



Submitted to: Ministry of Agriculture,  
Water and Land Reform  
Attention: The Executive Director: Mr  
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# REPORT:

## GROUNDWATER ASSESSMENT AND DEVELOPMENT – FARM GAI KAISA NO. 159

PROJECT NUMBER: ECC-118-611-REP-02-A

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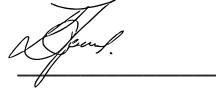
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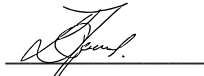
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## ABBREVIATIONS

ABBREVIATION	DESCRIPTION
%	percentage
~	approximately
°	degree
DWA	Department of Water Affairs
ECC	Environmental Compliance Consultancy Pty Ltd
MAWLR	Ministry of Agriculture, Water and Land Reform
mamsl	metres above mean sea level
m	metre
mbgl	metres below ground level
mg/l	milligrams per litre
m <sup>3</sup> /d	cubic metres per day
ML	mining licence
mm	millimetre
No.	number
WRMA	Water Resources Management Act, no 11 of 2013

# 1 INTRODUCTION

## 1.1 BACKGROUND

Environmental Compliance Consultancy (Pty) Ltd (ECC) was appointed by Retort Charcoal Producers (Pty) Ltd (RCP) to prepare a groundwater assessment for Farm Gai Kaisa no. 159 (the farm).

RCP is a 100%, broad-based, Namibian owned and operated industrial charcoal and biochar manufacturing company producing significant quantities of high-quality charcoal using an industrial, mechanised, process. In addition to the production of charcoal, the industrial process produces large quantities of biochar. The biochar is applied to local (and in future, global) soils, which in turn improves water and water soluble nutrient retention. Over time, RCP will be conducting tests to see if the biochar can be used to improve crop yields in the northern communal areas and are engaging tertiary research institutions to conduct scientific feasibility studies.

To date, the charcoal project has made investments in the region of NAD100 million, creating and sustaining over 250 local jobs. Further, the project has seen over NAD 20 million reinvested into the local farming community over the last 3 years.

RCP are expanding investments into crop production, thus making use of the biochar enriched soils on the farm. In assessing the agronomic feasibility of the farm, over NAD 1.5 million has been invested to ensure the required environmental legislative requirements are met, to secure sustainable water supply, to assess soil conditions, and evaluate risks related to the effects of climate change.

RCP plan to cultivate and irrigate a minimum of 270 hectare (ha) on Farm Gai Kaisa with a combination of staples (grains) to feed Namibia and assist with food security and high-value export crops (at trial scale initially) to develop a new export crop zone for the country.

The irrigation activity is included as an amendment to the environmental clearance certificate issued to RCP for the mechanised bush thinning operations on the farm (ECC-2402040).

The desktop groundwater assessment and results from geophysical surveying (Electromagnetics – EM), borehole drilling, and test pumping aim to support sustainable groundwater abstraction and use. The objective of this report is to provide the regulator sufficient physiographic and hydrogeological information to evaluate a groundwater abstraction licence application.

## 2 SITE DESCRIPTION

### 2.1 LOCALITY

The farm (Latitude: -19.885995°, Longitude: 17.837234°) covers an area of ~5000 hectare (ha) and is located 30 km southeast of the Kombat settlement and 42 km southwest of Grootfontein in the Otavi Constituency, Otjozondjupa Region (Figure 1).

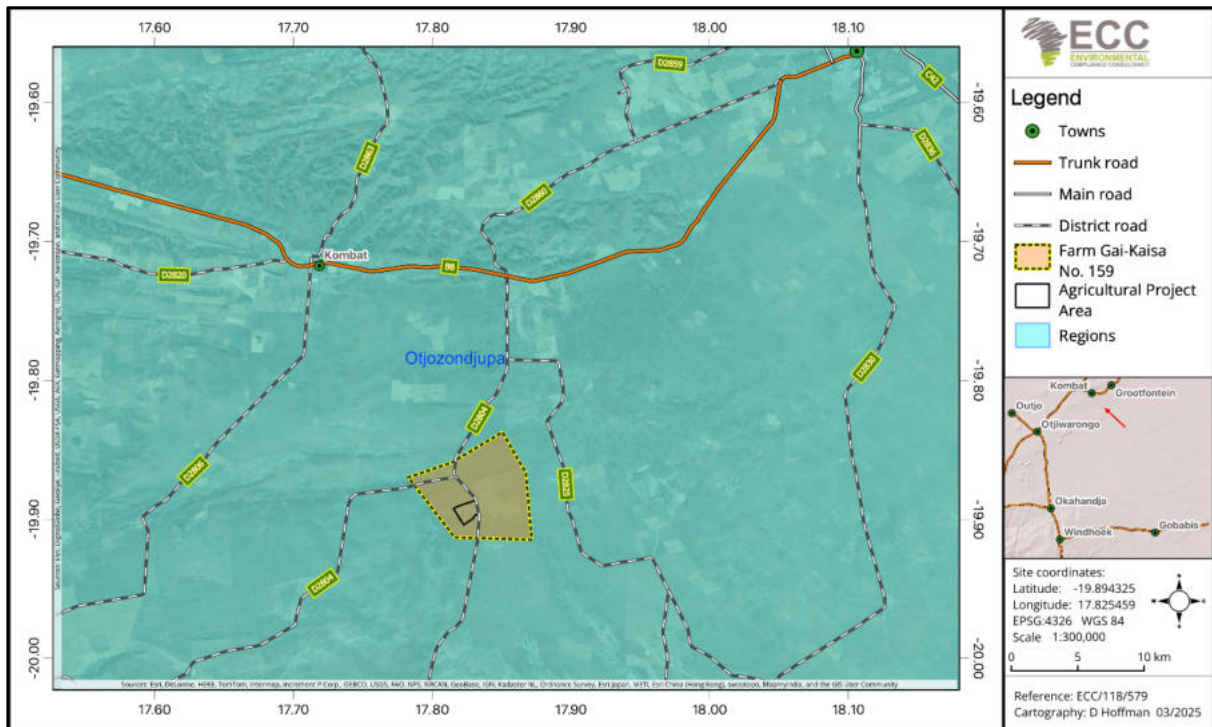


Figure 1 – Locality map of Farm Gai Kaisa no. 159

### 2.2 CLIMATE

Farm Gai Kaisa occurs in the BWh region of the Köppen-Geiger classification which is hot arid desert climate characterised by low annual precipitation (450-500 mm per annum, Figure 3) and high temperatures throughout the year (23.9°C mean annual temperature). Mean annual evaporation (MAE) is reportedly between 3000 – 3200 mm; exceeding MAP by an order of magnitude and resulting in a hydrological deficit for the region. Climatic data from the nearby area of Kombat is shown as representative of the farm in Figure 2.

Rainfall is predominantly in the summer months of November to March and is experienced as brief but intense downpours, often resulting in localised flooding. The rest of the year is relatively dry, with minimal rainfall and low humidity levels. Rainfall distribution and evapotranspiration are important factors to consider in developing the crop water requirements.

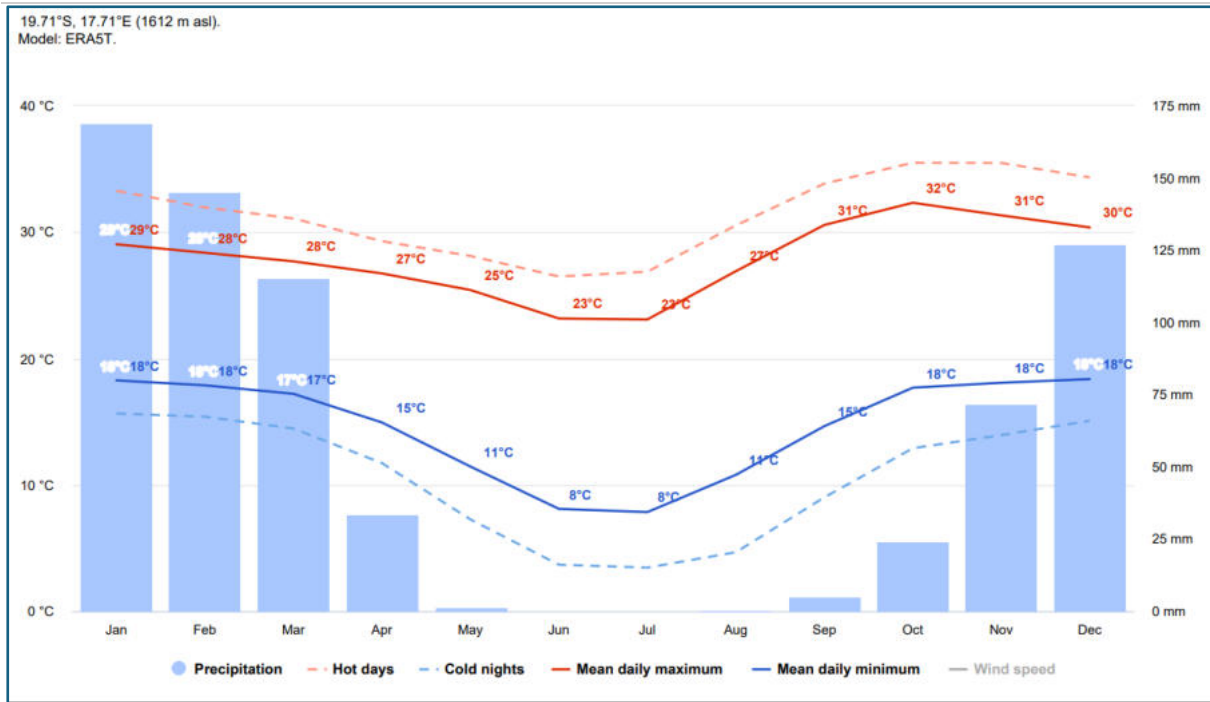


Figure 2 – Precipitation and mean daily maximum and minimum temperatures for the area of Farm Gai Kaisa

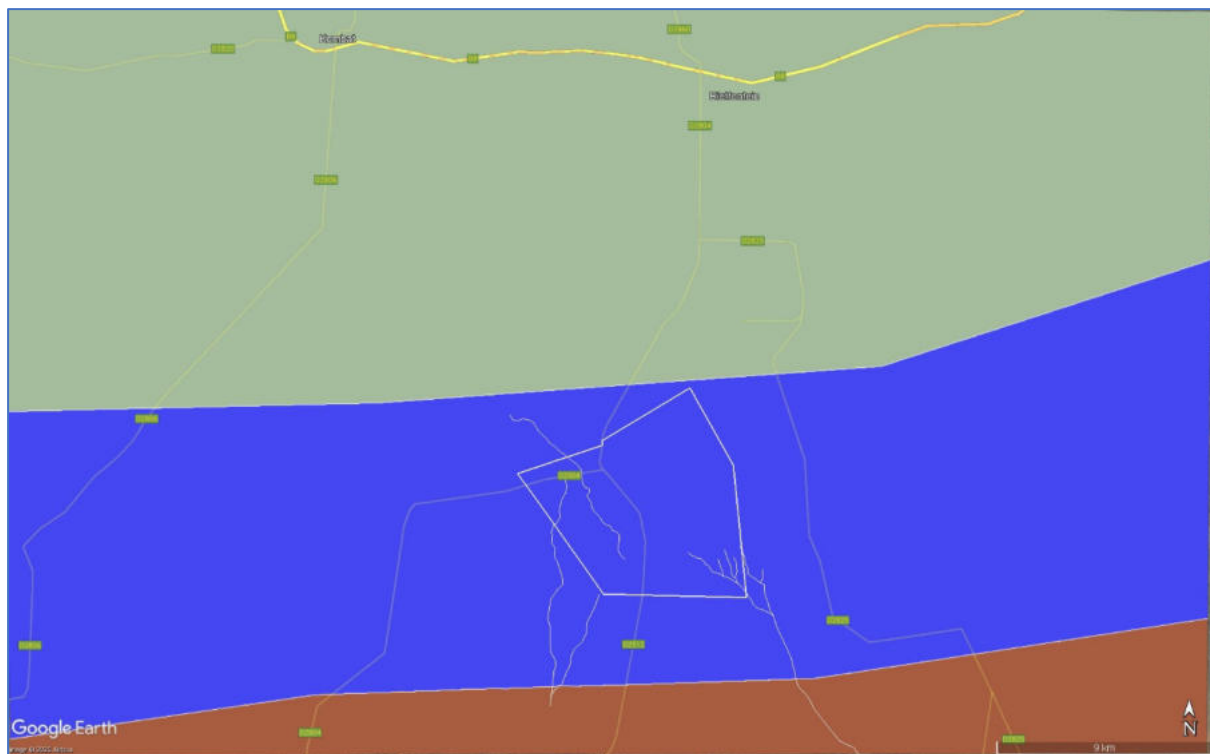
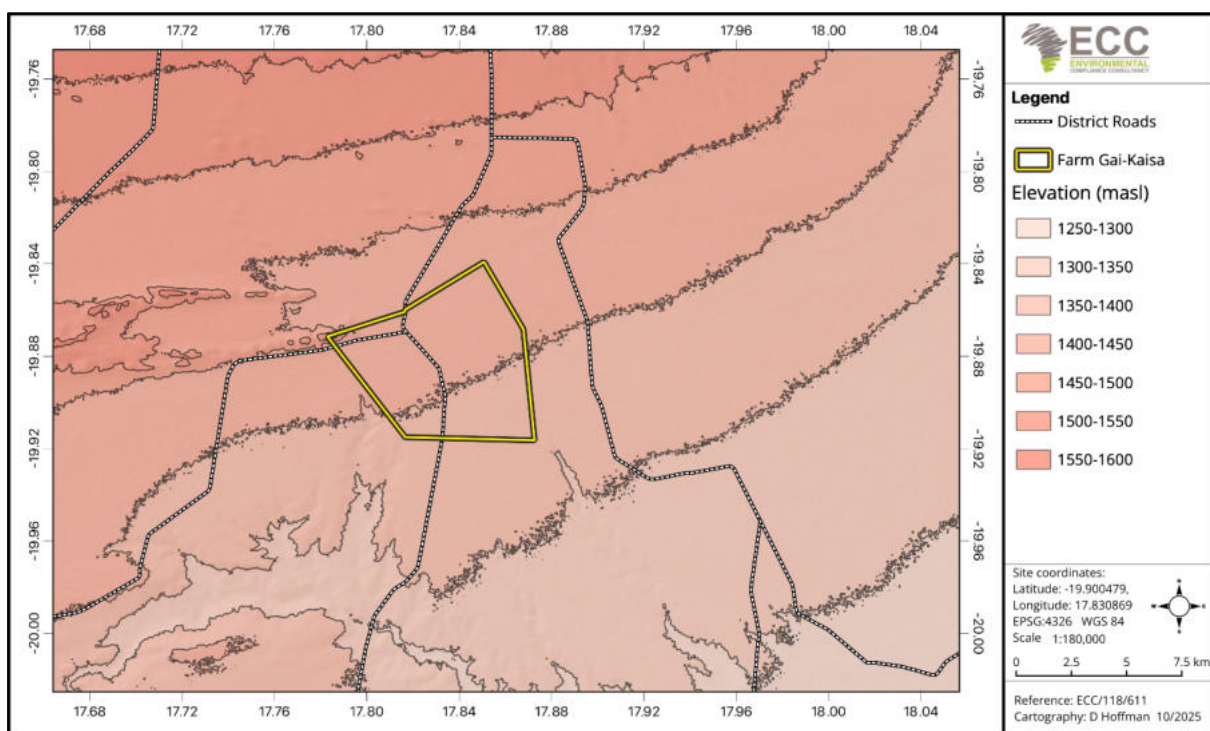


Figure 3 – Mean Annual Precipitation map for Farm Gai Kaisa (blue band = 450 – 500 mm/a)

### 2.3 TOPOGRAPHY, SOIL AND DRAINAGE

The general topography of the area (Figure 4) shows a gradual decrease in elevation from north to south, ranging from approximately 1430 meters above mean sea level (mamsl) to 1381 mamsl. Similarly, the elevation decreases from west to east, ranging from ~1414 mamsl to 1398 mamsl resulting in a regional south easterly gradient. The north western corner of the farm boundary abuts an area of high relief formed by folded outcrop of resistant marble and calc-silicate rocks. The terrain is influenced by the underlying geology, with variations in elevation shaped by geological structures and natural erosion processes. Further north, the Otavi Mountains dominate the landscape, serving as a notable topographical feature in the region.



**Figure 4 - Terrain map of the study area showing decrease in elevation to the south east**

Based on the 1:1 000 000 soil classification of Namibia, Petric Calcisol are the dominant soil type, followed by Leptosol as the secondary type, and Calcic Cambisol as the tertiary type. The dominant Petric Calcisol is characterised by a significant accumulation of secondary calcium carbonate ( $\text{CaCO}_3$ ), often forming a hardened layer known as the petrocalcic horizon (calcrete). These soils typically develop in arid and semi-arid regions, where low rainfall limits leaching and allows calcium carbonate to precipitate and accumulate. Petric Calcisols are commonly found in desert landscapes, where they are primarily used for rangelands or agricultural activities, often with irrigation.

A typical Petric Calcisol profile has an A Horizon (topsoil) that is usually weakly developed; can be sandy, loamy, or silt-rich; may have organic matter but the amount is often limited due to

arid/semi-arid climate conditions. The B Horizon (subsoil) may contain more clay and some carbonate accumulation, but the key feature is the transition to the Petrocalcic Horizon – a cemented carbonate layer, often occurring at 10–100 cm depth, sometimes thicker.

The soil below the petrocalcic horizon may be unconsolidated material (parent material) or more calcareous layers. Texturally these soils are usually loamy or sandy loam above the petrocalcic horizon; below, it may be more calcareous and coarse. The soil structure is typically weak to moderate in the topsoil; massive and cemented in the petrocalcic layer with high porosity in the upper layers and very low porosity in the petrocalcic layer where water infiltration is slow. Soil chemistry is usually alkaline due to the high calcium carbonate content, low salinity but also low nitrogen and phosphorous (nutrients) content (moderate in potassium).

Numerous studies have demonstrated that incorporating biochar into soils can significantly enhance water retention, with improvements often exceeding 10% (Santos, 2022; Thao, 2024, Kabir, 2023, Acharya, 2023). These enhancements are attributed to biochar's ability to increase soil porosity, improve pore size distribution, and enhance the soil's water-holding capacity. Such improvements are particularly beneficial in the region of the farm where soil properties show poor water retention and water conservation is crucial for sustainable agriculture.

## 2.4 HYDROLOGY

The farm occurs in the central western extent of the Omatako River Catchment and has two minor ephemeral drainage lines passing through the farm, one flowing southward to join the ephemeral Ondanguara River (tributary of the Omabonda River) and the other has a confluence directly with the Omabonda River. The Omabonda River in turn flows south eastward to the confluence with the Omatako River.

Increased erosion associated with the water courses can be seen within the sandstones known to occur in the southern portion of the farm, as opposed to the more competent carbonatitic rocks occurring in the south, resulting in preferential; weathering and incised water courses. Depending on the thickness of the sandstones, paleo springs may be associated with the contact between the two identified lithologies, giving rise to the drainage features observed.

None of the farm's boreholes are located within ~400 m of any water courses.

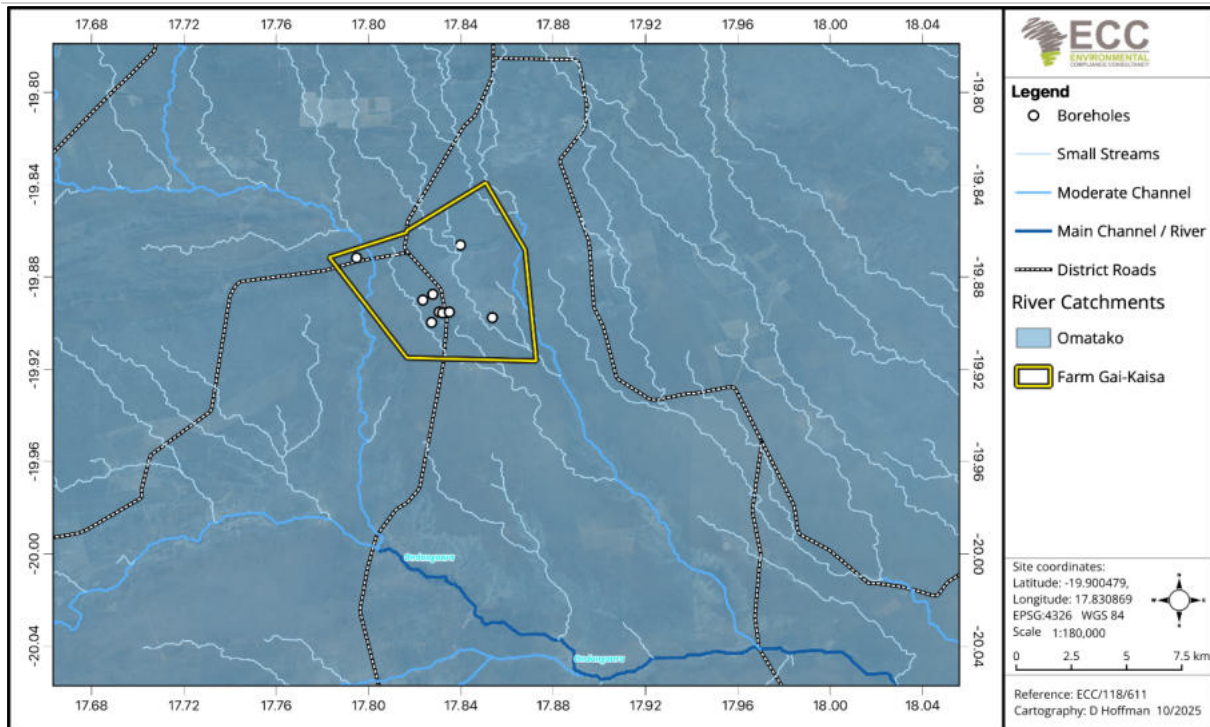


Figure 5 – Hydrological drainage map of the study area

## 2.5 GEOLOGY

The farm occurs within the southern central tectonographic zone of Namibia's Damara belt. A significant structural feature, the Omaruru Lineament (OL), transects the property (Figure 6). This lineament is considered an extension of the Waterberg Thrust, a prominent regional tectonic structure / fault line extending over ~250km from Grootfontein to Omaruru. The Waterberg Thrust is characterised by large-scale, low-angle thrusting that accommodated significant shortening of the Damara Supergroup during continental collision. The Omaruru Lineament similarly represents a zone of crustal-scale deformation, where intense fracturing and shearing have occurred.

Along this structural trend, the lineament juxtaposes metasedimentary rocks of the Swakop Group, Karibib Formation (Damara Supergroup) against sandstones of the Etjo Formation (Karoo Supergroup). The Swakop Group rocks are older, having been deposited during the Neoproterozoic era (~750–540 Ma). Within the Swakop Group, the Karibib Formation is a prominent lithostratigraphic unit dominated by medium- to thick-bedded dolomitic and calcitic carbonates, locally interbedded with calcareous shales. It is generally light grey in colour and displays karstic features, solution cavities, and minor brecciation along structural zones. The formation represents shallow marine carbonate deposition (approximately 700–580 Ma).

The Etjo Formation of the Karoo Supergroup is significantly younger, having been deposited in the Early Jurassic (~200–180 Ma). It is characterised by well-sorted, cross-bedded aeolian

sandstones, reflecting deposition in an extensive desert dune system. These sandstones are typically medium- to coarse-grained, with high primary porosity, and are often interbedded with minor interdune mudstones.

The juxtaposition of these older and younger units along the Omaruru Lineament results in a sharp lithological and structural contrast, with older, lithified carbonates of the Karibib Formation abutting younger, porous aeolian sandstones of the Etjo Formation. This contact is of considerable significance for both structural interpretation and hydrogeological assessment, as it represents a zone of potential groundwater accumulation, preferential flow, and structural control on aquifer connectivity.

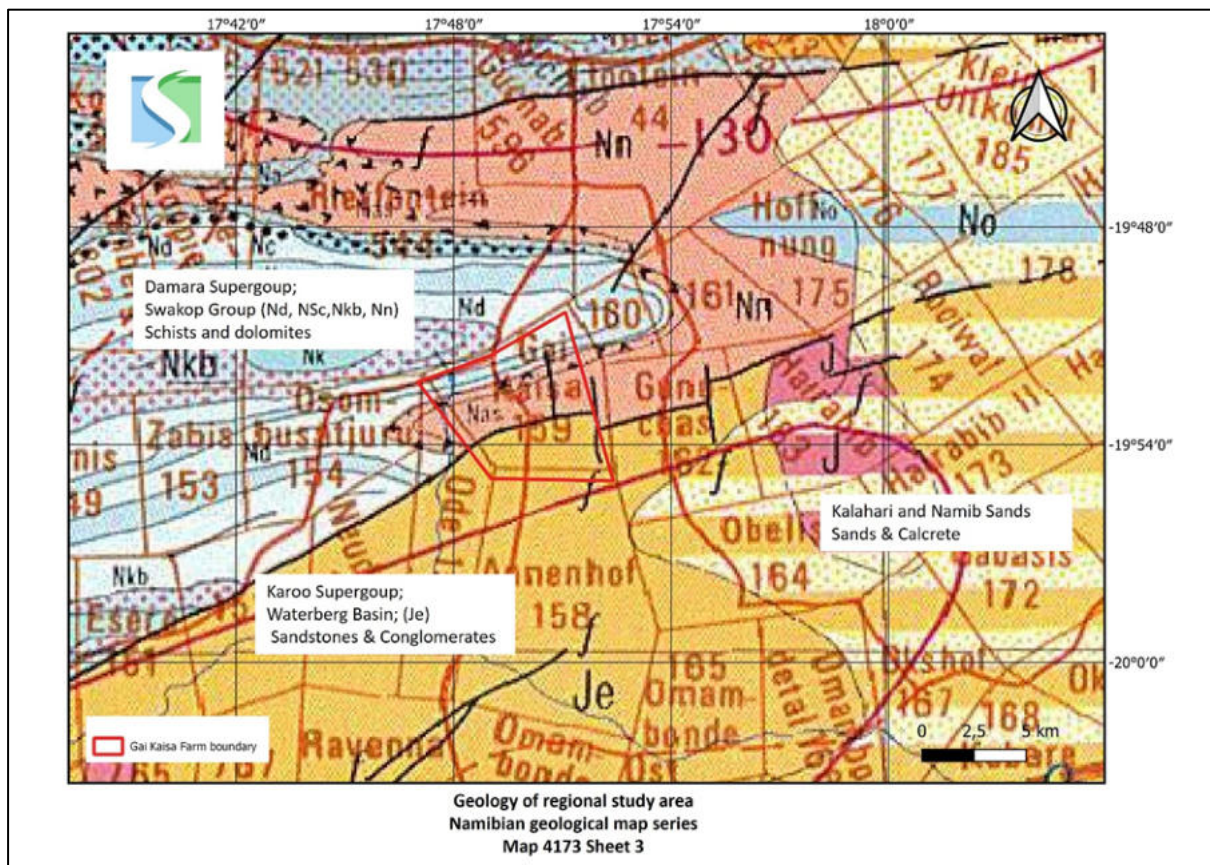
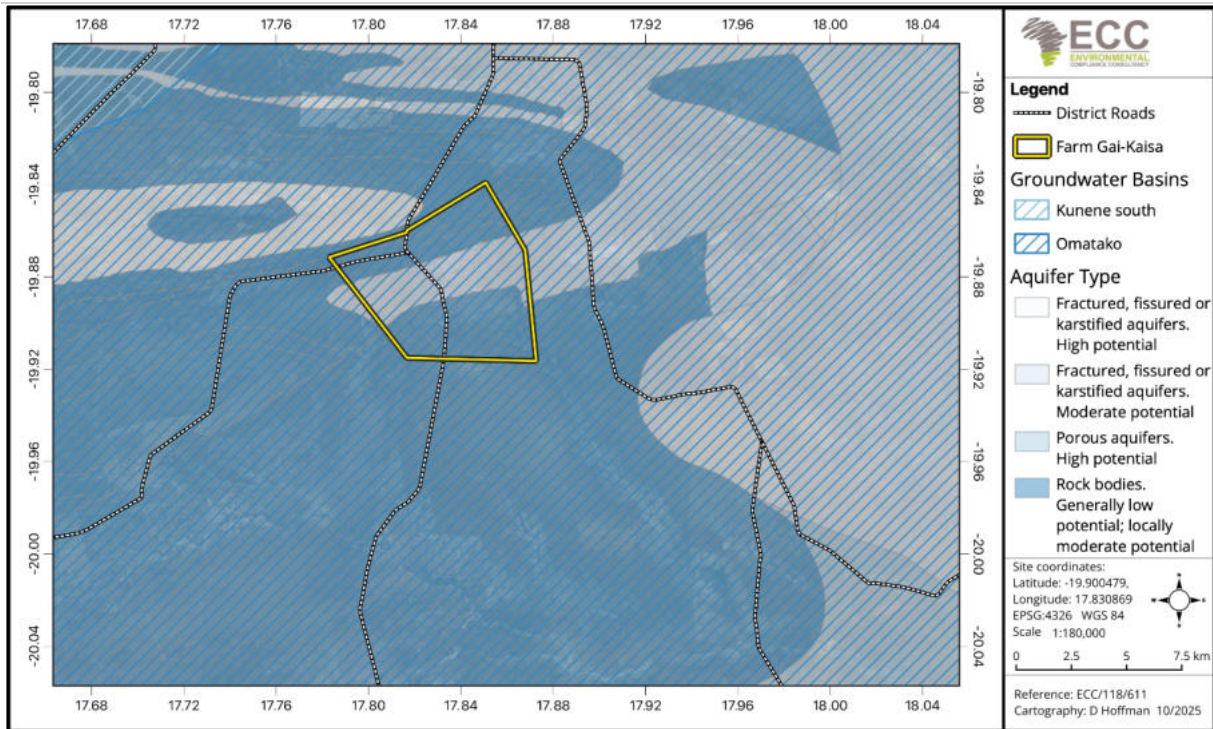


Figure 6 – Digital geological map of the study area

## 2.6 HYDROGEOLOGY

### 2.6.1 AQUIFER CHARACTERISATION

The farm lies ~20 km to the south, outside of the Grootfontein-Tsumeb-Otavi (GTO) water control area. According to the Hydrogeological Map of Namibia (Ministry of Agriculture, Water and Lan Reform, 2021), the project area is underlain by two distinct aquifer types (Figure 7). These reflect the contrasting lithologies and structural characteristics of the geological units present, namely the Swakop Group sediments in the north and the Karoo sediments in the south (see Table 2).



**Figure 7 – Hydrogeological map of Namibia showing two aquifer types of varies potential beneath Farm Gai Kaisa**

The Swakop Group sediments form a fractured, fissured, or karstic aquifer (secondary aquifer) with high groundwater potential. These aquifers are developed within non-porous lithologies such as marbles, quartzites, conglomerates, and dolomitic limestones, where secondary porosity has formed through fracturing, faulting, and dissolution. In the study area, this aquifer type is associated with the metasedimentary rocks of the Karibib Formation and undifferentiated meta-sediments of the Swakop Group, occurring in the northern portion of the farm and further north toward Kombat and Rietfontein.

These marble dominated units, exhibit well-developed karstification and structural permeability along fractures and lineaments associated with the Omaruru Lineament and the Waterberg Thrust system. Such conditions create zones of enhanced groundwater storage and transmissivity, making them highly prospective for groundwater development. It is anticipated that, the Karstic aquifer behaves in a semi-confined manner, with unconfined conditions potentially developing around structural features and near surface. Pressure changes in fractures and karsts, particularly at depth, may be expected to behave in a confined manner, where by saturated thickness does not change, but there remains a release of water per decline in head and a change in a potentiometric surface level. This approach will be adopted when undertaking first order groundwater storage estimations.

The Karoo sediments with generally low to locally moderate groundwater potential occur within poorly fissured or compacted lithologies, forming localised aquifers or regional aquitards. The Etjo sandstones are well-cemented aeolian deposits with limited intergranular

porosity and low fracture permeability. Groundwater occurrence in these units is typically discontinuous and perched, and borehole yields are variable to low unless structurally enhanced. The presence of the OL likely enhances hydraulic conductivity within the sandstones on the farm and provides increased groundwater potential. The sandstones are anticipated to respond in an unconfined manner, as is seen in areas to the south west where these sandstones are known to outcrop and be exposed (e.g., Waterberg Plateau).

The Omaruru Lineament, a major structural feature traversing the farm, juxtaposes the karstified Swakop Group metasediments against the Etjo sandstones. This structure, while not explicitly represented in regional hydrogeological models, is likely to play a significant role in groundwater movement and storage, as fault and fracture zones often act as preferential flow pathways in otherwise low-permeability formations.

Groundwater development within the area should therefore focus on lineament zones and structural intersections within the Swakop Group units north of the farm, where secondary porosity is greatest and groundwater yields are typically higher. Conversely, the Etjo Formation in the southern portion of the property is less favourable for groundwater development due to its limited primary porosity and weak fracture permeability. The potential of the sandstones (including the thickness of the unit) should however be explored in future to gain a better understanding of the hydrodynamics between the different aquifer types.

#### 2.6.2 GROUNDWATER FLOW AND RECHARGE

Regional studies by Mukwenda (2009), who developed a groundwater flow model for the Kombat region (including the area south of the Otavi Mountain Land and encompassing the farm), indicate that groundwater flow occurs predominantly toward the south and southeast (Figure 8), within the Omatako Groundwater Basin in the region of the farm. Recharge is derived primarily from precipitation over the Otavi Mountain Land to the north, where Otavi Group and Swakop Group metasediments are karstified and outcrop facilitating significant infiltration and recharge.

While the Omaruru Lineament was not included in Mukwenda's modelled flow framework, its structural influence likely enhances local recharge and subsurface connectivity between karstic and fractured zones.

Recharge in semi-arid central Namibia typically represents ~1–5% of the Mean Annual Rainfall (MAR), depending on lithology and soil infiltration capacity (MAWLR, 2021). Based on a MAR of approximately 500 mm/a, estimated average recharge for the area ranges between 5 and 25 mm/a, with locally higher recharge rates (>5%) expected in karstified and fractured zones within the Swakop Group.

As a first order estimate and based on a conservative adoption of rainfall (500 mm/a) and recharge (5 - 25mm/a), the 5000 ha farm surface area may facilitate between 250 000 m<sup>3</sup> – 1.25 million m<sup>3</sup> of recharge per annum. This is strictly theoretical, however, as groundwater is not constrained by property boundaries, and consideration of infiltration rates, residence time, flow boundaries, lateral recharge, and flow direction are not accounted for.

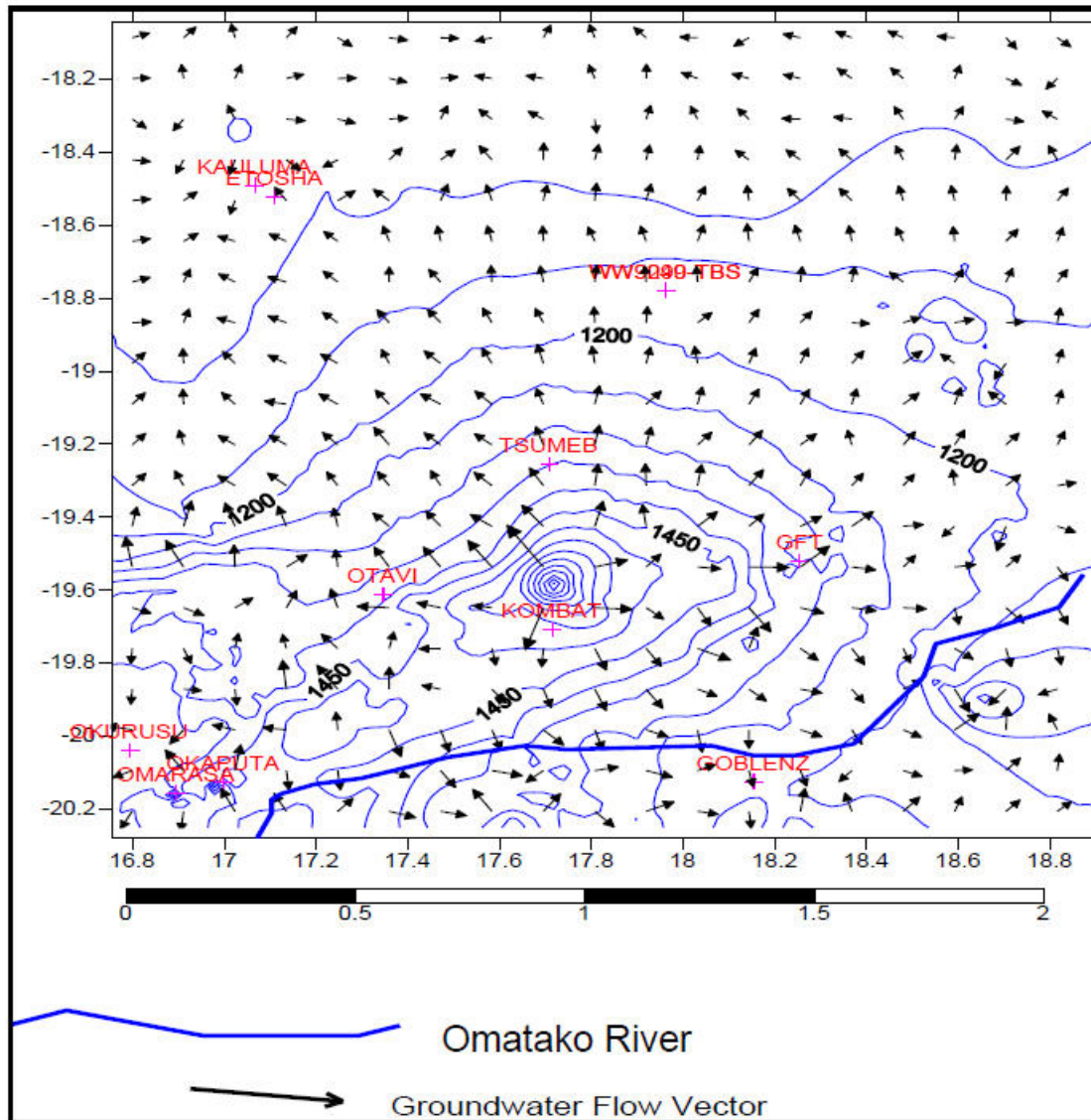


Figure 8 – Regional groundwater flow modelled by Mukwenda (2009)

### 2.6.3 GROUNDWATER LEVEL

Groundwater levels in the broader Otavi-Omatako basin region are generally shallow, typically less than 20 metres below ground level (mbgl). Converting groundwater levels to metres above mean sea level (mamsl), shows a consistent water table elevation, with the minor depression seen at borehole Site Water Feed, likely influenced by historic abstraction for the existing industrial and domestic uses. Regional groundwater flow broadly follows the

natural topographic gradient toward the south and southeast, consistent with Mukwenda’s (2009) model.

**Table 1 – Groundwater levels measure on Farm Gai Kaisa**

BH Name	Lat	Long	Elev (mamsl)	BH Depth (m)	Rest water level (mbgl)	Rest water level (mamsl)
Land I	-19.89001	17.8234	1408	105	11.9	1396
Land II	-19.8875	17.8278	1407	129	10.7	1396
Site Water Feed	-19.8952	17.8305	1402	45	8.8	1393
Site Workers Camp	-19.8997	17.8272	1404	51	7.4	1397
House	-19.8956	17.8320	1404	105	8.0	1396

Local deviations from this trend are observed where geological structures, lithological contrasts, and historical abstraction practices influence hydraulic gradients. Lineament or structure-controlled flow paths are particularly significant within the Swakop Group terrains, enhancing both recharge and lateral connectivity between discrete aquifer compartments.

#### 2.6.4 GROUNDWATER QUALITY

Regionally, groundwater in the Otavi–Omatoko Basin is mapped as excellent quality, suitable for potable and agricultural use. Results from sampling on the farm provide the following insights to groundwater quality:

Low salinity: Total Dissolved Solids (TDS < 600 mg/L), pH: Neutral to slightly alkaline (~7.0–7.5), Hardness: Slight to moderate, primarily due to dissolved calcium and magnesium from carbonate lithologies, nitrate and sulphate concentrations are low, typically below drinking water guideline limits. Trace metals (Fe, Mn): Low concentrations, generally below detection thresholds.

These parameters reflect good recharge quality, limited anthropogenic influence, and carbonate buffering from the Karibib Formation. The overall groundwater chemistry is consistent with a Ca–HCO<sub>3</sub> hydrochemical facies, typical of fresh groundwater circulating within carbonate and mixed lithological terrains.

### 3 HYDROGEOLOGICAL IMPLICATIONS AND DEVELOPMENT POTENTIAL

Given the contrasting hydrogeological characteristics of the two main lithostratigraphic units, groundwater exploration and borehole siting should target fractured and karstified zones within the Swakop Group north of the Omaruru Lineament, particularly along structural intersections, and fault-related fracture zones.

The Etjo Formation in the southern portion of the property is expected to yield lower borehole productivity, with drilling efforts here considered less favourable unless supported by structural enhancement or perched aquifers.

Future groundwater development should integrate structural mapping, geophysical lineament analysis, and targeted test drilling to refine the local hydrogeological model and optimise borehole yields.

A first order groundwater availability assessment based on the aerial extent of Swakop sediment underlying the farm (~3500 ha) and literature based values for aquifer parameters such as aquifer thickness (150 m) and Storativity (specific storage –  $1E-5$  and specific yield: 0.05 – depending on confined or unconfined conditions) the following volumes are derived: Unconfined conditions indicate a total drainable pore volume of ~260 million  $m^3$  (water in static storage beneath the farm). Confined conditions, drainage per decrease in 1 m head is estimated at 52500  $m^3$ .

Note the above calculations are order of magnitude planning values to derive an indication of the groundwater potential within the farm boundaries only. Volumes are indicative only and do not account for larger areas of flow (as opposed to property boundaries only), addition of recharge and variation in aquifer parameters and thickness. Volumes derived indicate a positive groundwater potential, supporting bulk abstraction from the aquifer, supported by high frequency monitoring of volumes, pump rates and groundwater levels.

**Table 2 - Geological and hydrogeological characterisation underlying Farm Gai Kaisa**

Geological Unit	Supergroup / Group	Age & Era	Typical Lithology	Depositional Environment	Structural Relationship	Hydrogeological Characteristics
Etjo Formation	Karoo Supergroup	Early Jurassic (~200–180 Ma, Mesozoic)	Well-sorted, cross-bedded aeolian sandstones, locally with thin interdune siltstones and mudstones	Aeolian dune and interdune depositional system under arid continental conditions	Overlies the Omingonde Formation or, where eroded, rests unconformably on older Damara metasediments. Along the Omaruru Lineament, it is juxtaposed against the Karibib Formation by faulting.	Acts as a secondary fractured and porous aquifer. Primary porosity in uncemented zones may exceed 15–20%. Recharge is local through rainfall and preferential infiltration along fractures and lineaments. Water quality is generally fresh, though locally variable depending on cementation and depth.
Karibib Formation	Swakop Group, Damara Supergroup	Neoproterozoic (~700–580 Ma)	Thick-bedded dolostones and limestones with subordinate calcareous schists and quartzites; locally karstified and brecciated	Shallow marine carbonate platform environment during Damara basin sedimentation	Thrust and fault-bounded unit along the Omaruru Lineament (extension of the Waterberg Thrust). Intensely deformed and recrystallized under greenschist-facies metamorphism.	Locally forms a karstic to fractured carbonate aquifer with moderate to high secondary permeability along joints and dissolution cavities. Groundwater yield is variable (low in crystalline zones, higher in karstified sections). Water quality can be hard due to dissolved carbonates.
Structural Feature: Omaruru Lineament	—	Neoproterozoic in origin; reactivated during Mesozoic and later	Zone of shearing, faulting, and fracturing extending northeast–southwest across central Namibia	Deep-seated crustal discontinuity; marks the contact between the Damara Orogenic Belt and the Karoo Basin margin	Controls juxtaposition of Neoproterozoic metasediments (Karibib Fm.) and Mesozoic sandstones (Etjo Fm.)	Provides enhanced secondary permeability; acts as a hydrogeological conduit for regional and localised groundwater flow and storage.

### 3.1.1 EXISTING BOREHOLES

A request for details of existing boreholes on the farm and its immediate neighbours (farm Ode no.156, Gunuchas no. 162, Gesundbunnen no. 1326 and Kududam no. 161) was submitted to the Geohydrology Division of Department of Water Affairs. Very limited details were available in the DWA records, with only some borehole locations derived from the GROWAS database. The lack of records, coupled with limited land use activities in the region imply limited to no bulk abstraction taking place in the vicinity of the farm.

There are four existing registered boreholes on the farm, however, an additional five boreholes (EB1-EB5) require registration and are planned for abstraction (Table 1). Work undertaken to develop groundwater on the farm (i.e. from the five aforementioned boreholes) is described in subsequent sections.

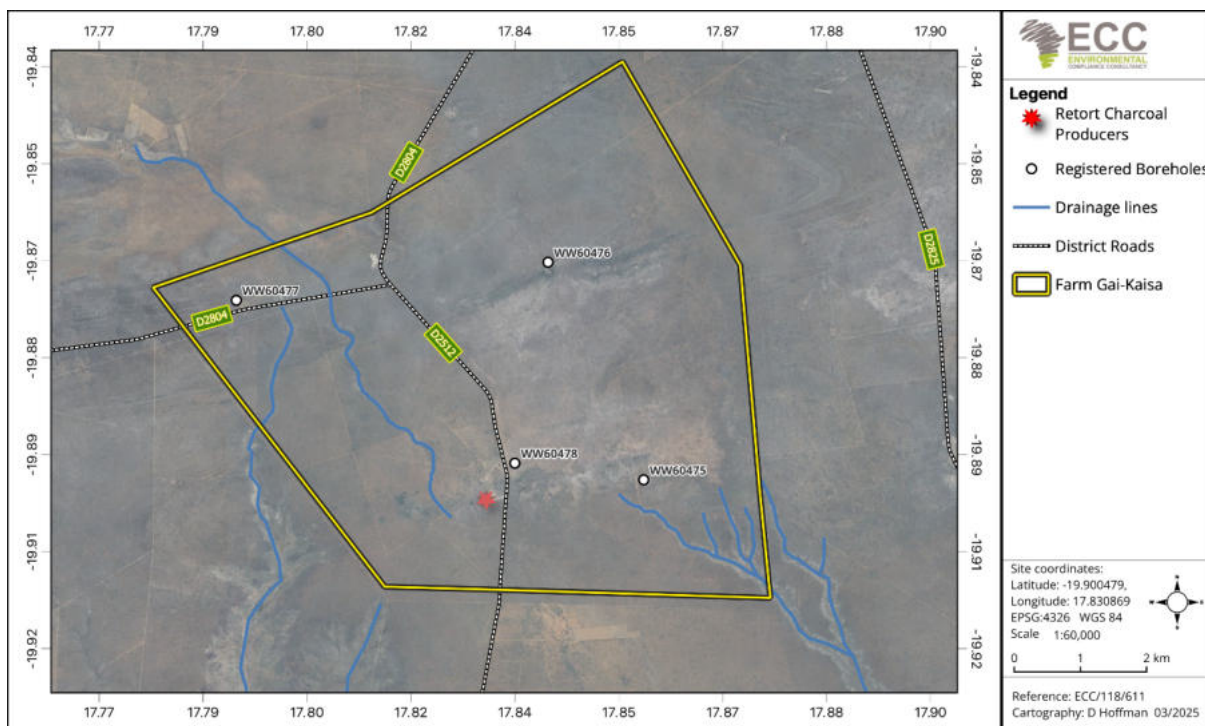


Figure 9 – Map of existing borehole locations derived from GROWAS and DWA databases

## 4 WATER REQUIREMENT AND IRRIGATION

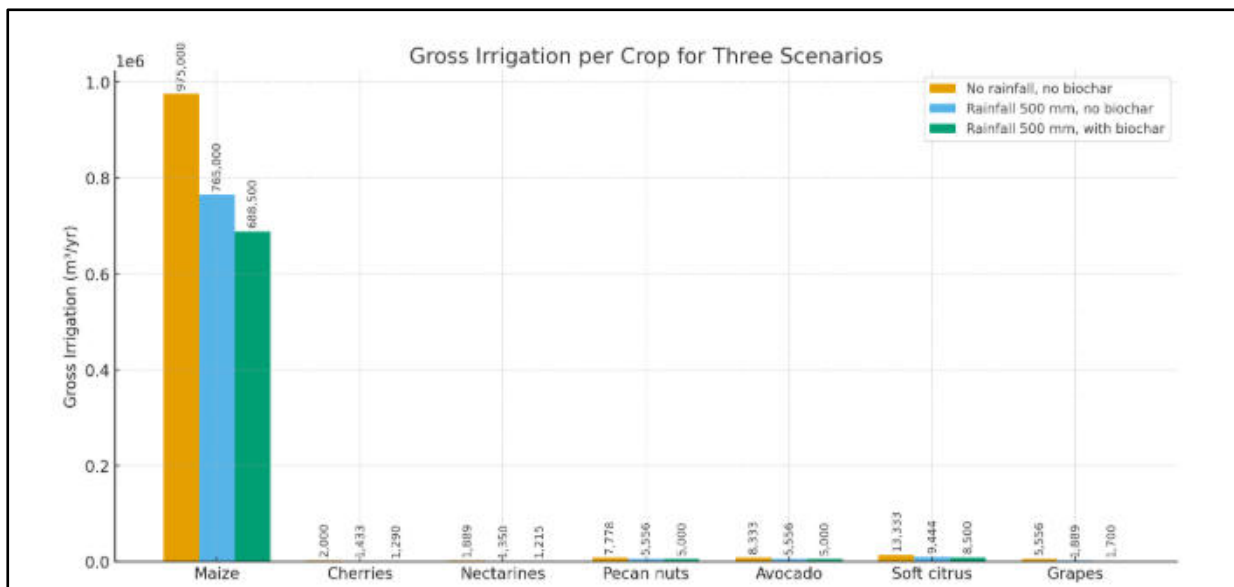
Existing groundwater use is estimated at 800 m<sup>3</sup>/a for charcoal and biochar production and 200 m<sup>3</sup>/a for domestic use, totalling 1000 m<sup>3</sup>/a.

Irrigation is planned under two (2) phases each comprising a total cultivation of ~135 ha. Table 3 calculates the expected crop water requirement (CWR) and the gross volumetric abstraction requirement for phase 1 under various scenarios adopting the following assumptions:

- Total rainfall of 500 mm per annum with effective rainfall of 60 % (this is the portion of rainfall that is available to crops);
- Maize growing season = Oct–Apr (~362 mm effective rainfall)
- Perennials = full year = 300 mm effective rainfall
- Biochar is assumed to increase plant available water and reduce irrigation need by ~10%
- Scenario 1: no rainfall contribution i.e. crops must be fully irrigated to meet the crop water requirement and no influence of biochar;
- Scenario 2:
  - For annual crops (maize) the CWR is treated as a single-season value; for perennials (fruit trees, grapes, pecans, avocado) an annual crop water requirement is used.
  - “Typical CWR” values used:
    - o Maize: ~600 mm/season
    - o Cherries: ~900 mm/a
    - o Nectarines: ~850 mm/a
    - o Pecans: ~1,400 mm/a
    - o Avocado: ~1,500 mm/a
    - o Soft citrus: ~1,200 mm/a
    - o Grapes: ~500 mm/a
- 1 mm = 10 m<sup>3</sup>/ha for volume calculations
- Seasonal distribution of rainfall has an impact on CWR and gross abstraction requirements
- Drip irrigation for trees/vineyards reduces losses and can often achieve crop water needs with smaller volumes (applied closer to root zone); however, the CWR stays roughly the same
- Drip irrigation efficiency is adopted at 90% and pivot irrigation efficiency at 80%.

**Table 3 – Gross abstraction volumes required for irrigation under various cultivation and rainfall scenarios**

Crop (method)	Area (ha)	CWR (mm/yr or season)	Gross irrigation Scenario 1: No rainfall, no biochar (m <sup>3</sup> /a)	Gross irrigation Scenario 2: Rainfall 500 mm, no biochar (m <sup>3</sup> /a)	Gross irrigation Scenario 3: Rainfall 500 mm, with biochar (10% saving) (m <sup>3</sup> /a)
Maize (pivot)	130.0	600	975000	765000	688500
Cherries (drip)	0.2	900	2000	1433	1290
Nectarines (drip)	0.2	850	1889	1350	1215
Pecan nuts (drip)	0.5	1400	7778	5556	5000
Avocado (drip)	0.5	1500	8333	5556	5000
Soft citrus (drip)	1.0	1200	13333	9444	8500
Grapes (drip)	1.0	500	5556	1889	1700
<b>TOTAL</b>	134	—	<b>1013889</b>	<b>790228</b>	<b>711205</b>



**Figure 10 – Gross volume of water to abstract (includes losses) under various cultivations and rainfall scenarios**



**Figure 11 – Area on Farm Gai Kaisa (red polygon) planned for centre pivot irrigation (green circles)**

Based on existing use and typical crop water requirements, Phase 1 has a water requirement of ~1 million m<sup>3</sup> per annum. Phase 2 includes an increased hectarage to ~260 ha and motivates a total groundwater requirement of 2 million m<sup>3</sup> per annum. As shown in Table 3, actual volumes are anticipated to decrease depending on rainfall conditions and the efficacy of the biochar application. Values given are typical/representative seasonal or annual CWR estimates — local evapotranspiration, crop variety, management, phenology, planting density, and seasonal rainfall timing will influence values.

Based on the high level groundwater potential determined in preceding sections, it is anticipated that groundwater sourced on the farm can sustainably supply the required volumes of water required for both phases of irrigation.

## 5 GROUNDWATER DEVELOPMENT

### 5.1 GEOPHYSICS AND BOREHOLE DRILLING

A geophysical contractor undertook a survey using the Electromagnetic (EM) technique (Figure 12) targeting lineaments, potential structures and contacts presumably identified during desktop mapping. Results of the MLEM survey identified several areas of increased potential and boreholes were sited, however, for unknown reasons, boreholes were drilled in different locations, not coinciding with the locations of increased potential (Figure 13).

It is noted that while mapped as a lineament or single linear feature, it is likely that the OL incorporates a larger area or zone along which increased groundwater potential may be expected, likely resulting in the positive outcomes obtained during borehole drilling.



Figure 12 – Photos taken during the EM survey on Farm Gai Kaisa

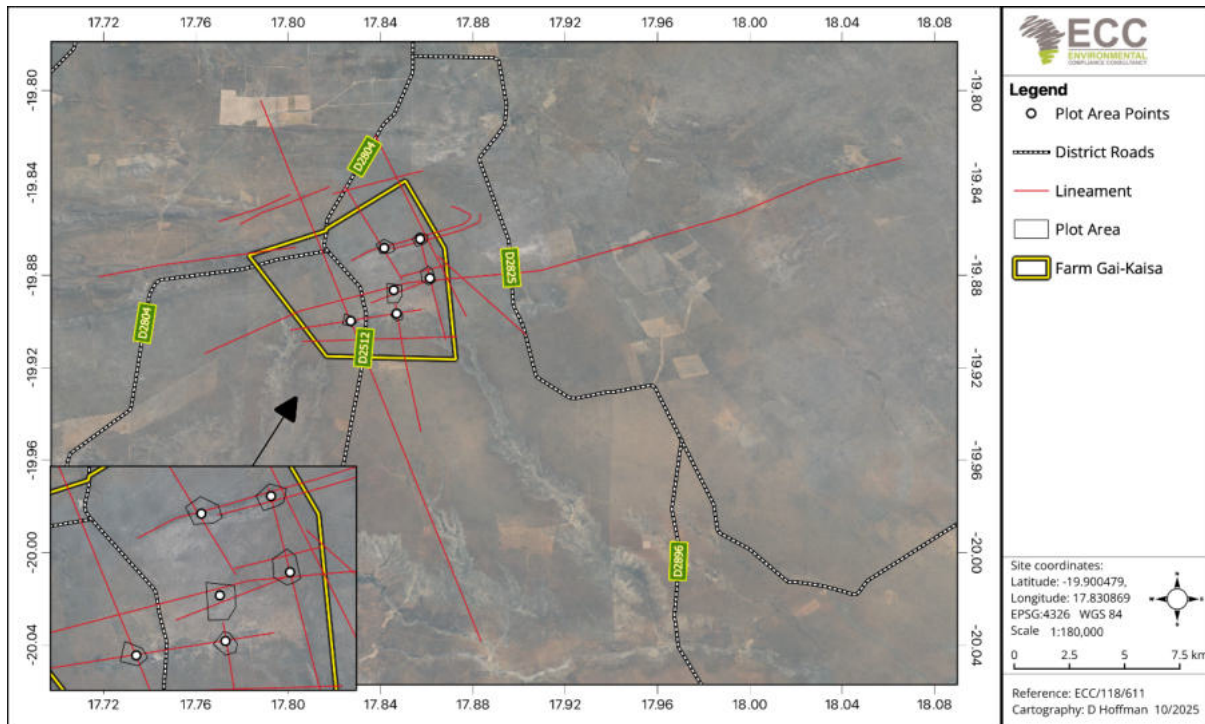
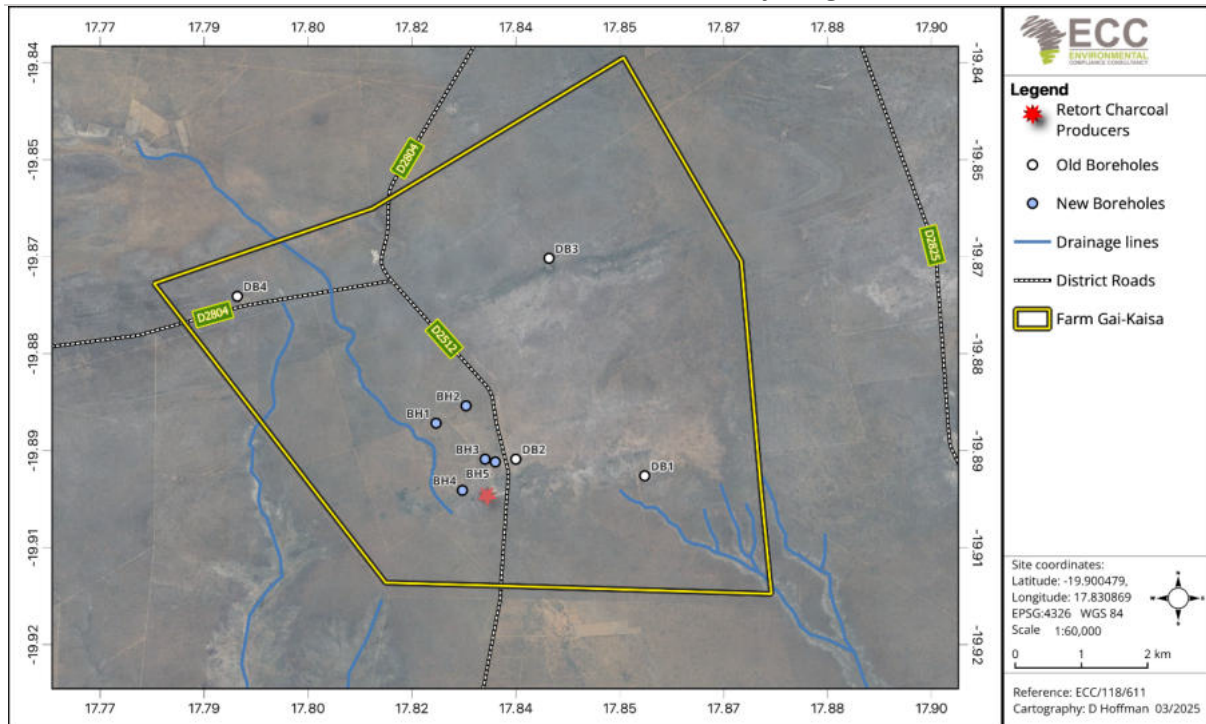


Figure 13 – Lineament mapping, areas of increased groundwater potential and proposed borehole drilling locations

Table 4 provides a summary of the borehole drilling details, Figure 14 shows borehole locations and drillers / borehole completion reports are provided in Appendix A.



**Figure 14 – Map of drilled borehole locations (note DB denotes existing, registered boreholes)**

**Table 4 – Borehole drilling details and results**

BH No.	BH Name	Lat	Long	BH Depth (m)	Drilling Diameter (mm)	Drilling Interval (mbgl)		Casing interval (mm)		Casing Type and diameter	Water Strike (mbgl)	Blow Yield (m <sup>3</sup> /h)	Collar Height (m)	RWL (mbgl)
						From	To	From	To					
BH1	Land I	-19.89	17.82	105	254	0	6	0	6	219 mm plain steel casing	19, 22, 32, 63, 85	24	0.5	12.5
					203	6	105	6	105	None (open)				
BH2	Land II	-19.89	17.83	129	254	0	6	0	6	219 mm steel casing	13, 23, 42, 112	42	0.5	10.85
					203	6	129	6	129	None (open)				
BH3	Site Workers Camp	-19.90	17.83	51	304	0	6	0	3	274 mm plain steel casing	9, 13, 37, 31, 36	250	0.5	8.6
					254	6	30	0	30	219 mm plain steel casing				
					203	30	51	30	51	219 mm perforated steel casing				
BH4	House	-19.90	17.83	105	254	0	6	0	6	219 mm plain steel casing	14, 47, 87, 101	159	0.5	7.9
					203	6	105	6	105	None (open)				
BH5	Site Water Feed	-19.90	17.83	111	254	0	6	0	6	219 mm plain steel casing	30, 38, 41, 58, 65, 106	111	0.5	10.4
					203	6	111	6	111	None (open)				

## 5.2 TEST PUMPING

After borehole drilling was complete, test pumping was undertaken on the five (5) drilled boreholes. Test design comprised a step discharge test, recovery, constant rate discharge test, followed by recovery measurements. Table 5 provides an overview of the various tests undertaken at the five (5) boreholes and all test pumping data is in Appendix B with water quality results in Appendix C. As analytical solutions for karstic aquifers are not readily available, a combination of unconfined Theis (1935) and Neumann (1974) solutions were applied to determine the aquifer parameters for the karstic aquifer. The aquifer thickness was conservatively assumed to be 120 m for all boreholes. Analysis for aquifer parameters and forward solution modelling of long term drawdown values was undertaken in Aqtesolv software developed by HydroSolve Inc., while FC programme was used to evaluate derivative curves and subjective information regarding boundaries and flow regimes. Parameter estimation was undertaken for periods of radial flow where possible. All analyses were carried out with conservative available drawdown values to protect main water strikes intersected during drilling (similarly for recommended pump installation depths).

**Table 5 - Test pumping details per borehole**

BH Name	Lat	Long	BH Depth (m)	Rest water level (mbgl)	Rest water level (mamsl)	Test Yield (m <sup>3</sup> /hr)					CDT Duration (min)	Final drawdown (m)
						Step1	Step2	Step3	Step4	CDT		
Land I	-19.89001	17.82349	105	11.9	1396	30	50	80	100	100	1440	5.99
Land II	-19.8875	17.82782	129	10.7	1396	20	30	50	70	40	1440	15.02
Site Water Feed	-19.8952	17.83057	45	8.8	1393	30	50	70	100	100	1440	3.98
Site Workers Camp	-19.8997	17.82729	51	7.4	1397	30	60	80	112	110	1440	1.4
House	-19.8956	17.83204	105	8.0	1396	30	60	90	113	105	1440	2.5

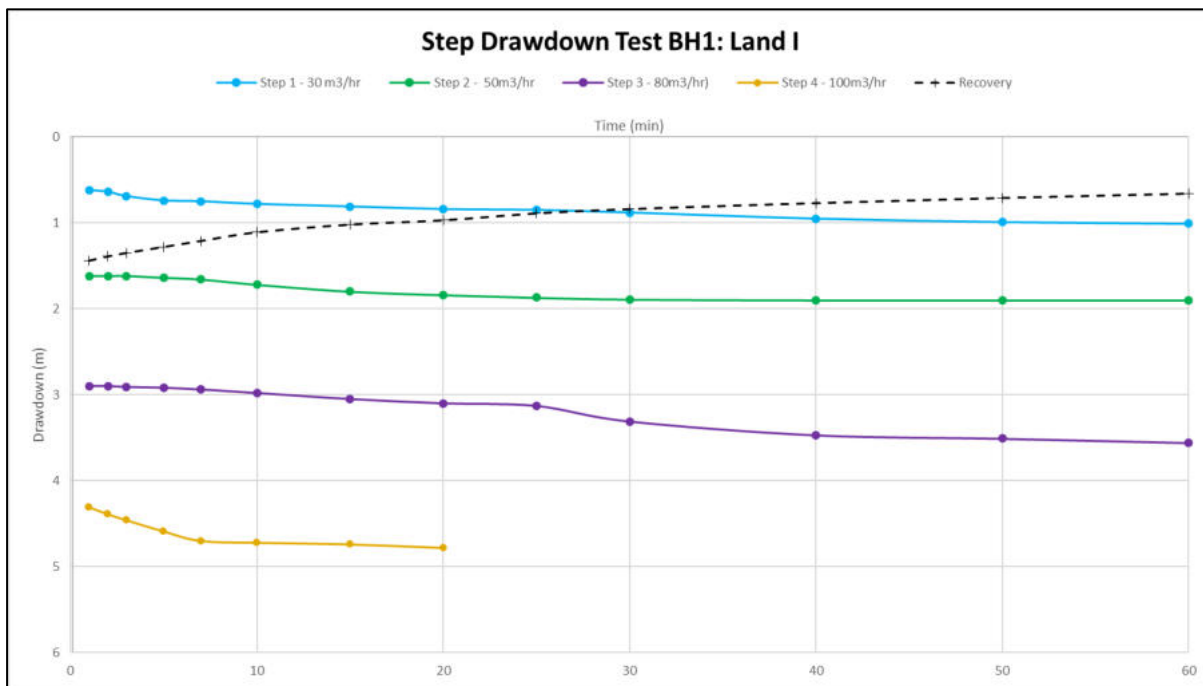
### 5.2.1 LAND I

Land I underwent a stepped discharge test on 23/09/2024 comprising four (4) one hour long discharge steps, followed by recovery monitoring for 240 minutes until the water level recovered to 100% of the rest level measured prior to testing. Table 5 provides a summary of the borehole construction and testing details. Figure 15 provides an overview of elapsed time since start of pumping versus drawdown of water level recorded during the step test. Step 4 (100 m<sup>3</sup>/hr) was cut short for unknown reasons.

The Constant Rate Discharge Test (CDT) was undertaken for 24 hours (1440 minutes) on 24/09/2024 at a rate of 100 m<sup>3</sup>/h. Figure 16 shows the time versus drawdown during the constant rate discharge test and recovery monitoring. The borehole is high yielding, with limited drawdown and shows rapid recovery after cessation of pumping.

Applying a combination of the Theis (1935) and Neumann (1974) analytical solutions (Figure 17), a Transmissivity value of 379 m<sup>2</sup>/d was determined. The recommended yield of 65 m<sup>3</sup>/hr is determined based on subjective information related to flow boundaries, a two year forward modelling of drawdown and the assumption of zero recharge entering the system. It is recommended that the borehole be allowed to recover for at least 24 hours per week. A

summary of results and recommendations is provided in Table 6. Abstraction rates (weekly), volumes (weekly and collated monthly) and groundwater levels (twice daily) are recommended to be monitored at the borehole, allowing a revision (upward or downward) of the recommended yield after 6 months of operation.



**Figure 15 Step test at BH Land I**

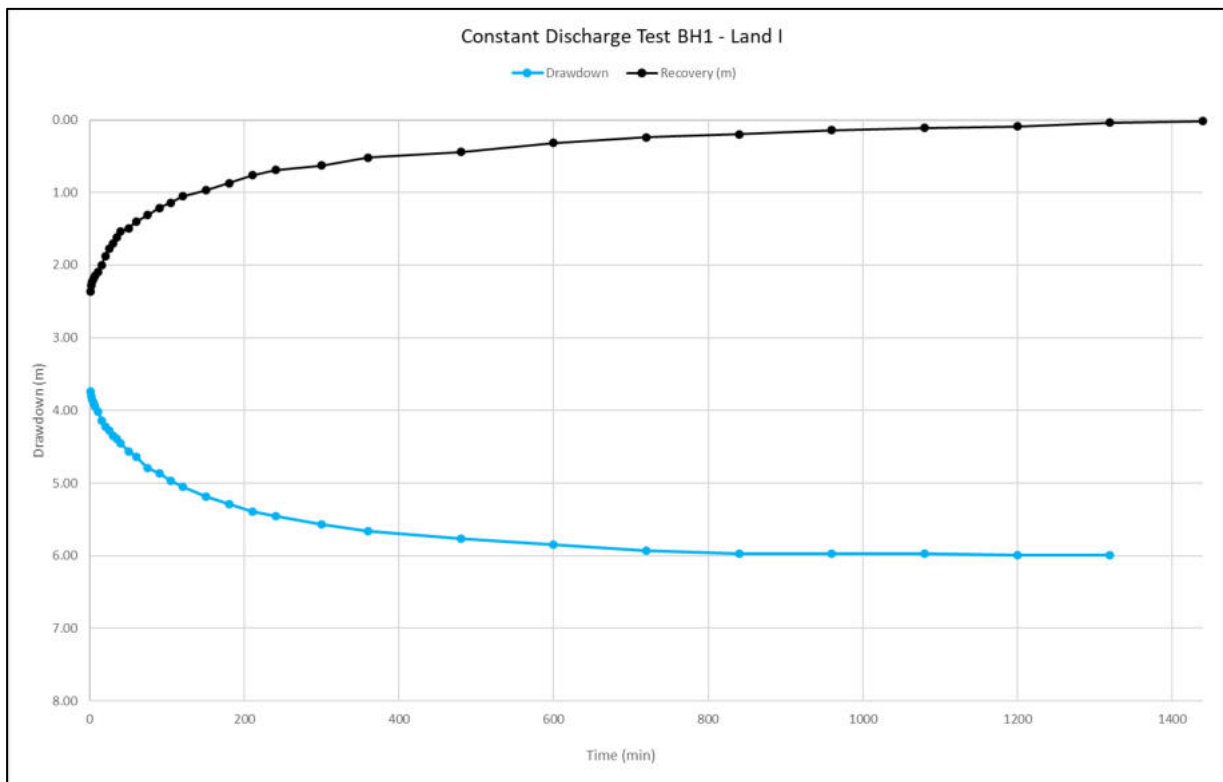


Figure 16 – CDT at BH1 – Land I at a rate of 100 m<sup>3</sup>/h for 24 hours

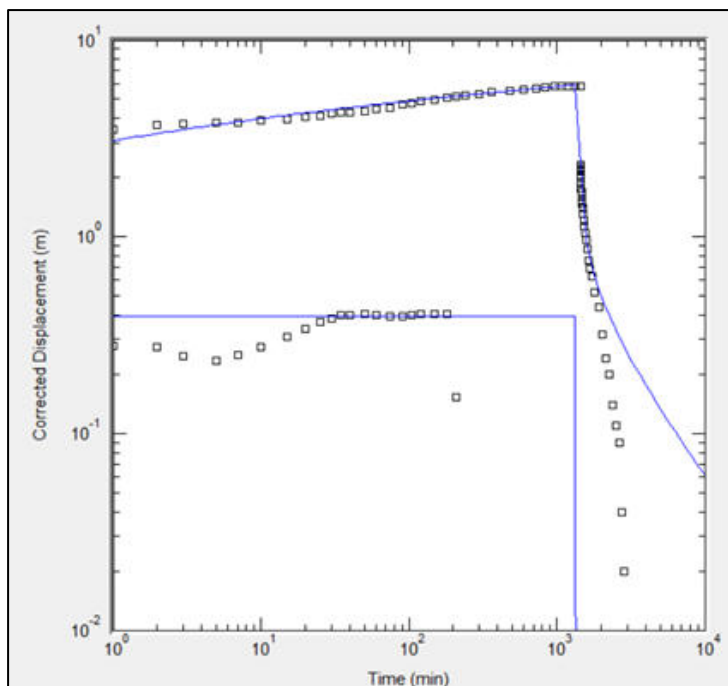


Figure 17 – Curve matching drawdown vs time and derivative data with the Theis (1934) solution for aquifer parameter estimation

### 5.2.2 LAND II

Land II underwent a stepped discharge test on 17/10/2024 comprising four (4) one hour long discharge steps, followed by recovery monitoring for 480 minutes until the water level recovered to 100% of the rest level measured prior to testing. Table 5 provides a summary of the borehole construction and testing details. Figure 18 provides an overview of elapsed time since start of pumping versus drawdown of water level recorded during the step test. Step 4 (70 m<sup>3</sup>/hr) could not be maintained for a full hour before the available drawdown was exhausted.

The Constant Rate Discharge Test (CDT) was undertaken for 24 hours (1440 minutes) on 18/10/2024 at a rate of 40 m<sup>3</sup>/h. Figure 19 shows the time versus drawdown during the constant rate discharge test and recovery monitoring. The borehole is moderately high yielding and shows rapid recovery after cessation of pumping.

Applying a combination of the Theis (1935) and Neumann (1974) analytical solutions (Figure 20), a Transmissivity value of 93 m<sup>2</sup>/d was determined. The recommended yield of 25 m<sup>3</sup>/hr is determined based on subjective information related to flow boundaries, a two year forward modelling of drawdown and the assumption of zero recharge entering the system. It is recommended that the borehole be allowed to recover for at least 24 hours per week. A summary of results and recommendations is provided in Table 6.

Abstraction rates (weekly), volumes (weekly and collated monthly) and groundwater levels (twice daily) are recommended to be monitored at the borehole, allowing a revision (upward or downward) of the recommended yield after 6 months of operation.

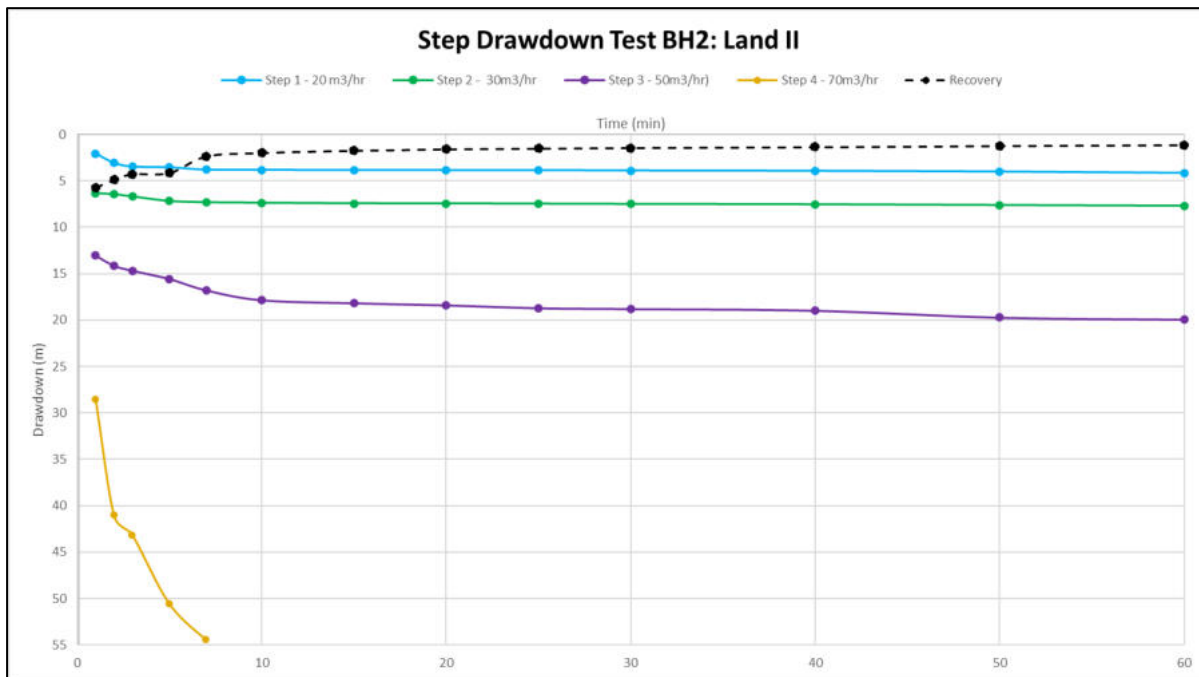
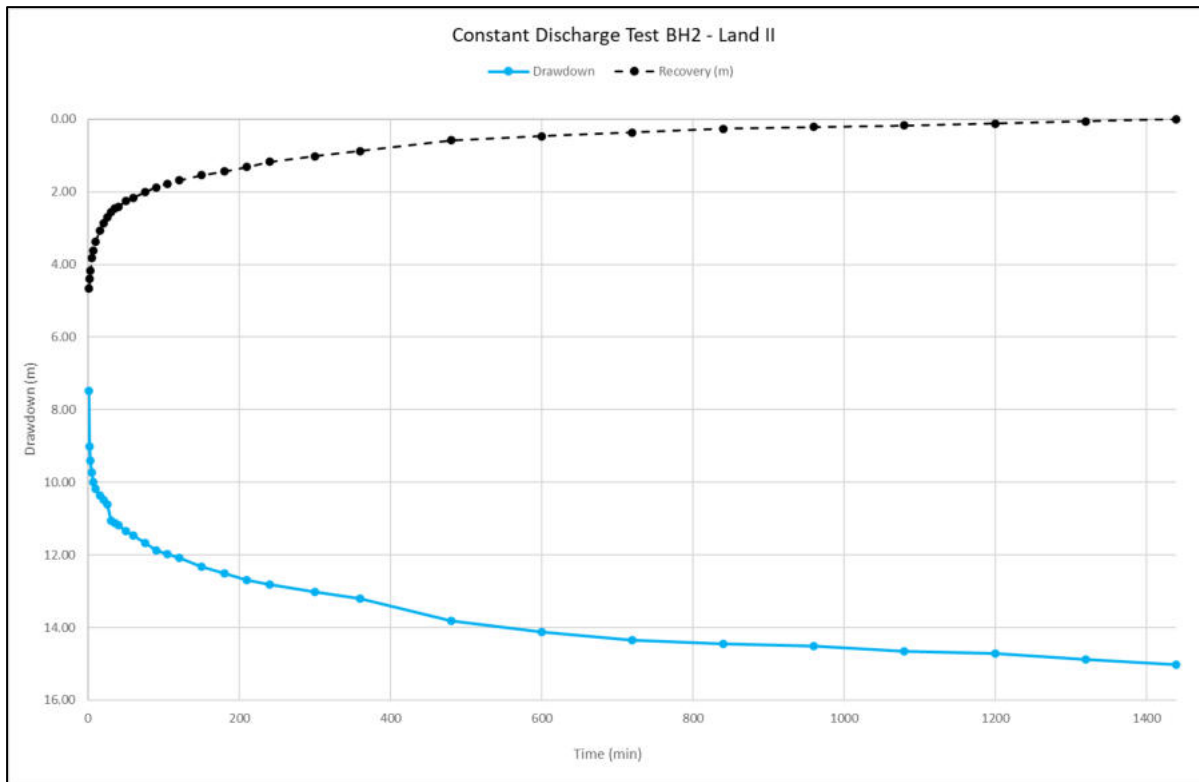
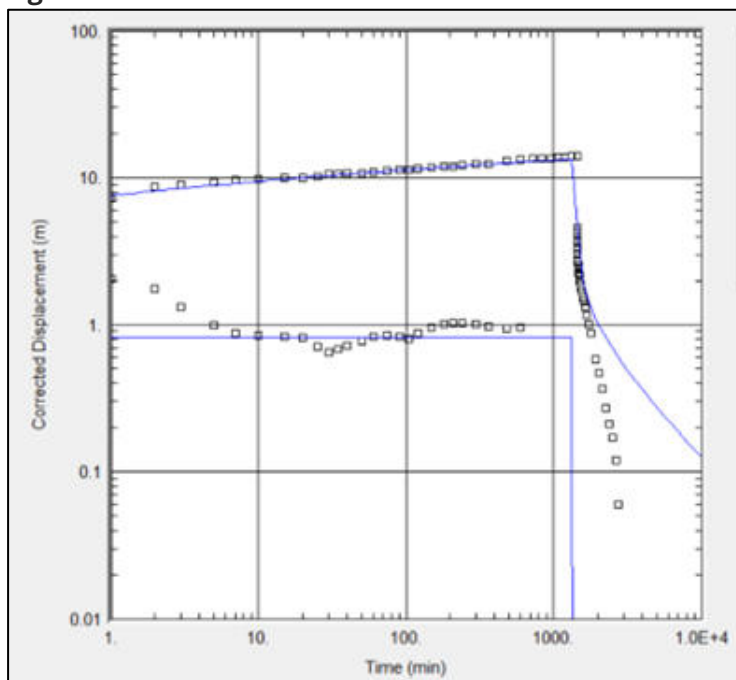


Figure 18 - Step test at BH2 – Land II



**Figure 19 – CDT at BH2 – Land II at a rate of 40 m<sup>3</sup>/h for 24 hours**



**Figure 20 - Curve matching drawdown vs time and derivative data with the Theis (1934) solution for aquifer parameter estimation**

### 5.2.3 SITE WATER FEED

Site Water Feed underwent a stepped discharge test on 12/11/2024 comprising four (4) one hour long discharge steps, followed by recovery monitoring for 120 minutes until the water level recovered to 100% of the rest level measured prior to testing. Table 5 provides a summary of the borehole construction and testing details. Figure 21 provides an overview of elapsed time since start of pumping versus drawdown of water level recorded during the step test.

The Constant Rate Discharge Test (CDT) was undertaken for 24 hours (1440 minutes) on 13/11/2024 at a rate of 100 m<sup>3</sup>/h. Figure 22 shows the time versus drawdown during the constant rate discharge test and recovery monitoring. The borehole is high yielding and shows rapid recovery after cessation of pumping.

Applying a combination of the Theis (1935) and Neumann (1974) analytical solutions (Figure 24), a Transmissivity value of 3250 m<sup>2</sup>/d was determined. The recommended yield of 80 m<sup>3</sup>/hr is determined based on subjective information related to flow boundaries, a two year forward modelling of drawdown and the assumption of zero recharge entering the system. It is recommended that the borehole be allowed to recover for at least 24 hours per week. A summary of results and recommendations is provided in Table 6.

Abstraction rates (weekly), volumes (weekly and collated monthly) and groundwater levels (twice daily) are recommended to be monitored at the borehole, allowing a revision (upward or downward) of the recommended yield after 6 months of operation. This borehole is

~160 m west of BH – House and should be monitored to ensure no hydraulic connection (borehole interference) exists between the two boreholes if pumped simultaneously.

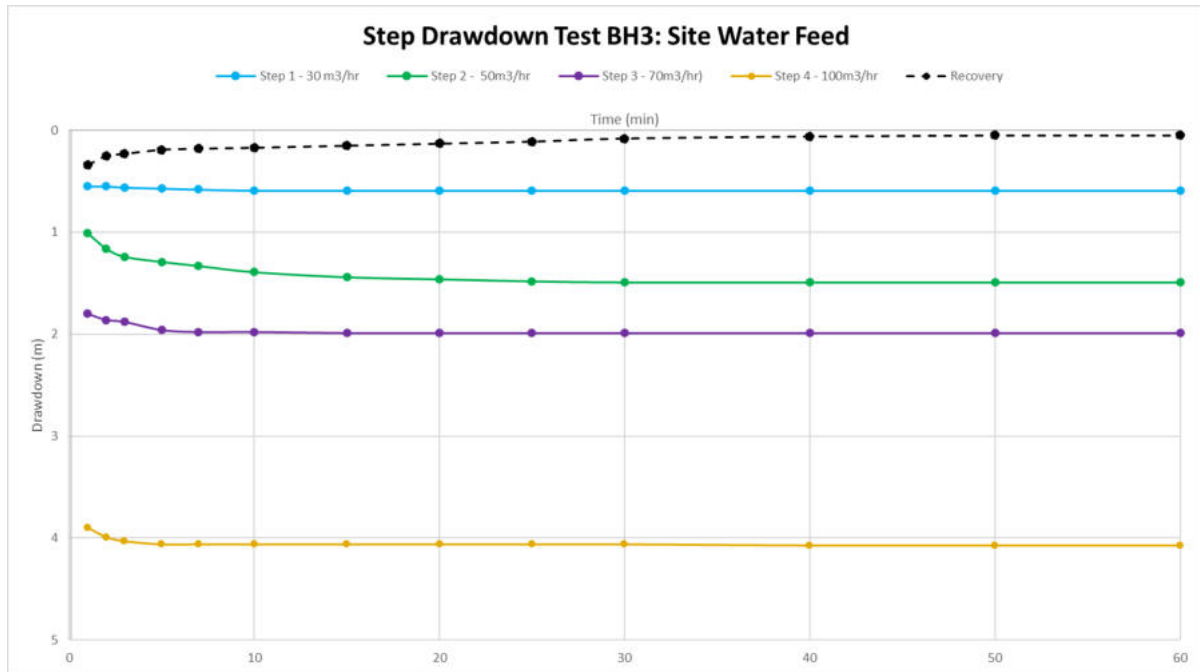


Figure 21 - Step test at BH3 – Site Water Feed

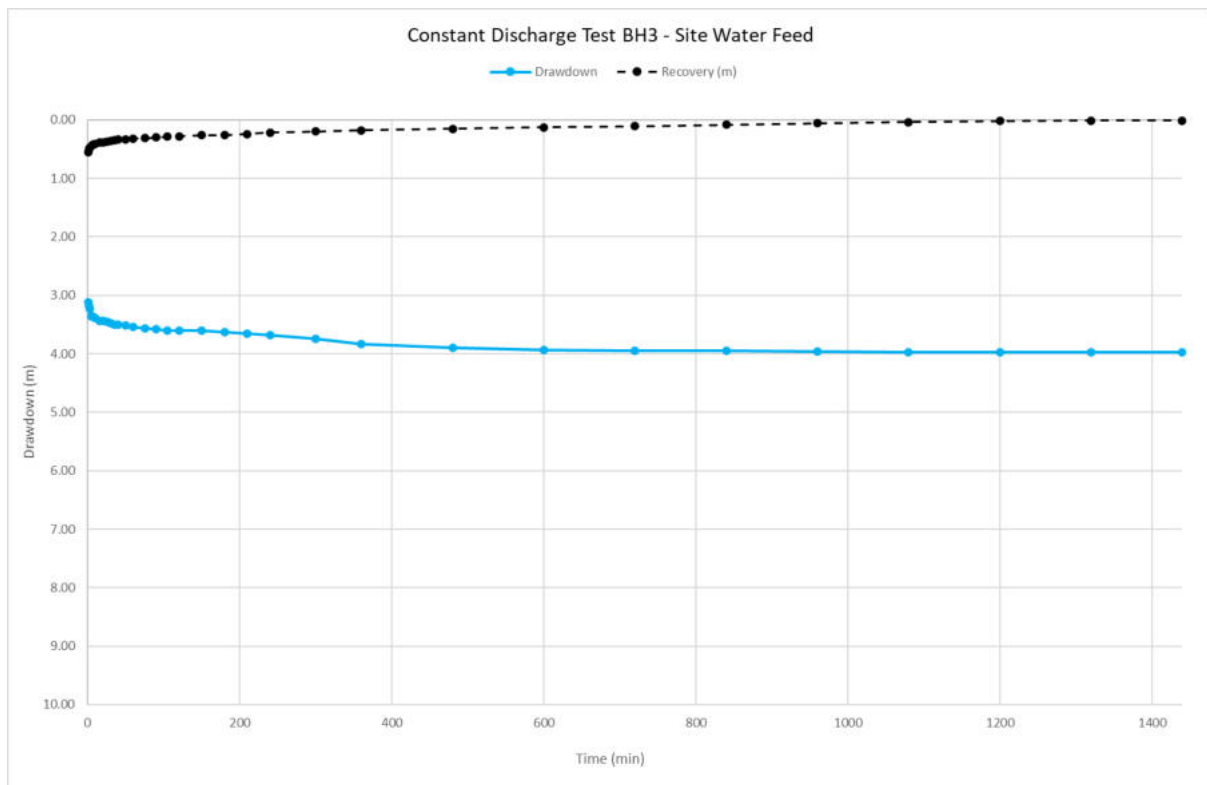
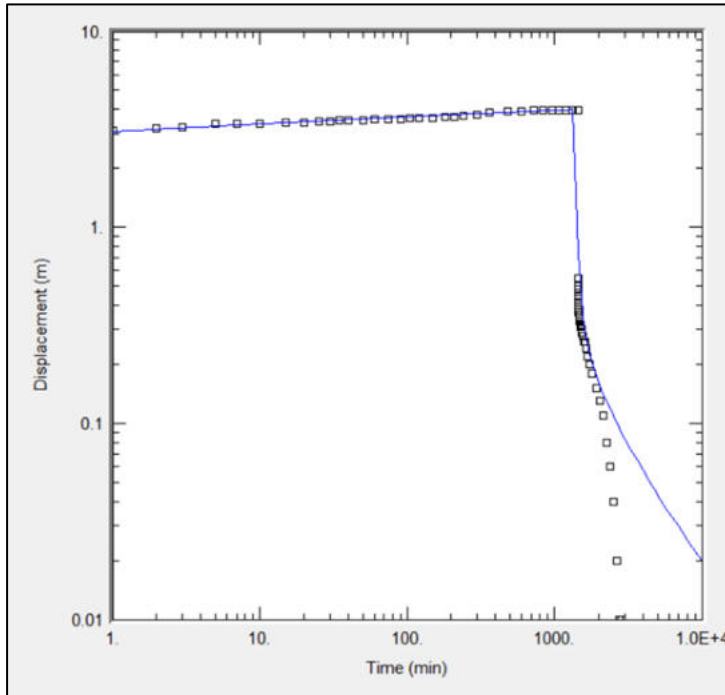


Figure 22 - CDT at BH3 – Site Water Feed at a rate of 100 m<sup>3</sup>/h for 24 hours



**Figure 23 - Curve matching drawdown vs time and derivative data with the Theis (1934) solution for aquifer parameter estimation**

#### 5.2.4 SITE WORKERS CAMP

Site Workers Camp underwent a stepped discharge test on 15/11/2024 comprising four (4) one hour long discharge steps, followed by recovery monitoring for 300 minutes until the water level recovered to 100% of the rest level measured prior to testing. Table 5 provides a summary of the borehole construction and testing details. Figure 24 provides an overview of elapsed time since start of pumping versus drawdown of water level recorded during the step test.

The Constant Rate Discharge Test (CDT) was undertaken for 24 hours (1440 minutes) on 16/11/2024 at a rate of 110 m<sup>3</sup>/h. Figure 25 shows the time versus drawdown during the constant rate discharge test and recovery monitoring. The borehole is high yielding and shows rapid recovery after cessation of pumping.

Applying a combination of the Theis (1935) and Neumann (1974) analytical solutions (Figure 26), a Transmissivity value of 2700 m<sup>2</sup>/d was determined. The recommended yield of 90 m<sup>3</sup>/hr is determined based on subjective information related to flow boundaries, a two year forward modelling of drawdown and the assumption of zero recharge entering the system. It is recommended that the borehole be allowed to recover for at least 24 hours per week. A summary of results and recommendations is provided in Table 6.

Abstraction rates (weekly), volumes (weekly and collated monthly) and groundwater levels (twice daily) are recommended to be monitored at the borehole, allowing a revision (upward or downward) of the recommended yield after 6 months of operation.

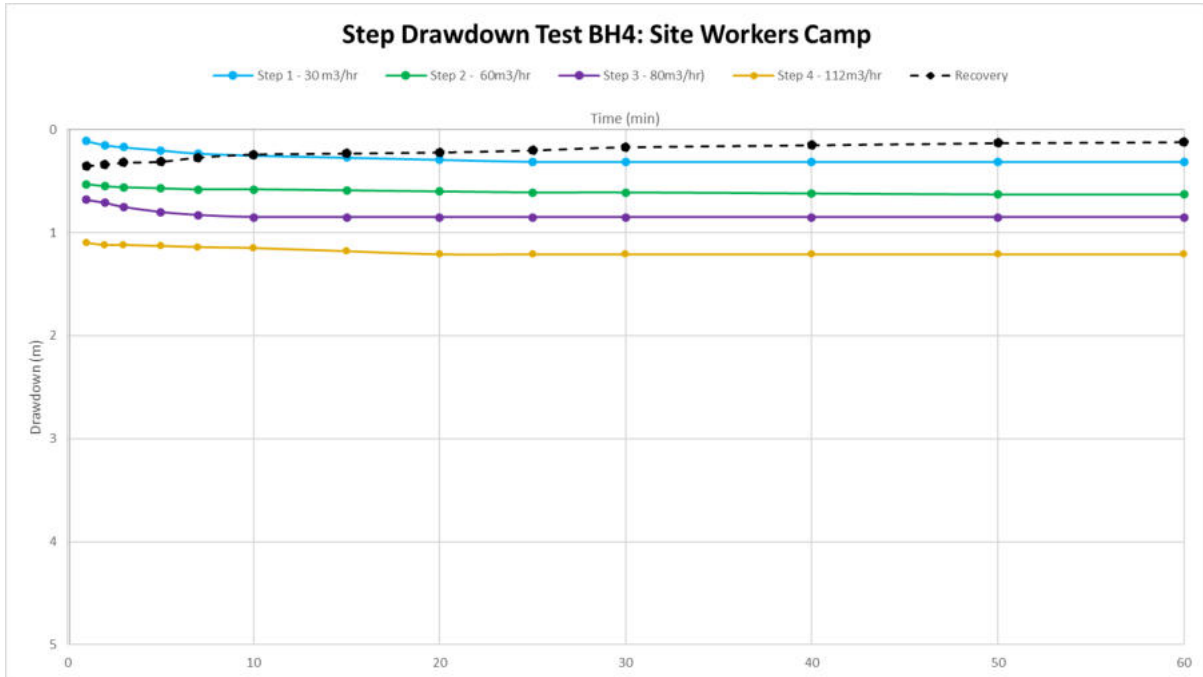
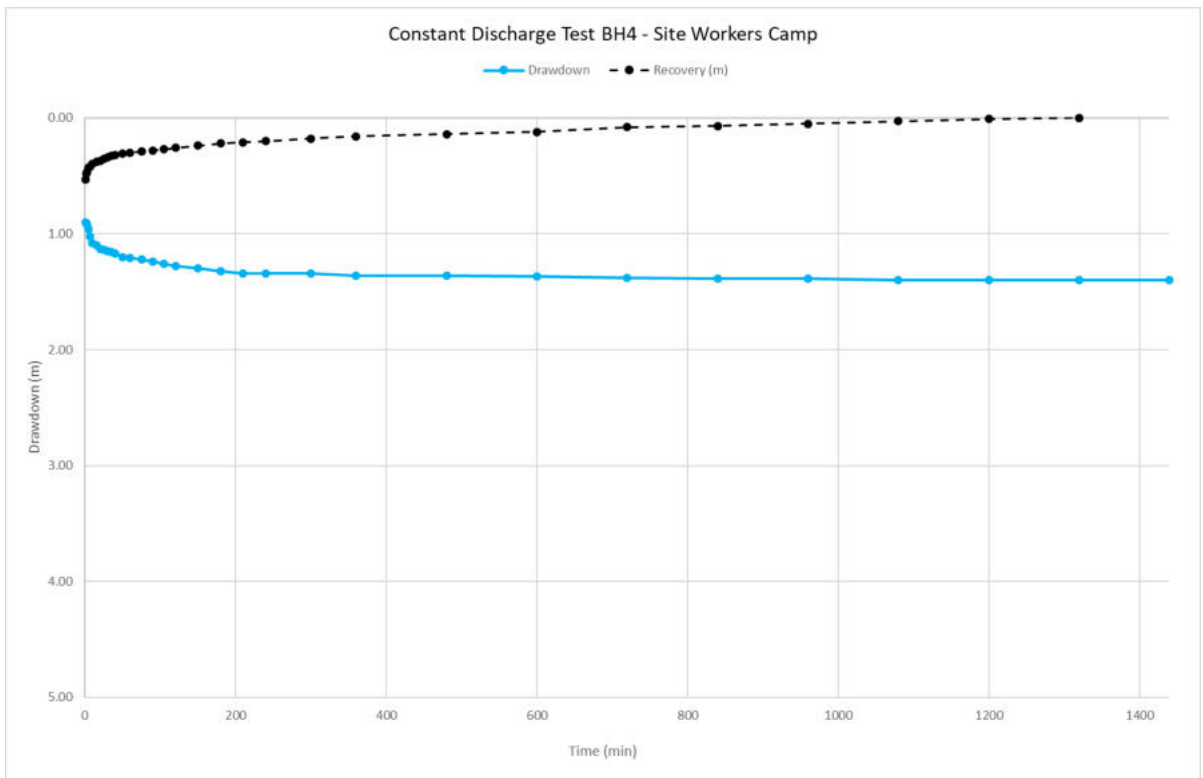
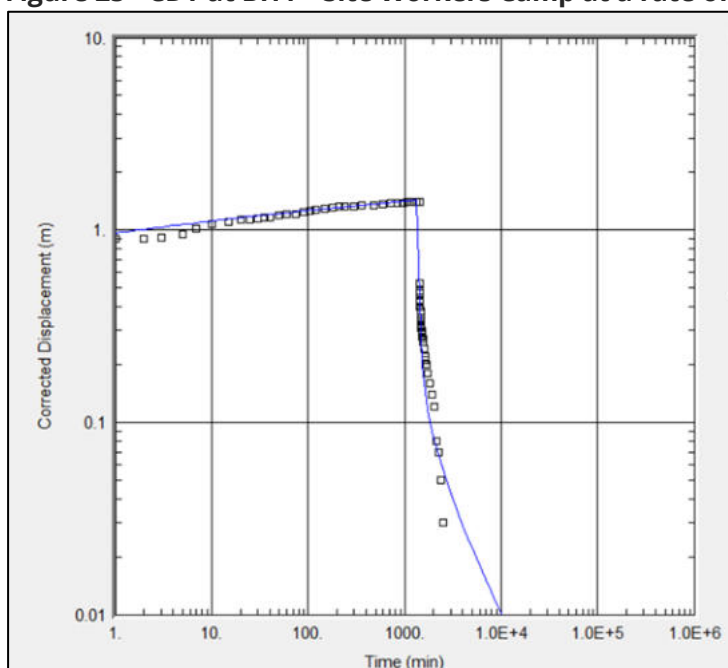


Figure 24 - Step test at BH4 – Site Workers Camp



**Figure 25 - CDT at BH4 – Site Workers Camp at a rate of 110 m<sup>3</sup>/h for 24 hours**



**Figure 26 - Curve matching drawdown vs time and derivative data with the Theis (1934) solution for aquifer parameter estimation**

### 5.2.5 HOUSE

BH House underwent a stepped discharge test on 18/11/2024 comprising four (4) one hour long discharge steps, followed by recovery monitoring for 180 minutes until the water level recovered to 100% of the rest level measured prior to testing. Table 5 provides a summary of the borehole construction and testing details. Figure 27 provides an overview of elapsed time since start of pumping versus drawdown of water level recorded during the step test.

The Constant Rate Discharge Test (CDT) was undertaken for 24 hours (1440 minutes) on 19/11/2024 at a rate of 105 m<sup>3</sup>/h. Figure 28 shows the time versus drawdown during the constant rate discharge test and recovery monitoring. The borehole is high yielding and shows rapid recovery after cessation of pumping.

Applying a combination of the Theis (1935) and Neumann (1974) analytical solutions (Figure 29), a Transmissivity value of 1440 m<sup>2</sup>/d was determined. The recommended yield of 90 m<sup>3</sup>/hr is determined based on subjective information related to flow boundaries, a two year forward modelling of drawdown and the assumption of zero recharge entering the system. It is recommended that the borehole be allowed to recover for at least 24 hours per week. A summary of results and recommendations is provided in Table 6.

Abstraction rates (weekly), volumes (weekly and collated monthly) and groundwater levels (twice daily) are recommended to be monitored at the borehole, allowing a revision (upward or downward) of the recommended yield after 6 months of operation. BH 5 is nearest BH3 (~160m) and while it is unknown if the same karstic feature is targeted, it is recommended

that groundwater level monitoring be undertaken during separate and combine pumping to evaluate borehole interference and compounding of drawdown effects. All recommendations do however account for the possibility of interference / hydraulic connection between boreholes and recommended yields are anticipated to provide protection to main water strikes and pump infrastructure.

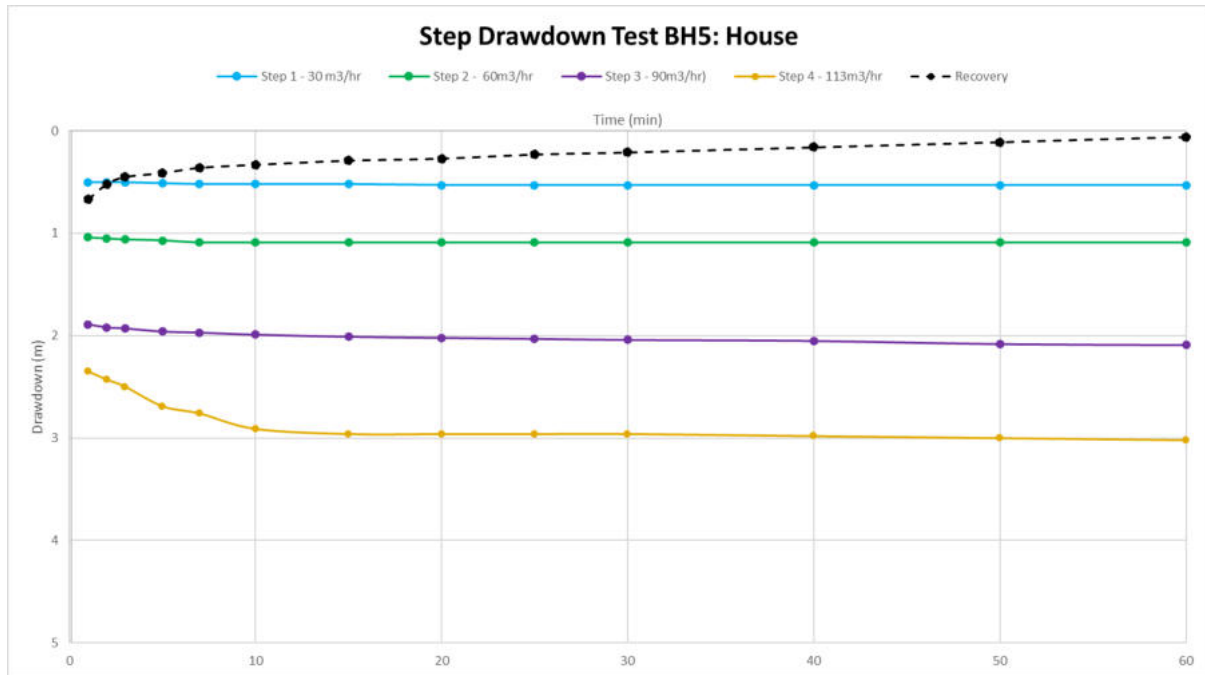


Figure 27 - Step test at BH5 – House

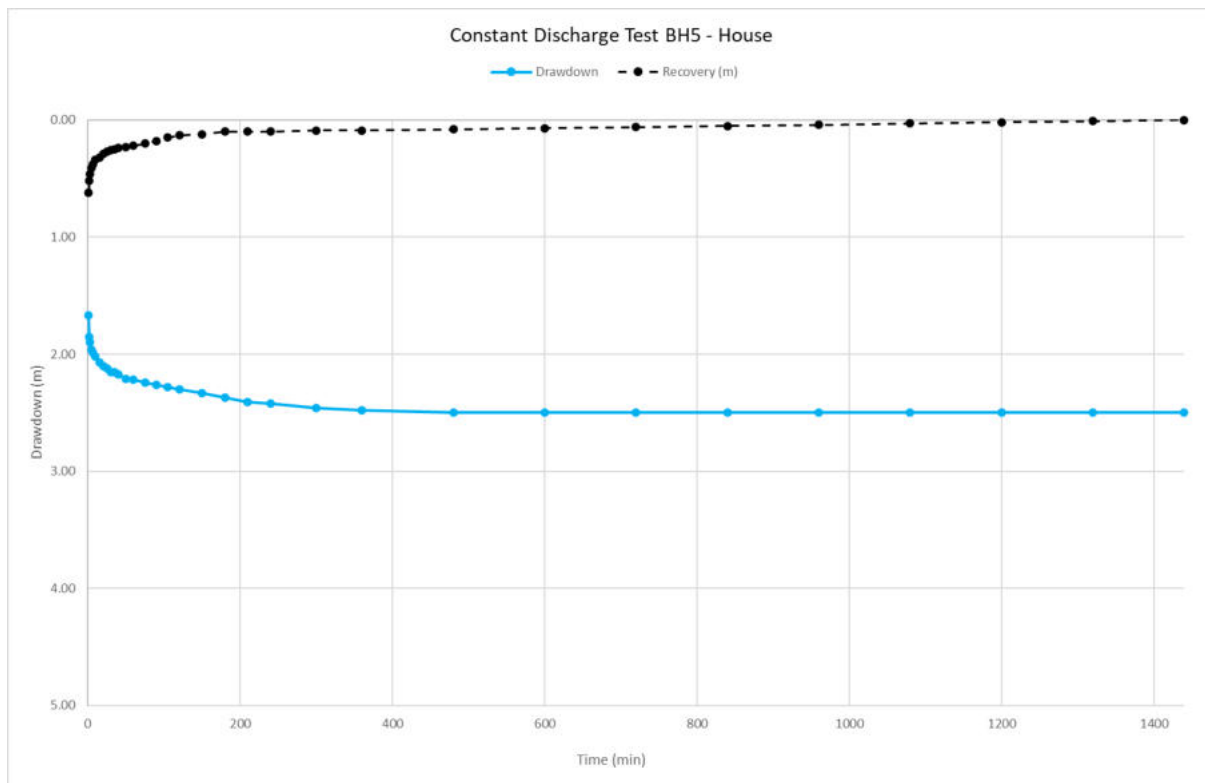


Figure 28 – CDT at BH5 – House at a rate of 105 m<sup>3</sup>/h for 24 hours

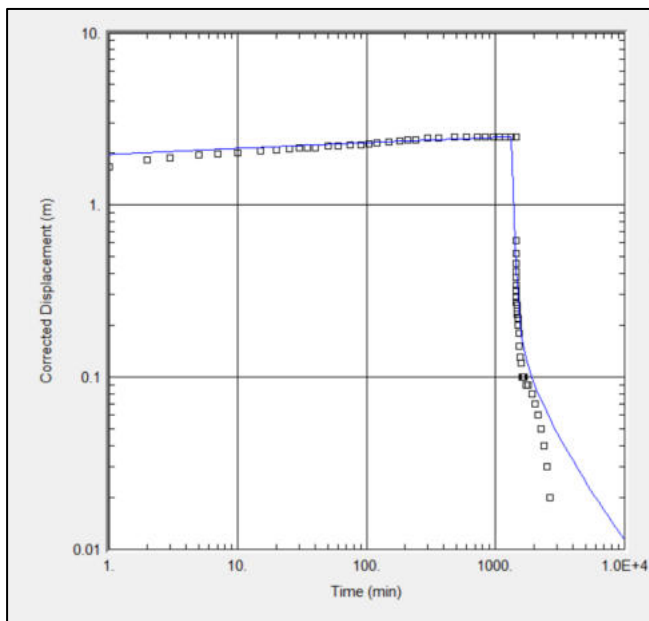


Figure 29 - Curve matching drawdown vs time and derivative data with the Theis (1934) solution for aquifer parameter estimation

All boreholes drilled targeted the karstic aquifer and are resultantly high yielding. It is recommended that bi-annual sampling of groundwater be included in the water level and volumetric monitoring prescribed per borehole. The analysis undertaken and results obtained (Table 6) may be used in support of an abstraction licence application to the Department of Water Affairs, for a volume of ~2 million cubic metres per annum.

Table 6 – Summary table of results and recommendations

BH ID	T (m <sup>2</sup> /d) (Theis)	K (m/d)	Recommended Pump Installation Depth (mbgl)	Available Drawdown based on pump	Recommended Yield (m <sup>3</sup> /hr)	Pumping regime (hrs/month)	Yield per month (m <sup>3</sup> )	Yield per annum (m <sup>3</sup> /a)	Aquifer Type	Modelled Drawdown after 2 years, zero recharge
BH1 - Land I	379	3.00	30	18	65	625	40625	487500	Karstic	9
BH2 - Land II	93	0.8	30	20	25	625	15625	187500	Karstic	10
BH3 - Site Water Feed	1450	12	30	21	80	625	50000	600000	Karstic	4
BH4 - Site worker Camp	3250	27	30	22	90	625	56250	675000	Karstic	2
BH5	2700	22	30	22	90	625	56250	675000	Karstic	2.5
<b>Total</b>					<b>350</b>	<b>625</b>	<b>218750</b>	<b>2625000</b>		

## 6 CONCLUSION AND RECOMMENDATIONS

A desktop groundwater assessment was undertaken for Farm Gai Kaisa no. 159. The farm occurs in the Omatako groundwater basin, to the south of the Otavi-Grootfontein-Tsumeb water control area.

The farm requires groundwater supply for irrigation to support a new agricultural project on the farm, comprising predominantly maize and minor perennials. The groundwater demand for irrigation has been estimated at a maximum of 1 million m<sup>3</sup> per annum per phase, there are two planned phases of cultivation.

The farm is underlain to the north by meta-sediments (marbles) of the Swakop Group while the southern portion of the farm is underlain by less productive Etjo sandstones of the Karroo Super Group.

Borehole drilling yielded favourable results with very high blow yields recorded per borehole. These yields were further supported and confirmed through test pumping, wherein each of the boreholes underwent a step discharge test followed by a constant rate drawdown test. Test pumping results further supported the favourable groundwater potential of the farm, as was alluded to during the desktop assessment.

The following recommendations are provided:

- All boreholes should have a lockable cap to protect the borehole if not in use.
- All boreholes should be ring fenced by a 2 m diameter fence to prevent game or livestock from contaminating the borehole.
- Pump installation depths, pump specifications and pumping rates should adhere to the recommendations provided in Table 6.
- Groundwater monitoring is recommended to comprise the following:
- All production boreholes should be fitted with automated level loggers and measure water level during and after pumping has ceased at a frequency of 30 minutes. Loggers are to be downloaded, and measurements verified annually on a monthly basis.
- Abstraction volumes should be measured through the installation of flow meters on each production borehole. Volumes should be collated on a monthly basis and compared to recommended abstraction volumes. Each borehole abstraction rate should also be checked once a month to ensure borehole productivity is monitored.
- A hydrogeologist should assess water level responses, abstracted volumes, borehole yields every six months for the first two (2) years of abstraction and adjust recommended yields (upward or downward) based on monitoring results.
- At least six (6) shallow groundwater monitoring boreholes should be installed across the farm in strategic locations informed by a hydrogeologist. This is to monitor aquifer health in areas where pumping is not taking place.

- Groundwater quality sampling should be undertaken every three months for the first two years of abstraction, thereafter every six months will suffice. Parameters requiring analysis include the following (as a minimum):

Electrical Conductivity (EC), Total Dissolved solids (TDS), pH, major ions (potassium, sodium, calcium, magnesium, bicarbonate, sulphate, chloride, fluoride), nutrients (nitrates, nitrites, orthophosphate), total hardness, trace metals (aluminium, iron, manganese, copper, lead, zinc, nickel, cadmium, cobalt, chromium, arsenic, uranium).

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## APPENDIX A - DRILLING REPORT

*Land I*

**BOREHOLE COMPLETION REPORT**

*7*


Please indicate at reverse side the position of the borehole and draw a casing plan.

Page 1 of 2

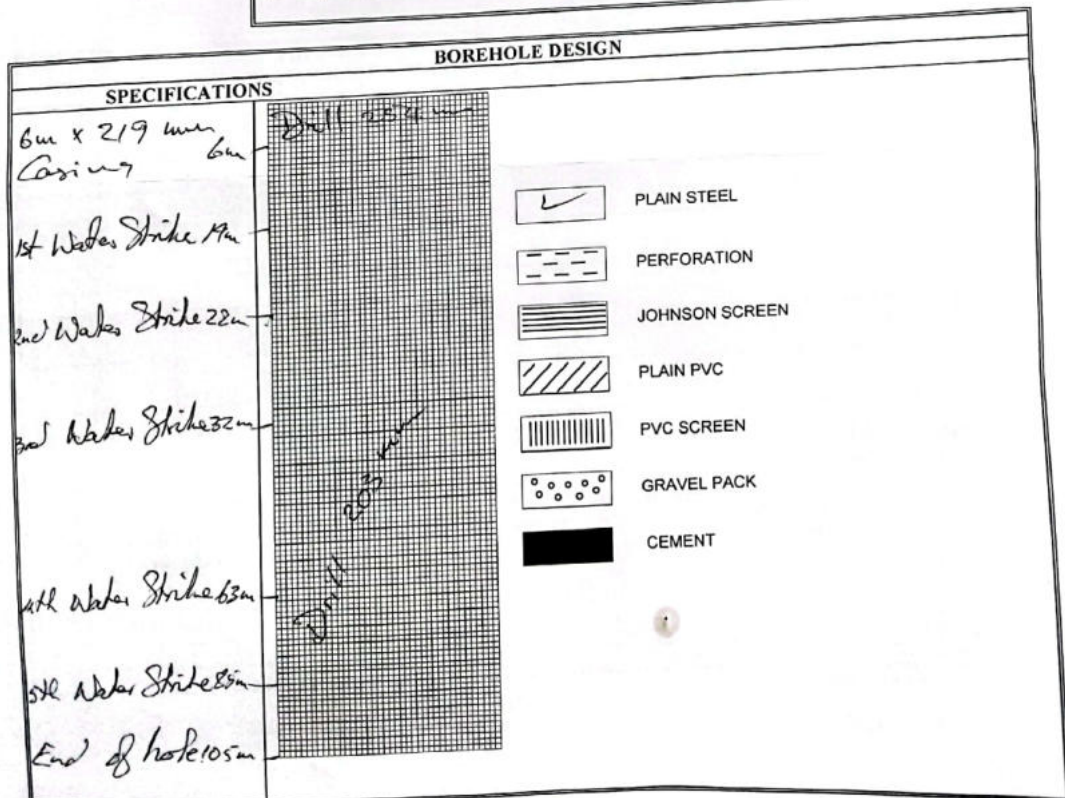
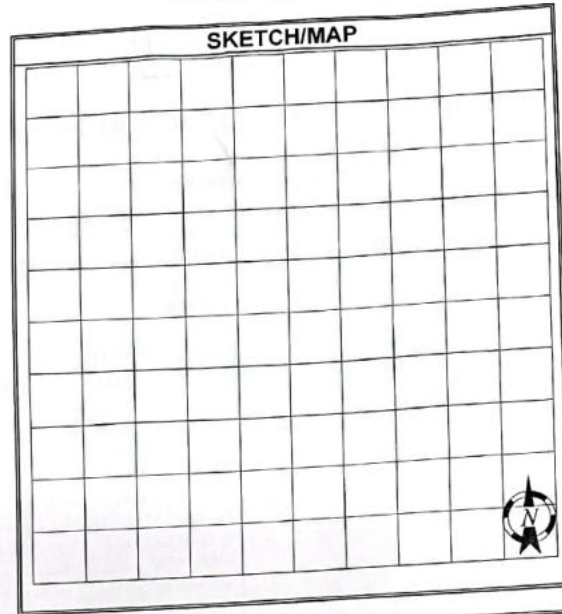
APPLICANT: <i>Robert Chascoal Producers</i>		BOREHOLE NUMBER: WW	
FARM: <i>Gai Kaisa</i> NUMBER: 159		TOPO & WELL NUMBER:	
DISTRICT: <i>Great Karoo</i>		LATITUDE: <i>S. 19° 53,399</i>	
DATE COMMENCED:		LONGITUDE: <i>E. 017° 49,413</i>	
DATE COMPLETED:		COLLAR HEIGHT: <i>0.5</i> m	
<b>GEOLOGY</b>		TOTAL DEPTH FROM SURFACE: <i>105</i> m	
From - to in (m)	DESCRIPTION	DIAMETER OF BOREHOLE	
<i>0 - 6m</i>	<i>Drill 6m x 254mm</i>	.....mm from..... to.....	
	<i>with 6m x 219mm</i>	<i>254</i> mm from <i>0</i> to <i>6</i>	
	<i>Casing.</i>	<i>203</i> mm from <i>6</i> to <i>105</i>	
		.....mm from..... to.....	
		FIRST WATER STRIKE .....m	
		SECOND WATER STRIKE .....m	
		THIRD WATER STRIKE .....m <i>63m, 85m</i>	
		WATER LEVEL .....m <i>12.5</i>	
		YIELD m <sup>3</sup> /h ..... <i>24</i>	
		APPARENT QUALITY OF WATER: <i>Good</i>	
		TDS WHEN DRILLED:.....	
<b>INITIAL CAPACITY TEST</b>			
<i>6m - 105m</i>	<i>Drill 203mm x</i>	AIRLIFT YIELD * <input checked="" type="checkbox"/>	
	<i>99m</i>	PUMP YIELD * <input type="checkbox"/>	
		YIELD IN m <sup>3</sup> /h:..... <i>24</i>	
		DATE:.....	
		DURATION:..... <i>1 Hour</i>	
<b>DRILLING COSTS</b>			
		ITEM	N \$
		m drilled	NS per m
		testing of borehole:	
<b>CASING</b>			
		plain	length m
		NS per m	
		perforated	length m
		NS per m	
		<b>TOTAL COST</b>	
State whether the borehole is*:			
<input checked="" type="checkbox"/> successful		<input checked="" type="checkbox"/> Casing left in borehole	
<input type="checkbox"/> unsuccessful		<input type="checkbox"/> Casing recovered	
<b>DECLARATION BY DRILLER AND DRILLING INSPECTOR</b>			
I, the driller, declare that the information supplied above is true and correct		I, the drilling inspector, declare that the information supplied above is true and correct	
Signature: <i>[Signature]</i>		Signature:	
Rank: <i>Driller</i>		Rank:	
Place: <i>[Place]</i>		Place:	
Date:		Date:	
* mark applicable block			
Remarks:			
..... RESPONSIBLE GEOHYDROLOGIST		..... DATE	

Appendix 3.1 (002)

App\_3-1\_Borehole\_Completion\_Report



Land I



Appendix 3.1  
(002)

App\_3-1\_Borehole\_Completion\_Report

*Donny*  
**BOREHOLE COMPLETION REPORT**  
2

Please indicate at reverse side the position of the borehole and draw a casing plan.

APPLICANT:		BOREHOLE NUMBER: WW	
FARM:	NUMBER:	TOPO & WELL NUMBER:	
DISTRICT:		LATITUDE:	19° 52, 080'
DATE COMMENCED:		LONGITUDE:	E, 017° 50, 511'
DATE COMPLETED:		COLLAR HEIGHT: 0.5 m	
<b>GEOLOGY</b>		TOTAL DEPTH FROM SURFACE: 111 m	
from - to in (m)	DESCRIPTION	DIAMETER OF BOREHOLE	
0 - 6	Drill 6m x 254 mm	254 mm from 0 to 6	
	with 6m x 219 mm	203 mm from 6 to 111	
	Casing		
		FIRST WATER STRIKE	28 m
		SECOND WATER STRIKE	41 m
		THIRD WATER STRIKE	58, 65, 106 m
		WATER LEVEL	10.4 m
		YIELD m <sup>3</sup> /h	111.8
		APPARENT QUALITY OF WATER:	Good
		TDS WHEN DRILLED:	
6 - 111	Drill 105m x 203 mm	INITIAL CAPACITY TEST	
		AIRLIFT YIELD * <input checked="" type="checkbox"/>	
		PUMP YIELD * <input type="checkbox"/>	
		YIELD IN m <sup>3</sup> /h:	111.8
		DATE:	
		DURATION:	1 Hour
DRILLING COSTS			
		ITEM	NS
		m drilled	NS per m
		testing of borehole:	
CASING			
		plain	length m
		NS per m	
		perforated	length m
		NS per m	
TOTAL COST			
State whether the borehole is*:			
<input checked="" type="checkbox"/> successful		<input checked="" type="checkbox"/> Casing left in borehole	
<input type="checkbox"/> unsuccessful		<input type="checkbox"/> Casing recovered	
DECLARATION BY DRILLER AND DRILLING INSPECTOR			
I, the driller, declare that the information supplied above is true and correct		I, the drilling inspector, declare that the information supplied above is true and correct	
Signature:		Signature:	
Rank: Driller		Rank:	
Place:		Place:	
Date:		Date:	

\* mark applicable block

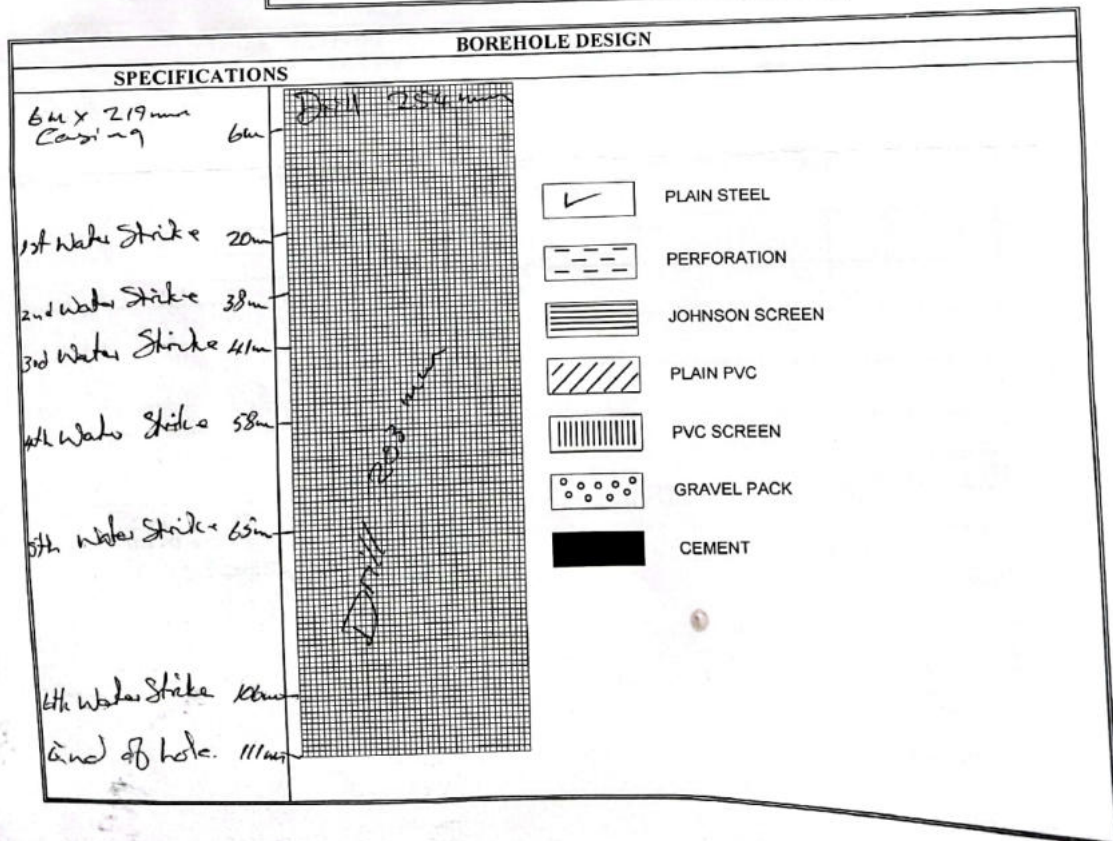
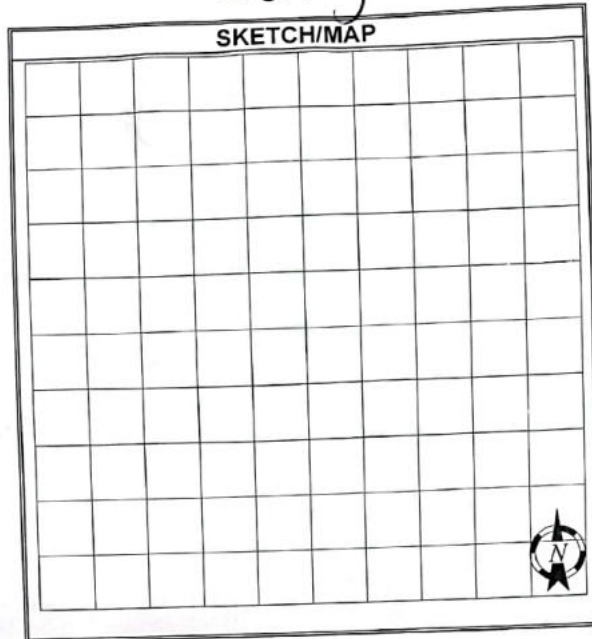
Remarks:

.....  
RESPONSIBLE GEOHYDROLOGIST

.....  
DATE

Appendix 1

Donny.



Appendix 3.1  
(002)

App\_3-1 Borehole -

3  
Haise

### BOREHOLE COMPLETION REPORT

Please indicate at reverse side the position of the borehole and draw a casing plan.

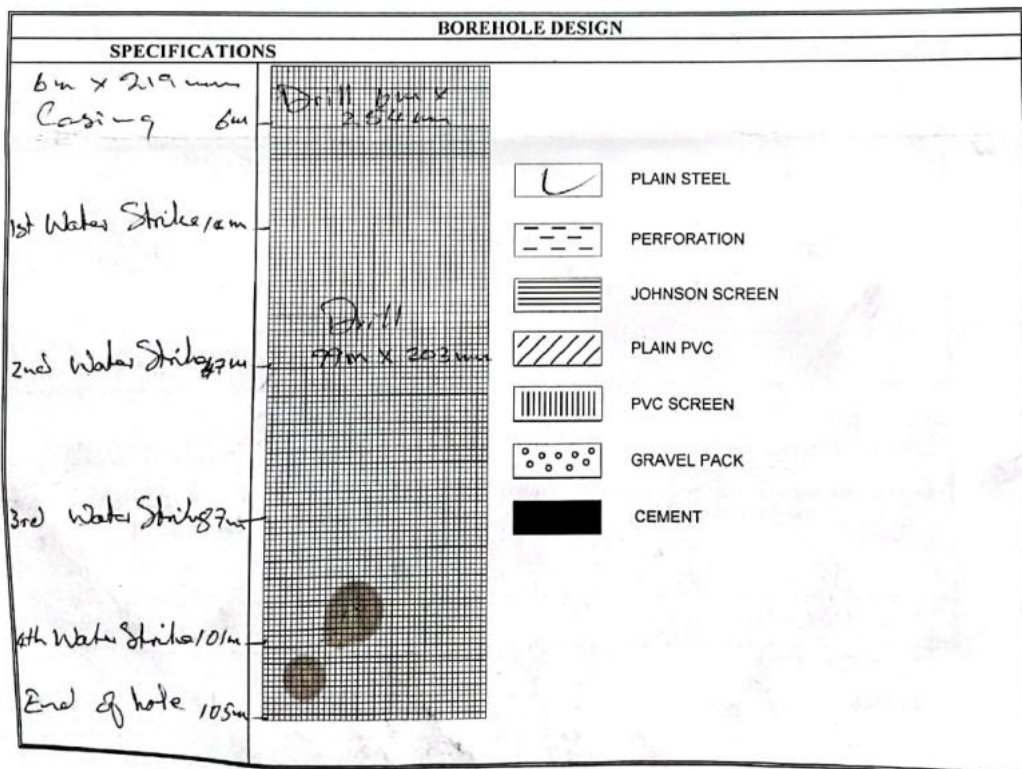
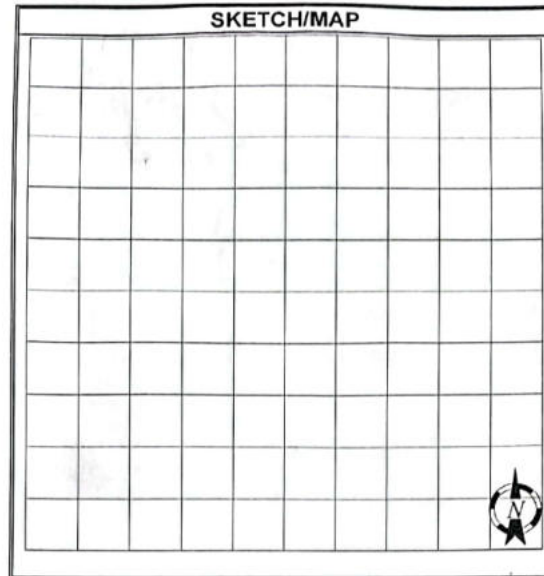
APPLICANT:		BOREHOLE NUMBER: WW	
FARM:	NUMBER:	TOPO & WELL NUMBER:	
DISTRICT:		LATITUDE: S,	19° 53, 727'
DATE COMMENCED:		LONGITUDE: E,	017° 49, 928'
DATE COMPLETED:		COLLAR HEIGHT:	0-4 m
<b>GEOLOGY</b>		TOTAL DEPTH FROM SURFACE: 105 m	
from - to in (m)	DESCRIPTION	DIAMETER OF BOREHOLE	
0 - 6	Drill 254mm x 6m	.....254.....mm from.....0..... to.....6.....	
	with 219mm x 6m	.....203.....mm from.....6..... to.....105.....	
	Casing,	.....mm from..... to.....	
		FIRST WATER STRIKE	14 m
		SECOND WATER STRIKE	47 m
		THIRD WATER STRIKE	87 m 101m
		WATER LEVEL	7.9 m
		YIELD m <sup>3</sup> /h	159.8
		APPARENT QUALITY OF WATER:	Good
		TDS WHEN DRILLED:	
6 - 105	Drill 203mm x 99m	<b>INITIAL CAPACITY TEST</b>	
		AIRLIFT YIELD * <input checked="" type="checkbox"/>	
		PUMP YIELD * <input type="checkbox"/>	
		YIELD IN m <sup>3</sup> /h:.....	
		DATE:.....	
		DURATION .....	
		<b>DRILLING COSTS</b>	
		ITEM	NS
		m drilled	NS per m
		testing of borehole:	
		<b>CASING</b>	
		plain	length m
		NS per m	
		perforated	length m
		NS per m	
		<b>TOTAL COST</b>	
State whether the borehole is*:			
<input checked="" type="checkbox"/> successful		<input checked="" type="checkbox"/> Casing left in borehole	
<input type="checkbox"/> unsuccessful		<input type="checkbox"/> Casing recovered	
<b>DECLARATION BY DRILLER AND DRILLING INSPECTOR</b>			
I, the driller, declare that the information supplied above is true and correct		I, the drilling inspector, declare that the information supplied above is true and correct	
Signature:		Signature:	
Rank: Driller		Rank: 3	
Place: Date:		Place: Date:	

\* mark applicable block

Remarks:

.....  
RESPONSIBLE GEOHYDROLOGIST

House.




Appendix 3.1  
(002)

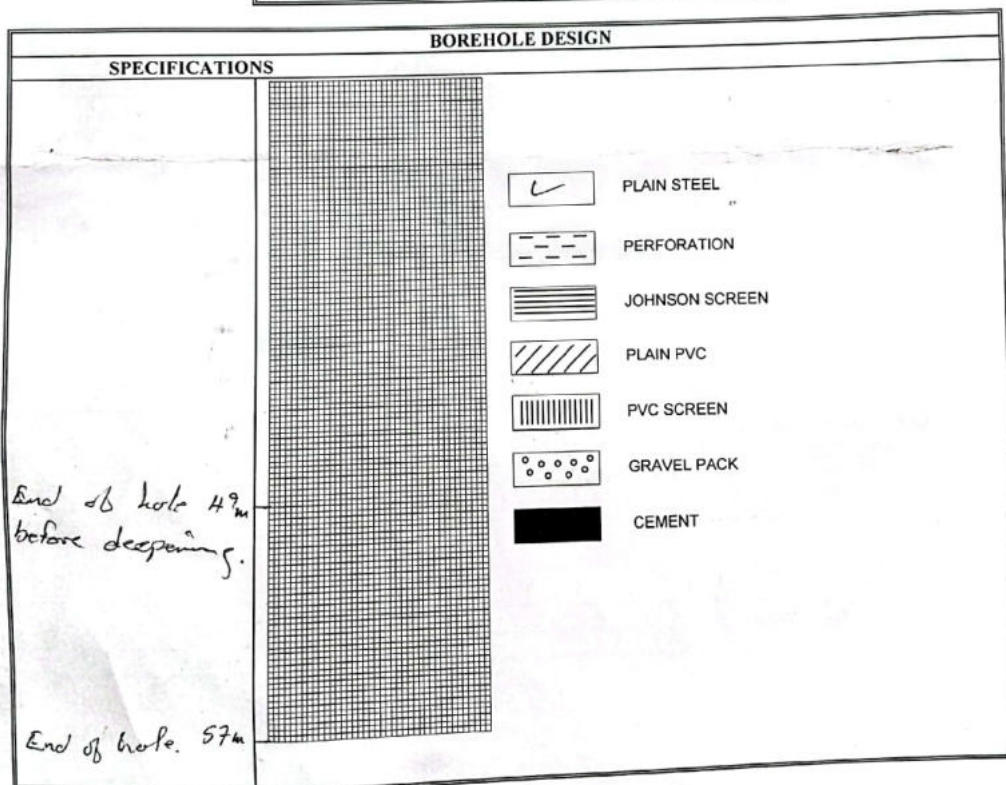
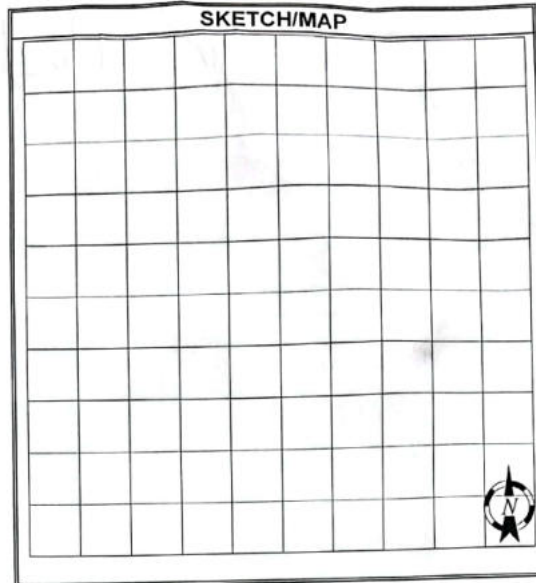
App\_3-1\_Borehole\_Completion\_Report

4  
 Solar Panel  
**BOREHOLE COMPLETION REPORT**

Please indicate at reverse side the position of the borehole and draw a casing plan.

APPLICANT:		BOREHOLE NUMBER: WW	
FARM:	NUMBER:	TOPO & WELL NUMBER:	
DISTRICT:		LATITUDE: S, 19° 53,716'	
DATE COMMENCED:		LONGITUDE: E, 017° 49,337'	
DATE COMPLETED:		COLLAR HEIGHT: 0.4 m	
<b>GEOLOGY</b>		TOTAL DEPTH FROM SURFACE: 57 m	
from - to in (m)	DESCRIPTION	DIAMETER OF BOREHOLE	
0 - 49	Clean 165mm hole.	.....165.....mm from.....0..... to.....49 Clean	
		.....165.....mm from.....49..... to.....57	
		.....mm from..... to.....	
		FIRST WATER STRIKE .....m	
		SECOND WATER STRIKE .....m	
		THIRD WATER STRIKE .....m	
		WATER LEVEL .....m	
49 - 57	Drill 8m x 165mm.	YIELD m <sup>3</sup> /h 50	
		APPARENT QUALITY OF WATER: Good	
		TDS WHEN DRILLED:.....	
<b>INITIAL CAPACITY TEST</b>			
AIRLIFT YIELD * <input checked="" type="checkbox"/>			
PUMP YIELD * <input type="checkbox"/>			
YIELD IN m <sup>3</sup> /h: 50			
DATE:.....			
DURATION: 1.1 hour			
<b>DRILLING COSTS</b>			
ITEM		N \$	
m drilled	N\$ per m		
testing of borehole:			
<b>CASING</b>			
plain	length	m	
N\$ per m			
perforated	length	m	
N\$ per m			
<b>TOTAL COST</b>			
State whether the borehole is*:			
<input checked="" type="checkbox"/> successful		<input checked="" type="checkbox"/> Casing left in borehole	
<input type="checkbox"/> unsuccessful		<input type="checkbox"/> Casing recovered	
<b>DECLARATION BY DRILLER AND DRILLING INSPECTOR</b>			
I, the driller, declare that the information supplied above is true and correct		I, the drilling inspector, declare that the information supplied above is true and correct	
Signature: 		Signature: .	
Rank: Driller.		Rank:	
Place: .....		Place:	
Date: .....		Date:	
* mark applicable block			
Remarks:			

Solar Panel.



App\_3-1\_Borehole\_Completion\_Report

Appendix 3.1  
(002)

Land II

Page 1 of 2

### BOREHOLE COMPLETION REPORT

Please indicate at reverse side the position of the borehole and draw a casing plan.

APPLICANT: <u>Stefan Ralk</u>		BOREHOLE NUMBER: <u>WW</u>	
FARM: <u>Gai Kaisa</u> NUMBER: <u>159</u>		TOPO & WELL NUMBER:	
DISTRICT: <u>Grootbuis</u>		LATITUDE: <u>S, 19°53,231'</u>	
DATE COMMENCED:		LONGITUDE: <u>E, 017°01'26.4"</u>	
DATE COMPLETED:		COLLAR HEIGHT: <u>0-5 m</u>	
<b>GEOLOGY</b>		TOTAL DEPTH FROM SURFACE: <u>129 m</u>	
from - to in (m)	DESCRIPTION	DIAMETER OF BOREHOLE	
<u>0 - 6</u>	<u>Drill 6m x 219mm</u>	<u>219 mm from 0 to 6</u>	
	<u>with 6m x 219mm</u>	<u>319 mm from 6 to 129</u>	
	<u>Casing Plain.</u>		
		FIRST WATER STRIKE <u>13 m</u>	
		SECOND WATER STRIKE <u>23 m</u> <u>112</u>	
		THIRD WATER STRIKE <u>42 m</u>	
		WATER LEVEL <u>10.35m</u>	
		YIELD m <sup>3</sup> /h <u>42 m<sup>3</sup></u>	
		APPARENT QUALITY OF WATER: <u>Good</u>	
		TDS WHEN DRILLED:	
<u>6 - 129</u>	<u>Drill 123m x 203mm</u>	<b>INITIAL CAPACITY TEST</b>	
		AIRLIFT YIELD * <input checked="" type="checkbox"/>	
		PUMP YIELD * <input type="checkbox"/>	
		YIELD IN m <sup>3</sup> /h: .....	
		DATE: .....	
		DURATION: .....	
		<b>DRILLING COSTS</b>	
		ITEM	N \$
		m drilled	N\$ per m
		testing of borehole:	
		<b>CASING</b>	
		plain	length m
		N\$ per m	
		perforated	length m
		N\$ per m	
		<b>TOTAL COST</b>	
State whether the borehole is:			
<input checked="" type="checkbox"/> successful		<input checked="" type="checkbox"/> Casing left in borehole	
<input type="checkbox"/> unsuccessful		<input type="checkbox"/> Casing recovered	
<b>DECLARATION BY DRILLER AND DRILLING INSPECTOR</b>			
I, the driller, declare that the information supplied above is true and correct		I, the drilling inspector, declare that the information supplied above is true and correct	
Signature: <u>[Signature]</u>		Signature: <u>[Signature]</u>	
Rank: <u>Driller</u>		Rank: <u>[Signature]</u>	
Place: <u>Grootbuis</u> Date: <u>[Signature]</u>		Place: <u>Grootbuis</u> Date: <u>[Signature]</u>	
* mark applicable block			

Remarks:

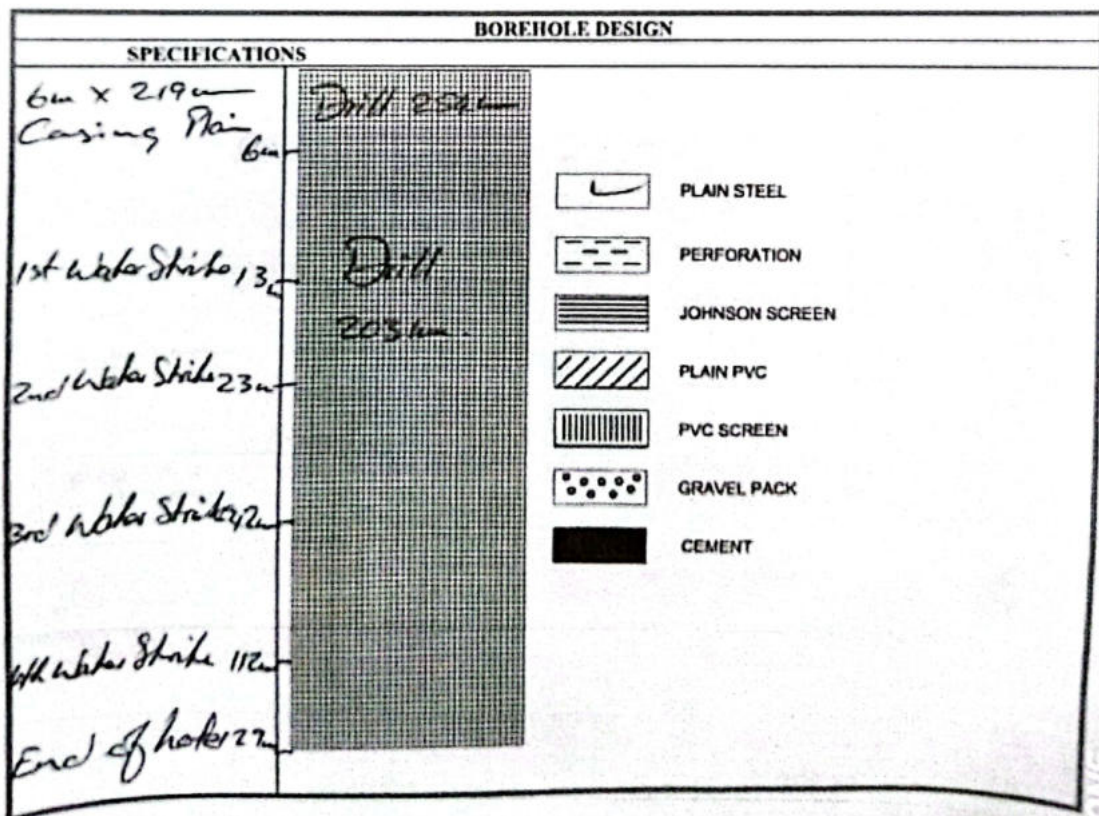
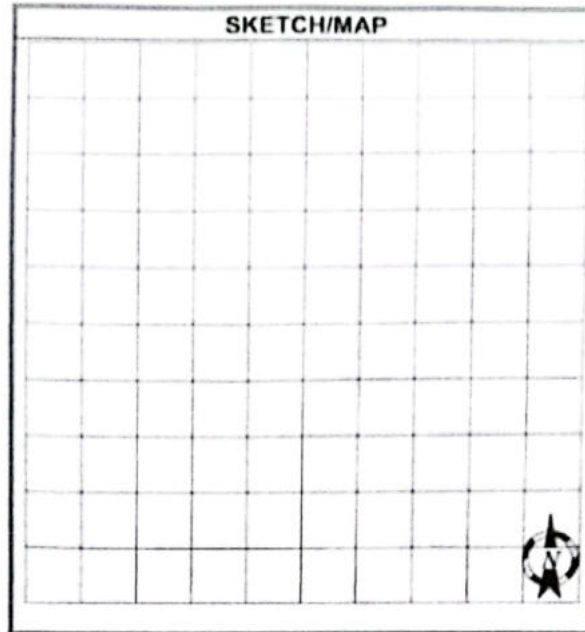
RESponsible GEOHYDROLOGIST

DATE

Borehole\_Completion.doc

Appendix 3.1

Land II



Page 1 of 2

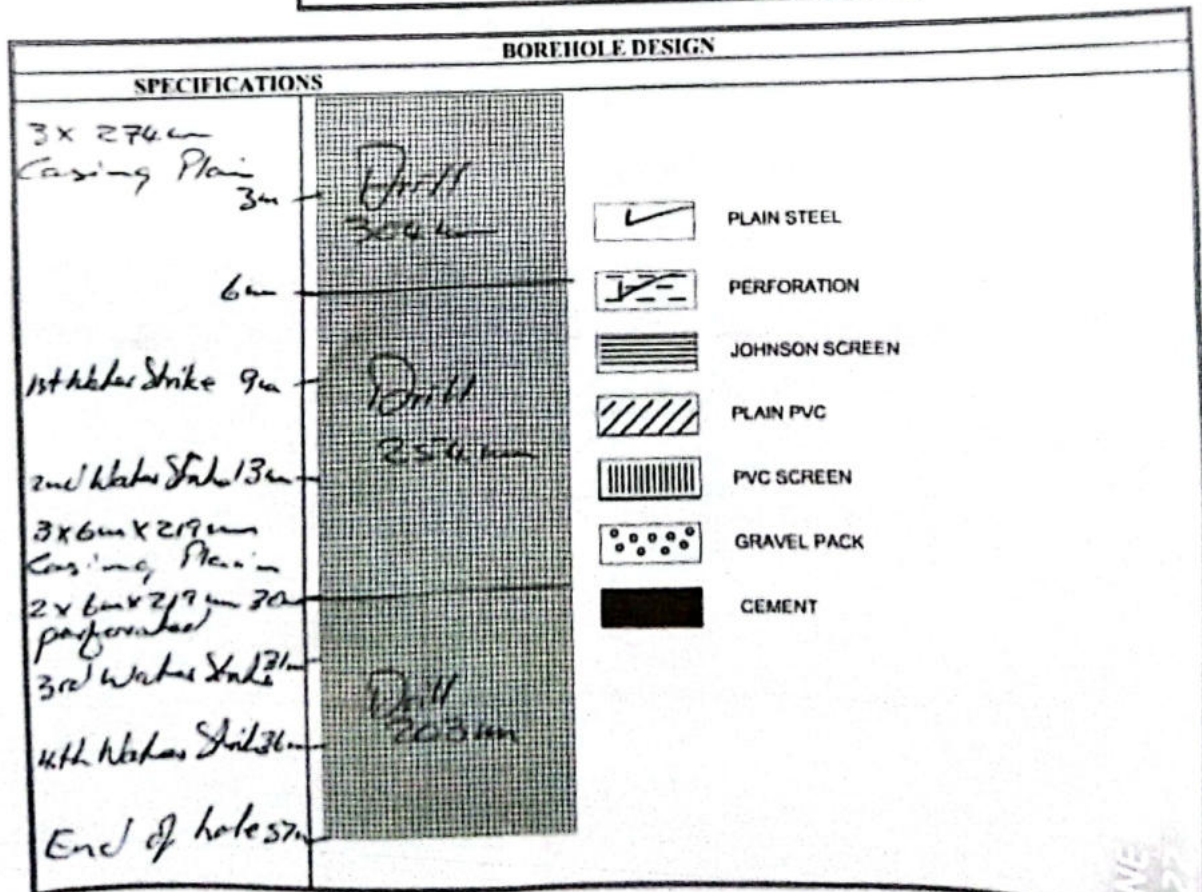
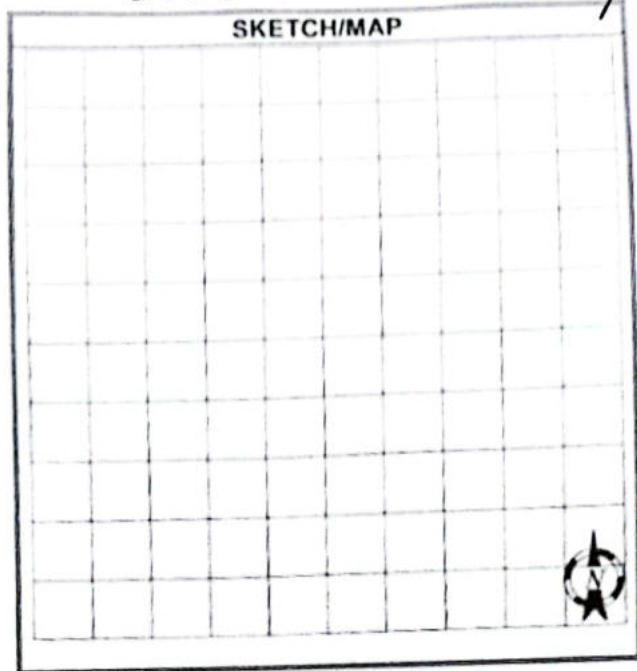
yout 5  
**Site Workers Camp.**  
**BOREHOLE COMPLETION REPORT**

Please indicate at reverse side the position of the borehole and draw a casing plan.

APPLICANT: <u>Sepa Park</u>		BOREHOLE NUMBER: <u>WW</u>	
FARM: <u>Gaikaia</u> NUMBER: <u>159</u>		TOPO & WELL NUMBER:	
DISTRICT: <u>Gwattankwa</u>		LATITUDE: <u>S. 19°53'48.4"</u>	
DATE COMMENCED:		LONGITUDE: <u>E. 017°41'36"</u>	
DATE COMPLETED:		COLLAR HEIGHT: <u>0.5m</u>	
<b>GEOLOGY</b>		TOTAL DEPTH FROM SURFACE: <u>51 m</u>	
from - to in (m)	DESCRIPTION	DIAMETER OF BOREHOLE	
0 - 6	Drill 254mm x 6m with 3m x 23m casing plain	6.12 mm from 0 to 6 2.54 mm from 6 to 30 203 mm from 30 to 51	
		FIRST WATER STRIKE <u>4 m</u>	
		SECOND WATER STRIKE <u>13 m</u>	
		THIRD WATER STRIKE <u>37 m</u> 36m	
		WATER LEVEL <u>8.6 m</u>	
		YIELD m <sup>3</sup> /h <u>250</u>	
		APPARENT QUALITY OF WATER: <u>Good</u>	
		TDS WHEN DRILLED:	
6 - 30	Drill 254mm x 24m with 4x6m x 219mm casing plain and 2x6m x 219mm perforated	<b>INITIAL CAPACITY TEST</b>	
		AIRLIFT YIELD * <input checked="" type="checkbox"/>	
		PUMP YIELD * <input type="checkbox"/>	
		YIELD IN m <sup>3</sup> /h: .....	
		DATE: .....	
		DURATION: .....	
		<b>DRILLING COSTS</b>	
		ITEM	NS
		m drilled	N\$ per m
		testing of borehole:	
		<b>CASING</b>	
		plain	length m
		N\$ per m	
		perforated	length m
		N\$ per m	
		<b>TOTAL COST</b>	
State whether the borehole is:			
<input checked="" type="checkbox"/> successful		<input type="checkbox"/> Casing left in borehole	
<input type="checkbox"/> unsuccessful		<input type="checkbox"/> Casing recovered	
<b>DECLARATION BY DRILLER AND DRILLING INSPECTOR</b>			
I, the driller, declare that the information supplied above is true and correct		I, the drilling inspector, declare that the information supplied above is true and correct	
Signature: <u>[Signature]</u>		Signature: <u>[Signature]</u>	
Rank: <u>Driller</u>		Rank: <u>[Rank]</u>	
Place: <u>Gwattankwa</u> Date: .....		Place: <u>Gwattankwa</u> Date: .....	
* mark applicable block			

Remarks:

Site Workers Camp.



## APPENDIX B – TEST PUMPING DATA

### Land I

Rate (l/s)	Step 1 - 30 m <sup>3</sup> /hr		Step 2 - 50m <sup>3</sup> /hr		Step 3 - 80m <sup>3</sup> /hr		Step 4 - 100m <sup>3</sup> /hr		Recovery		AD	RWL
Time	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)	(m)	11.86
0	11.86	0		0		0		0		0		
1	12.48	0.62	13.48	1.62	14.76	2.9	16.17	4.31	13.30	1.44		54.14
2	12.5	0.64	13.48	1.62	14.76	2.9	16.25	4.39	13.25	1.39		54.14
3	12.55	0.69	13.48	1.62	14.77	2.91	16.32	4.46	13.21	1.35		54.14
5	12.6	0.74	13.5	1.64	14.78	2.92	16.45	4.59	13.14	1.28		54.14
7	12.61	0.75	13.52	1.66	14.8	2.94	16.56	4.7	13.07	1.21		54.14
10	12.64	0.78	13.58	1.72	14.84	2.98	16.58	4.72	12.97	1.11		54.14
15	12.67	0.81	13.66	1.8	14.91	3.05	16.6	4.74	12.88	1.02		54.14
20	12.7	0.84	13.7	1.84	14.96	3.1	16.64	4.78	12.83	0.97		54.14
25	12.71	0.85	13.73	1.87	14.99	3.13		-11.86	12.75	0.89		54.14
30	12.74	0.88	13.75	1.89	15.17	3.31		-11.86	12.70	0.84		54.14
40	12.81	0.95	13.76	1.9	15.33	3.47		-11.86	12.63	0.77		54.14
50	12.85	0.99	13.76	1.9	15.37	3.51		-11.86	12.57	0.71		
60	12.87	1.01	13.76	1.9	15.42	3.56		-11.86	12.52	0.66		
									12.45	0.59		
									12.30	0.44		
									12.23	0.37		
									12.09	0.23		
									12.00	0.14		
									11.96	0.1		
									11.89	0.03		
									11.87	0.01		
									11.86	0		

RWL	11.86			
Time (min)	Drawdown (m)	Water Level (mbgl)	Recovery (m)	Recovery (mbgl)
1	3.54	15.4	2.36	14.22
2	3.74	15.6	2.28	14.14
3	3.80	15.66	2.23	14.09
5	3.85	15.71	2.19	14.05
7	3.89	15.75	2.15	14.01
10	3.95	15.81	2.09	13.95
15	4.02	15.88	2.00	13.86
20	4.14	16	1.88	13.74
25	4.22	16.08	1.77	13.63
30	4.28	16.14	1.70	13.56
35	4.35	16.21	1.62	13.48
40	4.39	16.25	1.54	13.4
50	4.45	16.31	1.49	13.35
60	4.57	16.43	1.40	13.26
75	4.64	16.5	1.31	13.17
90	4.79	16.65	1.21	13.07
105	4.87	16.73	1.14	13
120	4.97	16.83	1.05	12.91
150	5.05	16.91	0.97	12.83
180	5.19	17.05	0.87	12.73
210	5.29	17.15	0.76	12.62
240	5.39	17.25	0.69	12.55
300	5.46	17.32	0.63	12.49
360	5.57	17.43	0.52	12.38
480	5.66	17.52	0.44	12.3
600	5.77	17.63	0.32	12.18
720	5.85	17.71	0.24	12.1
840	5.93	17.79	0.20	12.06
960	5.97	17.83	0.14	12
1080	5.97	17.83	0.11	11.97
1200	5.97	17.83	0.09	11.95
1320	5.99	17.85	0.04	11.9
1440	5.99	17.85	0.02	11.88

Land II

Rate (l/s)	Step 1 - 20 m <sup>3</sup> /hr		Step 2 - 30m <sup>3</sup> /hr		Step 3 - 50m <sup>3</sup> /hr		Step 4 - 70m <sup>3</sup> /hr		Recovery	
	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)
0	10.73	0		0		0		0		0
1	12.78	2.05	17.05	6.32	23.77	13.04	39.3	28.57	16.45	5.72
2	13.81	3.08	17.18	6.45	24.87	14.14	51.8	41.07	15.61	4.88
3	14.2	3.47	17.42	6.69	25.4	14.67	53.91	43.18	15.00	4.27
5	14.29	3.56	17.91	7.18	26.29	15.56	61.29	50.56	14.87	4.14
7	14.54	3.81	18.04	7.31	27.51	16.78	65.18	54.45	13.08	2.35
10	14.56	3.83	18.1	7.37	28.57	17.84			12.71	1.98
15	14.59	3.86	18.16	7.43	28.9	18.17			12.46	1.73
20	14.59	3.86	18.17	7.44	29.12	18.39			12.31	1.58
25	14.6	3.87	18.2	7.47	29.43	18.7			12.24	1.51
30	14.63	3.9	18.23	7.5	29.52	18.79			12.17	1.44
40	14.67	3.94	18.27	7.54	29.7	18.97			12.08	1.35
50	14.75	4.02	18.35	7.62	30.45	19.72			11.95	1.22
60	14.9	4.17	18.43	7.7	30.67	19.94			11.86	1.13
70									11.79	1.06
80									11.72	0.99
90									11.64	0.91
100									11.60	0.87
120									11.54	0.81
150									11.41	0.68
180									11.30	0.57
210									11.24	0.51
240									11.19	0.46
270									11.10	0.37
300									11.06	0.33
330									11.00	0.27
360									10.95	0.22
390									10.91	0.18
420									10.87	0.14
450									10.82	0.09
480									10.77	0.04

RWL	10.73			
Time (min)	Drawdown (m)	Water Level (mbgl)	Recovery (m)	Recovery (mbgl)
1	7.48	18.21	4.66	15.39
2	9.02	19.75	4.40	15.13
3	9.41	20.14	4.17	14.9
5	9.74	20.47	3.83	14.56
7	9.99	20.72	3.62	14.35
10	10.17	20.9	3.37	14.1
15	10.37	21.1	3.07	13.8
20	10.49	21.22	2.87	13.6
25	10.61	21.34	2.70	13.43
30	11.05	21.78	2.56	13.29
35	11.12	21.85	2.46	13.19
40	11.18	21.91	2.41	13.14
50	11.35	22.08	2.26	12.99
60	11.47	22.2	2.17	12.9
75	11.67	22.4	2.01	12.74
90	11.88	22.61	1.88	12.61
105	11.98	22.71	1.78	12.51
120	12.07	22.8	1.69	12.42
150	12.32	23.05	1.54	12.27
180	12.51	23.24	1.44	12.17
210	12.69	23.42	1.32	12.05
240	12.81	23.54	1.17	11.9
300	13.02	23.75	1.02	11.75
360	13.21	23.94	0.88	11.61
480	13.82	24.55	0.58	11.31
600	14.12	24.85	0.47	11.2
720	14.35	25.08	0.37	11.1
840	14.45	25.18	0.27	11
960	14.52	25.25	0.21	10.94
1080	14.65	25.38	0.17	10.9
1200	14.72	25.45	0.12	10.85
1320	14.88	25.61	0.06	10.79
1440	15.02	25.75	0.00	10.73

Site Water Feed

Rate (l/s)	Step 1 - 30 m <sup>3</sup> /hr		Step 2 - 50m <sup>3</sup> /hr		Step 3 - 70m <sup>3</sup> /hr		Step 4 - 100m <sup>3</sup> /hr		Recovery	
	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)
0	8.80	0		0		0		0		0
1	9.35	0.55	9.81	1.01	10.6	1.8	12.7	3.9	9.14	0.34
2	9.35	0.55	9.96	1.16	10.66	1.86	12.79	3.99	9.05	0.25
3	9.36	0.56	10.04	1.24	10.68	1.88	12.83	4.03	9.03	0.23
5	9.37	0.57	10.09	1.29	10.76	1.96	12.86	4.06	8.99	0.19
7	9.38	0.58	10.13	1.33	10.78	1.98	12.86	4.06	8.98	0.18
10	9.39	0.59	10.19	1.39	10.78	1.98	12.86	4.06	8.97	0.17
15	9.39	0.59	10.24	1.44	10.79	1.99	12.86	4.06	8.95	0.15
20	9.39	0.59	10.26	1.46	10.79	1.99	12.86	4.06	8.93	0.13
25	9.39	0.59	10.28	1.48	10.79	1.99	12.86	4.06	8.91	0.11
30	9.39	0.59	10.29	1.49	10.79	1.99	12.86	4.06	8.88	0.08
40	9.39	0.59	10.29	1.49	10.79	1.99	12.87	4.07	8.86	0.06
50	9.39	0.59	10.29	1.49	10.79	1.99	12.87	4.07	8.85	0.05
60	9.39	0.59	10.29	1.49	10.79	1.99	12.87	4.07	8.85	0.05
70									8.84	0.04
80									8.83	0.03
90									8.82	0.02
100									8.82	0.02

RWL	8.8			
Time (min)	Drawdown (m)	Water Level (mbgl)	Recovery (m)	Recovery (mbgl)
1	3.12	11.92	0.55	9.35
2	3.18	11.98	0.50	9.3
3	3.23	12.03	0.48	9.28
5	3.36	12.16	0.45	9.25
7	3.36	12.16	0.43	9.23
10	3.39	12.19	0.41	9.21
15	3.44	12.24	0.39	9.19
20	3.44	12.24	0.38	9.18
25	3.45	12.25	0.37	9.17
30	3.47	12.27	0.36	9.16
35	3.50	12.3	0.35	9.15
40	3.50	12.3	0.34	9.14
50	3.52	12.32	0.33	9.13
60	3.54	12.34	0.32	9.12
75	3.56	12.36	0.31	9.11
90	3.58	12.38	0.30	9.1
105	3.60	12.4	0.29	9.09
120	3.61	12.41	0.28	9.08
150	3.61	12.41	0.26	9.06
180	3.63	12.43	0.26	9.06
210	3.65	12.45	0.24	9.04
240	3.68	12.48	0.22	9.02
300	3.75	12.55	0.20	9
360	3.83	12.63	0.18	8.98
480	3.90	12.7	0.15	8.95
600	3.93	12.73	0.13	8.93
720	3.95	12.75	0.11	8.91
840	3.95	12.75	0.08	8.88
960	3.96	12.76	0.06	8.86
1080	3.98	12.78	0.04	8.84
1200	3.98	12.78	0.02	8.82
1320	3.98	12.78	0.01	8.81
1440	3.98	12.78	0.01	8.81

**Site Worker Camp**

Rate (l/s)	Step 1 - 30 m <sup>3</sup> /hr		Step 2 - 60m <sup>3</sup> /hr		Step 3 - 80m <sup>3</sup> /hr		Step 4 - 112m <sup>3</sup> /hr		Recovery	
	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)
0	7.40	0		0		0		0		0
1	7.51	0.11	7.93	0.53	8.08	0.68	8.5	1.1	7.75	0.35
2	7.55	0.15	7.95	0.55	8.11	0.71	8.52	1.12	7.74	0.34
3	7.57	0.17	7.96	0.56	8.15	0.75	8.52	1.12	7.72	0.32
5	7.6	0.2	7.97	0.57	8.2	0.8	8.53	1.13	7.71	0.31
7	7.63	0.23	7.98	0.58	8.23	0.83	8.54	1.14	7.67	0.27
10	7.65	0.25	7.98	0.58	8.25	0.85	8.55	1.15	7.64	0.24
15	7.67	0.27	7.99	0.59	8.25	0.85	8.58	1.18	7.63	0.23
20	7.69	0.29	8	0.6	8.25	0.85	8.61	1.21	7.62	0.22
25	7.71	0.31	8.01	0.61	8.25	0.85	8.61	1.21	7.60	0.2
30	7.71	0.31	8.01	0.61	8.25	0.85	8.61	1.21	7.57	0.17
40	7.71	0.31	8.02	0.62	8.25	0.85	8.61	1.21	7.55	0.15
50	7.71	0.31	8.03	0.63	8.25	0.85	8.61	1.21	7.53	0.13
60	7.71	0.31	8.03	0.63	8.25	0.85	8.61	1.21	7.52	0.12
70									7.50	0.1
80									7.49	0.09
90									7.49	0.09
100									7.48	0.08
120									7.48	0.08
150									7.46	0.06
180									7.44	0.04
210									7.42	0.02
240									7.42	0.02
270									7.41	0.01


RWL	7.4			
Time (min)	Drawdown (m)	Water Level (mbgl)	Recovery (m)	Recovery (mbgl)
1	0.90	8.3	0.53	7.93
2	0.91	8.31	0.48	7.88
3	0.92	8.32	0.47	7.87
5	0.96	8.36	0.43	7.83
7	1.02	8.42	0.42	7.82
10	1.08	8.48	0.40	7.8
15	1.10	8.5	0.38	7.78
20	1.13	8.53	0.37	7.77
25	1.14	8.54	0.35	7.75
30	1.15	8.55	0.34	7.74
35	1.16	8.56	0.33	7.73
40	1.17	8.57	0.32	7.72
50	1.20	8.6	0.31	7.71
60	1.21	8.61	0.30	7.7
75	1.22	8.62	0.29	7.69
90	1.24	8.64	0.28	7.68
105	1.26	8.66	0.27	7.67
120	1.28	8.68	0.26	7.66
150	1.30	8.7	0.24	7.64
180	1.32	8.72	0.22	7.62
210	1.34	8.74	0.21	7.61
240	1.34	8.74	0.20	7.6
300	1.34	8.74	0.18	7.58
360	1.36	8.76	0.16	7.56
480	1.36	8.76	0.14	7.54
600	1.37	8.77	0.12	7.52
720	1.38	8.78	0.08	7.48
840	1.39	8.79	0.07	7.47
960	1.39	8.79	0.05	7.45
1080	1.40	8.8	0.03	7.43
1200	1.40	8.8	0.01	7.41
1320	1.40	8.8	0.00	7.4
1440	1.40	8.8		

House

Rate (l/s)	Step 1 - 30 m <sup>3</sup> /hr		Step 2 - 60m <sup>3</sup> /hr		Step 3 - 90m <sup>3</sup> /hr		Step 4 - 113m <sup>3</sup> /hr		Recovery	
	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)	WL mbgl	s (m)
0	7.98	0		0		0		0		0
1	8.48	0.5	9.02	1.04	9.87	1.89	10.33	2.35	8.65	0.67
2	8.48	0.5	9.03	1.05	9.9	1.92	10.41	2.43	8.50	0.52
3	8.48	0.5	9.04	1.06	9.91	1.93	10.48	2.5	8.43	0.45
5	8.49	0.51	9.05	1.07	9.94	1.96	10.67	2.69	8.39	0.41
7	8.5	0.52	9.07	1.09	9.95	1.97	10.74	2.76	8.34	0.36
10	8.5	0.52	9.07	1.09	9.97	1.99	10.89	2.91	8.31	0.33
15	8.5	0.52	9.07	1.09	9.99	2.01	10.94	2.96	8.27	0.29
20	8.51	0.53	9.07	1.09	10	2.02	10.94	2.96	8.25	0.27
25	8.51	0.53	9.07	1.09	10.01	2.03	10.94	2.96	8.21	0.23
30	8.51	0.53	9.07	1.09	10.02	2.04	10.94	2.96	8.19	0.21
40	8.51	0.53	9.07	1.09	10.03	2.05	10.96	2.98	8.14	0.16
50	8.51	0.53	9.07	1.09	10.06	2.08	10.98	3	8.09	0.11
60	8.51	0.53	9.07	1.09	10.07	2.09	11	3.02	8.04	0.06
70									8.02	0.04
80									8.00	0.02
90									8.00	0.02
100									7.99	0.01
120									7.99	0.01
150									7.99	0.01

RWL	7.98			
Time (min)	Drawdown (m)	Water Level (mbgl)	Recovery (m)	Recovery (mbgl)
1	1.67	9.65	0.62	8.6
2	1.85	9.83	0.52	8.5
3	1.90	9.88	0.46	8.44
5	1.96	9.94	0.41	8.39
7	1.99	9.97	0.38	8.36
10	2.02	10	0.34	8.32
15	2.07	10.05	0.32	8.3
20	2.10	10.08	0.29	8.27
25	2.12	10.1	0.27	8.25
30	2.15	10.13	0.26	8.24
35	2.15	10.13	0.25	8.23
40	2.17	10.15	0.24	8.22
50	2.21	10.19	0.23	8.21
60	2.22	10.2	0.22	8.2
75	2.24	10.22	0.20	8.18
90	2.26	10.24	0.18	8.16
105	2.28	10.26	0.15	8.13
120	2.30	10.28	0.13	8.11
150	2.33	10.31	0.12	8.1
180	2.37	10.35	0.10	8.08
210	2.41	10.39	0.10	8.08
240	2.42	10.4	0.10	8.08
300	2.46	10.44	0.09	8.07
360	2.48	10.46	0.09	8.07
480	2.50	10.48	0.08	8.06
600	2.50	10.48	0.07	8.05
720	2.50	10.48	0.06	8.04
840	2.50	10.48	0.05	8.03
960	2.50	10.48	0.04	8.02
1080	2.50	10.48	0.03	8.01
1200	2.50	10.48	0.02	8
1320	2.50	10.48	0.01	7.99
1440	2.50	10.48	0.00	7.98

## APPENDIX C – LAB RESULTS



**Analytical  
Laboratory  
Services**  
OUR QUALITY IS IN THE DETAIL

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P. O. Box 86782, Windhoek, Namibia

**TEST REPORT I231776/1**

To: **Retort Charcoal Producers( Pty)**  
P.O.Box 30098  
Windhoek

Date received: 18/Sep/23  
Date analysed: 20-27 September 2023  
Date reported: 30/Sep/23

Attn: Stefan  
e-mail: stefan@charcoal.com.na  
Tel: 081-316 5539


Client Reference no.: Verbal  
Quotation no.: QU-A20402  
Lab Reference: I231776  
Enquiries: Mrs Imogen Carew

---

**Sample details** Water Sample  
**Location of sampling point** -  
**Description of sampling point** Site  
**Date of sampling** 2023/09/18; 08h40  
**Test item number** I231776/1

**Recommended maximum limits**  
**Human consumption**      **Livestock**  
**watering**

Parameter	Value	Units	Classification	Human consumption			Livestock watering
				Group A	Group B	Group C	
p H	7.1		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	80.5	mS/m	A	150	300	400	
Turbidity	0.10	NTU	A	1	5	10	
Total Dissolved Solids (calc.)	445	mg/l					6000
P-Alkalinity as CaCO <sub>3</sub>	<10	mg/l					
Total Alkalinity as CaCO <sub>3</sub>	435	mg/l					
Total Hardness as CaCO <sub>3</sub>	431	mg/l	B	300	650	1300	
Ca-Hardness as CaCO <sub>3</sub>	275	mg/l	A	375	500	1000	2500
Mg-Hardness as CaCO <sub>3</sub>	156	mg/l	A	290	420	840	2057
Chloride as Cl	11	mg/l	A	250	600	1200	1500-3000
Fluoride as F	0.3	mg/l	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO <sub>4</sub> <sup>2-</sup>	13	mg/l	A	200	600	1200	1000
Nitrate as N	0.8	mg/l	A	10	20	40	100
Nitrite as N	<0.01	mg/l					10
Sodium as Na	6.8	mg/l	A	100	400	800	2000
Potassium as K	0.9	mg/l	A	200	400	800	
Magnesium as Mg	38	mg/l	A	70	100	200	500
Calcium as Ca	110	mg/l	A	150	200	400	1000
Manganese as Mn	<0.01	mg/l	A	0.05	1.0	2.0	10
Iron as Fe	<0.01	mg/l	A	0.1	1.0	2.0	10
Stability pH, at 25°C	6.8						
Langelier Index	0.3	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	6.5	scaling		<6.5=scaling, >7.5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	0.1	no corrosive properties		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			



**Approved Technical Signatory**  
Ms. Helena Daniel

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FM 7.8-4: Water Quality (SOC)

Version 001  
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P. O. Box 86782, Windhoek, Namibia

**TEST REPORT I231776/1**

**Remark:** Overall classification of water, considering only constituents that have been tested for:  
Group B: good quality water

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.  
The highest group assigned to any of the constituents determines the classification of the water as a whole.  
Group A: excellent quality water  
Group B: good quality water  
Group C: low risk water  
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

**Sample acceptance:** Sample was collected in bottles provided by the laboratory.  
Sample was suitable for testing



**Approved Technical Signatory**  
Ms. Helena Daniel

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FM 7.8-4: Water Quality (SOC)

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**TEST REPORT I231776/2**

To: **Retort Charcoal Producers( Pty)**  
P.O.Box 30098  
Windhoek

Date received: 18/Sep/23  
Date analysed: 20-27 September 2023  
Date reported: 30/Sep/23

Attn: Stefan  
e-mail: stefan@charcoal.com.na  
Tel: 081-316 5539

Client Reference no.: Verbal  
Quotation no.: QU-A20402  
Lab Reference: I231776  
Enquiries: Mrs Imogen Carew

Sample details	Water Sample
Location of sampling point	-
Description of sampling point	Donny
Date of sampling	2023/09/18; 08h15
Test item number	I231776/2

Parameter	Value	Units	Classification	Recommended maximum limits			Livestock watering
				Group A	Group B	Group C	
pH	7.1		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	93.7	mS/m	A	150	300	400	
Turbidity	0.20	NTU	A	1	5	10	
Total Dissolved Solids (calc.)	533	mg/l					6000
P-Alkalinity as CaCO <sub>3</sub>	<10	mg/l					
Total Alkalinity as CaCO <sub>3</sub>	525	mg/l					
Total Hardness as CaCO <sub>3</sub>	518	mg/l	B	300	650	1300	
Ca-Hardness as CaCO <sub>3</sub>	357	mg/l	A	375	500	1000	2500
Mg-Hardness as CaCO <sub>3</sub>	161	mg/l	A	290	420	840	2057
Chloride as Cl <sup>-</sup>	11	mg/l	A	250	600	1200	1500-3000
Fluoride as F <sup>-</sup>	0.3	mg/l	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO <sub>4</sub> <sup>2-</sup>	13	mg/l	A	200	600	1200	1000
Nitrate as N	0.8	mg/l	A	10	20	40	100
Nitrite as N	<0.01	mg/l					10
Sodium as Na	6.8	mg/l	A	100	400	800	2000
Potassium as K	0.9	mg/l	A	200	400	800	
Magnesium as Mg	39	mg/l	A	70	100	200	500
Calcium as Ca	143	mg/l	A	150	200	400	1000
Manganese as Mn	<0.01	mg/l	A	0.05	1.0	2.0	10
Iron as Fe	0.01	mg/l	A	0.1	1.0	2.0	10
Stability pH <sub>t</sub> at 25°C	6.6						
Langelier Index	0.5	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	6.1	scaling		<6.5=scaling, >7.5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	0.1	no corrosive properties		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

  
Approved Technical Signatory  
Ms. Helena Daniel

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P. O. Box 86782, Windhoek, Namibia

**TEST REPORT I231776/2**

**Remark:** Overall classification of water, considering only constituents that have been tested for:  
Group B: good quality water

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.  
The highest group assigned to any of the constituents determines the classification of the water as a whole.  
Group A: excellent quality water  
Group B: good quality water  
Group C: low risk water  
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

**Sample acceptance:** Sample was collected in bottles provided by the laboratory.  
Sample was suitable for testing



**Approved Technical Signatory**  
Ms. Helena Daniel

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FM 7.8-4: Water Quality (SOC)

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C



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Unit 16 & 17, Ben Amathila Ave.

**TEST REPORT – I231628**

To: **Retort Charcoal Producers (PTY) Ltd**  
PO Box 30098  
Windhoek

Date sample(s) received: 24/08/2023  
Date sample(s) analysed: 24 - 30/08/2023  
Date reported: 30/08/2023

Att: Mr. Stefan Falk  
E-mail: [stefan@charcoal.com.na](mailto:stefan@charcoal.com.na)  
Tel: 081 316 5539

Client reference No.: Not applicable  
Quotation No.: QUA30302  
Lab. Reference: I231628  
Enquiries: Ms. Tanja Düvel | Windhoek Lab

1. Temperature of cooler box at receipt: Unsatisfactory (13°C)
2. Number and Type of samples received: 5 x water samples
3. Sampling date & time: 23/08/2023, 17:55 – 18:25
4. Sampling location: not provided
5. Sampling done by: Customer

6. Remark: Sample acceptance

**Samples were accepted with exception**

Difference(s) against the criteria was/were observed that may have influenced the accuracy of the results

- The sample was warm upon receipt, improper storage or transport of sample has occurred prior to receipt

**7. Test(s) Requested**

- METH M 026: Total Colony count (TCC), cfu/ml
- METH M 046: Total coliforms, MPN/100ml
- METH M 046: *E. coli*, MPN/100ml

**8. Results**

Sample Description	Matrix	Lab Sample Number	Total Colony Count cfu/ml	Total coliforms MPN/100ml	<i>E. coli</i> MPN/100ml
Staff	Potable water	I231628/1	290	<1	<1
Residence	Potable water	I231628/2	540	2	<1
Alex	Potable water	I231628/3	640	2	<1
Donny	Potable water	I231628/4	3 200	23	<1
Site	Potable water	I231628/5	3 100	12	<1

**Comments:**

- < = less than
- cfu/ml = Colony forming units per millilitre
- MPN/100ml = Most probable number per 100 ml; this number is based on probability formulas and is an estimate of the mean density of bacteria in the sample
- External reference methods are listed on FM 7.1-1-5 Sample Submission Form: Microbiology Testing version 001



Approved Technical Signatory  
Ms. Rosina Shangula

The result(s) relate(s) only to the specific sample(s) tested as identified herein and do not apply to any similar sample that has not been tested

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**TEST REPORT – I231628**

**Remark: Statement of conformity**

- **Potable water:** test results should meet acceptable limits as per guideline of the water act (ACT 54 of 1956) and its requirements in terms of water supplies for drinking water and for wastewater treatment and discharge, Department of Water Affairs, Namibia, July 1988, to be considered as pass.

**Overall classification of water considering only constituents that have been tested for:**

- Group A: a very safe water
- Group B: microbiologically still suitable for human consumption
- Group C: water with a risk factor which requires rectification
- Group D: unsuitable for human consumption

Group	A	B	C	D
Total colony count, cfu/ml	≤100	≤1 000	≤10 000	>10 000
Coliform, MPN/100ml	<1	≤10	≤100	>100
<i>E.coli</i> , MPN/100ml	<1	<1	≤10	>10
Faecal coliform, MPN/100ml	<1	≤5	≤50	>50

Sample Description	Lab Sample Number	Classification of water
Staff	I231628/1	Group B
Residence	I231628/2	Group B
Alex	I231628/3	Group B
Donny	I231628/4	Group C
Site	I231628/5	Group C



**Approved Technical Signatory**  
Ms. Rosina Shangula

The result(s) relate(s) only to the specific sample(s) tested as identified herein and do not apply to any similar sample that has not been tested  
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P. O. Box 86782, Windhoek, Namibia

**TEST REPORT I231628/1**

To: **Retort Charcoal Producers**  
P.O.Box 30098  
Windhoek

Date received: 24/Aug/23  
Date analysed: 29 August - 05 September 2023  
Date reported: 07/Sep/23

Attn: Stefan Falk  
e-mail: stefan@charcoal.com.na  
Tel: 081-316 5539

Client Reference no.: Verbal  
Quotation no.: QU-A30302  
Lab Reference: I231628  
Enquiries: Mrs Imogen Carew

<b>Sample details</b>	Water Sample
<b>Location of sampling point</b>	-
<b>Description of sampling point</b>	Staff
<b>Date of sampling</b>	2023/08/23; 18h00
<b>Test item number</b>	I231628/1

Parameter	Value	Units	Classification	Recommended maximum limits			Livestock watering
				Group A	Group B	Group C	
pH	7.0		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	94.7	mS/m	A	150	300	400	
Turbidity	0.15	NTU	A	1	5	10	
Total Dissolved Solids (calc.)	545	mg/l					6000
P-Alkalinity as CaCO <sub>3</sub>	<10	mg/l					
Total Alkalinity as CaCO <sub>3</sub>	515	mg/l					
Total Hardness as CaCO <sub>3</sub>	545	mg/l	B	300	650	1300	
Ca-Hardness as CaCO <sub>3</sub>	385	mg/l	B	375	500	1000	2500
Mg-Hardness as CaCO <sub>3</sub>	161	mg/l	A	290	420	840	2057
Chloride as Cl <sup>-</sup>	9	mg/l	A	250	600	1200	1500-3000
Fluoride as F <sup>-</sup>	0.2	mg/l	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO <sub>4</sub> <sup>2-</sup>	15	mg/l	A	200	600	1200	1000
Nitrate as N	2.5	mg/l	A	10	20	40	100
Nitrite as N	<0.01	mg/l					10
Sodium as Na	7.2	mg/l	A	100	400	800	2000
Potassium as K	1.0	mg/l	A	200	400	800	
Magnesium as Mg	39	mg/l	A	70	100	200	500
Calcium as Ca	154	mg/l	B	150	200	400	1000
Manganese as Mn	<0.01	mg/l	A	0.05	1.0	2.0	10
Iron as Fe	<0.01	mg/l	A	0.1	1.0	2.0	10
Stability pH <sub>t</sub> at 25°C	6.6						
Langelier Index	0.4	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	6.2	scaling		<6.5=scaling, >7.5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	0.1	no corrosive properties		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

  
Approved Technical Signatory  
Ms. Helena Daniel

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P. O. Box 86782, Windhoek, Namibia

**TEST REPORT I231628/1**

**Remark:** Overall classification of water, considering only constituents that have been tested for:  
Group B: good quality water

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.  
The highest group assigned to any of the constituents determines the classification of the water as a whole.  
Group A: excellent quality water  
Group B: good quality water  
Group C: low risk water  
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

**Sample acceptance:** Sample was collected in clients' own bottle  
Sample was suitable for testing



**Approved Technical Signatory**  
Ms. Helena Daniel

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FM 7.8-4: Water Quality (SOC)

Version 001  
Effective Date: 01.10.2022

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**TEST REPORT I231628/1**

**Assessment of water quality for human consumption**

Naturally occurring chemicals that are of health significance in drinking water

Fluoride: Exposure to high levels of fluoride, which occurs naturally, can lead to mottling of teeth and, in severe cases, crippling skeletal fluorosis.

0-1.0 mg/l fluoride: no adverse health effects or tooth damage occurs

Chemicals from agricultural activities that are of health significance in drinking water

Nitrate and nitrite: In water it has been associated with methaemoglobinaemia, especially in bottle-fed infants  
0-6 mg/l nitrate as N: no adverse health effects

Some of the naturally occurring chemicals which occur in drinking water at concentrations below those at which toxic effects may occur.

Chloride: high concentrations of chloride give a salty taste to water. Concentrations in excess of 250 mg/l are increasingly likely to be detected by taste.

Hardness: Depending on the interaction of other factors, such as, pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the pipe work and tanks. On heating, hard waters form deposits of calcium carbonate scale.

pH: Optimum pH 6.5-8.

pH does not exert direct health effects, but may exert indirect health effects via metal solubility.

Sodium: The average taste threshold for sodium is about 200 mg/l.

Sulphate: It is generally considered that the taste impairment is minimal at levels below 250 mg/l.

Magnesium: The average taste threshold for magnesium is about 70 mg/l

Total dissolved solids: The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l.

Turbidity is a measure of the light-scattering ability of water and is indicative of the concentration of suspended matter in water.

Microorganisms are often associated with turbidity, hence low turbidity minimises the potential for transmission of infectious diseases. Turbidity also affects the aesthetic quality of water.

Turbidity in water is caused by the presence of suspended matter which usually consists of a mixture of inorganic matter, such as clay and soil particles and organic matter.

Turbidity may also be associated with the presence of inorganic ions such as manganese(II) and iron(II).

The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination or the ingestion of substances bound to particulate matter, do.

Aesthetic effects (appearance, taste, odour) of turbidity can be mitigated or removed by decantation or by filtration (or by both), accelerated, if necessary, by previous aeration



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P. O. Box 86782, Windhoek, Namibia

**TEST REPORT I231628/2**

To: **Retort Charcoal Producers**  
P.O.Box 30098  
Windhoek

Date received: 24/Aug/23  
Date analysed: 29 August - 05 September 2023  
Date reported: 07/Sep/23

Attn: Stefan Falk  
e-mail: stefan@charcoal.com.na  
Tel: 081-316 5539

Client Reference no.: Verbal  
Quotation no.: QU-A30302  
Lab Reference: I231628  
Enquiries: Mrs Imogen Carew

<b>Sample details</b>	Water Sample
<b>Location of sampling point</b>	-
<b>Description of sampling point</b>	Residence
<b>Date of sampling</b>	2023/08/23; 18h05
<b>Test item number</b>	I231628/2

Parameter	Value	Units	Classification	Recommended maximum limits			Livestock watering
				Group A	Group B	Group C	
pH	7.0		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	88.5	mS/m	A	150	300	400	
Turbidity	1.7	NTU	B	1	5	10	
Total Dissolved Solids (calc.)	511	mg/l					6000
P-Alkalinity as CaCO <sub>3</sub>	<10	mg/l					
Total Alkalinity as CaCO <sub>3</sub>	490	mg/l					
Total Hardness as CaCO <sub>3</sub>	517	mg/l	B	300	650	1300	
Ca-Hardness as CaCO <sub>3</sub>	352	mg/l	A	375	500	1000	2500
Mg-Hardness as CaCO <sub>3</sub>	165	mg/l	A	290	420	840	2057
Chloride as Cl <sup>-</sup>	8	mg/l	A	250	600	1200	1500-3000
Fluoride as F <sup>-</sup>	0.2	mg/l	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO <sub>4</sub> <sup>2-</sup>	15	mg/l	A	200	600	1200	1000
Nitrate as N	1.0	mg/l	A	10	20	40	100
Nitrite as N	<0.01	mg/l					10
Sodium as Na	7.3	mg/l	A	100	400	800	2000
Potassium as K	1.0	mg/l	A	200	400	800	
Magnesium as Mg	40	mg/l	A	70	100	200	500
Calcium as Ca	141	mg/l	A	150	200	400	1000
Manganese as Mn	<0.01	mg/l	A	0.05	1.0	2.0	10
Iron as Fe	0.05	mg/l	A	0.1	1.0	2.0	10
Stability pH <sub>t</sub> at 25°C	6.6						
Langelier Index	0.4	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	6.3	scaling		<6.5=scaling, >7.5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	0.1	no corrosive properties		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

  
Approved Technical Signatory  
Ms. Helena Daniel

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**TEST REPORT I231628/2**

**Remark:** Overall classification of water, considering only constituents that have been tested for:  
Group B: good quality water

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.  
The highest group assigned to any of the constituents determines the classification of the water as a whole.  
Group A: excellent quality water  
Group B: good quality water  
Group C: low risk water  
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

**Sample acceptance:** Sample was collected in clients' own bottle  
Sample was suitable for testing



**Approved Technical Signatory**  
Ms. Helena Daniel

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FM 7.8-4: Water Quality (SOC)

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P. O. Box 86782, Windhoek, Namibia

**TEST REPORT I231628/3.**

To: **Retort Charcoal Producers**  
P.O.Box 30098  
Windhoek

Date received: 24/Aug/23  
Date analysed: 29 August - 05 September 2023  
Date reported: 07/Sep/23

Attn: Stefan Falk  
e-mail: stefan@charcoal.com.na  
Tel: 081-316 5539

Client Reference no.: Verbal  
Quotation no.: QU-A30302  
Lab Reference: I231628  
Enquiries: Mrs Imogen Carew

<b>Sample details</b>	Water Sample
<b>Location of sampling point</b>	-
<b>Description of sampling point</b>	Alex
<b>Date of sampling</b>	2023/08/23; 18h15
<b>Test item number</b>	I231628/3.

Parameter	Value	Units	Classification	Recommended maximum limits			Livestock watering
				Group A	Group B	Group C	
pH	7.0		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	76.4	mS/m	A	150	300	400	
Turbidity	0.25	NTU	A	1	5	10	
Total Dissolved Solids (calc.)	454	mg/l					6000
P-Alkalinity as CaCO <sub>3</sub>	<10	mg/l					
Total Alkalinity as CaCO <sub>3</sub>	440	mg/l					
Total Hardness as CaCO <sub>3</sub>	445	mg/l	B	300	650	1300	
Ca-Hardness as CaCO <sub>3</sub>	410	mg/l	B	375	500	1000	2500
Mg-Hardness as CaCO <sub>3</sub>	35	mg/l	A	290	420	840	2057
Chloride as Cl <sup>-</sup>	6	mg/l	A	250	600	1200	1500-3000
Fluoride as F <sup>-</sup>	0.3	mg/l	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO <sub>4</sub> <sup>2-</sup>	5	mg/l	A	200	600	1200	1000
Nitrate as N	0.7	mg/l	A	10	20	40	100
Nitrite as N	<0.01	mg/l					10
Sodium as Na	2.0	mg/l	A	100	400	800	2000
Potassium as K	0.6	mg/l	A	200	400	800	
Magnesium as Mg	8.6	mg/l	A	70	100	200	500
Calcium as Ca	164	mg/l	B	150	200	400	1000
Manganese as Mn	0.03	mg/l	A	0.05	1.0	2.0	10
Iron as Fe	0.01	mg/l	A	0.1	1.0	2.0	10
Stability pH <sub>t</sub> at 25°C	6.6						
Langelier Index	0.4	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	6.2	scaling		<6.5=scaling, >7.5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	0.0	no corrosive properties		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

  
Approved Technical Signatory  
Ms. Helena Daniel

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P. O. Box 86782, Windhoek, Namibia

**TEST REPORT I231628/3.**

**Remark:** Overall classification of water, considering only constituents that have been tested for:  
Group B: good quality water

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.  
The highest group assigned to any of the constituents determines the classification of the water as a whole.  
Group A: excellent quality water  
Group B: good quality water  
Group C: low risk water  
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

**Sample acceptance:** Sample was collected in clients' own bottle  
Sample was suitable for testing



**Approved Technical Signatory**  
Ms. Helena Daniel

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FM 7.8-4: Water Quality (SOC)

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**TEST REPORT I231628/4**

To: **Retort Charcoal Producers**  
P.O.Box 30098  
Windhoek

Date received: 24/Aug/23  
Date analysed: 29 August - 05 September 2023  
Date reported: 07/Sep/23

Attn: Stefan Falk  
e-mail: stefan@charcoal.com.na  
Tel: 081-316 5539

Client Reference no.: Verbal  
Quotation no.: QU-A30302  
Lab Reference: I231628  
Enquiries: Mrs Imogen Carew

<b>Sample details</b>	Water Sample
<b>Location of sampling point</b>	-
<b>Description of sampling point</b>	Donny
<b>Date of sampling</b>	2023/08/23; 18h25
<b>Test item number</b>	I231628/4

Parameter	Value	Units	Classification	Recommended maximum limits			Livestock watering
				Group A	Group B	Group C	
pH	7.0		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	108.7	mS/m	A	150	300	400	
Turbidity	0.30	NTU	A	1	5	10	
Total Dissolved Solids (calc.)	619	mg/l					6000
P-Alkalinity as CaCO <sub>3</sub>	<10	mg/l					
Total Alkalinity as CaCO <sub>3</sub>	630	mg/l					
Total Hardness as CaCO <sub>3</sub>	626	mg/l	B	300	650	1300	
Ca-Hardness as CaCO <sub>3</sub>	285	mg/l	A	375	500	1000	2500
Mg-Hardness as CaCO <sub>3</sub>	342	mg/l	B	290	420	840	2057
Chloride as Cl <sup>-</sup>	7	mg/l	A	250	600	1200	1500-3000
Fluoride as F <sup>-</sup>	0.5	mg/l	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO <sub>4</sub> <sup>2-</sup>	17	mg/l	A	200	600	1200	1000
Nitrate as N	0.5	mg/l	A	10	20	40	100
Nitrite as N	<0.01	mg/l					10
Sodium as Na	16	mg/l	A	100	400	800	2000
Potassium as K	1.2	mg/l	A	200	400	800	
Magnesium as Mg	83	mg/l	B	70	100	200	500
Calcium as Ca	114	mg/l	A	150	200	400	1000
Manganese as Mn	<0.01	mg/l	A	0.05	1.0	2.0	10
Iron as Fe	<0.01	mg/l	A	0.1	1.0	2.0	10
Stability pH <sub>t</sub> at 25°C	6.6						
Langelier Index	0.4	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	6.3	scaling		<6.5=scaling, >7.5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	0.0	no corrosive properties		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

  
Approved Technical Signatory  
Ms. Helena Daniel

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**TEST REPORT I231628/4**

**Remark:** Overall classification of water, considering only constituents that have been tested for:  
Group B: good quality water

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.  
The highest group assigned to any of the constituents determines the classification of the water as a whole.  
Group A: excellent quality water  
Group B: good quality water  
Group C: low risk water  
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

**Sample acceptance:** Sample was collected in clients' own bottle  
Sample was suitable for testing



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Ms. Helena Daniel

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FM 7.8-4: Water Quality (SOC)

Version 001  
Effective Date: 01.10.2022

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**TEST REPORT I231628/5**

To: **Retort Charcoal Producers**  
P.O.Box 30098  
Windhoek

Date received: 24/Aug/23  
Date analysed: 29 August - 05 September 2023  
Date reported: 07/Sep/23

Attn: Stefan Falk  
e-mail: stefan@charcoal.com.na  
Tel: 081-316 5539

Client Reference no.: Verbal  
Quotation no.: QU-A30302  
Lab Reference: I231628  
Enquiries: Mrs Imogen Carew

<b>Sample details</b>	Water Sample
<b>Location of sampling point</b>	-
<b>Description of sampling point</b>	Site
<b>Date of sampling</b>	2023/08/23; 17h55
<b>Test item number</b>	I231628/5

Parameter	Value	Units	Classification	Recommended maximum limits			Livestock watering
				Group A	Group B	Group C	
pH	7.0		A	6-9	5.5-9.5	4-11	
Electrical Conductivity	93.6	mS/m	A	150	300	400	
Turbidity	0.20	NTU	A	1	5	10	
Total Dissolved Solids (calc.)	540	mg/l					6000
P-Alkalinity as CaCO <sub>3</sub>	<10	mg/l					
Total Alkalinity as CaCO <sub>3</sub>	520	mg/l					
Total Hardness as CaCO <sub>3</sub>	549	mg/l	B	300	650	1300	
Ca-Hardness as CaCO <sub>3</sub>	385	mg/l	B	375	500	1000	2500
Mg-Hardness as CaCO <sub>3</sub>	165	mg/l	A	290	420	840	2057
Chloride as Cl <sup>-</sup>	8	mg/l	A	250	600	1200	1500-3000
Fluoride as F <sup>-</sup>	0.3	mg/l	A	1.5	2.0	3.0	2.0-6.0
Sulphate as SO <sub>4</sub> <sup>2-</sup>	14	mg/l	A	200	600	1200	1000
Nitrate as N	0.8	mg/l	A	10	20	40	100
Nitrite as N	<0.01	mg/l					10
Sodium as Na	7.3	mg/l	A	100	400	800	2000
Potassium as K	1.0	mg/l	A	200	400	800	
Magnesium as Mg	40	mg/l	A	70	100	200	500
Calcium as Ca	154	mg/l	B	150	200	400	1000
Manganese as Mn	<0.01	mg/l	A	0.05	1.0	2.0	10
Iron as Fe	<0.01	mg/l	A	0.1	1.0	2.0	10
Stability pH <sub>t</sub> at 25°C	6.6						
Langelier Index	0.4	scaling		>0=scaling, <0=corrosive, 0=stable			
Ryznar Index	6.1	scaling		<6.5=scaling, >7.5=corrosive, ≥6.5 and ≤7.5=stable			
Corrosivity ratio	0.0	no corrosive properties		Applies to water in the pH range 7-8 which also contains dissolved oxygen ratios <0.2 no corrosive properties ratios >0.2 increasing corrosive tendency			

  
Approved Technical Signatory  
Ms. Helena Daniel

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**TEST REPORT I231628/5**

**Remark:** Overall classification of water, considering only constituents that have been tested for:  
Group B: good quality water

Interpretation based on guidelines for the evaluation of drinking water for human consumption, DWA, Namibia, April 1988 and South African Water Quality Guidelines Volume 5: Agricultural water use: Livestock watering, Second Edition, 1996

For practical reasons, the guidelines are divided into four groups.  
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Group B: good quality water  
Group C: low risk water  
Group D: high risk or water unsuitable for human consumption

Ideally water should be either Group A or Group B. If water is classified as Group C, the situation is not yet critical, but attention should be given to those constituents over the Group B limit. If however, the water is classified as Group D urgent and immediate attention is required to reduce the levels of the problem constituents in the water to suitable levels.

**Sample acceptance:** Sample was collected in clients' own bottle  
Sample was suitable for testing



**Approved Technical Signatory**  
Ms. Helena Daniel

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FM 7.8-4: Water Quality (SOC)

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**TEST REPORT – I231776**

**To:** Retort Charcoal Producers (PTY) Ltd  
PO Box 30098  
Windhoek

Date sample(s) received: 18/09/2023  
Date sample(s) analysed: 19 - 24/09/2023  
Date reported: 25/09/2023

**Att:** Mr. Stefan Falk  
**E-mail:** [stefan@charcoal.com.na](mailto:stefan@charcoal.com.na)  
**Tel:** 081 316 5539

Client reference No.: Not applicable  
Quotation No.: QUA20402  
Lab. Reference: I231776  
Enquiries: Ms. Tanja Düvel | Windhoek Lab

1. Temperature of cooler box at receipt: Acceptable
2. Number and Type of samples received: 2 x water samples
3. Sampling date & time: 18/09/2023, 08:40 and 08:45
4. Sampling location: not provided
5. Sampling done by: Customer

6. Remark: Sample acceptance
  - Samples were suitable for testing

7. Test(s) Requested
  - METH M 026: Total Colony count (TCC), cfu/ml
  - METH M 046: Total coliforms, MPN/100ml
  - METH M 046: *E. coli*, MPN/100ml

**8. Results**

Sample Description	Matrix	Lab Sample Number	Total Colony Count cfu/ml	Total coliforms MPN/100ml	<i>E. coli</i> MPN/100ml
Site	Potable water	I231776/1	1 200	16	<1
Donny	Potable water	I231776/2	420	<1	<1

- Comments:**
- < = less than
  - cfu/ml = Colony forming units per millilitre
  - MPN/100ml = Most probable number per 100 ml; this number is based on probability formulas and is an estimate of the mean density of bacteria in the sample
  - External reference methods are listed on FM 7.1-1-5 Sample Submission Form: Microbiology Testing version 001



**Approved Technical Signatory**  
Ms. Rosina Shangula

The result(s) relate(s) only to the specific sample(s) tested as identified herein and do not apply to any similar sample that has not been tested  
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**TEST REPORT – I231776**

**Remark: Statement of conformity**

- **Potable water:** test results should meet acceptable limits as per guideline of the water act (ACT 54 of 1956) and its requirements in terms of water supplies for drinking water and for wastewater treatment and discharge, Department of Water Affairs, Namibia, July 1988, to be considered as pass.

**Overall classification of water considering only constituents that have been tested for:**

Group A: a very safe water  
Group B: microbiologically still suitable for human consumption  
Group C: water with a risk factor which requires rectification  
Group D: unsuitable for human consumption

Group	A	B	C	D
Total colony count, cfu/ml	≤100	≤1 000	≤10 000	>10 000
Coliform, MPN/100ml	<1	≤10	≤100	>100
<i>E. coli</i> , MPN/100ml	<1	<1	≤10	>10
Faecal coliform, MPN/100ml	<1	≤5	≤50	>50

Sample Description	Lab Sample Number	Classification of water
Site	I231776/1	Group C
Donny	I231776/2	Group B



**Approved Technical Signatory**  
Ms. Rosina Shangula

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FM 7.8-2 Microbiology: Statement of Conformity

Version 000  
Effective Date: 07.06.2022

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**TEST REPORT**

Client: **Carbon Capital (Pty) Ltd**  
Address: **P O Box 81009**  
**Windhoek**

Attn: **Mr C. Lindeque**  
email: **colin@carboncapital.com.na**  
Tel: **0813433424**

Date received: **0-Jan-00**  
Date analysed: **3-May-21**  
Date reported: **05-19-May-21**  
Client Reference: **verbal**  
Quotation: **none**  
Lab Reference: **I210866**  
Enquiries: **Ms Silke Rügheimer**

Test:	Manganese	Iron	Copper	Zinc	Boron	Molybdenum
Method Description:	1M ammonium acetate	extractable EDTA (pH 4.65) followed by ICP-OES			hot water ICP-OES	ammonium oxalate ICP-OES
Unit:	mg Mn/kg	mg Fe/kg	mg Cu/kg	mg Zn/kg	mg B /kg	mg Mo /kg
Lab No. <b>Gai Kaisa, 2021/03/24</b>						
1 Hole 1 <30cm	<b>44</b>	<b>48</b>	<b>1.6</b>	<b>6.1</b>	<b>0.3</b>	<b>0.5</b>
2 Hole 1 >30 <60cm	<b>38</b>	<b>13</b>	<b>1.3</b>	<b>0.6</b>	<b>0.5</b>	<b>0.7</b>

**Remark Assessment of soil fertility: micronutrients**

Availability of most micronutrients is largely pH dependent, availability decreases as pH increases (except for molybdenum, which becomes more available as pH increase. Deficiencies rarely occur in soils with pH below 6.5. Lowering soil pH to increase zinc, manganese and iron availability on a field scale is not economical. However, adding acidifying materials such as elemental sulphur to fertiliser mixes can acidify microzones around the fertilizer material and increase micronutrient availability. If you suspect a micronutrient deficiency, plant tissue testing may be a better diagnostic tool than soil testing.

  
Approved Technical Signatory  
Ms S. Rügheimer