increased by 0.5 L/s every hour to a final discharge of 2.5 L/s. The drawdown at the end of the last step was 3.34 m. EC values were constantly below 270 mS/m for the duration of the step discharge test (Appendix A). After water level recovery, the borehole was pumped for 48 h at a constant discharge rate of 1 L/s. The borehole experienced a maximum drawdown of *c.*2.73 m by the end of the 48 h CDT (Table 4-4) and took a period of 48 h to recover to *c.*0.31 m (89% recovery). It is notable that the observation borehole KB-BH3 *c.*10 m away, responded in the same manner as the tested borehole, suggesting that these two boreholes are directly linked and abstract water from the same fractured-rock fault zone and aquifer. This is expected as these boreholes are in close proximity (*c.*10 m apart), therefore, a calibration and step test were deemed sufficient to understand the hydrogeological response of KB-BH3.

Borehole KB-BH3 underwent a calibration test with discharge steps ranging from 0.7 to 5.6 L/s. Thereafter, step tests were conducted at 1, 2, 4 and 5.7 L/s. The maximum drawdown at the end of the last step was 6.11 m. EC values were constantly below 342 mS/m for the duration of the step test (Table 4-3). After a period of 2 h the water level recovered to 11.40 mbgl from an initial rest water level of 10.82 mbgl, which equates to a drawdown deficit of 0.58 m (91% recovery).

Table 4-3: Summary of step yield tests

Borehole No.	Borehole Depth	Pre-Pumping Water Level	60 min Step Discharge Rates L/s					Max. Drawdown at Last Step
	mbgl	mbgl	Step 1	Step 2	Step 3	Step 4	Step 5	m
KB_BH1	54.30	13.12	1	2	3.5	5		38.62
KB_BH2	17.25	10.45	0.4	0.8	1.5	2	2.5	3.34
KB_BH3	30.20	10.82	1	2	4	5.7		6.11

Table 4-4: Summary of constant discharge yield tests

Borehole No.	Borehole Depth	Pre-Pumping Water Level	48 hr Constant Discharge Test	
	mbgl	mbgl	Pump Rate L/s	Final Drawdown m
KB_BH1	54.30	13.22	3	21.56
KB_BH2	17.52	10.57	1	2.73

To estimate the maximum long-term pumping rate, pumping schedule, pumping depth, management measures and aquifer parameters, the test pumping data were analysed using an Excel based software package developed by Van Tonder *et al* (2002). In the software package, various methods such as the Flow Characteristic method (FC-method), porous aquifer solutions (Theis, Cooper-Jacob and Hantush methods), fractional pumping test analysis (Barkers Generalised Radial Flow Model) and Step drawdown analysis were used to estimate risk-based sustainable yields for the boreholes as well as aquifer parameters such as transmissivity (T) and the storage coefficient (S). In the FC-Analysis the following aquifer input parameters were used:

- Effective recharge of 0.16 mm/a (GRA-2 data for F30A, DWAF, 2005); and
- Based on a Drought Index of 3.4 years (GRA-2 data for F30A, DWAF, 2005), the data were conservatively extrapolated for eight years.

Safe yields are defined as the amount of water that can be withdrawn from an aquifer without producing an undesired effect (Todd, 1959). It is important to monitor groundwater levels over a prolong period to determine whether the 'safe' yield is still sustainable. The safe yields of the Kamiebees boreholes were calculated using the aquifer transmissivity, storativity as well concurrent borehole abstractions. For example, the safe yield calculations of KB-BH1 accounts for the simultaneous abstraction of boreholes KB-BH2 and KB-BH3. A summary of the analyses results with recommended safe yields are presented in Table 4-5.

The safe yields for the following boreholes are:

- KB-BH1: 0.40 L/s
- KB-BH2: 0.20 L/s
- KB-BH3: 0.30 L/s

This equates to a total of 77.8 kilolitres per day or 28 382 KL per annum (Table 4-8). Comparing these yields to the groundwater availability in the quaternary catchment, it is apparent that the yield amounts to:

- Approximately >1 % of the groundwater potentially stored in the aquifers of the catchment;
- Approximately.4.7 % of the Mean Annual Groundwater Recharge; and
- Approximately.6.3 % of the Utilisable Groundwater Exploitation Potential

Table 4-5: Summary of recommended safe borehole yields

Borehole No.	Borehole depth	Rest Water Level	Pump Intake	Available Drawdown	Pump Sensor Depth*	Maximum Yield		Maximum Abstraction Limit		
	mbgl	mbc	mbgl	m	mbc	L/s	KL/h	KL/d	KL/m	KL/a
KB-BH1	54.3	12.41	50.0	47.0	45.0	0.40	1.440	34.6	1 051	12 614
KB-BH2	17.3	10.16	15.0	4.5	13.5	0.20	0.720	17.3	526	6 307
KB-BH3	30.2	10.56	27.0	16.0	25.0	0.30	1.080	25.9	788	9 461
Total						**0.90**	**3.240**	**77.8**	**2 365**	**28 382**

Note: Source – Aquifer test (AB Pumps, 2019)

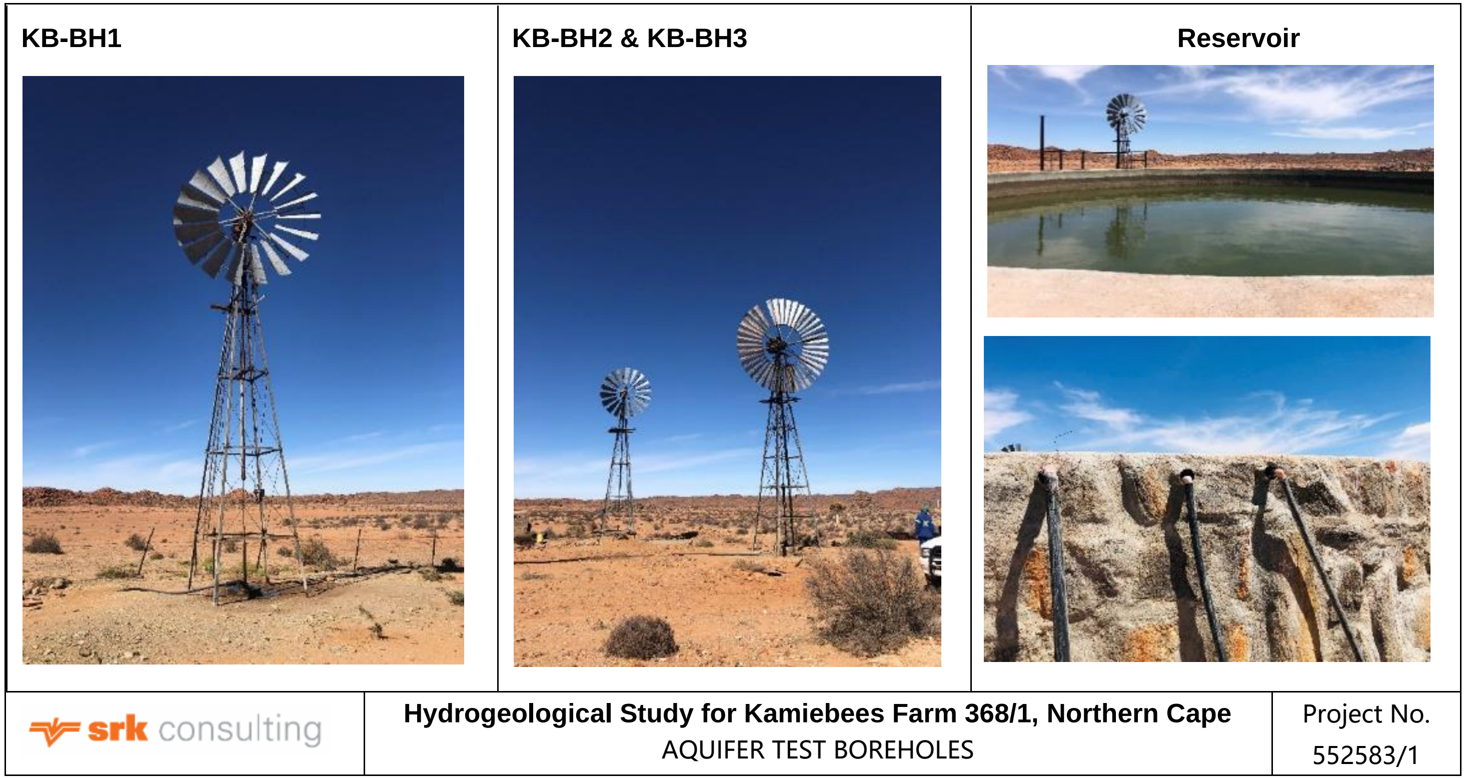


Figure 4-3: Images of aquifer test boreholes

4.6 Groundwater Monitoring, Sampling and Chemical Analysis

Water samples were collected for the three boreholes that underwent yield testing (KB-BH1, KB-BH2 and KB-BH3). Water quality analyses of the samples collected are summarised and compared to the *South African National Standard for Drinking Water (SANS 241:2015)* in Table 4-6.

Chemical and microbial concentration values exceeding the SANS 241:2015 acute and chronic health[1] risk related drinking limit are shown in bold red and those exceeding aesthetic[2] and operational[3] limits in bold. Values indicated with <-symbol are below the laboratory's method detection limits. The laboratory reports are included in Appendix C.

The water quality of boreholes KB-BH2 and KB-BH3 is similar in chemistry (little variation) which is expected as they are only 10 m apart. Borehole KB-BH1 displays slightly higher concentrations with poorer water quality. All boreholes exceed the SANS 241-2015 human health risk drinking limits for fluoride and sulfate concentrations. In addition, water at borehole KB-BH1 displayed above human health risk limits for nitrate and nitrite concentrations whilst at KB-BH2 and KB-BH3 manganese at both and iron at the latter, also exceed health related limits. From an aesthetic and operational risks, EC, TDS, chloride and sodium exceeds the limits

To render the water from these three boreholes fit for human drinking, it will have to be treated to reduce the exceedances to acceptable levels. Commonly used treatment options to reduce iron and manganese include oxidation (aeration, chlorination or ozonation), coagulation followed by settlement and filtration. To reduce sulphate, fluoride, sodium, chloride, TDS and EC (salinity) levels, the only treatment options desalination. pH balancing (stabilisation) might also be required[4] as will disinfection.

The pH values for all the boreholes visited during the hydrocensus range between 7.76 to 8.57 (Table 4-1). Therefore, the groundwater in the study area is neutral to alkaline in nature.

Borehole KB-BH1 has a positive Langelier Index, which is indicative of a scaling tendency (Table 4-7), whereas boreholes KB-BH2 and KB-BH3 have negative Langelier Indices, which is indicative of a corrosive tendency. All boreholes display Ryznar Indices above >6.5 suggesting a corrosive tendency (Table 4-7). In addition, the Larson-Skold Indices are all well above >1.2 (Table 4-7) implying a high-corrosive tendency to metal (mild steel) fittings.

[1] Acute human health risk - Determinand that poses an immediate unacceptable human health risk if ingested if present at concentration values exceeding the numerical limits specified in the SANS 241-2015.

Chronic human health risk - Determinant that poses an unacceptable human health risk if ingested over an extended period if present at concentration values exceeding the numerical limits specified in the SANS 241-2015.

[2] Aesthetic risk - Determinand that taints water with respect to taste, odour or colour and that does not pose an unacceptable human health risk if present at concentration values exceeding the numerical limits specified in the SANS 241-2015.

[3] Operational risk - Determinand that is essential for assessing the efficient operation of treatment systems and risks to infrastructure.

[4] Dissolved Iron and other trace-metal analysis were done on a filtered (0.45 micron) and preserved (1% Ultrapure nitric acid) sample. Iron and manganese concentrations may vary over time and the form of iron and manganese may be affected by chlorination. Pilot testing will increase the chance that any iron problems are detected before long term use of the water.

Table 4-6: Summary of groundwater quality indicators of the tested water boreholes at Kamiebees

Determinand	Units	KB-BH1	KB-BH2	KB-BH3	"SANS 241-1:2015 RECOMMENDED LIMITS & RISKS"
Ammonia	mg N/L	0.18	0.23	0.26	Aesthetic: ≤1.5
Chloride	mg Cl/L	**831**	**585**	**628**	Aesthetic: ≤ 300
Colour*	mg Pt-Co/L	<1	<1	<1	Aesthetic: ≤15
Dissolved Aluminium	µg Al/L	2.55	2.84	2.60	Operational: ≤300
Dissolved Antimony	µg Sb/L	0.43	0.45	0.39	Chronic Health: ≤20
Dissolved Arsenic	µg As/L	0.44	0.68	0.12	Chronic Health: ≤10
Dissolved Barium	µg Ba/L	35	64	67	Chronic Health: ≤700
Dissolved Boron	µg B/L	714	500	519	Chronic Health: ≤2 400
Dissolved Cadmium	µg Cd/L	0.02	0.06	0.04	Chronic Health: ≤3
Dissolved Calcium	mg Ca/L	235	128	134	Not specified
Total Chromium	µg Cr/L	41.00	39.00	41.00	Chronic Health: ≤50
Dissolved Copper	µg Cu/L	0.98	1.07	1.06	Chronic Health: ≤2 000
Dissolved Iron	µg Fe/L	9.46	7.16	4.98	"Chronic Health: ≤2 000
Dissolved Lead	µg Pb/L	0.04	0.07	0.04	Chronic Health: ≤10
Dissolved Magnesium	mg Mg/L	102	65	66	Not specified
Dissolved Manganese	µg Mn/L	4.39	**516.00**	**830.00**	"Chronic Health: ≤ 400 Aesthetic: ≤100
Dissolved Mercury	µg Hg/L	0.94	0.10	0.09	Chronic Health: ≤6
Dissolved Nickel	µg Ni/L	1.21	0.72	0.58	Chronic Health: ≤70
Dissolved Selenium	µg Se/L	5.28	1.67	1.55	Chronic Health: ≤40
Dissolved Uranium	µg U/L	8.53	10.90	10.90	Chronic Health: ≤30
Dissolved Zinc	µg Zn/L	7.38	23.00	17.80	Aesthetic: ≤5 000
Electrical Conductivity at 25°C	mS/m	**364**	**302**	**302**	Aesthetic: ≤170
Fluoride	mg F/L	**2.68**	**3.63**	**3.56**	Chronic Health: ≤1.5
Nitrate	mg N/L	**15.80**	2.83	3.38	Acute Health: ≤11
Nitrite	mg N/L	<0.01	0.03	0.08	Acute Health: ≤0.9
Combined Nitrate + Nitrite (sum of Ratios)*		**1.40**	0.29	0.40	Acute Health: ≤1
pH at 25°C	pH units	7.40	7.40	7.40	Operational: ≥5.0 ≤9.7
Potassium	mg K/L	11.00	7.92	7.92	Not specified
Sodium	mg Na/L	**504**	**498**	**498**	Aesthetic: ≤200
Sulphate	mg SO_4/L	**599**	**566**	**561**	Aesthetic: ≤250 "Acute Health: ≤ 500
Total Alkalinity	mg $CaCO_3$/L	251	288	287	Not specified
Total Dissolved Solids at 180°C	mg/L	**2 428**	**1 916**	**1 910**	Aesthetic: ≤1 200
Total Iron	µg Fe/L	422	243	**5 001**	Aesthetic: ≤300 "Chronic Health: ≤2 000
Dissolved Manganese	µg Mn/L	4.39	**516.00**	**830.00**	Aesthetic: ≤100 "Chronic Health: ≤400
Turbidity	NTU	**1.20**	0.80	**47.00**	"Operational: ≤1 Aesthetic: ≤5"
E.coli	counts/100mL	0	0	0	Acute Health: 0

Determinand	Units	KB-BH1	KB-BH2	KB-BH3	"SANS 241-1:2015 RECOMMENDED LIMITS & RISKS"
Faecal Coliforms	counts/100mL	0	0	0	Acute Health: 0
Total Coliforms	counts/100mL	0	0	3	Operational: ≤10

Exceeds health related SANS 241-2015 long-term drinking limits	**Exceeds non-health related SANS 241-2015 long-term drinking limits, i.e. aesthetic and operational limits**		
Values indicated with <-symbol are below the laboratory analytical method's detection limit		NS = Not Specified	ND = Not Determined

Table 4-7: Summary of groundwater corrosivity/scaling indicators of the tested water boreholes at Kamiebees

Index	KB_BH1	KB_BH2	KB_BH3	Tendency
Langelier Index	0.14	-0.05	-0.03	Negative = Corroding tendency Positive = Scaling tendency
Ryznar Index	7.1	7.5	7.5	< 6.5 = Scale-forming tendency > 6.5 = Corrosive tendency
Larson-Skold Index for Mild Steel	3.6	2.5	2.6	< 0.8 = non-corrosive 0.8 - 1.2 = slightly corrosive > 1.2 = highly corrosive - increasing with rates

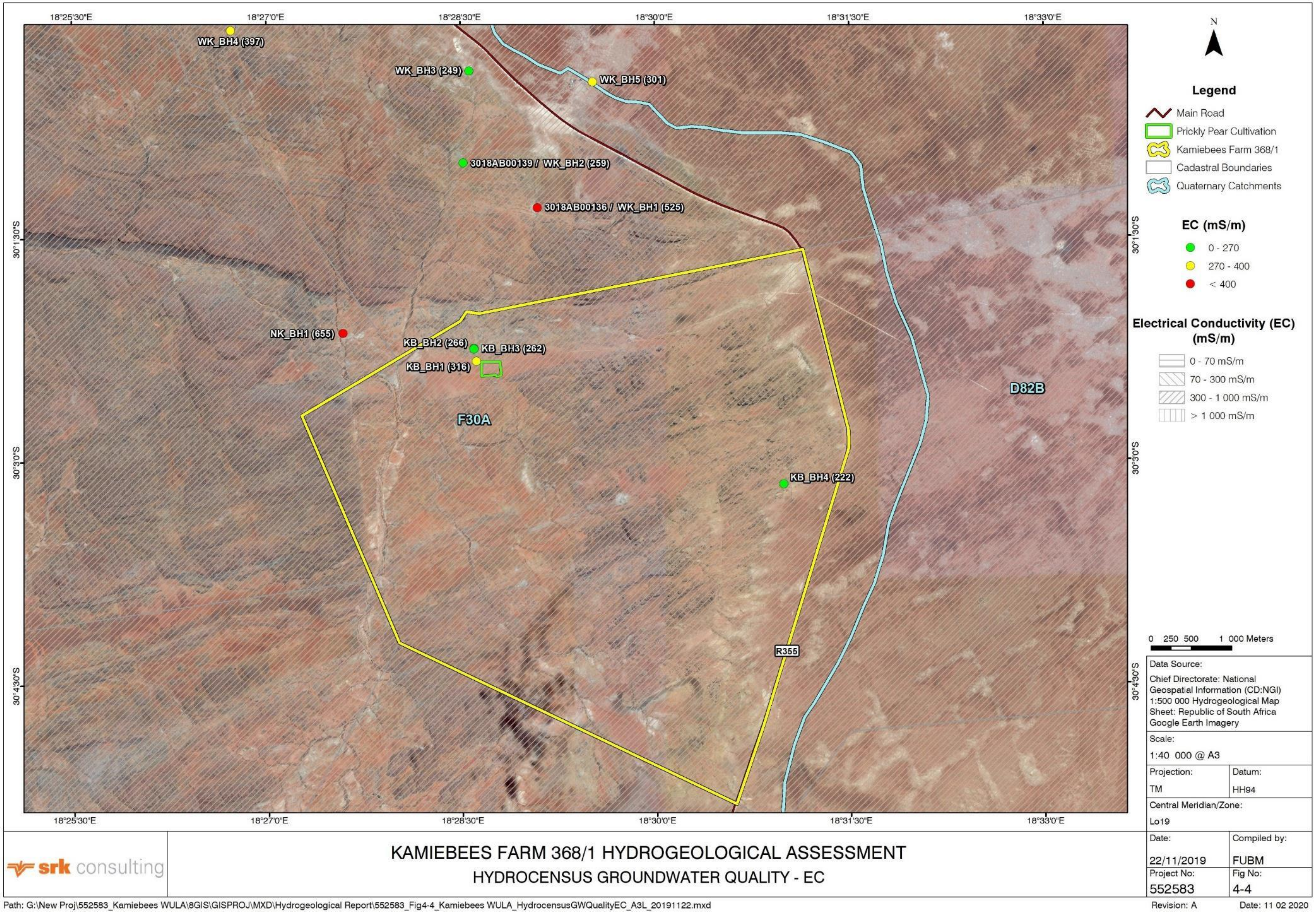


Figure 4-4: Hydrocensus groundwater quality as EC (mS/m)

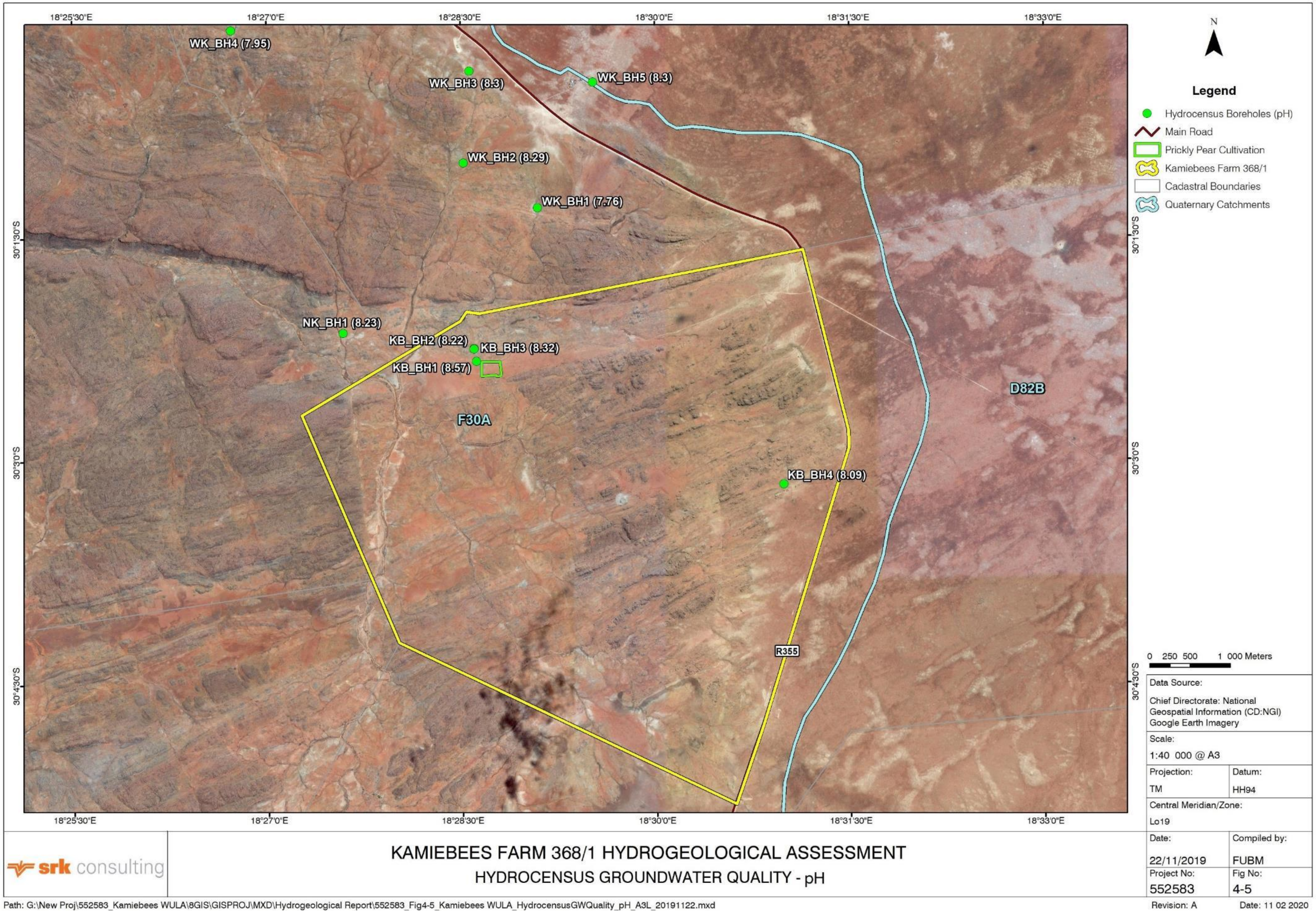


Figure 4-5: Hydrocensus groundwater quality as pH

4.7 Groundwater Recharge

The F30A quaternary catchment has a low mean annual potential recharge of 0.16 mm/a (DWAF, 2005), which equates to 0.1% of the mean annual precipitation (MAP). The total recharge of the catchment according to the DWS' EWR report (DWS, 2016) is *c*.1.24 million kilolitres per annum (MKL/a), which equates to a mean recharge potential of 0.64 mm/a, or 6.4 KL/ha/a.

4.8 Groundwater Modelling

Groundwater modelling was not deemed necessary due to the low yielding nature of the boreholes under consideration and the low groundwater demand of the applicant.

4.9 Groundwater Availability Assessment

Data (Table 4-8) supporting the Groundwater availability assessment was sourced from:

- The DWAF (2005) GRA-2 dataset; and
- The DWS (2016) Groundwater EWR report.

The site is located in Quaternary Catchment F30A, which is *c.*43% dependent on groundwater. This catchment receives a relatively low mean annual precipitation of 162 mm/a (DWS, 2016) with a mean groundwater recharge of 1.24 MKL/a, or *c*.6.4 KL/ha/a (DWAF, 2016), which equates to a mean recharge of *c*.19 300 KL/a for the 3 012 ha Kamiebees Farm. The Drought Index is low at 3.84 years and groundwater baseflow contribution is zero (DWAF, 2005). The potential groundwater stored in the catchment's aquifers is *c*.91 872 MKL, or 471 KL/ha. Based on this storage potential, likely storage of the aquifers at the 3 012 ha Kamiebees Farm is *c*.1 418 650 KL

The catchment does not have any associated ecological water requirements but reserves 0.0026 MKL for Basic Human Needs (BHN) and 0.0026 MKL as a groundwater reserve. The catchment has a reported 0.696 MKL/a allocatable groundwater (DWS, 2016). The catchment's General Authorisation (GA) volume for taking groundwater is listed as 0 KL/hectare/annum (DWS, 2016).

The catchment is predominantly dependent on groundwater. Domestic use and small-scale livestock watering do not require licensing or registration as they are listed as a Schedule 1 authorisation. However, higher volume water use such as prickly pear irrigation, as proposed by the SJR Boerdery requires a WUL. The current groundwater abstraction at the Kamiebees Farm is *c.*5 000 KL/a, sourced from the three boreholes equipped with windpumps. This volume is used to irrigate 10 ha's of Prickly Pear crop, comprising of 3 ha mature crop and 7 ha of crop that will mature within two to three years. The 10 ha of mature crop will consume *c.*9 300 KL/a. The Kamiebees Farm is proposing to expand their Prickly Pear plot by a further 10 ha in about six to eight years', enquiring authorisation to abstract a maximum of 18 800 KL/a from the three boreholes. The recommended maximum safe tested yield for the three Kamiebees Farm boreholes h is 28 382 KL/a, which equates to *c.2*% of the farm's potential aquifer storage. This requested volume is significantly lower than the recommended maximum safe yield (i.e. *c.*10 000 KL/a lower) of the three boreholes.

The groundwater information published for F30A by the DWAF (2005) and the DWS (2016) is summarised in Table 4-8.

The Hydrogeological Map Series of The Republic of South Africa (DWAF, 2002), indicates that the site falls within an area zoned as b2, with the median borehole yield (excluding dry boreholes) of the fractured-rock aquifers listed as 0.1 – 0.5 L/s (Figure 5-3)The catchment is predominantly dependent on groundwater. Domestic use and small-scale livestock watering do not require licensing or registration as it is listed as a Schedule 1 authorisation. However, higher volume water use such as prickly pear irrigation, as proposed by the SJR Boerdery requires a WUL. The recommended maximum safe yield for the three Kamiebees Farm boreholes is quantified as 28 382 KL/a, which equates to *c.2%* of the farm's potential aquifer storage. Current combined abstraction at the three boreholes is estimated at *c*.5 100 KL/a. This equates to *c*.26% of the mean potential recharge to the farm's aquifers, or *c*.0.36% of the groundwater potentially stored in the farm's aquifers.

The groundwater information published for F30A by the DWAF (2005) and the DWS (2016) is summarised in Table 4-8.

Table 4-8: Summary of groundwater information for Quaternary Catchment F30A

Information Piece	Unit	Amount
Extent	ha	165 320
Potential Aquifer Storage	KL/catchment	91 871 900
	KL/ha	471
Mean Recharge to Groundwater	M KL/a	1.24
	KL/ha/a	2
Drought Index5	Years	3.84
Mean Groundwater River Baseflow Contribution	KL/a	0
Estimated Groundwater Abstraction (2003)	KL /a	241 247
Utilisable Groundwater Exploitation Potential	KL /a	1 068 185
Harvest Potential (Vegter, 1995)	KL /a	10 251 600
Catchment groundwater dependency (DWS, 2016)	%	43.41
Allocable groundwater (DWS, 2016)	M KL /a	0.696
Groundwater reserve (DWS, 2016)	M KL /a	0.0026
Mean Annual Precipitation (MAP)	mm	162

[5] The Drought Index or Di is used to assess the number of years required to bridge cycles of negligible or no aquifer recharge from rainfall, where groundwater abstracted will almost entirely be removed from aquifer storage.

5 Prevailing Groundwater Conditions

5.1 Geology

The quaternary catchment F30A is classified as part of the Namaqualand East Groundwater Resource Unit (GRU). The Namaqualand East is underlain by rocks of the Nama and Vanrhynsdorp Groups, which is characterised as Metamorphic Terrane. The Namaqualand East typically contains Mokolian metasediments and metavolcanics consisting of gneisses, schists, amphibolite, metaquartzite, andesite, quartz porphyry, Intrusive granites, granodiorite, tonalite, mafic and ultramafic's. In addition, tertiary and quaternary fluvial and coastal deposits are often present (Department of Water and Sanitation, 2016).

The Kamiebees Farm is primarily underlain by Lekkerdrink Gneiss of the Little Namaqualand Suite and Grey Migmatitic Biotite Gneiss of the Kamiesberg Group. The southern section of the farm is underlain by Burtons Puts Granite, which form part of the younger Spektakel Suite (Council of Geoscience, 2010). A brief description of the site geology is presented in Table 5-1 and a representation of the geology is displayed in Figure 5-1.

Table 5-1: Stratigraphy and lithology of the area surrounding the site

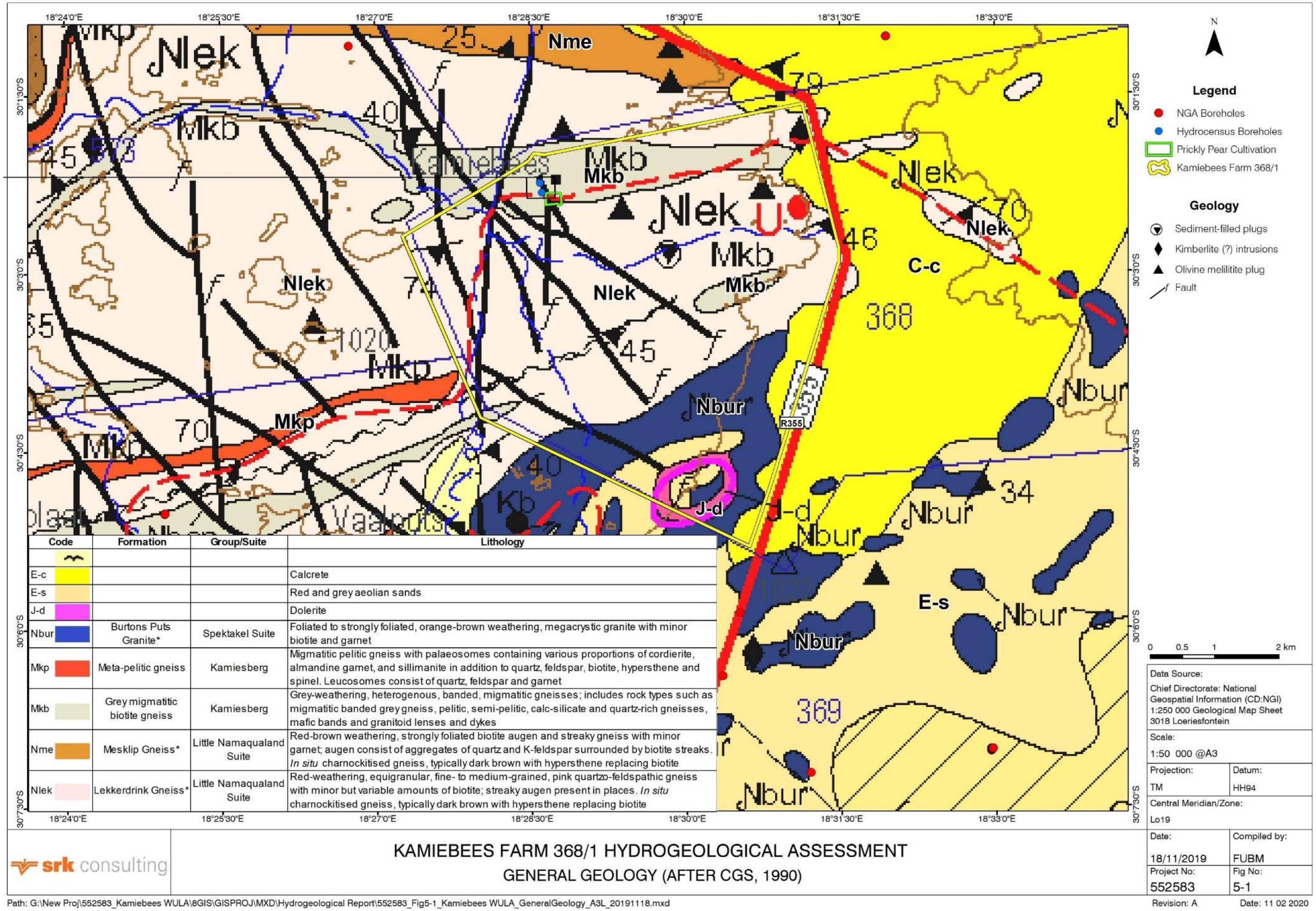
Map Code	Formation/ Intrusive	Group/ Suite	Lithology
Nbur	Burtons Puts Granite	Spektakel Suite	Foliated to strongly foliated, orange-brown weathering, megacrystic granite with minor biotite and garnet.
Mkp	Grey migmatitic biotite gneiss	Kamiesberg Group	Grey-weathering, heterogenous, banded, migmatitic gneisses: includes rocks types such as migmatitic banded grey gneiss, semi-pelitic, calc-silicate and quartz-rich gneisses, mafic bands and granitoid lenses and dykes.
Nlek	Lekkerdrink Gneiss	Little Namaqualand Suite	Red-brown weathering, strongly foliated biotite augen and streaky gneiss with minor garnet, augen consist of aggregates of quartz and K-feldspar surrounded by biotite streaks. In-situ charnockitised gneiss typically brown with hypersthene replacing biotite.

Note: Source – 1:250 000 Geological Series Sheet 3018 Loeriesfontein.

Several northwest-southeast striking faults have been mapped at the middle and western parts of Kamiebees Farm (Figure 5-1). The three targeted boreholes are all located on a single fault line, which intercepts the grey migmatitic biotite gneiss Formation.

5.2 Acid Generation Capacity

Not applicable to this investigation and proposed development.



Code	Formation	Group/Suite	Lithology
E-c			Calcrete
E-s			Red and grey aeolian sands
J-d			Dolerite
Nbur	Burtons Puts Granite*	Spektakel Suite	Foliated to strongly foliated, orange-brown weathering, megacrystic granite with minor biotite and garnet
Mkp	Meta-pelitic gneiss	Kamiesberg	Migmatitic pelitic gneiss with palaeosomes containing various proportions of cordierite, almandine garnet, and sillimanite in addition to quartz, feldspar, biotite, hypersthene and spinel. Leucosomes consist of quartz, feldspar and garnet
Mkb	Grey migmatitic biotite gneiss	Kamiesberg	Grey-weathering, heterogenous, banded, migmatitic gneisses; includes rock types such as migmatitic banded grey gneiss, pelitic, semi-pelitic, calc-silicate and quartz-rich gneisses, mafic bands and granitoid lenses and dykes
Nme	Mesklip Gneiss*	Little Namaqualand Suite	Red-brown weathering, strongly foliated biotite augen and streaky gneiss with minor garnet; augen consist of aggregates of quartz and K-feldspar surrounded by biotite streaks. *In situ* charnockitised gneiss, typically dark brown with hypersthene replacing biotite
Nlek	Lekkerdrink Gneiss*	Little Namaqualand Suite	Red-weathering, equigranular, fine- to medium-grained, pink quartzo-feldspathic gneiss with minor but variable amounts of biotite; streaky augen present in places. *In situ* charnockitised gneiss, typically dark brown with hypersthene replacing biotite

Figure 5-1: General geology

5.3 Hydrogeology

5.3.1 Aquifers

Regionally, the Namaqualand East GRU is underlain by rocks of the Nama and Vanrhynsdorp Groups. Typically, the aquifers in this region are fractured and weathered in nature. Locally, the Kamiebees Farm is underlain by gneiss, which forms part of the Little Namaqualand Suite. The gneiss is predominantly poorly fractured, hence its aquifer forming capacity is limited. Therefore, very little, groundwater is found in this fractured-rock aquifer and the main source of groundwater in the area is limited to a few narrow, linear fractures or fault zones. Boreholes drilled away from these fractured zones, or on the up-dip side of them, are normally dry, or very low yielding.

The Kamiebees Farm has numerous faults (Nuwerus lineaments) in the northwestern portion of the site (Figure 5-2). The three existing/ targeted and tested boreholes (KB-BH1, KB-BH2 and KB-BH3) are all located on a single, narrow, north-nortwest striking fault zone. Shallow groundwater levels are present in these boreholes with depths ranging from c.10 - 12 mbgl. To date, low volumes of c.0.053 L/s water were pumped from this fault via the use of wind driven pumps (windpumps). Aquifer testing conducted on these boreholes presents low recommended safe yields ranging between 0.2 and 0.4 L/s (subsection 4.5).

Water boreholes (WK-BH1, WK-BH2, WK-BH3, WK-BH4) used for livestock watering on the neighbouring Wolfkraal Farm, are all located on different and separate linear features to the north of the Kamiebees Farm. There boreholes are up-gradient of the Kamiebees Farm and the majority are relatively shallow in depth (>70 mbgl). These boreholes are separated by solid geological formations from the Kamiebees Farm, which implies that it is unlikely that the pumping from the Kamiebees Farm could have any effect on boreholes and groundwater abstraction at Wolfkraal. It is predicted that the current severe drought experienced in the region would be the main impact driver on declining groundwater levels and boreholes pumping dry. In addition, it is evident that all borehole yields are dependent on mean groundwater recharge, which, together with a drought index of 3.84 years, is a meagre 0.16 mm/a for catchment F30A.

5.3.2 Unsaturated Zone

Water levels taken during aquifer testing indicated that groundwater levels range between 10 – 13 mbgl on the Kamiebees Farm, implying that the unsaturated zone is *c.*10 m thick. No additional water level data could be collected from neighbouring farms, as all boreholes are being equipped with windpumps preventing access. However, based on verbal communication with the owner, Mr Karel Louw, who stated that water levels range between 18 – 60 mbgl, implying that the unsaturated zone on the higher lying Wolfkraal Farm ranges between 18 – 60 mbgl.

5.3.3 Saturated Zone

The saturated zone for the Kamiebees Farm ranges between 10 – 54 mbgl, whereas the saturated zone from the Wolfkraal Farm ranges between 18 – 60 mbgl.

5.3.4 Hydraulic Conductivity

The hydraulic conductivity (K) is based on the transmissivity (T) values calculated from analysis of borehole pump test data by dividing T (m^2/d) by the saturation thickness (m), as well as using published values for similar aquifer types. The derived K values are summarised as follows:

- K for fractured granite and gneiss: 43 to 2.2×10^{-4} m/d (Freeze and Cherry, 1979);
- K for unfractured granite and gneiss: 6.5×10^{-5} to 8.6×10^{-10} m/d (Freeze and Cherry, 1979);

- K fractured-rock aquifers of F30A: 0.09 m/d (based on DWAF, 2005 GRA-2 data and the average T values from the aquifer tests. Transmissivity polygon for the 17.5 m^2/d, i.e. 17.5 m^2/d divided by GRA2 aquifer thickness of 188 m);
- K fractured-rock aquifer at KB-BH1: *c.*0.16 m/d (based on dividing the average pumping test derived T-value of *c.*6.67 m^2/d by the *c*.41.6 m saturation depth of the borehole, i.e. 6.67÷41.6);
- K fractured-rock aquifer at KB-BH2: *c*.2.55 m/d (based on dividing the average pumping test derived T-value of c.17.5 m^2/d by the c.6.8 m saturation depth of the borehole, i.e. 17.5÷6.8); and
- K fractured-rock aquifer at KB-BH3: *c*.0.97 m/d (based on dividing the average pumping test derived T-value of c.18.8 m^2/d by the *c.*19.4 m saturation depth of the borehole, i.e. 18.8÷19.4).

Aquifer parameters, derived from yield testing at boreholes KB-BH1, KB-BH2 and KB-BH3 indicate T values between 6.67 and 18.81 m^2/d.

A specific yield (S_y) of 0.0059 and storativity of 0.000049 is reported in the GRA-2 (DWAF, 2005) for the fractured-rock aquifers of F30A. Various pumping test data analysis methods yielded S_y values as follows:

- KB-BH1 range from 0.00020 to 0.00044, with an average of 0.00028;
- KB-BH2 range from 0.00017 to 0.00044, with an average of 0.00019; and
- KB-BH3 range from 0.00017 to 0.00044, with an average of 0.00018.

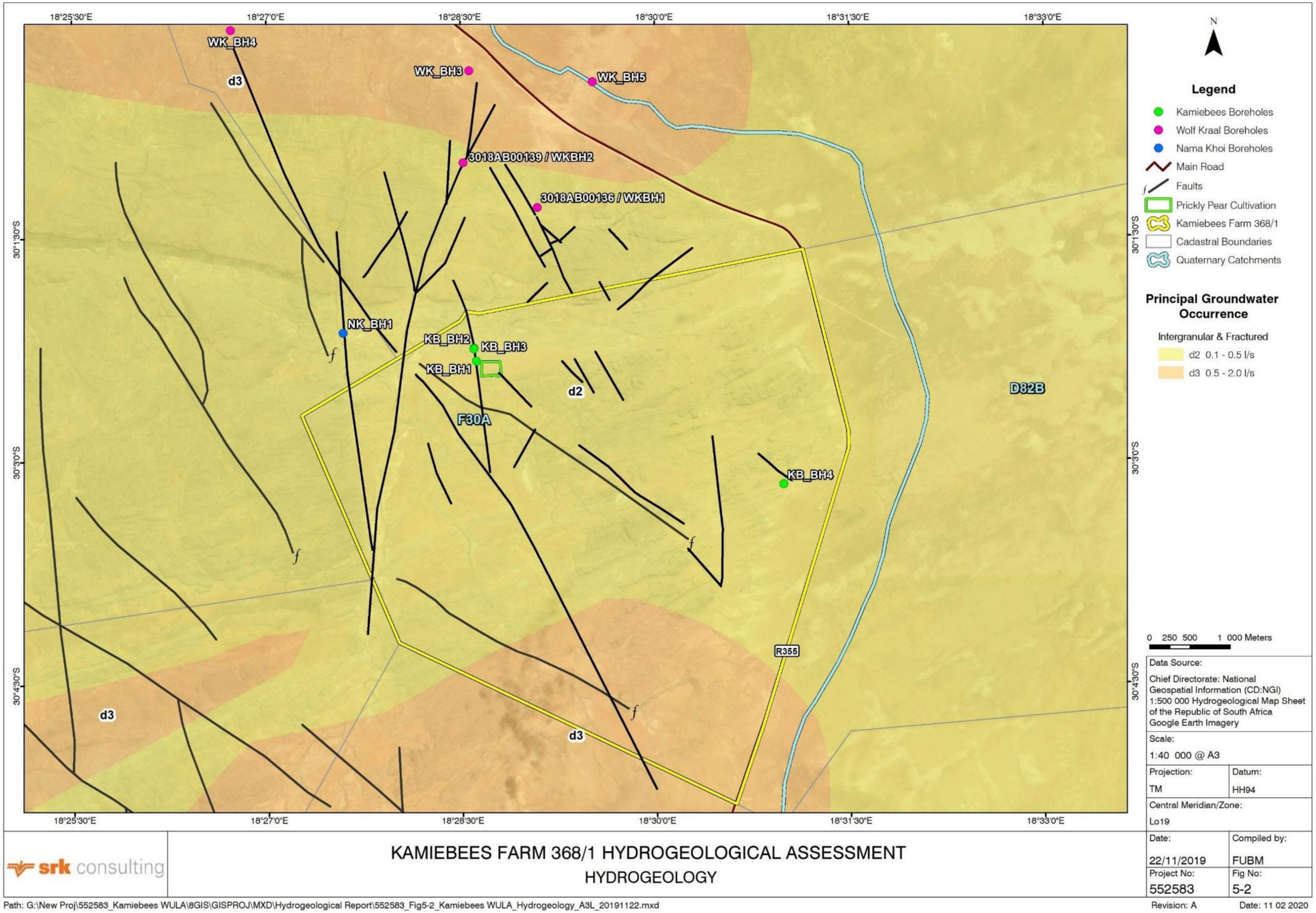


Figure 5-2: Hydrogeology

5.4 Groundwater Levels

Water levels derived from the aquifer tests indicate that groundwater levels range between 10 – 13 mbgl on the Kamiebees Farm. The neighbouring Nama-Khoi Municipal abandoned borehole (number?) displays a water level of 8.53 mbgl, no water levels could be taken on the Wolfkraal Farm, as all boreholes were equipped with windpumps preventing access. The Wolfkraal Farm owner (Mr Karel Louw), however, communicated that water levels range between 18 – 60 mbgl. These water levels vastly vary, and the reliability of this information is uncertain.

The groundwater flow at the site and its surrounds is inferred to be in a westerly direction (Figure 5-3) and regionally north-westwards towards the Buffelsrivier.

5.5 Groundwater Potential Contaminants

Groundwater abstraction for this application does not introduce any contaminants into the hydrogeological system, thus groundwater potential contamination is not applicable. Furthermore, naturally high Total Dissolved Solids (TDS) concentrations are evident due to the groundwater contact with the existing geology.

5.6 Groundwater Quality

No previous groundwater quality data was sourced directly from the Kamiebees Farm 368/1; therefore, water quality was inferred by secondary sources. According to the Groundwater EWR Report (Department of Water and Sanitation, 2016), water quality values of the Median +10% are summarised the Table 5-2. It is evident that all groundwater quality parameters are within the SANS 241-1:2015 Drinking Water Standards, which confirms that the F30A quaternary catchment is of a better water quality class than most of the surrounding Namaqualand quaternary catchments as 79% of groundwater is potable (Department of Water and Sanitation, 2016).

Table 5-2: Summary of groundwater quality values of the F30A quaternary catchment

Constituent	Unit	Value	SANS 241-1:2015 Recommended Limits & Risks"
Ca	mg/l	69.85	Not specified
Mg	mg/l	366.74	Not specified
Na	mg/l	43.07	Aesthetic ≤200
Cl	mg/l	159.72	≤300
SO_4	mg/l	94.38	Acute Health ≤500
pH	mg/l	8.27	pH operational ≥5.0 ≤ 9.7

Note: Source – Department of Water and Sanitation, 2016 – Groundwater EWR Report

EC (salinity) values at the site and its surrounds range between 300 and 1 000 mS/m, according to the hydrogeological map (DWAF, 2000). These are high values for EC and exceed the SANS 241-1 2015 Drinking Limits of 1 200 mg/l (aesthetic). Besides being unpalatable, using groundwater for livestock watering and prickly pear irrigation will not result in negative impacts. Locally, the EC values in the study area tend to increase from the 161 - 655 mS/m. No spatial trend is evident from the measured EC values from the hydrocensus boreholes.

The pH values over the study area range between 7.76 and 8.57 and remain fairly constant throughout the study area. This indicates that groundwater in the study area is neutral to alkaline in nature.

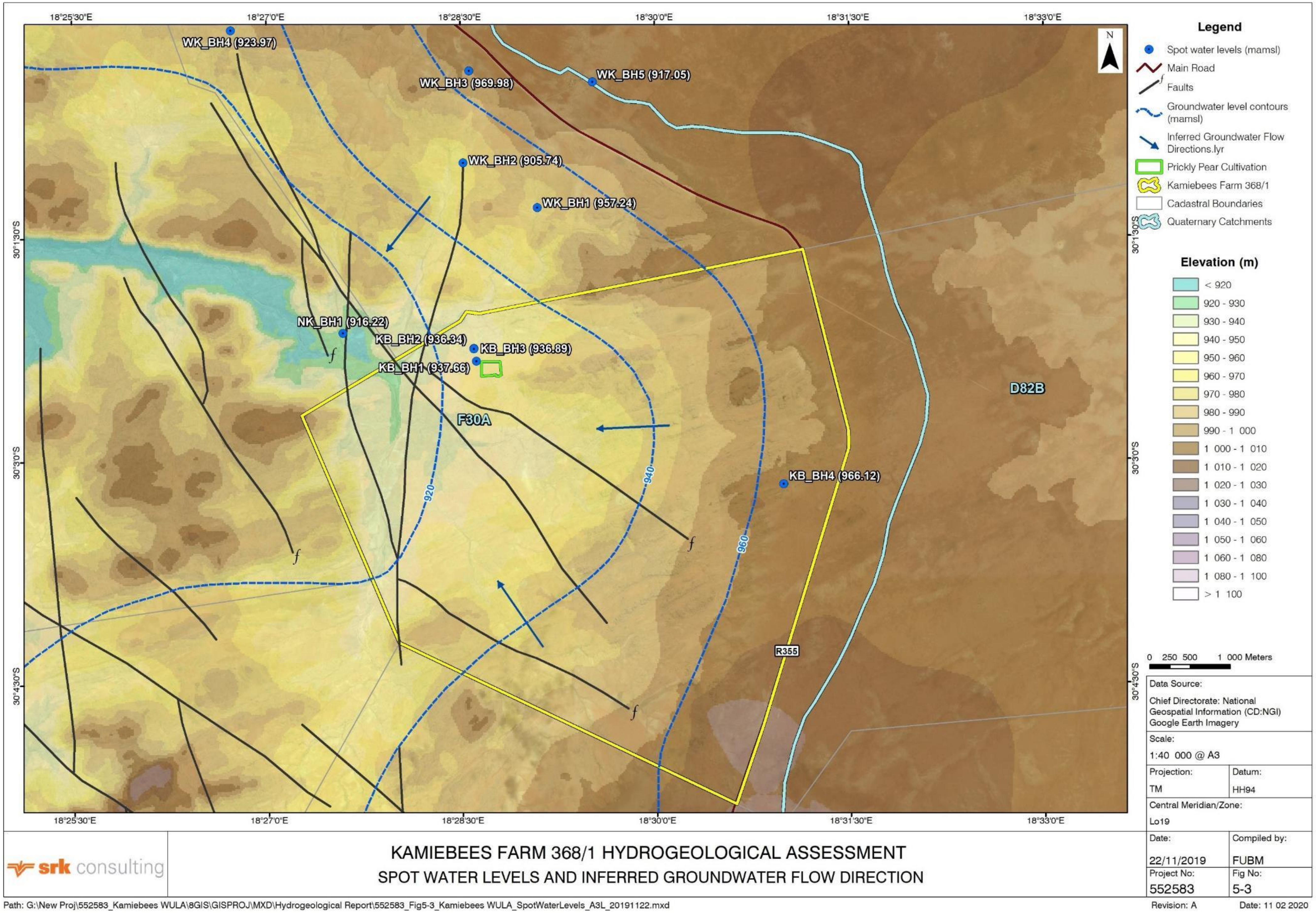


Figure 5-3: Spot water levels and inferred regional groundwater flow direction

6 Aquifer Characterisation

6.1 Groundwater Vulnerability

Groundwater vulnerability was considered in terms of the 'DRASTIC' method of assessment of the intrinsic vulnerability of an aquifer to contamination from the surface (Aller *et. al*., 1987) and is shown in Figure 6-1. The method considers the following factors, which control the vulnerability of an aquifer to contamination from surface:

- Depth to water table (D)
- Recharge (R)
- Aquifer material (A)
- Soils (S)
- Topography and slope (T)
- Impact of the vadose (unsaturated) zone (I)
- Hydraulic conductivity (C)

Aquifer vulnerability is defined as the likelihood for contamination to reach a specified position in the groundwater system after being introduced at some point above the uppermost aquifer.

According the DWAF's aquifer vulnerability map (DWAF, 2013), the site's vulnerability rating is 'Low' to 'Medium' (Figure 6-1). The area where the three water boreholes are located is rated 'Low'.

6.2 Aquifer Classification

An aquifer classification system provides a framework and objective basis for identifying and setting appropriate levels of ground water resource protection. This facilitates the adoption of a policy of differentiated ground water protection.

Other uses include:

- Defining levels of investigation required for decision making;
- Setting of monitoring requirements; and
- Allocation of manpower resources for contamination control functions.

The aquifer classification system used to classify the aquifers is the proposed South African Aquifer System Management Classification of Parsons (1995). This system has a certain amount of flexibility and can be linked to secondary classifications, such as a vulnerability or usage classification. Parsons suggests that aquifer classification forms a very useful planning tool that can be used to guide the management of ground water. Parsons also suggests that some level of flexibility should be incorporated when using such a classification system.

The South African Aquifer System Management Classification (Parsons, 1995) is presented by five major classes[6]:

- Sole Source Aquifer System;
- Major Aquifer System;
- Minor Aquifer System;
- Non-Aquifer System; and
- Special Aquifer System.

The DWS Aquifer Classification Map of South Africa (DWS, 2012) presents three classes of aquifers, namely:

[6] Definitions are provided in the report glossary

- Poor;
- Minor; and
- Major.

The aquifer in the site area is classified as a 'Poor' aquifer system (Figure 6-2), according to the DWS classification system (DWS, 2012).

A second variable classification is needed for sound decision making, as the ability of an aquifer to yield water to a user is not adequately stated. In this case it was decided to use the aquifer vulnerability to contamination (as described below) as a second parameter. A weighting and rating approach is then used to decide on the appropriate level of ground water protection (Table 6-1).

Table 6-1: Ratings for the aquifer quality management classification system

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

6.3 Aquifer Protection Classification

After rating the aquifer system management and the aquifer vulnerability, the ratings are added to obtain a Groundwater Quality Management (GQM) index (Table 6-2).

Table 6-2: Appropriate level of groundwater protection required

GQM Index	Level of Protection
<1	Limited Protection
1 – 3	Low Level Protection
4 – 6	Medium Level Protection
7 – 10	High Level Protection
>10	Strictly Non-degradation

Based on the above, the aquifers in the Study Area are classified for protection as follows (Table 6-3):

Table 6-3: Site aquifer classification and vulnerability assessment

Description	Aquifer	Vulnerability	Rating	Protection Level
Fractured Aquifer	Minor (2)	Low (1)	3	Low Level Protection

The above classification implies that the fractured aquifer at the site requires a low level of protection, which will primarily include conservative abstraction to limit drawdown as recommended in Section 4.5, as well as monitoring of the abstraction boreholes (KB-BH1, KB-BH2 and KB-BH3).

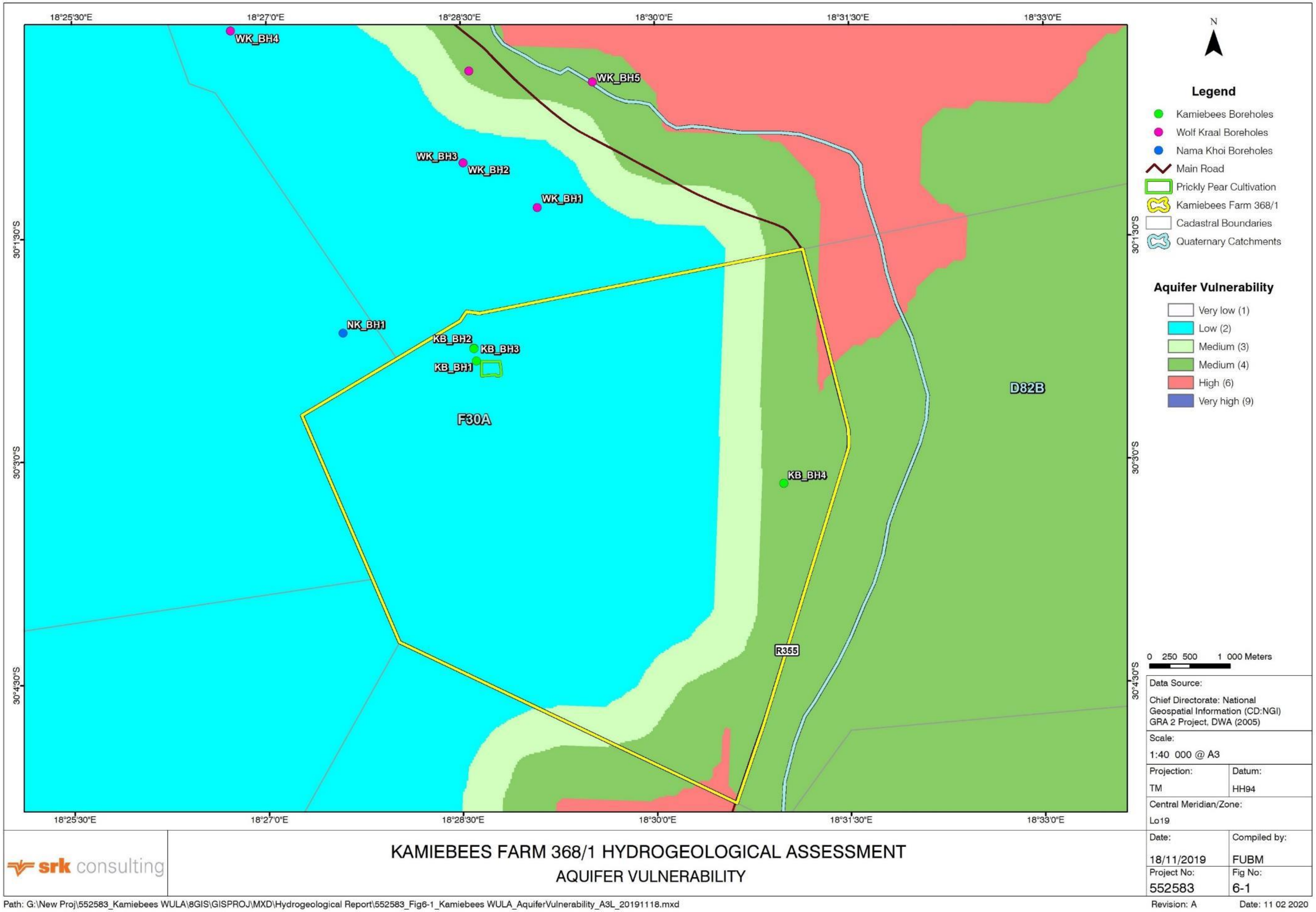


Figure 6-1: Aquifer vulnerability

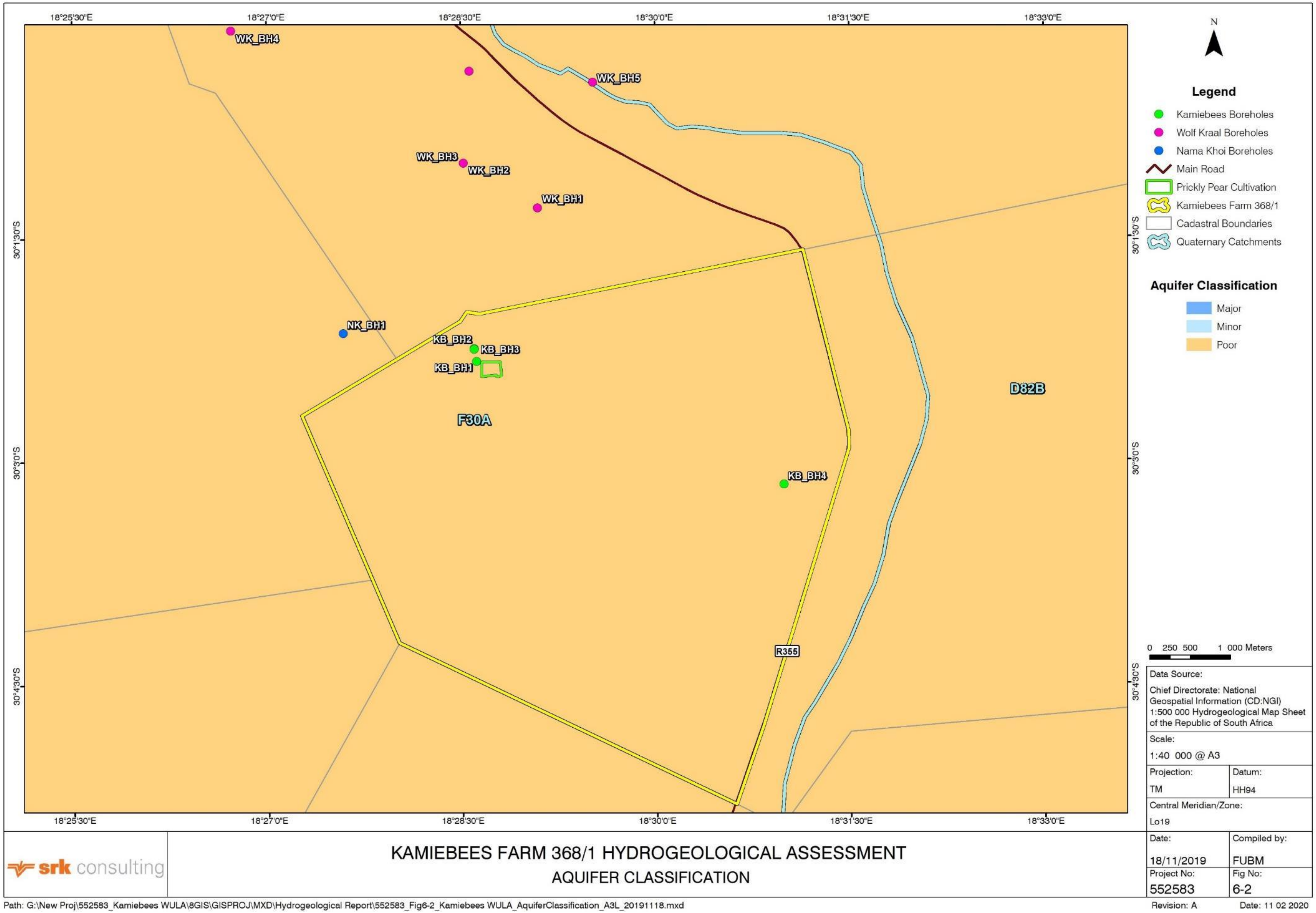


Figure 6-2: Aquifer classification

7 Groundwater Modelling

Groundwater modelling was not deemed necessary due to the low yielding nature of the site's water boreholes and the low groundwater volume applied for licensing.

8 Assessment of Potential Geohydrological Impacts

This section asses the significance of potential hydrogeological impacts. Practicable mitigation and optimisation measures are recommended, and impacts are rated both without and with the assumed effective implementation of mitigation and optimisation measures. Mitigation and optimisation measures are either:

Essential: measures that must be implemented and are non-negotiable; and

Best Practice: recommended to comply with best practice, with adoption dependent on the proponent's risk profile and commitment to adhere to best practice, and which must be shown to have been considered and sound reasons provided by the applicant if not implemented.

The assessment methodology used to rank and weight these impacts are presented in Appendix D.

8.1 Construction Phase

Not applicable for this study

8.2 Operational Phase

8.2.1 Impacts on Groundwater Quantity

The only concern that have been identified that could potentially impact the groundwater quantity is exceeding 77.8 KL/d (28 400 KL/a) of groundwater from the site's three boreholes resulting in drawdown in the local fractured-rock aquifer and which could risk the boreholes running temporarily dry.

Abstraction from boreholes normally results in a water level decline in the abstraction borehole and local surrounding area. As these three boreholes (KB-BH1, KB-BH2 and KB-BH3) are located on a single fault zone, this presents a higher impact should over abstraction and mutual interference occur. For example, boreholes KB-BH2 and KB-BH3, which have fairly shallow depths of 17.3 and 30.2 mbgl, respectively, might run dry should the groundwater table drops to these depths. The extent of the drawdown is dependent on the aquifer's hydraulic conductivity, storage and recharge. Due to the low hydraulic conductivity, the zone of drawdown at the site is likely to be limited and extending along the fault zone in a southeast-northwest direction. As the yield recommended for these boreholes are much lower than the maximum pump yields obtained during the step tests and CDT, coupled with the observed limited drawdown during testing, a reported drought index of *c.*3.84 years (8 years were conservatively allowed in the tests analysis) and very high aquifer storage potential, the significance of impact of abstraction is expected to be **low**.

Best practise to reduce impact is to apply a 12 hour a day pumping schedule at a rate of 0.8 L/s for KB-BH1; 0.4 L/s for KB-BH2 and 0.6 L/s for KB-BH3. This will allow the borehole sufficient time (12 h/d) to recover after each day's abstraction schedule. Such reduced pumping hours will allow the water level to recover and will reduce the significance of the impact to **very low**. See impact rating in Table 8-1 and the impact assessment methodology in Appendix D.

Table 8-1: Impact rating assessment groundwater quantity – Operational Phase

<table>
<tr><th>Mitigation</th><th>Impact no.</th><th>Extent</th><th>Intensity</th><th>Duration</th><th>Consequence</th><th>Probability</th><th>Significance</th><th>Status</th><th>Confidence</th></tr>
<tr><td>Without</td><td>1</td><td>Local
1</td><td>Low
1</td><td>Long-term
3</td><td>Low
5</td><td>Possible</td><td>LOW</td><td>–</td><td>High</td></tr>
<tr><td colspan="10">Essential mitigation measures:
• Limit abstraction to ≤77.8 KL/d
• If solar or electrical submersible pumps are used, instal a low-level cut-off switch to prevent the water level from dropping below 45 mbgl; 13.5 mbgl and 25 mbgl for boreholes KB-BH1, KB-BH2 and KB-BH3, respectively.
• Implement and adhere to water saving procedures and methodologies, e.g. drip irrigation, covering reservoir to reduce evaporation, etc.
Best practice measures:
• Abstract groundwater volumes necessary for the proposed activity, i.e.c.18 700 KL/a or c.51 KL/d;
• Limit abstraction to 12 hours per day, or shorter to allow the borehole sufficient time to recover daily. Alternatively, use solar or windpumps.
• Abstract the required groundwater volume over 12-hour period per day based on the following rates:
o KB_BH1: 0.26 L/s;
o KB_BH2: 0.13 L/s; and
o KB_BH3: 0.20 L/s
• Implement a groundwater monitoring system to monitor groundwater quality, volumes abstracted and water levels.
Natural mitigation:
• Very low groundwater abstraction, regular recharge (drought index of 3.8 years) and storage potential of the aquifers naturally mitigate the negative effects of abstraction on the aquifers of this area.</td></tr>
<tr><td>With</td><td>1</td><td>Local
1</td><td>Low
1</td><td>Long-term
3</td><td>Low
5</td><td>Improbable</td><td>VERY LOW</td><td>–</td><td>High</td></tr>
</table>

8.2.2 Impacts on Groundwater Quality

No impacts on groundwater quality were identified.

8.2.3 Groundwater Management

The following groundwater management measures are recommended:

- To prevent groundwater over-abstraction and damage to the pumps if solar or electrical submersible pumps are used, install a low-level pump cut-off switch at 45 mbgl; 13.5 mbgl and 25 mbgl for boreholes KB-BH1, KB-BH2 and KB-BH3, respectively.;
- Limit abstraction form the three water boreholes not to exceed the daily pumping rates recommended in Table 4-5;
- Initiate a groundwater monitoring programme for the three targeted boreholes, as follows:
  - The water level and volumes abstracted must be recorded on at least a monthly basis. Best results are obtained if automatic flow meters and water level recorders set to take hourly readings are installed;
  - Water samples should be collected at the water borehole on a six-monthly basis and submitted to SANAS accredited laboratories for water quality analysis as per the SANS 241:2015 guidelines; and
  - A SACNASP registered hydrogeologist should evaluate the monitoring data on an annual basis and compile a monitoring report for submission to the regulatory authority.
- Implement all the essential mitigation measures included in Table 8-1.

8.3 Decommissioning Phase

Not applicable.

8.4 Post-Operational Phase

Not applicable.

9 Groundwater Monitoring System

9.1 Introduction

A groundwater monitoring plan should be implemented as soon as possible to identify trends in water level and water quality behaviour in the aquifers during operation. As the proposed activity does not introduce any contamination, only groundwater level and abstraction rates should be monitored on a monthly basis for the duration of the activity, whereas groundwater quality may be measured on a bi-annual (at least annual) basis. This information will inform the ongoing implementation and development of a water management strategy and management of impacts within the site area and water boreholes.

The results of monitoring, and any changes to the water management strategies, must be reported to management and DWS as per the WUL for specific items, and a detailed monitoring report submitted to the DWS on an annual basis. The report serves to notify DWS of areas of reduction in water supply and the actions implemented, in progress or planned to address the identified impacts including source identification and control.

Water quality and quantity data is assessed against the baseline data (i.e. data contained in this report) and subjected to trend analysis. Should a reduction in water supply be detected, the applicant will notify the Regional Director of DWS as soon as it is practicable.

9.2 Groundwater Monitoring Network

9.2.1 Source Plume, Impact and Background Monitoring

Not applicable as the proposed activity does not introduce contaminants into the hydrogeological system

9.2.2 System Response Monitoring Network

Not applicable as the proposed activity does not introduce contaminants into the hydrogeological system

9.2.3 Monitoring Frequency

- Water level and abstraction monitoring frequency should be monthly unless the monitoring results indicated that a change in frequency is required;
- Monitoring must commence as soon as possible;
- Water levels in the borehole should be measured on a monthly, preferably weekly basis. Best practise is to install an automatic recorder (logger) in the borehole to measure the water level, temperature and electrical conductivity (salinity) hourly; and
- Water quality should be measured on a bi-annual basis (at least annually), to ensure that the water quality is fit for purpose and not deteriorating.

9.3 Monitoring Parameters

The following parameters should be included in the monitoring programme at each water borehole:

- Water level depth (metres below collar), total volumes abstracted to date (KL or m^3), pumping rate (KL/h) and pumping schedules (h/day); and

- Key parameters for the water quality analysis include pH, EC, TDS, macro-chemistry (Na, Mg, K, Ca, NH_4, Cl, SO_4, total alkalinity, PO_4, F, NO_3) and microbiology if used for human consumption.

It is advisable that the following parameters are monitored to determine if the water is suitable for irrigation, livestock watering and human consumption: COD, TOC, SAR and trace-metals (Fe, Mn, Al, Se, Cu, Pb, Zn, Cd, As, Sb).

9.4 Monitoring Boreholes

No suitable boreholes were identified. Monitoring of the three water supply boreholes will suffice for purpose of this WULA.

10 Groundwater Environmental Management Programme

10.1 Current Groundwater Conditions

These are summarised in the Sections above.

10.2 Predicted Impacts of Facility

The impacts are assessed above (Section 8) as Low to Very Low.

10.3 Mitigation Measures

10.3.1 Lowering of Groundwater Levels during Operation

The following mitigation measures are recommended:

- Maintain conservative abstraction rates recommended in Table 4-5;
- If solar or electrical submersible pumps are used, install a low-level cut-off switch to prevent water level from dropping below 45 mbgl; 13.5 mbgl and 25 mbgl for boreholes KB-BH1, KB-BH2 and KB-BH3 respectively; and
- Implement and adhere to water saving procedures and methodologies.

10.3.2 Rise of Groundwater Levels Post-Facility Operation

Not applicable to this application as the proposed activity does not introduce additional recharge or change hydraulic properties which could potentially facilitate a rise in groundwater levels.

10.3.3 Spread of Groundwater Pollution Post-Facility Operation

Not applicable to this application as the proposed activity does not introduce contaminants into the hydrogeological system Post Closure Management Plan

10.4 Remediation of Physical Activity

Not applicable to this application.

10.5 Remediation of Storage Facilities

Not applicable to this application.

10.6 Remediation of Environmental Impacts

Not applicable to this application.

10.7 Remediation of Water Resources Impacts

Not applicable to this application.

10.8 Backfilling of the Pits

Not applicable to this application.

11 Conclusions and Recommendations

Based on the data and information discussed in this report, the following can be concluded regarding the geohydrology and water borehole use at Kamiebees Farm 368/1 site:

- All three targeted boreholes were yield tested and the data analysed to determine their safe yields. The safe yields for boreholes KB-BH1, KB-BH2 and KB-BH3 are 0.4 L/s, 0.2 L/s and 0.3 L/s, respectively. This equates to a total of 77.8 KL of groundwater per day or 28 382 KL per annum, which are considered as conservatively low abstraction rates. Furthermore, SJR Boerdery plans on abstracting a groundwater volume of *c.*51 KL/d or *c*.18 700 KL/a, which is significantly lower (35% lower) than the recommended safe yield of the three boreholes;
- The hydrocensus gathered groundwater quality and groundwater quality data within a 5 km radius of the three Kamiebees Farm water boreholes under consideration for a WUL. A total of 10 boreholes were surveyed, which comprise four Kamiebees boreholes, five Wolfkraal boreholes and one Nama Khoi Municipal borehole;
- Water quality in Kamiebees Farm targeted boreholes has relatively high salinity implying that itis classified as ‘brackish water’;
- Data gathered on the hydrogeology of the area and the localities of surrounding boreholes, imply that it is highly unlikely that the abstraction of groundwater from the Kamiebees Farm would negatively impact the Wolfkraal Farm or any other farms in the surrounding area. This statement is made on the basis that Wolfkraal’s boreholes are located on different lineaments (faults) and are spatially separated by impenetrable, solid geological formations from the Kamiebees Farm boreholes. It is postulated that reported groundwater drawdown at Wolfkraal could be attributed to the severe drought being experienced in the region;
- The proposed impact of groundwater abstraction is ‘low’. Should the proposed mitigation measures be implemented the impact on groundwater quantity would reduce to ‘very low’; and
- From a hydrogeological perspective, there is no obvious reason why utilising groundwater to support the proposed activity should not be authorised provided the recommendations in this report are implemented and adhered to.

Based on the data and information discussed in this report, the following is recommended regarding the groundwater resources at the site:

- Equip and use water boreholes KB-BH1, KB-BH2 and KB-BH3 as indicated in Table 4-5;
- If solar or electrical submersible are to be used, install low-level cut-off switches in these boreholes at 45, 13.5 and 25 mbgl, respectively;
- Install a volume meter (flow meter) at each borehole being used for irrigation water supply;
- Obtain a water level dip meter for the operator to measure and record the water level depth in each borehole on at least a monthly basis, preferably before abstraction has commenced for that day. Alternatively, best practise is to install an automatic flow meter and water level recorder (logger) at each borehole set to take hourly readings;
- Implement a groundwater monitoring and management plan as indicated in Subsections 8.2.3 and 9 of this report; and
- Implement all essential mitigation measures listed in this report (subsection 8).

Prepared By

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Hydrogeologist

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C Dalgliesh *CEAPSA*

Registered EAP Partner

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted hydrogeological practices

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Appendices

Appendix A: Pumping Test Data, Graphs and Photographs

Telephone: 043-732 1211
Fax no: 043-732 1422
Fax to e-mail: 0866 717 732
E mail: office@abpumps.co.za

Abbreviations	
EC	Electrical conductivity
mbgl	Meters below ground level
mbch	Meters below casing height
mbdl	Meters below datum level
magl	Meters above ground level
L/S	Litres per second
RPM	Rates per minute
S/W/L	Static water level
µS/cm	Microsiemens per centimeter

BOREHOLE TEST RECORD

Ground water solutions t/a AB Pumps CC

PR0JECT #	P2239
BBR	ABEL
PRODUCTION BONUS:	ISAAC
	KOLEN
	ZANELE
EC meter number	

CONSULTANT: AARDBBOR
DISTRICT: SPRINGBOK
PROVINCE: NORTHERN CAPE
FARM / VILLAGE NAME : KAMIEBEES

DATE TESTED: 19/09/2019

MAP REFERENCE:

CO-ORDINATES:

FORMAT ON GPS: hddd ° mm ' ss.s " | hddd ° mm.mmm ' | hddd.ddddd

LATITUDE: ° ' " OR ° ' OR S 30.03885
LONGITUDE: ° ' " ° ' E 18.47694

BOREHOLE NO: BH 1
TRANSMISSIVITY VALUE:
TYPE INSTALLATION: WINDPUMP
BOREHOLE DEPTH: (mbgl) 54.30

COMMENTS:

SAMPLE INSTRUCTIONS :

Water sample taken	Yes	No	Test for:	macro	bacterio-logical	
Date sample taken	20/09/2019		If consultant took sample, give name:			
Time sample taken	09H00					

DATA CAPTURED BY:	ELZAAN
DATA CHECKED BY:	AVN

CONSULTANT GUIDELINES

BOREHOLE DEPTH:		m	STEP 1:		l/s	WATER STRIKE 1:			m
BLOW YIELD:		m	STEP 2:		l/s	WATER STRIKE 2:			m
STATIC WATER LEVEL:		m	STEP 3:		l/s	WATER STRIKE 3:			m
PUMP INSTALLATION DEPTH:		m	STEP 4:		l/s	**COMMENTS:**			
RECOVERY:			STEP 5:		l/s				
AFTER STEPS:		h	STEP 6:		l/s	TELEPHONE NUMBERS PHONE : (NAME & TEL)			
AFTER CONSTANT:		h	STEP DURATION:		min				

DESCRIPTION:	UNIT	QTY		UNIT	QTY
STRAIGHTNESS TEST:	NO	0	BOREHOLE DEPTH AFTER TEST:	M	54.30
VERTICALLY TEST:	NO	0	BOREHOLE WATER LEVEL AFTER TEST: (mbch)	M	15.06
CASING DETECTION:	NO	RUST	SAND/GRAVEL/SILT PUMPED?	YES/NO	0
SUPPLIED NEW STEEL BOREHOLE COVER:	NO	0	DATA REPORTING AND RECORDING	NO	1
BOREHOLE MARKING	NO	0	SLUG TEST:	NO	0
SITE CLEANING & FINISHING	NO	1	LAYFLAT (M):	M	50
LOGGERS FOR WATERLEVEL MONITORING	NO	1	LOGGERS FOR pH AND EC:	NO	0

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

NAME: ________________ **SIGNATURE:** ______________
DESIGNATION: ________________ **DATE:** ______________

BOREHOLE TEST CONTROL SHEET
Groundwater Solutions t/a AB PUMPS

Borehole number:	BH 1	Old / Alternative number:	
Contractor:	AB PUMPS	Supervisor:	ABEL
Operator:	ISAAC	Rig number & Type rig:	27

EXISTING EQUIPMENT

Type pump	Depth	Condition	Drive unit	Condition	Pump house	Condition	Remarks
WINDPUMP	21.5	GOOD	WIND	GOOD			

TESTING EQUIPMENT

Pump type	Depth installed (m)	Date & time (started)	Date & time (completed)
BP 50	51.74	19/09/2019 13H30	19/09/2019 20H50

MULTI-RATE OR STEPTEST DETAILS

STEP	DURATION (MIN)	RECOVERY (MIN)	YIELD (L/S)		DRAWDOWN (m)
1	60		1.04	l/s	2.01
2	60		2.02	l/s	5.75
3	60		3.51	l/s	17.79
4	15	240	5.04	l/s	38.62
5				l/s	
6				l/s	
7				l/s	
8				l/s	
Calibration:	40	40		l/s	
TOTAL:	235	280		l/s	
COMMENT:					

CONSTANT RATE DISCHARGE TEST

Pump type	Depth installed (m)	Date & time (started)		Date & time (completed)	
BP 50	51.74	20/09/2019	08H20	24/09/2019	08H20
Yield l/s	**Drawdown (m)**	**Duration (min)**		**Recovery (min)**	
3.04	21.56	2880		2880	
Total: (Multi-rate and Constant Discharge rate)		3115		3160	
COMMENT:					

MAINTENANCE

Work time:	hour	Transport existing equipm.	Km	Travelling (To fix);	Km
List of parts replaced or repaired:					

	Borehole number	Duration (min) CONSTANT	Drawdown (m)	Hand/logger	Distance (m)
Observation Hole 1	BH 2	2880	0.8	HAND	180
Observation Hole 2	BH 3	2880	0.79	HAND	170.9
Observation Hole 3					0
Observation Hole 4					
Observation Hole 5					

GENERAL

ESTABLISHMENT	From:		To:			
Site Move	From project#	P2239	To #:	P2239	Travelling km:	0.18
	Village	Borehole no	Village	Borehole no		
	KAMIEBEES	BH 3	KAMIEBEES	BH 1		
Maintenance:	Work time hr		Parts repaired/ replaced		Travelling km	
After test measurements	Water level	15.06	Borehole depth	54.30	Casing depth m	RUST

Water level before installing test pump: (mbch)	12.41			
Depth before installing test pump:	54.30			
Testpump Installed	**Once** /Twice /More	Reason:		
Installed Testpump	**<10 l/s** / >10ls/s	Reason:		
Was existing equipment re-installed:	Yes:	**No:**	If not where was it left:	
GPS Unit number:				
EC Unit number:		0		
Remarks:				
Signed Contractor:			Signed Consultant:	

FORM 5 D

CALIBRATION TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P2239	MAP REFERENCE:	0	PROVINCE:	NORTHERN CAPE
BOREHOLE NO:	BH 1			DISTRICT:	SPRINGBOK
ALT BH NO:	0			SITE NAME:	KAMIEBEES
ALT BH NO:					
BOREHOLE DEPTH	54.30	DATUM LEVEL ABOVE CASING (m):	0.33	EXISTING PUMP:	WINDPUMP
WATER LEVEL (mbdl):	12.79	CASING HEIGHT (magl):	0.12	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	51.74	DIAM PUMP INLET (mm):	170.00	PUMP TYPE:	BP 50

CALIBRATION TEST AND RECOVERY

DISCHARGE RATE 1			RPM	194	DISCHARGE RATE 2			RPM	384	DISCHARGE RATE 3			RPM	711
DATE:	19/09/2019	TIME:	11H00		DATE:	19/09/2019	TIME:	11H15		DATE:	19/09/201	TIME:	11H30	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	0.29		1		1	3.98	2.70	1		1	11.91		1	17.15
2	0.50		2		2	5.19		2		2	15.88	5.40	2	7.34
3	0.86		3		3	6.16	3.13	3		3	20.32		3	2.92
5	1.54	1.51	5		5	7.30		5		5	28.34	6.01	5	1.43
7	2.01		7		7	7.76	3.10	7		7	36.04		7	1.32
10	2.15	1.50	10		10	8.04		10		10	38.99		10	1.20
15	2.27		15		15	8.37	3.09	15			38.99	5.05	15	1.03
			20					20			38.99	5.04	20	0.86
			30					30			38.99	5.04	30	0.72
			40					40					40	0.57
			50					50					50	
			60					60					60	
			70					70					70	
			80					80					80	
			90					90					90	
			100					100					100	
			110					110					110	
			120					120					120	
			150					150					150	
DISCHARGE RATE 4			RPM		DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE:		TIME:			DATE:		TIME:			DATE:		TIME:		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1			1		1			1		1			1	
2			2		2			2		2			2	
3			3		3			3		3			3	
5			5		5			5		5			5	
7			7		7			7		7			7	
10			10		10			10		10			10	
15			15		15			15		15			15	
			20					20					20	
			30					30					30	
			40					40					40	
			50					50					50	
			60					60					60	
			70					70					70	
			80					80					80	
			90					90					90	
			100					100					100	
			110					110					110	
			120					120					120	
			150					150					150	

COMMENTS:

S/W/L: (mbch) 12.41

FORM 5 E

STEPPED DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P2239	MAP REFERENCE:	0	PROVINCE:	NORTHERN CAPE
BOREHOLE NO:	BH 1			DISTRICT:	SPRINGBOK
ALT BH NO:	0			SITE NAME:	KAMIEBEES
ALT BH NO:	0				
BOREHOLE DEPTH (m)	54.30	DATUM LEVEL ABOVE CASING (m):	0.33	EXISTING PUMP:	WINDPUMP
WATER LEVEL (mbdl):	13.12	CASING HEIGHT: (magl):	0.12	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	51.74	DIAM PUMP INLET (mm):	170.00	PUMP TYPE:	BP 50

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1			RPM	172	DISCHARGE RATE 2			RPM	249	DISCHARGE RATE 3			RPM	416
DATE:	19/09/2019	TIME:	13H30		DATE:	19/09/2019	TIME:	14H30		DATE:	19/09/2019	TIME:	15H30	
TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY
(MIN)	DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DOWN (M)	(L/S)	(MIN)	(M)
1	0.36		**1**		**1**	2.70	1.73	**1**		**1**	6.97		**1**	
2	0.84		**2**		**2**	3.13		**2**		**2**	8.38	2.94	**2**	
3	1.26		**3**		**3**	3.98	2.02	**3**		**3**	12.49		**3**	
5	1.46	1.05	**5**		**5**	4.46		**5**		**5**	14.75	3.51	**5**	
7	1.51		**7**		**7**	4.89	2.00	**7**		**7**	15.59		**7**	
10	1.58	1.01	**10**		**10**	4.97		**10**		**10**	16.12	3.53	**10**	
15	1.70		**15**		**15**	5.04	2.03	**15**		**15**	16.40		**15**	
20	1.75	1.04	**20**		**20**	5.12		**20**		**20**	16.61	3.53	**20**	
30	1.80		**30**		**30**	5.31	2.01	**30**		**30**	16.93		**30**	
40	1.89	1.04	**40**		**40**	5.44		**40**		**40**	17.23	3.54	**40**	
50	1.95		**50**		**50**	5.63	2.02	**50**		**50**	17.46		**50**	
60	2.01	1.04	**60**		**60**	5.75		**60**		**60**	17.79	3.51	**60**	
70			**70**		**70**			**70**		**70**			**70**	
80			**80**		**80**			**80**		**80**			**80**	
90			**90**		**90**			**90**		**90**			**90**	
100			**100**		**100**			**100**		**100**			**100**	
110			**110**		**110**			**110**		**110**			**110**	
120			**120**		**120**			**120**		**120**			**120**	
pH			**150**		**pH**			**150**		**pH**			**150**	
TEMP		°C	**180**		**TEMP**		°C	**180**		**TEMP**		°C	**180**	
EC	3.91	MS/cm	**210**		**EC**	3.89	MS/cm	**210**		**EC**	3.87	MS/cm	**210**	

DISCHARGE RATE 4			RPM	599	DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE:	19/09/2019	TIME:	16H30		DATE:		TIME:			DATE:		TIME:		
TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY
(MIN)	DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DOWN (M)	(L/S)	(MIN)	(M)
1	21.91		**1**	13.82	**1**			**1**		**1**			**1**	
2	23.82		**2**	6.17	**2**			**2**		**2**			**2**	
3	26.58	4.67	**3**	3.20	**3**			**3**		**3**			**3**	
5	30.33	5.01	**5**	2.58	**5**			**5**		**5**			**5**	
7	32.60		**7**	2.44	**7**			**7**		**7**			**7**	
10	34.15	5.04	**10**	2.30	**10**			**10**		**10**			**10**	
15	38.62		**15**	2.07	**15**			**15**		**15**			**15**	
	38.62	4.86	**20**	1.92	**20**			**20**		**20**			**20**	
	38.62	4.84	**30**	1.64	**30**			**30**		**30**			**30**	
	38.62	4.84	**40**	1.42	**40**			**40**		**40**			**40**	
			50	1.27	**50**			**50**		**50**			**50**	
			60	1.15	**60**			**60**		**60**			**60**	
			70	1.07	**70**			**70**		**70**			**70**	
			80	0.99	**80**			**80**		**80**			**80**	
			90	0.91	**90**			**90**		**90**			**90**	
			100	0.86	**100**			**100**		**100**			**100**	
			110	0.81	**110**			**110**		**110**			**110**	
			120	0.76	**120**			**120**		**120**			**120**	
pH			**150**	0.66	**pH**			**150**		**pH**			**150**	
TEMP		°C	**180**	0.58	**TEMP**		°C	**180**		**TEMP**		°C	**180**	
EC		µS/cm	**210**	0.52	**EC**		µS/cm	**210**		**EC**		µS/cm	**210**	
			240	0.47				**240**					**240**	
			300					**300**					**300**	
			360					**360**					**360**	

S/W/L:(mbch) 12.41

FORM 5 F

CONSTANT DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P2239	MAP REFERENCE:	S 30.03885	PROVINCE:	NORTHERN CAPE
BOREHOLE NO:	BH 1		E 18.47694	DISTRICT:	SPRINGBOK
ALT BH NO:	0			SITE NAME:	KAMIEBEES
ALT BH NO:	0				
BOREHOLE DEPTH:	54.30	DATUM LEVEL ABOVE CASING (m):	0.33	EXISTING PUMP:	WINDPUMP
WATER LEVEL (mbdl):	13.22	CASING HEIGHT: (magl):	0.12	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	51.74	DIAM PUMP INLET(mm):	170	PUMP TYPE:	BP 50

CONSTANT DISCHARGE TEST & RECOVERY

TEST STARTED				**TEST COMPLETED**					
DATE:	20/09/2019	TIME:	08H20	DATE:	22/09/2019	TIME:	08H20	TYPE OF PUMP:	BP 50

DISCHARGE BOREHOLE					OBSERVATION HOLE 1			OBSERVATION HOLE 2			OBSERVATION HOLE 3	
					NR:	**BH 2**		NR:	**BH 3**		NR:	
					Distance(m);		180	Distance(m);		170.9	Distance(m);	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME MIN	RECOVERY (M)	TIME: (min)	Drawdown m	Recovery (m)	TIME: (min)	Drawdown (m)	Recovery	TIME: (min)	Drawdown (m)
1	1.36		**1**	10.80	**1**			**1**			**1**	
2	2.04		**2**	8.61	**2**			**2**			**2**	
3	3.22		**3**	8.50	**3**			**3**			**3**	
5	3.90	2.40	**5**	8.48	**5**			**5**			**5**	
7	7.66	3.03	**7**	8.40	**7**			**7**			**7**	
10	9.36		**10**	8.32	**10**			**10**			**10**	
15	10.02	3.01	**15**	8.14	**15**			**15**			**15**	
20	10.52		**20**	8.02	**20**			**20**			**20**	
30	11.02	3.04	**30**	7.81	**30**			**30**			**30**	
40	11.36		**40**	7.63	**40**			**40**			**40**	
60	11.70	3.00	**60**	7.31	**60**	0.00	0.80	**60**	0.00	0.79	**60**	
90	11.98		**90**	6.92	**90**			**90**			**90**	
120	12.27	3.04	**120**	6.61	**120**	0.00		**120**	0.00	0.79	**120**	
150	12.40		**150**	6.38	**150**	0.00	0.80	**150**	0.00	0.79	**150**	
180	12.61	3.05	**180**	6.19	**180**	0.00	0.80	**180**	0.00	0.79	**180**	
210	12.75		**210**	6.00	**210**	0.03	0.80	**210**	0.02	0.78	**210**	
240	12.88	3.00	**240**	5.60	**240**	0.04	0.80	**240**	0.03	0.78	**240**	
300	13.29		**300**	5.61	**300**	0.07	0.80	**300**	0.05	0.78	**300**	
360	13.74	3.04	**360**	5.41	**360**	0.09	0.80	**360**	0.06	0.78	**360**	
420	14.24		**420**	5.23	**420**	0.10	0.80	**420**	0.07	0.78	**420**	
480	14.54	3.02	**480**	5.04	**480**	0.12	0.80	**480**	0.09	0.78	**480**	
540	14.82		**540**	4.91	**540**	0.12	0.80	**540**	0.09	0.78	**540**	
600	15.03	3.04	**600**	4.79	**600**	0.13	0.80	**600**	0.10	0.78	**600**	
720	15.38		**720**	4.52	**720**	0.14	0.79	**720**	0.11	0.78	**720**	
840	15.87	3.04	**840**	4.33	**840**	0.16	0.79	**840**	0.13	0.77	**840**	
960	16.26		**960**	4.16	**960**	0.18	0.78	**960**	0.16	0.76	**960**	
1080	16.69	3.03	**1080**	3.93	**1080**	0.21	0.77	**1080**	0.18	0.76	**1080**	
1200	17.09		**1200**	3.75	**1200**	0.23	0.77	**1200**	0.20	0.75	**1200**	
1320	17.46	3.05	**1320**	3.56	**1320**	0.25	0.76	**1320**	0.22	0.74	**1320**	
1440	17.96		**1440**	3.39	**1440**	0.30	0.76	**1440**	0.27	0.73	**1440**	
1560	18.28	3.02	**1560**	3.24	**1560**	0.33	0.75	**1560**	0.29	0.72	**1560**	
1680	18.56		**1680**	3.11	**1680**	0.36	0.71	**1680**	0.32	0.72	**1680**	
1800	18.74	3.01	**1800**	2.98	**1800**	0.40	0.70	**1800**	0.36	0.70	**1800**	
1920	19.11		**1920**	2.88	**1920**	0.47	0.69	**1920**	0.38	0.70	**1920**	
2040	19.38	3.01	**2040**	2.79	**2040**	0.52	0.69	**2040**	0.43	0.69	**2040**	
2160	19.78		**2160**	2.70	**2160**	0.55	0.69	**2160**	0.47	0.68	**2160**	
2280	20.08	3.03	**2280**	2.58	**2280**	0.60	0.67	**2280**	0.52	0.67	**2280**	
2400	20.34		**2400**	2.50	**2400**	0.64	0.65	**2400**	0.56	0.65	**2400**	
2520	20.60	3.01	**2520**	2.41	**2520**	0.70	0.64	**2520**	0.61	0.65	**2520**	
2640	20.93		**2640**	2.35	**2640**	0.73	0.62	**2640**	0.67	0.63	**2640**	
2760	21.24	3.04	**2760**	2.27	**2760**	0.76	0.61	**2760**	0.72	0.62	**2760**	
2880	21.56		**2880**	2.21	**2880**	0.80	0.60	**2880**	0.79	0.61	**2880**	
3000			**3000**		**3000**			**3000**			**3000**	
3120			**3120**		**3120**			**3120**			**3120**	
3240			**3240**		**3240**			**3240**			**3240**	
3360			**3360**		**3360**			**3360**			**3360**	
3480			**3480**		**3480**			**3480**			**3480**	
3600			**3600**		**3600**			**3600**			**3600**	
3720			**3720**		**3720**			**3720**			**3720**	
3840			**3840**		**3840**			**3840**			**3840**	
3960			**3960**		**3960**			**3960**			**3960**	
4080			**4080**		**4080**			**4080**			**4080**	
4200			**4200**		**4200**			**4200**			**4200**	
4320			**4320**		**4320**			**4320**			**4320**	
Total time pumped(min):				2880		**W/L**	**10.64**		**W/L**	**10.66**		**W/L**
Average yield (l/s):				3.04								

FORM 6 A

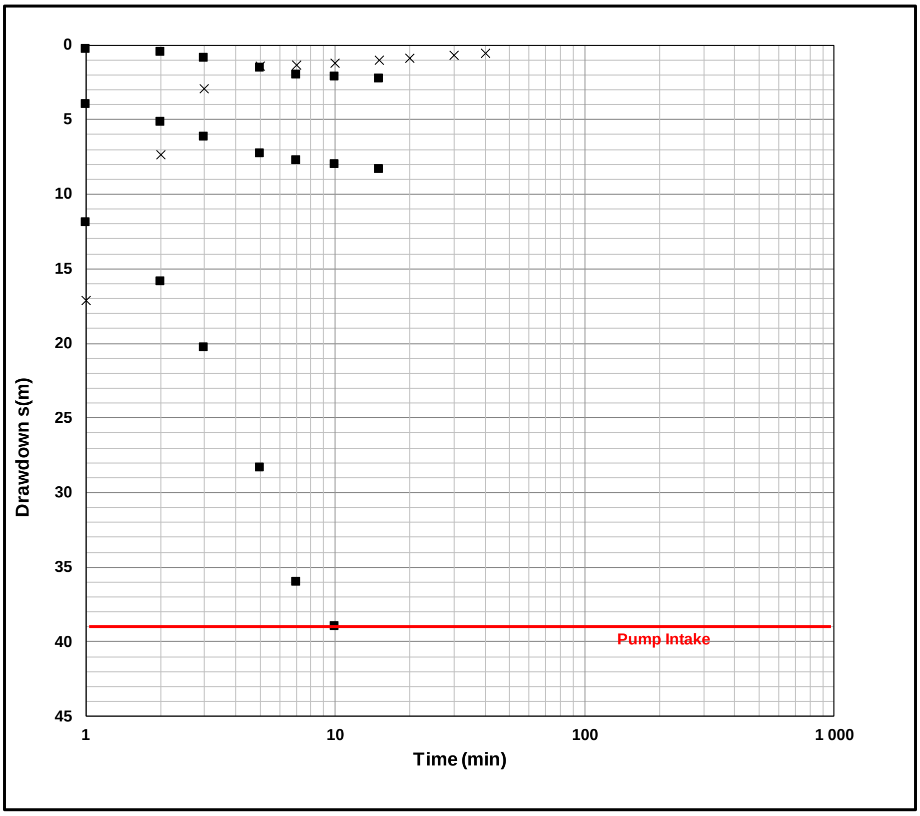
RECORD OF EXISTING EQUIPMENT AT BOREHOLE

BOREHOLE NO:	BH 1	DATE:	
DISTRICT:	SPRINGBOK	CONTRACTOR:	AB PUMPS
VILLAGE/FARM:	KAMIEBEES		
LOCALITY	NORTHERN CAPE		

ITEM(S) PARAMETERS	**DESCRIPTION OF EQUIPMENT**
TYPE OF INSTALLATION (Type of pump,eg, reciprocal cylinder,mono-type,handpump)	
Type	RECIPROCAL CYLINDER
Name &model	WINDPUMP
Depth installed (m)	21.5
Element Diameter (m)	0.08
Element stroke (m)	0.6
PIPE COLUMNS & SHAFTS	
Diameter (mm)	40
Length / section (m)	3
No of sections	7
Pipe material	GALVANISED STEEL
Shaft diameter (mm)	16
MOTORIZED PUMP INSTALLATION	
Type	
Name model of motor	
motor power rating	
motor pulley diam	
Pump pulley diam	
HANDPUMP	
Name / model	
WIND PUMP	
Wheel diam (m)	3
Mast height (m)	7
SOLAR PUMP	
No of panels	
Rating per panel	

ANCILLARY EQUIPMENT			
Storage tank (lt)		**Type riser**	
Stand height(m)		Class riser	HDPE
Water meter name		Diameter of riser	40
Water meter reading		Condition of riser	GOOD
Type of reservoir		**Pump rooms**	
Reservoir size		Type of pump room	
Reservoir condition		Material of enclosure	
Stand height (m)		Condition of enclosure	
DE-ESTABLISHMENT FROM SITE TO WHERE:			

CALIBRATION TEST DATA PLOT



▪ = Drawdown
X = Recovery data.

LOCALITY

NORTHERN CAPE
KAMIEBEES

BOREHOLE NO:

BH 1

DATE TESTED

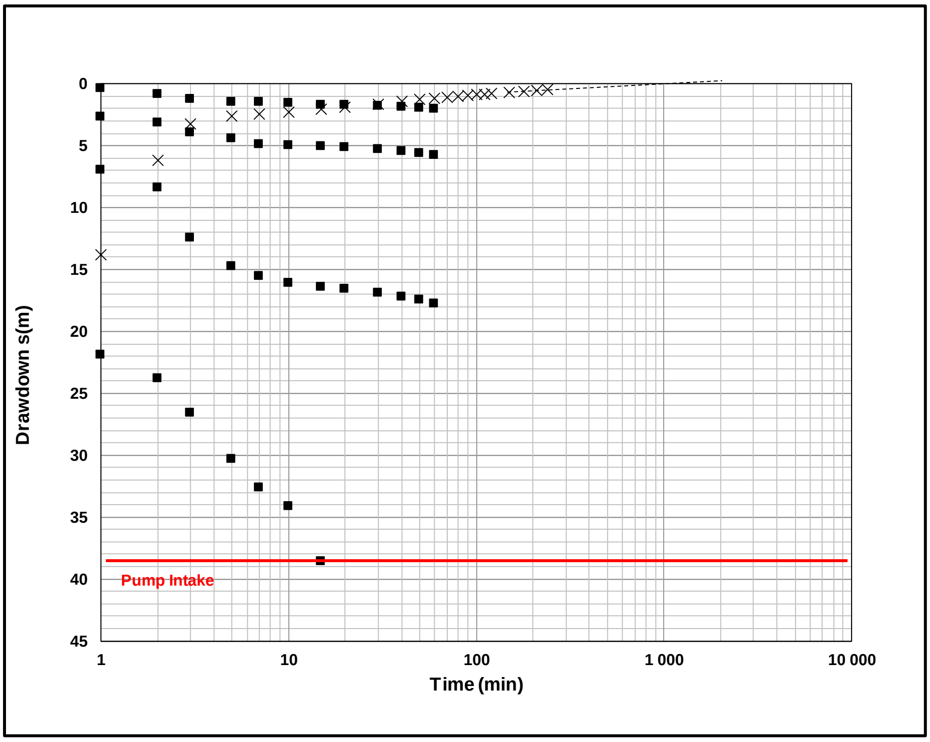
19/09/2019

DISCHARGE RATES (Q)

Q1 =	**1.51**	l/s
Q2 =	**3.13**	l/s
Q3 =	**6.0**	l/s

S.W.L = **12.41** m.b.g.l.

STEP DRAWDOWN TEST DATA PLOT



▪ = Drawdown data.
X = Recovery data.

LOCALITY

NORTHERN CAPE
KAMIEBEES

BOREHOLE NO:

BH 1

DATE TESTED

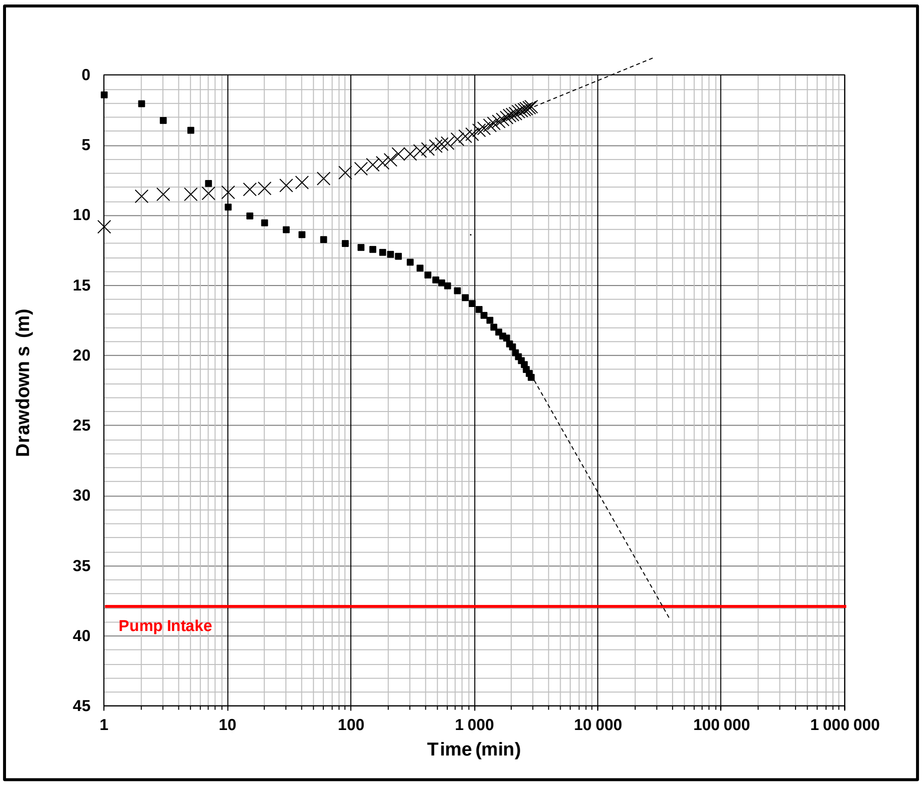
19/09/2019

DISCHARGE RATES (Q)

Q1 =	**1.04**	l/s
Q2 =	**2.02**	l/s
Q3 =	**3.51**	l/s
Q4 =	**5.04**	l/s

S.W.L = **13.12** mbc

CONSTANT DISCHARGE TEST DATA PLOT



▪ = Drawdown data.
X = Recovery data.

PUMPED B.H. NO:

BH 1

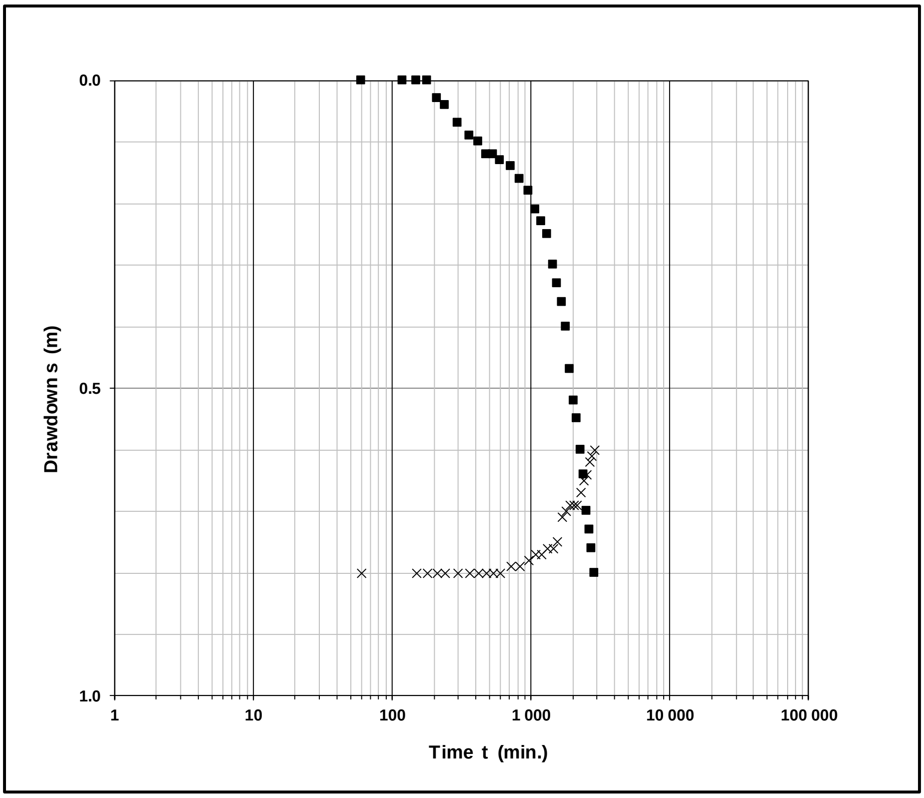
DATE TESTED

20/09/2019

Q = **3.0** l/s.

S.W.L = **13.22** mbc

MONITORING BOREHOLE TEST DATA PLOT



▪ = Drawdown data.
X = Recovery data.

PUMPED B.H. NO:

BH 1

Pumping Borehole Discharge

Q = **3.0** l/s.

MONITORING B.H. NO:

BH 2

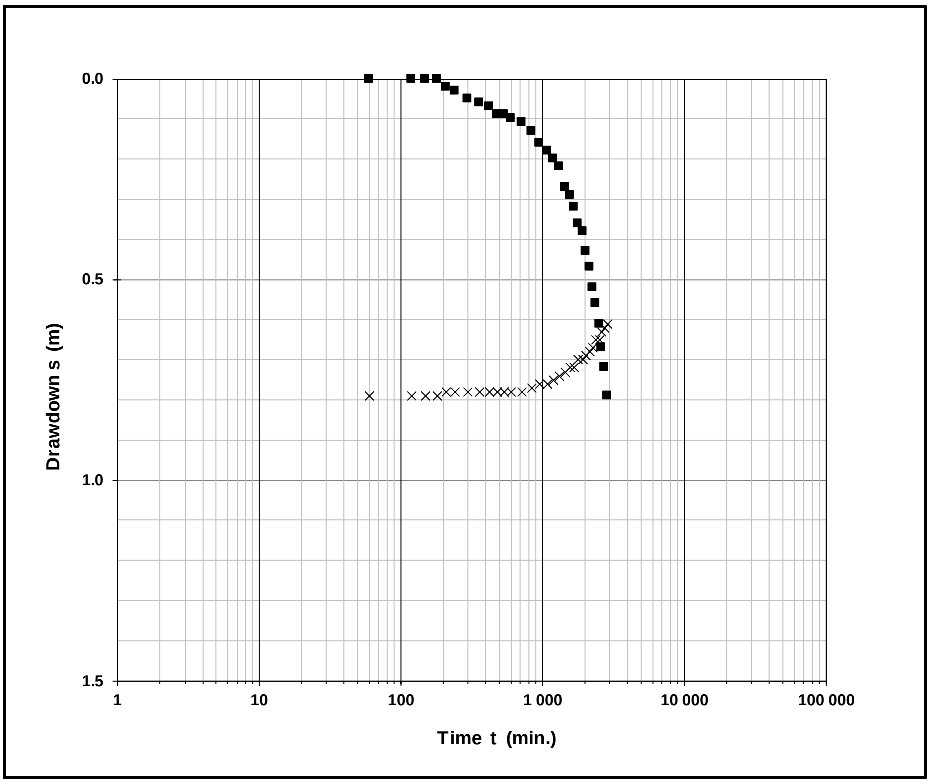
MONITORING TEST DATE

20/09/2019

S.W.L = **10.64** mbc

DISTANCE
(from pumping borehole)
r = **180** (m)

MONITORING BOREHOLE TEST DATA PLOT



■ = Drawdown data.
X = Recovery data.

PUMPED B.H. NO:

BH 1

Pumping Borehole Discharge

Q = **3.0** l/s.

MONITORING B.H. NO:

BH 3

MONITORING TEST DATE

20/09/2019

S.W.L = **10.66** m.b.g.l.

DISTANCE
(from pumping borehole)
r = **171** (m)

Telephone: 043-732 1211
Fax no: 043-732 1422
Fax to e-mail: 0866 717 732
E mail: office@abpumps.co.za

Abbreviations	
EC	Electrical conductivity
mbgl	Meters below ground level
mbch	Meters below casing height
mbdl	Meters below datum level
magl	Meters above ground level
L/S	Litres per second
RPM	Rates per minute
S/W/L	Static water level
µS/cm	Microsiemens per centimeter

BOREHOLE TEST RECORD

Ground water solutions t/a AB Pumps CC

PR0JECT #	P22339
BBR	ABEL
PRODUCTION BONUS:	ISAAC
	KOLEN
	ZANELE
EC meter number	

CONSULTANT: AARDBOOR

DISTRICT: SPRINGBOK

PROVINCE: NORTHERN CAPE

FARM / VILLAGE NAME : KAMIESBEES

DATE TESTED: 13/09/2019

MAP REFERENCE:

CO-ORDINATES:

FORMAT ON GPS: hddd ° mm ' ss.s " — hddd ° mm.mmm ' — hddd.ddddd °

LATITUDE: ° ' " OR ° ' OR S 30.03738 °

LONGITUDE: ° ' " ° ' E 18.47659 °

BOREHOLE NO: KAMIESBEES BH 2

TRANSMISSIVITY VALUE:

TYPE INSTALLATION: WINDMILL

BOREHOLE DEPTH: (mbgl) 17.25

COMMENTS: THE OWNER OF THE FARM REMOVED THE EXISTING PUMP HIMSELF

SAMPLE INSTRUCTIONS :

Water sample taken	Yes	No	Test for:	macro	bacterio-logical	DATA CAPTURED BY:	ELZAAN
Date sample taken	16/09/2019		If consultant took sample, give name:			DATA CHECKED BY:	AVN
Time sample taken	07H00						

CONSULTANT GUIDELINES

BOREHOLE DEPTH:		m	STEP 1:		l/s	WATER STRIKE 1:			m
BLOW YIELD:		m	STEP 2:		l/s	WATER STRIKE 2:			m
STATIC WATER LEVEL:		m	STEP 3:		l/s	WATER STRIKE 3:			m
PUMP INSTALLATION DEPTH:		m	STEP 4:		l/s	**COMMENTS:**			
RECOVERY:			STEP 5:		l/s				
AFTER STEPS:		h	STEP 6:		l/s	TELEPHONE NUMBERS PHONE : (NAME & TEL)			
AFTER CONSTANT:		h	STEP DURATION:		min				

DESCRIPTION:	UNIT	QTY		UNIT	QTY
STRAIGHTNESS TEST:	NO	0	BOREHOLE DEPTH AFTER TEST:	M	17.25
VERTICALLY TEST:	NO	0	BOREHOLE WATER LEVEL AFTER TEST: (mbch)	M	10.59
CASING DETECTION:	NO	RUST	SAND/GRAVEL/SILT PUMPED?	YES/NO	0
SUPPLIED NEW STEEL BOREHOLE COVER:	NO	0	DATA REPORTING AND RECORDING	NO	1
BOREHOLE MARKING	NO	0	SLUG TEST:	NO	0
SITE CLEANING & FINISHING	NO	1	LAYFLAT (M):	M	50
LOGGERS FOR WATERLEVEL MONITORING	NO	1	LOGGERS FOR pH AND EC:	NO	0

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

NAME: ________________ SIGNATURE: ______________

DESIGNATION: ________________ DATE: ______________

BOREHOLE TEST CONTROL SHEET
Groundwater Solutions t/a AB PUMPS

Borehole number:	KAMIESBEES BH 2	Old / Alternative number:	
Contractor:	AB PUMPS	Supervisor:	ABEL
Operator:	KOLEN	Rig number & Type rig:	27

EXISTING EQUIPMENT

Type pump	Depth	Condition	Drive unit	Condition	Pump house	Condition	Remarks

TESTING EQUIPMENT

Pump type	Depth installed (m)	Date & time (started)	Date & time (completed)
WA 22-2	15.10	13/09/2019 10H20	13/09/2019 20H20

MULTI-RATE OR STEPTEST DETAILS

STEP	DURATION (MIN)	RECOVERY (MIN)	YIELD (L/S)		DRAWDOWN (m)
1	60		0.41	l/s	0.43
2	60		0.82	l/s	0.81
3	60		1.52	l/s	1.58
4	60		2.03	l/s	2.25
5	60	300	2.54	l/s	3.34
6				l/s	
7				l/s	
8				l/s	
Calibration:				l/s	
TOTAL:	300	300		l/s	
COMMENT:					

CONSTANT RATE DISCHARGE TEST

Pump type	Depth installed (m)	Date & time (started)		Date & time (completed)	
WA 22-2	15.10	14/09/2019	07H40	18/09/2019	07H40
Yield l/s	**Drawdown (m)**	**Duration (min)**		**Recovery (min)**	
1.03	2.73	2880		2880	
Total: (Multi-rate and Constant Discharge rate)		3180		3180	
COMMENT:					

MAINTENANCE

Work time:	hour	Transport existing equipm.	Km	Travelling (To fix);	Km
List of parts replaced or repaired:					

	Borehole number	Duration (min) CONSTANT	Drawdown (m)	Hand/logger	Distance (m)
Observation Hole 1	BH 3	2880	2.7	HAND	9.1
Observation Hole 2	BH 1	2880	0.45	HAND	180
Observation Hole 3					0
Observation Hole 4					
Observation Hole 5					

GENERAL

ESTABLISHMENT	From:	***KAMIESKROON***		To:		
Site Move	From project#		To #:	P22339	Travelling km:	162
	Village	Borehole no	Village	Borehole no		
	KAMIESKROON	KK-MUN-SKOOL 2	KAMIESBEES	KAMIESBEES BH 2		
Maintenance:	Work time hr		Parts repaired/ replaced		Travelling km	
After test measurements	Water level	10.59	Borehole depth	17.25	Casing depth m	RUST

Water level before installing test pump: (mbch)		10.15	
Depth before installing test pump:		17.25	
Testpump Installed	**Once** /Twice /More	Reason:	
Installed Testpump	**<10 l/s** / >10ls/s	Reason:	
Was existing equipment re-installed:	Yes:	**No:**	If not where was it left:
GPS Unit number:			
EC Unit number:		0	
Remarks:			
Signed Contractor:		Signed Consultant:	

FORM 5 D

CALIBRATION TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P22339	MAP REFERENCE:	0	PROVINCE:	NORTHERN CAPE
BOREHOLE NO:	KAMIESBEES BH 2			DISTRICT:	SPRINGBOK
ALT BH NO:	0			SITE NAME:	KAMIESBEES
ALT BH NO:					
BOREHOLE DEPTH	17.25	DATUM LEVEL ABOVE CASING (m):	0.29	EXISTING PUMP:	0
WATER LEVEL (mbdl):	10.45	CASING HEIGHT (magl):	0.28	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	15.10	DIAM PUMP INLET (mm):	170.00	PUMP TYPE:	WA 22-2

CALIBRATION TEST AND RECOVERY

DISCHARGE RATE 1			RPM		DISCHARGE RATE 2			RPM		DISCHARGE RATE 3			RPM	
DATE:		TIME:			DATE:		TIME:			DATE:		TIME:		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1			1		1			1		1			1	
2			2		2			2		2			2	
3			3		3			3		3			3	
5			5		5			5		5			5	
7			7		7			7		7			7	
10			10		10			10		10			10	
15			15		15			15		15			15	
			20					20					20	
			30					30					30	
			40					40					40	
			50					50					50	
			60					60					60	
			70					70					70	
			80					80					80	
			90					90					90	
			100					100					100	
			110					110					110	
			120					120					120	
			150					150					150	

DISCHARGE RATE 4			RPM		DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE:		TIME:			DATE:		TIME:			DATE:		TIME:		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1			1		1			1		1			1	
2			2		2			2		2			2	
3			3		3			3		3			3	
5			5		5			5		5			5	
7			7		7			7		7			7	
10			10		10			10		10			10	
15			15		15			15		15			15	
			20					20					20	
			30					30					30	
			40					40					40	
			50					50					50	
			60					60					60	
			70					70					70	
			80					80					80	
			90					90					90	
			100					100					100	
			110					110					110	
			120					120					120	
			150					150					150	

COMMENTS:

S/W/L: (mbch)

FORM 5 E

STEPPED DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P22339	MAP REFERENCE:	PROVINCE:	NORTHERN CAPE
BOREHOLE NO:	KAMIESBEES BH 2	S 30.03738	DISTRICT:	SPRINGBOK
ALT BH NO:	0	E 18.47659	SITE NAME:	KAMIESBEES
ALT BH NO:	0			

BOREHOLE DEPTH (m)	17.25	DATUM LEVEL ABOVE CASING (m):	0.29	EXISTING PUMP:	0
WATER LEVEL (mbdl):	10.45	CASING HEIGHT: (magl):	0.28	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	15.10	DIAM PUMP INLET (mm):	170.00	PUMP TYPE:	WA 22-2

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1			RPM	248	DISCHARGE RATE 2			RPM	320	DISCHARGE RATE 3			RPM	456
DATE:	13/09/2019	TIME:	10H20		DATE:	13/09/2019	TIME:	11H20		DATE:	13/09/2019	TIME:	12H20	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	0.05		**1**		**1**	0.46		**1**		**1**	0.83		**1**	
2	0.07		**2**		**2**	0.49	0.83	**2**		**2**	0.85		**2**	
3	0.10	0.35	**3**		**3**	0.51		**3**		**3**	0.91	1.52	**3**	
5	0.12		**5**		**5**	0.55	0.81	**5**		**5**	0.95		**5**	
7	0.15	0.44	**7**		**7**	0.57		**7**		**7**	1.03	1.54	**7**	
10	0.19		**10**		**10**	0.59	0.84	**10**		**10**	1.10		**10**	
15	0.25	0.43	**15**		**15**	0.63		**15**		**15**	1.17	1.51	**15**	
20	0.27		**20**		**20**	0.66	0.82	**20**		**20**	1.23		**20**	
30	0.32	0.42	**30**		**30**	0.70		**30**		**30**	1.33	1.53	**30**	
40	0.36		**40**		**40**	0.74	0.85	**40**		**40**	1.43		**40**	
50	0.40	0.41	**50**		**50**	0.77		**50**		**50**	1.52	1.52	**50**	
60	0.43		**60**		**60**	0.81	0.82	**60**		**60**	1.58		**60**	
70			**70**		**70**			**70**		**70**			**70**	
80			**80**		**80**			**80**		**80**			**80**	
90			**90**		**90**			**90**		**90**			**90**	
100			**100**		**100**			**100**		**100**			**100**	
110			**110**		**110**			**110**		**110**			**110**	
120			**120**		**120**			**120**		**120**			**120**	
pH			**150**		**pH**			**150**		**pH**			**150**	
TEMP		°C	**180**		**TEMP**		°C	**180**		**TEMP**		°C	**180**	
EC	2.52	MS/cm	**210**		**EC**	2.44	MS/cm	**210**		**EC**	2.51	MS/cm	**210**	

DISCHARGE RATE 4			RPM	583	DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE:	13/09/2019	TIME:	13H20		DATE:	13/09/2019	TIME:	14H20		DATE:		TIME:		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	1.62		**1**		**1**	2.31		**1**	2.84	**1**			**1**	
2	1.65	1.98	**2**		**2**	2.35		**2**	2.77	**2**			**2**	
3	1.68		**3**		**3**	2.48	2.53	**3**	2.68	**3**			**3**	
5	1.73	2.01	**5**		**5**	2.57		**5**	2.52	**5**			**5**	
7	1.82		**7**		**7**	2.66	2.53	**7**	2.27	**7**			**7**	
10	1.85	2.02	**10**		**10**	2.79		**10**	2.01	**10**			**10**	
15	1.92		**15**		**15**	2.85	2.50	**15**	1.68	**15**			**15**	
20	1.98	2.04	**20**		**20**	2.94		**20**	1.52	**20**			**20**	
30	2.08		**30**		**30**	3.04	2.51	**30**	1.28	**30**			**30**	
40	2.16	2.05	**40**		**40**	3.13		**40**	1.13	**40**			**40**	
50	2.22		**50**		**50**	3.25	2.54	**50**	1.02	**50**			**50**	
60	2.28	2.03	**60**		**60**	3.34		**60**	0.92	**60**			**60**	
70			**70**		**70**			**70**	0.85	**70**			**70**	
80			**80**		**80**			**80**	0.81	**80**			**80**	
90			**90**		**90**			**90**	0.77	**90**			**90**	
100			**100**		**100**			**100**	0.72	**100**			**100**	
110			**110**		**110**			**110**	0.68	**110**			**110**	
120			**120**		**120**			**120**	0.65	**120**			**120**	
pH			**150**		**pH**			**150**	0.58	**pH**			**150**	
TEMP		°C	**180**		**TEMP**		°C	**180**	0.54	**TEMP**		°C	**180**	
EC	2.67	MS/cm	**210**		**EC**	2.71	MS/cm	**210**	0.49	**EC**		µS/cm	**210**	
			240					**240**	0.46				**240**	
			300					**300**	0.42				**300**	
			360					**360**					**360**	

S/W/L:(mbch) 10.16

FORM 5 F

CONSTANT DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P22339	MAP REFERENCE:	S 30.03738	PROVINCE:	NORTHERN CAPE
BOREHOLE NO:	KAMIESBEES BH 2		E 18.47659	DISTRICT:	SPRINGBOK
ALT BH NO:	0			SITE NAME:	KAMIESBEES
ALT BH NO:	0				
BOREHOLE DEPTH:	17.25	DATUM LEVEL ABOVE CASING (m):	0.29	EXISTING PUMP:	0
WATER LEVEL (mbdl):	10.57	CASING HEIGHT: (magl):	0.28	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	15.10	DIAM PUMP INLET(mm):	170	PUMP TYPE:	WA 22-2

CONSTANT DISCHARGE TEST & RECOVERY

TEST STARTED				**TEST COMPLETED**					
DATE:	14/09/2019	TIME:	07h40	DATE:		TIME:		TYPE OF PUMP:	WA 22-2

					OBSERVATION HOLE 1			OBSERVATION HOLE 2			OBSERVATION HOLE 3	
					NR:	**BH 3**		NR:	**BH 1**		NR:	
DISCHARGE BOREHOLE					Distance(m);	9.1		Distance(m);	180		Distance(m);	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME MIN	RECOVERY (M)	TIME: (min)	Drawdown m	Recovery (m)	TIME: (min)	Drawdown (m)	Recovery	TIME: (min)	Drawdown (m)
1	0.08		**1**	2.67	**1**	0.07	2.65	**1**			**1**	
2	0.12		**2**	2.61	**2**	0.13	2.50	**2**			**2**	
3	0.16	0.89	**3**	2.58	**3**	0.19	2.54	**3**			**3**	
5	0.30		**5**	2.47	**5**	0.24	2.50	**5**			**5**	
7	0.33	1.00	**7**	2.45	**7**	0.33	2.42	**7**			**7**	
10	0.41		**10**	2.35	**10**	0.36	2.37	**10**			**10**	
15	0.49	1.02	**15**	2.25	**15**	0.48	2.25	**15**			**15**	
20	0.56		**20**	2.20	**20**	0.53	2.15	**20**			**20**	
30	0.65	1.04	**30**	2.06	**30**	0.62	2.07	**30**	0.00	0.43	**30**	
40	0.73		**40**	1.99	**40**	0.70	1.97	**40**	0.00	0.43	**40**	
60	0.82	1.01	**60**	1.87	**60**	0.78	1.87	**60**	0.00	0.43	**60**	
90	0.98		**90**	1.77	**90**	0.93	1.78	**90**	0.00	0.43	**90**	
120	1.06	1.03	**120**	1.69	**120**	1.02	1.69	**120**	0.00	0.43	**120**	
150	1.15		**150**	1.62	**150**	1.10	1.63	**150**	0.00	0.43	**150**	
180	1.20	1.01	**180**	1.57	**180**	1.17	1.57	**180**	0.02	0.43	**180**	
210	1.27		**210**	1.52	**210**	1.23	1.53	**210**		0.43	**210**	
240	1.32	1.05	**240**	1.50	**240**	1.28	1.48	**240**	0.04	0.43	**240**	
300	1.39		**300**	1.41	**300**	1.34	1.41	**300**	0.06	0.43	**300**	
360	1.45	1.02	**360**	1.35	**360**	1.42	1.34	**360**	0.08	0.43	**360**	
420	1.50		**420**	1.27	**420**	1.48	1.27	**420**	0.10	0.43	**420**	
480	1.55	1.00	**480**	1.20	**480**	1.50	1.21	**480**	0.10	0.43	**480**	
540	1.59		**540**	1.15	**540**	1.55	1.14	**540**	0.10	0.41	**540**	
600	1.64		**600**	1.10	**600**	1.61	1.11	**600**	0.11	0.41	**600**	
720	1.74		**720**	1.01	**720**	1.71	0.97	**720**	0.12	0.41	**720**	
840	1.87	1.03	**840**	0.95	**840**	1.82	0.95	**840**	0.14	0.41	**840**	
960	1.94		**960**	0.80	**960**	1.91	0.92	**960**	0.16	0.40	**960**	
1080	2.06	1.02	**1080**	0.88	**1080**	2.03	0.86	**1080**	0.18	0.40	**1080**	
1200	2.11		**1200**	0.81	**1200**	2.08	0.80	**1200**	0.20	0.39	**1200**	
1320	2.15	1.01	**1320**	0.73	**1320**	2.12	0.72	**1320**	0.21	0.38	**1320**	
1440	2.20		**1440**	0.67	**1440**	2.17	0.66	**1440**	0.23	0.37	**1440**	
1560	2.28	1.05	**1560**	0.65	**1560**	2.25	0.64	**1560**	0.25	0.37	**1560**	
1680	2.35		**1680**	0.63	**1680**	2.32	0.62	**1680**	0.27	0.36	**1680**	
1800	2.39	1.01	**1800**	0.60	**1800**	2.36	0.61	**1800**	0.29	0.36	**1800**	
1920	2.42		**1920**	0.56	**1920**	2.39	0.56	**1920**	0.29	0.36	**1920**	
2040	2.45	1.03	**2040**	0.50	**2040**	2.41	0.50	**2040**	0.31	0.35	**2040**	
2160	2.49		**2160**	0.47	**2160**	2.45	0.47	**2160**	0.32	0.33	**2160**	
2280	2.55	1.02	**2280**	0.45	**2280**	2.52	0.45	**2280**	0.33	0.33	**2280**	
2400	2.59		**2400**	0.42	**2400**	2.55	0.42	**2400**	0.36	0.32	**2400**	
2520	2.63	1.04	**2520**	0.39	**2520**	2.60	0.39	**2520**	0.39	0.32	**2520**	
2640	2.67		**2640**	0.37	**2640**	2.64	0.37	**2640**	0.41	0.31	**2640**	
2760	2.70	1.03	**2760**	0.35	**2760**	2.66	0.35	**2760**	0.43	0.31	**2760**	
2880	2.73		**2880**	0.31	**2880**	2.70	0.31	**2880**	0.45	0.30	**2880**	
3000			**3000**		**3000**			**3000**			**3000**	
3120			**3120**		**3120**			**3120**			**3120**	
3240			**3240**		**3240**			**3240**			**3240**	
3360			**3360**		**3360**			**3360**			**3360**	
3480			**3480**		**3480**			**3480**			**3480**	
3600			**3600**		**3600**			**3600**			**3600**	
3720			**3720**		**3720**			**3720**			**3720**	
3840			**3840**		**3840**			**3840**			**3840**	
3960			**3960**		**3960**			**3960**			**3960**	
4080			**4080**		**4080**			**4080**			**4080**	
4200			**4200**		**4200**			**4200**			**4200**	
4320			**4320**		**4320**			**4320**			**4320**	
Total time pumped(min):				2880		**W/L**	**10.3**		**W/L**	**12**		**W/L**
Average yield (l/s):				1.03								

FORM 5 F

BOREHOLE TEST RECORD SHEET

PROJ NO :	P22339	MAP REFERENCE:		PROVINCE:	NORTHERN CAPE
BOREHOLE NO:	KAMIESBEES BH 2		S 30.03738	DISTRICT:	SPRINGBOK
ALT BH NO:			E 18.47659	SITE NAME:	KAMIESBEES
ALT BH NO:					

BOREHOLE DEPTH:	17.25	DATUM LEVEL ABOVE CASING (m):	0.29	EXISTING PUMP:	Windpump
WATER LEVEL (mbdl)::	10.57	CASING HEIGHT (magl):	0.28	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	15.10	DIAM PUMP INLET(mm):	170		

CONSTANT DISCHARGE TEST

DISCHARGE BOREHOLE

No	TIME (MIN)	REAL TIME	MEASUREMENTS			No	TIME (MIN)	REAL TIME	MEASUREMENTS		
			pH	TEMP °C	EC MS/cm				pH	TEMP °C	EC µS/cm
1	1				2.71	43					
2	120				2.67	44					
3	240				2.68	45					
4	360				2.87	46					
5	480				2.87	47					
6	600				2.91	48					
7	720				2.93	49					
8	840				2.98	50					
9	960				3.01	51					
10	1080				3.04	52					
11	1200				3.08	53					
12	1320				3.07	54					
13	1440				0.06	55					
14	1800				3.09	56					
15	2160				3.09	57					
16	2520				3.11	58					
17	2880				3.15	59					
18	3240					60					
19	3600					61					
20	3960					62					
21	4320					63					
22	4680					64					
23	5040					65					
24	5400					66					
25	5760					67					
26	6120					68					
27	6480					69					
28	7200					70					
29	7560					71					
30	7920					72					
31	8280					73					
32	8640					74					
33	9000					75					
34	9360					76					
35	9720					77					
36	10080					78					
37	10440					79					
38	10800					80					
39	11160					81					
40	11520					82					
41	11880					83					
42	12240					84					

FORM 6 A

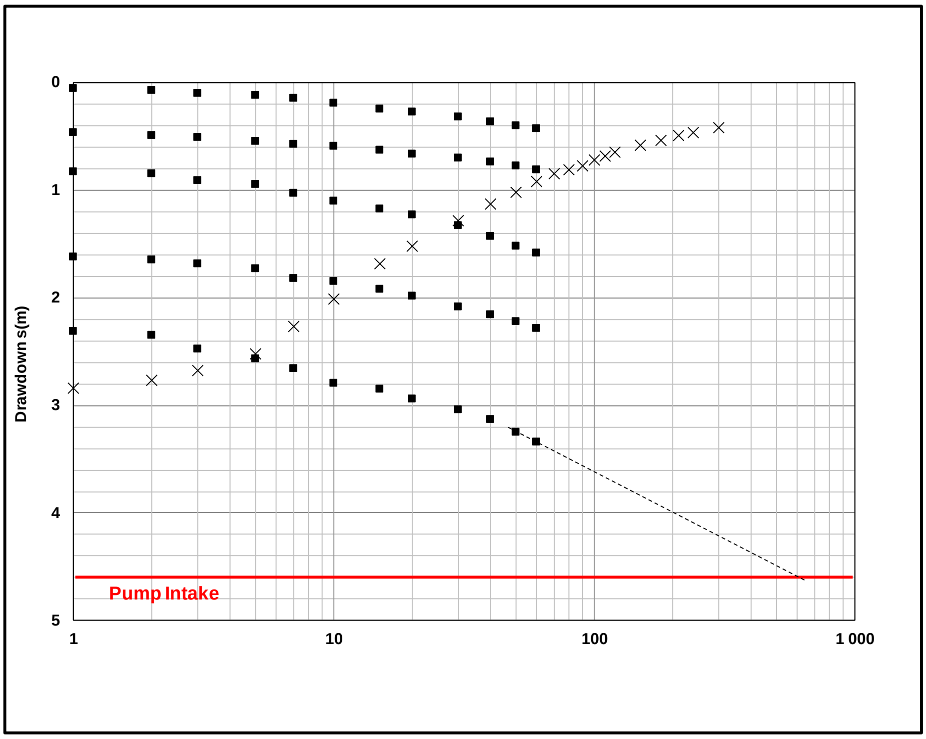
RECORD OF EXISTING EQUIPMENT AT BOREHOLE

BOREHOLE NO:	KAMIESBEES BH 2	DATE:	13/09/2019
DISTRICT:	SPRINGBOK	CONTRACTOR:	AB PUMPS
VILLAGE/FARM:	KAMIESBEES		
LOCALITY	NORTHERN CAPE		

ITEM(S) PARAMETERS	**DESCRIPTION OF EQUIPMENT**
TYPE OF INSTALLATION (Type of pump,eg, reciprocal cylinder,mono-type,handpump)	
Type	WINDPUMP
Name &model	RECAPROCAL CYLINDER 60 mm
Depth installed (m)	16.43
Element Diameter (m)	0.07
Element stroke (m)	0.6
PIPE COLUMNS & SHAFTS	
Diameter (mm)	50
Length / section (m)	3
No of sections	5 & 1M
Pipe material	GALVANISED STEEL
Shaft diameter (mm)	16
MOTORIZED PUMP INSTALLATION	
Type	
Name model of motor	
motor power rating	
motor pulley diam	
Pump pulley diam	
HANDPUMP	
Name / model	
WIND PUMP	
Wheel diam (m)	3
Mast height (m)	7
SOLAR PUMP	
No of panels	
Rating per panel	

ANCILLARY EQUIPMENT			
Storage tank (lt)		**Type riser**	
Stand height(m)		Class riser	HDPE
Water meter name		Diameter of riser	40
Water meter reading		Condition of riser	GOOD
Type of reservoir		**Pump rooms**	
Reservoir size		Type of pump room	
Reservoir condition		Material of enclosure	
Stand height (m)		Condition of enclosure	
DE-ESTABLISHMENT FROM SITE TO WHERE:			

STEP DRAWDOWN TEST DATA PLOT



▪ = Drawdown data.
X = Recovery data.

LOCALITY

NORTHERN CAPE
KAMIESBEES

BOREHOLE NO:

KAMIESBEES BH 2

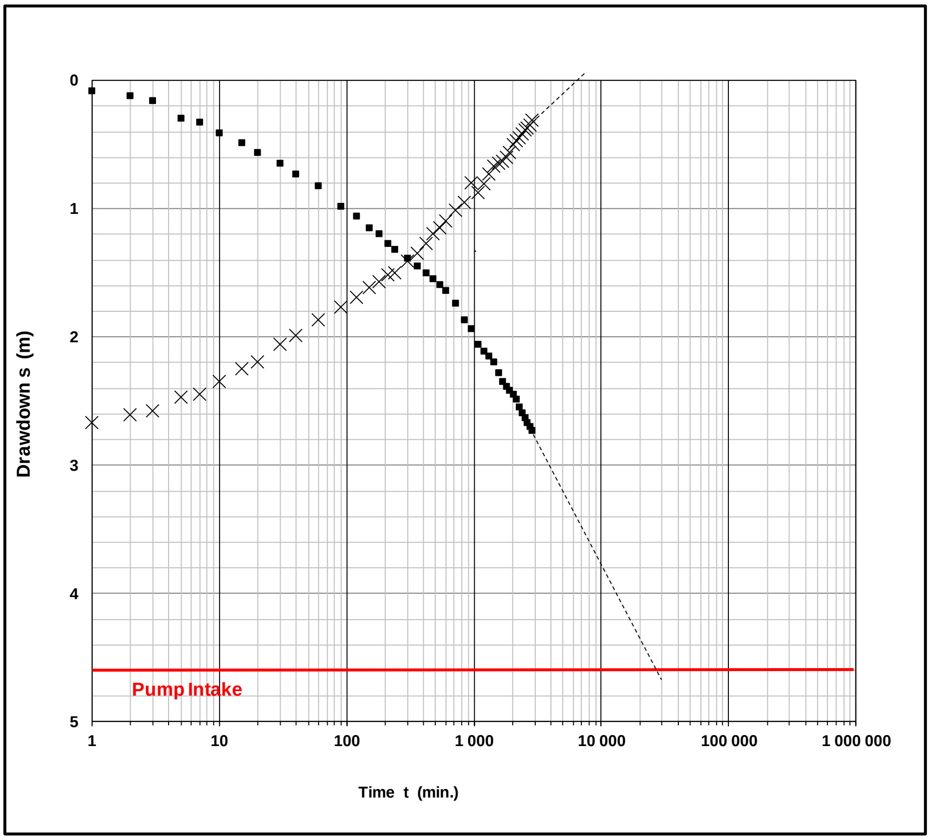
DATE TESTED

13/09/2019

DISCHARGE RATES (Q)

Q1 =	**0.41**	l/s
Q2 =	**0.82**	l/s
Q3 =	**1.52**	l/s
Q4 =	**2.03**	l/s
Q5 =	**2.54**	l/s
S.W.L =	**10.45**	m.b.g.l.

CONSTANT DISCHARGE TEST DATA PLOT



▪ = Drawdown data.
X = Recovery data.

PUMPED B.H. NO:

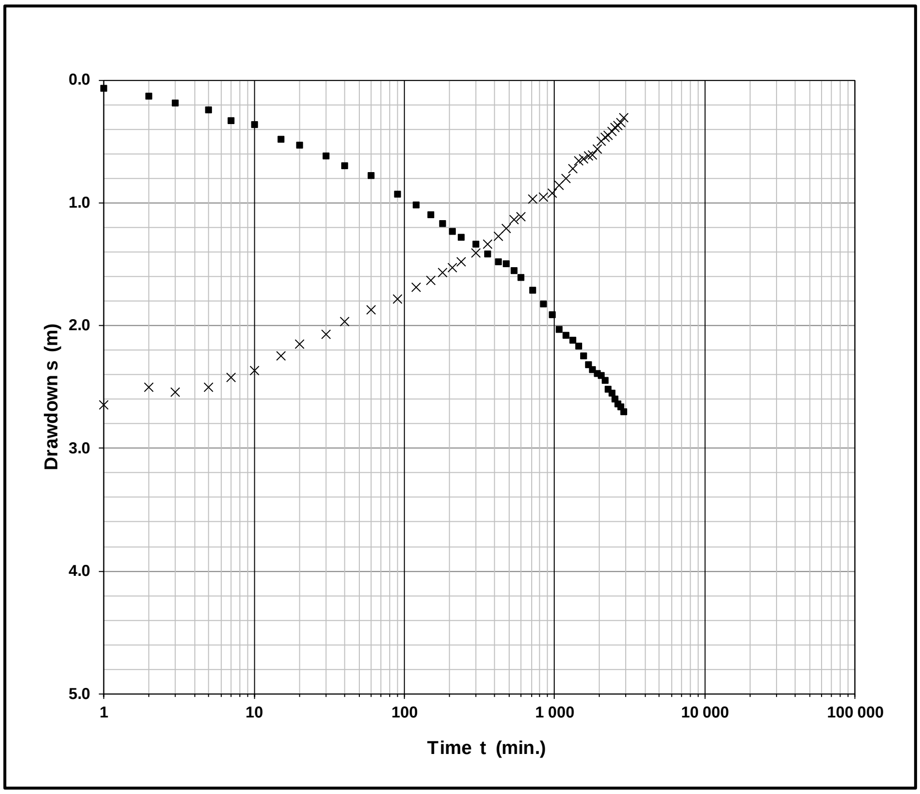
KAMIESBEES BH 2

DATE TESTED

14/09/2019

Q =	**1.0**	l/s.
S.W.L =	**10.57**	mbc

MONITORING BOREHOLE TEST DATA PLOT



▪ = Drawdown data.
X = Recovery data.

PUMPED B.H. NO:

KAMIESBEES BH 2

Pumping Borehole Discharge

Q = **1.0** l/s.

MONITORING B.H. NO:

BH 3

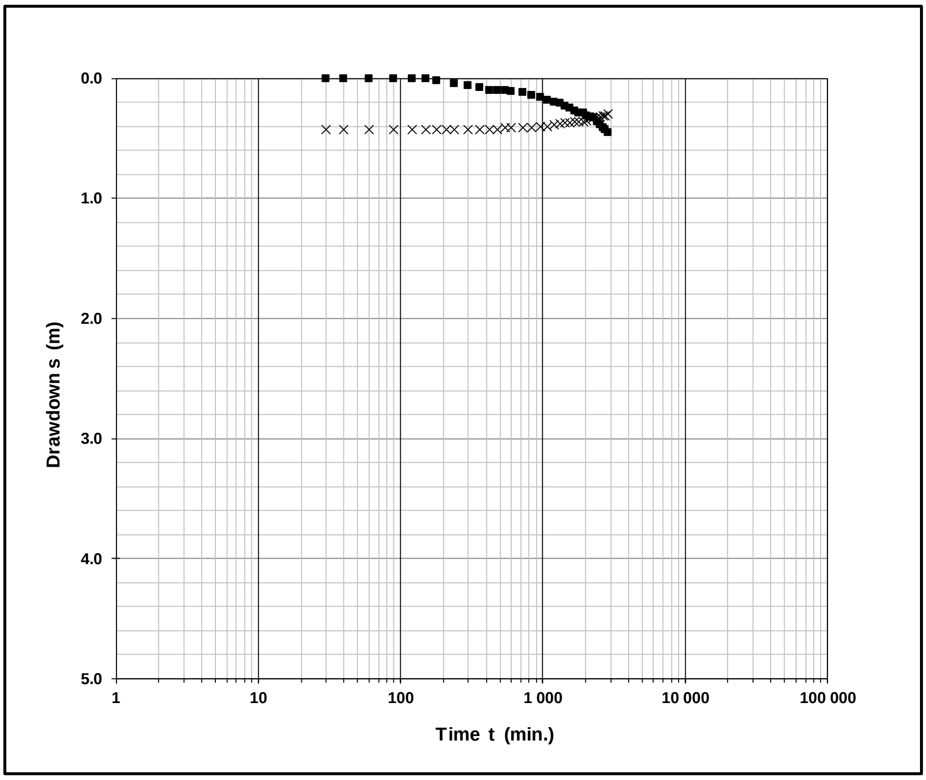
MONITORING TEST DATE

14/09/2019

S.W.L = **10.30** mbc

DISTANCE
(from pumping borehole)
r = **9** (m)

MONITORING BOREHOLE TEST DATA PLOT



▪ = Drawdown data.
X = Recovery data.

PUMPED B.H. NO:

KAMIESBEES BH 2

Pumping Borehole Discharge

Q = **1.0** l/s.

MONITORING B.H. NO:

BH 1

MONITORING TEST DATE

14/09/2019

S.W.L = **12.00** mbc

DISTANCE
(from pumping borehole)
r = **180** (m)

Telephone: 043-732 1211
Fax no: 043-732 1422
Fax to e-mail: 0866 717 732
E mail: office@abpumps.co.za

Abbreviations	
EC	Electrical conductivity
mbgl	Meters below ground level
mbch	Meters below casing height
mbdl	Meters below datum level
magl	Meters above ground level
L/S	Litres per second
RPM	Rates per minute
S/W/L	Static water level
µS/cm	Microsiemens per centimeter

BOREHOLE TEST RECORD

Ground water solutions t/a AB Pumps CC

PR0JECT #	P2239
BBR	ABEL
PRODUCTION BONUS:	ISAAC
	ZANELE
	KOLEN
EC meter number	

CONSULTANT: AARDBOOR

DISTRICT: SPRINGBOK

PROVINCE: NORTHERN CAPE

FARM / VILLAGE NAME : KAMIESBEES

DATE TESTED: 18/09/2019

MAP REFERENCE:

CO-ORDINATES:

FORMAT ON GPS:	hddd ° mm ' ss.s "		hddd ° mm.mmm '		hddd.ddddd °
LATITUDE:	° ' "	OR	° '	OR	S 30.03748 °
LONGITUDE:	° ' "		° '		E 18 47666 °

BOREHOLE NO: BH 3

TRANSMISSIVITY VALUE:

TYPE INSTALLATION: WINDMILL

BOREHOLE DEPTH: (mbgl) 30.20

COMMENTS: THE FARM OWNER REMOVED THE EXISTING PUMP HIMSELF,

SAMPLE INSTRUCTIONS :

Water sample taken	Yes	No	Test for:	macro	bacterio-logical	
Date sample taken	19/09/2019		If consultant took sample, give name:			
Time sample taken	08H00					

DATA CAPTURED BY:	ELZAAN
DATA CHECKED BY:	AVN

CONSULTANT GUIDELINES

BOREHOLE DEPTH:		m	STEP 1:		l/s	WATER STRIKE 1:			m
BLOW YIELD:		m	STEP 2:		l/s	WATER STRIKE 2:			m
STATIC WATER LEVEL:		m	STEP 3:		l/s	WATER STRIKE 3:			m
PUMP INSTALLATION DEPTH:		m	STEP 4:		l/s	COMMENTS:			
RECOVERY:			STEP 5:		l/s				
AFTER STEPS:		h	STEP 6:		l/s	TELEPHONE NUMBERS PHONE : (NAME & TEL)			
AFTER CONSTANT:		h	STEP DURATION:		min				

DESCRIPTION:	UNIT	QTY		UNIT	QTY
STRAIGHTNESS TEST:	NO	0	BOREHOLE DEPTH AFTER TEST:	M	30.20
VERTICALLY TEST:	NO	0	BOREHOLE WATER LEVEL AFTER TEST: (mbch)	M	10.99
CASING DETECTION:	NO	RUST	SAND/GRAVEL/SILT PUMPED?	YES/NO	0
SUPPLIED NEW STEEL BOREHOLE COVER:	NO	0	DATA REPORTING AND RECORDING	NO	1
BOREHOLE MARKING	NO	1	SLUG TEST:	NO	0
SITE CLEANING & FINISHING	NO	1	LAYFLAT (M):	M	50
LOGGERS FOR WATERLEVEL MONITORING	NO	1	LOGGERS FOR pH AND EC:	NO	0

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

NAME: ________________ **SIGNATURE:** _____________

DESIGNATION: ________________ **DATE:** _____________

BOREHOLE TEST CONTROL SHEET

Groundwater Solutions t/a AB PUMPS

Borehole number:	BH 3	Old / Alternative number:	
Contractor:	AB PUMPS	Supervisor:	ABEL
Operator:	ISAAC	Rig number & Type rig:	27

EXISTING EQUIPMENT

Type pump	Depth	Condition	Drive unit	Condition	Pump house	Condition	Remarks

TESTING EQUIPMENT

Pump type	Depth installed (m)	Date & time (started)	Date & time (completed)
WA 22.2	27.10	18/09/2019 13H00	18/09/2019 21H00

MULTI-RATE OR STEPTEST DETAILS

STEP	DURATION (MIN)	RECOVERY (MIN)	YIELD (L/S)		DRAWDOWN (m)
1	60		1.04	l/s	0.88
2	60		2.02	l/s	1.74
3	60		4.04	l/s	3.46
4	60	240	5.70	l/s	6.11
5				l/s	
6				l/s	
7				l/s	
8				l/s	
Calibration:	60	60		l/s	
TOTAL:	300	300		l/s	
COMMENT:					

CONSTANT RATE DISCHARGE TEST

Pump type	Depth installed (m)	Date & time (started)	Date & time (completed)
WA 22.2	27.10		
Yield l/s	**Drawdown (m)**	**Duration (min)**	**Recovery (min)**
0.00		0	
Total: (Multi-rate and Constant Discharge rate)		300	300
COMMENT:			

MAINTENANCE

Work time:	hour	Transport existing equipm.	Km	Travelling (To fix);	Km
List of parts replaced or repaired:					

	Borehole number	Duration (min) CONSTANT	Drawdown (m)	Hand/logger	Distance (m)
Observation Hole 1					0
Observation Hole 2					0
Observation Hole 3					0
Observation Hole 4					
Observation Hole 5					

GENERAL

ESTABLISHMENT	From:	***KAMIESBEE***	To:			
Site Move	From project#	2239	To #:	P2239	Travelling km:	0.91
	Village	Borehole no	Village	Borehole no		
	KAMIESBEES	BH2	KAMIESBEES	BH 3		
Maintenance:	Work time hr		Parts repaired/ replaced		Travelling km	
After test measurements	Water level	10.99	Borehole depth	30.20	Casing depth m	RUST

Water level before installing test pump: (mbch)		10.56	
Depth before installing test pump:		30.20	
Testpump Installed	**Once** /Twice /More	Reason:	
Installed Testpump	**<10 l/s** / >10ls/s	Reason:	
Was existing equipment re-installed:		**No:**	If not where was it left:
GPS Unit number:			
EC Unit number:		0	
Remarks:			

Signed Contractor:	Signed Consultant:

FORM 5 D

CALIBRATION TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P2239	MAP REFERENCE:	0	PROVINCE:	NORTHERN CAPE
BOREHOLE NO:	BH 3			DISTRICT:	SPRINGBOK
ALT BH NO:	0			SITE NAME:	KAMIESBEES
ALT BH NO:					
BOREHOLE DEPTH	30.20	DATUM LEVEL ABOVE CASING (m):	0.26	EXISTING PUMP:	0
WATER LEVEL (mbdl):	10.82	CASING HEIGHT (magl):	0.32	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	27.10	DIAM PUMP INLET (mm):	170.00	PUMP TYPE:	WA 22.2

CALIBRATION TEST AND RECOVERY

DISCHARGE RATE 1 — RPM 363 — DATE: 17/09/2019 TIME: 10H30

TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	0.04		1	
2	0.06		2	
3	0.09	0.71	3	
5	0.19		5	
7	0.26	1.03	7	
10	0.36		10	
15	0.49	1.02	15	
			20	
			30	
			40	
			50	
			60	
			70	
			80	
			90	
			100	
			110	
			120	
			150	

DISCHARGE RATE 2 — RPM 365 — DATE: 17/09/2019 TIME: 10H45

TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	0.52	1.60	1	
2	0.61	2.01	2	
3	0.72		3	
5	0.83	2.03	5	
7	0.91		7	
10	1.01	2.02	10	
15	1.13		15	
			20	
			30	
			40	
			50	
			60	
			70	
			80	
			90	
			100	
			110	
			120	
			150	

DISCHARGE RATE 3 — RPM 975 — DATE: 17/09/201 TIME: 11H00

TIME (MIN)	DRAW DOWN (M	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	1.18		1	
2	1.39	4.01	2	
3	1.55		3	
5	1.79	4.08	5	
7	1.96		7	
10	2.17	4.06	10	
15	2.34		15	
			20	
			30	
			40	
			50	
			60	
			70	
			80	
			90	
			100	
			110	
			120	
			150	

DISCHARGE RATE 4 — RPM 1491 — DATE: 17/09/2019 TIME: 11H15

TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	2.44		1	3.06
2	2.49		2	2.98
3	2.59	5.20	3	2.89
5	2.75		5	2.76
7	2.90	5.70	7	2.61
10	3.08		10	2.38
15	3.32	5.68	15	1.89
			20	1.48
			30	1.09
			40	0.87
			50	0.75
			60	0.66
			70	
			80	
			90	
			100	
			110	
			120	
			150	

DISCHARGE RATE 5 — RPM — DATE: TIME:

TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1			1	
2			2	
3			3	
5			5	
7			7	
10			10	
15			15	
			20	
			30	
			40	
			50	
			60	
			70	
			80	
			90	
			100	
			110	
			120	
			150	

DISCHARGE RATE 6 — RPM — DATE: TIME:

TIME (MIN)	DRAW DOWN (M	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1			1	
2			2	
3			3	
5			5	
7			7	
10			10	
15			15	
			20	
			30	
			40	
			50	
			60	
			70	
			80	
			90	
			100	
			110	
			120	
			150	

COMMENTS:

S/W/L: (mbch) 10.56

FORM 5 E

STEPPED DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P2239	MAP REFERENCE:	0	PROVINCE:	NORTHERN CAPE
BOREHOLE NO:	BH 3			DISTRICT:	SPRINGBOK
ALT BH NO:	0			SITE NAME:	KAMIESBEES
ALT BH NO:	0				
BOREHOLE DEPTH (m)	30.20	DATUM LEVEL ABOVE CASING (m):	0.26	EXISTING PUMP:	0
WATER LEVEL (mbdl):	10.82	CASING HEIGHT: (magl):	0.32	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	27.10	DIAM PUMP INLET (mm):	170.00	PUMP TYPE:	WA 22.2

STEPPED DISCHARGE TEST & RECOVERY

DISCHARGE RATE 1			RPM	410	DISCHARGE RATE 2			RPM	398	DISCHARGE RATE 3			RPM	1002
DATE:	18/09/2019	TIME:	13H00		DATE:	18/09/2019	TIME:	14H00		DATE:	18/09/201	TIME:	15H00	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	0.11		**1**		**1**	0.95	1.94	**1**		**1**	1.81		**1**	
2	0.21	1.05	**2**		**2**	1.01		**2**		**2**	1.85	4.03	**2**	
3	0.29		**3**		**3**	1.06	2.03	**3**		**3**	1.90		**3**	
5	0.32	1.03	**5**		**5**	1.13		**5**		**5**	2.00	4.04	**5**	
7	0.39		**7**		**7**	1.19	2.01	**7**		**7**	2.10		**7**	
10	0.45	1.04	**10**		**10**	1.28		**10**		**10**	2.22	4.02	**10**	
15	0.55		**15**		**15**	1.36	2.01	**15**		**15**	2.39		**15**	
20	0.60	1.03	**20**		**20**	1.44		**20**		**20**	2.52	4.03	**20**	
30	0.70		**30**		**30**	1.55	2.03	**30**		**30**	2.74		**30**	
40	0.77	1.03	**40**		**40**	1.64		**40**		**40**	2.97	4.01	**40**	
50	0.82		**50**		**50**	1.69	2.02	**50**		**50**	3.20		**50**	
60	0.88	1.04	**60**		**60**	1.74		**60**		**60**	3.46	4.04	**60**	
70			**70**		**70**			**70**		**70**			**70**	
80			**80**		**80**			**80**		**80**			**80**	
90			**90**		**90**			**90**		**90**			**90**	
100			**100**		**100**			**100**		**100**			**100**	
110			**110**		**110**			**110**		**110**			**110**	
120			**120**		**120**			**120**		**120**			**120**	
pH			**150**		**pH**			**150**		**pH**			**150**	
TEMP		°C	**180**		**TEMP**		°C	**180**		**TEMP**		°C	**180**	
EC	2.81	MS/cm	**210**		**EC**	2.86	MS/cm	**210**		**EC**	2.91	MS/cm	**210**	

DISCHARGE RATE 4			RPM		DISCHARGE RATE 5			RPM		DISCHARGE RATE 6			RPM	
DATE:	18/09/2019	TIME:	16H00		DATE:		TIME:			DATE:		TIME:		
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)	TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME (MIN)	RECOVERY (M)
1	3.59		**1**	5.55	**1**			**1**		**1**			**1**	
2	3.68	4.87	**2**	5.37	**2**			**2**		**2**			**2**	
3	3.76		**3**	5.06	**3**			**3**		**3**			**3**	
5	3.99	5.68	**5**	4.68	**5**			**5**		**5**			**5**	
7	4.18		**7**	4.39	**7**			**7**		**7**			**7**	
10	4.40	5.69	**10**	4.07	**10**			**10**		**10**			**10**	
15	4.70		**15**	3.53	**15**			**15**		**15**			**15**	
20	4.92	5.72	**20**	3.15	**20**			**20**		**20**			**20**	
30	5.40		**30**	2.82	**30**			**30**		**30**			**30**	
40	5.66	5.72	**40**	2.55	**40**			**40**		**40**			**40**	
50	5.90		**50**	2.33	**50**			**50**		**50**			**50**	
60	6.11	5.70	**60**	2.13	**60**			**60**		**60**			**60**	
70			**70**	1.88	**70**			**70**		**70**			**70**	
80			**80**	1.72	**80**			**80**		**80**			**80**	
90			**90**	1.53	**90**			**90**		**90**			**90**	
100			**100**	1.37	**100**			**100**		**100**			**100**	
110			**110**	1.25	**110**			**110**		**110**			**110**	
120			**120**	1.17	**120**			**120**		**120**			**120**	
pH			**150**	1.03	**pH**			**150**		**pH**			**150**	
TEMP		°C	**180**	0.86	**TEMP**		°C	**180**		**TEMP**		°C	**180**	
EC	3.42	µS/cm	**210**	0.69	**EC**		µS/cm	**210**		**EC**		µS/cm	**210**	
			240	0.58				**240**					**240**	
			300					**300**					**300**	
			360					**360**					**360**	

S/W/L:(mbch) 10.56

FORM 5 F

CONSTANT DISCHARGE TEST & RECOVERY

BOREHOLE TEST RECORD SHEET

PROJ NO :	P2239	MAP REFERENCE:	S 30.03748	PROVINCE:	NORTHERN CAPE
BOREHOLE NO:	BH 3		E 18 47666	DISTRICT:	SPRINGBOK
ALT BH NO:	0			SITE NAME:	KAMIESBEES
ALT BH NO:	0				
BOREHOLE DEPTH:	30.20	DATUM LEVEL ABOVE CASING (m):	0.26	EXISTING PUMP:	0
WATER LEVEL (mbdl):		CASING HEIGHT: (magl):	0.32	CONTRACTOR:	AB PUMPS
DEPTH OF PUMP (m):	27.10	DIAM PUMP INLET(mm):	170	PUMP TYPE:	WA 22.2

CONSTANT DISCHARGE TEST & RECOVERY

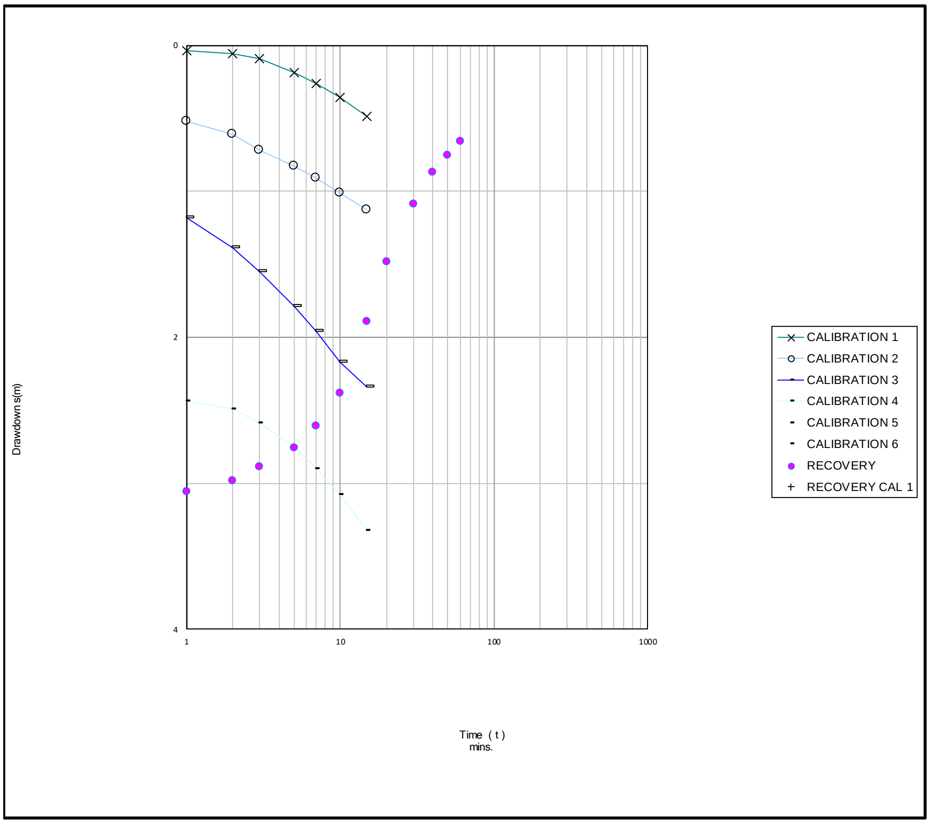
TEST STARTED				TEST COMPLETED					
DATE:		TIME:		DATE:		TIME:		TYPE OF PUMP:	WA 22.2

					OBSERVATION HOLE 1			OBSERVATION HOLE 2			OBSERVATION HOLE 3	
					NR:			NR:			NR:	
DISCHARGE BOREHOLE					Distance(m);			Distance(m);			Distance(m);	
TIME (MIN)	DRAW DOWN (M)	YIELD (L/S)	TIME MIN	RECOVERY (M)	TIME: (min)	Drawdown m	Recovery (m)	TIME: (min)	Drawdown (m)	Recovery	TIME: (min)	Drawdown (m)
1			**1**		**1**			**1**			**1**	
2			**2**		**2**			**2**			**2**	
3			**3**		**3**			**3**			**3**	
5			**5**		**5**			**5**			**5**	
7			**7**		**7**			**7**			**7**	
10			**10**		**10**			**10**			**10**	
15			**15**		**15**			**15**			**15**	
20			**20**		**20**			**20**			**20**	
30			**30**		**30**			**30**			**30**	
40			**40**		**40**			**40**			**40**	
60			**60**		**60**			**60**			**60**	
90			**90**		**90**			**90**			**90**	
120			**120**		**120**			**120**			**120**	
150			**150**		**150**			**150**			**150**	
180			**180**		**180**			**180**			**180**	
210			**210**		**210**			**210**			**210**	
240			**240**		**240**			**240**			**240**	
300			**300**		**300**			**300**			**300**	
360			**360**		**360**			**360**			**360**	
420			**420**		**420**			**420**			**420**	
480			**480**		**480**			**480**			**480**	
540			**540**		**540**			**540**			**540**	
600			**600**		**600**			**600**			**600**	
720			**720**		**720**			**720**			**720**	
840			**840**		**840**			**840**			**840**	
960			**960**		**960**			**960**			**960**	
1080			**1080**		**1080**			**1080**			**1080**	
1200			**1200**		**1200**			**1200**			**1200**	
1320			**1320**		**1320**			**1320**			**1320**	
1440			**1440**		**1440**			**1440**			**1440**	
1560			**1560**		**1560**			**1560**			**1560**	
1680			**1680**		**1680**			**1680**			**1680**	
1800			**1800**		**1800**			**1800**			**1800**	
1920			**1920**		**1920**			**1920**			**1920**	
2040			**2040**		**2040**			**2040**			**2040**	
2160			**2160**		**2160**			**2160**			**2160**	
2280			**2280**		**2280**			**2280**			**2280**	
2400			**2400**		**2400**			**2400**			**2400**	
2520			**2520**		**2520**			**2520**			**2520**	
2640			**2640**		**2640**			**2640**			**2640**	
2760			**2760**		**2760**			**2760**			**2760**	
2880			**2880**		**2880**			**2880**			**2880**	
3000			**3000**		**3000**			**3000**			**3000**	
3120			**3120**		**3120**			**3120**			**3120**	
3240			**3240**		**3240**			**3240**			**3240**	
3360			**3360**		**3360**			**3360**			**3360**	
3480			**3480**		**3480**			**3480**			**3480**	
3600			**3600**		**3600**			**3600**			**3600**	
3720			**3720**		**3720**			**3720**			**3720**	
3840			**3840**		**3840**			**3840**			**3840**	
3960			**3960**		**3960**			**3960**			**3960**	
4080			**4080**		**4080**			**4080**			**4080**	
4200			**4200**		**4200**			**4200**			**4200**	
4320			**4320**		**4320**			**4320**			**4320**	
Total time pumped(min):						**W/L**			**W/L**			**W/L**
Average yield (l/s):												

FORM 6 A			
RECORD OF EXISTING EQUIPMENT AT BOREHOLE			
BOREHOLE NO:	BH 3	DATE:	
DISTRICT:	SPRINGBOK	CONTRACTOR:	AB PUMPS
VILLAGE/FARM:	KAMIESBEES		
LOCALITY	NORTHERN CAPE		

ITEM(S) PARAMETERS	**DESCRIPTION OF EQUIPMENT**
TYPE OF INSTALLATION (Type of pump,eg, reciprocal cylinder,mono-type,handpump)	
Type	RECIPROCAL CYLINDER
Name &model	WINDMILL
Depth installed (m)	19.6
Element Diameter (m)	0.07
Element stroke (m)	0.6
PIPE COLUMNS & SHAFTS	
Diameter (mm)	
Length / section (m)	
No of sections	
Pipe material	
Shaft diameter (mm)	
MOTORIZED PUMP INSTALLATION	
Type	40
Name model of motor	3
motor power rating	
motor pulley diam	GALVANISED STEEL
Pump pulley diam	
HANDPUMP	
Name / model	
WIND PUMP	
Wheel diam (m)	3
Mast height (m)	6
SOLAR PUMP	
No of panels	
Rating per panel	

ANCILLARY EQUIPMENT			
Storage tank (lt)		**Type riser**	
Stand height(m)		Class riser	HDPE
Water meter name		Diameter of riser	40MM
Water meter reading		Condition of riser	GOOD
Type of reservoir		**Pump rooms**	
Reservoir size		Type of pump room	
Reservoir condition		Material of enclosure	
Stand height (m)		Condition of enclosure	
DE-ESTABLISHMENT FROM SITE TO WHERE:			



CALIBRATION TEST DATA PLOT

X = Drawdown data. CAL 1
O = Drawdown data. CAL 2
▬ = Drawdown data. CAL 3
+ = Recovery data.

LOCALITY

NORTHERN CAPE
KAMIESBEES

BOREHOLE NO:

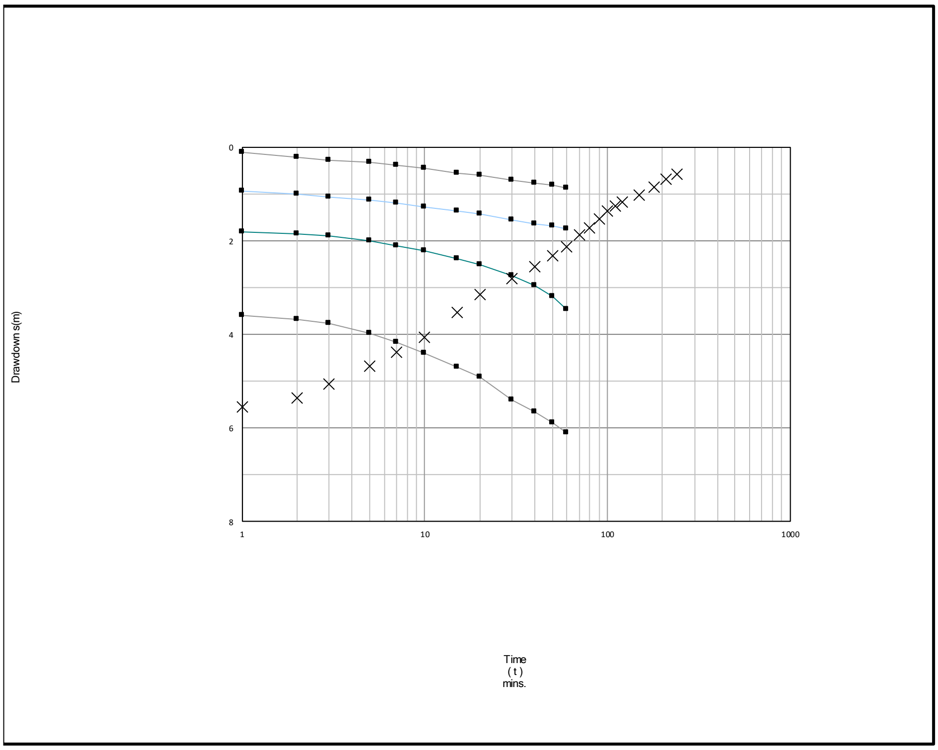
BH 3

DATE TESTED

17/09/2019

DISCHARGE RATES (Q)

Q1 =	0.71	l/s
Q2 =	2.01	l/s
Q3 =	0.0	l/s
Q4 =	5.2	l/s
Q5 =	0.0	l/s
Q6 =	0.0	l/s
S.W.L =	10.56	m.b.g.l.



STEP DRAWDOWN TEST DATA PLOT

▪ = Drawdown data.
X = Recovery data.

LOCALITY

NORTHERN CAPE
KAMIESBEES

BOREHOLE NO:

BH 3

DATE TESTED

18/09/2019

DISCHARGE RATES (Q)

Q1 =	1.04	l/s
Q2 =	2.02	l/s
Q3 =	4.04	l/s
Q4 =	5.70	l/s
Q5 =	0.00	l/s
S.W.L =	10.82	m.b.g.l.

Photo's of boreholes on site

BH2 & 3

BH1

Appendix B: Pumping Test Analysis Results

FC-METHOD : Estimation of the sustainable yield of a borehole

Kamiebees BH1 | Main | Deriv | Inflection point method

Extrapolation time in years = (enter)	8	4204800	Extrapol.time in minutes
Effective borehole radius (r_e) = (enter)	9.22	9.22	Est. r_e / From r(e) sheet
Q (l/s) from pumping test =	3	4.40E-03	S-late / Change r_e
s_a (available drawdown), sigma_s = (enter)	20.0		Sigma_s from risk / Down
Annual effective recharge (mm) =	0.16	21.60	s_available working drawdown(m)
t(end) and s(end) of pumping test =	2880	21.56	End time and drawdown of test
Average maximum derivative = (enter)	14.1	14.1	Estimate of average of max deriv
Average second derivative = (enter)	0.1	0.1	Estimate of average second deriv
Derivative at radial flow period = (enter)	3.78	3.78	Read from derivative graph
	T-early[m²/d] =	12.54	Aqui. thick (m) 20
T and S estimates from derivatives	T-late [m²/d] =	3.36	Est. S-late = 1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	4.40E-03	S-estimate could be wrong

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

Maximum influence of boundaries at long time

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	72.16	116.90	161.63	295.85
Q_sust (l/s) =	0.90	0.55	0.40	0.22
	Best case	→		Worst case

Average Q_sust (l/s) = 0.46

with standard deviation= 0.29

(If no information exists about boundaries skip advanced solution and go to final recommendation)

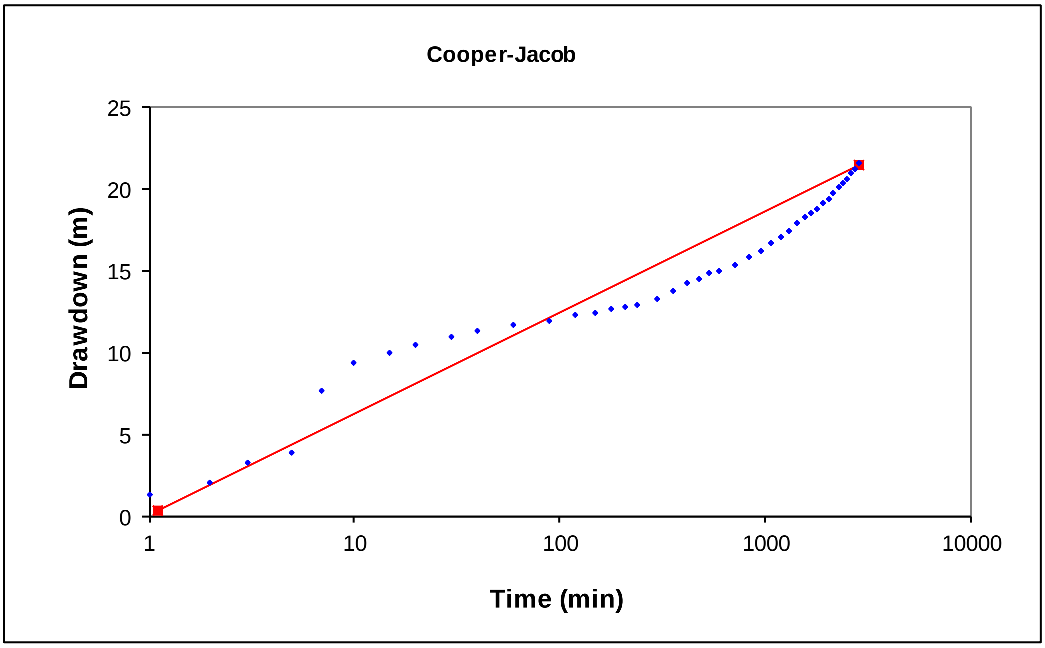
Cooper-Jacob method

Main | Theis | Cooper-Jacob 2

Kamiebees BH1

T(m²/d) =	7.7	r_e (m)=	5.82	5.82
S =	3.48E-04	Q (l/s) =	3	

	No boundaries	1 no-flow	2 no-flow	Closed	
Q_sust	1.06	0.53	0.35	0.27	including influence of bh's
Avg. Q_sust =	0.55	std. dev =	0.36		



FC - Non Linear Method to estimate Q_Sust

Top

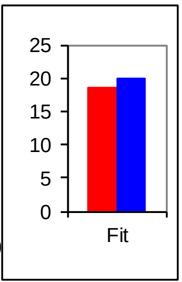
$s(t)=AQ+BQ^e(\log(t))^G+CQ^p\log(t)$

Fit stepdraw down data first: Manual - use buttons OR : Auto - solver

comment

Extrapolation	
Ext_pol time (min)	
4204800	
Q (L/s)	Drawdown (m)
1.7	18.50

Fit graph →



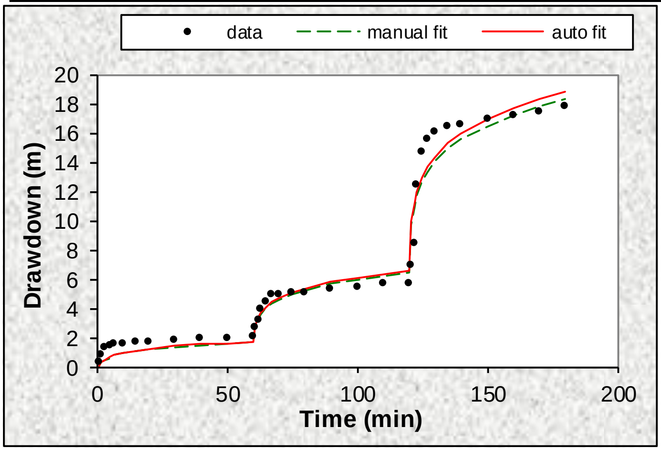
skin effect	Non-Darcian loss		Darcian loss		
A	C	p	B	n	e
2.57E-04	0.00E+00	3	2.63E-04	1.76	1.82
2.66E-04	0.00E+00	3.49	2.66E-04	1.76	1.82

☐ Manual param ☑ Auto fit param

(Choose which parameter set to use for Q_sust)

Available drawdown (m) =	20		
No boundaries	1 no-flow	2 no-flow	Closed
1.7	0.9	0.6	0.3

Q_Sust (L/s)= **0.69** std.dev = 0.61



Barker- Method

Main

Kamiebees BH1

r =	5.00	Extpol. t (y)	8	avail. draw	20.00

Manual Fit — NO

K_f [m/d]	S_f [1/m]	b	n
35395	1.49E-05	0.1	1.54

Automatic Fit with SOLVER — YES

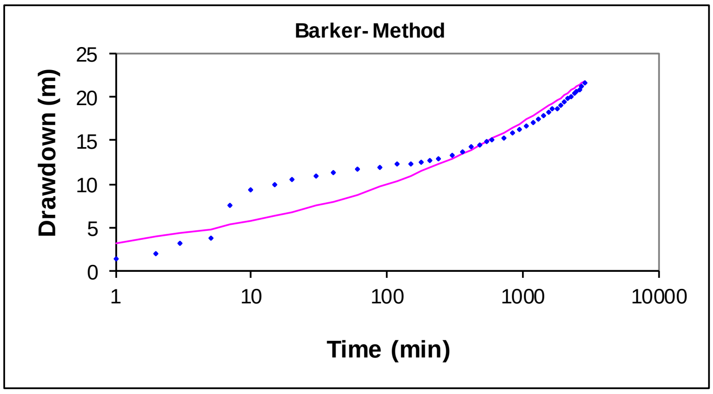
	Min	Value	Max		
K_f [m/d] =	1	35395.342	100000		
S_f [1/m] =	1.00E-07	1.49E-05	0.005	Min, Max time to fit (min)	
b =	0.1	0.1000075	100	min	max
n =	1	1.5394754	3	0	10000

	K_f [m/d]	S_f [1/m]	b	n	N
Fit Parameters	35395.34	1.49E-05	0.10	1.54	0.2303

RMSE = 108.8993

	No boundaries	1 no-flow	2 no-flow	Closed
sWell(Extrapol.time)	123.76	213.23	257.97	302.71
Q_sust	0.48	0.28	0.23	0.20

Fractal n = 1.54 **Average Q-sust (l/s)=** 0.30 std. dev = 0.13



Final Fit Parameters	
K_f [m/d] =	35395.34
S_f [1/m] =	1.49E-05
$b^{(3-n)}$ =	0.03
n =	1.54
b =	0.10
K_f*$b^{(3-n)}$	1225.94

Recovery Method Kamiebees BH1

Safe yield = $\frac{\text{Volume Pumped}}{\text{(Days pumped + Days Full Recovery)}}$

Pump Rate		L/s
CDT Duration	3.25	h
Steps Abstraction	27	m^3
Pump duration	0.179166667	d
Full recovery	1200	min
	0.83	d
Safe yield	26	m^3/d
	0.30	L/s

Summary | Main | **KG2**

Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)		Late T (m^2/d)		S	AD used
☑	**Basic FC**	0.52	0.33	3		2.4		4.40E-03	40.0
☐	**Advanced FC**								
☐	**FC inflection point**								
☑	**Cooper-Jacob**	0.63	0.41			3.3		4.91E-04	40.0
☑	**FC Non-Linear**	0.45	0.40			3.0		5.40E-05	40.0
☑	**Recovery**	0.79		9.2		2.8			
☑	**Barker**	0.54	0.34	K_f =	1		S_s =	7.07E-04	40.0
	Average Q_sust (l/s)	**0.59**	**0.13**	b =	3.35	Fractal dimension n =		1.94	

Recommended abstraction rate (L/s)	**0.60**	for 24 hours per day	2.72E-04	2.88
Amount of water allowed to be abstracted per month	**1555.2**	m^3		
Amount of water allowed to be abstracted per day	**51**	m^3		
Amount of water allowed to be abstracted per hour	**2.2**	m^3		
Is the water suitable for domestic use (Yes/No)				

Recommended pump depth below surface (m)	**65**
Total casing length (m)	**70**
Blow yield (l/s)	**N.A.**
Low level pump protection depth (mbgl)	**60**
Depth of borehole (m)	**70**
Pre-pumping rest water level (mbgl)	**14.83**

Management recommendations

Pump borehole at maximum 2.2 m^3/h for 24 hours per day

Note: Data extrapolated for 15 years and available drawdown taken as 40 m.

FC-METHOD : Estimation of the sustainable yield of a borehole

Kamiebees BH2 | Main | Deriv | Inflection point method

Extrapolation time in years = (enter)	8	4204800	Extrapol.time in minutes
Effective borehole radius (r_e) = (enter)	24.75	24.75	Est. r_e / From r(e) sheet
Q (l/s) from pumping test =	1	4.40E-03	S-late / Change r_e
s_a (available drawdown), sigma_s = (enter)	4.5		Sigma_s from risk / Down
Annual effective recharge (mm) =	0.16	6.10	s_available working drawdown(m)
t(end) and s(end) of pumping test =	2880	2.73	End time and drawdown of test
Average maximum derivative = (enter)	2.0	2.0	Estimate of average of max deriv
Average second derivative = (enter)	0.0	0.0	Estimate of average second deriv
Derivative at radial flow period = (enter)	0.58	0.58	Read from derivative graph
	T-early[m^2/d] =	27.10	Aqui. thick (m) 5
T and S estimates from derivatives	T-late [m^2/d] =	8.06	Est. S-late = 2.75E-04
(To obtain correct S-value, use program RPTSOLV)	S-late =	4.40E-03	S-estimate could be wrong

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)
(No values of T and S are necessary)

Maximum influence of boundaries at long time

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	12.49	18.70	24.91	43.54
Q_sust (l/s) =	0.49	0.33	0.24	0.14
	Best case	→		Worst case

Average Q_sust (l/s) = 0.27
with standard deviation= 0.15

(If no information exists about boundaries skip advanced solution and go to final recommendation)

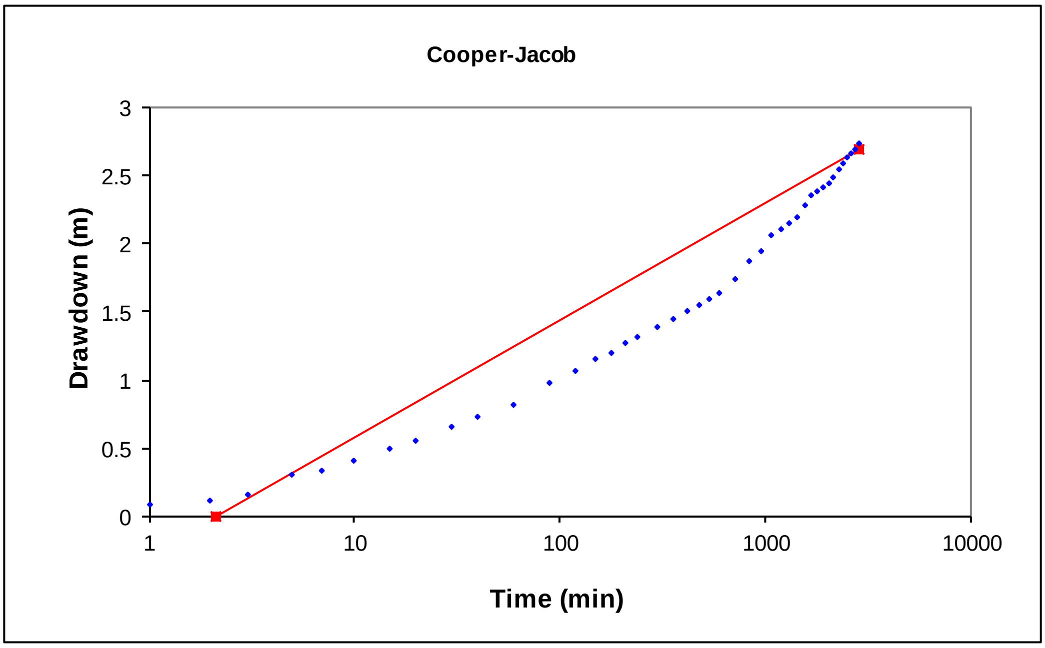
Cooper-Jacob method

Main | Theis | Cooper-Jacob 2

Kamiebees BH2

T(m^2/d) =	**18.4**	r_e (m)=	18.91	**18.91**
S =	**1.69E-04**	Q (l/s) =	1	

	No boundaries	1 no-flow	2 no-flow	Closed	
Q_sust	0.22	0.11	0.07	0.05	including influence of bh's
Avg. Q_sust =	**0.11**	std. dev =	0.07		



FC - Non Linear Method to estimate Q_Sust

Top

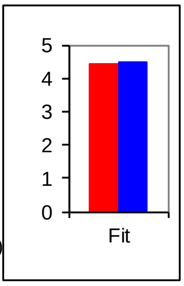
$s(t)=AQ+BQ^{e}(\log(t))^{G}+CQ^{p}\log(t)$

Fit stepdraw down data first: Manual - use buttons OR : Auto - solver

comment

Extrapolation	
Ext_pol time (min)	
4204800	
Q (L/s)	Drawdown (m)
0.8	4.43

Fit graph →



skin effect	Non-Darcian loss		Darcian loss		
A	C	p	B	n	e
1.76E-03	0.00E+00	3	3.16E-03	1.14	1.03
2.59E-03	0.00E+00	3.49	2.90E-03	1.14	1.03

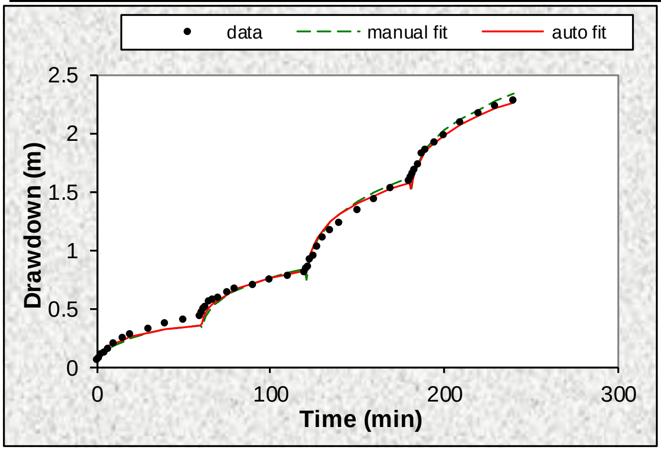
☐ Manual param ☑ Auto fit param

(Choose w hich parameter set to use for Q_sust)

Available drawdown (m) = 4.5

No boundaries	1 no-flow	2 no-flow	Closed
0.8	0.4	0.3	0.1

Q_Sust (L/s)= **0.33** std.dev = 0.29



Barker- Method

Main

Kamiebees BH2

r =	18.00	Extpol. t (y)	8	avail. draw	4.50

Manual Fit — YES

K_f [m/d]	S_f [1/m]	b	n
361	4.00E-07	16.03	1.26

Automatic Fit with SOLVER — NO

	Min	Value	Max
K_f [m/d] =	1	213.18627	100000
S_f [1/m] =	1.00E-07	1.00E-07	0.005
b =	0.1	27.554875	100
n =	1	1.2434284	3

Min, Max time to fit (min)

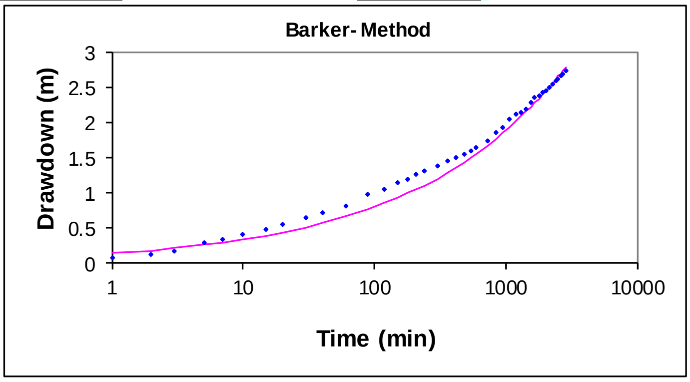
min	max
0	10000

	K_f [m/d]	S_f [1/m]	b	n	N
Fit Parameters	361.00	4.00E-07	16.03	1.26	0.3700

RMSE = 0.562362

	No boundaries	1 no-flow	2 no-flow	Closed
sWell(Extrapol.time)	44.76	57.18	63.39	69.60
Q_sust	0.10	0.08	0.07	0.06

Fractal n = 1.26 **Average Q-sust (l/s)=** 0.08 std. dev = 0.02



Final Fit Parameters	
K_f [m/d] =	361.00
S_f [1/m] =	4.00E-07
$b^{(3-n)}$ =	124.91
n =	1.26
b =	16.03
$K_f*b^{(3-n)}$	45091.17

Recovery Method Kamiebees BH2

Safe yield = $\frac{\text{Volume Pumped}}{\text{(Days pumped + Days Full Recovery)}}$

Pump Rate		L/s
CDT Duration	3.25	h
Steps Abstraction	27	m^3
Pump duration	0.179166667	d
Full recovery	1200	min
	0.83	d
Safe yield	26	m^3/d
	0.30	L/s

Summary | Main | **Kamiebees BH2**

Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)		Late T (m^2/d)		S	AD used
☑	**Basic FC**	0.27	0.15	27		8.1		4.40E-03	4.5
☐	**Advanced FC**								
☐	**FC inflection point**								
☑	**Cooper-Jacob**	0.11	0.07			18.4		1.69E-04	4.5
☑	**FC Non-Linear**	0.33	0.29			26.0		2.04E-04	4.5
☑	**Recovery**	0.19		42.3		15.7			
☑	**Barker**	0.08	0.02	K_f =	361		S_s =	4.00E-07	4.5
	Average Q_sust (l/s)	**0.20**	**0.10**	b =	16.03	Fractal dimension n =		1.26	=Linear flow

Recommended abstraction rate	**0.20**	L/s
Maximum amount of water to be abstracted per month	**518**	m^3
Maximum amount of water to be abstracted per day	**17**	m^3
Maximum amount of water to be abstracted per hour	**0.7**	m^3

Average T & S:	17.48	1.86E-04

Recommended pump depth below surface	**15**	m
Total Casing length	**?**	m
Reported blow yield	**5.6**	L/s
Low level pump protection depth	**14**	mbgl
Depth of borehole	**17**	m
Pre-pumping rest water level	**10.16**	mbc

Estimated abstraction by existing windpump with a 60 mm Jooste cylinder yielding ±770 L/h	**0.21**	Ave. L/s
	25%	Ave. Wind/a
	1 656	Ave. m^3/a
	5	Ave. m^3/d

Discussion & Management Recommendations

Kamiebees BH2 can be utilise at maximum rate of 0.7 m^3/h with the pump at 15 m below ground level.

Based on Drought Index of 3.8 years for the Quaternary Catchment F30A, the data were extrapolated for 8 years.

Available drawdown concervatively taken as 4.5 m and allowance was made for pumping 0.4L/s form BH1 and 0.2 L/s from BH3.

Note: This borehole has collapsed and borehole BH3, which is 9 m away on the same fault zone, should rather be used for abstraction.

FC-METHOD : Estimation of the sustainable yield of a borehole

Kamiebees BH3

Main | Deriv | Inflection point method

Extrapolation time in years = (enter)	8	4204800	Extrapol.time in minutes
Effective borehole radius (r_e) = (enter)	24.75	24.75	Est. r_e / From r(e) sheet
Q (l/s) from pumping test =	1	4.40E-03	S-late / Change r_e
s_a (available drawdown), sigma_s = (enter)	10.0		Sigma_s from risk / Down
Annual effective recharge (mm) =	0.16	11.60	s_available working drawdown(m)
t(end) and s(end) of pumping test =	2880	2.73	End time and drawdown of test
Average maximum derivative = (enter)	2.0	2.0	Estimate of average of max deriv
Average second derivative = (enter)	0.0	0.0	Estimate of average second deriv
Derivative at radial flow period = (enter)	0.58	0.58	Read from derivative graph
T and S estimates from derivatives	T-early[m^2/d] =	27.10	Aqui. thick (m) 5
(To obtain correct S-value, use program RPTSOLV)	T-late [m^2/d] =	8.06	Est. S-late = 2.75E-04
	S-late =	4.40E-03	S-estimate could be wrong

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)
(No values of T and S are necessary)

Maximum influence of boundaries at long time

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	15.17	21.38	27.59	46.22
Q_sust (l/s) =	0.76	0.54	0.42	0.25
	Best case	→	→	Worst case

Average Q_sust (l/s) = 0.46
with standard deviation= 0.22

(If no information exists about boundaries skip advanced solution and go to final recommendation)

Cooper-Jacob method

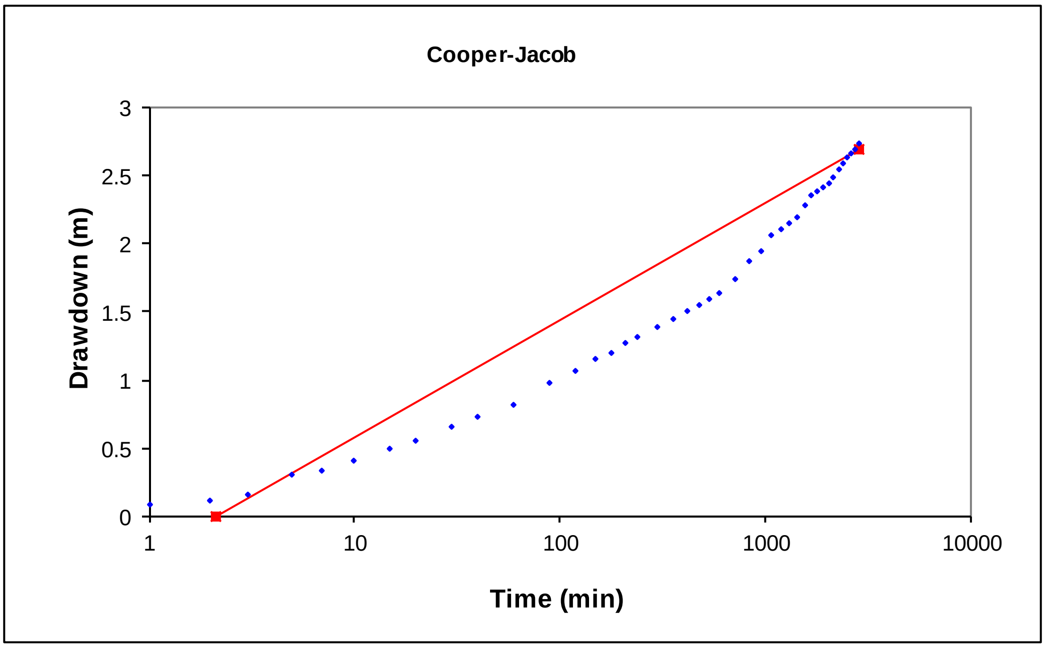
Main | Theis | Cooper-Jacob 2

Kamiebees BH3

T(m^2/d) =	**18.4**	r_e (m)=	18.91 / **18.91**
S =	**1.69E-04**	Q (l/s) =	1

	No boundaries	1 no-flow	2 no-flow	Closed
Q_sust	0.74	0.37	0.24	0.18
Avg. Q_sust =	**0.38**	std. dev =	0.25	

including influence of bh's



FC - Non Linear Method to estimate Q_Sust

Top

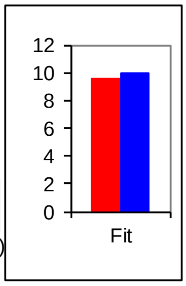
$s(t)=AQ+BQ^e(\log(t))^G+CQ^p\log(t)$

Fit stepdraw down data first: Manual - use buttons OR : Auto - solver

comment

Extrapolation	
Ext_pol time (min)	
4204800	
Q (L/s)	Drawdown (m)
1.5	9.54

Fit graph →



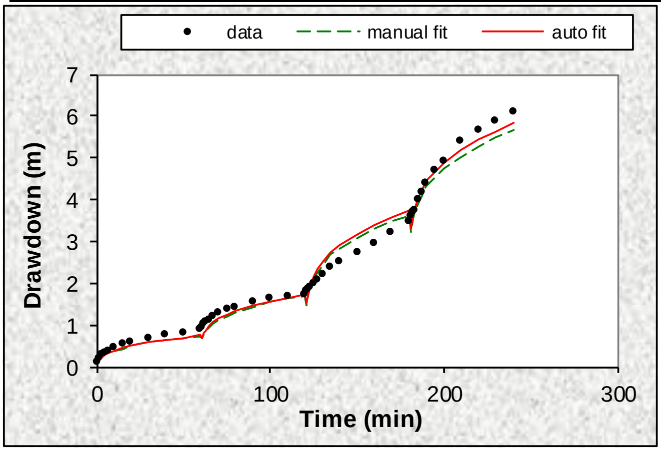
skin effect	Non-Darcian loss		Darcian loss		
A	C	p	B	n	e
1.83E-03	0.00E+00	3	1.83E-03	1	1.06
1.83E-03	0.00E+00	3.49	1.83E-03	1.00	1.07

☐ Manual param ☑ Auto fit param

(Choose which parameter set to use for Q_sust)

Available drawdown (m) =	10		
No boundaries	1 no-flow	2 no-flow	Closed
1.5	0.8	0.5	0.3

Q_Sust (L/s)= **0.61** std.dev = 0.54



Barker- Method

Main

Kamiebees BH3

r =	18.00	Extpol. t (y)	8	avail. draw	10.00

Manual Fit

YES

K_f [m/d]	S_f [1/m]	b	n
361	4.00E-07	16.03	1.26

Automatic Fit with SOLVER

NO

	Min	Value	Max
K_f [m/d] =	1	213.18627	100000
S_f [1/m] =	1.00E-07	1.00E-07	0.005
b =	0.1	27.554875	100
n =	1	1.2434284	3

Min, Max time to fit (min)

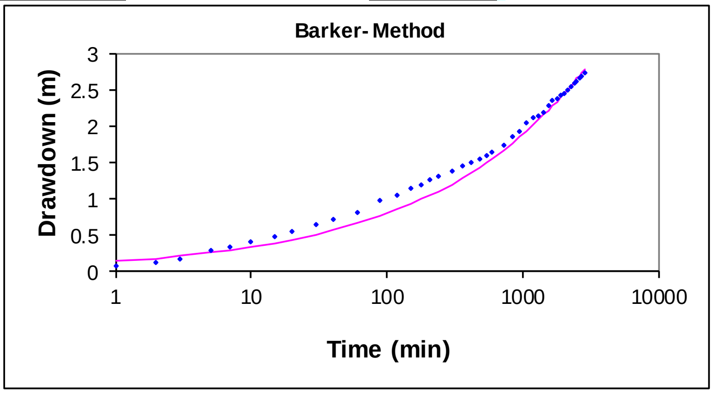
min	max
0	10000

	K_f [m/d]	S_f [1/m]	b	n	N
Fit Parameters	361.00	4.00E-07	16.03	1.26	0.3700

RMSE = 0.562362

	No boundaries	1 no-flow	2 no-flow	Closed
sWell(Extrapol.time)	47.44	59.86	66.07	72.28
Q_sust	0.21	0.17	0.15	0.14

Fractal n = 1.26 **Average Q-sust (l/s)=** 0.17 std. dev = 0.03



Final Fit Parameters	
K_f [m/d] =	361.00
S_f [1/m] =	4.00E-07
$b^{(3-n)}$ =	124.91
n =	1.26
b =	16.03
$K_f{*}b^{(3-n)}$	45091.17

Recovery Method Kamiebees BH3

$$\text{Safe yield} = \frac{\text{Volume Pumped}}{\text{(Days pumped + Days Full Recovery)}}$$

Pump Rate		L/s
CDT Duration	4	h
Steps Abstraction	46	m^3
Pump duration	0.179166667	d
Full recovery	1000	min
	0.69	d
Safe yield	53	m^3/d
	0.61	L/s

Summary | Main | **Kamiebees BH3**

Applicable	Method	Sustainable yield (l/s)	Std. Dev	Early T (m^2/d)		Late T (m^2/d)		S	AD used
☑	Basic FC	0.46	0.22	27		8.1		4.40E-03	10.0
☐	Advanced FC								
☐	FC inflection point								
☑	Cooper-Jacob	0.38	0.25			18.4		1.69E-04	10.0
☑	FC Non-Linear	0.61	0.54			30.0		1.69E-04	10.0
☑	Recovery	0.19		42.3		15.7			
☑	Barker	0.17	0.03	K_f =	361		S_s =	4.00E-07	10.0
	Average Q_sust (l/s)	0.36	0.19	b =	16.03	Fractal dimension n =		1.26	=Linear flow

Recommended abstraction rate	**0.30**	L/s
Maximum amount of water to be abstracted per month	**778**	m^3
Maximum amount of water to be abstracted per day	**26**	m^3
Maximum amount of water to be abstracted per hour	**1.1**	m^3

Average T & S:	18.81	1.69E-04

Recommended pump depth below surface	**27**	m
Total Casing length	**?**	m
Reported blow yield	**5.6**	L/s
Low level pump protection depth	**25**	mbgl
Depth of borehole	**30**	m
Pre-pumping rest water level	**10.56**	mbc

Estimated abstraction by existing windpump with a 60 mm Jooste cylinder yielding ±770 L/h	**0.21**	Ave. L/s
	25%	Ave. Wind/a
	1 656	Ave. m^3/a
	5	Ave. m^3/d

Discussion & Management Recommendations

Kamiebees BH3 can be utilise at maximum rate of 1 m^3/h with the pump at 27 m below ground level.
Based on Drought Index of 3.8 years for the Quaternary Catchment F30A, the data were extrapolated for 8 years.
Available drawdown concervatively taken as 10 m and allowance was made for pumping 0.4L/s form BH1 and 0.2 L/s from BH2
CDT results of BH2, which is 9 m away on the same fracture zone, was used for the yield analysis.

Appendix C: Laboratory Water Quality Reports

Certificate of Analysis

Project details

Customer Details

Quotation number:	QU103742
Order number:	113330
Company name:	AB PUMPS
Contact address:	PRIVATE BAG X39, BEACON BAY, EAST LONDON, 5205
Contact person:	AILENE VAN NIEKERK

Sampling Details

Sampled by:	CUSTOMER
Sampled date:	2019/09/20

Sample Details

Sample type(s):	WATER SAMPLES
Date received:	2019/09/26
Delivered by:	COURIER SERVICE

Report Details

Testing commenced:	2019/09/26
Testing completed:	2019/10/08
Report date:	2019/10/09
Our reference:	007465/19

Analytical Results

Methods	Determinands	Units	017974/19 P2239, BH01 KAMIESBEES 09:00 20.09.19
Chemical			
85	Dissolved Calcium	mg Ca/ℓ	235
85	Potassium	mg K/ℓ	11.0
85	Dissolved Magnesium	mg Mg/ℓ	102
84	Sodium	mg Na/ℓ	**504**
83A	Dissolved Aluminium	µg Al/ℓ	2.55
83A	Dissolved Arsenic	µg As/ℓ	0.44
83A	Dissolved Boron	µg B/ℓ	714
83A	Dissolved Barium	µg Ba/ℓ	35
83A	Dissolved Cadmium	µg Cd/ℓ	0.02
83A	Dissolved Copper	µg Cu/ℓ	0.98
83A	Dissolved Iron	µg Fe/ℓ	9.46
83A	Dissolved Mercury	µg Hg/ℓ	0.94
83A	Dissolved Manganese	µg Mn/ℓ	4.39
83A	Dissolved Nickel	µg Ni/ℓ	1.21
83A	Dissolved Lead	µg Pb/ℓ	0.04
83A	Dissolved Antimony	µg Sb/ℓ	0.43
83A	Dissolved Selenium	µg Se/ℓ	5.28
83A	Dissolved Uranium	µg U/ℓ	8.53
83A	Dissolved Zinc	µg Zn/ℓ	7.38
83A	Total Chromium	µg Cr/ℓ	41
83A	Total Iron	µg Fe/ℓ	422
10G	Total Alkalinity	mg $CaCO_3$/ℓ	251
16G	Chloride	mg Cl/ℓ	**831**
-	Cyanide*	µg CN/ℓ	20
48	Colour*	mg Pt-Co/ℓ	<1
2A	Electrical Conductivity at 25°C	mS/m	**364**
18G	Fluoride	mg F/ℓ	**2.68**

Methods	Determinands	Units	017974/19 P2239, BH01 KAMIESBEES 09:00 20.09.19
Chemical			
64G	Ammonia	mg N/ℓ	0.18
65Gc	Nitrate	mg N/ℓ	**15.8**
65Gb	Nitrite	mg N/ℓ	<0.01
-	Combined Nitrate + Nitrite (sum of Ratios)*	-	**1.4**
4	Turbidity	NTU	1.2
1A	pH at 25°C	pH units	7.4
67G	Sulphate	mg SO_4/ℓ	**599**
41	Total Dissolved Solids at 180°C	mg/ℓ	**2428**
Microbiological			
31	*E.coli*	colonies/100mℓ	0
31	Faecal Coliforms	colonies/100mℓ	0
31	Total Coliforms	colonies/100mℓ	0

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

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

Specific Observations

Results that appear in bold do not meet the specification limits in Appendix 2 of this report.

Quality Assurance

Technical signatories

Chemistry: Dr. Abie Khan

Microbiology: Jocelyn Winchester

Notes to this report

Limitations

This report shall not be reproduced except in full without prior written approval of the laboratory.
Results in this report relate only to the samples as taken, and the condition received by the laboratory.
Any opinions and interpretations expressed herein are outside the scope of SANAS accreditation.
The decision rule applicable to this laboratory is available on request.
Sample preparation may require filtration, dilution, digestion or similar. Final results are reported accordingly. Customers to contact Talbot Laboratories for further information.

Uncertainty of measurement

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

- Identified for relevant tests in the attached Appendix.
- Calculated as a percentage of the respective results.
- Applicable to total, dissolved and acid soluble metals for ICP element analyses.
- Available upon request for microbiological results.
- Available upon request for subcontracted tests.

Analysis explanatory notes

Tests may be marked as follows:

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

Appendix 1: Uncertainty of Measurement (UoM)

Determinands	Method No	Uncertainty of Measurement (%)
Alkalinity (Total)	10	± 3.49
Alkalinity (Total)	10G	± 4.39
Ammonia	64G	± 6.29
Aluminium (ICP-MS)	83A	± 20.62
Aluminium (ICP-OES)	87	± 8.09
Antimony (ICP-MS)	83A	± 17.73
Antimony (ICP-OES)	87	± 30.16
Arsenic (ICP-MS)	83A	± 12.04
Arsenic (ICP-OES)	87	± 20.17
Barium (ICP-MS)	83A	± 12.29
Barium (ICP-OES)	87	± 10.25
Beryllium (ICP-MS)	83A	± 23.10
Beryllium (ICP-OES)	87	± 7.96
Boron (ICP-MS)	83A	± 24.83
Boron (ICP-OES)	87	± 17.33
Cadmium (ICP-MS)	83A	± 9.59
Cadmium (ICP-OES)	87	± 7.69
Calcium (ICP-OES)	85	± 5.09
Chromium (ICP-MS)	83A	± 8.45
Chromium (ICP-OES)	87	± 8.13
Cobalt (ICP-MS)	83A	± 8.39
Cobalt (ICP-OES)	87	± 7.83
Copper (ICP-MS)	83A	± 8.36
Copper (ICP-OES)	87	± 7.77
Chemical Oxygen Demand	3	± 16.04
Chloride	16G	± 3.56
Electrical Conductivity	2A	± 2.87
Fluoride	18G	± 17.67
Hexavalent Chromium	68G	± 5.36
Iron (ICP-MS)	83A	± 14.03
Iron (ICP-OES)	87	± 7.83
Lead (ICP-MS)	83A	± 10.64
Lead (ICP-OES)	87	± 8.18
Lithium (ICP-MS)	83A	± 20.65
Lithium (ICP-OES)	87	± 6.79
Manganese (ICP-MS)	83A	± 10.71
Manganese (ICP-OES)	87	± 8.01

Determinands	Method No	Uncertainty of Measurement (%)
Magnesium (OES)	85	± 5.38
Mercury (ICP-MS)	83A	± 16.32
Mercury (ICP-OES)	86	± 10.54
Molybdenum (ICP-MS)	83A	± 11.08
Molybdenum (ICP-OES)	87	± 15.20
Nickel (ICP-MS)	83A	± 10.00
Nickel (ICP-OES)	87	± 8.06
Nitrate/Nitrite	65Ga	± 12.55
Nitrite	65Gb	± 12.83
Nitrate	65Gc	± 12.55
Oxygen Absorbed	39	± 6.37
Potassium (ICP-OES)	85	± 15.20
Orthophosphate	66G	± 11.76
Phosphate (Total)	90	± 9.16
pH Value 25°C	1A	± 1.22
Selenium (ICP-MS)	83A	± 21.40
Selenium (ICP-OES)	88	± 31.56
Silver (ICP-MS)	83A	± 11.35
Sodium (ICP-OES)	84	± 8.99
Strontium (ICP-MS)	83A	± 10.55
Strontium (ICP-OES)	87	± 8.29
Sulphate	67G	± 6.96
Suspended Solids	5	± 3.72
Thallium (ICP-MS)	83A	± 12.51
Thallium (ICP-OES)	87	± 8.57
Tin (ICP-MS)	83A	± 12.17
Tin (ICP-OES)	87	± 12.39
Titanium (ICP-OES)	87	± 7.20
Total Dissolved Solids	41	± 1.29
Total Solids at 105°C	59	± 0.59
Turbidity	4	± 4.60
Uranium (ICP-MS)	83A	± 12.13
Uranium (ICP-OES)	87	± 7.26
Vanadium (ICP-MS)	83A	± 10.17
Vanadium (ICP-OES)	87	± 7.18
Zinc (ICP-MS)	83A	± 22.86
Zinc (ICP-OES)	87	± 7.41

Determinands	Method No	Uncertainty of Measurement (%)
Total Hydrocarbons	101	± 22.76
Vinyl Chloride	100	± 23.42
Bromomethane	100	± 22.89
Ethyl Chloride	100	± 23.25
1,1-Dichloroethylene	100	± 20.00
Trans1,2-Dichlororethylene	100	± 19.22
Tert-Butylmethyl Ether (MTBE)	100	± 22.90
1,1-Dichloroethane	100	± 17.24
Cis-1,2-Dichloroethylene	100	± 22.06
Chloroform (THM)	100	± 18.67
2,2-Dichloropropane	100	± 19.27
1,2-Dichloroethane	100	± 15.27
1,1,1-Trichloroethane	100	± 21.72
1,1-Dichloropropene	100	± 20.33
Carbon Tetrachloride	100	± 19.86
Benzene (BTEX)	100	± 22.33
Dibromomethane	100	± 18.63
1,2-Dichloropropane	100	± 18.26
Trichloroethylene	100	± 21.76
Bromodichloromethane (THM)	100	± 15.31
Trans-1,3-Dichloropropene	100	± 14.50
Cis-1,3-Dichloropropene	100	± 15.77
1,1,2-Trichloroethane	100	± 16.46
Toluene (BTEX)	100	± 24.36
1,3-Dichloropropane	100	± 15.78
Dibromochloromethane (THM)	100	± 18.00
1,2-Dibromoethane	100	± 14.72

Determinands	Method No	Uncertainty of Measurement (%)
Tetrachloroethylene	100	± 17.04
1,1,1,2-Tetrachloroethane	100	± 21.13
Chlorobenzene	100	± 16.08
Ethylbenzene (BTEX)	100	± 20.59
m,p-Xylene (BTEX)	100	± 24.59
Styrene	100	± 18.91
Bromoform (THM)	100	± 19.74
1,1,2,2-Tetrachloroethane	100	± 24.71
o-Xylene (BTEX)	100	± 23.70
1,2,3-Trichloropropane	100	± 22.64
Isopropylbenzene	100	± 21.01
Bromobenzene	100	± 19.61
n-Propylbenzene	100	± 24.17
2-Chlorotoluene	100	± 22.92
4-Chlorotoluene	100	± 22.11
1,3,5-Trimethylbenzene	100	± 18.19
Tert-Butylbenzene	100	± 18.74
1,2,4-Trimethylbenzene	100	± 24.08
Sec-Butylbenzene	100	± 20.11
1,3-Dichlorobenzene	100	± 24.31
1,4-Dichlorobenzene	100	± 24.31
1,2-Dichlorobenzene	100	± 20.31
n-Butylbenzene	100	± 14.50
1,2,4-Trichlorobenzene	100	± 18.90
Naphthalene	100	± 23.66
Hexachlorobutadiene	100	± 18.39
1,2,3-Trichlorobenzene	100	± 24.70

Appendix 2: Specifications - SANS 241-1:2015 RECOMMENDED LIMITS

Reported Determinands	Limits
E.coli	0 Count per 100mℓ
F.coli	0 Count per 100mℓ
Cryptosporidium species	Not Detected
Giardia species	Not Detected
Total Coliforms	≤10 Count per 100mℓ
Standard Plate Count	≤1000 Count per 1mℓ
Somatic Coliphages	Not Detected
Cytopathogenic viruses	Not detected
Enteric Virus (Sub#)	Not Detected
Colour	≤15 mg/ℓ Pt-Co
Electrical Conductivity	≤170 mS/m
Total Dissolved Solids at 180°C	≤1200 mg/ℓ
Turbidity	Operational ≤1 NTU
Turbidity	Aesthetic ≤5 NTU
pH	≥ 5 to ≤ 9.7
Odour	Inoffensive
Free Chlorine	≤5 mg/ℓ
Monochloramine	≤3000 µg/ℓ (≤3 mg/ℓ)
Nitrate	≤11 mg/ℓ
Nitrite	≤0.9 mg/ℓ
Combined Nitrate plus Nitrite (sum of Ratios)	≤1
Sulphate	Acute: ≤ 500 mg/ℓ
Sulphate	Aesthetic: ≤ 250 mg/ℓ
Fluoride	≤1500 µg/ℓ (≤1.5 mg/ℓ)
Ammonia	≤1.5 mg/ℓ
Chloride	≤ 300 mg/ℓ
Sodium	≤200 mg/ℓ

Reported Determinands	Limits
Zinc	≤5000 µg/l (≤5 mg/ℓ)
Antimony	≤20 µg/ℓ (≤0.02 mg/ℓ)
Arsenic	≤10 µg/ℓ (≤0.01 mg/ℓ)
Barium	≤700 µg/ℓ (≤0.7 mg/ℓ)
Boron	≤2400 µg/ℓ (≤2.4 mg/ℓ)
Cadmium	≤3 µg/ℓ (≤0.003 mg/ℓ)
Total Chromium	≤50 µg/ℓ (≤0.05 mg/ℓ)
Copper	≤2000 µg/ℓ (≤2 mg/ℓ)
Cyanide	≤200 µg/ℓ (≤0.2 mg/ℓ)
Iron	Chronic: ≤ 2000 µg/ℓ (≤2 mg/ℓ)
Iron	Aesthetic: ≤ 300 µg/ℓ (≤0.3 mg/ℓ)
Lead	≤10 µg/ℓ (≤0.01 mg/ℓ)
Manganese	Chronic: ≤ 400 µg/ℓ (≤0.4 mg/ℓ)
Manganese	Aesthetic: ≤100 µg/ℓ (≤0.1 mg/ℓ)
Mercury	≤6 µg/ℓ (≤0.006 mg/ℓ)
Nickel	≤70 µg/ℓ (≤0.07 mg/ℓ)
Selenium	≤40 µg/ℓ (≤0.04 mg/ℓ)
Uranium	≤30 µg/ℓ (≤0.03 mg/ℓ)
Aluminium	≤300 µg/ℓ (≤0.3 mg/ℓ)
Total Organic Carbon	≤10 mg/ℓ
Chloroform	≤300 µg/ℓ (≤0.3 mg/ℓ)
Bromoform	≤100 µg/ℓ (≤0.1 mg/ℓ)
Dibromochloromethane	≤100 µg/ℓ (≤0.1 mg/ℓ)
Bromodichloromethane	≤60 µg/ℓ (≤0.06 mg/ℓ)
Trihalomethanes Ratio	≤1
Microcystins	≤1 µg/ℓ
Phenols	≤10 µg/ℓ (≤0.01 mg/ℓ)

End of Report

Appendix D: Impact Assessment Methodology

The assessment of impacts was based on specialists' expertise, SRK's professional judgement, field observations and desk-top analysis.

The significance of potential impacts that may result from the proposed project was determined in order to assist decision-makers (typically by a designated competent authority or state agency, but in some instances, the applicant).

The **significance** of an impact is defined as a combination of the **consequence** of the impact occurring and the **probability** that the impact will occur.

The criteria used to determine impact consequence are presented in the table below.

Table 12-1: Criteria used to determine the consequence of the impact

Rating	Definition of Rating	Score
A. *Extent* *– the area (distance) over which the impact will be experienced*		
Local	Confined to project or study area or part thereof (e.g. the development site and immediate surrounds)	1
Regional	The region (e.g. Municipality or Quaternary catchment)	2
(Inter) national	Nationally or beyond	3
B. ***Intensity*** *– the magnitude of the impact in relation to the extent of the impact and sensitivity of the receiving environment, taking into account the degree to which the impact may cause irreplaceable loss of resources*		
Low	Site-specific and wider natural and/or social functions and processes are negligibly altered	1
Medium	Site-specific and wider natural and/or social functions and processes continue albeit in a modified way	2
High	Site-specific and wider natural and/or social functions or processes are severely altered	3
C. ***Duration*** *– the timeframe over which the impact will be experienced and its reversibility*		
Short-term	Up to 2 years and reversible	1
Medium-term	2 to 15 years and reversible	2
Long-term	More than 15 years and irreversible	3

The combined score of these three criteria corresponds to a **Consequence Rating**, as follows:

Table 12-2: Method used to determine the consequence score

Combined Score **(A+B+C)**	3 – 4	5	6	7	8 – 9
Consequence Rating	Very low	Low	Medium	High	Very high

Once the consequence was derived, the probability of the impact occurring was considered, using the probability classifications presented in the table below.

Table 12-3: Probability classification

Probability *– the likelihood of the impact occurring*	
Improbable	< 40% chance of occurring
Possible	40% - 70% chance of occurring
Probable	> 70% - 90% chance of occurring
Definite	> 90% chance of occurring

The overall **significance** of impacts was determined by considering consequence and probability using the rating system prescribed in the table below.

Table 12-4: Impact significance ratings

		Probability			
		Improbable	Possible	Probable	Definite
Consequence	Very Low	INSIGNIFICANT	INSIGNIFICANT	VERY LOW	VERY LOW
	Low	VERY LOW	VERY LOW	LOW	LOW
	Medium	LOW	LOW	MEDIUM	MEDIUM
	High	MEDIUM	MEDIUM	HIGH	HIGH
	Very High	HIGH	HIGH	VERY HIGH	VERY HIGH

Finally, the impacts were also considered in terms of their status (positive or negative impact) and the confidence in the ascribed impact significance rating. The prescribed system for considering impacts status and confidence (in assessment) is laid out in the table below.

Table 12-5: Impact status and confidence classification

Status of impact	
Indication whether the impact is adverse (negative) or beneficial (positive).	+ ve (positive – a 'benefit')
	– ve (negative – a 'cost')
Confidence of assessment	
The degree of confidence in predictions based on available information, SRK's judgment and/or specialist knowledge.	Low
	Medium
	High

The impact significance rating should be considered by authorities in their decision-making process based on the implications of ratings ascribed below:

- **INSIGNIFICANT**: the potential impact is negligible and **will not** have an influence on the decision regarding the proposed activity/development.
- **VERY LOW**: the potential impact is very small and **should not** have any meaningful influence on the decision regarding the proposed activity/development.
- **LOW**: the potential impact **may not** have any meaningful influence on the decision regarding the proposed activity/development.
- **MEDIUM**: the potential impact **should** influence the decision regarding the proposed activity/development.
- **HIGH**: the potential impact **will** affect the decision regarding the proposed activity/development.
- **VERY HIGH**: The proposed activity should only be approved under special circumstances.

Practicable mitigation and optimisation measures are recommended, and impacts are rated in the prescribed way both without and with the assumed effective implementation of mitigation and optimisation measures. Mitigation and optimisation measures are either:

- **Essential**: measures that must be implemented and are non-negotiable; and
- **Best Practice:** recommended to comply with best practice, with adoption dependent on the proponent's risk profile and commitment to adhere to best practice, and which must be shown to have been considered and sound reasons provided by the applicant if not implemented.