Hydrogeological Desktop Assessment for the Village Ridge Housing Development, Erven 21028 and 21029, George – Impact on Wetland/Groundwater Interaction

19 February 2022

Prepared for:

Power Construction (Pty) Ltd

PO Box 129

Blackheath

7581

By

Divan Stroebel

DHS GROUNDWATER CONSULTING SERVICES (PTY) LTD

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Authors Resume

Divan Stroebel is a SACNASP registered and active member of the Geological Society of South Africa, hydrogeologist and professional geoscientist with more than 15 years of industry experience. He obtained his B.Sc. (Geology) degree in 2005 and his B.Sc. Honours (Geology) degree in 2006 from Stellenbosch University. From 2007, he worked throughout Africa as an exploration geologist in base metal, iron ore and gold exploration. In 2009 he joined a hydrogeological consultancy and completed additional groundwater modules at the Institute for Groundwater Studies (IGS), University of Free State. He was employed by mining giant, Rio Tinto in 2010 in Guinea as a Geologist, after which he was the Superintendent Geologist at Goldfields' Kloof mine from 2012. He joined AEON at the Nelson Mandela University (NMU) in 2014 as Associate Research Manager for the Karoo Shale Gas Research Programme- focussed on Karoo hydrogeology.

Divan's technical experience includes all aspects of mineral exploration, extraction and reserve management as well as hydrogeological assessments, aquifer characterisation, groundwater supply development, groundwater and surface water characterisation and monitoring as well as water quality assessments.

Divan is very active in the hydrogeological community and has attended, presented at and co-organised numerous water-research workshops and conferences. In June 2016, he was appointed as a visiting researcher at Queen's University, Belfast. In China (2017), he successfully completed an international training programme on the Sustainable Development of Water Resources in Arid Regions for Developing Countries.

He is nearing completion of his PhD (Geosciences) with his research focusing on the creation of a Groundwater Hydrochemistry and Aquifer Connectivity Baseline of the Eastern Cape Karoo. In anticipation of the controversial hydraulic fracturing planned for the Eastern Cape, he has obtained unique experience in the determination of salinity, aquifer yields and groundwater levels of the Karoo's scarce groundwater resources and has published an article in a special publication by the Geological Society of London on fractured aquifers on the topic. https://sp.lyellcollection.org/content/479/1/129

Divan is the founder and owner of DHS Groundwater Consulting Services and leads the team as principal hydrogeologist, overseeing all projects from inception to completion.

9 Schubert Road
Walmer Heights
Port-Elizabeth
6070
South Africa

T +27 (0) 82 099 2366
E divan@dhsgroundwater.co.za
W https://dhsgroundwater.co.za

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Divan Stroebel (B.Sc. Honours Geoscience, Pr.Sci.Nat, MGSSA)
Hydrogeologist
Director: DHS Groundwater Consulting Services (Pty) Ltd
SACNASP Registration Number 400371/12

DHS GROUNDWATER
CONSULTING SERVICES

9 Schubert Road
Walmer Heights
Port-Elizabeth
6070
South Africa

T +27 (0) 82 099 2366
E divan@dhsgroundwater.co.za
W https://dhsgroundwater.co.za

Executive Summary

DHS Groundwater Consulting Services (Pty) Ltd were appointed by Power Construction (Pty) Ltd to conduct a hydrogeological desktop assessment of a proposed high density housing development on Erven 21028 and 21029 in George, Western Cape. The objective of the assessment was to determine whether the proposed development could possibly affect the wetland flat from a groundwater perspective. Existing specialist reports, data and correspondence covering various aspects of the site and development were scrutinised for this purpose.

The site is underlain by the Maalgaten Granite, with the Saasveld Formation to the north. Hydrogeologically, it is underlain with both intergranular and fractured aquifers typically yielding between 0.1- to 0.5 l/s.

The wetland within the perimeter of the site, is, however supported by a perched aquifer. Water table fluctuations are delineated from data obtained from the geotechnical test pits. Fluctuations as shallow as 1 mbgl is inferred, which was confirmed by the presence of mineralization (such as ferricrete) and weathering processes linked to a fluctuating water level. No groundwater, however, was intersected between ground level and 2 mbgl – the maximum depth of the test pits. It is, however, suggested that the upper level of the perched water table be set at 1 mbgl.

Artificial dewatering below a depth of 1 mbgl will negatively affect the groundwater – wetland interaction. The geothechnical report and preferred layout makes no mention of any dewatering plans, with the deepest foundations planned to a depth of only 600mm.

Based on the available data and reports, the proposed construction of the Village Ridge Housing Development will have a negligible – negative, if any, impact on the investigated groundwater – wetland interaction.

The following “hydrogeological” buffers, however, are recommended during and after the construction:

- No artificial groundwater table lowering is allowed;
- All construction foundations must be shallower than the perched water table of 1 mbgl;
- No construction within the 19 m buffer zone;
- Implementation of a groundwater monitoring plan as suggested herein (“Environmental Management & Groundwater Monitoring Programme”).

It is the assessor’s professional opinion that adequate information was available to appropriately assess the potential impact on the groundwater – wetland interaction. Should the aforementioned hydrogeological buffers be met, and based on the results of this assessment, it is recommended that the application be approved.

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Term	Definition
%	Percentage
CFB	Cape Fold Belt
DEA	Department of Environmental Affairs
DWAF	Department of Water Affairs & Forestry
DWS	Department of Water & Sanitation
EC	Electrical Conductivity
GMA	Groundwater Management Area
GRO	Gasoline Range Organics
Ha	Hectare
km	Kilometre
l/s	litres/second
M	meter
m/d	Meters per day
m^3	Cubic Meters
m^3/a	Cubic Meters/annum
$m^3/ha/a$	Cubic Meters/hectare/annum
mamsl	meters above mean sea level
mbgl	meters below ground level
mm/a	Millimetres/annum
Mm^3/a	Million Cubic Meters/annum
mS/m	Millisiemens per meter
^oC	Degrees Centigrade
SWL	Static water level

1 Introduction

DHS Groundwater Consulting Services (Pty) Ltd were appointed by Power Construction (Pty) Ltd to conduct a hydrogeological desktop assessment of a proposed high density housing development on Erven 21028 and 21029 in George, Western Cape, hereafter also referred to as the site.

The objective of this assessment is to determine whether the proposed development could possibly affect the wetland flat from a groundwater perspective.

2 Geographical Setting

2.1 Site Location

The site is located within the suburb of King George Park, George and covers approximately 4.45 ha. (Map 1, Appendix A).

2.2 Topography and Drainage

The site is located in quaternary catchment K30B within the Breede-Gouritz Water Management Area (WMA) at an elevation of ~228 mamsl (with a variation of not more than 1% across the site).

The topography of the site is characterised by gently sloping terrain with slight undulations with local drainage towards the south-east to the Camphersdrift Wetland[1].

2.3 Climate

The area experiences a warm temperate climate, with year-round rainfall. The average daily minimums are 18°C for February and 10°C for July, whilst the average daily maximums are 24°C for February and 19°C for August. The highest temperatures reach above 30°C, generally associated with northerly Berg Winds typically occurring in autumn, whilst temperatures can get close to 0°C on still, clear nights in winter, typically after the passage of a cold front. However, on average, temperatures are mild due to the proximity of the Indian Ocean and moderately humid conditions.

Winds are generally light to moderate, with the most common direction being from the west.

Winter rain can come from large cold front systems that sweep across the Cape, particularly in late winter/spring, whilst summer rain comes largely from moisture advected off the Indian Ocean, associated with the South Indian Ocean High Pressure cell, feeding moist air inland to power the low-pressure thunderstorm systems over the interior of the country.

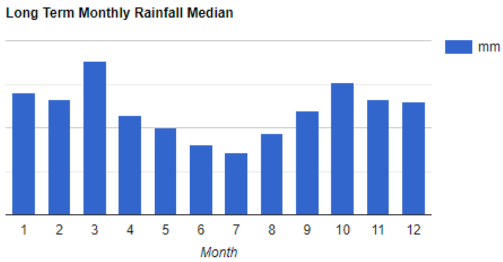
Meteorological data obtained from Elsenburg Cape Farm Mapper[2] is presented in Figure 1. Figures of 857 mm for the mean annual precipitation (MAP) and 1004 mm for the mean annual evaporation (MAE) is reported. The MAE exceeds the MAP, resulting in a negative moisture index.

[1] **Paton, I., 2021. Phase 1 Geotechnical Report Proposed New Development on erf 21028 & 21029 George, Western Cape (the village ridge). Outeniqua Geotechnical Services. Ref No.: 2021\Zutari\The Village Ridge Housing Project\Report\Phase 1 Geotech Report 21.05.2021 Rev 0**

[2] **https://gis.elsenburg.com/apps/cfm/**

Rainfall within the study area is bimodal where both summer and winter rainfall occurs, a feature typical of the south-east coastal region of the country.

Long Term Climate Graph (1950 - 2000)

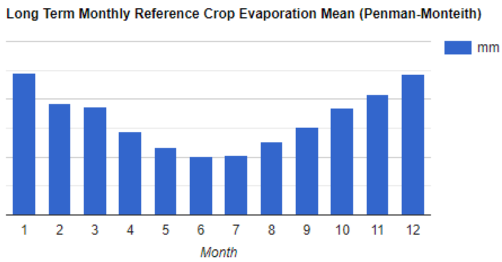


Data Table

Month	mm
January	70.0
February	66.0
March	88.0
April	57.0
May	50.0
June	40.0
July	36.0
August	47.0
September	60.0
October	76.0
November	66.0
December	65.0

Annual Total: 857 mm

Long Term Climate Graph (1950 - 2000)



Data Table

Month	mm
January	122.5
February	96.6
March	93.6
April	72.3
May	58.9
June	50.7
July	52.1
August	63.5
September	75.6
October	92.7
November	104.1
December	121.5

Annual Total: 1004 mm

Figure 1. Precipitation and Evapotranspiration of the site.

3 Scope of Work

The objective of this assessment is to:

- Complete a hydrogeological characterization of the groundwater in the vicinity of the site;
- Evaluate potential impacts of groundwater disturbance on the receiving hydrogeological environment ***with the focus being on the wetland located within the site perimeter***,
- Propose measures to mitigate identified negative impacts;
- Develop a monitoring program as part of an environmental management plan;

This report is not intended to be an exhaustive description of the assessment, but rather serves as a specialist hydrogeological assessment to evaluate the overall hydrogeological character of the site, to inform the ***wetland impact assessment***, and propose mitigation measures where applicable.

4 Methodology

It should be noted that this assessment is desktop based with data and information used from specialist reports which form part of the Section 24G application in terms of the National Environmental Management Act and the Water Use License Application (WULA) in terms of the National Water Act (Act No. 36 of 1998).

4.1 Desk Study

Data and reports from which the hydrogeological assessment was compiled include

- Published geological and hydrogeological maps and reports;
- Geotechnical report by ***Outeniqua Geotechnical Services***[3];
- Aquatic report, by ***Confluent***[4]***;***
- E-mail correspondence between ***Cofluent*** and ***Prof. Josh Louw*** (soil scientist);
- Building plans by ***FORMAPLAN;***
    - Approved Layout[5];
    - Preferred Layout[6].

4.2 Aquifer Characterisation

The aquifer(s) underlying the site was classified in accordance with "A South African Aquifer System Management Classification"[7] developed by the Water Research Commission and DWAF.

4.3 Aquifer and Wetland Interaction

Conceptualise the interaction between the aquifer and the wetland located within the site perimeter.

4.4 Impact Assessment

Scrutinise the preferred layout to determine whether the development design will have an impact, if any, on the groundwater – wetland interaction.

4.5 Monitoring Network

Design a monitoring network to ensure the groundwater – wetland interaction is not compromised during construction and upon completion.

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[3] **Paton, I., 2021. Phase 1 Geotechnical Report Proposed New Development on erf 21028 & 21029 George, Western Cape (the village ridge). Outeniqua Geotechnical Services. Ref No.: 2021\Zutari\The Village Ridge Housing Project\Report\Phase 1 Geotech Report 21.05.2021 Rev 0**

[4] **Dabrowski, J., 2022. Aquatic Specialist Impact Assessment for the Section 24G and Water Use License Applications required for the proposed Village Ridge housing development on Erven 21028 and 21029, George. Cofluent Report February 2022.**

[5] **FORMAPLAN, 2021. Proposed Rezoning, Subdivision Plan Preferred Option B. September 2021, Drawing number Bult 2.8.**

[6] **FORMAPLAN, 2021. Proposed Rezoning Subdivision Plan - Amendment of Approval. December 2021, Drawing number Village R 1.2.**

[7] **Department of Water Affairs and Forestry & Water Research Commission (1995). A South African Aquifer System Management Classification. WRC Report No. KV77/95.**

5 Regional Geology

The site is underlain with Maalgaten Granite and forms part of the George Pluton, and is part of the Cape Granite Suite of rocks[8] (Map 2, Appendix A). The Cape Granite Suite was emplaced during several distinct cycles of magmatism during the late Ediacaran to Early Cambrian. These granites were probably derived from melting of the Neoproterozoic Kaaimans Group of the Pan-African Saldania Belt, which they intrude[9]. The Saasveld Formation which forms part of the Kaaimans Group is seen to the North of the site.

The Maalgaten Granite is a leucocratic, mostly porphyritic, biotite-muscovite granite with variable degrees of deformation[10]. The Saasveld Formation is pelitic and consists of narrow, alternating bands and lenses of slightly differing chemical composition. The rocks are classified as metasediments consisting mostly of Andalusite Schist, Hornfels and Mica Schist. Phyllite formed where increased biotite and/or chlorite is observed[11].

Table 1. Lithostratigraphy of regional geology.

Supergroup	Group	Formation	Lithology
Cape Granite Suite	~	Maalgaten Granite (Nmg)	Leucocratic, mostly porphyritic, biotite-muscovite granite
~	Kaaimans	Saasveld (Nk)	Mica rich schist to phyllite

6 Hydrogeology

The site, at regional scale, is located within the Cape Fold Belt consisting mainly of consolidated hard rocks belonging to the Cape Supergroup, which predominantly consist of quartzitic sandstone and shales. As stated, the site, however, is underlain by the Cape Granite Suite and the Kaaimans Group to the north which pre-dates the Cape sediments. The Cape Fold Belt formed over a period of about 800 million years, experienced intrusion episodes in an early stage and subsequently endured several deformation phases. The deformation processes and succeeding orogenesis, continental uplift, weathering and erosion all aided in the development of the present groundwater environment. Competent rocks underwent brittle failure, resulting in numerous fracture structures in formations containing significant arenaceous material, thus furthering the formation of fracture porosity.

[8] 1:250 000 Geological Map (3322 Oudtshoorn). Geological Survey, 1979.

[9] Browning, C. and Macey P.H., 2015. Lithostratigraphy of the George Pluton Units (Cape Granite Suite), South Africa. September 2015. South African Journal of Geology 118.3(3):323-330 DOI:10.2113/gssajg.118.3.323

[10] Macey, P.H., Roberts, D.L., Viljoen, J. and Nhkelo, L., 2008. The geology of George and environs. Explanation of the 3322CD and 3422AB, 1:50 000 sheets. January 2008. Council for Geoscience ISBN: 978-1-920226-03-9

[11] Krynauw, J.R. and Gresse, P.G., 1980. The Kaaimans Group in the George area, Cape Province: a model for the origin of deformation and metamorphism in the southern cape fold belt. Trans. geol. Soc. S. Afr,.83 (1980), 23-38.

In contrast, the incompetent rocks were more flexible and less inclined to break, thereby inhibiting the formation of fracture porosity. The existence or absence of fracture structures and prevailing groundwater recharge conditions thus play a decisive role in the occurrence and characteristics of groundwater in the consolidated rocks of the Cape Fold Belt[12]

The metasediments of the Saasveld Formation are mostly incompetent and as described above, less inclined to brittle breaking, thus inhibiting the formation of secondary fracture porosity.

Aquifers within the Cape Granites are mostly associated with erosion processes and other secondary deformation processes. Older granites have better water potential, due to a more developed and higher erosion structure. If the erosion is deeper than the water table, the likelihood of water is very high[13].

Unless otherwise stated, the published 1:500 000 General Hydrogeological Map[14] and associated explanatory booklet[15] was used as basis to describe the regional geohydrological conditions.

6.1 Aquifer Types and Borehole Yields

Groundwater within the area occur in within intergranular interstices and fractured rock aquifers with reported yields of 0.1 – 0.5 L/s.

6.2 Depth to Groundwater

The depth to groundwater in the area is indicated as approximately 20 mbgl. It must be stated that this is low resolution interpolation and is an average. It is not intended to define water level depths on small scale.

6.3 Groundwater Quality

Electrical Conductivity (EC) of groundwater in the area range between 0- to 370 mS/m and displays a sodium-chloride-magnesium nature. Less potable groundwater is however occasionally drawn from boreholes drilled into interbedded shaly layers.

[12] **DWAF, 1999. An Explanation of the 1:500 000 General Hydrogeological Map Oudtshoorn 3320. Compiled by P.S. Meyer, ISBN 0-620-24314-7, Department of Water and Sanitation, Pretoria.**

[13] **DWAF, 2003. 1:500 000 Hydrogeological Map Series. Yield Class Map, Department of Water and Sanitation. Pretoria.**

[14] **1:500 000 General Hydrogeological Map, Oudtshoorn 3320 (1999)**

[15] **Meyer, P.S. (1999). An explanation of the 1:500 000 General Hydrogeological Map, Oudtshoorn 3320. Department of Water Affairs and Forestry, Pretoria.**

6.4 Groundwater Recharge and Baseflow

The site falls within quaternary catchment K60B. The mean annual precipitation and annual recharge figures for the study area is presented in Table 2. Vegter's (1995)[16] recharge and baseflow maps were used to obtain a first estimate of regional recharge and groundwater contribution to rivers and streams (baseflow).

Table 2. Regional Rainfall, Recharge and Baseflow.

Mean Annual Precipitation (mm):	857
Annual Recharge (mm):	204
Percentage recharge of MAP:	23
Annual Baseflow (mm):	50 - 100
Percentage Baseflow of MAP:	8 - 16

Due to the highly porous nature of the shallow, eroded granite, groundwater infiltration is high at a level of 23% of the MAP. Baseflow to wetlands and rivers equates to 8 – 16% of the MAP, which indicates that groundwater is stored to some extent within the intergranular and fractured pores of the eroded granite. The storage coefficient, however, is not significant, which is evident from the relatively high baseflow percentage.

6.5 Aquifer Vulnerability

The national scale Groundwater Vulnerability Map, which was developed according to the DRASTIC methodology (DWAF, 2005) and recompiled in 2013 was used to assess the aquifers underlying the site in terms of "Aquifer Vulnerability". Aquifer Vulnerability can be defined as *"the likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer"*.

The DRASTIC method takes into account the following factors:

- D = depth to groundwater (5)
- R = recharge (4)
- A = aquifer media (3)
- S = soil type (2)
- T = topography (1)
- I = impact of the vadose zone (5)
- C = conductivity (hydraulic) (3)

The number indicated in parenthesis at the end of each factor description is the weighting or relative importance of that factor.

[16] Vegter, J.R., 1995. An explanation of a set of national groundwater maps; WRC Report No. TT 74/95. Water Research Commission, Pretoria.

Aquifer Vulnerability is rated as follows:

Green represents the least vulnerable region that is only vulnerable to conservative pollutants in the long term when continuously discharged or leached
Yellow represents the moderately vulnerable region, which is vulnerable to some pollutants, but only when continuously discharged or leached.
Red represents the most vulnerable aquifer region, which is vulnerable to many pollutants except those strongly absorbed or readily transformed in many pollution scenarios.

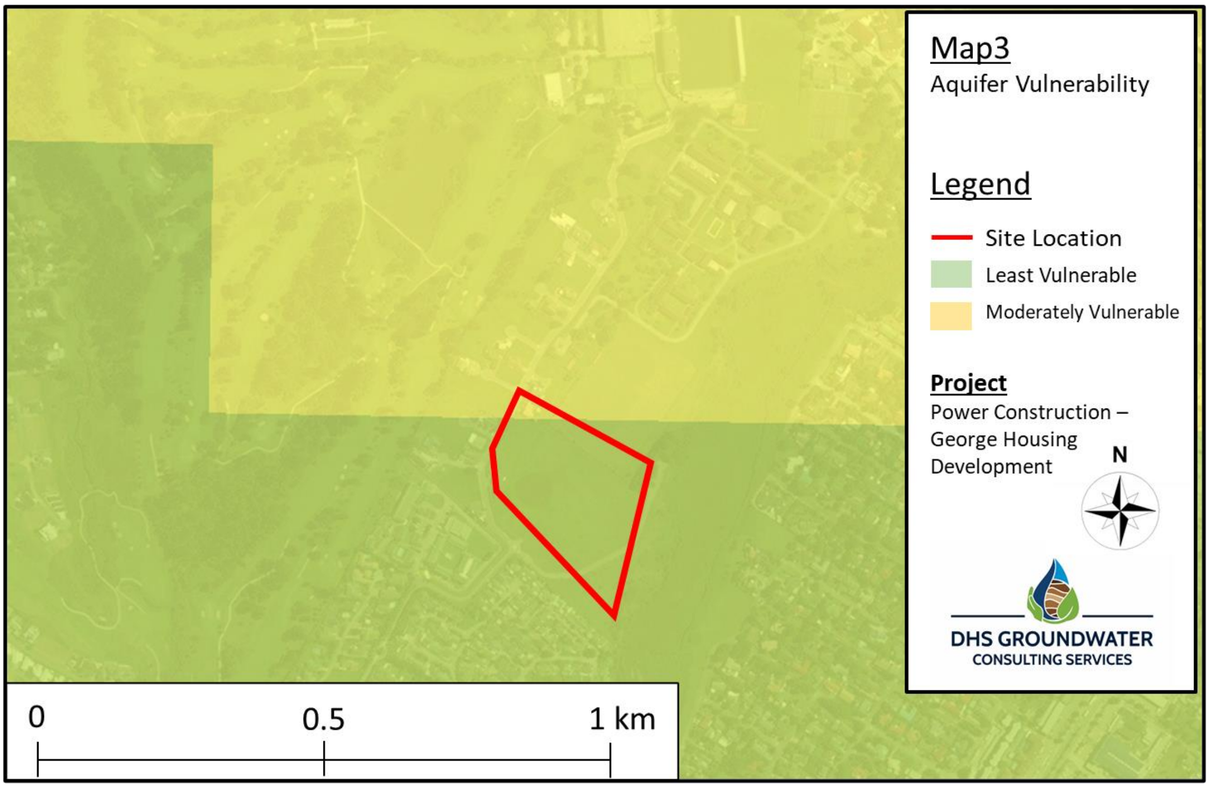

Figure 2. Regional groundwater vulnerability for the study area (DWAF, 2013).

The vulnerability of the aquifers within the project area is rated as "least to moderately vulnerable to pollutants".

7 Site Specific Assessment

As stated, the main objective of this assessment is to determine whether the proposed development could have an impact on the wetland located within the site perimeter (Figure 3).

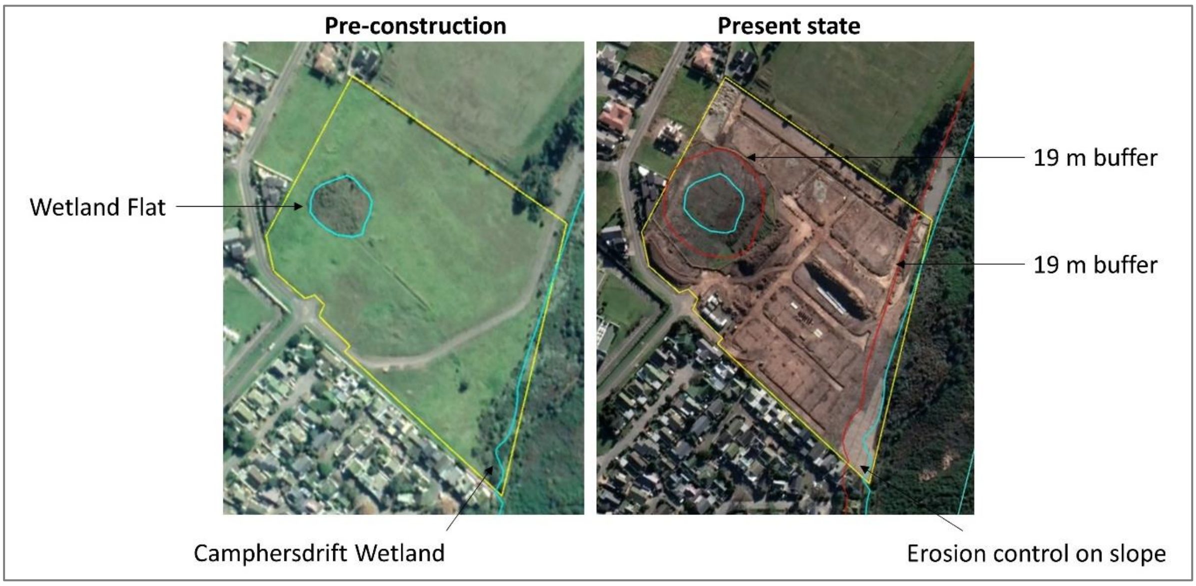

Figure 3. Development site overview indicating before and after construction work commenced (from the aquatic report).

7.1 Site Conceptualisation and Groundwater/Wetland Interaction

The aquatic report has indicated that the wetland on Erf 21028 is classified as a wetland flat due to its location on a flat bench with no inflowing or outflowing water from the system (Figure 4).

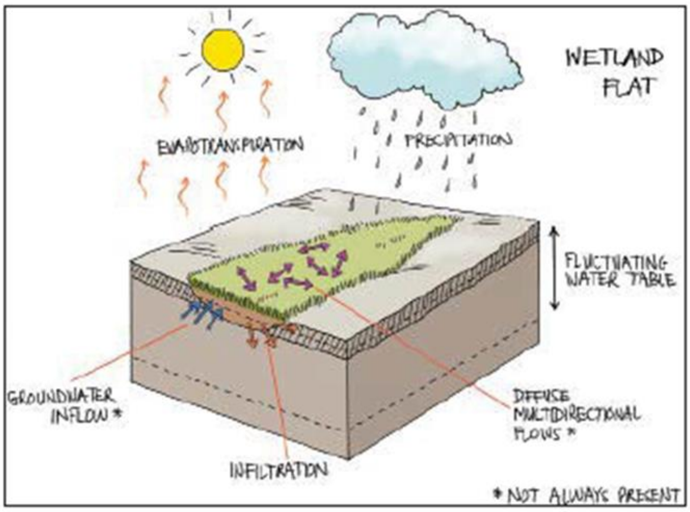

Figure 4. Conceptual illustration of the wetland flat (aquatic report from Ollis et al., 2013).

The above classification indicates a strong link between groundwater and the wetland. It is thus important to note that any altering of the groundwater recharge into the wetland could potentially affect the wetland negatively.

Furthermore, the geotechnical- and aquatic report and correspondence with Prof. Josh Louw identified the presence of weathered related processes and secondary mineralisation within the test pits linked to a fluctuating water table, which in itself is a function of fluctuating rainfall.

It has been shown in this assessment that up to 23% of the MAP infiltrates the groundwater system and it is thus safe to assume that the fluctuating water table is strongly dependent on rainfall, which coincides with previous specialist assessments. A baseflow percentage of 8- to 16% of MAP is reported across the area, which is considered a relatively high percentage. Wetlands are a common feature within the area, and with the high baseflow, it is evident that groundwater recharge is integral to health of the ecosystem.

The regional average depth to groundwater is indicated at approximately 20 mbgl, which suggest the site wetland forms part of a ***perched aquifer system***, as it is envisaged that the water table must be shallower than 20 mbgl in order to recharge the wetland (Figure 5).

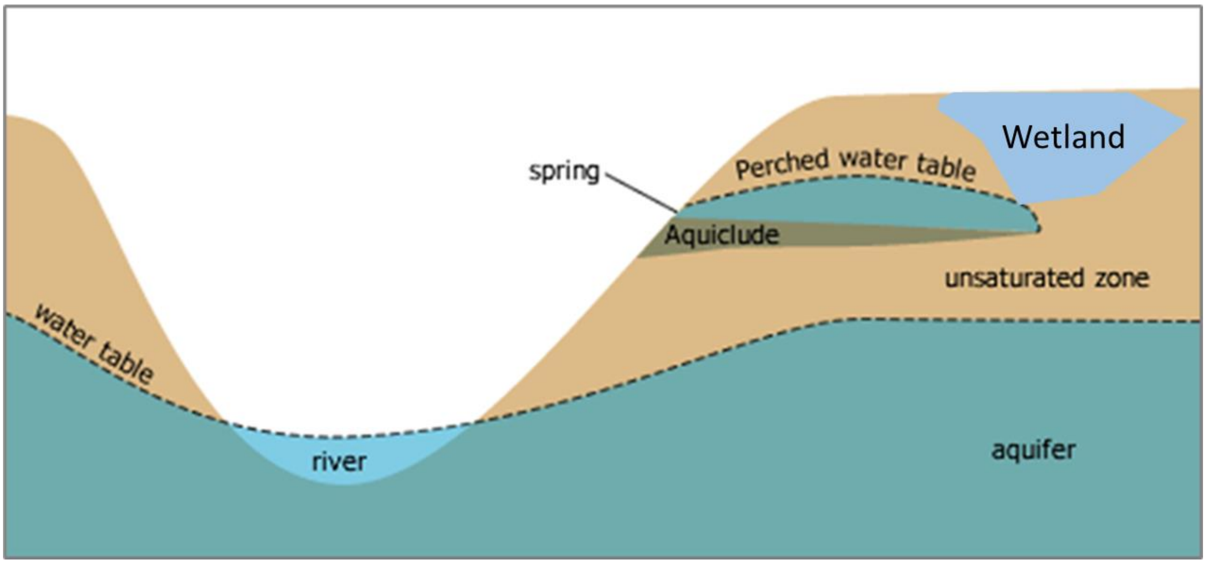

Figure 5. Conceptual illustration of the site groundwater conditions. (adapted from lumenlearning[17]).

The perched aquifer most probably formed on top of a clay rich layer to form an aquiclude. Shallow and limited erosion of the underlying granite could be the source of the perched aquifer, where groundwater is stored within the intergranular interstices of the erosion profile. The shallow erosion is supported by the fact that limited in- and outflow is present within the wetland flat, which inhibits water flow conditions favourable for erosion. It is also supported by the presence of erosion-resistant ferricrete.

The local groundwater environment is thus favourable for the formation of a perched aquifer, which recharges the wetland.

[17] **https://courses.lumenlearning.com/geophysical/chapter/groundwater/**

7.2 Groundwater - Wetland Interaction Impact Assessment

Artificial lowering of the perched water table could have a negative effect on the recharge of the site wetland. Typical methods used to lower the water table include "French" drain systems or dewatering boreholes. This is done in order to prevent groundwater compromising the foundations of built infrastructure. The construction of any such dewatering structures is identified as a ***high-risk activity*** and may affect the wetland negatively.

The geotechnical report indicated that no groundwater was intersected within the test pits, which was dug to a depth of 2 mbgl. This does suggest that the perched water table, recharging the site wetland, is below 2 mbgl. However, as discussed in the geotechnical report and covered in above section, there is evidence of a ***fluctuating water table from a depth of 1 mbgl downwards***, where ferricrete mineralisation is observed. ***This depth is interpreted to present the upper water level of the perched water table.***

7.2.1 Structural Foundations

The geotechnical report suggests reinforced strip foundations on well compacted in-situ soils at a nominal founding depth of ***600mm*** below GL with design bearing pressures limited to 100kPa. It is thus safe to assume that the proposed foundation depth is above the perched water table of ***1 mbgl*** and should not have any affect on the perched aquifer and wetland interaction.

7.2.2 Storm Water Drainage

The geotechnical report recommends the following:

- Kerb inlets and underground pipes which discharge at suitable points into ***existing stormwater network or natural drainage lines***.

- Well-designed access roads with sufficient level difference from the adjacent property, and adequate side drains and culverts is recommended. ***Subsoil drains are not envisaged along roads as the subgrade is generally well drained.***

- The ponding of storm water around the exterior of houses can be avoided by shaping the ground levels around the exterior to create a fall away from the house and constructing a 1m wide a concrete apron with a 10% fall away from the house. This will also assist in minimizing erosion around the house. The finished floor level of all houses should be a minimum of 150mm above final ground level to prevent flooding.

The proposed storm water drainage design has a low- to no risk impact on the perched water table, as all recommended construction is ***above 1 mbgl***. The recommended drainage systems are to connect to existing drainage structures or to be discharged into natural drainage lines.

7.2.3 Development Layout

The suggested buffer zone of 19m around the site wetland, as indicated in the preferred layout, is highly recommended and supported. The buffer zone along with the above discussed “shallow” construction will limit any impacts, if any, on the site wetland.

Table 3. Identified risks associated with groundwater-wetland interaction.

	Risk based on structures and development below 1 mbgl		
	Development Design		
	Structure Foundations	**Drainage Systems**	**Preferred layout**
Risk Profile	Low to no risk	Low to no risk	Low to no risk
Impact	Perched water table disturbance affecting groundwater recharge of site wetland		

7.2.4 Groundwater Chemistry

Potential pathways for contaminants to enter the groundwater system during the construction phase and upon development completion should be mitigated and remediated immediately should a pollutant enter the ecosystem.

Apart from anthropogenic impacts and equipment/infrastructure failure, this assessment has not identified any immediate risk towards the groundwater chemistry, which is based solely on the specialist data and reports supplied.

8 Environmental Management & Groundwater Monitoring Programme

As stated, the perched water table (recharge) is closely linked to rainfall, which in turn is closely linked to the site wetland. The findings based in this assessment are on the assumption that the perched water table is deeper than 1 mbgl, which is the depth at which water movement is inferred from the ferricrete soil horizon.

It is thus highly recommended that at least 2 monitoring holes be drilled to depth of 3 mbgl, or auger drill failure depth, along the 19m buffer zone perimeter. The water level, if any, along with water chemistry should be monitored throughout the construction phase of the development, as well as post-construction.

To mitigate any potential disturbance between the perched groundwater – wetland interaction, subsurface construction must be limited in depth and adhere to recommendations as per the geotechnical design and preferred layout.

The main objective of the proposed and discussed mitigation measures, pertaining to the identified impacts, is to maintain and monitor the perched groundwater table and quality to:

- Ensure that adequate water is available to maintain the groundwater dependent ecosystem, identified as a wetland confined to the perimeter of the site (baseflow feeding the wetland).

A groundwater monitoring program is proposed to reach the ecosystem quality objectives. Table 4 below presents the parameters and frequency that should form part of the groundwater monitoring program. It is proposed that the data should be captured into an appropriate electronic database for easy retrieval and submission to the relevant authority as required and reviewed by a hydrogeologist on an annual basis to ensure the wetland's groundwater source is not affected by the construction and development.

Table 4. Proposed Monitoring Requirements.

Class	Parameter	Frequency	Motivation
Physical	Static groundwater levels	Monthly	Time dependant data is required to understand the groundwater flow dynamics. A lowering in the perched static water levels may indicate artificial lowering due to construction. Conditions of the Water Use Licence.
Chemical	Major ions and trace elements.	Bi-annually	Changes in chemical composition may indicate areas of groundwater contamination and be used as an early warning system to implement management/remedial actions. To determine whether the water quality degrades the site wetland. Conditions of the Water Use Licence.

9 Conclusion & Recommendations

Based on the available data and reports, the proposed construction of the Village Ridge Housing Development will have a ***negligible – negative***, if any, impact on the investigated groundwater – wetland interaction.

The following "hydrogeological" buffers, however, are recommended during and after the construction:

- No artificial groundwater table lowering is allowed;
- All construction foundations must be shallower than the perched water table of 1 mbgl;
- No construction within the 19 m buffer zone;
- Implementation of a groundwater monitoring plan as suggested herein ("Environmental Management & Groundwater Monitoring Programme".

It is the assessor's professional opinion that adequate information was available to appropriately assess the potential impact on the groundwater – wetland interaction. Should the aforementioned hydrogeological buffers be met, and based on the results of this assessment, it is recommended that the application be approved.

Disclaimer: *The assessment is based on data acquired during a short-term. The groundwater – wetland interaction can change for various reasons (lower than average rainfall, increased abstraction within the groundwater resource, mine dewatering, unknown geological boundary conditions, etc.). Continuous groundwater monitoring is critical to provide essential data needed to evaluate changes in the resource over time; as well as the long-term sustainability of the groundwater – wetland interaction. In the event of anomalous groundwater level behaviour, a hydrogeologist should be consulted.*

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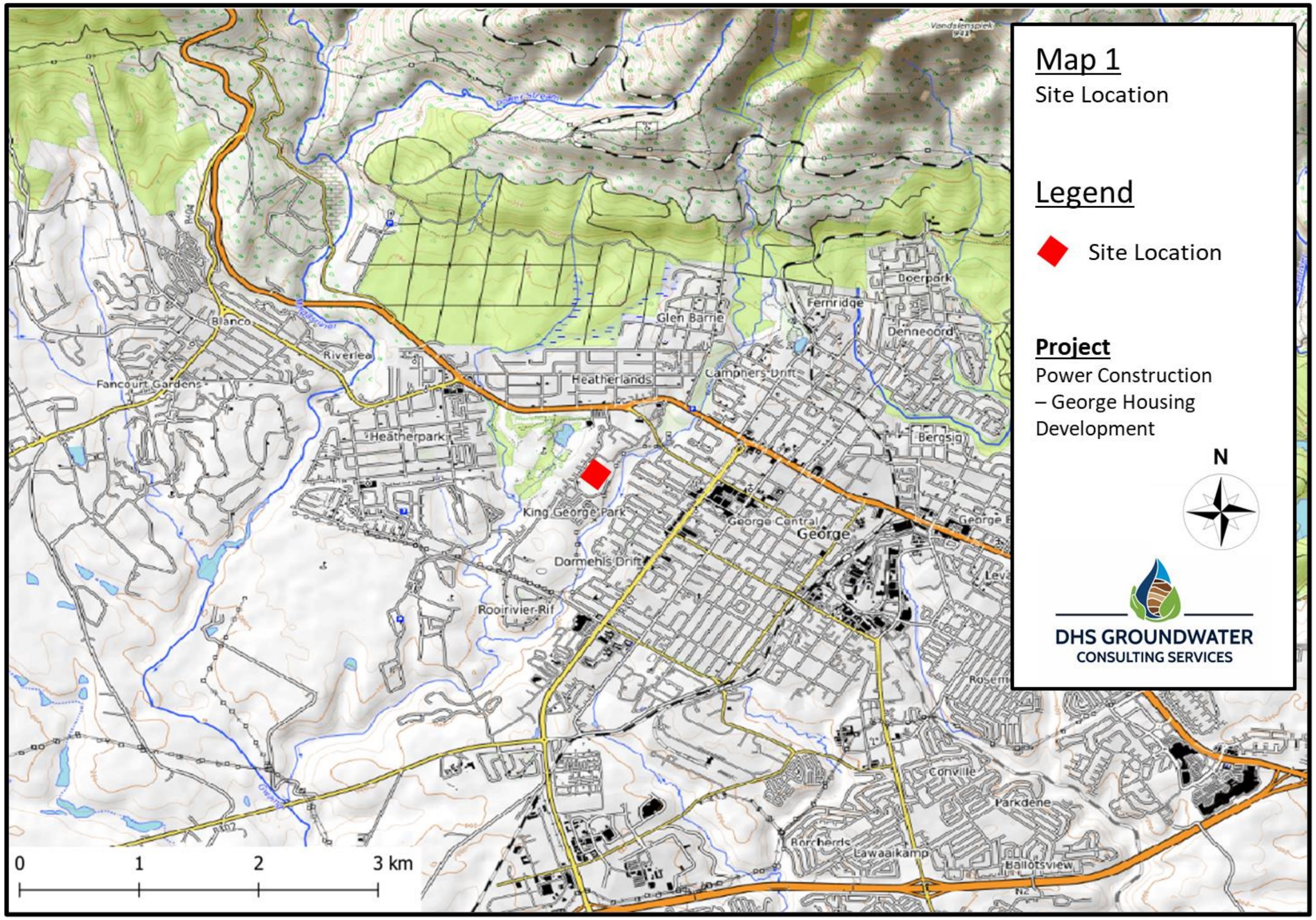
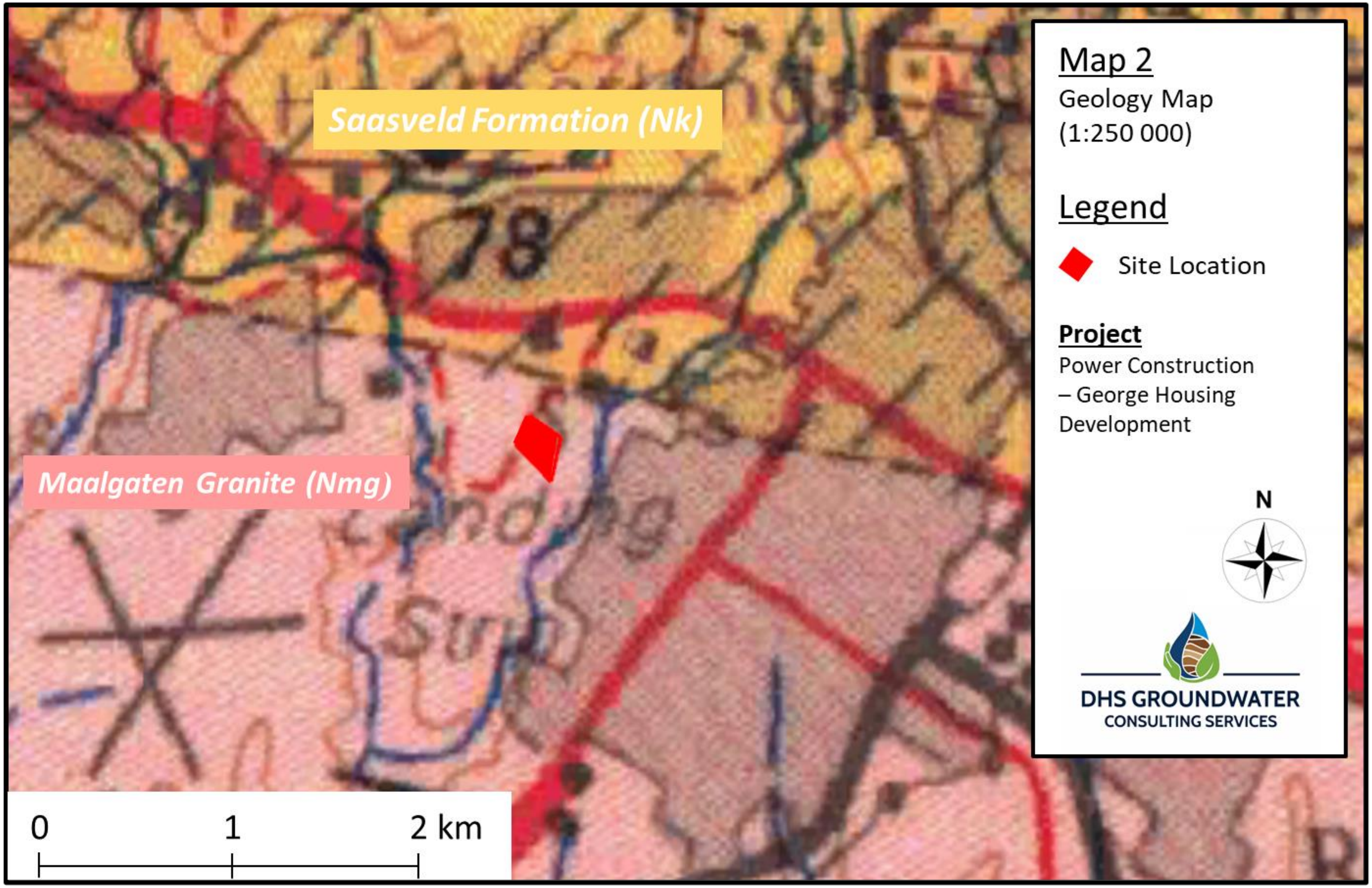
11 Appendix A




Saasveld Formation (Nk)
78
Maalgaten Granite (Nmg)
0
1
2 km
Map 2
Geology Map
(1:250 000)
Legend
Site Location
Project
Power Construction
– George Housing
Development
N
DHS GROUNDWATER
CONSULTING SERVICES