Groundwater impact assessment for a proposed development near Herolds Bay, Western Cape.

REPORT: GEOSS Report No: 2020/07-14 ***PREPARED FOR:*** Jacque Dreyer GFA Holdings/Long Island Trading (Pty) Ltd Postnet Suite 194, Private Bag X6590 George, Western Cape Email: dreyer.jacque@gfajholdings.co.za	***PREPARED BY:*** Neville Paxton GEOSS South Africa (Pty) Ltd Unit 12, Technostell Building, 9 Quantum Street, TechnoPark Stellenbosch 7600 Tel: (021) 880-1079 Email: info@geoss.co.za (www.geoss.co.za)

GROUNDWATER AND EARTH SCIENCES
GEOSS
SOUTH AFRICA (Pty) Ltd

22 July 2020

EXECUTIVE SUMMARY

Jacque Dreyer of GFA Holdings appointed GEOSS South Africa (Pty) Ltd to complete a groundwater impact assessment of a proposed development on Portion 7 of the Farm Buffelsfontein, just north of Herolds Bay near George in the Western Cape. The development includes housing, a filling station, offices, restaurant and shops. The current land use is small livestock farming which will continue on the undeveloped areas surrounding the estate. Irrigation of pastures will be supplemented by treated effluent from the planned housing by means of three package plants. The aim of the hydrogeological assessment is to determine the impacts that the proposed development may have on groundwater.

A total of seven trial pits and three auger holes were excavated during the site visit. None of which intersected groundwater for measurement of the water table depth or sampling of groundwater quality. This is likely due to the high clay content and resultant low permeability. The site visit was conducted in June, considered a dry month, however soil profiles in the riparian zone do indicate that there is a degree of seepage during times of high rainfall. This site is dominated at the surface by a sandy CLAY with a loose consistency and is regarded as the top soil layer. At depths of approximately 0.4 mbgl and deeper, the material changes to red-brown, firm, sandy CLAY. With depth moisture content decreases from moist to dry, while clay content increases. Weathered rock is expected 2.8 mbgl and beyond (topography dependent). Below the unconsolidated material is gneissic granite and granodiorite of the Cape Granite Suite.

The underlying aquifer at the site is classified by the Department of Water Affairs and Forestry (DWAF, 2000) as a "fractured and intergranular" aquifer with an average yield potential of 0.1 – 0.5 L/s. The regional groundwater quality, classified by electrical conductivity (EC) for the area is in the range of 300 – 1 000 mS/m. This is considered to be "poor" quality for water with respect to EC and the drinking water standards. A hydrocensus using existing data and a physical search showed no production boreholes within a 2 km radius of the study site. The general consensus is that boreholes which were historically drilled in the area (and have subsequently been abandoned) are too low yielding and too saline for use and that surface water availability negates the need for groundwater use.

The aquifer vulnerability to contamination is "low/medium" according to the national scale DRASTIC classification. This rating is associated with the confined nature of the fractured aquifer and overlying clay rich soil that is likely to provide sufficient protection against point and non-point sources of contamination. The depth to groundwater provides further opportunity for natural attenuation in the vadose zone prior to reaching the groundwater. The high clay content will promote surface water flow instead of subsurface seepage.

Given that no groundwater was intersected during the site investigation, likely due to the high clay content of the soil and resultant low permeability, the development of the filling station is deemed to have minimal impact on groundwater. The planned irrigation using treated effluent is a commendable example of re-use of water and will alleviate pressure on the current surface water

demand (given treated effluent will be within discharge water limits as required by NWA 1998). This will require on-going management and monitoring to be successful in the long term.

Surface water contamination on the other hand may occur more readily due to the low permeability of the soil in times of high rainfall. All measures need to be taken to ensure stormwater management reduces the chance of surface water contamination. This together with strict groundwater monitoring will further lower the risk posed from the filling station and treated effluent to groundwater and the environment.

The following recommendations are made:

- The site development can proceed with regard to constructing and operating the various aspects of the development. Relevant mitigation measures and best practice procedures must be employed to ensure no contamination of the subsurface (soil and groundwater) takes place (Table 6, 7, 8, – Proposed Mitigation).
- At least three groundwater monitoring boreholes should be installed downgradient of the filling station in order to detect any potential contamination.
- The monitoring boreholes should be appropriately designed and constructed.
- A rapid response plan must be developed should any hydrocarbon spillages or leakages be detected.
- The package plant integrity and operation must be closely monitored and managed together with analysis of the treated effluent to ensure that the treated effluent is suitable for irrigation.

Note that these recommendations are based on GEOSS's opinion and the final decision on the necessary groundwater monitoring requirements resides with the regulatory authorities.

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ABBREVIATIONS

BH	Borehole
CGS	Council for Geoscience
DWA	Department of Water Affairs (used to be Department of Water Affairs and Forestry)
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water Affairs and Sanitation
EC	electrical conductivity
L/s	litres per second
LRA	Langebaan Road Aquifer
m	metres
mbch	meters below collar height
mbgl	metres below ground level
mm	millimetre
mS/m	milli-Siemens per metre
NGA	National Groundwater Archive
SGWCA	Subterranean Government Water Control Area
UST	Underground Storage Tank

GLOSSARY OF TERMS

Aquifer: a geological formation, which has structures or textures that hold water or permit appreciable water movement through them [from National Water Act (Act No. 36 of 1998)].

Borehole: includes a well, excavation, or any other artificially constructed or improved groundwater cavity which can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and information on water in an aquifer; or recharging an aquifer [from National Water Act (Act No. 36 of 1998)].

Electrical Conductivity: the ability of groundwater to conduct electrical current, due to the presence of charged ionic species in solution (Freeze and Cherry, 1979).

Fractured aquifer: Fissured and fractured bedrock resulting from decompression and/or tectonic action. Groundwater occurs predominantly within fissures and fractures.

Groundwater: Water found in the subsurface in the saturated zone below the water table or piezometric surface i.e. the water table marks the upper surface of groundwater systems.

Suggested reference for this report:

GEOSS (2012). Groundwater impact assessment for a proposed development near Herolds Bay, Western Cape. GEOSS Report Number: 2020/07-14. GEOSS South Africa (Pty) Ltd. Stellenbosch, South Africa.

Cover photo:

Photo of excavation of Trial Pit 6

GEOSS project number:

2020_03-3906A.

Review by:

Dale Barrow and Julian Conrad (21 July 2020).

SPECIALIST EXPERTISE

CURRICULUM VITAE – Dale Barrow

GENERAL

Nationality:	South African
Profession:	Geohydrologist and Director
Specialization:	Groundwater exploration, development, management and monitoring including numerical modeling. Development of the groundwater component of catchment management strategies and other Resource Directed Measures (RDM) activities.
Position in firm:	Geohydrologist at GEOSS - SA (Pty) Ltd
Date commenced:	February 2008
Year of birth & ID #:	1985 – 851205 5227 082
Language skills:	English (mother tongue), Afrikaans (average)

KEY SKILLS

- Groundwater component of Catchment Management Strategies and other Groundwater Resource Directed Measures.
- Groundwater exploration - (aerial photo interpretation, resistivity, magnetic and EM34 geophysical surveys for borehole siting purposes)
- Groundwater development - borehole drilling and test pumping supervision and analysis.
- Groundwater monitoring –development and analysis of groundwater level and quality data.
- Groundwater management – sustainable aquifer development and management.
- Numerical modelling of groundwater flow and mass transport.
- Groundwater contamination assessments.
- GIS / WISH and GW Vistas and typical software skills.

EDUCATIONAL AND PROFESSIONAL STATUS

Qualifications

2017	MBA (Cum Laude)	University of Stellenbosch, South Africa
2010	M.Sc. (Geohydrology)	University of the Free State, South Africa
2007	B.Sc (Hons) Structural Geology	University of Stellenbosch, South Africa
2006	B.Sc Geology – Applied Earth Science	University of Stellenbosch, South Africa

Courses

2016	SPRING Software Modelling Course
2013	Aquifer Firm Yield; Wellfield Design; Wellfield costing
2010	Introduction to QGIS (GISSA)
2010	Presentation Skills (Elsabé Daneel productions cc)
2009	Introduction to Isotope Hydrology in Southern Africa (GSSA)
2009	Aquifer Mechanics (IGS-UOFS)
2009	Groundwater Chemistry (IGS-UOFS)
2009	Groundwater Geophysics (IGS-UOFS)
2009	Groundwater Modelling (IGS-UOFS)
2009	Groundwater Management (IGS-UOFS)

Memberships

- Groundwater Division of the Geological Society of South Africa
- South African Council for National Scientific Professions (SACNASP) Mem. No. 400289/13

EMPLOYMENT RECORD

1 February 2008 to present: GEOSS – Geohydrological and Spatial Solutions International (Pty) Ltd, Stellenbosch

23 July - November 2019 Design and part time lecturing of the Hydrogeology course for 3rd year students at Stellenbosch University.

CURRICULUM VITAE – Neville Paxton

GENERAL

Nationality:	South African
Profession:	Hydrogeologist GEOSS South Africa (Pty) Ltd
Specialization:	Groundwater exploration, development, and management.
Position in firm:	Hydrogeologist
Year of birth & ID #:	1986 - 861228 5151 084
Language skills:	Afrikaans (very good), English (mother tongue)

KEY SKILLS

- Groundwater sampling, field measurements, borehole logging, data logging for groundwater monitoring, borehole depth and water level measurements, piezometer installation, groundwater geophysics, hydrocensus work and groundwater contamination studies.

EDUCATIONAL AND PROFESSIONAL STATUS

Qualifications

2017	**MSc**	Geohydrology	University of the Free State
2014	**BSc (Hons)**	(Env. & Eng. Geology: Hydrogeology)	University of Pretoria
2013	**BSc Bridging Course**	(Geology)	University of Pretoria
2009	**BSc**	(Geography)	University of Pretoria

Memberships

- Groundwater Division of the Geological Society of South Africa
- Geological Society of South Africa

EMPLOYMENT RECORD

- Jan 2015 to present day GEOSS South Africa (Pty) Ltd
- Mar 2014 – Dec 2014 Student geohydrologist – GCS (Groundwater Consulting Services)
- 2012 - 2014 University of Pretoria, GIS Assistant.

SPECIALIST DECLARATION

I Neville Paxton, as the appointed independent specialist, hereby declare that I:

- act/acted as the independent specialist in this application;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct, and
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- have and will not have vested interest in the proposed activity proceeding;
- have disclosed, to the applicant, EAP and competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- are fully aware of and meet the responsibilities in terms of NEMA, the Environmental Impact Assessment Regulations, 2010 (specifically in terms of regulation 17 of GN No. R. 543) and any specific environmental management Act, and that failure to comply with these requirements may constitute and result in disqualification;
- have provided the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not; and
- am aware that a false declaration is an offence in terms of regulation 71 of GN No. R. 543.

Neville Paxton
GEOSS South Africa (Pty) Ltd.
SACNASP - Pri.Sci.Nat: 115125
20 July 2020

1. INTRODUCTION

GEOSS South Africa (Pty) Ltd was appointed by Jacque Dreyer of GFA Holdings to complete a groundwater impact assessment of a property just north of Herolds Bay near George in the Western Cape (**Map 1**). The development includes housing, a filling station, offices, restaurant and shops. The current use of the proposed development on Portion 7 of the Farm Buffelsfontein is small livestock farming. This will continue on the sections surrounding the estate where development is not to take place. Irrigation of pastures will be supplemented by treated effluent from the planned housing by means of three package plants. During the Public Participation Process, as part of the Water Use License Application, concern was raised by Interested and Affected Parties (I&AP's) specifically on the potential impact the encroachment of the development will have on the aquatic buffer area where the filling station is to be built. The aim of the hydrogeological assessment is to determine the impacts that the proposed development may have on groundwater.

The assessment comprised a desktop study to assess existing groundwater data followed by a site visit to neighbouring farms, properties and small-holdings that surround the proposed site to determine groundwater use (if any). The on-site assessment included the excavation of seven trial pits and three auger holes to determine groundwater presence, groundwater depth and quality, and conduct soil profiling to characterise the hydrogeological conditions of the study site.

2. SCOPE OF WORK

The groundwater specialist report scope of work includes the tasks outlined below:

- Assessment of impact on groundwater resources as a result of the construction and operation of the planned development and associated businesses.
- Provide recommendations to minimize or mitigate impacts.

The results of the field investigation are presented in this report along with the data analysis and interpretation.

3. METHODOLOGY

The procedure adopted for this study involved a desktop study followed by field work. The initial desktop study involved obtaining and reviewing all relevant data to the project. This included analysing data from the NGA, as well as groundwater yield, groundwater chemistry and geological maps of the area.

A site visit was then conducted to verify as much of this data as possible, as well as collect any additional data. This included a hydrocensus of groundwater users in the area, as well as noting subsurface conditions where possible. Three holes were augured and seven holes were excavated using a TLB, in an attempt to find groundwater, measure the groundwater depth and groundwater quality. All collected data was analysed and interpreted to assess the potential risks associated with the intended site development, pertaining to groundwater.

Map 1: Locality of the proposed Development, Herolds Bay, Western Cape.

4. SETTING

4.1 Topography

The study area is situated just east of the R404 on the Oubaai Main Road, near Herolds Bay in the Western Cape. The surrounding topography comprises gently undulating hills with steep cliffs dropping off into the sea less than a kilometer south of the proposed estate. The site is situated in the Quaternary catchment, K30B, which has a General Authorisation abstraction volume of 150 m^3/ha/yr.

4.2 Climate

The Herolds Bay area has a temperate climate with warm summers reaching maximums of 25°C and rainfall occurring throughout the year. The highest average rainfall occurs in March and October and the least in the winter months of June and July. The average long-term rainfall is 723 mm/a. **Figure 1** shows the monthly average air temperature over the last ten years while the rainfall distribution for the same time period is presented in **Figure 2.** This data is collected at George Airport, approximately 4.2 km north east of the site.

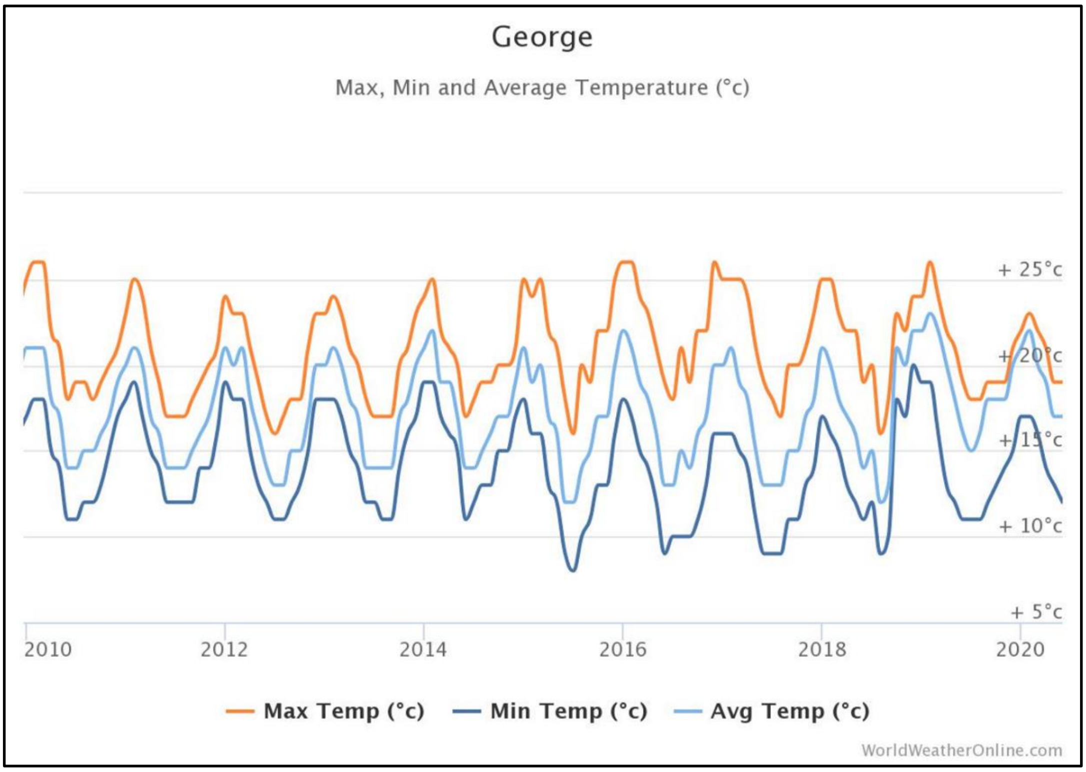


Figure 1: Air temperature of the last ten years for the George Airport, 4.2 km north east of study site (https://www.worldweatheronline.com – viewed 15 July 2020).

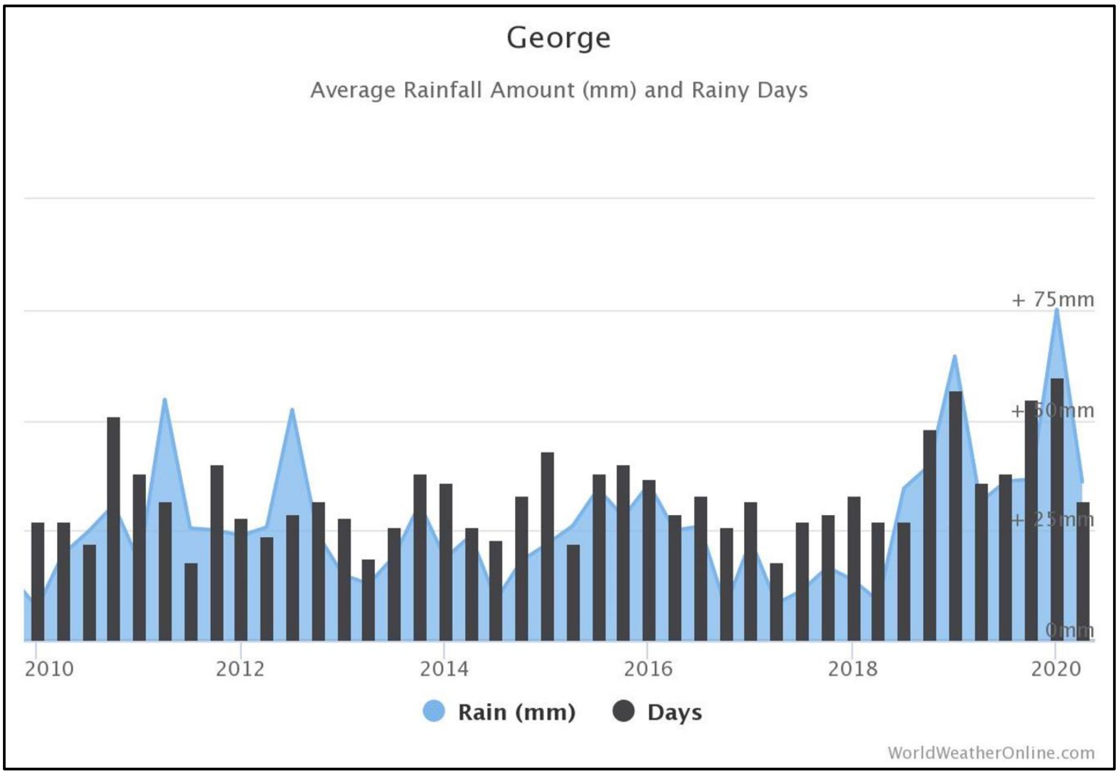


Figure 2: Rainfall for the last ten years for the George Airport, 4.2 km north east of study site (https://www.worldweatheronline.com – viewed 15 July 2020).

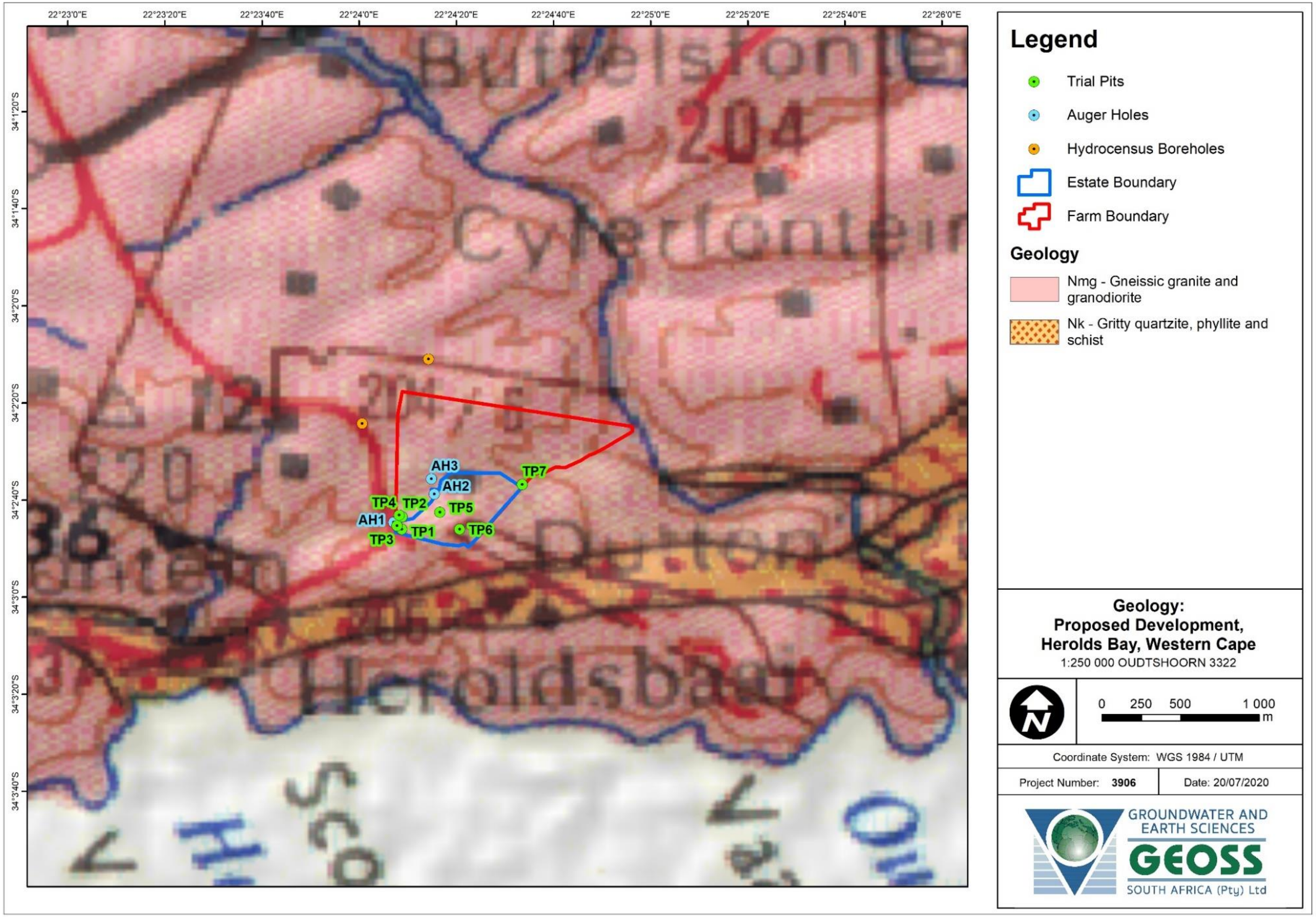
4.3 Geology

The Council for Geoscience (CGS) has mapped the area at 1:250 000 scale (3322 - Oudtshoorn, GCS 1979). The geological setting is shown in **Map 2** and the main geology of the study area is listed in **Table** 1.

Table 1: Geological formations within the study area.

Code	Suite	Lithology
Nmg	Cape Granite Suite	Gneissic granite and granodiorite

The proposed site is directly underlain by gneissic granite and granodiorite of the Cape Granite Suite.



Map 2: Geological setting of the area (3322 - Oudtshoorn, GCS 1979).

4.4 Hydrogeology

The underlying aquifer at the site is classified by the Department of Water Affairs and Forestry (DWAF, 2000) as a **fractured aquifer and intergranular aquifer** with an average **yield potential of 0.1 – 0.5 L/s**. A fractured aquifer describes an aquifer in which groundwater is stored and flows in fractures, joints, cracks and faults of hard rock bodies while an intergranular aquifer is the term used for groundwater stored in unconsolidated material such as soil, or highly weathered rock (**Map 3**). Based on the DWAF (2000) mapping of the regional **groundwater quality**, classified by electrical conductivity (EC), the area is in the range of 300 – 1 000 mS/m. This is considered to be "**poor**" quality for water (**Map 4**) with respect to EC and the drinking water standards.

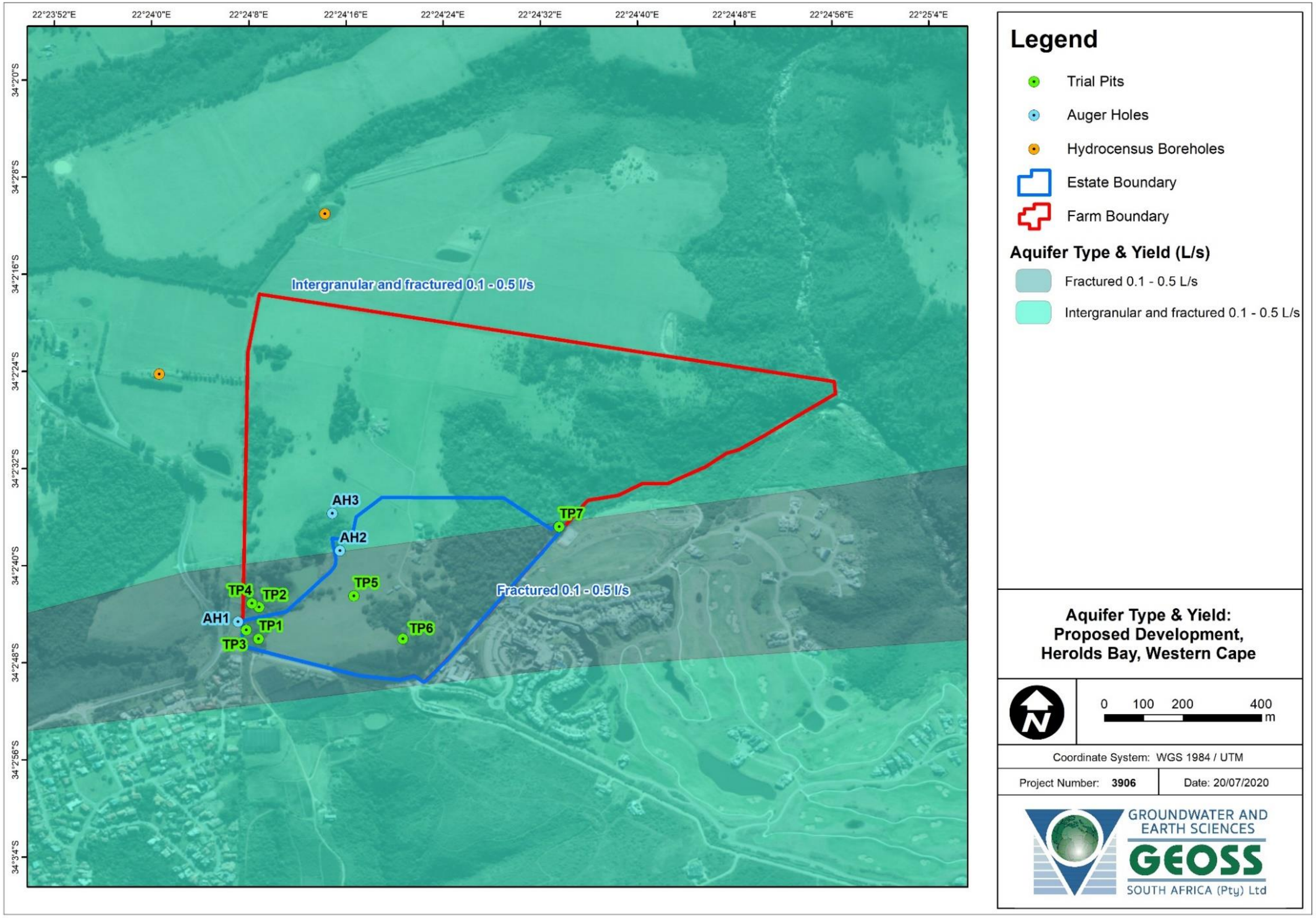
4.5 Aquifer vulnerability classification

The national scale groundwater vulnerability map, which was developed according to the DRASTIC methodology (DWAF, 2005), indicates that the site has a "**low/medium**" vulnerability to surface-based contaminants (Conrad and Munch, 2007) (**Map 5**).

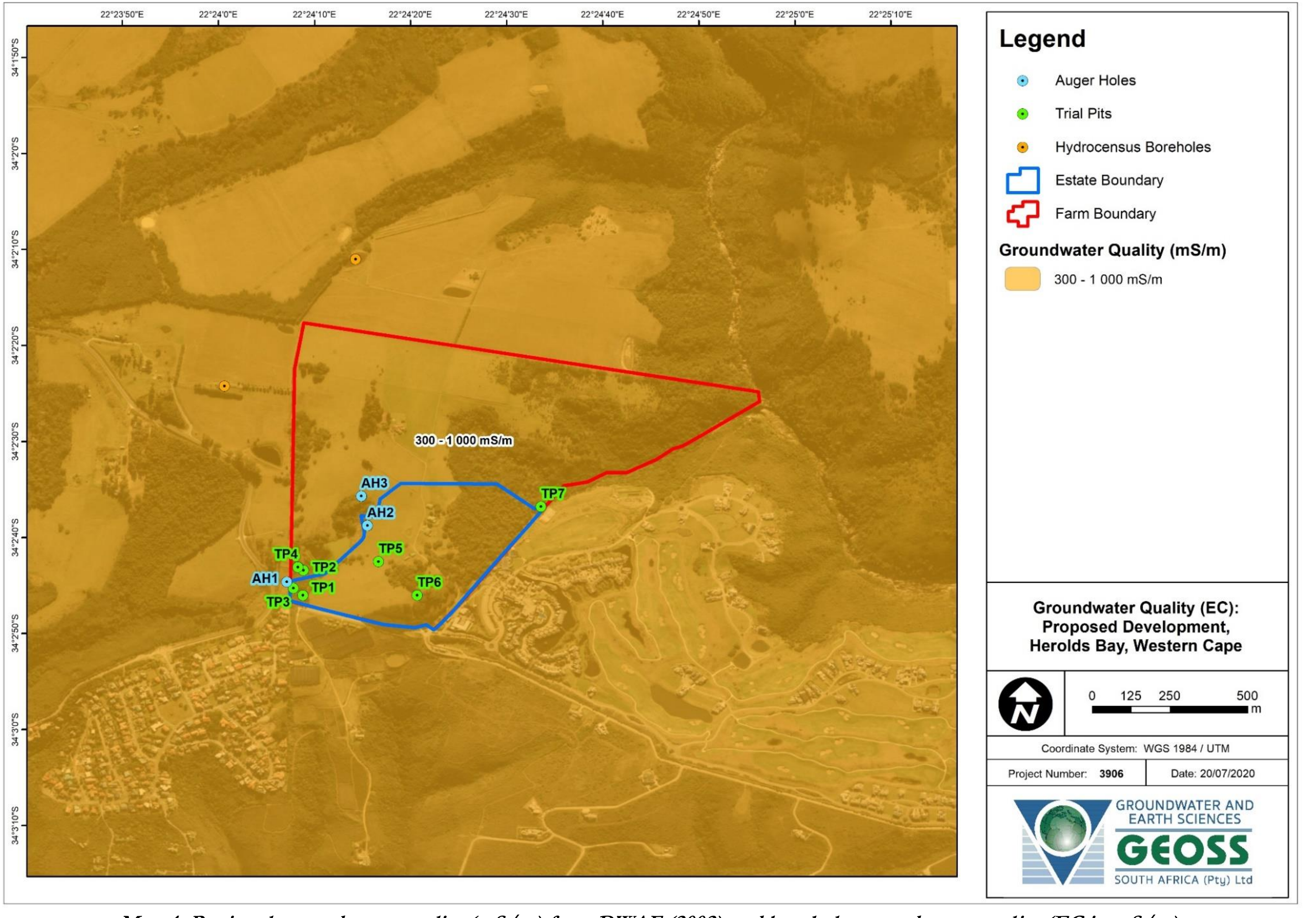
The DRASTIC method considers the following factors:

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)

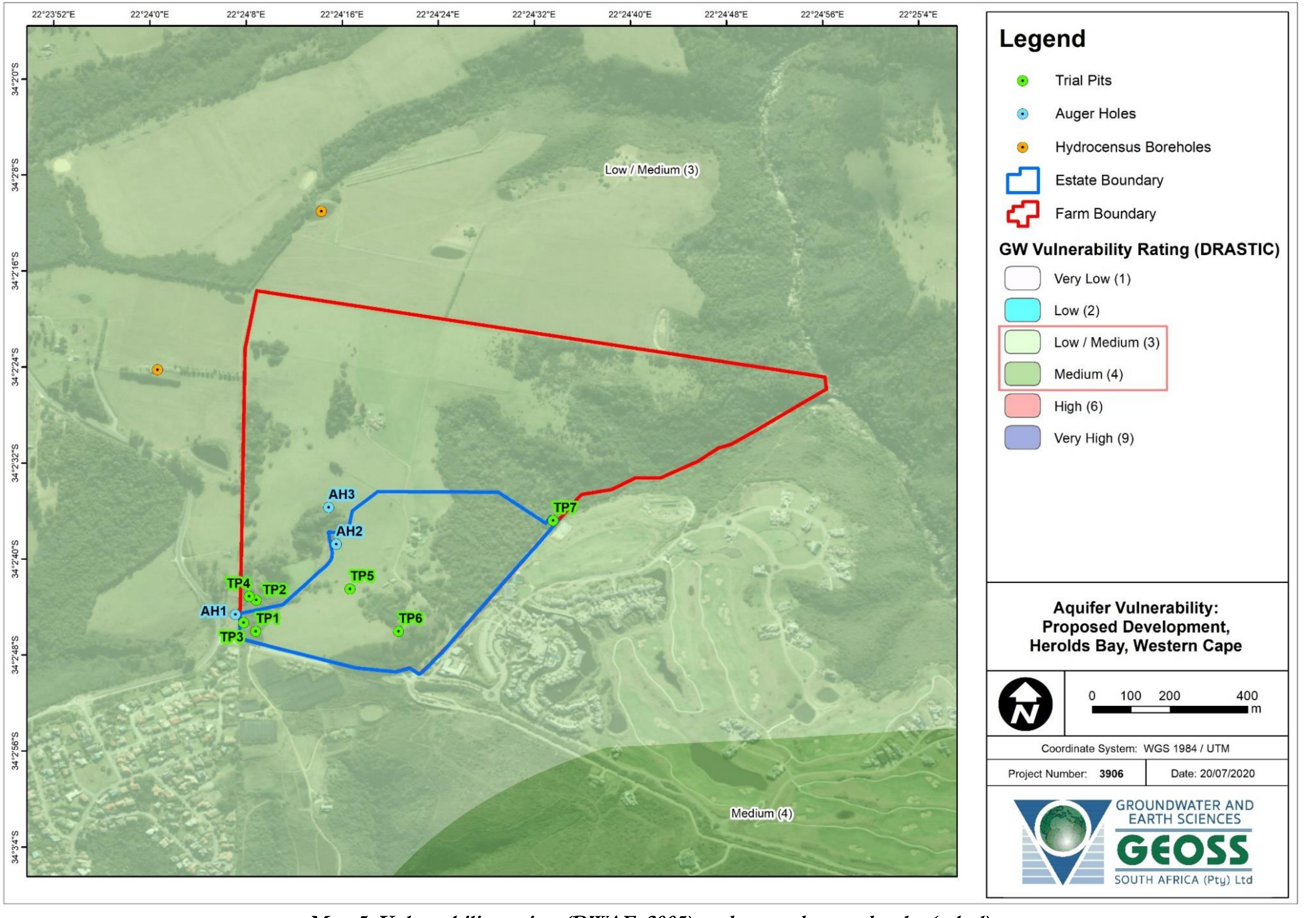
The number indicated in parenthesis at the end of each factor description is the weighting or relative importance of that factor. This "**low/medium**" rating is associated with the confined nature of the fractured aquifer below the clay rich soils which are likely to provide sufficient protection against point and non-point sources of contamination. The depth to groundwater with a weighting factor of five, provides further opportunity for natural attenuation in the vadose zone prior to reaching the groundwater.



Map 3: Regional aquifer yield (DWAF, 2002) and borehole yields (L/s).



Map 4: Regional groundwater quality (mS/m) from DWAF (2002) and borehole groundwater quality (EC in mS/m).

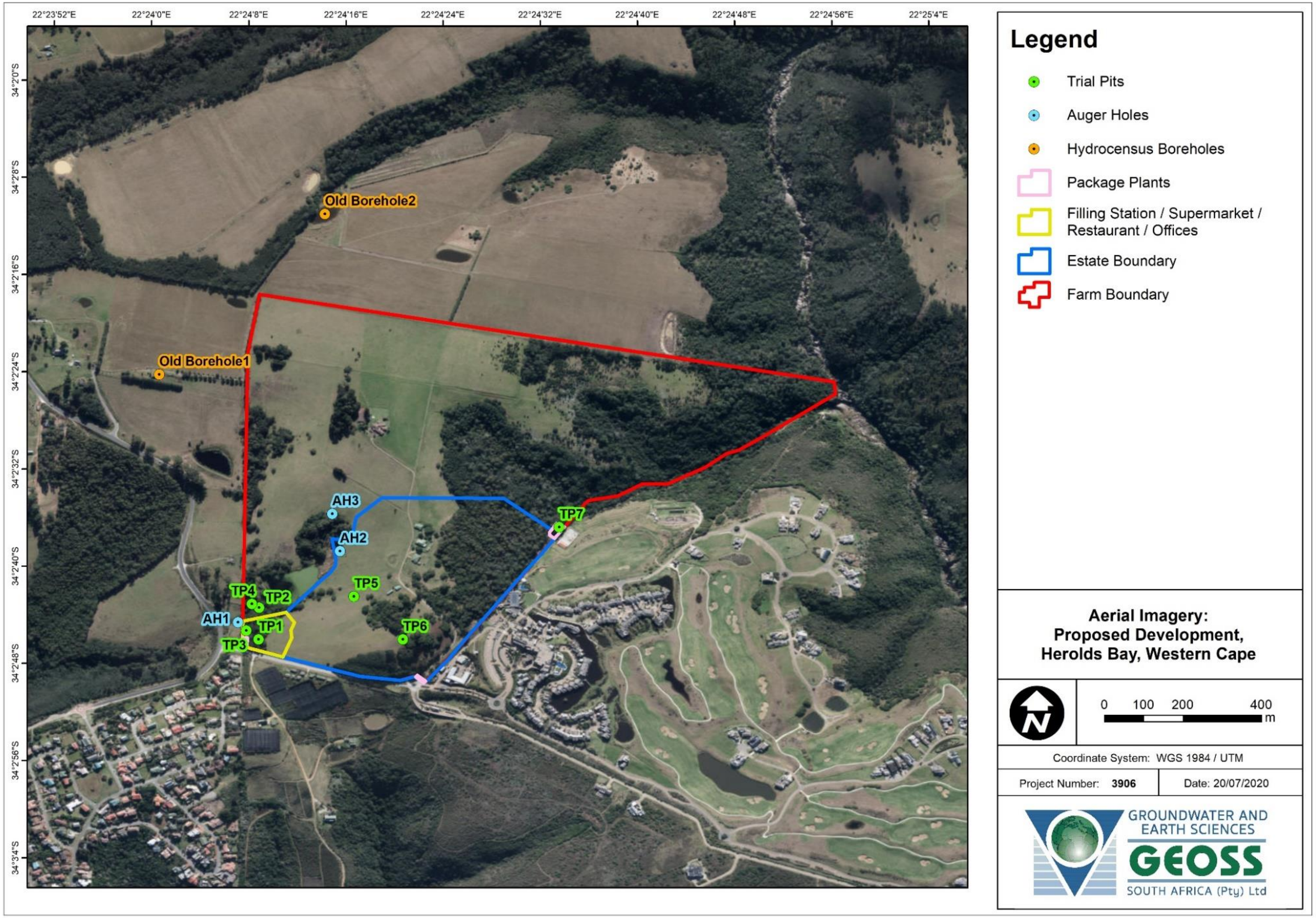


Map 5: Vulnerability rating (DWAF, 2005) and groundwater depths (mbgl).

5. HYDROCENSUS

5.1 Desktop Assessment and Hydrocensus

A desktop assessment was initially carried out around the property to determine if there were any groundwater users in the area. The National Groundwater Archive (NGA) database which provides data on borehole positions, groundwater chemistry and yield provided no boreholes within a 2 km search radius of the site. The neighbouring farmers and properties were contacted to determine presence of boreholes and groundwater use and a physical search was conducted in the residential area south of the Study site in Herolds Bay. One farmer with property directly to the north and west of the site does not have existing groundwater use, however recalls two borehole positions that were drilled during his parent's time (> 50 years ago). The approximate positions have been plotted, although these have since been covered, or corroded away. The general census is that boreholes drilled in the area are too low yielding and too saline for use (unless treated) and that the surface water availability negates the need for groundwater use.



Map 6: Hydrocensus boreholes, trial pits and piezometers.

6. SITE VISIT

6.1 Trial Pits and Auger Holes

The site visit involved the excavation of seven holes in an attempt to determine groundwater depth and the groundwater quality on site. It also provided an indication of soil types. The positions of the trial pits were chosen to provide a good spatial coverage of the study area (vegetation permitting) as well as focus on areas of concern – in this case the proposed area for the filling station. The trial pits were excavated using a tractor loader backhoe (TLB) to a maximum depth of 3.3 m. Following the excavation, each trial pit was logged and photographed (**Appendix A**). A site walk-over sought to identify and confirm hydrogeological and basic geotechnical features of relevance. The summarised details for the trial pits are presented in **Table 2**. None of the trial pits excavated intersected groundwater. It should be noted here that the most likely positions for groundwater were excavated. The location of the trial pits and auger holes are presented in **Map 7**.

Table 2: Summary of trial pits and auger holes.

Label	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Elevation (mamsl)	TP *EOH (mbgl)	Groundwater intersected (Y/N)
TP1	-34.0461°	22.40245°	166	2.7	N
TP2	-34.0454°	22.40246°	165	1.69	N
TP3	-34.0459°	22.40217°	163	2.8	N
TP4	-34.0453°	22.4023°	165	3.2	N
TP5	-34.0451°	22.40463°	175	2.8	N
TP6	-34.0461°	22.40575°	182	3.3	N
TP7	-34.0436°	22.40933°	156	2.5	N
Auger Holes					
AH1	-34.0457°	22.40198°	162	2.01	Very moist, though not measurable
AH2	-34.0441°	24.40431°	170	1.8	N
AH3	-34.0433°	22.40414°	175	1.9	N

**EOH = End of hole*

Following the excavation of trial pits, augering and a site walkover, the following generalised soil profile typifies this site (**Table 3)**.

Table 3: Generalised soil profile (note these are disturbed samples).

Depth (*mbgl)	Description
0.00 to ± 0.40	Slightly moist, brown, loose, sandy CLAY. Transported sediment with high organic component.
0.40 to ± 1.50	Slightly moist, red-brown, firm, sandy Clay. Residual.
1.50 to ± 2.8	Slightly moist, red-brown to grey with red mottling, firm, sandy Clay. Residual.
> 2.8	Refusal.

** mbgl – meters below ground level*

This site is dominated at the surface by a sandy CLAY with a loose consistency and is regarded as the top soil layer. At depths of approximately 0.4 mbgl and deeper, the material changes to red-brown, firm, sandy CLAY. With depth moisture content decreases while clay content increases and weathered rock (depth of refusal) is expected 2.8 mbgl and beyond. Trial Pit and Auger Holes photographs and logs are presented in **Appendix A**.

6.2 Piezometer Installation

The site visit involved the installation of a piezometer into an auger holes. The holes were excavated using a hand auger to a maximum depth of 3.3 m or until refusal (which ever comes fists). One piezometer was installed at AH1 where the soil had the highest degree of moisture. The details of this piezometer are presented in **Table 4**. As no groundwater was intersected in any of the remaining two auger holes and seven trial pits, no further piezometers were installed. The location of the installed piezometer and trial pits are shown in **Map 7**

Table 4: Summary of piezometer locations.

Label	Latitude	Longitude	Elevation (mamsl)	Depth (mbgl*)	Moisture/groundwater intersected?
AH1	-34.045730°	22.401980°	162	2.01	A layer at 0.96 – 1.01m of dark grey-brown, soft, sandy clay was found to be very moist, however water table was not measurable or possible to be sampled.

mbgl = meters below ground level*

Piezometer installation involves installing a 50 mm PVC pipe as deep as possible below the groundwater level. The PVC pipe is slotted (i.e. screened) to allow groundwater to flow into the pipe. The depth of the groundwater table can then be measured, and a sample collected for quality analysis. The general construction of such a screened piezometer can be seen in **Figure 3**.

The site visit was conducted in one day in the month of June, and it should therefore be stated that the level of groundwater will change seasonally. In the case of the lower lying areas, a high degree of mottling was found within the clays, indicating that there is potentially more subsurface flow during periods of high rainfall.

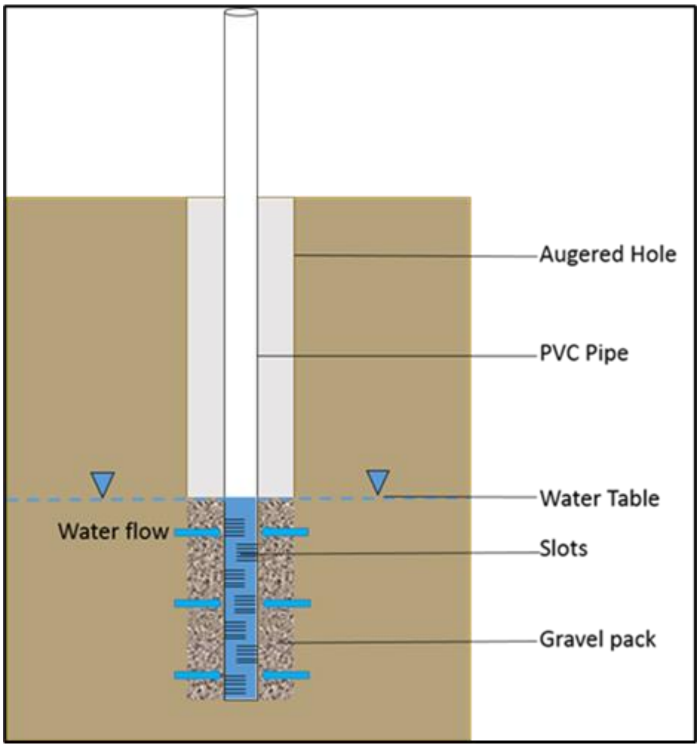
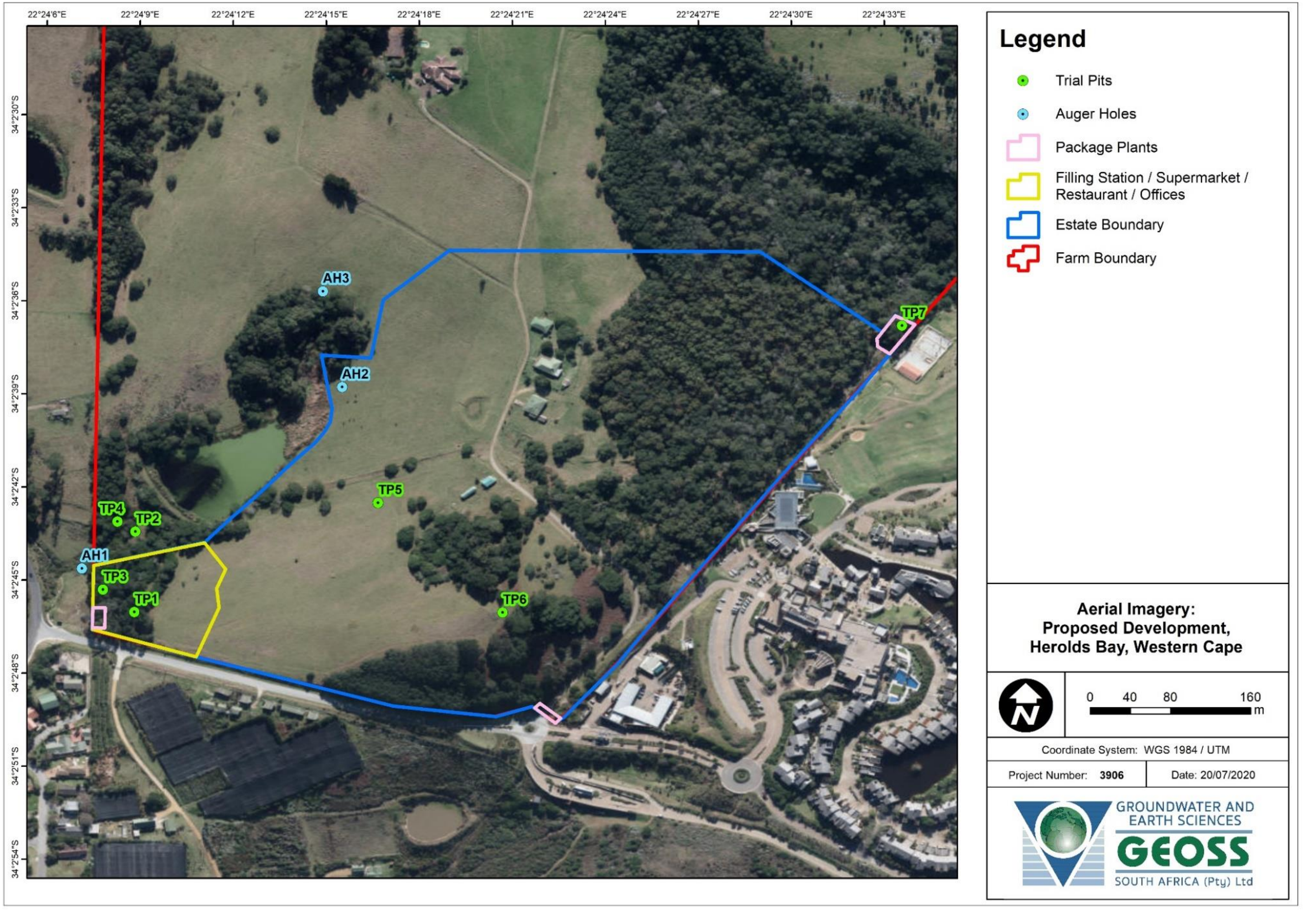


Figure 3: Typical piezometer installation.

6.3 Groundwater flow direction

During the site visit, no groundwater levels could be measured in the excavated and augered holes as well as neighbouring properties. This confirms that the groundwater levels are relatively deep (>3 m). Regional groundwater flow in the area is likely to be towards the coast, and more locally it is likely to mimick topography and surface flow. The high clay content of the soil and resulting low permeability means that any subsurface seepage and movement will be very limited.



Map 7: Aerial map showing trial pit and piezometer locations.

6.4 Groundwater Quality

No groundwater was found during the hydrogeological investigation. A surface water sample however was taken from the existing dam and quality was measured in field. As this is directly upgradient from the proposed filling station and riparian zone, this would serve as the ideal background sample to check if the dam is a source of shallow subsurface water (potentially as perched groundwater). Again, none was found, so the detail below (**Table 5**) serves as a reference point only.

Table 5: Dam sample quality (measure in field)

Name	EC (mS/m)	pH	TDS (mg/L)	Temperature (°C)
Dam sample	95	5.6	40	18.3

7. RISK IMPACT ASSESSMENT

There are risks associated with the proposed development and operation at the site.

Fuel and oil spills pose a risk to groundwater during the associated construction works. Fuel dispensing operations and the re-filling of underground storage tanks also pose a potential risk during the operational phase of the filling station. The underground fuel storage tanks, lines and filler points could leak and contaminate the soil and groundwater. In addition, if stormwater is not managed correctly on the site there is the potential for the stormwater runoff to negatively impact the environment, potentially causing pollution and contamination. The farming activities are to continue within and around the estate, with the treated effluent generated from the package plants to be used for irrigation of the pasture lands. The quality of the treated water must be of such a nature that it does not pose any risk to soil and the environment.

Exposure to contaminants could be through volatile components (fuel vapours) or contact with hazardous substances (contaminants or contaminated groundwater) via ingestion or dermal contact (with both groundwater and soil). In short, the following components are potential risks and are discussed in detail below:

- Filling station
- Stormwater management
- Irrigation with treated effluent

Table 6 presents a summary of possible impacts and proposed mitigation measures associated with on site development and operation of the fuel station.

Table 7 presents a summary of possible impacts and proposed mitigation measures for surface run-off caused by rain and stormwater management.

Table 8 presents a summary of possible impacts and proposed mitigation measures for irrigation with treated effluent.

Table 6: Impact table for contamination of groundwater as a result of operating the proposed filling station over a long period.

7.1 OPERATIONAL PHASE: FILLING STATION	
Potential impact and risk:	**Operation of a fuel station – Long-term low-level**
Nature of impact:	Negative
Extent and duration of impact:	Extent is local and duration is long term.
Consequence of impact or risk:	Contaminated soil and groundwater in surrounding environment.
Probability of occurrence:	High probability.
Degree to which the impact may cause irreplaceable loss of resources:	Marginal loss of resource.
Degree to which the impact can be reversed:	Partly reversible.
Cumulative impact prior to mitigation:	Medium
Significance rating of impact prior to mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Medium
Degree to which the impact can be managed or mitigated:	Can be mitigated
Proposed mitigation:	Due to the nature of the potential contamination (hydrocarbon contamination) the highest levels of protection and monitoring will need to be installed on site. The mitigation measures listed below must be employed to ensure no contamination of the aquifer or soil takes place. 1. Tanks must be double walled / "Jacketed" i.e. possessing secondary containment to prevent tank content release into surrounding soil and groundwater. The UST (underground Storage tank) must have an internal leak detection monitoring system between the two walls to monitor for product leakage; 2. Fuel lines and sumps must be secondary contained where lines are joined. 3. The SWMP must include the following design measures: • **<u>Fuel Containment Area</u>** The containment slab must be graded to drain a catch-pit that is connected to discharge to the stormwater system via an oil separator while the surrounding paved surface areas must be graded to ensure rainwater runoff to the stormwater system. No washing in this area is allowed.

	• **Forecourt Area** The roofed forecourt area must be provided with its own set of catch pits that are connected to discharge to the sewer via a separate oil separator. Please note that the aforesaid areas cannot be interconnected. The surface area of the forecourt must be graded to the abovementioned catch pits while the surrounding surface area is graded to drain rainwater to the stormwater system. Washing of the forecourt surface is allowed in this instance. Additionally, the following mitigation is required which is associated with petrol filling station Underground Storage Tank (UST) and pipework installations (applicable for the construction and operation phase): **National Standards** 4. All containment manholes must be regularly inspected as part of the normal management procedures at the service station. 5. The installation of Underground Storage Tanks (UST's) and associated pipework must be implemented in accordance with the relevant South African National Standards (SANS), specifically (not exclusive to) the following standards: a) SANS 10089-3 (2010) (English): The petroleum industry Part 3: The installation, modification, and decommissioning of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations. b) SANS 10 400TT (Fire Protection) 53 Sections 1-6 (The application of the National Building Regulations-Installation of Liquid Fuel Dispensing Pumps and Tanks); c) SANS 10087-3 (2008) (English): The handling, storage, distribution and maintenance of liquefied petroleum gas in domestic, commercial, and industrial installations Part 3: Liquefied petroleum gas installations involving storage vessels of individual water capacity exceeding 500 L. 6. The installation of the UST's and associated pipework must comply with the National Building Regulations and Standards Act No. 103 of 1977; 7. The installation must comply with local authority bylaws and all procedures and equipment used must be in accordance with the Occupational Health & Safety Act (No. 85 of 1993); 8. Upon completion of the UST installation, an engineer is to inspect and verify that the tanks and the associated infrastructure have been installed as per the design criteria described in the final BAR and to all required SABS / SANS standards and applicable legislation. A

	report thereafter, based on the engineer's findings, it to be submitted to the DEA & DP Land Management and Pollution Directorates for inspection. 9. Any repair work required is to be conducted according to SABS 1535 (Glass-reinforced polyester-coated steel tanks, including jacketed tanks, for the underground storage of hydrocarbons and oxygenated solvents and intended for burial horizontally); **Installation of Underground Storage Tanks** 10. The USTs must be reliable in the event of heavy rains and flooding. UST manholes shall be impermeable and resistant to fuel, they shall consist of a heavy-duty cast-iron cover, which shall prevent damage from surface traffic; 11. Construction of a reinforced concrete slab over the USTs, its thickness and strength are to be determined by a qualified Engineer; 12. The filler point and tank must be fitted with overfill protection. The critical level should be such that a space remains in the tank to accommodate the delivery hose volume (2%). Earthing and snap tight quick coupling is to be provided for loading of materials into tanks to minimise the risk of fires and prevent spillage and loss of materials; and 13. The USTs are to be fitted with a tank containment sump, fitted on top of the tank and a dispenser containment sump must be provided, fitted underneath the dispenser as containment. A Filler spill containment must also be provided for remote filler containment purposes; 14. The excavation must be protected against the ingress of surface run off water, and is to be kept reasonably free of sub-surface water by pumping out if necessary (unlikely); 15. The excavation must be lined with a HDPE liner or a suitable clay layer to prevent infiltration of product to the ground water should a spill or leak occur (an impermeable liner); 16. The UST is to be inspected before installation for damage, including factures or damage to coating work. 17. Leak and pressure tests must be conducted on tanks and pipelines to ensure integrity prior to operation and the inspection authority must issue pressure test certificates. 18. The UST must be buried 750mm below finished ground level in accordance with SANS 10089-3; 19. The local Fire Department must be informed two (2) working days before installation commences and to be called for inspection at the following stages: a) Installation of tank on clean sand bed before backfilling

b) Witness pressure test (delivery lines 1000kPa, tank 35kPa); and
c) Inspection of slab over tank before concreting;

Pipework

20. Installation of associated pipe work. This shall include the installation of internationally approved non-corrosive pipework systems. All underground piping is to be Petrotechniks UPP Extra piping (nylon lined, 10 bar rated). Nextube Kableflex sleeving (oil industry green with a smooth internal bore) to be used as secondary containment. This is to limit the possibility of pipe failure due to corrosion; this being the most common cause of pipe failure before this system was introduced to South Africa.
21. All pipeline connections are to be housed within impermeable containment chambers. A leak detector on all submersible pumps that automatically checks the integrity of the pipework on the pressure side of the pump must be provided. Pipelines must not retain product after use and no joints are to be made underground. An emergency shut-off valve must be supplied between the supply pipeline and dispenser inlet. All pipes (vent, filler and delivery) are to slope back to the USTs so that fuel does not remain in the pipes;
22. Vent pipes to be fitted with "Fulcrum" vertical vent roses, or an approved equally equivalent market product replacement, that conforms to these standards. Confirmation of filler point and vent position to be made by an approved Engineer for safety distances required;
23. Vent pipes above ground are to be galvanised mild steel and are to be at least 1000mm above the roof height and away from any doors, windows, chimney openings and other sources of ignition; and the tank product lines must be pressure tested prior to commissioning;

Leak detection and monitoring required

24. It is required to undertake integrity testing on Underground Storage Tanks (UST's) and underground pipe integrity testing. The frequency of integrity testing should be as follows as outlined here. Tank and pipe integrity testing shall be carried out in the following instances:
25. Following installation of a new UST and associated underground pipework or following repair, maintenance or upgrade of an existing UST or underground pipework (or both). Testing shall be carried out prior to burial of the installation;

	26. When ownership of the UST and associated underground pipework changes; 27. When leak detection monitoring methods that may be in place, such as Stock Inventory Reconciliation Analysis, Automatic Tank Gauging (with a reconciliation facility) or interstitial vapour or liquid monitoring of double-walled or jacketed steel tanks, indicate the possibility of a leak. In this instance, an investigation into the possible leak, including integrity testing in the final stages of the investigation, shall be used to track the reasons for a failure to reconcile; 28. Where continuous leak detection monitoring, such as Stock Inventory Reconciliation (SIR), is not carried out at a site. In this instance, UST and associated underground pipe integrity testing should be carried out every 2 years. If USTs and underground pipes do not operate with a continuous leak detection system, but do have cathodic protection installed, then this period may be extended to 10-year intervals. 29. USTs are to be fitted with a monitoring tube to allow for the monitoring of leaks through the tank surface; 30. Leak detectors are to be installed to the submersible pumps within UST manholes to ensure that there are no line leaks; 31. A relatively inexpensive soil vapour monitoring installation must be installed which can be monitored on a frequent basis (monthly intervals) using a Photo Ionisation Detector (PID) eg. Mini RAE 2000. 32. The installation of Soil Vapour Sampling Points will require the placement of a permeable coarse clean sand layer beneath the storage tanks for a vertical depth of approximately 0.5m to 1m in order to locate the vents in the 16mm diameter monitoring pipe over portion of this depth 33. The Groundwater Monitoring Action Plan must be included as an Annexure to the approved EMP. 34. Observation wells must be installed in the sand fill surrounding the underground storage tanks for regular ground water monitoring purposes 35. All containment manholes must be regularly inspected as part of the normal management procedures at the service station 36. Continuous electronic monitoring (CEM) of product must be carried out. Should discrepancies occur an alarm will be triggered and site management will review the finding and take appropriate action to rectify the situation as required. **37. Should a leak be found or should the groundwater in the monitoring wells be found to be contaminated with hydrocarbons, a baseline Phase 1 Contamination**

<table>
<tr><td></td><td>Assessment should be undertaken and the site remediated in consultation with a contamination remediation consultant and the Authorities.

Forecourt Dispensing Area

38. Installation of pump islands in the forecourt area. The pumps are to be fitted with a Spill Containment Chamber;
39. Construction of a concrete bunded reinforced graded slab over the forecourt area, with positive falls towards a centrally located catch-pit/sump. The slabs thickness and strength are to be determined by a qualified Engineer.
40. The centrally located catch-pit/sump shall drain into a pollution containment chamber i.e. an approved oil/water separator system. Once the wash water has passed through the system, the separated oil must be collected regularly by an approved waste contractor and removed to an approved hazardous waste disposal facility.
41. The forecourt shall be covered.

Groundwater Monitoring

42. At least three groundwater monitoring boreholes should be installed in order to detect any potential contamination as quickly as possible.
43. The monitoring boreholes should be drilled to a depth slightly deeper than the fuel storage tanks (depth and position to be determined by site layout). Monitoring boreholes should follow the specifications provided in the Groundwater Monitoring Action Plan (Section 10).</td></tr>
<tr><td>Cumulative impact post mitigation:</td><td>Low</td></tr>
<tr><td>Significance rating of impact after mitigation
(e.g. Low, Medium, Medium-High, High, or Very-High)</td><td>Low</td></tr>
</table>

Table 7: Impact table for contamination of groundwater as a result of stormwater.

7.2 OPERATIONAL PHASE: STORMWATER	
Potential impact and risk:	**Operation of a fuel station – Stormwater**
Nature of impact:	Negative
Extent and duration of impact:	Extent is local and impact duration is long term.
Consequence of impact or risk:	Contaminated surface water, soil, groundwater and surrounding environment.
Probability of occurrence:	High probability.
Degree to which the impact may cause irreplaceable loss of resources:	Marginal loss of resource.
Degree to which the impact can be reversed:	Partly reversible.
Cumulative impact prior to mitigation:	High
Significance rating of impact prior to mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	High
Degree to which the impact can be managed or mitigated:	Can be mitigated.
Proposed mitigation:	A proper stormwater system needs to be developed as to catch any surface run-off from the Filling station to be guided to an oil separator. No rainwater is allowed to be discharged to the sewer system. The containment slab must be graded to drain a catch-pit that is connected to discharge to the stormwater system via an oil separator while the surrounding paved surface areas must be graded to ensure rainwater runoff to the stormwater system. No washing in this area is allowed. The centrally located catch-pit/sump should drain into a pollution containment chamber i.e. an approved oil/water separator system. Once the wash water has passed through the system, the separated oil must be collected regularly by an approved waste contractor and removed to an approved hazardous waste disposal facility. At least three monitoring boreholes downgradient from the filling station infrastructure (but on site) must be installed on site for regular ground water monitoring purposes.

Cumulative impact post mitigation:	Low
Significance rating of impact after mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Low

Table 8: Impact table of groundwater as a result irrigation with treated effluent.

7.3 OPERATIONAL PHASE	
Potential impact and risk:	**Irrigation with treated effluent**
Nature of impact:	Negative
Extent and duration of impact:	Extent is local and impact duration is medium term.
Consequence of impact or risk:	Contaminated soil and surrounding environment.
Probability of occurrence:	Medium
Degree to which the impact may cause irreplaceable loss of resources:	Marginal loss of resource.
Degree to which the impact can be reversed:	Reversible
Cumulative impact prior to mitigation:	Medium
Significance rating of impact prior to mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Medium
Degree to which the impact can be managed or mitigated:	Can be mitigated.
Proposed mitigation:	The package plants will be Maskam Clarus Fusion plants comprised of a four stage treatment process which results in solid and odour free effluent to a standard that will be in line with the General limits for discharge water of the DWS (Element,2020). It is proposed that the treated effluent is monitored monthly by collecting samples and laboratory analysis.
Cumulative impact post mitigation:	Low
Significance rating of impact after mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Low

8. DISCUSSION

From the hydrocensus, it is clear that the number of groundwater users in the area is limited. No active production boreholes could be located. The groundwater quality of the area as classified by DWAF (2000) according to EC and falls within the poor (300 – 1 000 mS/m) classification. The average groundwater yield is low, classified as 0.1 – 0.5 L/s from a intergranular and fractured aquifer.

This site is dominated at the surface by a sandy CLAY with a loose consistency and is regarded as the top soil layer. At depths of approximately 0.4 mbgl and deeper, the material changes to red-brown, firm, sandy CLAY. With depth moisture content decreases while clay content increases and weathered rock (depth of refusal) is expected 2.8 mbgl. No groundwater was intersected in any the three auger holes and seven trial pits that were excavated on site. Very moist soil was found at approximately 1 mbgl in the middle of the riparian zone. A piezometer was installed here, however no groundwater accumulated in the piezometer to allow a water table measurement or a sample to be collected. The mottled clay at this position and at AH2 indicate a seasonal presence of seepage, though the high clay content means the permeability of the soil is very low.

The aquifer vulnerability to contamination is "**low/medium**". This rating is associated with the confined nature of the fractured aquifer and the high clay content of the soil that is likely to provide sufficient protection against point and non-point sources of contamination. The depth to groundwater provides further opportunity for natural attenuation in the vadose zone prior to reaching the groundwater.

For a risk to exist there must be a source (s), pathway(s) and receptor(s), these are presented in **Figure 4**. All three are present in this case. The proposed filling station, accompanying infrastructure and on-site activities, irrigation with treated effluent represent potential sources of contamination. The underlying aquifer and drainage channels represents both a potential pathway and receptor. The surrounding environment represent receptors of potential contamination.

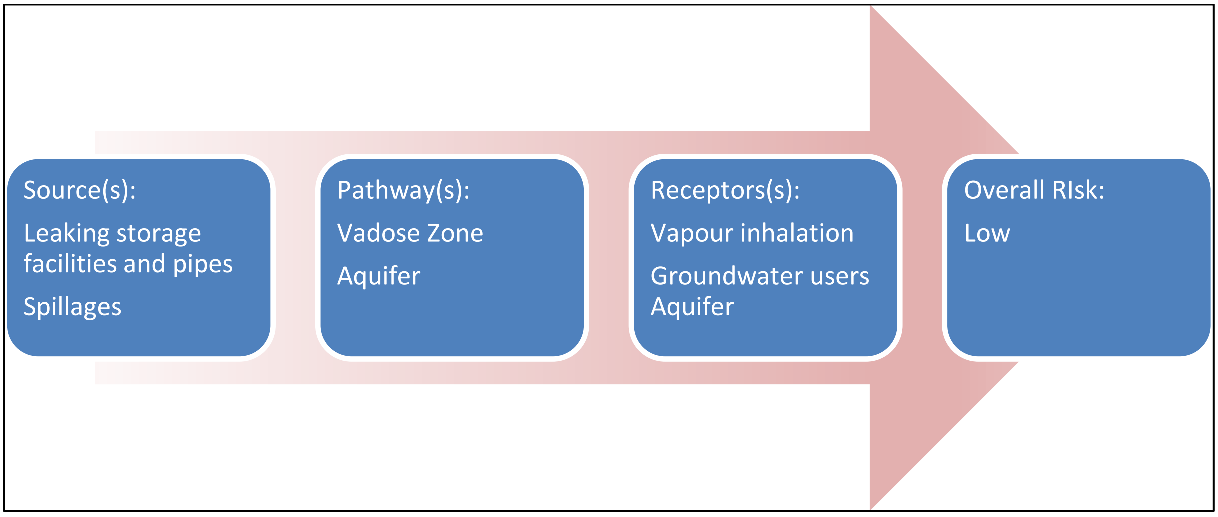


Figure 4: Source, Pathway and Receptor assessment.

Given the vulnerability of the aquifer and clay rich soil, the risk assigned to potential impacts of contamination is considered to be **low**. However, good practise dictate that no activities should be allowed that are likely to result in contaminants to enter into the subsurface. Mitigation is necessary to prevent any potential contamination. Regular groundwater monitoring is recommended to detect potential contamination proximal to the filling station and inspection of the integrity of package plants and sampling of treated water.

Although the soil has a low permeability and groundwater vulnerability is considered low, the potential contamination from contaminated surface water combined with the distance to the ocean necessitate strict stormwater management and groundwater monitoring specifically at the location of the proposed filling station in the south west of the proposed development.

9. RECOMMENDATIONS

The following recommendations are made:

- In terms of the site developments potential risk to groundwater, the data indicates that the site development can proceed with necessary mitigation measures employed. Monitoring should be installed on site, with regard to constructing and operating the filling station. Relevant mitigation measures and best practice procedures must be employed to ensure no contamination of the subsurface takes place (**Table 6**, **7**, **8**, – Proposed Mitigation).
- At least three groundwater monitoring boreholes should be installed in order to detect any potential contamination, downgradient of the filling station.
- The monitoring boreholes should be appropriately designed and constructed – that is the depth of the monitoring boreholes should be deeper than the bottom of the USTs and seated within the intact granite (just beyond the weathered zone), and below the water table.
- A rapid response plan must be developed should any hydrocarbon spillages or leakages be detected.

Note that these recommendations are based on GEOSS's opinion and the final decision on the necessary groundwater monitoring requirements resides with the regulatory authorities.

10. PROPOSED GROUNDWATER MONITORING PLAN:

It is recommended that at least three boreholes should be drilled at the proposed site as part of future site monitoring. This will allow for monitoring of the groundwater quality and groundwater levels across the site. The optimum position of the monitoring boreholes should be based on availability of open space surrounding the fuel stations, however, the two boreholes should be down-gradient of the proposed filling station. The borehole should be appropriately designed and constructed. The borehole water level (if present) and the groundwater quality should be monitored quarterly, so as to determine seasonal fluctuation. The development of a groundwater monitoring programme will be important for assessing any impacts of the site on groundwater and the environment.

It is recommended that groundwater monitoring be undertaken at the proposed site in accordance with guidelines set out in the publication by DWAF (1998). The various aspects of the monitoring are presented in this section, along with relevant recommendations.

10.1.1 Borehole drilling and construction specifications

The drilling will include at least three boreholes at the proposed site. The drilling should be supervised by a hydrogeologist and drill samples should be collected every 1 metre and logged. Additional information should also be collected such as the depth of water strikes, associated water strike yields and groundwater quality. This is crucial information for the optimal design of the boreholes. The driller should be supervised to ensure all site requirements are met. A graphical representation of a proposed borehole construction is presented in **Figure 5**; the exact construction will, however, be unique for the borehole.

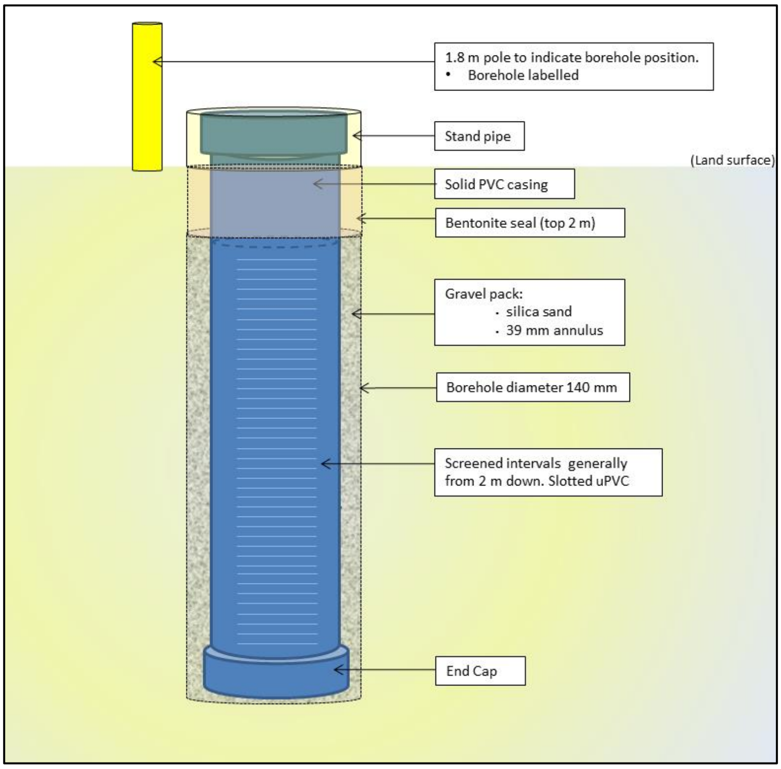


Figure 5: Schematic representation of the proposed general borehole construction.

The boreholes are to be drilled by means of air-percussion. It is not anticipated that multiple aquifers will be present in the unconsolidated material overlying the bedrock but it will still be important for drilling to be supervised by a hydrogeologist. The inner diameter of the uPVC casing must not be less than 110 mm.

A gravel pack should be installed with an annulus of about 5 mm. The boreholes should be developed with compressed air for at least two hours upon completion along with an airlift test to estimate the yield of the borehole. Each borehole must be protected with a concrete block or a flush manhole if there is traffic in the area. Each borehole also needs a permanent plate glued to the lid containing the details pertaining to the borehole. A bentonite plug of at least 500 mm needs to be installed at the top of the hole to prevent ingress of surface water.

10.1.2 Groundwater levels

Groundwater level measurements are recommended for the monitoring borehole at the study site. A dip meter can be used to measure the water level below the top of the borehole collar/casing height (mbch). The height of the collar/casing height must then also be measured (m). The water level (metres below ground level (mbgl)) can then be calculated by subtracting the collar/casing height from the water level (mbch). The value must be recorded along with the date and time of measurement. An interface meter can be used during monitoring to detect the presence of non-aqueous phase liquids (if present).

10.1.3 Sampling process

It is preferable to use a low volume sampling pump in most monitoring boreholes (known as a bladder pump). The groundwater should be pumped into a flow-through cell, an EC and pH probe should be placed into the flow-through cell and be pumped until field chemistry parameters stabilise prior to sampling.

10.1.4 Sample Collection, Preservation and Submission

Sample bottles must be labelled with the borehole name, site name and date. At the time of sampling field, chemistry parameters must be measured and recorded. These include electrical conductivity (EC), oxidation reduction potential (ORP), pH, temperature and dissolved oxygen (DO). Samples must be taken in their correct sampling container and preserved in the correct manner prior to submission to an accredited laboratory for the analysis parameters. The sample method and preservation must be discussed with the laboratory prior to sampling.

10.1.5 Sampling frequency and parameter analysis

In order to best understand and monitor the site, it is recommended that quarterly water level measurements be taken (to determine seasonal fluctuation). It is however, considered adequate for boreholes to be sampled for chemical analysis bi-annually. **Table 9** indicates the minimum set of parameters used to identify hydrocarbons contamination. It will also be important to sample for any microbial contamination associated with sewage treatment plant and effluent dam.

Table 9: Source-based selection of groundwater quality monitoring variables (DWAF,2004).

Source Activity	**Fuel storage tanks**
Indicators	**pH, EC and DOC**
Variables	pH EC Alkalinity DOC BTEX and VOC **<u>Trace Elements</u>** Cd, Cr,Cu, Fe, Ni, Zn, V

11. CONCLUSION

The study site has been classified as having a groundwater vulnerability classification of "low/medium". Given that no groundwater was intersected during the site investigation, likely due to the high clay content of the soil and resultant low permeability, the development of the filling station is deemed to pose a low risk to groundwater if appropriate mitigation measures are employed. The planned irrigation using treated effluent is a commendable example of re-use of water and will result in less pressure on the current surface water demand. This will require on-going management and monitoring to be successful in the long term, and to ensure quality is compliant with discharge limits.

Surface water contamination on the other hand may occur more readily due to the low permeability of the soil in times of high rainfall. Appropriate measures need to be taken to ensure stormwater management reduces the chance of surface water contamination, and this together with groundwater monitoring, will further lower the risk posed by the filling station and treated effluent to groundwater and the environment.

12. REFERENCES

CGS (1979). 1:250 000 scale Geological map Series. Map number 3322 Oudtshoorn. Council for Geoscience.

Conrad J. and Munch Z., (2007). Groundwater recharge and vulnerability mapping – a national scale approach; GWD Conference Bloemfontein, 8 – 10 October 2007 pp 46 – 56.

DWAF (1998). Waste Management Series. Minimum requirements for water monitoring at waste management facilities. Document 3 – monitoring of water at and around waste disposal facilities. Second Edition 1998. Department of Water Affairs and Forestry. Pretoria.

DWAF (2002). The hydrogeological map series of the republic of South Africa. Cape Town, 3318. Scale: 1:500 000.

DWAF (2005). Groundwater Resource Assessment Phase II (GRA II). Department of Water Affair and Forestry. Pretoria.

Element (2020), Proposed Development of Herolds Bay Estate on Portion 7 of the Farm Buffelsfontein, Herolds Bay, rev 4. Jan 2020, Element Consulting Engineers

GEOSS (2016). Geohydrological assessment – Louis Fourie Waste Disposal Site, Mossel Bay. GEOSS Report Number: 2016/06-12. GEOSS - Geohydrological & Spatial Solutions International (Pty) Ltd. Stellenbosch, South Africa.

Freeze, R.A., and Cherry, J.A., (1979), Groundwater: Englewood Cliffs, NJ, Prentice-Hall.

National Water Act (1998). The National Water Act, No 36. Department of Water Affair and Forestry. Pretoria.

Schulze, R. E., (2009). SA Atlas of Climatology and Geohydrology; obtained from Western Cape Government Agriculture - http://gis.elsenburg.com/apps/cfm/: Long term median rainfall per month (1950-2000).

WRC, (2012). A Groundwater Planning Toolkit for the Main Karoo Basin: Identifying and quantifying groundwater development options incorporating the concept of wellfield yields and aquifer firm yields. WRC Report No. 1763/1/11, Pretoria, South Africa.

13. APPENDIX A: SITE VISIT PHOTOS

TP_01

Figure 6: A shows the thick vegetation where surface water concentrates. AH1 was positioned in the foreground of this photo in an attempt to intersect groundwater.
B shows the grey-red-brown weathered clay found across the site, typical of the weathered granite.
C shows angular quartz crystals and micaceous minerals just before hole refusal when going from weathered zone to less weathered granites.
D shows piezometer installation – no groundwater was measurable here even though soil had greatest moisture content for the site.

TP_02

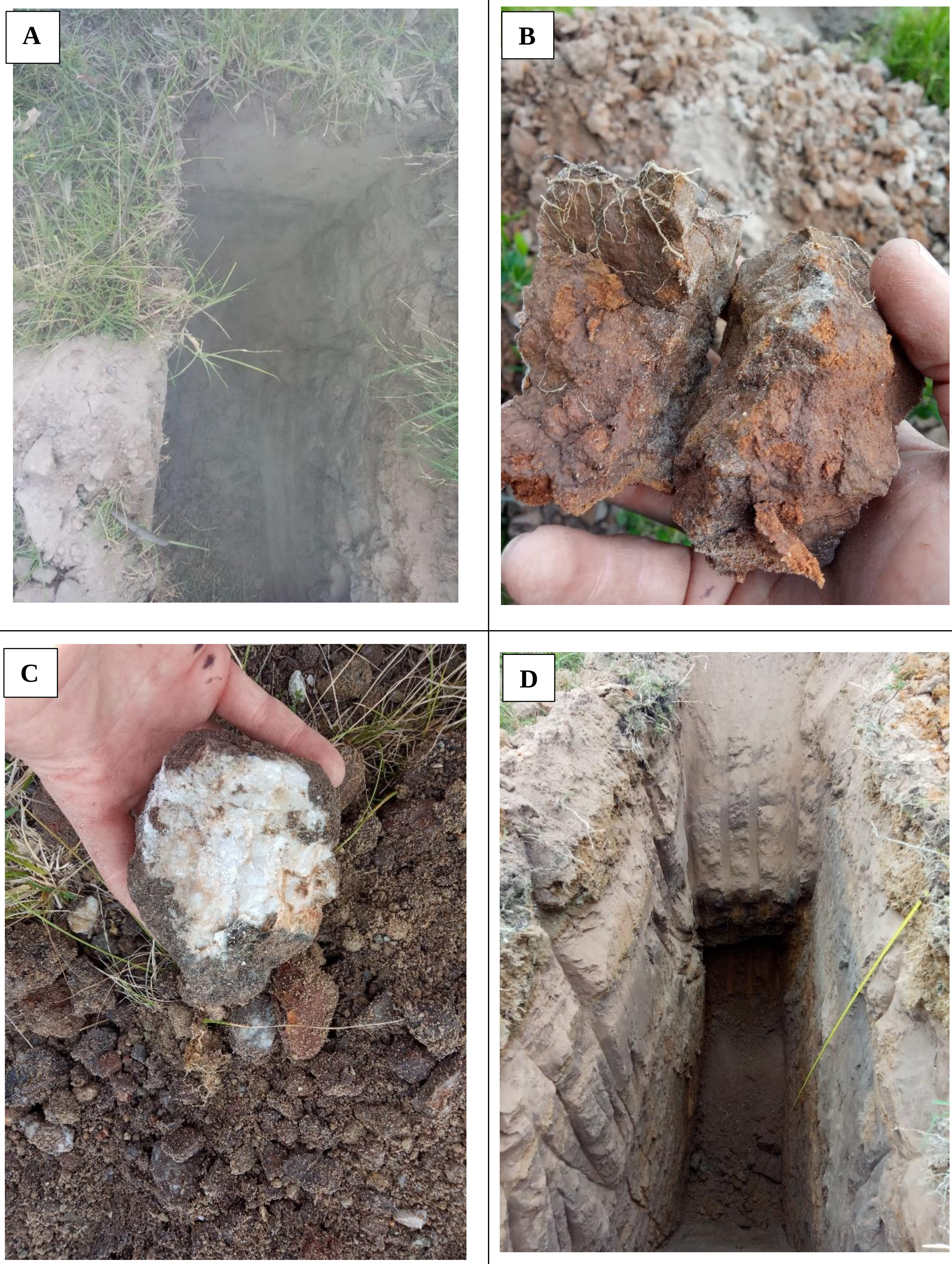


Figure 7: A shows excavation of TP1.
B shows dry, red, firm, sandy CLAY from TP1.
C presents a large quartz crystal just before refusal of shows final trial pit depth.
D shows Trial Pit 3 (TP3) with final depth of 2.8 m.

TP_02

Figure 8: A shows TP3 backfilled and levelled, no sign of collapsing soils,
B shows mounding of the stiff clay in TP4, keeping the shape of the TLB bucket,
C shows the excavation of TP5 and
D shows excavation of TP7 where a package plant is to be constructed.

14. APPENDIX B: SOIL PROFILES

Log of Auger Hole No.: AH1

Location:	Herolds Bay Country Estate	**Latitude:**	-34.04573
Date:	9-Jul-20	**Longitude:**	22.40198
Client:	GFA Holdings	**Ground Elevation:**	162 mamsl

Lithological Description | **Lithology (mbgl)** | **Construction** | **Comments**

Unit 1:
0.00 - 0.25

Moist, dark brown, clayey SAND with high organic volume. Transported

Slightly moist, grey-brown, loose, SAND. Transported

Unit 2:
0.25 - 1.01

Slightly moist, light grey-brown with red mottling, firm

Moist, dark brown, frim, sandy CLAY.

Very moist, dark grey-brown, soft, sandy CLAY.

Very moist, dark grey-brown, soft, sandy CLAY. Residual

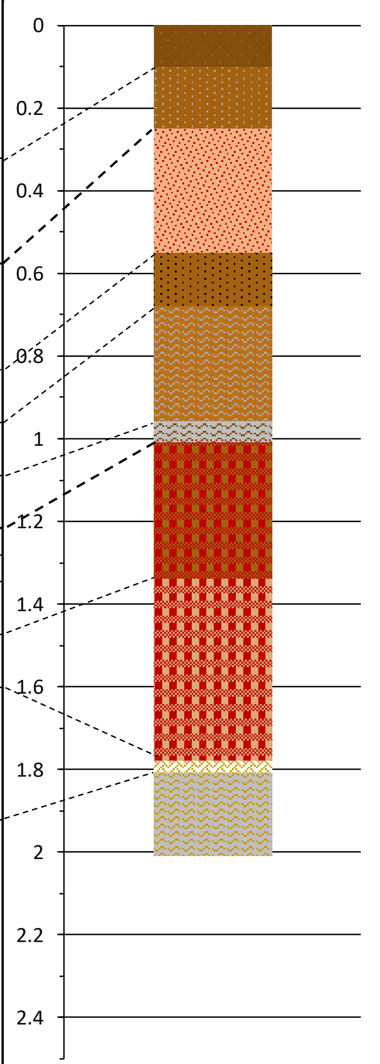
Unit 3:
1.01 - 2.01

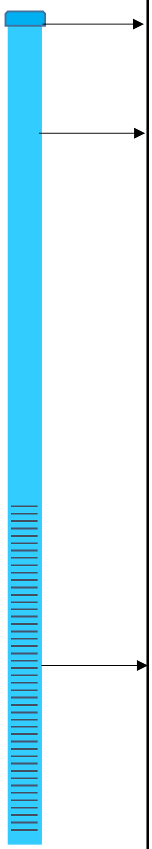
Moist, dark brown, with red mottling, firm, sandy CLAY.

Moist, grey brown with red mottling, firm, sandy CLAY.

Moist, grey brown, firm, sandy CLAY, with angular quartz and micaceous crystals.

Slightly moist, grey, sandy CLAY with high content of quartz and micaceous minerals. Residual. Hard augering conditions





Comments:

Cap

50 mm solid PVC

50 mm slotted PVC

End of Hole = 2.01 mbgl
Refusal

Excavated By:	GEOSS	**Remarks:**	Riparian zone. Moist soil, no measurable water table. Piezometer left
Drill Method:	TLB Excavator		
Logged By:	Neville Paxton		

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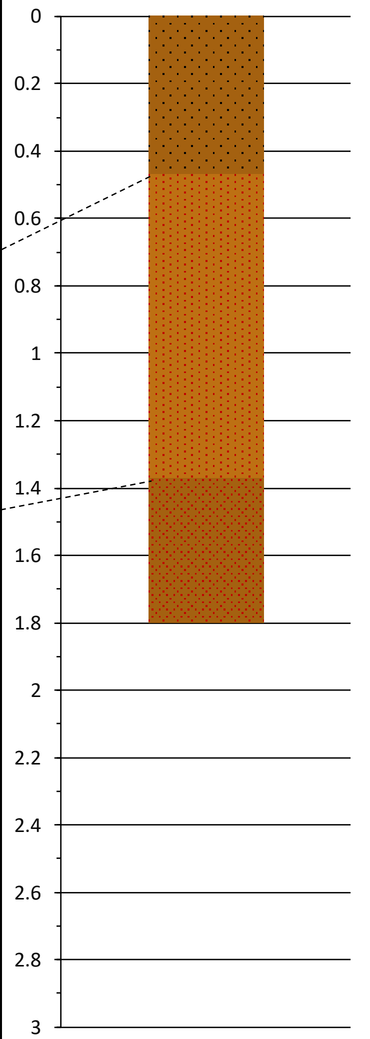
Log of Auger Hole No.: AH2

Location:	Herolds Bay Country Estate	**Latitude:**	-34.044107
Date:	9-Jul-20	**Longitude:**	24.404313
Client:	GFA Holdings	**Ground Elevation:**	170 mamsl

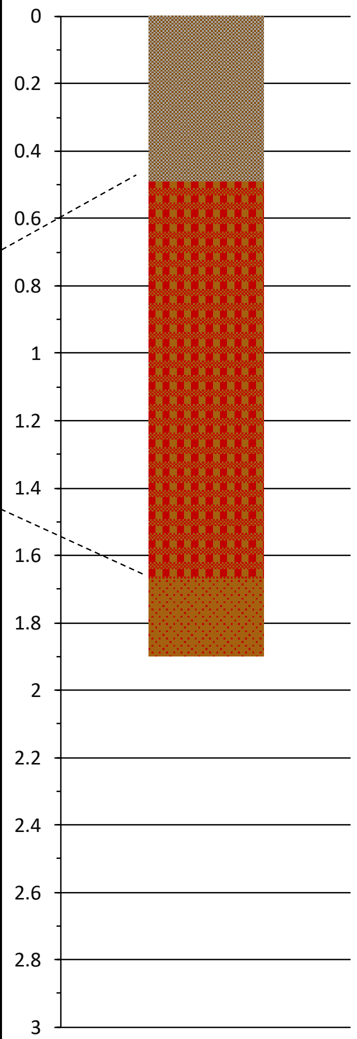
Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 0.47 Moist, dark-brown, loose to medium dense, sandy CLAY. Transported. Medium organic content		***No groundwater intersected*** ***Piezometer not installed***	Very slow progress with auger. No moisture, EOH 1.8m
Unit 2: 0.47 - 1.31 Moist, red-brown, stiff, sandy Clay. Residual			
Unit 3: 1.31 - 1.8 Dry, red brown, very stiff CLAY. Very slow progress with auger. No moisture, EOH.			

Excavated By:	GEOSS	**Remarks:**	Riparian zone. No groundwater.
Drill Method:	TLB Excavator		
Logged By:	Neville Paxton		

GEOSS SOUTH AFRICA (Pty) Ltd

Log of Auger Hole No.: AH3

Location:	Herolds Bay Country Estate	**Latitude:**	-34.04325
Date:	9-Jul-20	**Longitude:**	22.40414
Client:	GFA Holdings	**Ground Elevation:**	175mamsl

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 0.49 Slightly moist, dark grey-brown, loose, clayey SAND. Transported		***No groundwater intersected*** ***Piezometer not installed***	Cap
Unit 2: 0.49 - 1.67 Slightly moist, dark brown and grey with red mottling, firm, sandy CLAY. Residual			
Unit 3: 1.67 - 1.9 Clay very stiff and very slow progress with auger. No moisture above or within CLAY, EOH.			Very slow progress with auger. No moisture, EOH 1.9m

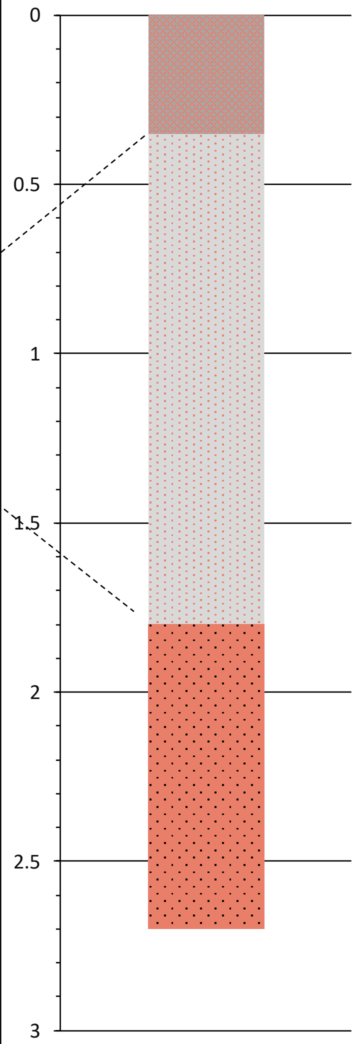
Excavated By:	GEOSS	**Remarks:**	Riparian zone. No groundwater.
Drill Method:	TLB Excavator		
Logged By:	Neville Paxton		

GEOSS SOUTH AFRICA (Pty) Ltd

Log of Trial Pit No.: TP1

Location:	Herolds Bay Country Estate	**Latitude:**	-34.04612
Date:	9-Jul-20	**Longitude:**	22.40245
Client:	GFA Holdings	**Ground Elevation (mamsl):**	166

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 0.35 Dry, red-grey, sandy CLAY. Residual			
Unit 2: 0.35 - 1.8 Dry, grey, fine-medium grained, clayey SAND. Residual			
Unit 3: 1.8 - 2.70 Dry, red, sandy CLAY with minor root structures. Residual		***No groundwater intersected*** ***Piezometer not installed***	EOH = 2.7m



Excavated By:	GEOSS	**Remarks:**	Test pit walls stable - no signs of collapse when backfilled. No Groundwater
Drill Method:	TLB Excavator		
Logged By:	Neville Paxton		

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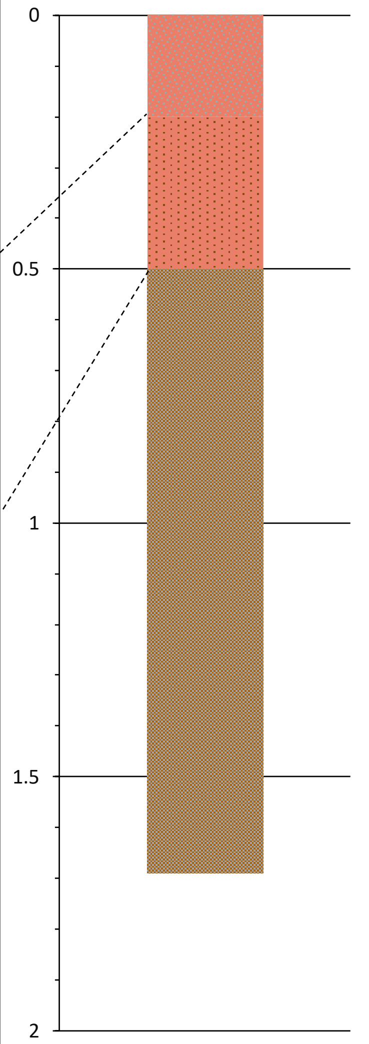
Log of Trial Pit No.: TP2

Location:	Herolds Bay Country Estate	**Latitude:**	-34.0454
Date:	9-Jul-20	**Longitude:**	22.40246
Client:	GFA Holdings	**Ground Elevation (mamsl):**	165

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 0.2 Slightly moist, grey-red, soft, clayey SAND. Residual granite.		***No groundwater intersected*** ***Piezometer not installed***	EOH = 1.69 m; Refusal on medium weathered granite
Unit 2: 0.2-0.5 Slightly moist, red, firm, sandy CLAY. Residual			
Unit 3: 0.5 - 1.69 Slighlty moist, grey brown, firm, sandy CLAY. Residual granite			

Excavated By:	GEOSS	**Remarks:**	Test pit walls stable - no signs of collapse when backfilled. No Groundwate
Drill Method:	TLB Excavator		
Logged By:	Neville Paxton		

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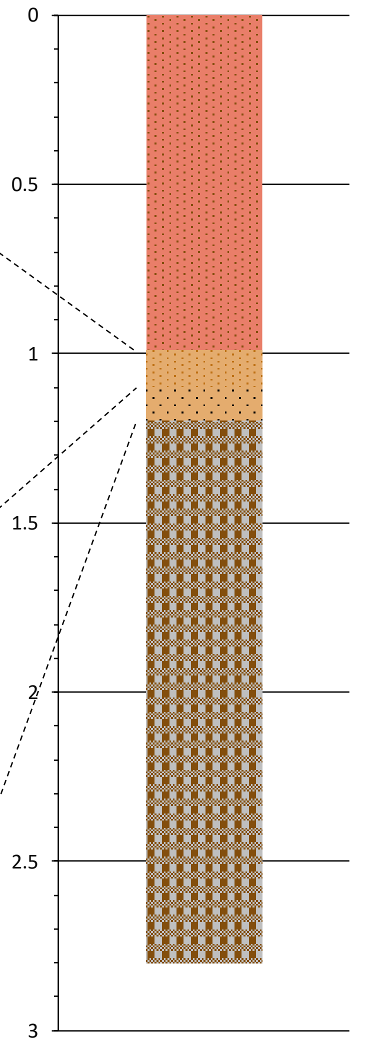
Log of Trial Pit No.: TP3

Location:	Herolds Bay Country Estate	**Latitude:**	-34.04592
Date:	9-Jul-20	**Longitude:**	22.40217
Client:	GFA Holdings	**Ground Elevation (mamsl):**	163

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 0.99 Slightly moist, red-brown, loose, sandy CLAY. Transported		***No groundwater intersected*** ***Piezometer not installed***	EOH = 2.8 m
Unit 2a: 0.99-1.1 Dry to Slightly moist, red-brown, loose, sandy CLAY. Residual			
Unit 2b: 1.1 - 1.2 Dry to slighlty moist,red brown and grey, firm, sandy CLAY. Residual			
Unit 3: 1.2 - 2.8 Dry to slightly moist, light grey-red to dark brown mottling, firm to stiff, CLAY. Residual			

Excavated By:	GEOSS	**Remarks:**	Side walls of test pt near vertical, soil is very stable. After backfill, no notable collapse of soil. No Groundwater
Drill Method:	TLB Excavator		
Logged By:	Neville Paxton		

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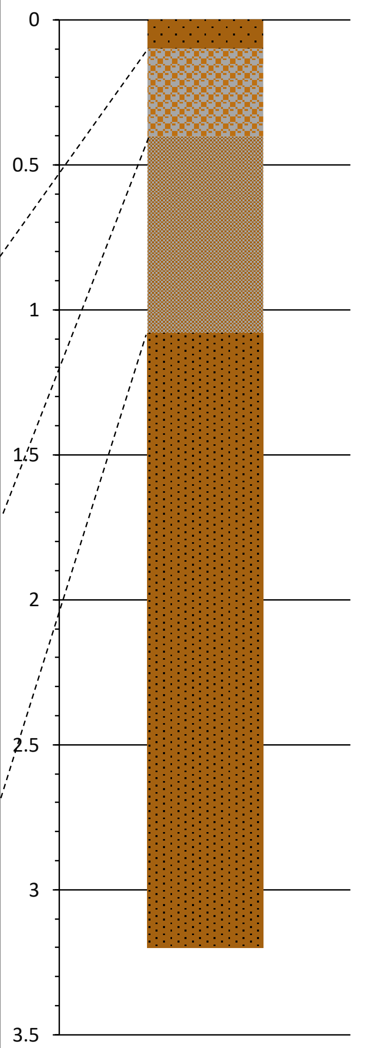
Log of Trial Pit No.: TP4

Location:	Herolds Bay Country Estate	**Latitude:**	-34.04531
Date:	9-Jul-20	**Longitude:**	22.4023
Client:	GFA Holdings	**Ground Elevation (mamsl):**	165

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 0.1 Slightly moist, dark brown, loose, sandy CLAY, high organic component. Transported			
Unit 2: 0.1 - 0.4 Slighlty moist, grey brown, soft, sandy CLAYwith large granite rock chunks.Transported			
Unit 3: 0.4 - 1.08 Moist, grey brown, loose, fine to medium grained, sandy CLAY. Residual		***No groundwater intersected*** ***Piezometer not installed***	
Unit 4: 1.8 - 3.2 Slightly moist, dark brown, firm, CLAY, slightly - medium weatherd granite. Residual			EOH = 3.2 m.; refusal



Excavated By:	GEOSS	**Remarks:**	EOH due to weathered granite and lack of moisture.
Drill Method:	TLB Excavator		
Logged By:	Neville Paxton		

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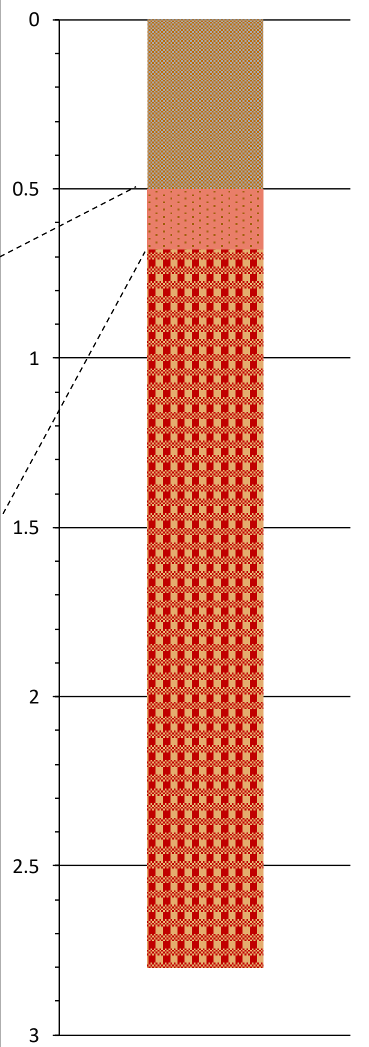
Log of Trial Pit No.: TP5

Location:	Herolds Bay Country Estate	**Latitude:**	-34.045144
Date:	9-Jul-20	**Longitude:**	22.404633
Client:	GFA Holdings	**Ground Elevation (mamsl):**	175

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.0 - 0.5 Slightly moist, grey brown, loose, fine to medium grained, clayey SAND. Transported			
Unit 2: 0.5 - 0.68 Dry, red brown, firm, sandy CLAY. Residual			
Unit 3: 0.68 - 2.8 Slightly moist, grey brown with red mottling, stiff, CLAY. Residual		***No groundwater intersected*** ***Piezometer not installed***	EOH = 2.8 m

Excavated By:	GEOSS	**Remarks:**	EOH due to weathered granite and lack of moisture.
Drill Method:	TLB Excavator		
Logged By:	Neville Paxton		

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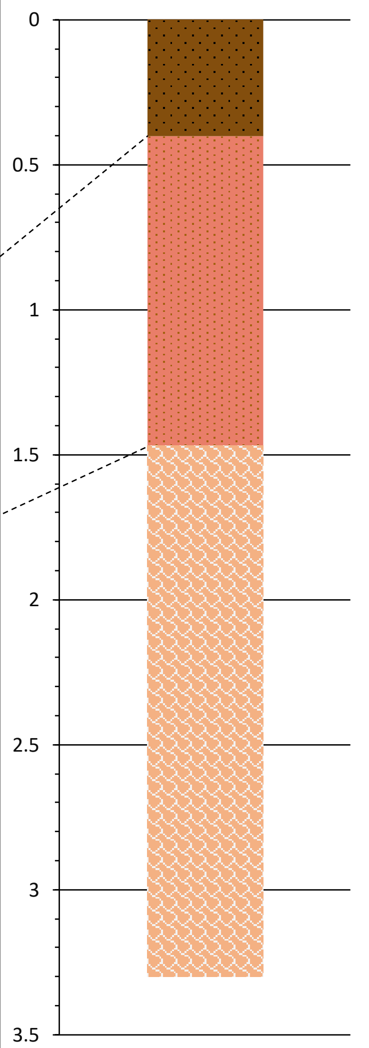
Log of Trial Pit No.: TP6

Location:	Herolds Bay Country Estate	**Latitude:**	-34.046125
Date:	9-Jul-20	**Longitude:**	22.405751
Client:	GFA Holdings	**Ground Elevation (mamsl):**	182

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.0 - 0.4 Dry, dark brown, fine to medium grained, sandy CLAY, with animal holes and root structures. Transported		***No groundwater intersected*** ***Piezometer not installed***	EOH = 3.3 m
Unit 2: 0.4 - 1.47 Dry, red, fine to medium grained, firm, sandy CLAY.			
Unit 3: 1.47 - 3.3 Dry, red with white calcareous fissures within clay, fine to medium grained, stiff, sandy CLAY. Residual			

Excavated By:	GEOSS	**Remarks:**	EOH at 3.3m. No shallow moisture.
Drill Method:	TLB Excavator		
Logged By:	Neville Paxton		

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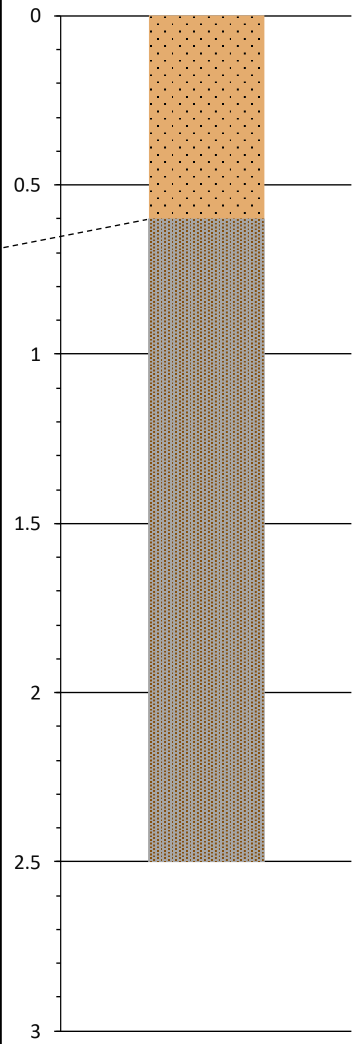
Log of Trial Pit No.: TP7

Location:	Herolds Bay Country Estate	**Latitude:**	-34.043556
Date:	9-Jul-20	**Longitude:**	22.40933
Client:	GFA Holdings	**Ground Elevation (mamsl):**	156

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.0 - 0.6 Dry, brown to grey, loose, clayey SAND. Transported		***No groundwater intersected*** ***Piezometer not installed***	EOH = 2.5 m
Unit 2: 0.6 - 2.5 Dry, brown grey, loose, clayey SAND with roots at 0.6m. Residual			

Excavated By:	GEOSS	**Remarks:**	EOH at 2.5 m. No shallow moisture and refusal
Drill Method:	TLB Excavator		
Logged By:	Neville Paxton		

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