Groundwater Impact Assessment for the Proposed Extension of the Hout Bay Cemetery, Western Cape.

REPORT: GEOSS Report No: 2023/12-21 ***PREPARED FOR:*** Angela Botha Zutari 1 Century City Drive Century City Cape Town 7446 Tel: 021 526 9400 Email: angela.botha@zutari.com	***PREPARED BY:*** Zita Harilall 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)

20 December 2023

GROUNDWATER AND EARTH SCIENCES
GEOSS
SOUTH AFRICA (Pty) Ltd

EXECUTIVE SUMMARY

Angela Botha of Zutari approached GEOSS to complete a groundwater impact assessment of the remaining extent of property 1469, Hout Bay. Due to the shortage of suitable burial locations within Cape Town, the city is seeking to extend the footprint of the existing cemetery. The aim of the hydrogeological assessment is to determine whether the proposed extension will have an impact on the local groundwater resources.

The study included a desktop assessment of various groundwater databases and a review of hydrogeological and geological maps for the study area. A field visit was conducted to determine the potential impact on the existing groundwater users. The field visit entailed conducting a hydrocensus of existing groundwater users surrounding the study site and inspecting makeshift trial pits in an attempt to understand the subsurface.

The site is mapped to overlie coarse-porphyritic granitic outcrops of the Cape Peninsula Pluton. Cambrian-aged granitic intrusions of the Cape Peninsula Pluton (which forms part of the Cape Granite Suite) are often overlain by thin layers of Quaternary alluvial deposits. Alluvium deposits are present along the riverbed and banks of the Hout Bay River, which is located nearby. Brackish calcareous soil is mapped along the Hout Bay River to the west and southwest of the study site. The competent sandstone of the Peninsula Formation is highly fractured and faulted, resulting in the formation forming an extensive aquifer. Southeast-northwest trending faults are mapped through the Peninsula Formation. Scree deposits are present along the slopes of the mountains southeast of the site.

The aquifer underlying the site is classified as a perched, intergranular aquifer with ideal water quality that is highly susceptible to point-based contamination. Beneath the primary aquifer is a secondary, fractured aquifer, which has an average yield potential of 0.5 – 2.0 L/s. The two aquifers are separated by a thick clay layer which has weathered from the granitic bedrock. Based on the regional groundwater quality, as indicated by electrical conductivity (EC), the groundwater quality in the area is in the range of 0 – 70 mS/m.

From the desktop study and fieldwork, it is evident that there are a number of small-scale groundwater users surrounding the study area, particularly in the residential areas to the north of the study area. Although little information is available for the CoCT boreholes, it is highly likely that groundwater abstraction mainly occurs from the secondary fractured aquifer as the primary aquifer is considered to be unproductive for large-scale abstraction. Due to the perched nature of the primary aquifer, is inferred that there is limited connectivity between the primary and secondary aquifer. Further, sample collection from a nearby borehole located down-gradient of the cemetery indicates that the water is of ideal to good quality. This is an indication that historical activities of the cemetery have not impacted the water quality in the deeper fractured aquifer.

Given the high vulnerability that is mapped for the underlying aquifer, the risk of contamination is considered. For a risk to exist there must be a source(s), pathway(s) and receptor(s). The proposed extension of the cemetery represents a potential source of contamination. The underlying aquifer represents both a potential pathway and receptor. Groundwater users and the surrounding environment represent receptors of potential contamination. It should, however, be noted that due to the depth of the water table being more than 1 metre deeper than the burial depth, the source-pathway-receptor linkages are considered to be incomplete.

The proposed extension of the cemetery is considered to have a low risk to groundwater resources. It does, however, remain necessary to implement appropriate screening measures to ensure that no activities impact the aquifer. It is of GEOSS's opinion that the site is suited for use as a cemetery, given the lack of shallow groundwater. Note that these recommendations are based on GEOSS's opinion, and the final decision on the necessary approval and groundwater monitoring requirements resides with the regulatory authorities.

The following recommendations are made:

* The burials of bodies should only take place where the water table is more than 4 mbgl. This is a proposed mitigation measure.
* It is recommended that a third piezometer be installed up-gradient of the site to continue groundwater monitoring.
* Biannual quality monitoring of the groundwater is recommended to ensure that the water quality remains unimpacted.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

ABBREVIATIONS

BH	Borehole
BOD	biological oxygen demand
CoCT	City of Cape Town
COD	chemical oxygen demand
CGS	Council for Geoscience
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water Affairs and Sanitation
EC	electrical conductivity
L/s	litres per second
m	metres
m^3/ha/a	cubic metres per hectare per annum
mamsl	metres above mean sea level
mbch	metres below collar height
mbgl	metres below ground level
mg/L	milligrams per litre
mm	millimetre
mm/a	millimetres per annum
mS/m	milli-Siemens per metre
NGA	National Groundwater Archive
nd	not detected
TOC	total organic carbon
WARMS	Water Authorisation and Registration Management System

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).
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.
Intergranular aquifer:	An aquifer in which groundwater is stored in and flows through open pore spaces in the unconsolidated Quaternary deposits.

Suggested reference for this report:

GEOSS (2023). Groundwater Impact Assessment for the Proposed Extension of the Hout Bay Cemetery, Western Cape. GEOSS Report Number: 2023/12-21. GEOSS South Africa (Pty) Ltd. Stellenbosch, South Africa.

Cover photo:

New Apostolic Church located on the grounds of the Hout Bay Cemetery.

GEOSS project number:

2023_09-5267

Reviewed by:

Julian Conrad (20 December 2023).

SPECIALIST EXPERTISE

CURRICULUM VITAE – Zita Harilall

GENERAL

Nationality:	South African
Profession:	Hydrogeologist
Specialization:	Groundwater management and monitoring including stable and radioisotope analysis.
Position in firm:	Hydrogeologist at GEOSS South Africa (Pty) Ltd
Date commenced:	November 2018
Language skills:	English (mother tongue), Afrikaans (average)

KEY SKILLS

- Groundwater sampling and monitoring – development and implementation of groundwater monitoring and management programmes; analysis of groundwater level and quality (chemistry) data.
- Advanced chemistry monitoring and residence time determination – stable and radioisotope analysis.
- Groundwater impact and contamination – investigation and assessment of industrial activities on groundwater resources.
- Writing of hydrogeological reports
- Conducting hydrocensus studies
- ArcMap / Geochemist's Workbench / WISH and typical software skills.

EDUCATIONAL AND PROFESSIONAL STATUS

Qualifications

2020	M.Sc. (Geology)	University of Stellenbosch, South Africa
2017	B.Sc. (Hons) Earth Science	University of Stellenbosch, South Africa
2016	B.Sc. Earth Science	University of Stellenbosch, South Africa

Courses and symposiums

2016	Introduction to C++ (US)
2017	Introduction to Micromine (US)
2018	Introduction to R (AEON – NMU)
2018	ArcGIS and Spatial Statistics (AEON – NMU)
2019	International Symposium of Isotope Hydrology (IAEA) [poster]
2019	Groundwater Age Dating using Noble Gas Concentrations (US)
2020	International Association of Hydrogeologists (IAH)
2022	NICOLA: Resiliency, Nature and Climate Solutions: Striving for Sustainable Land Management
2023	International Association of Hydrogeologists (50th Annual Congress)

Memberships/Organisations

- South African Council for National Scientific Professions (SACNASP) – Mem. No. 134005 (Cand.Sci. Nat)
- Groundwater Division (GWD) of the GSSA – Mem No. 2742/22
- Network for Industrially Contaminated Land in Africa (NICOLA) – Mem No. NM60b/2022
- Golden Key Honours Society

EMPLOYMENT RECORD

January 2023 – present:	GEOSS South Africa (Pty) Ltd, Stellenbosch ***Project Hydrogeologist: Impact and Contamination Business Unit Leader***
January 2020 – December 2022:	GEOSS South Africa (Pty) Ltd, Stellenbosch ***Project Hydrogeologist***
November 2018 – December 2019:	GEOSS – Geohydrological and Spatial Solutions International (Pty) Ltd ***Student Hydrogeologist***

SPECIALIST DECLARATION

We, Zita Harilall and Julian Conrad, as the appointed independent specialists hereby declare that we:

- act/ed as the independent specialist in this application;
- regard the information contained in this report as it relates to our 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 no 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
- are aware that a false declaration is an offence in terms of regulation 71 of GN No. R. 543.

Zita Harilall
GEOSS South Africa (Pty) Ltd
SACNASP – Cand. Sci. Nat 134005
20 December 2023

Julian Conrad
GEOSS South Africa (Pty) Ltd
SACNASP – Pr.Sci.Nat:
20 December 2023

1. INTRODUCTION

GEOSS was approached by Angela Botha of Zutari to complete a groundwater impact assessment of the remaining extent of property 1469, Hout Bay (**Map 1** and **Map 2**). Due to the shortage of suitable burial locations within the City of Cape Town, the City is seeking to extend the footprint of the existing cemetery. The aim of the hydrogeological assessment is to determine whether the proposed extension will have an impact on the local groundwater resources.

The study included a desktop assessment of various groundwater databases as well as the review of hydrogeological and geological maps for the study area. Thereafter, a field visit was conducted to determine the potential impact on the existing groundwater users. The field visit entailed conducting a hydrocensus of existing groundwater users surrounding the study site and inspecting makeshift trial pits in an attempt to understand the subsurface.

2. SCOPE OF WORK

The scope of work is to provide groundwater specialist services, including the tasks outlined below:

- Review of available literature and studies pertaining to the study site.
- Assess the presence and quality of groundwater in the study area.
- Assess the potential impact of the proposed development on hydrogeological resources.
- Provide recommendations and mitigation measures to minimize risk and impacts from mining operations.

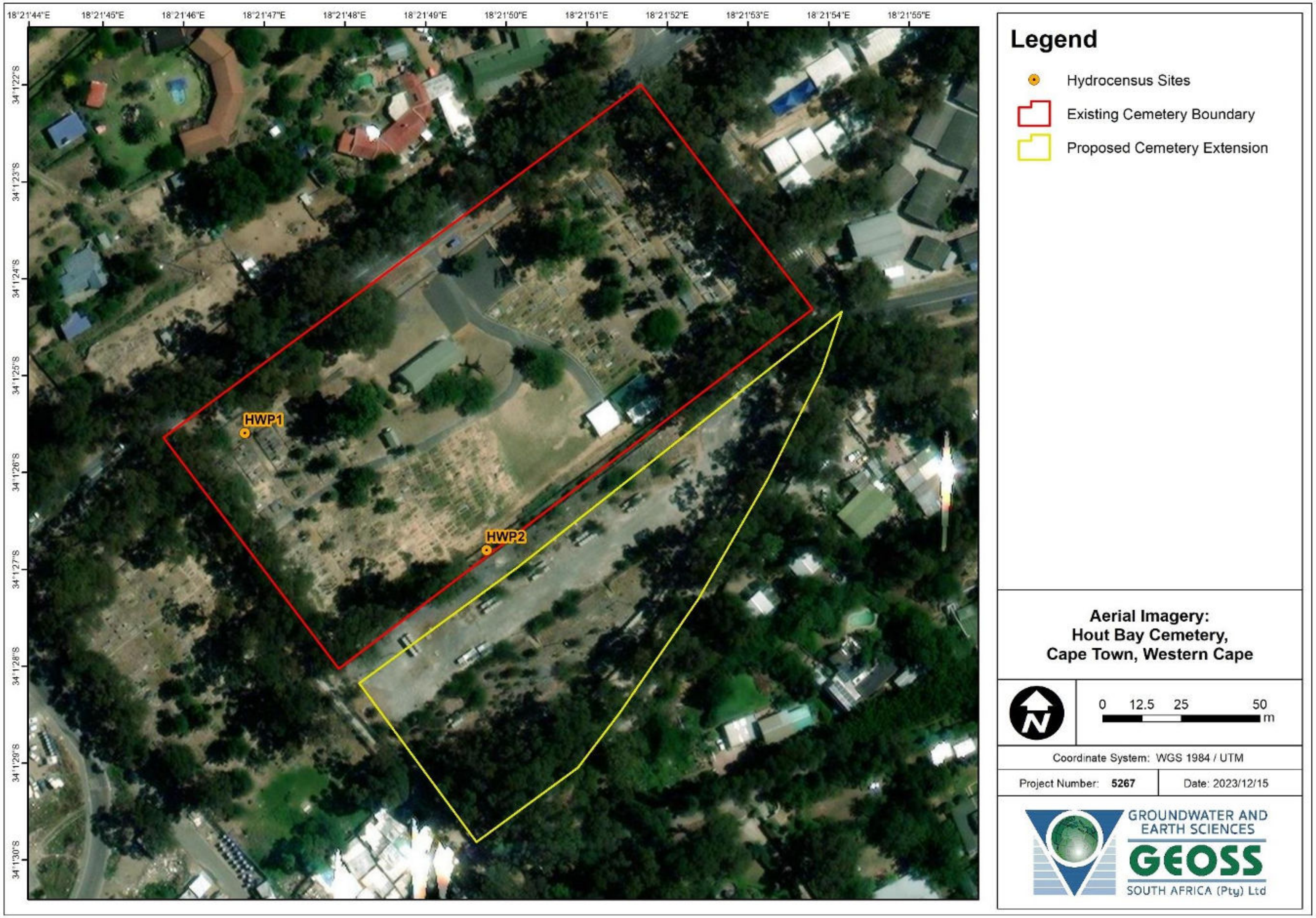
The assessment has been conducted in accordance with accepted best practice principles, particularly the DEA&DP Guideline for involving Hydrogeologists in the EIA Process (June 2005).

3. METHODOLOGY

The procedure adopted for this study involved a desktop study followed by fieldwork. The initial desktop study involved obtaining and reviewing all relevant data for the project. This included reviewing relevant site plans, reports, and geological maps of the area and analysing data from multiple groundwater databases, which included information on groundwater yield and quality.

A site visit was then conducted to collect additional data and verify as much of the existing data as possible. This included a hydrocensus of groundwater users in the area and noting any subsurface conditions where possible. All collected data was analysed and interpreted to assess the potential risks associated with the intended site development as they pertain to groundwater.

Map 1: Locality of the Hout Bay Cemetery, Hout Bay, Cape Town.



Map 2: The existing cemetery and the land demarcated for the proposed extension of the Hout Bay Cemetery.

4. REGIONAL SETTING

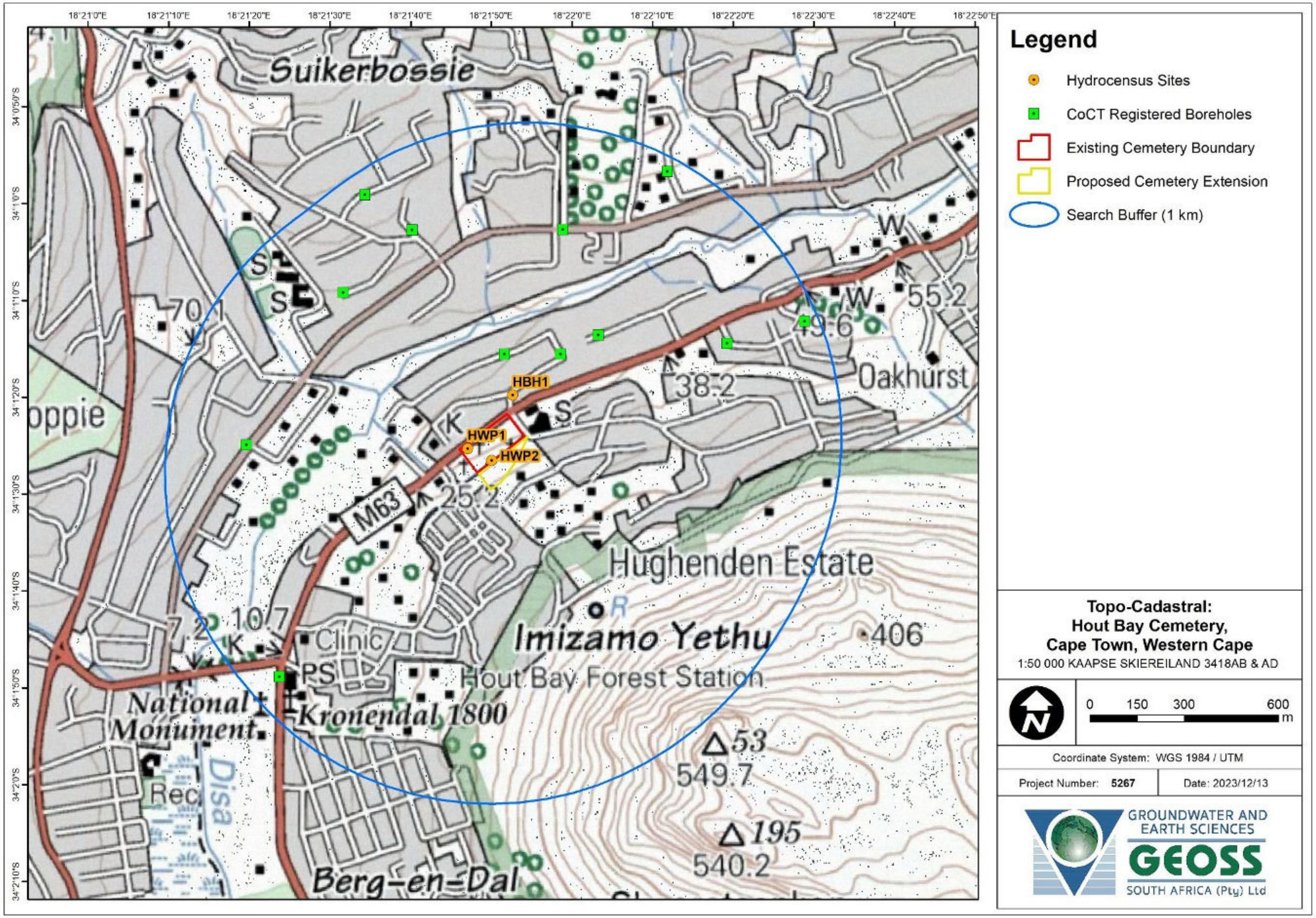
4.1 Site Context

The study area is located in the southern suburbs of Cape Town, approximately 12.5 km south west of Cape Town city centre. The cemetery is located in Hout Bay on Erfs 1460, 1461, 1462, 2531, 2532 and 2533 and is approximately 1.71 hectares (17 100 m^2) in size. The site is located along Hout Bay Main Road, is owned by the City of Cape Town, and is managed by the Parks and Recreation Department. Due to the shortage of suitable burial locations within Cape Town, the city is seeking to extend the footprint of the existing cemetery. Adjacent land to the south of the existing cemetery is targeted for the proposed extension. The proposed development area is approximately 0.8 hectares (7 982 m^2) in size.

The demarcated land is located within quaternary catchment G22B and forms part of the Berg River Management Area. The quaternary catchment is approximately 110 km^2 in extent and has a General Authorisation (GA) of 400 m^3/ha/a for groundwater use. The relief is northwest sloping, from the mountainous outcrop in the southeast towards the Hout Bay River with an elevation range of 69 – 42 metres above mean sea level (mamsl). The cemetery is surrounded by standard residential areas to the north, east and southeast, while an informal settlement is located to the southwest. A topocadastral map of the study area is presented in **Map 3**.

4.2 Climate

The study area experiences a Mediterranean climate with cool wet winters and warm dry summers. **Figure 1** illustrates the monthly average minimum and maximum air temperatures and **Figure 2** illustrates the monthly mean rainfall and evaporation distribution for the study area (Schulze, 2009). Long-term rainfall data (1950 – 2000) indicates that the study area receives a mean annual precipitation of 839 mm/a. Rainfall occurs throughout the year with rainfall volumes exceeding evaporation rates during the cooler months of the year (April to September). Consequently, the peak groundwater recharge period for the Hout Bay area is during the rainy season.



Map 3: Topocadastral map of the study site and the hydrocensus boreholes (1:50 000 scale 3418 AB and AD Kaapse Skiereiland (CGS, 2010)).

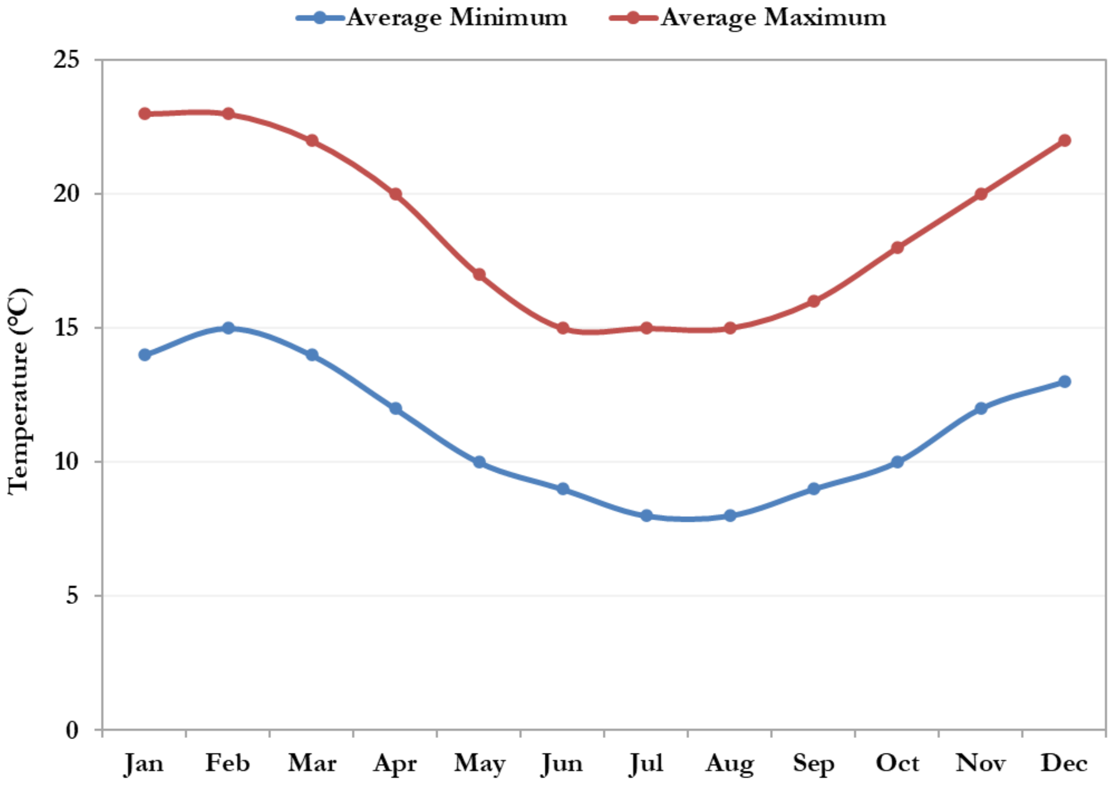


Figure 1: Monthly average minimum and maximum air temperatures for the study area (Schulze, 2009).

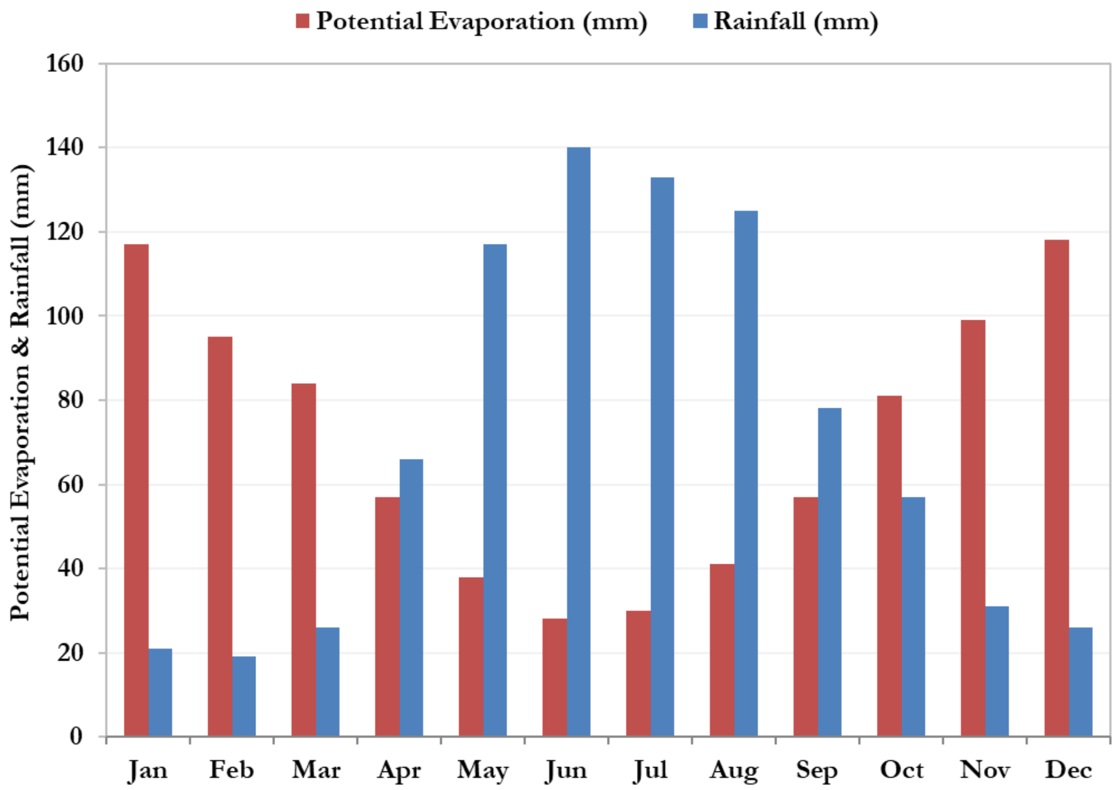


Figure 2: Monthly average rainfall and evaporation distribution for the study area (Schulze, 2009).

5. REGIONAL GEOLOGY

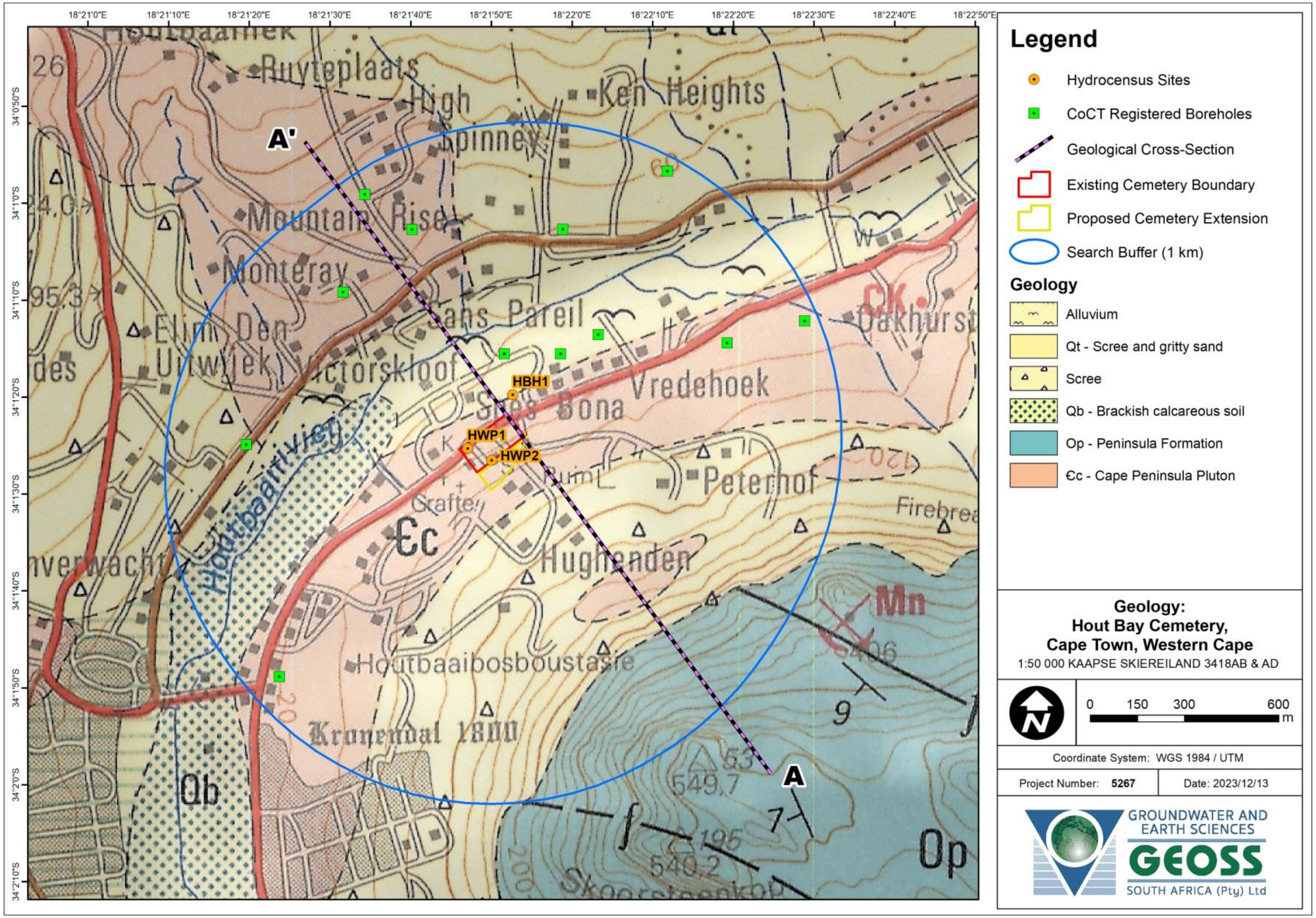
The Geological Survey of South Africa (now the Council for Geoscience (CGS)) has mapped the area at 1:50 000 scale (3418AB and AD Kaapse Skiereiland). The geological setting is shown in **Map 4** and the main geology of the area is listed in **Table 1**.

Table 1: Geological formations within the study area

Code	Formation	Group	Lithology
	-	Quaternary Deposits	**Alluvium**
Qt	-		Scree and gritty sand
△	-		Scree
Qb	-		Brackish calcareous soil
Op	Peninsula	Table Mountain	Quartzitic sandstone with thin lenses of grit, conglomerate and shale
Єc	**Cape Peninsula Pluton**	**Cape Granite Suite**	**Coarse-porphyritic granite**

The site is mapped to overlie coarse-porphyritic granitic outcrops of the Cape Peninsula Pluton. Cambrian-aged granitic intrusions of the Cape Peninsula Pluton (which forms part of the Cape Granite Suite) is often overlain by thin layers of Quaternary alluvial deposits. Alluvium deposits are present along the riverbed and banks of the Hout Bay River, which is located nearby. Brackish calcareous soil is mapped along the Hout Bay River to the west and southwest of the study site.

Competent sandstone of the Peninsula Formation outcrops as high-elevation mountainous regions to the southeast of the study site. The Peninsula Formation forms part of the Table Mountain Group (TMG) and comprises light-grey quartzitic sandstone with a maximum thickness of 700 m. The formation is highly fractured and faulted, resulting in the formation forming an extensive aquifer. Southeast-northwest trending faults are mapped through the Peninsula Formation. Scree deposits are present along the slopes of the mountains southeast of the site.



Map 4: Geological setting of the study site and the hydrocensus boreholes (1:50 000 scale 3418 AB and AD Kaapse Skiereiland (CGS, 1984)).

6. REGIONAL HYDROGEOLOGY

The unconfined aquifer that directly underlies the site is defined by the unconsolidated Quaternary sands. A drill log for a borehole located approximately 1.2 km east of the cemetery indicates that the top soil layer is relatively thin (~2 metres) and underlain by a thick clay layer that separates the unconsolidated aquifer from the fractured aquifer beneath (GEOSS, 2022). This borehole, however, is located at an elevation of 112 mamsl, whereas the cemetery site is located at an elevation of approximately 50 mamsl, and the top soil cover is anticipated to be thicker on site. The drill log is available in **Appendix A.** The aquifer yield and aquifer quality classifications are based on regional datasets and, therefore, only provide an indication of conditions to be expected.

6.1 Aquifer Yield

According to the 1:1 000 000 scale groundwater map of Cape Town (3418), the property on which the current cemetery is located hosts both an **intergranular** and a **fractured aquifer** with an average **borehole yield of 0.0 – 0.1 L/s** (**Map 5**) (DWAF, 2005). It should be noted that an intergranular aquifer exists above the fractured aquifer. The unconsolidated Quaternary deposits form the primary aquifer directly beneath the site. The intergranular aquifer is described as an aquifer in which groundwater is stored and flows through open pore spaces in the unconsolidated Quaternary deposits.

The Peninsula Formation sandstones and the granitic basement rock constitute the two types of fractured aquifers in the area. The Peninsula Formation Aquifer is present to the southeast of the study site, whilst the granitic aquifer is beneath the study site. A fractured aquifer is described as an aquifer in which groundwater is stored within and flows through a network of fractures and fissures. The north western portion of RE/1359 (the property demarcated for the proposed extension) is also located above the same **intergranular** and a **fractured aquifer** with an average **borehole yield of 0.0 – 0.1 L/s** whereas the south eastern portion is located on a **fractured aquifer** with an average **borehole yield of 0.5 – 2.0 L/s**.

6.2 Aquifer Quality

Electrical conductivity (EC) is a measure of the ability of the groundwater to conduct electricity. EC is directly related to the concentration of dissolved ions in the water and this parameter is used as an indication of groundwater quality. The groundwater map indicates that the aquifer has electrical conductivity values in the range of 0 – 70 mS/m (**Map 6**) (DWAF, 2005). In terms of drinking water standards (DWAF, 1998), water quality in the area is classified as **ideal** (Class 0) (0 – 70 mS/m).

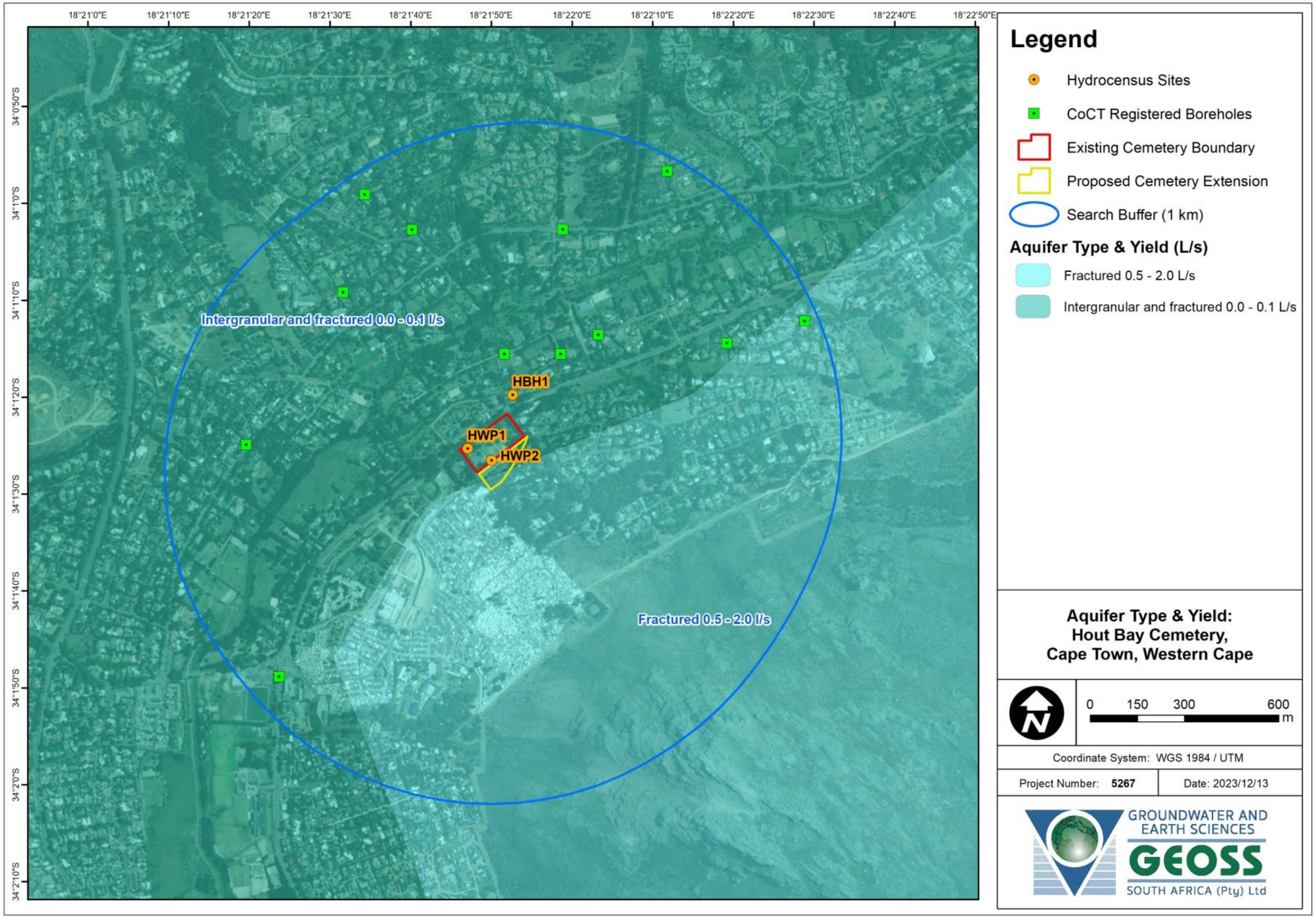
6.3 Aquifer Vulnerability Classification

The national scale groundwater vulnerability map, which was developed according to the DRASTIC methodology (Conrad and Munch, 2007), indicates that the study site has a "**very high**" vulnerability to surface-based contaminants (**Map 7**). The DRASTIC method considers the following factors:

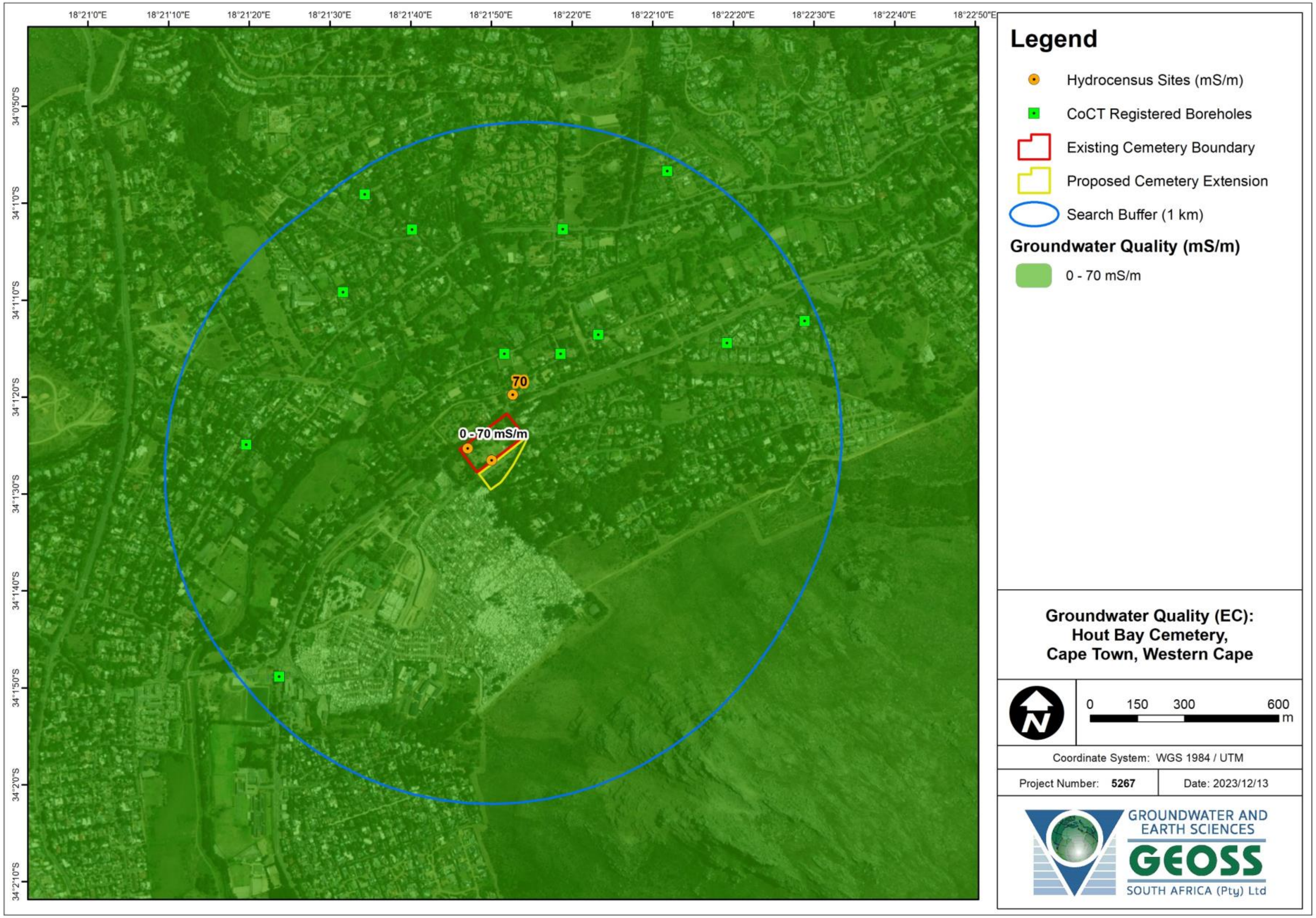
D	=	depth to groundwater	(5)
R	=	recharge	(4)
A	=	aquifer media	(3)
S	=	soil type	(2)
T	=	topography	(1)
I	=	impact of the vadose zone	(5)
C	=	conductivity (hydraulic)	(3)

The number indicated in parenthesis after each factor description is the weighting or relative importance of that factor. This classification, however, likely refers to the unconsolidated primary aquifer in the valley as mapped vulnerabilities decrease towards higher topographies in the southeast and northwest. The intergranular aquifer hosted in the unconsolidated sands directly beneath the site is highly porous and permeable. Primary aquifers generally have less capacity for attenuating contaminated recharge entering at their surface (WRC, 1995). It is, therefore, likely that the intergranular aquifer will be highly susceptible to point and non-point sources of contamination and classified as having a **very high** vulnerability to contamination.

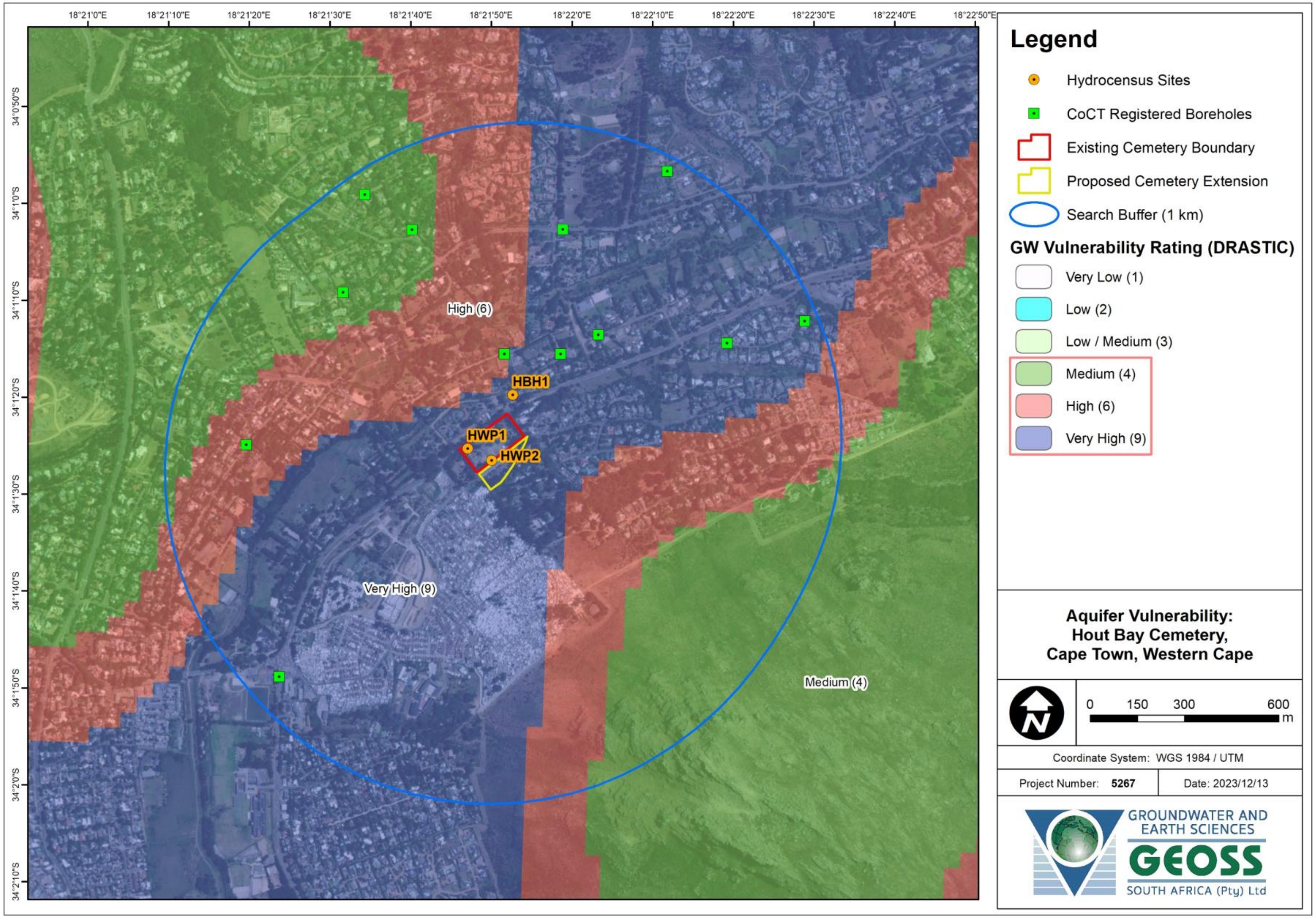
However, due to the presence of a clay layer a few metres directly beneath the sand, the aquifer is suspected to be a perched aquifer. The primary aquifer is likely not very productive and is likely unable to support large-scale abstraction for public supply and other purposes. The perched primary aquifer, however, is suspected to contribute to the baseflow of the Hout Bay River, which flows through the valley. Due to the thick clay layer present beneath the sandy topsoil, the underlying fractured aquifer is considered to have a **low/medium** vulnerability to contamination.



Map 5: Regional aquifer yield (L/s) (DWAF, 2002).



Map 6: Regional groundwater quality (EC in mS/m) from DWAF (2002).



Map 7: Vulnerability rating (DWAF, 2005) and groundwater depths (mbgl).

7. SITE SPECIFIC INFORMATION

7.1 Desktop Assessment (Existing Groundwater Information)

To determine whether there are any groundwater users in the area that may be affected by activities on site, a database search was conducted using a 1-km radius around the property boundary. This portion of the study was completed by studying and inquiring from existing databases that contain groundwater information. A search was conducted on a number of databases, namely the National Groundwater Archive (NGA), Water Use Authorisation and Registration Management System (WARMS), City of Cape Town (CoCT) database as well as the internal GEOSS database. These resources provide data on borehole positions, groundwater chemistry and yield, when available. Based on the desktop assessment of the various databases, it is evident that there are a number of groundwater users down-gradient of the proposed site. Groundwater users are concentrated to the north east of the study site.

7.1.1 National Groundwater Archive (NGA) Database

Assessment of the National Groundwater Archive (NGA) database, which provides data on borehole positions, groundwater chemistry and yield, indicated that there are no boreholes located within a 1-km search area of the site.

7.1.2 Water Use Authorisation and Registration Management System (WARMS) Database

Assessment of the Water Use Authorisation and Registration Management System (WARMS) Database revealed that there are no registered boreholes within 1-km of the study site.

7.1.3 GEOSS Internal Database

The GEOSS Internal Database stores information on location, lithology, yield and quality of all boreholes GEOSS has encountered in the field during various assessments. Assessment of the GEOSS Internal Database indicates that there are no boreholes within 1-km of the study site.

7.1.4 City of Cape Town (CoCT) Database

Assessment of the City of Cape Town Database indicates that there are 17 boreholes located in the residential area surrounding the study site. Little information is known about these boreholes and there are no water level or quality measurements associated with these sites. The borehole details are listed in **Table 2**, and the sites are indicated on **Map 8**.

Table 2: Summary of City of Cape Town borehole details.

Site ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)
CoCT_BH1	18.356459	-34.030287
CoCT_BH2	18.356459	-34.030287
CoCT_BH3	18.359518	-34.016471
CoCT_BH4	18.374640	-34.020181
CoCT_BH5	18.356459	-34.030287
CoCT_BH6	18.369938	-34.015864
CoCT_BH7	18.355376	-34.023628
CoCT_BH8	18.356459	-34.030287
CoCT_BH9	18.367528	-34.020541
CoCT_BH10	18.371965	-34.020797
CoCT_BH11	18.358741	-34.019274
CoCT_BH12	18.364294	-34.021068
CoCT_BH13	18.366230	-34.021080
CoCT_BH14	18.366325	-34.017509
CoCT_BH15	18.361138	-34.017494
CoCT_BH16	18.366325	-34.017509
CoCT_BH17	18.356459	-34.030287

7.2 *Hydrocensus*

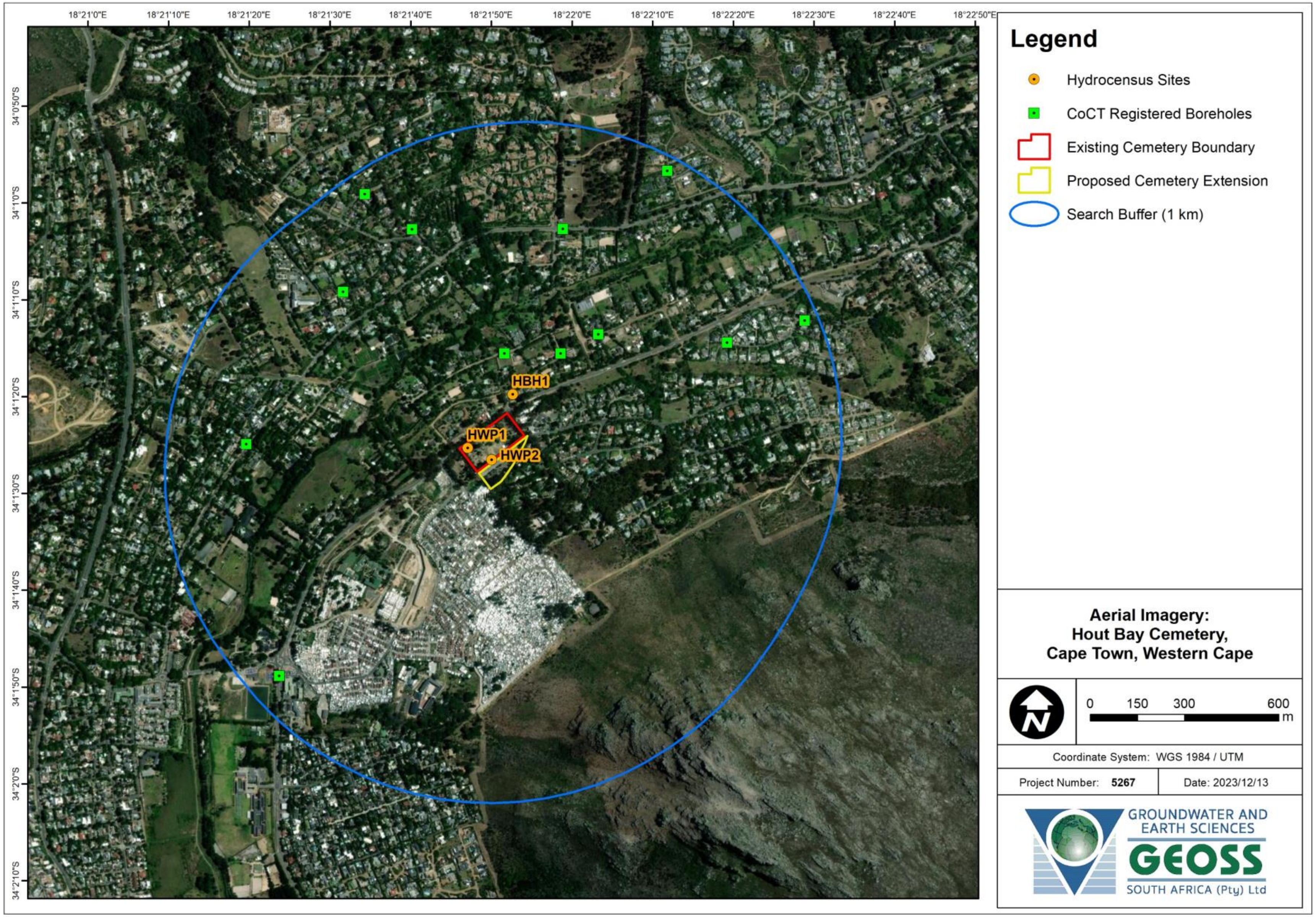
A site visit was conducted on 29 November 2023 to assess groundwater use within the study area. The results of the field investigation are spatially represented on **Map 8** and summarised in **Table 3**.

During the site visit, two City of Cape Town monitoring piezometers were discovered on the cemetery grounds. Access to the first piezometer was restricted by a stainless steel casing and the second piezometer was dry. After a request was made to the City, monitoring data was made available for this study (T and A Services, 2012). Various attempts were made to sample the monitoring piezometers/wells between 2014 and 2016 and once again in 2022. Sampling dates indicate that visits were made in both the wet and dry seasons and on all occasions the wells were observed to be dry.

Additionally, only one down-gradient borehole was located during the site visit. A sample was collected from this borehole and chemistry was measured. The sites are illustrated in **Map 8** pictures are available in **Appendix B**.

Table 3: Hydrocensus Site Descriptions (29 November 2023)

Site_ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Elevation (mamsl)	Comments
HBH1	-34.02225	18.36457	35	Private, sealed BH located down-gradient of the cemetery. BH is used for irrigation of a vegetable garden, no potable use.
HWP1	-34.02378	18.36300	32	City of Cape Town monitoring site. Located down-gradient of the cemetery. Depth = 3 mbgl.
HWP2	-34.02412	18.366383	41	City of Cape Town monitoring site. Located up-gradient of the cemetery. Depth = unknown.



Map 8: Desktop and field hydrocensus groundwater locations.

8. SITE VISIT (FIELD WORK)

8.1 Subsurface Observations

Before the site visit, it was initially planned to auger into the subsurface and install piezometers to determine groundwater depth and groundwater quality on site. This exercise also provides an indication of soil types. The targeted positions for the piezometers are chosen to provide good spatial coverage of the study area (vegetation permitting). Typically, the holes are hand dug using an auger kit to a maximum depth of 5 m or until water is reached, whichever comes first. The site visit occurred in late November 2023, soon after the beginning of the dry season, when the water table is expected to still be relatively shallow after the winter rainfall.

During the site visit, however, four graves were being dug. These graves provided valuable information of the subsurface and further augering was deemed to be unnecessary. The graves were dug to a depth of 2 metres beneath the ground level at elevations ranging between 53 – 57 mamsl. All of the graves were observed to be dry. Communication with staff on site further confirmed that to the best of their knowledge, water has never been intersected during the digging of graves.

A site walk-over sought to identify and confirm hydrological and hydrogeological features of relevance. Following the site visit, each pit (grave) was logged and photographed (**Appendix B**). The details for the sites are summarised in **Table 4** and locations of the sites are illustrated in **Map 9**.

Table 4: Summary of grave sites.

Site_ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Depth (m)	Elevation (mamsl)	WL (mbgl)
GS1	-34.023911	18.364075	2.0	57	Dry
GS2	-34.023820	18.364013	2.0	55	Dry
GS3	-34.023675	18.363938	2.0	53	Dry
GS4	-34.023892	18.363603	2.0	54	Dry

This site is dominated at the surface by a dry, unconsolidated, fine- to medium-grained, medium-brown sand. Small quartz grains (~1 – 2 mm) are present. Small roots may be present and this is regarded as the top soil layer. This soil type was observed at all of the grave sites which were dug to a depth of 2 metres below ground level.

Based on the field observations as well as data from the GEOSS database and the City of Cape Town, the water level in the primary aquifer has historically (the last decade) been deeper than 2 mbgl). Further, the primary unconsolidated aquifer is likely perched and is suspected to be unconnected to the fractured aquifer beneath.

Based on the available data, a site conceptual model has been constructed. The conceptual model is based on the geological cross-section in **Map 4** and is presented in **Figure 3.**

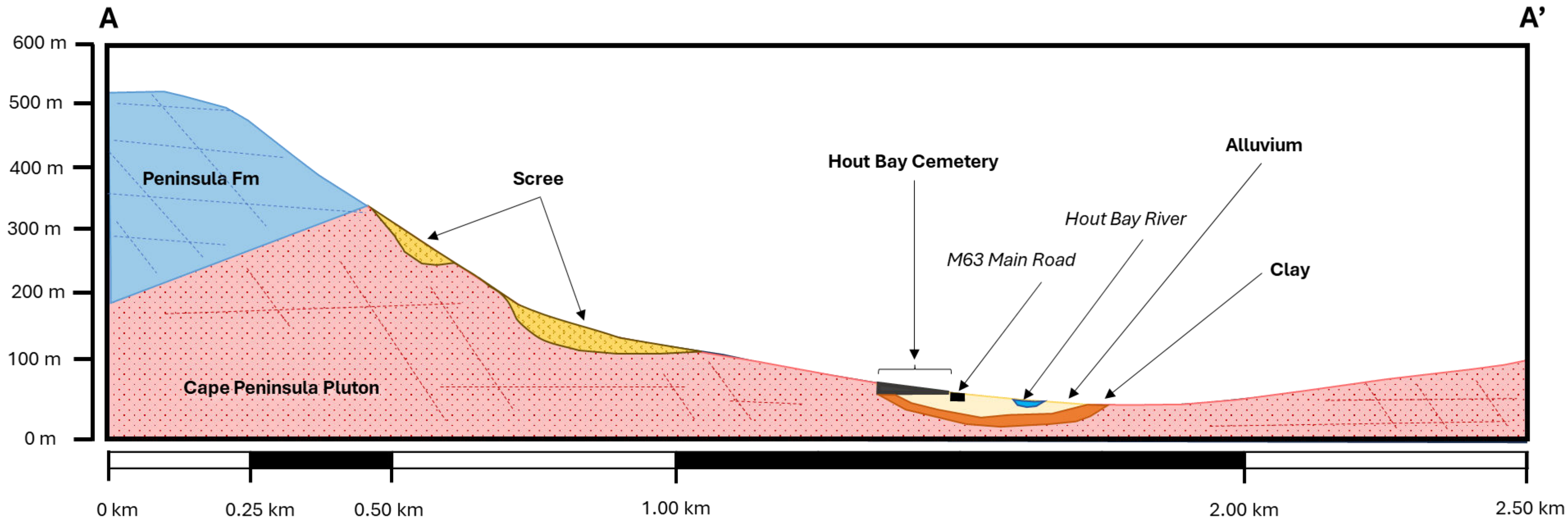
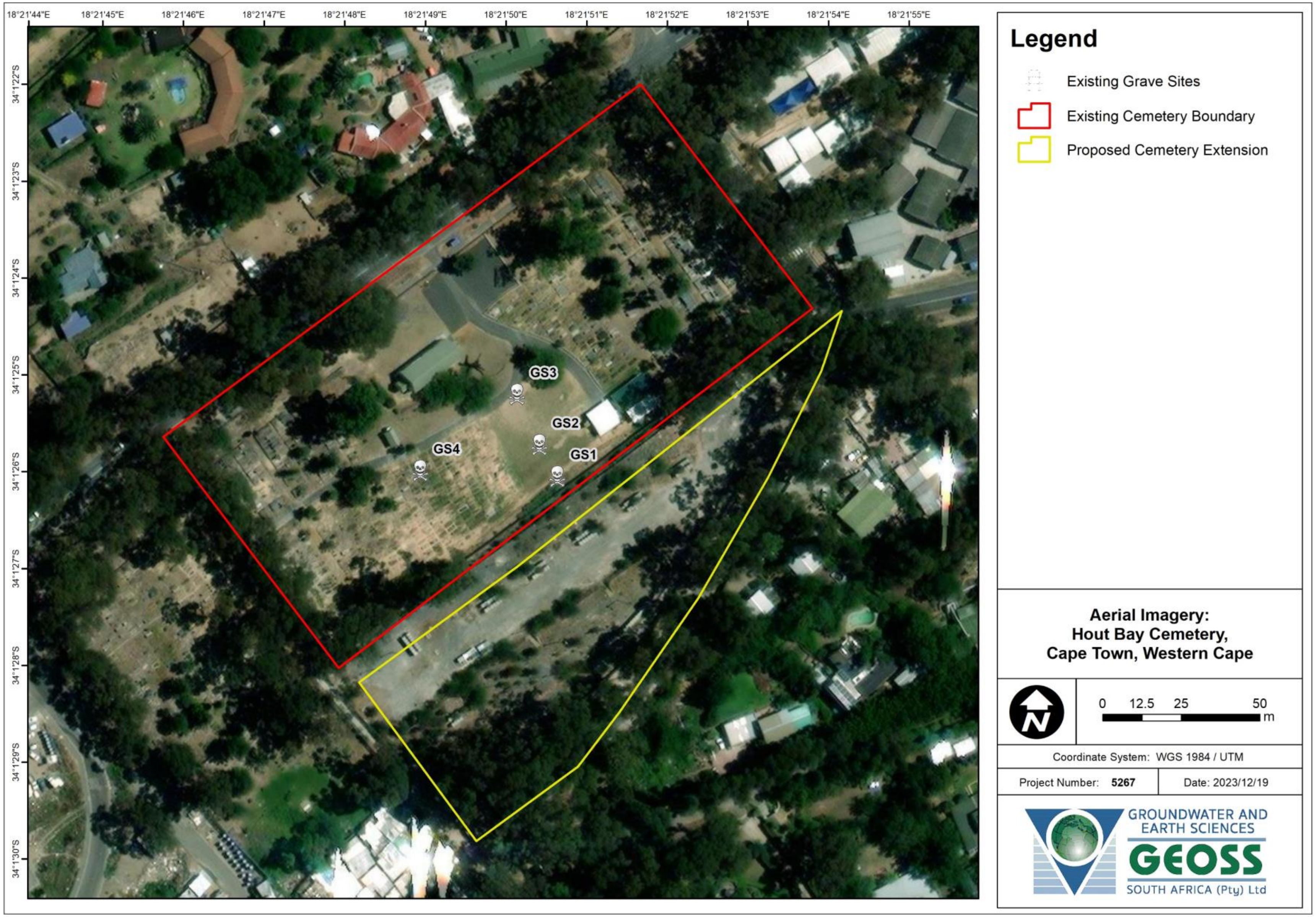


Figure 3: Conceptual diagram of the underlying geology



Map 9: Grave sites observed during the November 2023 site visit.

8.2 Field Chemistry

During the site visit, field chemistry was recorded where possible. Groundwater temperature, electrical conductivity (EC), total dissolved salt (TDS) content and pH were recorded from HBH1 prior to sample collection. Measurements are available in **Table 5** below.

Table 5: Chemistry field measurements (29 November 2023).

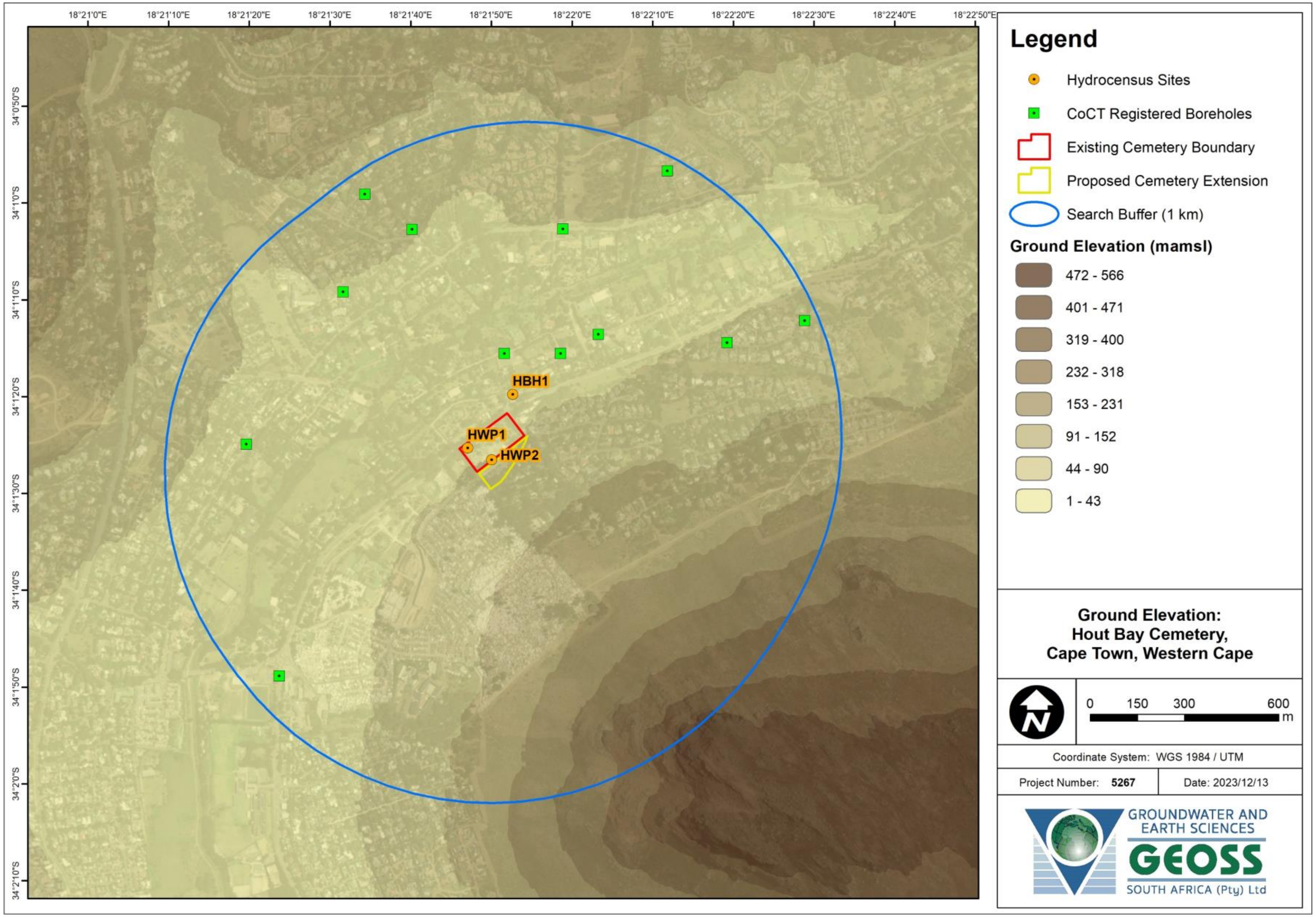
Site_ID	Temp (ºC)	EC (mS/m)	TDS (mg/L)	pH
HC_BH1	23.3	70.0	350.0	9.7

The field chemistry indicates that the groundwater quality is ideal in terms of dissolved solids but groundwater pH is elevated above ideal standards.

8.3 Groundwater Flow Direction

Groundwater flow generally follows surface topography, flowing from areas of high elevation to areas of lower elevation. In order to evaluate the relationship between groundwater levels and topography, the surface elevations and water table elevations are plotted relative to each other to assess the applicability of an interpolation technique. Where close correlation between surface elevations and water table elevations exist, interpolation techniques are an appropriate method to estimate values for areas with limited data.

Due to the lack of water levels within 2 kilometres of the study site, however, a groundwater flow direction map could not be constructed. As groundwater is assumed to flow from topographical highs to lows, a surface elevation map has been constructed and is presented in **Map 10**. There are topographical highs to the southeast of the study site. As a result, groundwater likely flows through the study site roughly from the southeast towards the northwest, towards the Hout Bay River.



Map 10: Surface elevation map for the Hout Bay area.

8.4 Water Quality Analysis

Only one groundwater sample was collected during the field visit on 29 November 2023. The sample was collected from a nearby hydrocensus borehole, HBH1, located down-gradient of the Hout Bay Cemetery. The chemistry data from the sample has been evaluated to give an indication of the groundwater quality that can be expected in the vicinity of the study site.

The chemistry results for these sites have been classified according to the SANS241-1: 2015 standards for domestic water (**Table 6**). **Table 8** presents the water chemistry analysis results, colour coded according to the SANS241-1: 2015 drinking water assessment standards.

Table 6: Classification table for specific limits.

Acute Health	Aesthetic	Chronic Health	Operational	Acceptable

The chemistry results have also been classified according to the DWAF (1998) standards for domestic water. **Table 7** enables an evaluation of the water quality with regards to the various parameters measured (DWAF, 1998). **Table 9** presents the water chemistry analysis results colour coded according to the DWAF drinking water assessment standards.

Table 7: Classification table for the groundwater results (DWAF, 1998)

Class	Water quality	Description
Class 0	Ideal	Suitable for lifetime use.
Class I	Good	Suitable for use, rare instances of negative effects.
Class II	Marginal	Conditionally acceptable. Negative effects may occur.
Class III	Poor	Unsuitable for use without treatment. Chronic effects may occur.
Class IV	Dangerous	Totally unsuitable for use. Acute effects may occur.

From the chemical results presented in **Table 8** and **Table 9**, the groundwater from the collected sample ranges from ideal to good quality in terms of dissolved minerals and salts. Groundwater pH is highly alkaline at a value of 9.8. Groundwater electrical conductivity and total dissolved salt concentrations indicate good quality water at 69.6 mS/m and 471.9 mg/L, respectively.

Metal concentrations were below detection limits in the sample and pose no risks to human health should the water be used for domestic purposes. Parameters that are typically known to be elevated in groundwater originating from granitic aquifers like fluoride and iron, are within prescribed limits.

Microbiological quality of the water, however, is considered to be marginal. Although E.coli bacteria was undetected in the groundwater sample, total coliforms were measured at 40 cfu/mL which may result in operational issues. It must be noted that total coliform bacteria is not an indication of contamination from the up-gradient cemetery and may have arisen from another source. It is suspected that if contamination has arisen from the cemetery, E. coli would also be present in the groundwater. Should this water be used for domestic purposes in future, the water must be disinfected prior to consumption.

Table 8: Groundwater quality analysis results according to SANS 214-1:2015

Analyses	HBH1	SANS 241-1:2015
pH (at 25 ºC)	9.8	≥5 - ≤9.7 Operational
Conductivity (mS/m) (at 25 ºC)	69.6	≤170 Aesthetic
Total Dissolved Solids (mg/L)	471.89	≤1200 Aesthetic
Turbidity (NTU)	0.86	≤5 Aesthetic ≤1 Operational
Colour (mg/L as Pt)	<15	≤15 Aesthetic
Sodium (mg/L as Na)	131	≤200 Aesthetic
Potassium (mg/L as K)	7	N/A
Magnesium (mg/L as Mg)	5	N/A
Calcium (mg/L as Ca)	8	N/A
Chloride (mg/L as Cl)	113.59	≤300 Aesthetic
Sulphate (mg/L as SO_4)	12.08	≤250 Aesthetic ≤500 Acute Health
Nitrate & Nitrite Nitrogen (as a ratio)	0.068	≤1 Acute Health
Nitrate Nitrogen (mg/L as N)	<1.00	≤11 Acute Health
Nitrite Nitrogen (mg/L as N)	<0.05	≤0.9 Acute Health
Ammonia Nitrogen (mg/L as N)	<0.15	≤1.5 Aesthetic
Total Alkalinity (mg/L as $CaCO_3$)	149.1	N/A
Total Hardness (mg/L as $CaCO_3$)	40.5	N/A
Fluoride (mg/L as F)	0.26	≤1.5 Chronic Health
Aluminium (mg/L as Al)	0.011	≤0.3 Operational
Total Chromium (mg/L as Cr)	<0.004	≤0.05 Chronic Health
Manganese (mg/L as Mn)	<0.018	≤0.1 Aesthetic ≤0.4 Chronic Health
Iron (mg/L as Fe)	0.029	≤0.3 Aesthetic ≤2 Chronic Health
Nickel (mg/L as Ni)	<0.008	≤0.07 Chronic Health
Copper (mg/L as Cu)	0.010	≤2 Chronic Health
Zinc (mg/L as Zn)	0.096	≤5 Aesthetic
Arsenic (mg/L as As)	<0.010	≤0.01 Chronic Health
Selenium (mg/L as Se)	<0.008	≤0.04 Chronic Health
Cadmium (mg/L as Cd)	<0.001	≤0.003 Chronic Health
Antimony (mg/L as Sb)	<0.013	≤0.02 Chronic Health
Mercury (mg/L as Hg)	<0.001	≤0.006 Chronic Health
Lead (mg/L as Pb)	<0.008	≤0.01 Chronic Health
Uranium (mg/L as U)	<0.028	≤0.03 Chronic Health
Cyanide (mg/L as CN^-)	<0.01	≤0.2 Acute Health
Total Organic Carbon (mg/L as C)	2.00	N/A
E.coli (cfu/100 ml)	nd	Not Det. Acute Health-1
Total Coliform Bacteria (cfu/100 ml)	40	Not Det.≤10 Operational
Heterotrophic Plate Count (cfu/ml)	50	≤1000 Operational
Charge balance %	1.9	≥-5 - ≤5 Acceptable

**nd – not detected*

Table 9: Classified groundwater sample results according to DWAF 1998.

Sample:	HBH1	DWA (1998) Drinking Water Assessment Guide				
		Class 0	Class I	Class II	Class III	Class IV
pH	9.8	5-9.5	4.5-5 & 9.5-10	4-4.5 & 10-10.5	3-4 & 10.5-11	< 3 & >11
Conductivity (mS/m)	69.6	<70	70-150	150-370	370-520	>520
Turbidity (NTU)	0.86	<0.1	0.1-1	1.0-20	20-50	>50
	mg/L					
Total Dissolved Solids	471.89	<450	450-1000	1000-2400	2400-3400	>3400
Sodium (as Na)	131	<100	100-200	200-400	400-1000	>1000
Potassium (as K)	7	<25	25-50	50-100	100-500	>500
Magnesium (as Mg)	5	<70	70-100	100-200	200-400	>400
Calcium (as Ca)	8	<80	80-150	150-300	>300	
Chloride (as Cl)	113.59	<100	100-200	200-600	600-1200	>1200
Sulphate (as SO_4)	12.08	<200	200-400	400-600	600-1000	>1000
Nitrate & Nitrite (as a ratio)	0.068	<6	6.0-10	10.0-20	20-40	>40
Fluoride (as F)	0.26	<0.7	0.7-1.0	1.0-1.5	1.5-3.5	>3.5
Manganese (as Mn)	<0.018	<0.1	0.1-0.4	0.4-4	4.0-10.0	>10
Iron (as Fe)	0.029	<0.5	0.5-1.0	1.0-5.0	5.0-10.0	>10
Copper (as Cu)	0.010	<1	1-1.3	1.3-2	2.0-15	>15
Zinc (as Zn)	0.096	<20	>20			
Arsenic (as As)	<0.010	<0.010	0.01-0.05	0.05-0.2	0.2-2.0	>2.0
Cadmium (as Cd)	<0.001	<0.003	0.003-0.005	0.005-0.020	0.020-0.050	>0.050
Hardness (as $CaCO_3$)	40.500	<200	200-300	300-600	>600	
	counts/100 mL					
Faecal coliforms	nd	0	0-1	1.0-10	10-100	>100
Total coliforms	40	0	0-10	10-100	100-1000	>1000
Charge Balance %	1.9	≥-5 - ≤5 Acceptable				

8.5 Chemical Diagrams

The Piper diagram in **Figure 4** shows the cation and anion distribution relative to one another for the sample collected from the hydrocensus borehole during the field visit. Cation concentrations of Na^+ and K^+ are dominant in the groundwater. HCO_3^- and CO_3^{2-} and Cl^- are present in close to equal concentrations in the sample with SO_4^{2-} being least dominant. Cl^-, however, is present in the highest concentrations and as a result, this sample is classified as Na-Cl-type water.

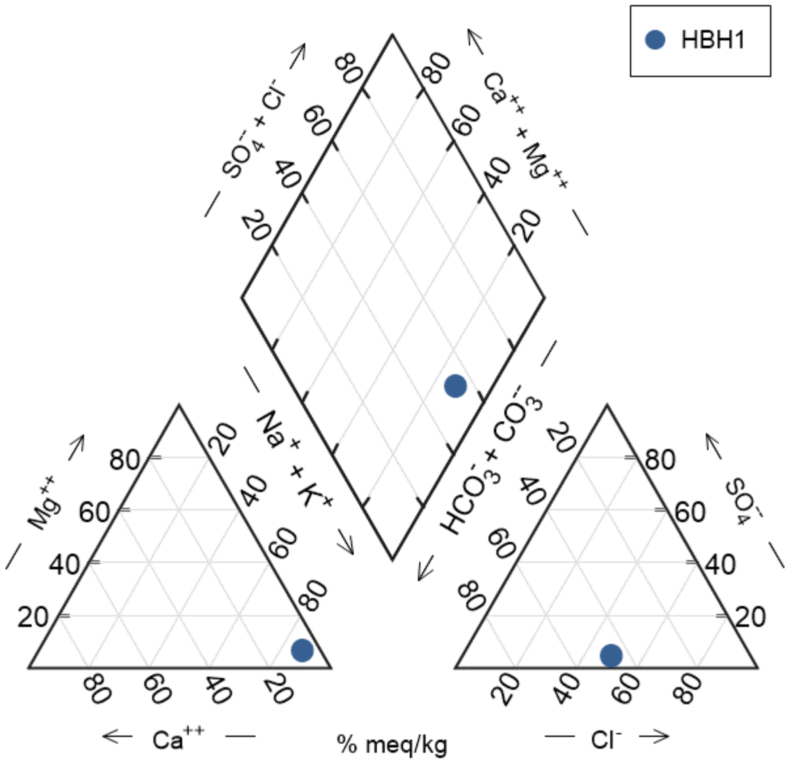


Figure 4: Piper diagram for the collected samples

Stiff diagrams are a quick visual representation of the distribution of major anions and cations within a sample, and are presented in **Figure 5**. The Stiff Diagrams substantiate the ionic distribution observed in the Piper diagram. Na^+ and K^+ are the dominant cations in the groundwater whereas HCO_3^- and CO_3^{2-} and Cl^- are present in close to equal amounts.

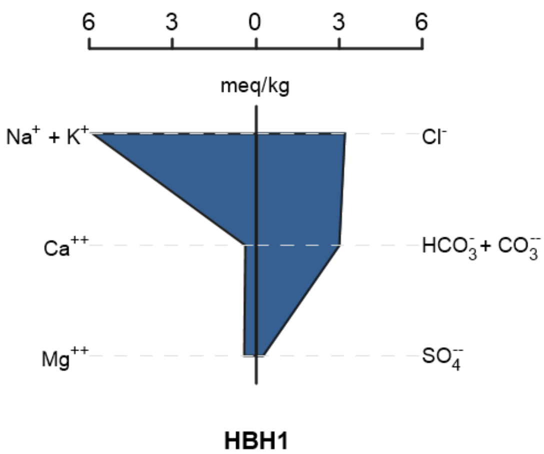


Figure 5: Stiff diagrams for the collected samples

9. RISK IMPACT ASSESSMENT

The site is located on a highly permeable intergranular aquifer which has a "**very high**" vulnerability classification indicating that the aquifer has high susceptibility to contamination from anthropogenic activities. The inference that the primary aquifer is perched would mean that the fractured aquifer is not susceptible to the same risks. As a result, the following impact assessment pertains to the primary unconsolidated aquifer.

There are risks associated with the cemetery site. These include (from Dippenaar et al., 2018):

- decomposition of the bodies producing leachate,
- chemicals used in the embalming process,
- metals from the ornamental hinges on coffins and/or jewellery, and
- other nutrient and pathogen sources from poor sanitary practices or landscaping.

The decomposition of human remains result in the formation of leachate which is comprised of 60% water, 30% salts (N, P, Cl, HCO_3, Ca, Na and compounds of metals such as Ti, Cr, Cd, Pb, Fe, Mn and Ni) and 10% organic substances (Żychowski and Bryndal, 2015).

Other contaminants associated with the decomposition of bodies include:

- Chemical substances derived from chemotherapy or the embalming process which could include arsenic, formaldehyde and methanol.
- Makeup such as cosmetics, pigments and other chemical compounds.
- Items such as cardiac pacemakers, paints, varnishes, metal hardware, chemicals batteries and dentures.
- Microorganisms such as bacteria, viruses, intestinal fungi, protozoa, and other pathogens.

Exposure to potential contaminants could be through contact with substances (contaminants or contaminated groundwater) via ingestion or dermal contact (with both groundwater and soil).

- **Table 10** summarises the possible impacts and proposed mitigation measures associated with the increased decomposition of human remains.
- **Table 11** presents a summary of the possible impacts and proposed mitigation measures associated with the corrosion of metals used as ornaments, plastics, paints and varnishes.
- **Table 12** summarises the possible impacts and proposed mitigation measures associated with the formation of organics from the embalming process.

The risk assessment includes the identification and rating of the potential risks associated with the proposed development and any mitigation measures are proposed where possible. Each risk is qualitatively assessed based on the existing information. The risk rating is measured according the criteria in **Appendix D**.

Table 10: Impact table for contamination of groundwater as a result of decomposition of human remains.

OPERATIONAL PHASE	
Potential impact and risk:	**Contamination of Groundwater due to the Decomposition of Human Remains**
Nature of impact:	Negative
Extent and duration of impact:	Extent is local and duration is short term.
Consequence of impact or risk:	Increased nutrient and inorganic parameter concentrations in groundwater, and proximal drainage channels, and Hout Bay River.
Probability of occurrence:	Low probability
Degree to which the impact may cause irreplaceable loss of resources:	Marginal loss of resource.
Degree to which the impact can be reversed:	Reversible in shallow groundwater. This is challenging where infiltration into the deeper fractured aquifer takes place.
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:	Low
Proposed mitigation:	Ensure burial occurs sufficiently above water table depth to enable natural attenuation in the vadose zone (region between surface and water table). Harmful bacteria, viruses and pathogens tend to die off during final stages of decomposition and therefore tend to not persist in the environment. Limit groundwater use of the shallow aquifer immediately down-gradient /downstream of the site. Monitoring wells are required in order to detect any potential contamination as quickly as possible.
Cumulative impact post mitigation:	Low
Significance rating of impact after mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Low

Table 11: Impact table for contamination of groundwater as a result of metal corrosion, paints and varnishes.

OPERATIONAL PHASE	
Potential impact and risk:	**Groundwater contamination due to the addition of paints and varnishes to the environment and corrosion (and liberation of metals).**
Nature of impact:	Negative
Extent and duration of impact:	Extent is local and duration is short term
Consequence of impact or risk:	Contamination of the local groundwater, proximal drainage channel and the Hout Bay River
Probability of occurrence:	Low probability
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:	Low-Medium
Proposed mitigation:	• Standardise coffin size with ordinary dimensions. • **Coffin materials should primarily consist of untreated wood and/or other biodegradable materials.** • Refrain from using excessive ornamental metals, plastics, paints varnishes, etc. • Where possible, all jewellery, watches, batteries, excessive cosmetics, and other such materials should be removed prior to burial. It is harder to remove dentures and pace makers.
Cumulative impact post mitigation:	Low
Significance rating of impact after mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Low

Table 12: Impact table for contamination of groundwater as a result of compounds used during embalming.

OPERATIONAL PHASE	
Potential impact and risk:	**Potential leaching of chemicals used in the embalming process (formaldehyde) into the groundwater**
Nature of impact:	Negative
Extent and duration of impact:	Extent is local and duration is short term
Consequence of impact or risk:	Contaminated groundwater and proximal drainage channel
Probability of occurrence:	Low probability
Degree to which the impact may cause irreplaceable loss of resources:	Minimal loss of resource
Degree to which the impact can be reversed:	Reversible
Cumulative impact prior to mitigation:	Low
Significance rating of impact prior to mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Low
Degree to which the impact can be managed or mitigated:	Typically, mitigation is not required
Proposed mitigation:	When formaldehyde comes into contact with water it tends to breakdown into methanol, amino acids and several other chemicals and therefore does not persist in the environment (World Health Organisation, 2002).
Cumulative impact post mitigation:	Low
Significance rating of impact after mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Low

10. DISCUSSION

From the desktop study and fieldwork, it is evident that there are a number of small-scale groundwater users surrounding the study area, particularly in the residential areas to the north of the study area. Although little information is available for the CoCT boreholes, it is highly likely that groundwater abstraction mainly occurs from the secondary fractured aquifer as the primary aquifer is considered to be unproductive for large-scale abstraction. Due to the perched nature of the primary aquifer, is inferred that there is limited connectivity between the primary and secondary aquifer. Further, sample collection from a nearby borehole located down-gradient of the cemetery indicates that the water is of ideal to good quality. This is an indication that historical activities of the cemetery have not impacted the water quality in the deeper fractured aquifer.

Ideal quality groundwater (0 – 70 mS/m) is mapped for the area, and information obtained from the hydrocensus borehole indicates that groundwater quality is within this range. The primary aquifer is considered to be **highly vulnerable** to surface-based contaminants. The classification is due to the high permeability of the sands. If contamination does occur, it would most likely follow the groundwater flow direction (assumed to be southeast to northwest), i.e., towards the Hout Bay River.

Due to multiple graves being dug on-site at the time of the site visit, it was deemed that further augering was unnecessary. The grave sites were used as trial pits to make observations of the subsurface. This site is dominated at the surface by a dry, unconsolidated, fine- to medium-grained, medium-brown sand. Small quartz grains (~1 – 2 mm) are present. Small roots may be present, and this is regarded as the top soil layer. This soil type was observed at all of the grave sites, which were dug to a depth of 2 metres below ground level. All four of the graves observed on site were dry.

Based on the field observations as well as data from the GEOSS database and the City of Cape Town, the water level in the primary aquifer has historically (i.e. the last decade) been deeper than 2 mbgl). Further, the primary unconsolidated aquifer is likely perched and is suspected to be unconnected to the fractured aquifer beneath. The fractured aquifer is likely targeted for water supply as alluvial cover is noted to be thin in the area. Further, the proposed extension of the cemetery is located at higher elevations than the current cemetery, and it is therefore expected that the water level will be even deeper beneath the proposed extension area.

Given the high vulnerability that is mapped for the underlying aquifer, the risk of contamination is considered. For a risk to exist, there must be a source(s), pathway(s) and receptor(s). The proposed extension of the cemetery represents a potential source of contamination. The underlying aquifer represents both a potential pathway and a receptor. Groundwater users and the surrounding environment represent receptors of potential contamination. It should, however, be noted that due to the depth of the water table being more than 1 metre deeper than the burial depth (i.e. more than 3 metres), the source-pathway-receptor linkages are considered to be incomplete. The source-pathway-receptor-model is illustrated in **Figure 6**.

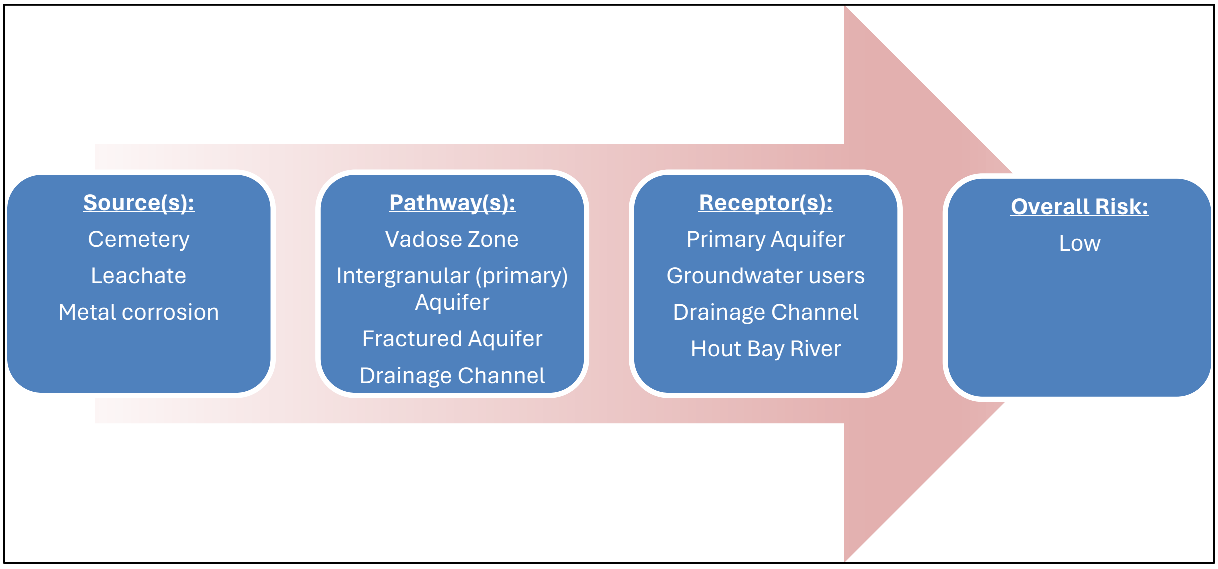


Figure 6: Source, Pathway and Receptor Assessment.

The proposed extension of the cemetery is considered to have a low risk to groundwater resources. It does, however, remain necessary to implement appropriate screening measures to ensure that no activities impact on the aquifer. Relevant screening measures are discussed in **Chapter 11** and **12**.

11. RECOMMENDATIONS

The following recommendations are made:

* The burials of bodies should only take place where the water table is more than 4 mbgl. This is a proposed mitigation measure.
* It is recommended that a third piezometer be installed up-gradient of the site to continue groundwater monitoring.
* Biannual quality monitoring of the groundwater is recommended to ensure that the water quality remains unimpacted.

It is of GEOSS's opinion that the site is suited for use as a cemetery, given the lack of shallow groundwater. Note that these recommendations are based on GEOSS's opinion and the final decision on the necessary approval and groundwater monitoring requirements resides with the regulatory authorities.

12. PROPOSED GROUNDWATER MONITORING PLAN

It is recommended that at least three groundwater sites should be monitored at the cemetery during its operation of the site. This will allow for monitoring of the groundwater quality and groundwater levels across the site. The primary aquifer is likely perched, and land use activities are not expected to affect the secondary aquifer. As a result, it is not required that boreholes be drilled into the fractured aquifer. The two existing piezometers will suffice as potential monitoring points through which to measure water quality. It will then be necessary to install a third piezometer up-gradient of the new extension. It is recommended that the existing piezometers be upgraded to monitoring wells by deepening and widening the hole and wider diameter casing be installed.

Groundwater flow in the area generally follows the topography, flowing from southeast to northwest towards topographical lows northwest of the study site. It is recommended that one monitoring site be located up-gradient of the site to monitor background water quality and that two boreholes be located down-gradient to identify any potential impact on down-gradient users. The three suggested monitoring sites are shown in **Table 13** and **Map 11**, however, if this is not possible due to site restrictions (infrastructure, access), the site locations can be reviewed.

Table 13: Details for the proposed monitoring sites.

Site_ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Depth (mbgl)
HPW1	-34.023780	18.363000	5 m or until the clay layer is reached
HPW2	-34.024120	18.363830	5 m or until the clay layer is reached
HPW3	-34.024477	18.364346	5 m or until the clay layer is reached

12.1 Groundwater Level Monitoring

Groundwater level measurements are recommended for the monitoring points 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.

12.2 Groundwater Quality Monitoring

It is recommended that the piezometers or monitoring wells be purged prior to sampling. A low-volume sampling pump can be used, or the site can be bailed and allowed to recover prior to sample collection. When using a low-volume sampling pump, the groundwater should be pumped through a flow-through cell until field chemistry parameters have stabilised. Alternatively, a bailer can be used.

12.2.1 Sample Collection, Preservation and Submission

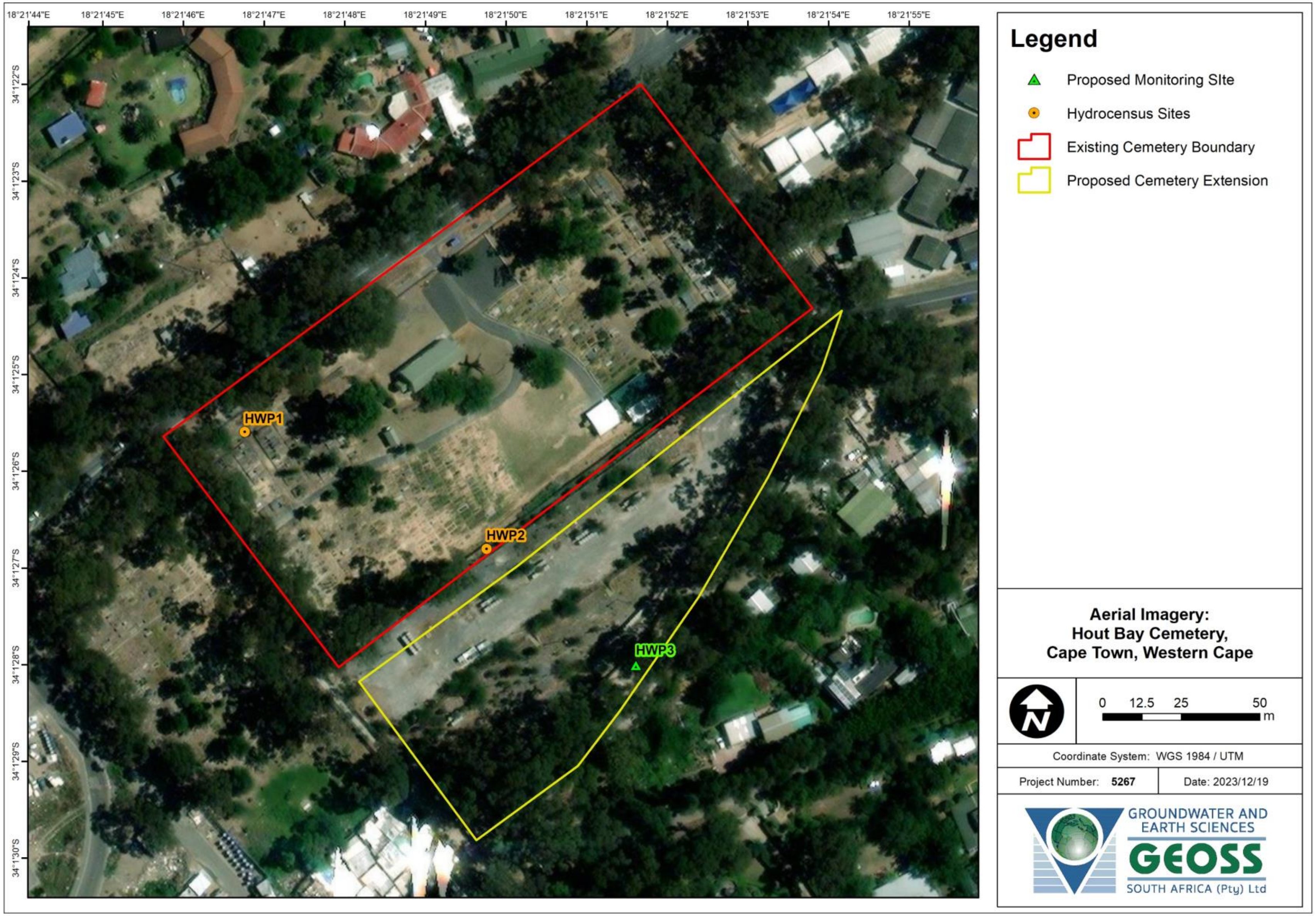
Sample bottles must be labelled with the site name, borehole name and date. At the time of sampling, field chemistry parameters must be measured and recorded. These include electrical conductivity (EC), oxidation-reduction potential (ORP), pH, temperature and dissolved oxygen (DO). During sampling, disposable nitrile gloves should be worn to minimise the transfer of any potential contaminants. Nitrile gloves should be dedicated to a sampling location and disposed of after use. Samples must be collected in an appropriate 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.

12.3 Monitoring Frequency and Parameter Analysis

In order to best understand and monitor the site, it is recommended that monthly water level measurements be taken to determine seasonal fluctuation. It is further recommended that the water quality on site is monitored on a quarterly basis for the first year, after which the frequency can be reduced based on the first year's monitoring results. **Table 14** indicates the potential parameters for ongoing monitoring.

Table 14: Proposed groundwater monitoring parameters and their recommended frequency.

Parameter	Frequency*		
	MB_BH1	MB_BH2	MB_BH3
Groundwater Level	Monthly	Monthly	Monthly
pH	Quarterly	Quarterly	Quarterly
Electrical conductivity (EC)	Quarterly	Quarterly	Quarterly
Total Dissolved Solids (TDS)	Quarterly	Quarterly	Quarterly
Inorganic parameters: K, Cl, NO_3, NH_4, P, Na, Ca, HCO_3	Biannually	Biannually	Biannually
Metals: Fe, Mn, Ti, Cr, Cd, Pb, Ni	Biannually	Biannually	Biannually
Total Organic Carbon (TOC)	Biannually	Biannually	Biannually
Total Coliforms	Biannually	Biannually	Biannually
E. coli	Biannually	Biannually	Biannually
Biological Oxygen Demand (COD)	Biannually	Biannually	Biannually
Chemical Oxygen Demand (COD)	Biannually	Biannually	Biannually



Map 11: Proposed monitoring network, Hout Bay Cemetery.

13. CONCLUSION

The proposed extension of the cemetery poses a low risk of contamination to an aquifer considered to have a very high vulnerability to contamination. The risk of contamination to the aquifer is mitigated by the fact that the water table has been observed to be deeper than the burial depth over the past decade. Furthermore, drill logs for a borehole located just outside the 1-km buffer zone indicates that a thick clay layer is present beneath the topsoil cover. The clay layer will limit connectivity between the primary and secondary aquifers as the secondary aquifer is most likely targeted for abstraction in the area.

GEOSS is of the opinion that the site is suited for use as a cemetery given the lack of shallow water. Note that these recommendations are based on GEOSS's opinion and the final decision on the necessary approval and groundwater monitoring requirements resides with the regulatory authorities. The proposed development, however, will need to conform to the proposed mitigation measures in order to ensure that no contamination or impact on groundwater occurs on site.

14. ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitations were encountered during this study:

- Available data was sourced from the relevant groundwater databases and sources. The aquifer vulnerability, yield and quality data is predominantly accurate, albeit mapped at a regional scale.
- A further limitation was the temporal nature of the site visit. The field work was undertaken on a single day in November 2023, and does not account for the temporal variability of the water table. Since historical data has been made available by the City, this is not expected to impact the risk assessment for the site.
- Based on the available data, it is assumed that the impermeable clay layer is continuous throughout the site and not lenticular (lenses) in nature, preventing the primary aquifer from interacting with the underlying fractured aquifer.
- It is possible that there are a greater number of groundwater users in the area as what has been reported in this study. Not all groundwater users could be located or visited due to a large number of the dwellings, plots and farms being gated.

15. REFERENCES

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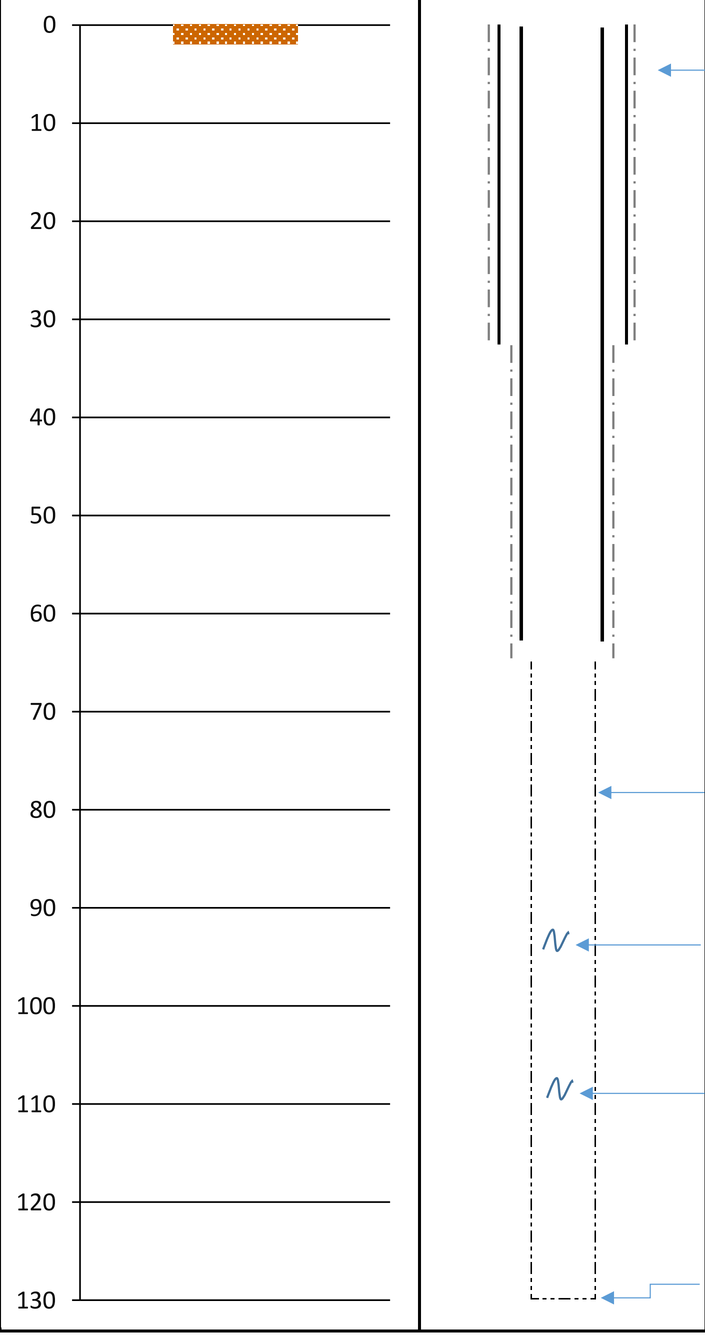
16. APPENDIX A: BOREHOLE LOG(S)

Log of Borehole No.: BH2_2022

Location:	Hout Bay	**Latitude:**	-34.023068°
Date:	08-Jul-22	**Longitude:**	18.377701°
Client:	-	**Ground Elevation:**	112 mamsl

Lithological Description	Lithology Symbol & Depth (m)	Borehole Construction	Description & water strike
Soils (0 - 2 m)			
Clay (2 - 19 m)			**254 mm air percussion drilling (0 - 30 m)** 219 mm OD solid steel casing (0 - 31 m)
Weathered Granite (19 - 36 m)			
Clay (36 - 50 m)			**203 mm air percussion drilling (30 - 66 m)** 177 mm OD solid steel casing (0 - 62 m)
Weathered Granite (50 - 65 m)			
Granite Bedrock (65 - 125 m)			**165 mm air percussion drilling (66 - 125 m)** Brown water droplets 93 m **Main water strike 109.5 m (1900 L/hour)** EOH at 125m



Drilled By:	Gerritsen Drilling SA	**Remarks:**	Airlift yield: 1 900 L/h
Drill Method:	Air percussion		EC: 52 mS/m
Logged By:	GEOSS (Kes Murray)		

GEOSS

17. APPENDIX B: SITE PHOTOS

Photo 1: New Apostolic Church located on the grounds of the Hout Bay Cemetery

Photo 2: Signage at the Hout Bay Cemetery

Photo 3: Stormwater channels at the cemetery

Photo 4: Eucalyptus trees located on the outskirts of the cemetery

Photo 5: Digging of a grave on site observed during the field work (GS1)

Photo 6: Digging of a second grave on site observed during the field work (GS2)

Photo 7: Digging of a third grave on site observed during the field work (GS3)

Photo 8: Digging of a fourth grave on site observed during the field work (GS4

Photo 9: HBH1 (down-gradient of the cemetery)

Photo 10: Storage tanks prior for borehole HBH1

Photo 11: Property demarcated for the extension of the cemetery (view from entrance)

Photo 12: Property demarcated for the extension of the cemetery

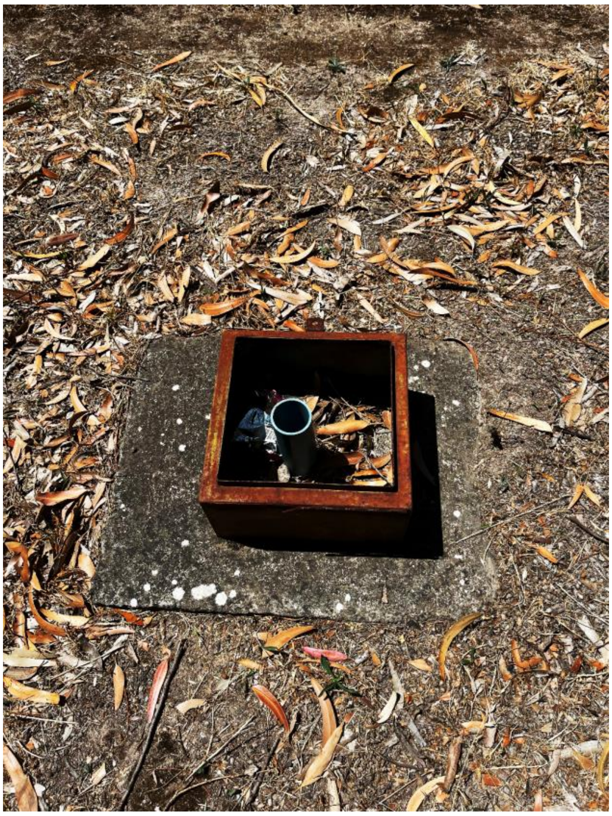


Photo 13: HWP1

Photo 14: HWP2

Photo 15: Soil type observed on site

Photo 16: Soil type observed on site

18. APPENDIX C: LABORATORY CERTIFICATES

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Your partner in quality water analysis

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Stellenbosch
Tel 021-8828866/7
info@vinlab.com
www.vinlab.com
2023-12-04

TEST REPORT

Water

Geoss South Africa (Pty) Ltd

Attn: Alison McDuling

P.O.Box 12412
Die Boord, Stellenbosch
7613
+27218801079

@VinlabSA

Sample Details					
SampleID	W45097				
Water Type	Drinking Water				
Water Source	Borehole				
Sample Temperature					
Description	5267_A_HBH 1				
Batch Number	5267_A_HBH 1				
PO Number	5267_A_HBH 1				
Date Received	2023-11-30				
Condition	Good				

Water - Routine	Unit	Method	Uncertainty	Limit	Results	Results	Results	Results	Results
pH@25C (Water)		VIN-05-MW01	^^^	>= 5 to <= 9.7	9.75				
Conductivity@25C (Water)	mS/m	VIN-05-MW02	^	<= 170	69.6				
Turbidity (Water)*	ntu			<= 5	0.86				
Total dissolved solids (Water)*	mg/L			<= 1200	471.89				
Free Chlorine (Water)*	mg/L			<= 5	<0.02				
Ammonia (NH4) as N (Water)	mg/L	VIN-05-MW08	8.90%	<= 1.5	<0.15				
Nitrate as N (Water)	mg/L	VIN-05-MW08	11.00%	<= 11	<1.00				
Nitrite as N (Water)	mg/L	VIN-05-MW08	4.50%	<= 0.9	<0.05				
Chloride (Cl-) - Water	mg/L	VIN-05-MW08	10.12%	<= 300	113.59				
Sulphates (SO4) - Water	mg/L	VIN-05-MW08	7.56%	<= 500	12.08				
Fluoride (F) - Water	mg/L	VIN-05-MW08	12.30%	<= 1.5	0.26				
Alkalinity as CaCO3 (Water)*	mg/L				149.10				
Colour (Water)*	mg/L Pt-Co			<= 15	<15				
Total Organic Carbon (Water)*	mg/L			<=10	2.00				
Date Tested					2023-11-30				

Water - Metals	Unit	Method	Uncertainty	Limit	Results	Results	Results	Results	Results
Calcium (Ca) - Water	mg/L	VIN-05-MW43	14.60%		8				

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<35 and a negative result (non-detected) indicates a Cq value of >35.

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^ - Conductivity <1000mS/m = ± 1mS/m , >1000mS/m = ±9mS/m
^^ - COD, LR = ± 16mg/L, MR = ±48mg/L, HR = ±477mg/L
^^^ - pH ± 0.1

Doc No V48320 | VIN 09-01 30-11-2022 | Page: 1 of 3 | Visit Vinlab H20

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Distillery Road
Stellenbosch
Tel 021-8828866/7
info@vinlab.com
www.vinlab.com
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TEST REPORT

Water

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Attn: Alison McDuling

P.O.Box 12412
Die Boord, Stellenbosch
7613
+27218801079

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Magnesium (Mg) - Water	mg/L	VIN-05-MW43	8.49%		5				
Sodium (Na) - Water	mg/L	VIN-05-MW43	11.45%	<= 200	131				
Potassium (K) - Water	mg/L	VIN-05-MW43	9.42%		7				
Zinc (Zn) - Water	mg/L	VIN-05-MW43	19.40%	<= 5	0.096				
Antimony (Sb) - Water*	µg/L			<=20	<13.0				
Arsenic (As) - Water*	µg/L			<= 10	<10.0				
Boron (B) Water	µg/L	VIN-05-MW43	11.79%	<= 2400	37				
Cadmium (Cd) Water	µg/L	VIN-05-MW43	12.26%	<= 3	<1				
Chromium (Cr) - Water	µg/L	VIN-05-MW43	13.03%	<= 50	<4				
Copper (Cu) - Water	µg/L	VIN-05-MW43	11.57%	<= 2000	10				
Iron (Fe) - Water	µg/L	VIN-05-MW43	12.49%	<= 2000	29				
Lead (Pb) - Water	µg/L	VIN-05-MW43	16.32%	<= 10	<8				
Manganese (Mn) - Water	µg/L	VIN-05-MW43	12.44%	<= 400	<4				
Nickel (Ni) - Water	µg/L	VIN-05-MW43	17.38%	<= 70	<8				
Selenium (Se) - Water*	µg/L			<= 40	<10.0				
Aluminium (Al) - Water	µg/L	VIN-05-MW43	13.49%	<= 300	11				
Cyanide (CN) - Water*	µg/L			<= 200	<10.0				
Mercury (Hg) - Water*	µg/L			<= 6	<1.0				
Barium (Ba) Water	µg/L	VIN-05-MW43	14.09%	<= 700	<8				
Uranium (U) - Water*	µg/L			<= 30	<28				
Date Tested					2023-12-01				

Water - Micro

	Unit	Method	Uncertainty	Limits	Results	Results	Results	Results	Results
Total Coliforms (Water)	cfu/100mL	VIN-05-MW09		<= 10	40				
E-Coli (Water)	cfu/100mL	VIN-05-MW09		not detected	nd				
Heterotrophic plate count*	cfu/mL			<= 1000	50				
Date Tested					2023-11-30				

Comments

W45097
Two Samples received,

Ion balance =5.6%

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Doc No V48320 | VIN 09-01 30-11-2022 | Page: 2 of 3 | Visit Vinlab H20

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Attn: Alison McDuling

P.O.Box 12412
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7613
+27218801079

@VinlabSA

AEFourie

Adelize Fourie
Laboratory Manager (Waterlab)
VIN-05-
M01,M02,M03,M04,M05,MO8,M10,M28,
M43, MW01, MW02, MW03, MW04,
MW05, MW06, MW07, MW08/9/10,
MW12, MW13, MW14

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Doc No V48320 | VIN 09-01 30-11-2022 | Page: 3 of 3 | Visit Vinlab H20

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19. APPENDIX D: RISK RATING CRITERIA

Nature of impact	**Description**
Positive	Impacts would benefit the receiving environment (including people).
Negative	Impacts would harm the receiving environment (including people).
Type of impact	Description
Direct	Impacts that result directly from the causal activity, usually at the same time and in the same space as that activity
Indirect	Secondary impacts may result from direct impacts, generally occurring later in time and may manifest elsewhere in space (e.g. downstream)
Induced	Impacts that may happen as a consequence of the Project (e.g., migration of people along newly created access routes)
Cumulative	Impacts that add to or magnify existing or reasonably foreseeable future impacts on the same receiving environment or specific resource
Extent Rating	Description
Site specific	Impact (and implications) limited to the project site.
Local	Impact extends only as far as the activity, limited to the site and its immediate surroundings, and local assets/ resources.
Regional	Impact extends to a regional scale, and affects provincial resources, e.g. District or Province; Western Cape
National	Impact extends to a national scale, and affects national resources; South Africa.
International	Impact extends across national borders, and affects global resources.
Duration Rating	Description
Short term	0 - 5 years
Medium term	5 - 15 years
Long term	Where the impact will cease after the operational life of the activity, either because of natural processes or by human intervention. Generally >15 years but <30 years
Permanent	Where the impact will, for all intents and purposes, endure in perpetuity. That is, it would be regarded as 'irreversible'
Intensity Rating	Description
Low	Where the impact affects the environment in such a way that a small or negligible proportion of resources and/or beneficiaries would be affected. Receptors in the receiving environment are not threatened or vulnerable, and affected communities have negligible or very low dependence on affected resources for livelihoods, health and safety.
Medium	Where a sizeable proportion of resources and/ or of beneficiaries would be affected, and natural, cultural and social functions and processes would continue, albeit in a modified way. Receptors in the receiving environment are moderately threatened or vulnerable, and/ or affected communities have some dependence on affected resources for livelihoods, health and safety, affected resources could be substituted.
High	Where most/ a major proportion of resources and/ or beneficiaries would be affected, and natural, cultural and social functions or processes are altered to the extent that they would temporarily or permanently cease. Receptors in the receiving environment are highly threatened or vulnerable (i.e. close to environmental or legal thresholds, standards or targets), and affected communities are highly dependent on affected resources for livelihoods, health and safety, and/

	or resources are considered to be irreplaceable (if lost they could not be substituted, and/ or their loss would undermine achieving targets, standards).
Probability Rating	Description
Improbable	Where the possibility of the impact materializing is very low, but it could occur e.g. in unplanned / upset conditions
Possible	Where there is a possibility that the impact will occur during normal operations.
Probable	Where the impact is expected to occur during normal operations
Definite	Where the impact will undoubtedly occur.
Confidence Rating	Description
High	High confidence in predictions.
Medium	Some uncertainty in predictions e.g. due to information gaps, constraints on study
Low	Little confidence in predictions e.g. due to constraints on study, information gaps, inherent uncertainties
Significance Rating	**Description**
Negligible	Where the receiving environment (including people) would not be materially affected by the proposed activity(ies). *There would be no need for mitigation.*
Very Low	Where there would be minimal effect on the environment or human wellbeing, and impacts would be well within environmental quality standards or targets, or legal requirements. *There would be no need for mitigation.*
Low	Where there would be little material effect on the environment or human wellbeing, and impacts would be well within environmental quality standards or targets, or legal requirements. *Minor mitigation measures may be required.*
Moderate	Where the activity (ies) would have a material effect on the receiving environment (including people), legal requirements would still be met but thresholds of potential concern with regard to environmental quality may be crossed. *Mitigation measures – avoidance, minimization and rehabilitation/ restoration, and in some cases offsets/ compensation - would be needed to reduce the impact significance.*
High	Where there would be major effects on the receiving environment to the extent where environmental quality standards or targets may be jeopardized, legal requirements may not be met, and the health, safety, livelihoods and/or wellbeing of affected people could be jeopardized. *Mitigation measures – preferably avoidance/ impact prevention, minimization, rehabilitation/ restoration, and offsets/ compensation – are essential to reduce the impact significance substantially.*
Very High	Where there would be severe or substantial effects on the receiving environment to the extent where environmental quality standards or targets would be undermined/ exceeded, there would be non-compliance with legal requirements or commitments, and the health, safety, livelihoods and/or wellbeing of affected people would be jeopardized. *Mitigation measures – avoidance or prevention of impacts as a priority would be required, since impacts are unacceptable. Additional measures to minimize, rehabilitate/ restore, and offset/ compensate for residual impacts would be – are essential to reduce the impact significance substantially*

(Last page)