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TECHNICAL REPORT

Upington Site 1- Housing Project- Dawid Kruiper Municipality

ZF Mgcawu District Municipality- Northern Cape Province

Preliminary Geotechnical Site Investigation

Prepared for
EnviroAfrica

Date
29/06/2023

Compiled by
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Technical Report

GC22/132A

29 June 2023

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Project Details

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1. Project Introduction

1.1. Background

This report describes the results of the **Preliminary Geotechnical Site Investigation** conducted in support of the planned housing project taking place across ERF 23228, 23229 and the Remaining Extent of 5645- herein referred to as **Site 1**- within the Paballelo Settlement of Upington. The planned township spans a **partially developed** parcel of land, with a surface area of roughly **44 Ha.**

The cumulative development falls under the jurisdiction of the Dawid Kruiper Municipality of the greater ZF Mgcawu District Municipality- Northern Cape Province of South Africa.

GeoCalibre Geotechnical Consultancy did not conduct a detailed engineering geological investigation across the planned township area. The information presented in this document is based purely off the available data bank of reports in the region and accompanying desktop level information. This document was created in order to assist with the EIA phase of the development.

1.2. Terms of Appointment

Initially, GeoCalibre Geotechnical Consultancy was appointed by *EnviroAfrica* to undertake a Phase 1 Township Investigation, however, permission was not granted by the local authority to undertake the required excavations- due to the risk of damaged services etc. For this reason, GeoCalibre was instructed by the Client to compile a desktop level report aligned with the standards of a Preliminary Geotechnical Site Investigation (GFSH-2/SANS634).

Procurement Authority: Dawid Kruiper Municipality.

Tender reference: NO47/2022DKM- Undertaking of EIA's for Sites 1 & 2 Housing Projects for Dawid Kruiper Municipality (DKM).

Ideally, the assessment of the geotechnical character of a portion of land depends on a detailed soils assessment, backed up by geomechanical- and geochemical laboratory tests. Due to the absence of excavations, a desktop level Preliminary Geotechnical Site Investigation was conducted. The results of this level of assessment provides an overview of the geotechnical character of the site, as well as listing prominent adverse geotechnical characteristics.

The information presented in this document is based on the information supplied by the Client prior to the commencement of the compilation of this technical report; therefore, GeoCalibre Geotechnical Consultancy (Pty) Ltd- shall not be held liable for, and is indemnified against all actions, claims, demands, losses, liabilities, costs, damages and expenses prompted by, or in connection with, inaccurately relayed information pertaining to the site and/or the development.

The National Home Builders Registration Council (NHBRC) was established in terms of the Housing Consumer Protection Measures Act, 1998 (Act No. 95 of 1998). According to the Act- all residential units must be enrolled with the NHBRC. A site-specific geotechnical investigation is required to justify the assigned Site Class Designation for the stand and guide structural design. Studies of this nature can be undertaken as part of future operations across the township.

1.3. Codes of Practise and Investigative Standard

The investigations are carried according to the following standard practice codes and guidelines:

- National Department of Housing; Geotechnical Site Investigations for Housing Developments, Project Linked to Greenfield Subsidy Project Developments, Generic Specification **GFSH-2,** September 2002, **Section 5.2**: **Preliminary Geotechnical Site Investigation**.
- The NHBRC Home Building Manual (2015).
- Geotechnical Investigations for Township Developments- SANS 634 (2012).
- Guidelines for Urban Engineering Geological Investigations (SAIEG & SAICE, 1997) for urban development.
- Site Investigation Code of Practice put forward by the Geotechnical Division of SAICE (2010)

1.4. GeoCalibre- Company Background and Information

GeoCalibre is a specialist geotechnical consulting firm made up of a team of qualified professional geo-practitioners. The firm was established out of a love for the industry and an urge to define a new calibre of professional consulting.

GeoCalibre uses advanced scientific methods to create accurate and reproducible geotechnical models; successfully guiding the implementation of site-specific design precautionary measures/engineering solutions.

The methodology followed throughout the investigative process accounts for the nature and location of the development as well as adhering to the standards of our practice (SANS and SAICE).

Investigations undertaken by GeoCalibre are overseen by suitably qualified Engineering Geologists *professionally registered* (Pr.Sci.Nat) with the South African Council of Natural Scientific Professions (SACNASP)- in accordance with all the relevant and required procedures and legislations. GeoCalibres employees are also members of the South African Institute for Engineering and Environmental Geologists (SAIEG).

1.5. Limitations of the Geotechnical Assessment

This document serves a basic overview of the site's nature; based solely on the available desktop level information and associated databases. The investigation has therefore attempted to identify problem issues of a geotechnical nature on which this report is based. Should the area be deemed safe for excavations/ probing; GeoCalibre can conduct a detailed investigation to quantify the sites geotechnical nature in the future.

Geological conditions are seldom uniformly developed and areas and positions where geological and geotechnical conditions on the site might vary locally from those described and assessed in this report. The engineering recommendations provided in this report are therefore preliminary and they must be confirmed by site investigations and testing.

The contents of this report are valid as of the date of preparation. However, changes in the condition of the site can occur over time as a result of either natural processes or human activity. If a substantial lapse of time occurs between the submission of our report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, we urge that our report be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions.

1.6. Information Sources

- **Geological Map:**
    - Geological Series Map 2820 Upington; scale 1: 250 000 (digital format)
- **Hydrogeological Map:**
    - Hydrogeological Series Map 2718 Upington, scale 1: 500 000 (2001)
    - SADC Groundwater Information Portal (SADC GIP)
    - Electronic Maps of the Water Management Areas and Drainage Regions in South Africa- DWAF [Department of Water Affairs and Forestry]- 1996 and 1999 (www.dwa.gov.za).
- **Topocadastral maps:**
    - 2821 Ac; scale 1:50 000 (digital format)
- **Provided by the Client:**
    - Site boundary
- **Remote Sensing Information:**
    - Google Earth Pro ™
    - Planet GIS
    - Elevation Models
    - Northern Cape Cadastral Land Layer (2022)
- **Available geotechnical reports:**
    - Numerous reports from the region compiled by Kevin Coertzen (Pri.Sci.Nat and MSAIEG) and Matthys Dippenaar (PhD).

SANS 10400 and the guideline and specification documents by the South African Institute of Engineering and Environmental Geologists (SAIEG) and South African Institution for Civil Engineers (1997), AEG/SAIEG/SAICE (2002) were consulted.

No site walkover was conducted by the author of this report, however, the Client provided GeoCalibre with a detailed photo library of the area. Furthermore- in the recent past- GeoCalibre has undertaken Phase 1 and Phase 2 Township investigations for both Paballelo North and North East, as well as a detailed investigation for the planned extension to the local Jupiter Cemetery.

1.7. Scope of the Investigation

The proposed development is understood to be the formalization of the existing Informal Settlement into a Township. The proposed infrastructure and service developments for this site are expected to primarily include residential/ commercial units and municipal services.

A preliminary phase engineering geological site investigation was carried out across the area in question. The results of this type of assessment provide an overview of the geotechnical character of the site, as well as listing prominent adverse physical characteristics that could limit the usefulness thereof.

It must be noted that this assessment was conducted to identify potentially adverse geotechnical conditions across the area in question to facilitate the planning and decision-making processes surrounding the proposed EIA, land-rezoning and associated future township developments.

The aim of the overall site investigation can be summarised as follows:

- Establishment of a **regional geological** model for the site.
- To determine, on a regional scale, the **hydrogeological nature** of the region.
- To predict the **succession of strata** (soil and rock) underlying the site; with the identification of problematic **physical, chemical** and **mechanical** characteristics which may influence the development.
- To predict the **excavatability properties** of the materials underlying the site.
- To predict shallow groundwater patterns.
- To predict the **re-usage potential** of the materials underlying the site.
- To aid the development moving forward through the formulation of a **geotechnical model** for the site under investigation; based on predominantly desktop level information.

The investigation excludes the following aspects, where applicable:

- Phase 1 or 2 geotechnical assessments with excavations and sampling
- Detailed hydrological, hydropedological, hydrogeological, pedological, flood line, or wetland delineation studies.
- Ground and/or surface water sampling/testing
- Undermining investigations
- Geophysical, resistivity, or corrosion studies
- Geo-environmental assessments.

1.8. Investigative Methodology

The investigation is undertaken in a number of phases in order to achieve the aims discussed above. The investigative phases are as follows:

1. Study area location and site **description.**
2. Determination of the **regional geomorphological** setting of the area.

   Review and assess the topographic data available for the region. Additional to the topographic nature of the site, this section will include the analysis of both climatic factors as well as vegetation in order to create an overall geomorphological model.

3. Determination of the **regional geological nature** of the study area.

   Review and assess the available geological data in the area (regional maps and remote sensing images etc.); this is undertaken to predict the mechanical properties of the underlying residual soils and decomposed parent material.

4. Determination of the **regional hydrogeological nature** of the study area.

   Review and assess all the available hydrogeological data (regional scale) including information regarding the quaternary catchment area.

5. Infer **geotechnical characteristics** of the site and underlaying materials.

   Making use of the available data base of geotechnical information, inferences are made surrounding the geotechnical character of the site- including attributes such as predicted ground profile, excavatability, ground water seepage, material re-usage, mechanical properties of the soft materials etc.

6. Cumulative **data assessment** and compilation of a **technical report**.

   The investigation concluded with the compilation of a technical report detailing the methodology utilised during the study and the summarised results obtained. This includes a desktop level potential geotechnical evaluation of the site as well as the recommendations with regards to site-specific engineering solutions.

1.9. Development within 1 : 100 year-flood lines

It must be noted that the National Water Act (Act 36 of 1998) states the following regarding development within the 1 : 100 year-flood lines of any stream or river (Thompson, 2006):

- **Section 21(c):** Impeding or diverting the flow of water in watercourses (including alteration of the hydraulic characteristics of flood events) requires licensing according to the Act.
- **Section 21(i):** Any action that may alter the bed, banks, courses or characteristics of watercourses (including flood events) requires licensing according to the Act, including: widening or straightening of the bed or banks of a river to allow for the construction the housing development and altering the course of a river partially or completely (i.e.: river diversion) to be able to use or develop the area where the watercourse originally was.

The National Water Act does not prohibit development within 1 : 100 year-flood lines; however, the Act requires detailed analysis of the effects of the proposed development on the surrounding environment, with special reference to surface and sub-surface water flow.

The Act requires that suitable precautionary measures be implemented to limit the effect within and downstream from the proposed development.

2. Description of the Environment

2.1. Site Location and Description

The **study area** for this investigation is seen to fall within the central portions of the Northern Cape Province of South Africa; situated within the western extent of Upington. Upington is located within the jurisdictive boundary of the Dawid Kruiper Municipality of the greater ZF Mgcawu District Municipality. On a more localised scale, the **study area** in question is situated along the northern perimeter of the **Paballelo Settlement**.

The **site** which forms the focal point of this investigation is comprised of **ERF 23228**, **23229** and the **Remaining Extent of 5645** (RE/5645) within Paballelo. As depicted by the green polygon on Image 1 below, the site ear-marked for township establishment- herein referred to as **Site 1**- entails a partially developed rectangular shaped parcel of land with a total extent of approximately **44 Ha.** Furthermore, access to the site is primarily achieved via either the Regional Road 360 (R360) or Groef Crescent which form the sites' north eastern and south eastern boundaries respectively, with the occurrence of numerous secondary access routes from the south west.

The site for this investigation is located at the following coordinates:

Latitude: 28.423963° S **Longitude:** 21.210065° E

The investigated area was defined by the Client prior to the commencement of the study and forms part of the greater Dawid Kruiper Municipality Housing Project (Ref.: NO47/2022DKM). The planned township establishment across the surface will encompass the subdivision of this land portion into various land-use zones i.e., infrastructural units, roadways, and services etc. Each of these zones may require their own set of geotechnical assessments and associated engineering solutions. This investigation was conducted to aid the decision-making processes during the EIA phase of the proposed development.

Image 1: Site Layout

2.2. Land-use and Anthropogenic Reworking

The vast majority of the site is previously disturbed land within informal settlements and is understood to be municipally owned property.

As visually depicted in the photo series below, the surface across the central to south eastern portions of the site has been **remoulded** though past **informal township establishment** practices. The exact extent of the infrastructure in the region is not known (both surface and subsurface). It is envisaged that the informal development across this region will **grow daily**. Furthermore, numerous gravel roads traverse the site, with these roads serving as the primary access points to the various portions. Due to the risk of damages to existing services, the local authorities did not authorise the excavation of tests pits across this area.

Additional to these practices, heaps of **dumped fill** materials were present adjacent to the gravel roads and residential dwellings. The surficial nature of the site was further diversified by its rocky surface. The combination of the items raised above have resulted in the formation of an anthropogenically induced undulating landscape, with the occurrence of localised topographic anomalies.

The photo series below graphically depicts the surficial nature of the site at the time of this study- as presented by *EnviroAfrica*.

2.3. Regional Topography

Topography is based on elevation profiles from the available remote sensing information and basic field observations. This does not substitute land survey data. Topography and regional hydrology (e.g., steep slopes, very flat slopes, defined drainage features, and rapid changes in slope) affect the distribution of ground as it affects the weathering, erosion, transport, and deposition of materials. As such, it provides a valuable indication of possible changes in subsurface ground and water conditions, but also affects the stability of slopes and the direction of surface runoff.

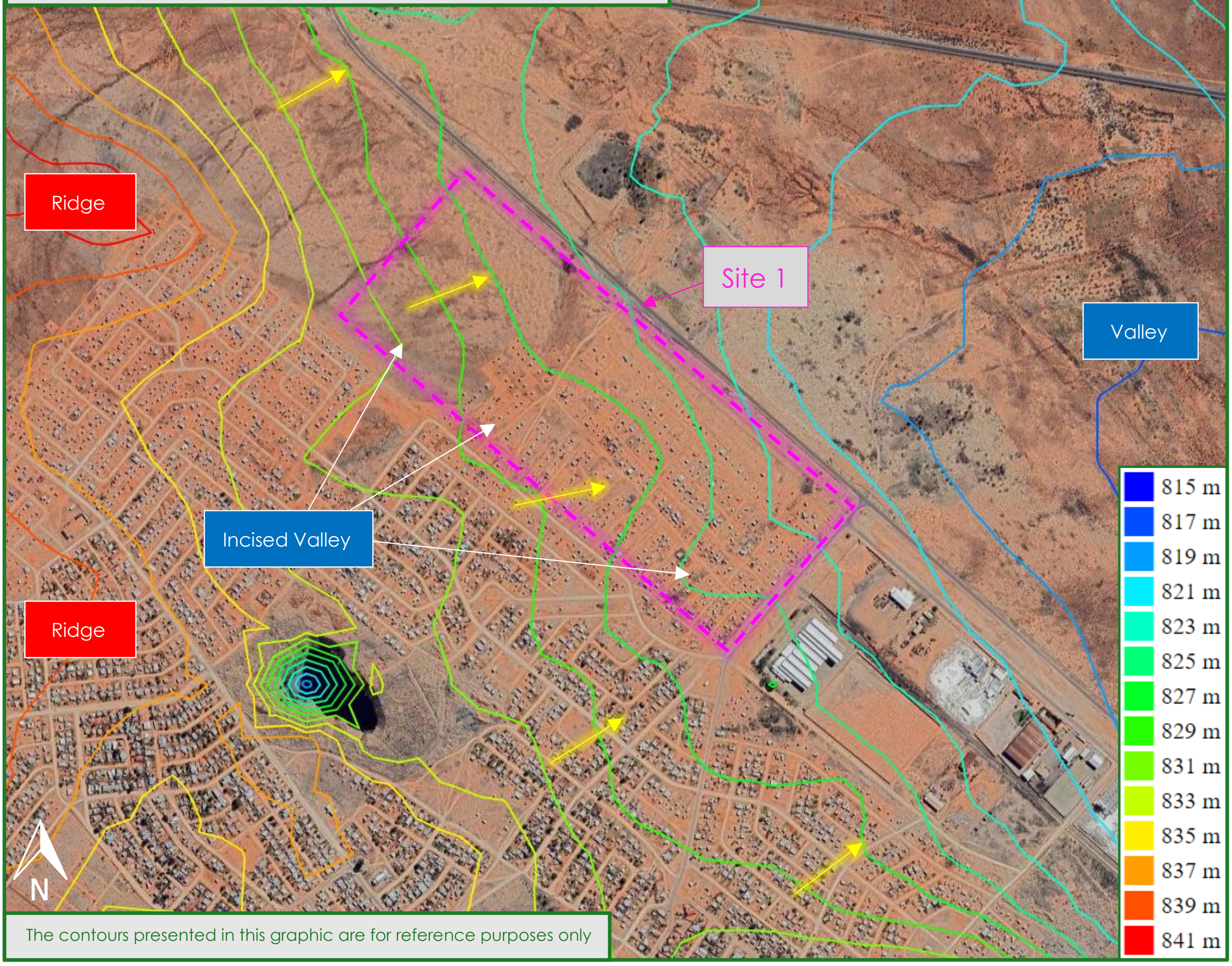
The regional setting is seen to display an **undulating surface morphology** with irregular shaped intermittent ridges separated by low lying incised valley landforms- typical to that of **regional gneissic terrains**. These rocks form part of an ancient batholithic intrusion which have subsequently been disturbed by various geological processes, resulting in a discontinuous underlying rock mass. Moreover, this **inherent variability** is exposed through **erosional processes**; with alternating water ways following zones of weakness in the rock mass. The low-lying areas- between alternating ridges- are frequently filled over time with transported sediments of varying shapes and sizes (quaternary aged sediments).

As seen in the annotated topographic map below (Image 2); the regional topography of the area is characterised by high-lying minor ridge landforms to both the west and north west and low-lying valley landforms to the east. The regional declivity decreases in a north easterly direction with an increased distance from the minor ridge landforms.

Furthermore, the annotated ridge landforms form the **primary watershed features** for the area, with the natural slopes **diverging** from their crests (yellow arrows on the image)- **converging** upon the low-lying eastern portions of the study area. Through the process of **headward erosion**, numerous valley structures have **incised** their way into the high-lying terrain; examples of which are pointed out on the image.

Refer to Image 2 below which depicts the topographic nature of the region.

Image 2: Study Area- Annotated Topographic Model



Although the image depicts a fluctuating geomorphological environment (constant changes in colour), the contours exhibit an irregular shape and the range in elevation is notably low. This serves as evidence for a uniform and continuous surficial morphology.

With reference to Image 2; the site is seen to fall primarily along the eastern side slope of the high-lying terrain. Consequently, the **natural** topographic nature of the site can be characterised by **very gentle slopes** (natural) typically extending from the higher lying areas to the west and north west- towards the low-lying eastern portions of the site. Localised slope variances were encountered due to the occurrence of small-scale anomalies- both natural and anthropogenic.

As a whole, the site is seen to host a **very gentle sloping surface morphology**, with average measured slopes of **less than 2 degrees**. The far western portions of the site were seen to display the highest measured elevations of approximately 834 meters above mean sea level (MAMSL); decreasing to an elevation of approximately 823 MAMSL in the far eastern portions (calculated using Google Earth PRO ^{tm}).

Additional to the natural slopes, the area was seen to display an **artificially reworked surficial nature** leading to topographic variability across its extent. In some areas, the reworking of the surface through ongoing human activities has affected the continuity and degree of natural slopes in the area, impacting its' natural drainage character and resulting in the formation of **small-scale topographic anomalies.** Based on the available information, the development will entail the rehabilitation of the site's surface within and immediately surrounding future structures.

2.4. Regional Drainage

The drainage nature of the study area will mirror its' topographic nature as described in Section 2.3 of this report. The ridge structures annotated on Image 2 will serve as the primary watershed features for the region, with the secondary occurrence of minor local divides. The developments orientation in relation to the natural slopes will impact the rate and associated energy of the overland flow. This orientation is expected to fluctuate across the footprint of the contract and will need to be addressed to ensure appropriate fluid dynamics.

Due to the sites' **very gentle sloping nature**, it will drain mainly by means of **low energy surface run-off (sheet-flow);** with storm water flowing from the high lying western to north western portions of the site, in a general easterly direction. The very gentle sloping portions of the site will be subjected to elevated degrees of **surface water infiltration** into the underlying soils, rather than rapid surface water flow, accentuating **surface water ponding** and **fluctuating moisture conditions** after prolonged precipitation events.

Surface water ponding- and associated temporary perched water tables- is exacerbated through the occurrence of compacted surfaces and localised depressions (artificial).

The land surface located upslope of the site is seen to exhibit a similar topographic nature. Should excessive infiltration take place across this area, it is predicted that elevated volumes of **shallow ground water throughflow** may occur across the investigated site.

Natural slopes **converge** upon the mapped incised valley landforms. Across these areas- and along roads- the rate of surface water flow is expected to **increase**- with medium energy surface water flow. **Channelized/converging surface water flow** elevates the risk for **erosion** in these areas.

The **anthropogenic reworking** of the surface will result in **local variations** of surface water flow- both rate and direction. The continuity and manipulation of the topography and associated drainage plays a pivotal role in the longevity and sustainability of the development. Topographic anomalies identified/ measured during the survey can be addressed individually in the design.

2.5. Mapped Rivers and/or Canals

The information presented in this section does not serve as a detailed hydrological study of the area, but rather as a **guideline/early indication** to the location of areas of possible concern. Smaller drainage anomalies- both natural and anthropogenic- not mapped on the graphic above may traverse the footprint of the development and can be mapped accordingly for the inclusion into the site's regional model. Furthermore, input from competent specialists in the co-dependent reports (i.e., botanical/freshwater) for the site overwrite the discussion points below where applicable.

According to the available information (Topocadastral Maps 2821 Ac- Image 3 and Figure 4), in combination with the available remote sensing information- numerous **non-perennial rivers** and/or **drainage landforms** are mapped to traverse the site in question. These features have been altered to varying degrees as a result of surrounding township developments. Emphasis needs to be placed on the areas bordering or traversing existing drainage structures.

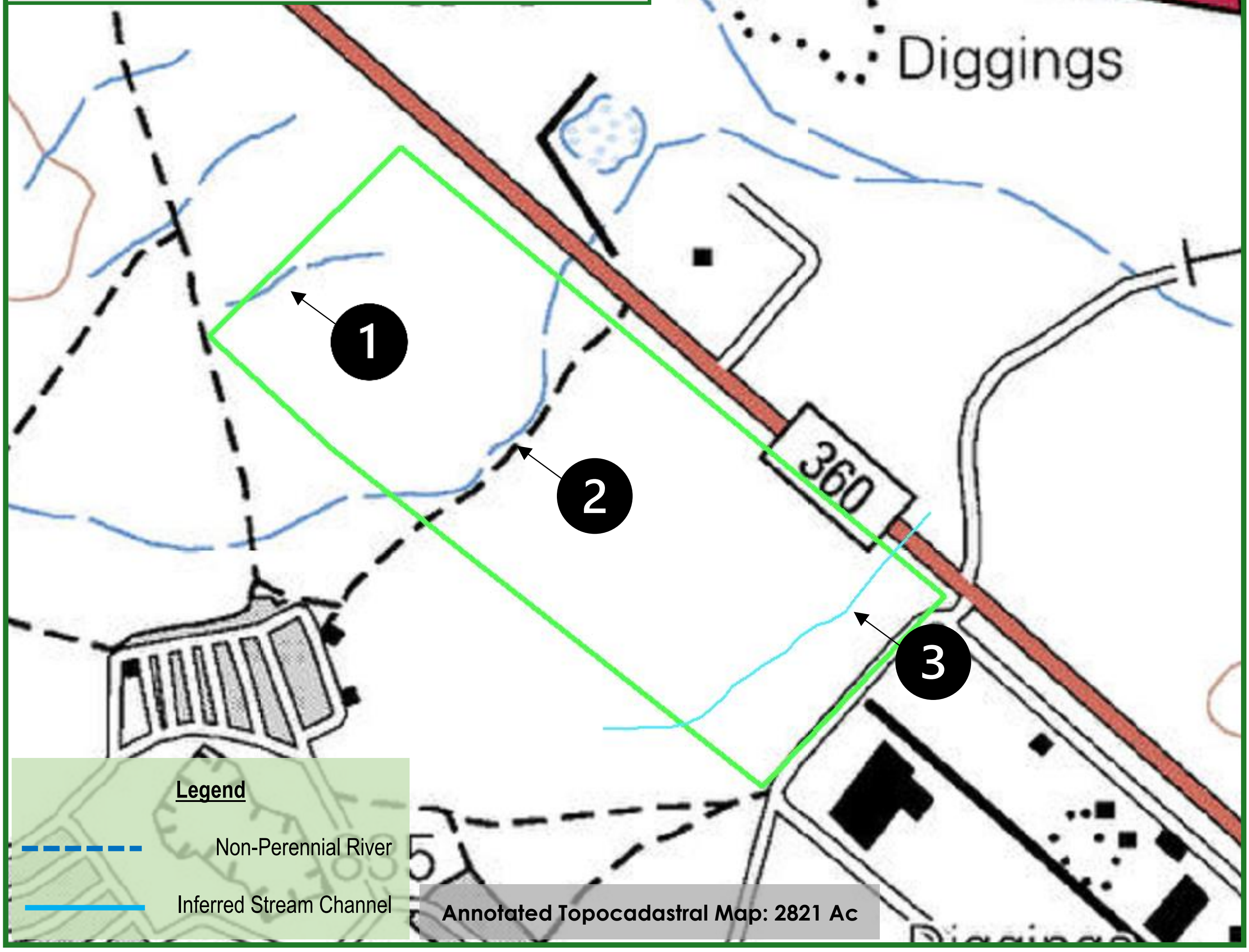
Although not favourable, engineering solutions can be applied to these portions of the site to allow for future development- with the actions aligned with the applicable law of South Africa and site specific OHS protocols.

General notes regarding the mapped rivers are as follows:

- Calculated flood lines for all nearby watercourses should be available from the Local and/or District Municipality Town Planning Department. If not, a hydrologist should undertake this determination.
- The **flood lines** of the mapped drainage structures should be modelled; with the implementation of suitable design measures adhering to the appropriate law of South Africa. By law, residential developments below the 1:50-year flood lines areas are prohibited. This is due to the risk of flooding leading to property damage, health and life hazards, inconveniences, etc.
- **Appropriate infrastructure**, including **scour protection**, should be implemented as part of the development- the exact nature of which is to be defined by the competent person.
- Surface seepage and/or swampy zones can be expected within- and immediately adjacent to- the mapped drainage channels following precipitation events.
- **Groundwater** flow may occur at shallow depths within- and adjacent to- stream channels.
- In these areas, **elevated volumes of surface water flow** can be expected following prolonged precipitation events- including elevated degrees of **erosion/turbulence** and possible localised quicksand conditions.

Image 3 below depicts the annotated topographic map of the region.

Image 3: Mapped Rivers- Topographic Map 2821 Ac



2.6. Regional Climate

The greater Upington area is considered an **arid desert climate** and is classified as **BWh** by the Köppen and Geiger system and **Arid Interior** (SANS 204-2). The area has an average annual temperature of 21.6 °C and an average annual rainfall of **219 mm** with both temperature and rainfall being highest during the summer months.

Climate determines the mode and rate of **weathering**. The effect of climate on the weathering process (i.e., soil formation) is determined by the climatic N value defined by Weinert, 1980. The N-value is calculated as 12 times the January evaporation divided by the annual precipitation and indicates whether an area is predominantly moisture-surplus (N < 5) or moisture-deficit (N > 5).

The climatic N-value (Weinert, 1980) of the area is deemed to be **more than 20**; therefore, **physical/mechanical disintegration** of the parent rocks in the regional setting is deemed the principal mode of weathering. This mode of weathering favours the formation of an abundance of rocky fragments occurring within the soil matrix. Due to the climatic regime of the region, a **shallow soil profile** is predicted in the area and shallow bedrock can be expected unless it is covered by transported soils.

Chemical decomposition will take place but on a lower scale.

2.7. Regional Vegetation and Biotic Activity

Input from competent specialists in the co-dependent reports (i.e., botanical) for the site overwrite the discussion points below where applicable.

The area is within the Nama-Karoo Biome very near to the northern border of the Bushmanland Arid Grassland (NKb) comprising intermingling units of Lower Gariep Broken Veld, Kalahari Karroid Shrubland and Gordonia Duneveld.

Across the vast majority of the site, the natural vegetation has been **denuded** to varying degrees as a result of surrounding **human activities**. The resulting vegetation across both the developed and undeveloped areas include a **sparse grass cover and scattered trees/bushes**. Areas subject to high traffic volumes have been scarred- leaving behind bare topsoils.

Abundant to traces of fine roots can be expected in the blanketing topsoil, with the degree of organic material and biotic activity is predicted to decrease with an increase in depth. Additional sub-surface vegetation is predicted to occur in areas hosting shrubs/bushes; however, the extent of these root zones is predicted to diminish with an increased distance from the trunk.

The effects of the removal of trees on sites should also be considered, particularly where trees have depressed the water table over a period of time. The removal of trees can result in the formation of highly compressible zones of voided soils.

Many structures are likely to be near planted or self-sown trees during their useful life. In some situations, trees can adversely affect structures and induce damage. All trees should be regarded as a potential source of damage. The greatest risk of direct damage occurs close to the tree from the growth of the main trunk and roots and diminishes rapidly with distance.

The following varieties are, however, particularly prone to causing damage:

a) all eucalyptus varieties

b) London planes

c) willows (Salix) of any type

d) jacarandas.

Trees can cause direct damage by

a) the growth of roots or the base of the trunk lifting or distorting structures

b) the disruption of underground services and pipelines

c) the direct contact of branches with the superstructure

Where adequate distances are not observed, precautions, such as the reinforcement of foundations to resist lateral thrusts and the bridging over of roots to allow for future growth, should be adopted.

3. Regional Geological and Hydrogeological Setting

3.1. Introduction

The regional geology provides geological context to the anticipated distribution of geological material and how these can affect the distribution of lithologies (rock types) with different chemical, mineralogical, structural, and mechanical properties. Bedrock refers to the rock directly underlying the site and, when exposed to surface, is referred to as outcrop. Bedrock can be underlain by other rock types at shallow depths, and it is usually overlain by residual soils derived of its in-situ weathering and transported soils deposited from other positions.

3.2. Regional Stratigraphic Setting

According to the available geological information (geological series map: 2820 Upington); the study area is underlain by the following geological units (Figure 2):

"Qg"- **Gordonia Formation** of the Kalahari Group (Qg); red-brown, wind-blown sand and dunes.

According to the findings of local geotechnical studies- it is predicted that the transported sediments are underlain by either- or a combination of- pyroxene, massive amphibolite; amphibole gneiss; hornblende-biotite, biotite and quartzo-feldspathic gneiss with lenses of calc-silicate rocks from the **Jannelspan Formation** (previously the Donkieboud Granite Gneiss).

Based on the available data base, bedrock is predicted to be highly variable, comprising amphibolite gneiss and calc-silicates of the Jannelspan Formation. Residual and completely weathered horizons are generally calcified, with the expected formation of hardpan calcrete on the bedrock interface. The bedrock surface is generally highly variable across the area. Variable bedrock topography and lithology (rock type) may influence excavatability and residual soil properties over small distances.

Historical development, excavation and/ or levelling practices may have disrupted the surficial materials and variations in soil properties should be accounted for. The likelihood of imported fill and building rubble should also be accounted for in shallow horizons- requiring the rehabilitation of the sites surface prior to the establishment of the township.

3.2.1. Quaternary Sediments

Based on surrounding exposures, the site is predicted to be blanketed by a fine sediment deposit deemed to be of an **aeolian origin.** The primary make-up of the **aeolian sediment deposits** include resistant quartz particles along with less resistant micas and feldspars (clays). The less resistant minerals typically weather to a clay which bridges the gaps between the more resistant minerals. These **clay bridges** give high strength to the aeolian soils under dry conditions, however very low strength under wet conditions. As such, these soils frequently undergo **collapse settlement** under an **increase in moisture conditions**.

These combined transported materials have been transported by a natural agent during relatively recent geological times and has not undergone lithification into a sedimentary rock. Furthermore, due to their age and shallow occurrence- these deposits may **lack essential pre-consolidation characteristics**. This may result in additional **movement** upon saturation and loading.

3.2.2. Calcrete/Pedocrete

Pedocretes are common surficial deposits across the majority of Southern Africa and form by the **cementation and/or replacement of pre-existing soils** by various authigenic minerals **precipitated by water**. The most common precipitating minerals are **carbonates (calcrete)** and **iron oxides (ferricrete).** Pedocretes may replace each other resulting in mixtures- for example, calcrete and ferricrete may be silicified (silcrete).

Calcrete may develop as a **groundwater** or **pedogenic** types depending on whether precipitation occurred above a shallow groundwater table or if the carbonate has been carried downwards through the soil by rainwater. Calcretes also typically form in areas with rainfall below 550 mm/y. In some instances, the groundwater table occurs directly below the hardpan horizon.

In terms of consistency, **two main types** of pedocrete can be distinguished, namely **indurated** and **non-indurated**. Indurated pedocretes consists of hardpan, honeycomb, and nodular forms while non-indurated is characterised by soft or powdery forms.

Pedocretes typically form at rates of between 20 and 200 mm per thousand years. After their formation, pedocretes will weather like any rock if the conditions for their development and preservation are no longer favourable. Cobbles and boulders of pedocrete may be transported as colluvium/alluvium and can be incorporated into younger pedocretes.

The geotechnical properties of pedocretes **vary** according to the **nature of the host material, the nature of the cementing and replacing minerals** as well as the **degree** of cementation and/or replacement.

Based on the photos provided by *EnviroAfrica,* calcrete outcrops/boulders were scattered across the site- more prolific in areas which have undergone erosion- with the shape, consistency and composition to fluctuate intermittently.

3.2.3. Gneiss- Jannelspan Formation

Based on the findings from local geotechnical studies- the site is modelled to be underlain by bedrock which resembles the physical and geotechnical characteristics of amphibolite **gneiss** and calc-silicates of the Jannelspan Formation.

The ancient age of the bedrock indicates the likelihood of highly disturbed bedrock including the presence of extensive jointing, hydrothermal veins, and a large degree of weathering. As such, it is predicted that highly variable bedrock, ranging from undisturbed competent rock to highly fractured and weathered incompetent rock, could be encountered.

The **banded character** of the gneiss leads to a variable weathering profile, where less weathered, moderately hard core-stones or bands may occur within a soil-like material. Quartz-rich zones will also undergo less weathering than its mica-rich counterpart. The orientation of these bands (i.e.: vertical or horizontal) may also lead to the occurrence of deeply weathered zones within generally less weathered material.

This undulating weathering profile results in a **variable bedrock topography,** which in turn will negatively affect both the **continuity of excavatability** and the **movement of fluids** across the site.

Furthermore, the mineralogy of gneissic rocks comprises of more resistant quartz along with less resistant micas and feldspars. The less resistant minerals typically weather to a clay which bridges the gaps between the more resistant minerals. These **clay bridges** give high strength to the residual soils under dry conditions, however low strength under wet conditions. As such, these soils frequently undergo **collapse settlement** under an **increase in moisture.**

3.3. Dolomitic Land and Sinkhole Formation

Information received from the Council for Geosciences and the available regional geological sheets indicate that the site is not characterised by soluble rocks such as dolomite or limestone. Therefore, the study area does not reflect any risk for the formation of sinkholes or subsidence's caused by the presence of water-soluble rocks, and as such is **not deemed "*dolomitic land*".**

3.4. Seismic Risk

The peak ground acceleration is the maximum acceleration of the ground shaking during an earthquake. According to **Kijko et al (2003)** the regional seismic hazard in the project area can be defined as **LOW**, exhibiting a 10% probability of a seismic event with a peak ground acceleration of **between 50 and 100 cm/s²** within a period of 50 years- which corresponds to a seismic intensity of I on the Modified Mercalli Scale (MMS).

3.5. Liquefaction

Liquefaction is a phenomenon in which the strength and stiffness of a soil is reduced by earthquake shaking/seismic activity or other rapid loading. Liquefaction occurs when loose, cohesionless, water- saturated soils (generally fine-grained sand and silt) are subject to strong seismic ground motion of significant duration. Prior to an earthquake, the water pressure is relatively low. However, earthquake shaking can cause the water pressure to increase to the point where the soil particles can readily move with respect to each other. These soils essentially behave similar to liquids, losing much of its shear strength.

Liquefaction more often occurs in earthquake prone areas underlain by young sandy sediments where the groundwater table is less than 15 m below the existing ground surface. According to the *Liquefaction Hazard Map of South Africa* map published by the Department of Human Settlements- Upington is not located within a potential liquefaction zone.

3.6. Prominent Geological Structures

According to the available information, there are no prominent geological structures traversing the investigated site.

Geological mapping is based on surficial outcrops and aeromagnetic data (regional geophysical data), either of which are not feasible in a geological setting of this nature. The thick sediment deposits blanket geological structures, with their extensive nature and thickness obscuring traceable geophysical patterns. It is recommended that the nature, stability, and extent of these geological structures be investigated for larger more sensitive structures.

3.7. Mineral Deposits and Mining Activities

According to the geological maps and accompanied explanation no specific mineral deposits are present on the site. A quarry is visible approximately 500 m south west of the site- the exact extent of mining in this area is not known but seems to be limited to surface operations. For this reason, it is envisaged that local mining operations will not have an adverse impact on or endanger the local community, with a limited impact on the proposed township development.

3.8. Palaeontology

Assessment of the palaeontology of the project area is not within the scope of this study. Detailed pre-construction recording and collection within the proposed township footprint should be undertaken by a professional palaeontologist- where deemed applicable.

3.9. Hydrogeological Setting

The findings of a detailed hydrological survey- conducted by a competent specialist- overwrites the information presented below (where applicable).

It is envisaged that the future development across the site will be serviced by local municipal services, for this reason, no site-specific hydraulic conductivity tests or borehole searches were undertaken. Based on the SADC Groundwater Information Portal; there are no recent boreholes drilled across or within close proximity to the study area in question. For this reason, the static rest level/chemistry of the ground water cannot be discussed.

The site falls within the Quaternary Catchment Areas D73F, within the greater Orange River Water Management Area.

According to the available hydrogeological information (hydrogeological series map: 2718 Upington, scale 1: 500 000 (2001); the study area is mainly underlain by **Fractured Aquifers** of medium yield with **limited potential (b3)-** an average borehole yield class of between **0.5 to 2.0 median l/s** can be expected**.**

The groundwater quality is deemed to be between 70 and 300 mS/m (electrical conductivity range).

The groundwater is of the $(Ca,Mg)Cl_2$ - $(Ca,Mg)SO_4$ - $(Na,K)Cl$ - $(Na,K)_2SO_4$ hydrochemical types. Total dissolved solids are 500- 1500 mg/l.

Groundwater levels are estimated between 30-50 m with recharge rates of ~1-10 mm per year. Enhanced groundwater recharge, and related localized seepage, may occur within the bedrock surrounding geological features.

The bedrock may act as a lower-permeability material with an irregular bedrock interface causing limited deep percolation or infiltrated water and upward perching. This is a function of the material distribution and, although not inferred to occur given the climatic conditions of the area, it is implied to be more likely to evaporation and lateral movement of moisture in the very shallow horizons, very low local deep percolation and groundwater recharge, and induced surface runoff in intensive rainfall events.

According to the available information, large scale groundwater abstraction does not take place within close proximity to the site.

4. Geotechnical Setting

4.1. Drainage, Slope Stability and Erosion

Developments of this nature typically include the rehabilitation/remoulding of the site's surface- within and immediately surrounding the planned structures. Emphasis should be placed on surface drainage and storm water control measures to avoid both surface water ponding and concentrated water flow (erosion) across the development area. Structures constructed perpendicular to the natural slopes will result in the ponding of surface water. Furthermore, the development will influence natural infiltration and run-off rates and appropriate precautions against concentrated flow must therefore be implemented.

No natural slope instabilities were visible in these areas at the time of the investigation (basic visual inspection). The probabilities of any mass movement events (landslides, mudslides, debris flows, rock falls, rock slides etc.) occurring across the site is inconsequential. The final layout of the development is not known but based on the natural slopes prior to modification, specialised methods for the stabilisation of cuts into the existing slopes are not deemed necessary. Due to the gradient- major cut to fill site preparation is also not expected for small structures and roadways.

The overall **very gentle sloping nature** of the site will aid surface **water infiltration** into the underlying soils, rather than rapid surface water flow, accentuating **surface water ponding** and **fluctuating moisture conditions** after prolonged precipitation events. Surface water ponding is aggravated through the reworked nature of the surface and low permeability subsoils upon compaction. Infiltrating water then moves laterally through the soft zone of the sub-terrain, converging upon the low-lying areas to the east.

Surficial stormwater control measures should be implemented across the site to limit ponding and the volume of infiltrating fluids. Furthermore, attention must be given to **site contouring** in these areas to ensure an effective gradient is achieved so that ponding does not occur, and the draining of water is efficient to minimise erosion and damage to the construction downslope.

According to the *Erodibility Potential of Soils in South Africa* map published by the Department of Human Settlements- Upington is located within the region of LOW (value= 16 to 20) erodibility potential. The modification of the sites' surface and the compaction of the topsoil through vehicle and/or foot traffic will result in poor drainage characteristics and the possibility of high energy channelized/ concentrated surface water flow. This high energy run-off elevates the risk of erosion in these areas. When subjected to concentrated flow, the blanketing soils are deemed to be erodible (typical for aeolian sand). Erosion is predicted to be more prolific in areas where the natural vegetation is stripped.

The anthropogenic reworking of the sites surface will result in local variations of surface water flow- both rate and direction. The continuity and manipulation of the topography and associated drainage plays a pivotal role in the longevity and sustainability of the development. Once surveyed, small scale topographic anomalies will need to be addressed individually in the engineering design and in so doing eliminating their localised effects. Adequate drainage measures can be discussed with the project team once the design/layout of the development has been formulated.

4.2. Predicted Ground Profile

4.2.1. Introduction and Discussion

Excavations were not permitted across the site. For this reason, the parameters presented below are inferred/predicted from a data bank of geotechnical information acquired by GeoCalibre from surrounding sites.

The following ground profile can be inferred/predicted:

- Based on the photos provided by *EnviroAfrica*- in combination with the available remote sensing information- localised portions of the site area are blanketed/underlain by material deemed to be of a **human origin**- dumped in an uncontrolled manner during past anthropogenic activities.
- The remaining- generally unaltered- extent of the site is predicted to be blanketed by transported sediments deemed to be **aeolian sand.** In this area, the aeolian sand displays an undulating thickness and is typically intercalated with rounded calcrete cobbles and boulders.
- In general, the transported materials are typically underlain by an intercalated successions of both calcrete and weathered rock.
- Bedrock in the vicinity of the site consists of amphibolite gneiss and calc-silicates of the Jannelspan Formation.
- As a whole the quality and continuity of the rock mass will increase with an increase in depth as seen in surrounding exposures.

4.2.2. Uncontrolled Fill

- Fills were generally present within- and immediately bordering- the informal township which traverse the central to south eastern portions of the site.
- These combined successions of fill material were dumped/reworked across the area in an **uncontrolled manner** during past anthropogenic activities.
- The mechanics of these deposits are predicted to be highly variable as a result of both the variable nature of the particles (both natural and anthropogenic) and the variable interaction between them.
- Unstable sidewalls in bulk excavations can be expected where thick successions of uncontrolled fill are encountered.
- Areas hosting extensive fills should be rehabilitated prior to the construction phase of the development.
- Due to the localised occurrence and planned rehabilitation of the area, fill materials will not form a dominant part in the site classification.

4.2.3. Aeolian Sand- Gordonia Formation

- It is predicted that the vast majority of the site is blanketed by a varying thickness of transported sediments deemed to be aeolian sand.
- Aeolian sands are mapped on a regional scale to blanket the vast majority of this portion of the Northern Cape Province- the prevalence of which can be linked to the region's geomorphology.
- The uppermost extent of this material is predicted to be reworked and/or contaminated to varying degrees through past anthropogenic processes.

- In general, the aeolian sands generally display a low in-situ density, fine-grained nature and a voided fabric; attributes typically associated with potentially collapsible soils.
- In these fine materials- a rapid reduction in shear strength is anticipated upon saturation.
- Due to their age and shallow occurrence- these sandy deposits may lack essential pre-consolidation characteristics. This will result in additional consolidation settlement upon saturation and loading.
- As seen in local exposures, the aeolian sand are generally intercalated with the calcrete; for this reason, the thickness and composition of this material can fluctuate sporadically.
- These transported soils are expected exhibit a low plasticity, low linear shrinkage values and an overall LOW potential for heave.
- Aeolian sands generally serve as good material for bedding and selected backfills around buried pipelines.

4.2.4. Pedocretes- Calcrete

- It is predicted that across the majority of the site, the above-described transported materials will be underlain by varying grades of pedogenic material and/or weathered bedrock.
- In this area, the host material is predicted to vary from aeolian sand in the upper extent, to residual/weathered gneiss at depth.
- The predicted occurrence of these pedogenic materials can be directly linked to the morphology of the area. Due to the very gentle sloping nature of the site, the processes of surface water ponding and infiltration will be favoured over surface water runoff (sheet flow). The blanketing sandy and voided soils allow for the infiltration of water. Following infiltration, the underlying shallow impermeable rock mass results in the development of a temporary perched water table- with conditions now favourable for the formation of pedogenic material.
- Furthermore, the geotechnical properties of the pedocretes encountered will vary according to the nature of the host material, the nature of the cementing and replacing minerals as well as the degree of cementation and/or replacement.
- Based on surrounding studies, the pedocretes in the region typically displays an indurated nature, consisting of hard particles (nodules)- ranging from coarse sand to cobble-sized concretions- with a fine-grained matrix. It should be noted that the geotechnical nature of this horizon will be a function of the properties of both the matrix and the individual hard clasts.
- Furthermore, shallow pedogenic horizons can be expected within close proximity to the mapped/modelled non-perennial rivers or areas which have undergone excessive erosion.
- As a whole, the pedocretes are predicted to exhibit a fair to good re-useability with regards to the planned development- typically serving as good material for the use in engineered fills.

4.2.5. Weathered Constituents of Gneissic Bedrock

- It is predicted that the above defined transported sediments and/or pedogenic materials are underlain by varying grades of weathered gneiss.
- The climatic N-value (Weinert, 1980) of the area is deemed to be **more than 20**; therefore, physical/mechanical disintegration of the parent rocks in the regional setting is deemed the principal mode of weathering. This mode of weathering favours the formation of an **abundance of rocky fragments occurring within the soil matrix.**
- Residual soil formation is not prolific in the region, generally with the blanketing soft materials transitioning rapidly onto weathered bedrock.
- The upper extent of the weathered protolith is typically reworked to various degrees through fluctuating moisture condition- with a gradual transition to less altered gneissic bedrock with depth. These residual soils are expected exhibit a low plasticity, low linear shrinkage values and an overall LOW potential for heave (acc. Van Der Merwe, 1964).
- Notably thin exposures of weathered bedrock are generally possible through the use of light excavation methods (i.e., TLBs, hand excavation etc.).
- Although shallow in local sites, the bedrock typically displays a variable depth of occurrence (intercalated with its' pedocrete counterpart)- resulting in the formation of an undulating bedrock topography- which in turn will negatively affect both the continuity of excavatability and the movement of fluids across the site.
- The quality and continuity of the weathered protolith is expected to increase with an increase in depth.
- Where deep excavations are undertaken for services etc, it is recommended that the excavated weathered rock be stockpiled for the re-use in the planned construction. This material- along with its granular residual counterpart- generally serves as good material for the use in selected and even subbase layers. It is essential that this material is not contaminated with the blanketing materials following removal.

4.3. Groundwater and Shallow Seepage

The natural seepage and ground water flow characteristics of the area have been modified/altered to varying degrees as a result anthropogenic processes across the site and surrounding township developments.

Without knowledge on the depth to <u>permanent</u> groundwater in the region- it is not possible to comment on the occurrence of permanent groundwater flow within/below the weathered bedrock. Based on surrounding studies, it is assumed that the natural <u>permanent</u> groundwater level on site is below the zone of foundation influence (light structures).

Groundwater flow may occur at shallow depths within- and adjacent to- mapped stream channels.

The predominant runoff will occur as **sheet wash** following the topography. Waterlogged conditions and/or surface water ponding following prolonged and intense precipitation events are anticipated across the site due to its very gentle sloping nature and anthropogenically induced undulating topography.

During rainfall events the upper granular materials will allow **infiltration** and **lateral** ground water movement. Should infiltration take place, it is predicted that **elevated volumes** of **shallow ground water throughflow** may occur- converging upon the mapped low-lying terrain.

Infiltrating water is predicted to flow/perch along the **rock-soil interface** at depth, with its flow dynamics dependant on the topography of the rock mass/ pedocrete at that point. It is predicted that the rock mass at depth is **practically impervious**. Localised infiltration may take place along extensive fractures. Furthermore, the predicted **undulating topography** of the underlying lithology affects the continuity of the **shallow water flow dynamics** of the site.

Good site drainage measures, on surface and subsurface, must be implemented to prevent moisture changes, which may add to the development of perched groundwater tables. Drainage precautions are required to minimise infiltration that may lead to perching on the underlying bedrock.

During construction and after development, shallow perched water systems may develop yet further due to stormwater management practices, localised infiltration and site modification practices. Provisions should be made for the dewatering of deep trenches following prolonged precipitation events.

The weight of the structures on the surface may result in an increased ground water rest level. For light structures, damp proofing of floors and foundation walls will be necessary to prevent rising damp due to possible surface water accumulation and life cycle changes.

Additional precautions should be implemented for deep structures such as sumps, subsoil tanks, deep pipelines etc. Excavations may need to be dewatered following prolonged precipitation events- to be undertaken in line with the prescribed HSE protocols of the development. Furthermore, the influx of water- both surface and sub-surface- into the trenches may impact their stability.

Foundations and installed services will cause soil density and texture changes which may lead to variations in soil moisture across the site with flow changes and build-up of moisture that may differ from the natural conditions.

If the site or a portion thereof is situated within the 1:100-year flood lines, or have been delineated as a wetland, it is the prerogative of the Civil Engineer or other suitably experienced specialist to overwrite the geotechnical recommendations for such portions.

4.4. Rock- and/or Pedocrete Outcrops

Making use of the available remote sensing information, coupled with the photos provided by *EnviroAfrica*, it is not clear if the site hosts bedrock outcrops.

As depicted in the photo series presented in Section 2 of this report, the site was seen to host scattered and somewhat variable occurrences of either hardpan calcrete outcrops or near-surface calcrete boulders. These features are expected to have an impact on the overall continuity of the excavatability across the site. Additional shallow anomalies may be masked by blanketing fills.

Uncontrolled fill and relict infrastructure may hamper the continuity of excavatability- similar to that of localised outcrops/boulders.

4.5. Site Excavatability with Respect to Services- Inferred

Excavatability is a measure of material to be excavated/dug/mined with conventional excavation equipment such as a bulldozer with rippers, mechanical excavator or other grading equipment.

In rock masses, this characteristic is governed by the shear strength of both the intact rock and the discontinuities separating them. Fluctuating excavation conditions correlate to the depth, spacing and degree of fracturing of the underlying rock mass.

Where deep excavations are undertaken for services, foundations or to modify the sites surface- the excavation properties of the hardpan calcrete and gneissic rock mass need to be considered.

The following excavatability parameters can be inferred/predicted:

- It is predicted that the "SOFT" zone- comprising of aeolian sand, nodular pedocrete and/or residual soil- with fluctuate across the site. This fluctuation relates to the varying degrees of induration and predicted undulating bedrock topography (typical of gneiss).
- Difficult excavation conditions can be expected within both the hardpan pedocrete and weathered bedrock at depth- through the use of a TLB-type light mechanical excavator or similar earth moving equipment.
- As a whole, it is predicted that Category 1 hard excavation estimated to be between approximately 10 and 40% of material to 1.5 m below ground level.
- Predicted localised occurrence of shallow rock/hardpan calcrete- in these areas Category 1 hard excavation is estimated to be in excess of 40% of material to 1.5 mbgl.
- The physical and mineralogical nature of gneiss- coupled with the varying degrees of induration may lead to the formation of a highly undulating bedrock topography. These sub-surface features are expected to have an impact on the overall continuity of the excavatability across the site, with pockets of deeper soils being present between the shallow pinnacles of rock.
- In a gneissic terrain, this variability can take place over a very short distance.
- The rock masses and hardpan pedocrete at depth will require hard rock excavation to unearth.
- The final layout of the development is not known (including associated earthworks); however, allowance should be made for HARD Excavation, typically requiring blasting, wedge and split, chemical fracturing and/or heavy pecking -the exact method of which is dependent on the required final working levels, available equipment and the local environment.
- Trenches/box-cuts may need to be dewatered between and following prolonged precipitation events because of water temporarily perching upon the underlaying less permeable materials at depth.
- Across the central to south eastern portions, informal infrastructure and uncontrolled fill materials will hamper terrain mobility and site excavatability.

The following attributes with regards to trench stability can be inferred/predicted:

- Localised sidewall instabilities are predicted in areas hosting thick fills and/or relict infrastructure.
- Across the majority of the site, it is envisaged that temporary shallow trenches and/or cuttings to depths of up to 1.5 m will remain stable (where dry)- the stability of which can be assessed periodically.
- No loading of the temporary slopes by machinery, equipment, excavated soil or materials shall be allowed. Sheet wash from stormwater or other waters shall be prevented from running over the trench flanks.
- Any excavation deeper than 1,5 mbgl must be stabilised as prescribed in the relevant act.
- Although it is predicted that fresh exposures exhibit stable conditions in near vertical cuts, it is recommended that excavations be adequately sloped (approximately 60 to 75 degrees) or stabilised to reduce the risk of instabilities. Instability is predicted to be in the form of localised rock block failure, necessitating the removal or stabilisation of unstable rock blocks.
- All excavations should be inspected by a competent person (engineer or geo-professional with relevant training and experience) at least once a day and following any periods of rain or any long periods where no work has taken place.
- The provisions of the Occupational Health and Safety Act of 1993 and Construction Regulations of 2014 must be followed in the excavations and workings therein. In terms of Section 11 of the Construction Regulations the contractor must appoint an excavation supervisor.
- Damages to existing wet services and/or existing leaking services will result in surface water ponding and unstable trench sidewall conditions; drastically hampering safety, terrain mobility and site excavatability.

4.6. In-Situ Mechanical Assessment- Inferred

4.6.1. Introduction

The soft materials underlying the site have not been visually inspected due to the absence of excavations. Furthermore, no soil/rock samples were extracted from the materials underlying the site. The engineering material properties presented below are inferred/predicted based on the predicted soil successions from surrounding investigations/exposures.

4.6.2. Bearing Capacity and Soil Shear Strength

Bearing capacity is defined as the pressure which would cause shear failure of the supporting soil immediately below and adjacent to a foundation.

The estimated allowable bearing capacity of a soil material is a function of the angle of internal friction (reflected in the grading), consistency/cohesion (reflected in the soil grading and density) and degree of saturation (moisture content). The allowable bearing pressures imposed on the material is a function of both the soils shear strength (ultimate limit state) and its' settlement characteristics (serviceability limit state).

Uncontrolled fills are predicted to have indeterminate mechanical properties. Similar highly variable soil mechanics can be expected in areas hosting extensive biological activity.

The estimated presumed bearing values of the foundation materials are only an empirical guide to the maximum load that can be placed on the soil/weathered rock particular to this site without shear failure, and as such are not an indicator of the possible settlement/heave/collapse that may occur at foundation pressures up to the bearing capacity of the soil.

The consistency of the blanketing transported materials is predicted to be generally loose in profile and typically increases to medium dense in the residuum and dense in the pedocrete/weathered bedrock horizons.

- Loose consistencies may be roughly correlated to allowable bearing pressure of 10 - 50 kPa, medium dense with allowable bearing pressures of 50 - 150 kPa, dense with allowable 150 - 300 kPa and very dense >350 kPa.
- Other sources list presumptive bearing capacity of sandy/gravelly soils (SC/SM) to 95 - 150 kPa (Alemdag et al, 2017; BS8004-1986; Builders Engineer 27 October 2012).

Should shallow rock not be present- taking the additional movements due to soil consolidation/collapse into account will imply that foundation improvements will be necessary for light structures.

For rock, the mechanical properties of a rock mass are dependant not only on the properties of the intact rock (Uniaxial Compressive Strength etc.) but also on the properties of the discontinuities (spacing, orientation, continuity, etc.). The various intact rock and discontinuity properties will each have their own impact on the overall geotechnical properties of the rock mass, such as the permeability and strength.

4.6.3. Collapse Settlement Characteristics of the In-Situ Soils

Collapsible soils are open-textured (high void ratio) soils that are stiff when dry but lose their stiffness when they become wet. This can lead to sudden, large settlements taking place when the moisture content of the soils below a foundation increase, even many years after construction.

The following parameters can be predicted:

- In accordance with the typical/predicted in-situ material properties- the aeolian sand, nodular calcrete and residuum are deemed to have a potentially slightly collapsible nature, with their inherent variability amplifying the predicted degree of differential settlement.
- Differential settlement is further aggravated in shallow horizons due to the predicted intercalated occurrence of soil and pedocrete/rock fragments.
- The over excavation, sorting and re-compaction (controlled layers) of these soils will result in the destruction of their non-favourable in-situ properties.
- Across the undeveloped areas, the predicted voided and open root channel presence in the upper soil horizons may in addition to the settlement also cause larger than normal settlements due to collapse under loading and saturation of these voids.

4.6.4. Heave Characteristics

Expansive soils are soils that undergo changes in volume due to changes in moisture content, swelling when the moisture content increases and shrinking when the moisture content decreases. The potential expansiveness of a soil depends upon its clay content, the type of clay mineral present, its chemical composition and mechanical character.

The natural wetting up of the soil profile below the central portions of a structure typically leads to the development of a domed profile under the building in the long term, known as the "central doming" mode of deformation. In the short term, ingress of water into the soil around the perimeter of the structure can lead to heave around the perimeter of the building resulting in the "edge heave" mode of deformation.

The following parameters can be predicted:

- Based on the predicted results from the on-site materials, an overall LOW potential for heave can be expected.
- The possibility of structural distress resulting from cyclic drying shrinkage in dry seasons and swell after wetting is therefore anticipated to be low.

4.6.5. Settlement Characteristics of the In-Situ Soils

Compressible soils are soils of low stiffness that settle significantly when loaded. In free-draining soils (e.g. sands), this settlement occurs during and shortly after loading. In low permeability soils (e.g. clays), this settlement occurs over a period of time as the pore pressures set up during loading dissipate.

The following parameters can be predicted:

- In accordance with the typical/predicted in-situ material properties- low in-situ consistency, fine grained nature and voided structure- the transported sediments underlaying the site are predicted to display a compressible nature at low structural loads.
- The degree of expected soil consolidation upon loading is expected to decrease with depth due to the predicted medium dense state of the underlaying residuum and the dense state of the pedocrete/weathered bedrock.
- The total settlement for the uncontrolled fill seen to intermittently blanket the site cannot be measured/calculated due to its highly variable in-situ state. Similar indeterminate settlements can be expected in areas hosting extensive biological tunnelling and decomposed organic material.

5. Geotechnical Site Classification- Inferred

5.1. Introduction and Discussion

This report describes the results of the Preliminary Geotechnical Site Investigation conducted in support of the planned housing project taking place across ERF 23228, 23229 and the Remaining Extent of 5645- herein referred to as Site 1- within the Paballelo Settlement of Upington. The planned township spans a partially developed parcel of land, with a surface area of roughly 44 Ha.

Initially, GeoCalibre Geotechnical Consultancy was appointed by EnviroAfrica to undertake a Phase 1 Township Investigation, however, permission was not granted by the local authority to undertake the required excavations- due to the risk of damaged services etc. For this reason, GeoCalibre was instructed by the Client to compile a desktop level report aligned with the standards of a Preliminary Geotechnical Site Investigation (GFSH-2/SANS634).

This assessment was conducted to identify potentially adverse geotechnical conditions across the area in question to facilitate the planning and decision-making processes surrounding the proposed EIA, land-rezoning and associated future township developments.

The investigated area was defined by the Client prior to the commencement of the study and forms part of the greater Dawid Kruiper Municipality Housing Project (Ref.: NO47/2022DKM). The planned township establishment across the surface will encompass the subdivision of this land portion into various land-use zones i.e., infrastructural units, roadways, and services etc. Each of these zones may require their own set of geotechnical assessments and associated engineering solutions.

Historical development, excavation and/ or levelling practices may have disrupted the surficial materials and variations in soil properties should be accounted for. The likelihood of imported fill and building rubble should also be accounted for in shallow horizons- requiring the rehabilitation of the sites surface prior to the establishment of the township.

The results of this geotechnical analysis models that the whole site exhibits geotechnical characteristics that may require the implementation of design and/or precautionary measures to reduce the risk of structural damage due to adverse geotechnical characteristics. However, these characteristics do **not** disqualify the site from being used for the development, but rather require the implementation of site-specific precautionary **engineering measures.**

On the completion of this phase of the investigation, no fatal flaws have been identified for the proposed site.

5.2. Impact of the Geotechnical Constraints on Housing Developments

The impact of the geotechnical constraints on housing development (single and double storey masonry structures) may be evaluated according to Table 2-Appendix A- which is a summary of the general geotechnical constraints relevant to urban development (Partridge, Wood and Brink, 1993). The Class column indicates the severity of the specific constraints for this site.

The classification criterion has been compiled for **township developments** spanning large areas.

The main **predicted/inferred** geotechnical constraints for this site are:

- The occurrence of localised surficial uncontrolled fill materials, relict infrastructure and an artificially reworked surface: **P fill**
- Areas within-or immediately adjacent to- known drainage features: **3L/2L**
- Expected low to moderate soil collapse predicted: **1A/2A**
- Expected shallow temporary perched groundwater tables and/or surface ponding/seepage during high intensity precipitation events: **2B**
- Expected moderately compressible soil horizons with expected larger than acceptable differential movements: **2D**
- The surficial soils are expected to have an intermediate risk for erosion in areas subjected to artificial concentrated surface water flow: **2E**
- Predicted localised shallow undulating bedrock impacting terrain excavatability and shallow water seepage/movement: **R**
- Predicted difficult and variable excavation conditions across the majority of the site attributed to the regional undulating bedrock topography:
    - Predicted localised occurrence of shallow very dense rock/pedocrete- with in excess of 40% of the material to a depth of 1.5 mbgl deemed to be Category 1 excavation: **3F**
    - Majority of the site- predicted between 10 and 40% of the material to a depth of 1.5 mbgl deemed to be Category 1 excavation: **2F**
- Very gentle slopes of less than 2 degrees, with an artificially induced variable surface morphology accentuating surface water ponding: **2I**

5.3. Site Class Designations

The site is <u>predicted</u> to be underlain by a variable sequence of materials; with the majority of the material deemed to be **compressible** and **slightly collapsible.** The degree of collapse and compressibility is predicted to decrease with an increase in depth.

These parameters require that structures be adequately strengthened, or the underlying soils be modified to prevent structural damage due to total and differential settlement beneath foundations. Due to the **potentially slightly collapsible nature**, elevated degrees of differential settlement (75% of the total settlement) are predicted **under fluctuating moisture conditions.**

The site has been classified into **THREE (3) Preliminary Site Class Designation zones** (Image 4 and Figure 6), based on the above constraints and the criteria as set out in Partridge, Wood and Brink, 1993- of which the appropriate table has been included in Appendix A.

Please note the following regarding these site class designations:

- The presented site classification is based off desktop level information and available exposures in the region. No test pits and associated laboratory testing was conducted as part of this phase of the assessment.
- Site class designations are based on the existing ground level, prior to any earthworks.

- The range of attributes/classes presented in each defined zone can be attributed to the predicted variable nature of the sub-terrain (i.e., fluctuating thickness of soft collapsible materials) and in some cases the anthropogenic reworking of the area.
- Localised phenomena such as anthropogenic depressions/canals, biological tunnelling, heaps of fill and relict infrastructure have been omitted from the primary site classification.
- The natural drainage characteristics of the region have been altered.
- The exact geotechnical nature of these areas can be confirmed during Phase 1 Investigations.

The predicted/inferred development potential zonation and associated terrain mapping units are presented overleaf.

Table 1: Development Potential Zonation- Preliminary Geotechnical Site Investigation

Development Potential Zone	Summary of the General Geotechnical Constraints Relevant to Urban Development (Partridge, Wood and Brink, 1993)
Zone A	**2A/1A-** A collapsible horizon or consecutive horizons more than 750 mm *expected* **2B-** Expected fluctuating moisture conditions less than 1.5 m below ground surface **2D/1D-** Low to moderate soil compressibility *expected* **2F-** Expected difficulty of excavation to a depth of 1.5 m with between 10 and 40 % of the material deemed to be Category 1 excavation **2I**- Very gentle slopes of less than 2 degrees **Localised** surficial **uncontrolled fill** **Localised shallow rock R/3F**- Difficulty of excavation to a depth of 1.5 m with in excess of 40 % of the material deemed to be Category 1 hard rock excavation **Localised 2E**- Predicted intermediate risk for erosion in areas subjected to artificial concentrated surface water flow **Highly localised 2L-** Areas adjacent to a known drainage channel
Zone B	**Informal Township Area** The occurrence of relict infrastructure and surface/subsurface **uncontrolled fill materials** **2A/1A-** A collapsible horizon or consecutive horizons more than 750 mm *expected* **2B-** Expected fluctuating moisture conditions less than 1.5 m below ground surface **2D/1D-** Low to moderate soil compressibility *expected* **2F-** Expected difficulty of excavation to a depth of 1.5 m with between 10 and 40 % of the material deemed to be Category 1 excavation **2I**- Very gentle slopes of less than 2 degrees **Localised shallow rock R/3F**- Difficulty of excavation to a depth of 1.5 m with in excess of 40 % of the material deemed to be Category 1 hard rock excavation **Localised 2E**- Predicted intermediate risk for erosion in areas subjected to artificial concentrated surface water flow **Highly localised 2L-** Areas adjacent to a known drainage channel
Zone C	**Mapped Stream Channels** **3L/2L-** Areas within/adjacent to known drainage features **3B/2B-** Expected fluctuating moisture conditions less than 1.0 m below ground surface and marshy area following precipitation **3E/2E**- High to intermediate erodibility *expected* (convergent flow) **2A/1A-** A collapsible horizon or consecutive horizons more than 750 mm *expected* **2D/1D-** Low to moderate soil compressibility *expected* **2F-** Expected difficulty of excavation to a depth of 1.5 m with between 10 and 40 % of the material deemed to be Category 1 excavation **2I**- Very gentle slopes of less than 2 degrees **Localised shallow rock R/3F**- Difficulty of excavation to a depth of 1.5 m with in excess of 40 % of the material deemed to be Category 1 hard rock excavation **Localised** surficial **uncontrolled fill**

Image 4: Development Potential Zonation Map

6. Preliminary Development Recommendations

6.1. Introduction

The soft materials underlying the site have not been visually inspected due to the absence of excavations. Furthermore, no soil/rock samples were extracted from the materials underlying the site. The engineering material properties presented in this report are inferred/predicted based on the predicted soil successions from surrounding investigations/exposures.

Uniform heave, shrinkage, collapse settlements or consolidation settlements generally do not cause damage to structures but might detrimentally affect service (water and sewer) pipe entries at the perimeter of structures. Non-uniform or differential movements can cause structural distress, deformations and overstressing of structural components, resulting in damage to the building.

Structural solutions shall improve the flexibility and strength of the structure to enable the building to tolerate potential soil movements so that the resulting response to actions is within the limits specified in SANS 10400-B. Due to the predicted variable founding conditions across the site it is recommended that the structure be adequately jointed and/or strengthened to allow for the predicted differential settlement.

The predicted general site conditions with regards the geotechnical considerations are such that any light structure placed on the compressible and potentially slightly collapsible materials occurring on site will need special precautionary measures to prevent serious damage to the structure. Additional foundation modifications to prevent damage to structures due to differential settlements may be necessary.

It is recommended that the structural engineers calculate the best economical foundation option for the proposed development based on the type of structure and the different available construction methods to remedy the negative effects of the predicted geotechnical constraints.

As for the removal of relict infrastructure, it is strongly recommended that fill materials be selectively mined and removed from within the footprint of the proposed development (to a depth deemed suitable by the design engineer).

Follow-up geotechnical studies are required to accurately quantify the in-situ nature of the sub-terrain and define associated geotechnical entities. That the exact design and configurations of the planned light structures was not known at the time of compiling this report. GeoCalibre is open to ongoing discussions regarding site specific engineering solutions following additional geotechnical studies and once final structural configurations are known.

6.2. Preliminary Foundation Recommendations

Considering the predicted mechanical properties of the in-situ soils underlying the site, in conjunction with the nature of the development, there are three main options for the mitigation of the deleterious effects of the uppermost compressible/collapsible soils:

- The **first option** entails the implementation of **deep foundations** whereby lightly reinforced foundations are placed upon a competent horizon below the blanketing problem horizons/soft materials. The exact depth and nature of the competent material to be defined in follow-up studies.

- The **second option** entails shallow foundations with the **reinforcement** of the foundations to the point at which they are able to withstand the expected total and differential movements (reinforced concrete foundations).
- The t**hird option** entails the destruction of unfavourable soil characteristics underlying the structure, through **over-excavation, replacement and compaction** of the in-situ material directly below the reinforced footings in controlled layers; and in so doing creating a uniform engineered fill/earth mattress. The engineered fill should be constructed/designed in such a way as to **dissipate** the load of the structure- ensuring that excessive loads are not transferred into the underlying compressible/collapsible natural soils.

6.3. Preliminary Design Considerations

The initial geotechnical attributes of the site have been discussed at length in the preceding sections of this report. At this stage, there are geotechnical attributes of the site which are not ideally suited for the planned development (delineated in this report)- for this reason, **engineering solutions** will be required to ensure the stability and longevity of the development.

The following geotechnical constraints should be taken into account during the **preliminary design** of the development:

The following **primary concerns** have been highlighted as part of this preliminary geotechnical site investigation:

- Rehabilitation of the sites surface- including earthworks to create stable working levels, surficial drainage measures, removal of relict infrastructure, fills and vegetation.
- Site topography/drainage- attributes discussed in Section 2.2/2.3 and 4.1.
- Mapped stream channels- attributes discussed in Section 2.4.
- Predicted ground profile depicting the inferred nature of the sub-terrain- discussed in Section 4.2.
- Predicted shallow seepage and possible fluctuating/temporary perched ground water tables- discussed in Section 4.3.
- Predicted variable site excavatability and associated concerns with respect to the excavation of services- discussed in Section 4.5.
- Predicted compressible and potentially collapsible soft materials with predicted poor/moderate strength characteristics- discussed in Section 4.6.
- Inferred geotechnical site classification- discussed in Sections 5.
- Discussions surrounding preliminary development recommendations and basic design considerations- discussed in Section 6.

As per the standards of SANS634/GFSH-2/NHBRC, follow-up geotechnical investigations will need to be undertaken across the site- the nature of which can be defined by GeoCalibre aligned with the layout and/or surface area of the planned township. These geotechnical studies will aim to accurately quantify the in-situ nature of the sub-terrain and define associated geotechnical entities.

7. Report Provisions

Initially, GeoCalibre Geotechnical Consultancy was appointed by EnviroAfrica to undertake a Phase 1 Township Investigation, however, permission was not granted by the local authority to undertake the required excavations- due to the risk of damaged services etc. For this reason, GeoCalibre was instructed by the Client to compile a desktop level report aligned with the standards of a Preliminary Geotechnical Site Investigation (GFSH-2/SANS634).

GeoCalibre did not conduct a detailed engineering geological investigation across the planned township area. The information presented in this document is based purely off the available data bank of reports in the region and accompanying desktop level information.

A preliminary phase engineering geological site investigation was carried out across the area in question. The results of this type of assessment provide an overview of the geotechnical character of the site, as well as listing prominent adverse physical characteristics that could limit the usefulness thereof. This document was created to facilitate the planning and decision-making processes surrounding the proposed EIA, land-rezoning and associated future township developments.

GeoCalibre has have employed accepted engineering geologic procedures, and our opinions and conclusions are made in accordance with generally accepted principles and practices in engineering geology. Information gathered during this investigation is considered suitable for the site assessment purposes, and once the proposed development is approved, Phase 1 Geotechnical Site Investigation will be required to provide guidance to designing engineers.

The design and implementation of the planned engineering fills remains the responsibility of the consulting engineers/competent person- with GeoCalibre and its' employees carrying no liability in this regard. The placement of engineered fill must be controlled with suitable field tests to ensure that the required densities are achieved during compaction, and that the quality of the fill material is within specification to ensure the longevity of the development.

The determination of flood lines and delineation of wetland areas were not part of this investigation scope and should be addressed by suitably competent professionals prior to the final site development plan is compiled, if deemed necessary. If the site or a portion thereof is situated within the 1:100-year flood line, or has been delineated as a wetland, it is the prerogative of the Civil Engineer or other suitably experienced specialist to overwrite the recommendations for such portions.

This investigation did not include the assessment of any potential environmental hazards, or groundwater impacts that may be present, or ensue from the construction of the proposed structures.

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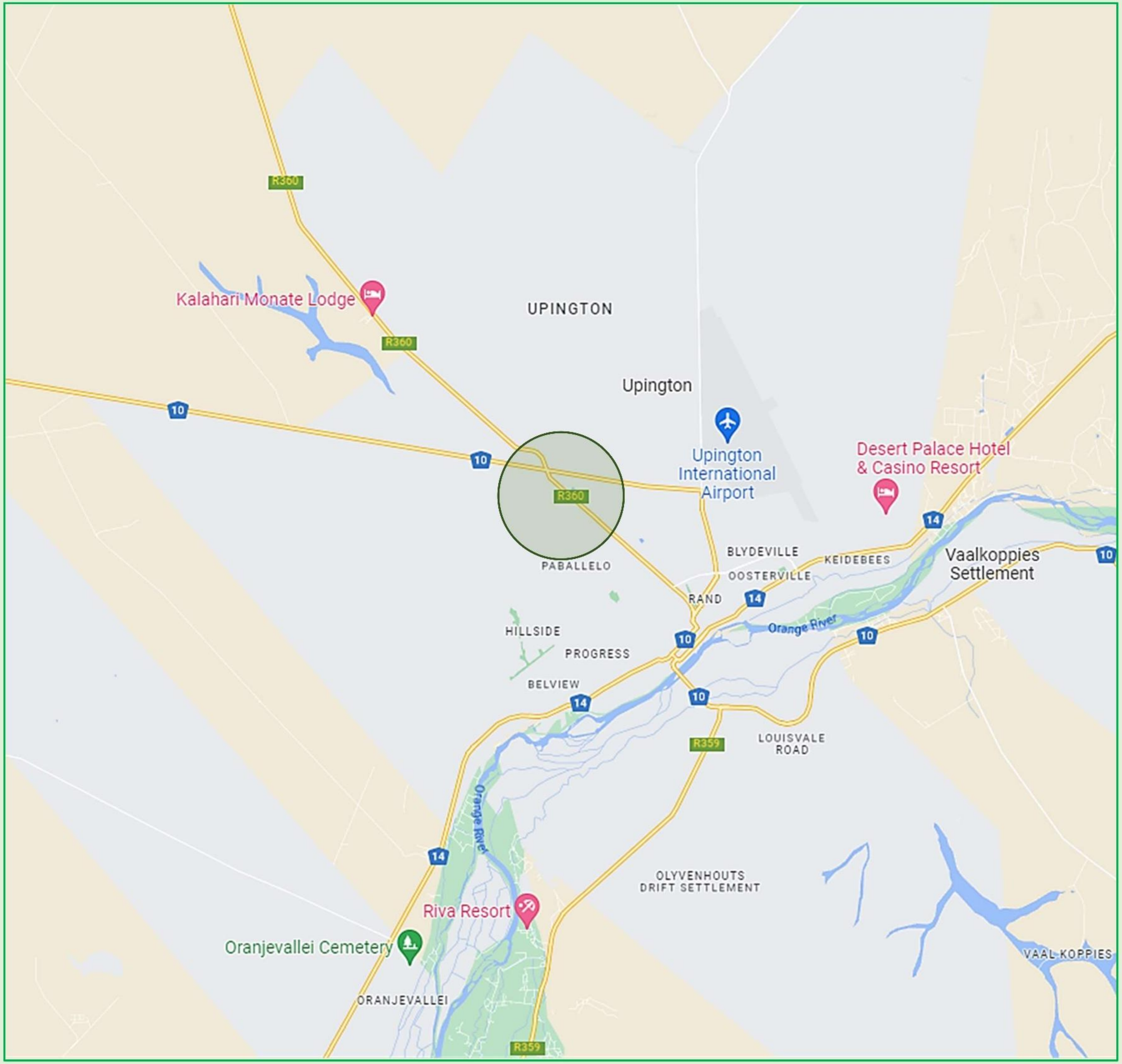
LAYOUT MAPS



GEOCALIBRE
GEOTECHNICAL CONSULTANCY

Figure 1

Study Area Location

LEGEND

Study Area

N

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Kevin Coertzen
Pri.Sci.Nat and MSAIEG

33 Denne Avenue
Bainsvlei
Bloemfontein

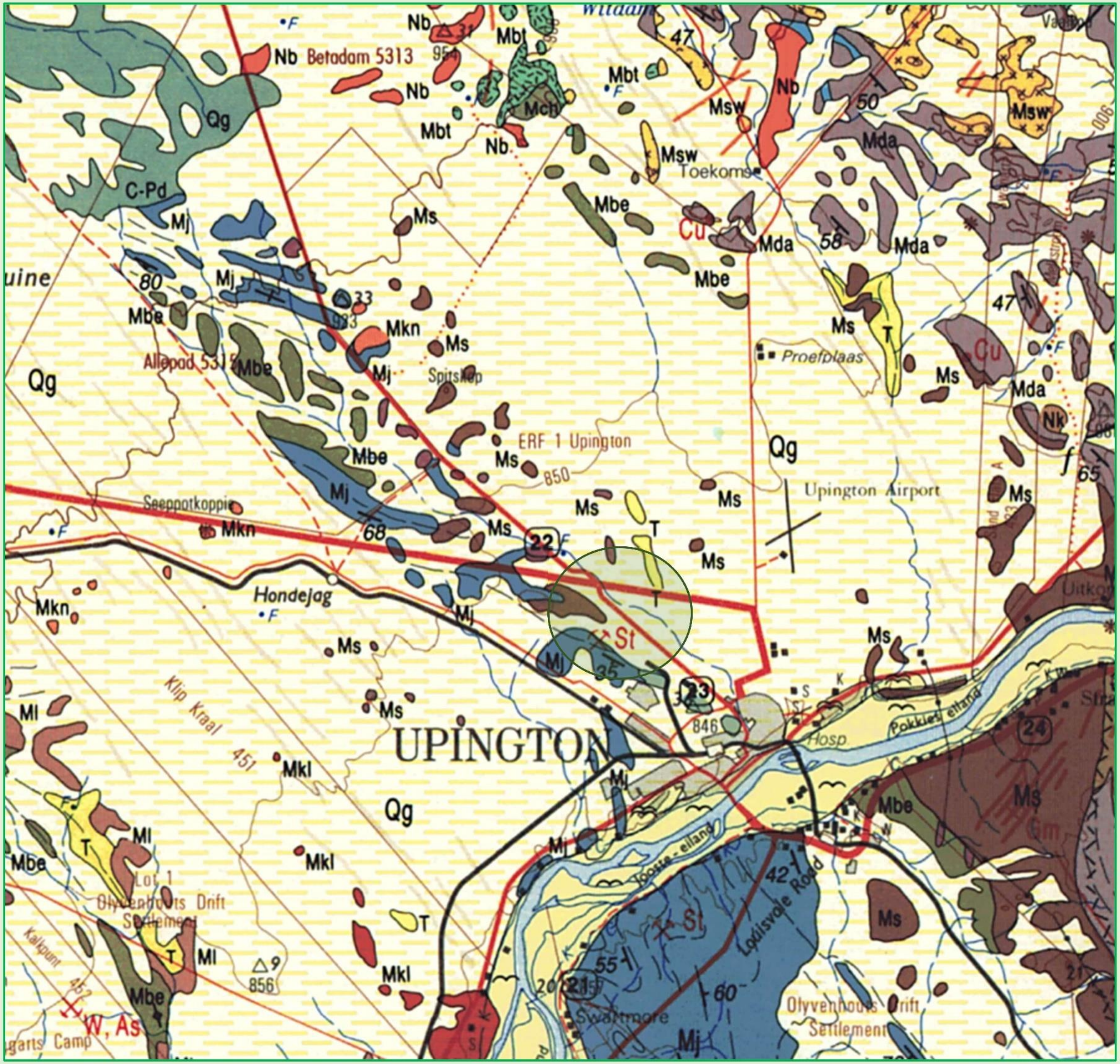

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Figure 2

Regional Geology Map

LEGEND

Qg	Red-brown wind-blown sand and dunes- Gordonia Formation
Mj	Amphibolite, amphibolite gneiss, biotite gneiss, pelitic gneisses, lenses of calc– silicate rocks
Mbe	Migmatic, biotite rich and alminous gneisses- Bethesda Formation
Ms	Weakly foliated biotite granite

Geological Series Map:
2820 Upington; Scale 1 : 250 000

N

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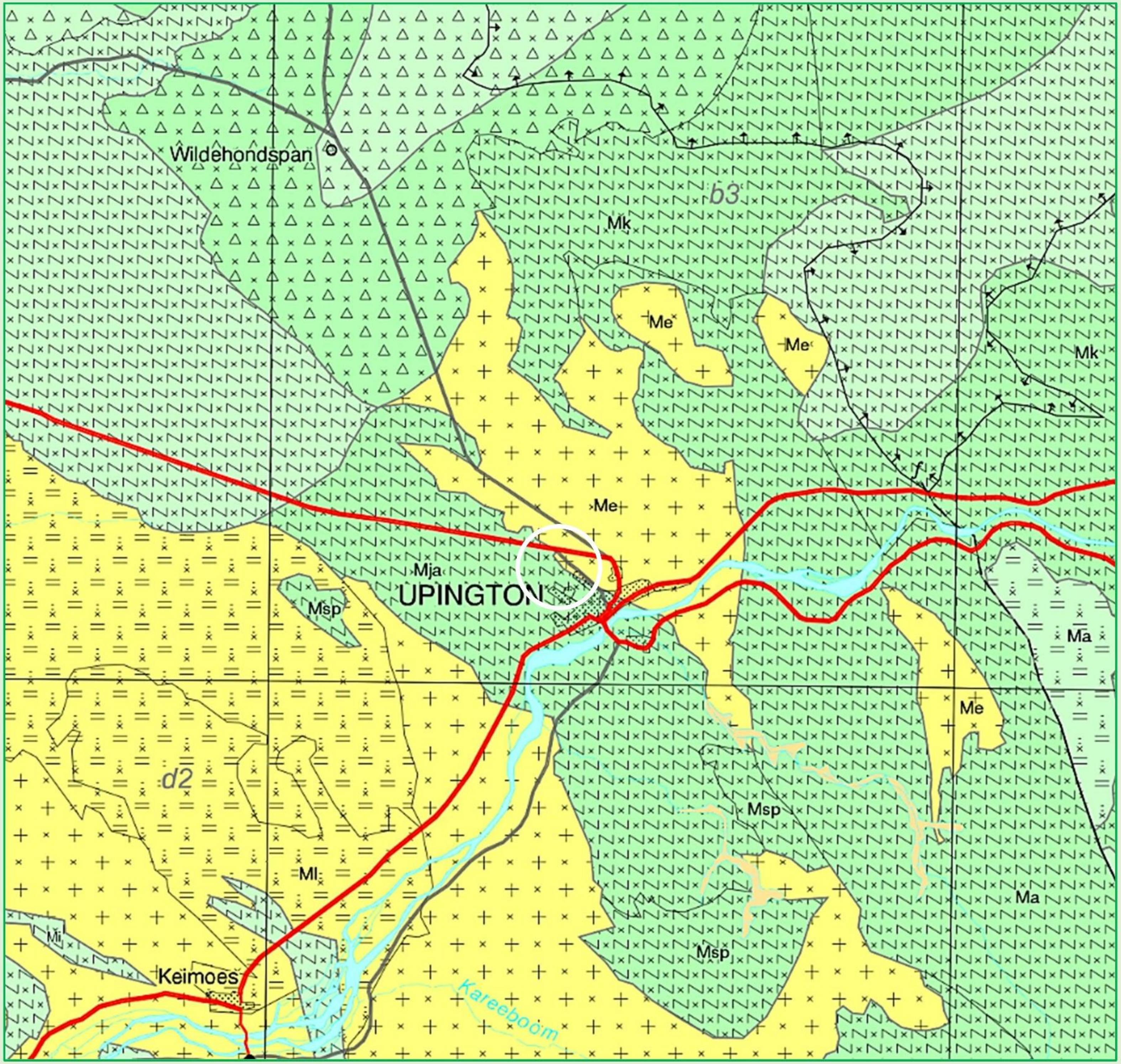

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Figure 3

Regional Hydrogeological Map

LEGEND

Borehole yield class (median l/s) (excluding dry boreholes)

Aquifer type	0.0 - 0.1	0.1 - 0.5	0.5 - 2.0	2.0 - 5.0	> 5.0
Intergranular	*	*	*	a4	a5
Fractured	*	b2	b3	b4	b5
Karst	*	*	*	*	*
Intergranular and fractured	*	d2	d3	d4	d5

Hydrogeological Series Map:
2714 Upington (2001); Scale 1 : 500 000

N

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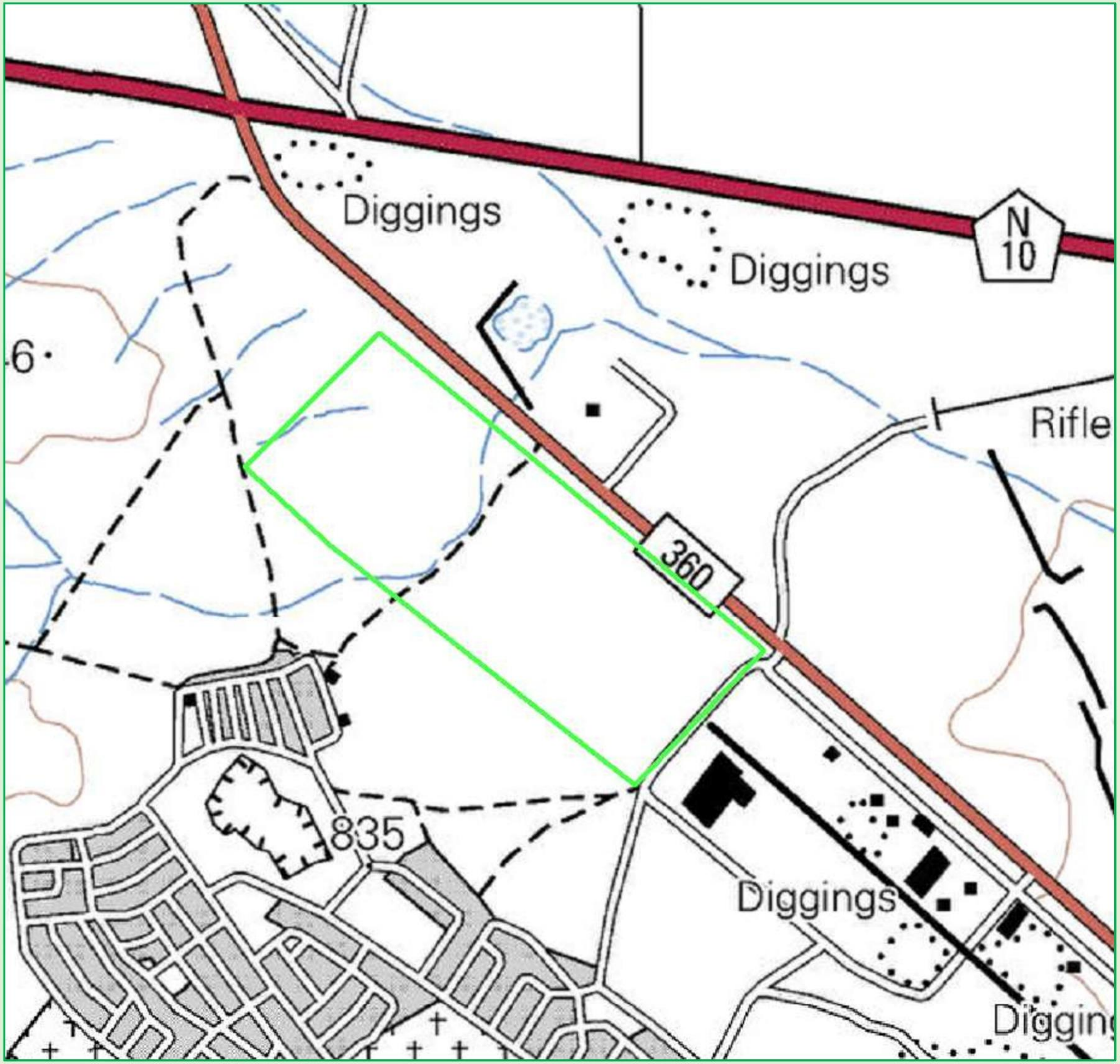

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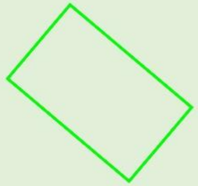
Figure 4

Topocadastral Map

LEGEND



Site 1

Topocadastral Maps:
2821 Ac; Scale 1 : 20 000

N

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Bloemfontein

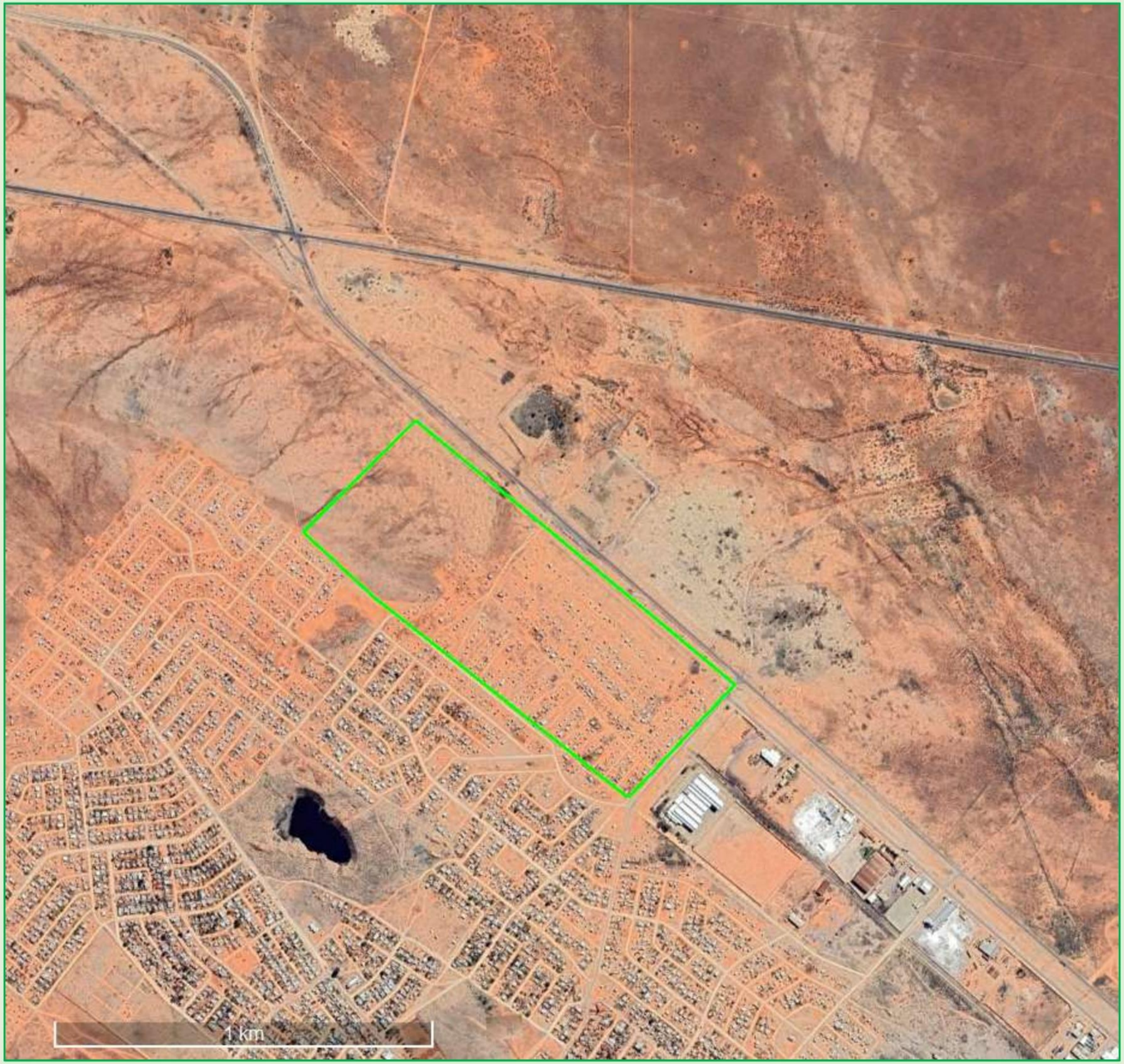

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Figure 5

Site Location- Aerial View

LEGEND

Site 1 Boundary

N

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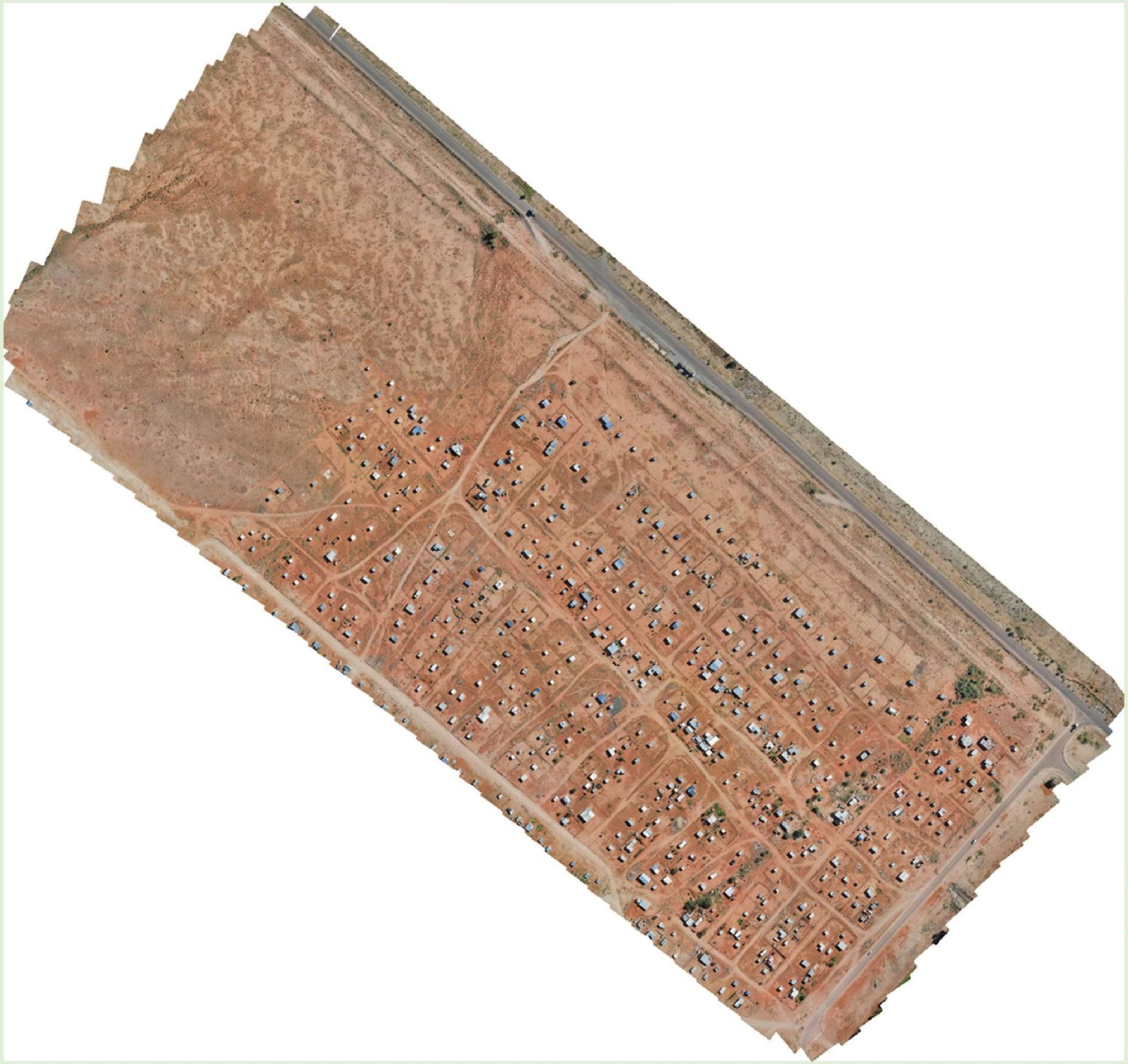

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Figure 6

Available Aerial Image

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Figure 7

Development Potential Zonation

LEGEND

Zone A

Zone B

Zone C

N

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Appendix A

Site Classification Reference Tables

Table 2: Geotechnical Constraints in Urban Development (SANS 634:2012)

CONSTRAINT		DESCRIPTOR		
DESCRIPTION		1 (most favourable)	2 (intermediate)	3 (least favourable)
A	Collapsible soil	Any collapsible horizon or consecutive horizons totalling depth of less than 750 mm in thickness	Any collapsible horizon or consecutive horizons totalling depth of more than 750 mm in thickness	n/a
B	Seepage	Permanent or perched water table more than 1.5 m below ground surface	Permanent or perched water table less than 1.5 m below ground surface	Swamps and marshes
C	Active soil	Low soil-heave potential anticipated	Moderate soil-heave potential anticipated	High soil-heave potential anticipated
D	Highly compressible soil	Low soil compressibility anticipated	Moderate soil compressibility anticipated	High soil compressibility anticipated
E	Erodibility of soil	Low	Intermediate	High
F	Difficulty of excavation to 1.5 m depth	Scattered or occasional boulders less than 10% of total volume	Rock or hardpan pedocretes between 10% and 40% of total volume	Rock or hardpan pedocretes more than 40% of total volume
G	Undermined ground	Undermining at a depth greater than 200 m below surface	Old, undermined areas to a depth of 200 m below surface	Mining within less than 200 m of surface with total extraction
H	Stability (dolomite land)	Possibly stable	Potentially instable	Known sinkholes and dolines
I	Steep slopes	2-6 degrees	< 2 degrees or 6-18 degrees	> 18 degrees
J	Unstable natural slopes	Low risk	Intermediate risk	High risk
K	Seismic activity	10% probability of an event less than 100 cm/s^2 in 50 years	Mining-induced seismicity > 100 cm/s^2	Natural seismicity > 100 cm/s^2
L	Flooding	n/a	Adjacent to known drainage or channel with slope < 1%	Areas within drainage channel or floodplain

(After Partridge, Wood & Brink)

Appendix B

Specialist Declaration Form

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

	(For official use only)
File Reference Number:	
NEAS Reference Number:	DEA/EIA/
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

PROJECT TITLE

NO47/2022DKM- Undertaking of EIA's for Sites 1 & 2 Housing Projects for Dawid Kruiper Municipality (DKM).

Kindly note the following:

1. This form must always be used for applications that must be subjected to Basic Assessment or Scoping & Environmental Impact Reporting where this Department is the Competent Authority.
2. This form is current as of 01 September 2018. It is the responsibility of the Applicant / Environmental Assessment Practitioner (EAP) to ascertain whether subsequent versions of the form have been published or produced by the Competent Authority. The latest available Departmental templates are available at https://www.environment.gov.za/documents/forms.
3. A copy of this form containing original signatures must be appended to all Draft and Final Reports submitted to the department for consideration.
4. All documentation delivered to the physical address contained in this form must be delivered during the official Departmental Officer Hours which is visible on the Departmental gate.
5. All EIA related documents (includes application forms, reports or any EIA related submissions) that are faxed; emailed; delivered to Security or placed in the Departmental Tender Box will not be accepted, only hardcopy submissions are accepted.

Departmental Details

Postal address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Private Bag X447
Pretoria
0001

Physical address:
Department of Environmental Affairs
Attention: Chief Director: Integrated Environmental Authorisations
Environment House
473 Steve Biko Road
Arcadia

Queries must be directed to the Directorate: Coordination, Strategic Planning and Support at:
Email: EIAAdmin@environment.gov.za

1. SPECIALIST INFORMATION

Specialist Company Name:	GeoCalibre Geotechnical Consultancy			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	Level 4	Percentage Procurement recognition	100 %
Specialist name:	Kevin Stuart Coertzen			
Specialist Qualifications:	BSc Hons. Geology			
Professional affiliation/registration:	Professional Natural Scientist (400011/17)			
Physical address:	33 Denne Avenue, Bainsvlei, Bloemfontein, 9301			
Postal address:	PO Box 12493, Steiltes, Nelspruit, 1200			
Postal code:	1200	Cell:	083 608 4426	
Telephone:	083 608 4426	Fax:	N/A	
E-mail:	kevin@geocalibre.co.za			

2. DECLARATION BY THE SPECIALIST

I, Kevin Stuart Coertzen, declare that –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist

GeoCalibre Geotechnical Consultancy

Name of Company:

29/06/2023

Date

3. UNDERTAKING UNDER OATH/ AFFIRMATION

I, ***Kevin Stuart Coertzen***, swear under oath / affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.

Signature of the Specialist

GeoCalibre Geotechnical Consultancy

Name of Company

29/06/2023

Date

Signature of the Commissioner of Oaths

2023-06-29

Date

SUID-AFRIKAANSE POLISIEDIENS
COMMUNITY SERVICE CENTRE
29-06-2023
SOUTH AFRICAN POLICE SERVICE