Hydropedological Assessment for the proposed Su Casa Burial Estate, Doornrug Cemetery Project

Emalahleni, Mpumalanga

November 2022

CLIENT

Prepared by:

The Biodiversity Company

Cell: +27 81 319 1225

Fax : +27 86 527 1965

info@thebiodiversitycompany.com

www.thebiodiversitycompany.com

Report Name	Level 2 Hydropedological Assessment for the Proposed Su Casa Burial Estate, Doornrug Cemetery Project, Emalahleni, Mpumalanga
Submitted to	EAGLESAGE ENHANCING LIVES
Report Reviewer	**Andrew Husted**
	Andrew Husted is Pr Sci Nat registered (400213/11) in the following fields of practice: Ecological Science, Environmental Science and Aquatic Science. Andrew is an Aquatic, Wetland and Biodiversity Specialist with more than 12 years' experience in the environmental consulting field. Andrew has completed numerous wetland training courses, and is an accredited wetland practitioner, recognised by the DWS, and the Mondi Wetlands programme as a competent wetland consultant.
Fieldwork	**Namitha Singh**
	Namitha Singh is a wetland ecologist with experience in wetland and hydropedological assessments, coastal geomorphology and estuary management. She possesses a BSc. Honours in Environmental Science from the University of KwaZulu-Natal, Westville Campus. Namitha has worked on projects related to residential developments, infrastructural developments, sand mining and general natural resource management.
Report Writer	**Matthew Mamera**
	Matthew Mamera is a Cand. Sci Nat registered (116356) in natural and agricultural sciences recognized in soil science. Matthew is a soil and hydropedology specialist with experience in soil, pedology, hydropedology, water and sanitation management and land contamination and has field experience and numerous peer reviewed scientific publications in international journals. Matthew completed his M.Sc. in soil science, hydropedology and water management at the University of Fort Hare, Alice. He is also a holder of a PhD in soil science, hydropedology, water and sanitation obtained at the University of the Free State, Bloemfontein. Matthew is also a member of the Soil Science Society of South Africa (SSSSA).
Declaration	The Biodiversity Company and its associates operate as independent consultants under the auspice of the South African Council for Natural Scientific Professions. We declare that we have no affiliation with or vested financial interests in the proponent, other than for work performed under the Environmental Impact Assessment Regulations, 2017. We have no conflicting interests in the undertaking of this activity and have no interests in secondary developments resulting from the authorisation of this project. We have no vested interest in the project, other than to provide a professional service within the constraints of the project (timing, time and budget) based on the principals of science.

Table of Contents

Tables

Figures

Declaration

I Matthew Mamera, declare that:

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that has or may have the potential of influencing any decision to be taken with respect to the application by the competent authority; and the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of Section 24F of the Act.

Matthew Mamera

Soil Hydropedology Scientist

The Biodiversity Company

November 2022

1 Introduction

The Biodiversity Company was commissioned to conduct a specialist hydropedological level two (2) assessment for the proposed Su Casa Burial Estate and associated activities. The hydropedological site assessment was conducted on the 10th of November 2022. The hydropedological assessment was completed in fulfilment to obtain the relevant Environmental Authorisation (EA) for development of the proposed Su Casa Burial Estate.

This report presents the results of a hydropedological assessment on the environment associated with the proposed development. This report should be interpreted after taking into consideration the findings and recommendations provided by the specialist herein. Further, this report should inform and guide the Environmental Assessment Practitioner (EAP) and regulatory authorities, enabling informed decision making, as to the ecological viability of the proposed project.

The proposed Su Casa Burial estate will consist various development activities such as but not limited to; office buildings, a dining hall, security houses, palisade fencing, parking areas, internal roads, walkways, ash scattering garden, ablution facilities connected to a septic tank and upgrades to the existing borehole, landscaping, water ponds and a wall of remembrance. However, it should be noted that items on this list may be amended or removed from the spatial development plan for the proposed development.

1.1 Project Area

The proposed development is in the Emalahleni municipality in the Mpumalanga Province. The project area occupies an approximate extent of 26 ha and is situated approximately 2 km South of the N4 road and about 17 km West of the town Emalahleni (Figure 1-1). The area surrounding the proposed project development site consists predominantly of agricultural fields and mining operations to the east of the project area.

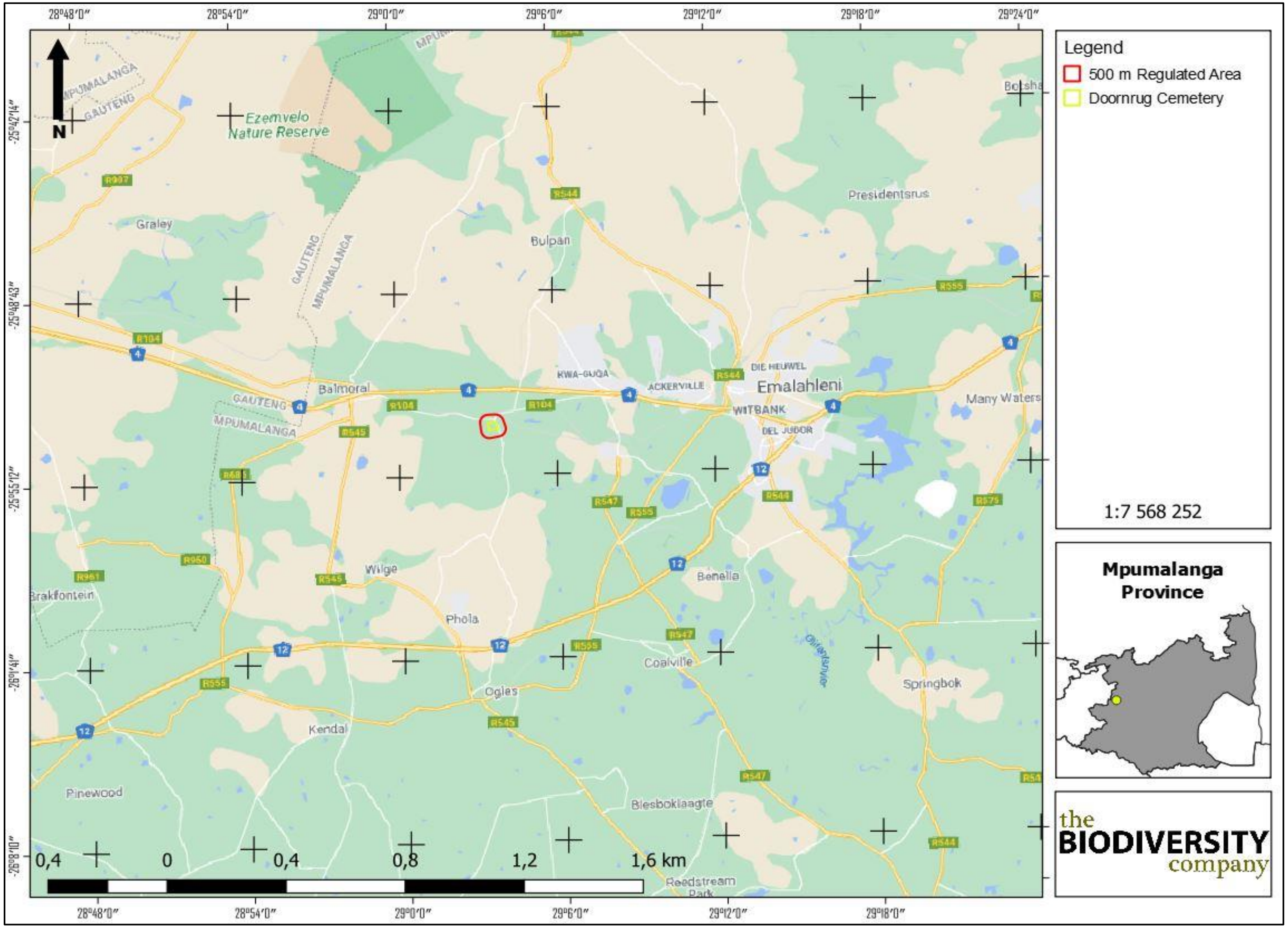

Figure 1-1 Spatial context of the proposed development

1.2 Scope of Work

The approach of this assessment is based on the protocols compiled by van Tol *et al.,* (2021) and issued by the Department of Water and Sanitation (DWS). According to these protocols, two main steps are required depending on the level of the hydropedology assessment;

1. Identification of dominant hillslopes; and
2. Conceptualise hillslope hydrological responses.

For impact assessments associated with activities that pose significant threats on the interflow volumes of a landscape or activities that are expected to drastically change the dynamics of a landscape (i.e., open cast mining), all four steps are required. For those activities that only include minor impacts (i.e., installation of a pipeline or infrastructure), only the first two steps are required.

Therefore, considering the intensity of some of the proposed activities, only the first two steps will be relevant to this assessment.

1.3 Limitations

The following aspects were considered as limitations;

- Only the slopes affected by the proposed development have been assessed;
- It has been assumed that the extent of the development area provided by the responsible party is accurate; and
- The GPS used for ground truthing is accurate to within five meters. Therefore, the wetland and the observation site's delineation plotted digitally may be offset by at up to five meters to either side.

2 Literature Review

2.1 Hydropedological Flow Paths

Given that hydropedology is a relatively new field, a short literature review has been added on this interdisciplinary research field. This literature is an excerpt from van Tol *et al.,* (2017).

Soil physical properties and hydrology play significant roles in the fundamentals of hydropedology. Physical properties including porosity, hydraulic conductivity, infiltration etc. determine micro preferential flow paths through a soil profile. The hydrology in turn is responsible for the formation of various morphological processes in soil, including mottling, colouration and the accumulation of carbonate.

These processes are used to construct models illustrating sub-surface flow paths, storage and interconnection between these flow paths. Hydropedology can therefore be used for a variety of functions. These functions include process-based modelling, digital soil mapping, pollution control management, impact of land use change on water resources, wetland protection, characterising ground and sub-surface flows as well as wetland protection and rehabilitation, of which the latter will be the main focus during this report (see Figure 2-1). The latter mentioned enables effective water resource management regarding wetlands and sub-surface flows in general.

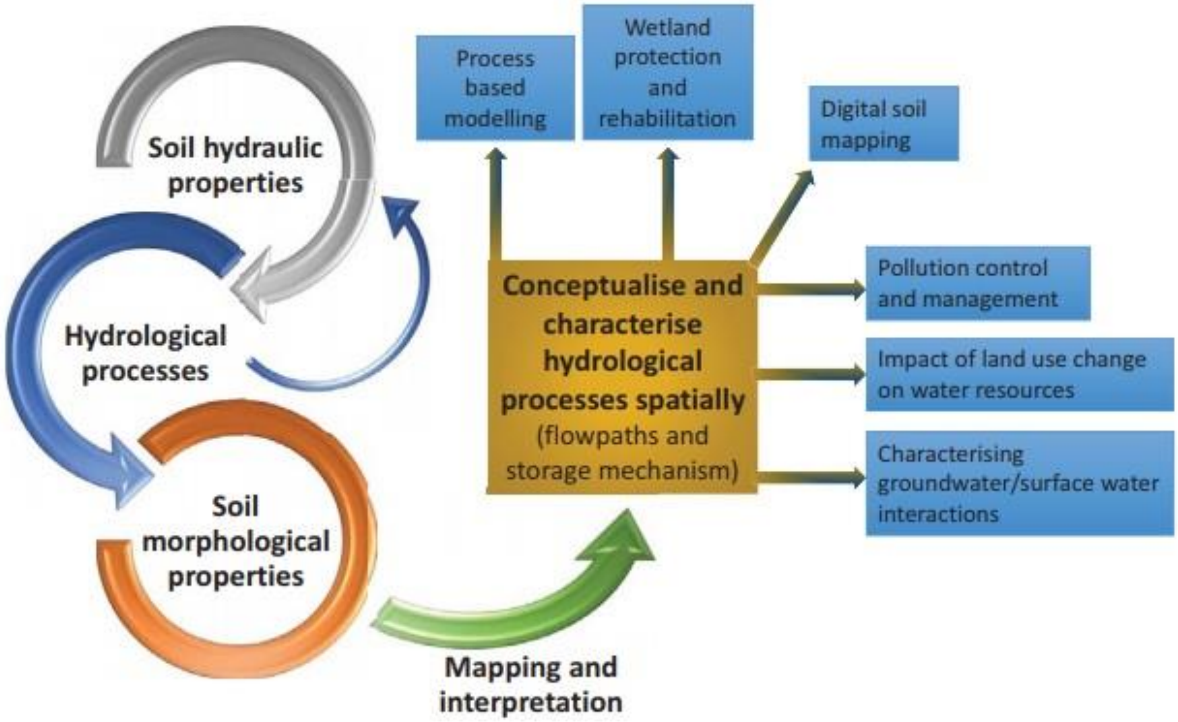

Figure 2-1 Illustration of the interactive nature of hydropedology and its potential applications (van Tol et al., 2017)

As can be seen in Figure 2-2, the hydropedological behaviour of soil types can differ significantly. Figure 2-2 (a) illustrates a typical red coloured soil (top- and sub-soil. This soil type will typically have a vertical flow path throughput the soil profile. Water will therefore infiltrate the topsoil and freely drain into the profile to such an extent that the water rapidly reaches the bedrock. After reaching this layer, water will penetrate the ground water source or be transported horizontally towards lower laying areas. This soil type is known as a recharge soil, given its ability to recharge ground and surface water sources.

Figure 2-2 (b) illustrates interflow soils. Lateral flows are dominant in this soil type and occurs due to differences in the hydraulic conductivity of soil horizons. The "sp" soil horizon restricts vertical movement and promotes lateral flows at the A/B interface. The lighter colour in this profile indicates leaching which is caused by lateral flows which often occurs on top of a bedrock layer due to the impermeable nature thereof. Mottles often occurs above this impermeable layer due to fluctuating water levels, see the magnified illustration in Figure 2-2 (b-i).

Figure 2-2 (c) illustrates responsive soils. This hydropedological soil type is characterised (in this case) by a dark top-soil and a grey coloured sub-soil. Other indicators include mottling and gleying. These soil types are saturated for very long periods. Therefore, rainfall is unlikely to infiltrate this layer and would likely be carried off via overland flow and are mostly fed by lateral sub-surface flows. Shallow soils are equally responsive in the sense that the soil profile will rapidly be saturated during precipitation, after which rainfall will be carried off by means of overland flows.

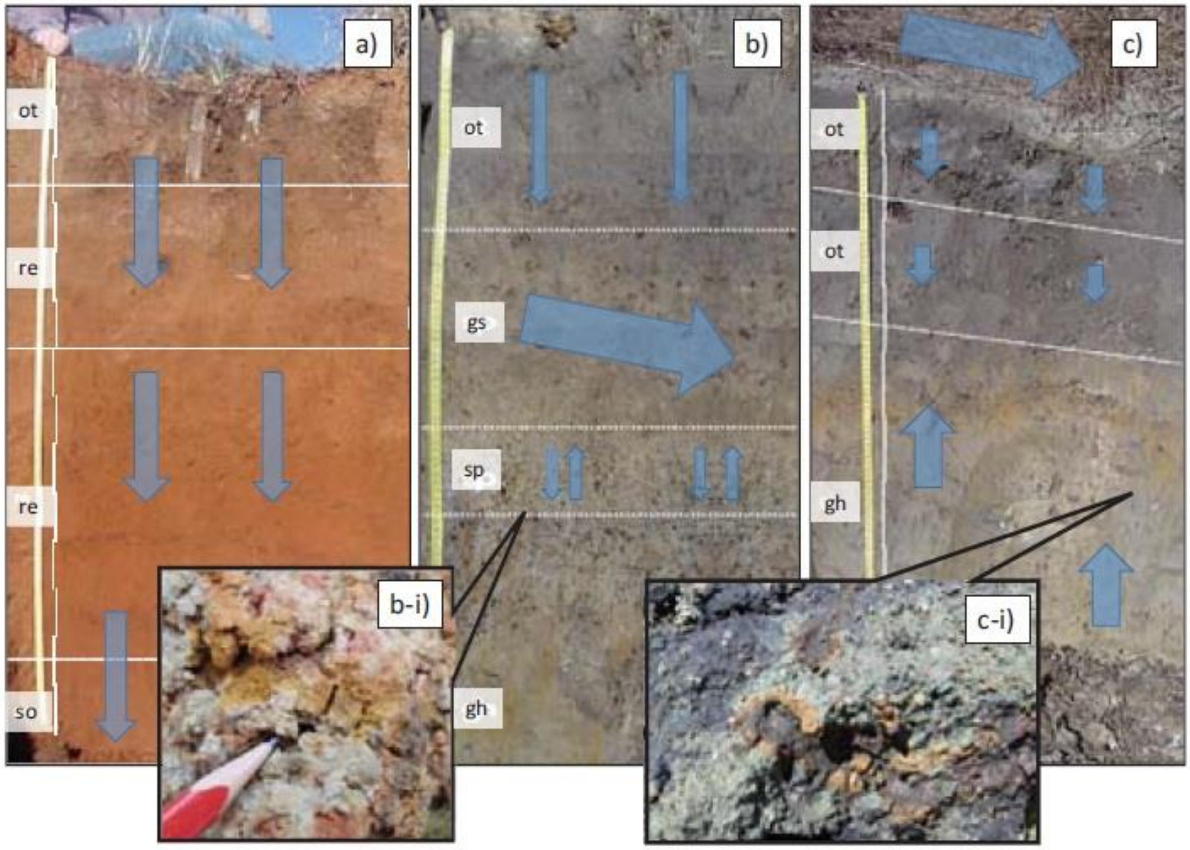

Figure 2-2 Illustration of different hydropedological soil types (van Tol et al., 2017)

A typical example of the hydropedological processes through a hillslope is illustrated in Figure 2-3. In this example, a recharge soil type is located at the upper reaches of the slope. Rainfall infiltrates this soil type and percolates vertically towards the bedrock. Water then, infiltrate into this bedrock given the permeability thereof and could now recharge groundwater or return to the soil in lower lying positions. The second soil type (the interflow zone) indicates lateral flows at the A/B interface and again at the soil/bedrock interface which feeds the responsive zone. The responsive zone is then simultaneously fed by lateral sub-surface flows and ground water recharge.

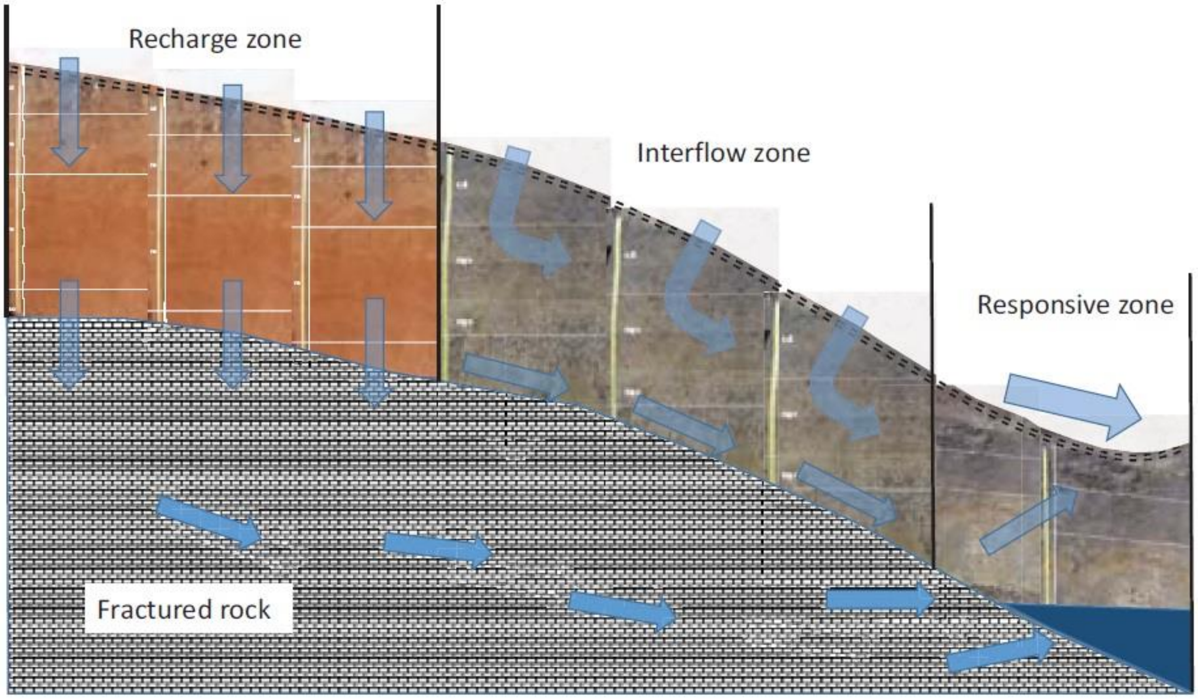

Figure 2-3 Theoretical example of various sub-surface flow paths (van Tol et al., 2017)

The methodology of van Tol *et al.,* (2017) has since been updated to include a “stagnant” hydropedological type. According to van *Tol et al.,* (2019), four different hydropedological types exist, namely Recharge, Interflow, Responsive and Stagnating hydropedological types. These soil types are divided into seven subgroups depending on the morphology of the relevant soil form. The latest addition to this methodology, as mentioned, is known as a stagnating hydropedological type.

This soil type is characterised by restrictive movement of water through profiles (both laterally and vertically) and is dominated by evapotranspiration. The A- and B-horizon of such a soil type usually has a high permeability with morphological indicators indicating very little movement through the profile. Lime and iron concretions as well as cementation of silica are typical indicators of such a soil form.

3 Methodology

3.1 Desktop assessment

The following information sources were considered for the desktop assessment;

- Aerial imagery (Google Earth Pro);
- Land Type Data (Land Type Survey Staff, 1972 - 2006);
- Topographical river line data;
- Contour data (5 m); and

- Mucina & Rutherford (2006).

3.2 Field Procedure

The slopes within the project area have been assessed during the desktop assessment to identify possible transects that will represent typical terrain and soil distribution patterns. These locations were then altered slightly during the survey depending on the extent of vegetation, slopes, access and any features that will improve the accuracy of data acquired.

3.2.1 Identification of Soil Types and Hydrological Soil Types

Soil types have been identified according to the South African soil classification system (Soil Classification Working Group, 2018) after which the link between soil forms and hydropedological response were established (van Tol & Le Roux, 2019), and the soils regrouped into various hydropedological soil types as shown in Table 3-1.

Table 3-1 Hydrological soil types of the studied hillslopes (van Tol et al., 2019).

Hydrological soil type	Description	Subgroup	Symbol
Recharge	Soils without any morphological indication of saturation. Vertical flow through and out the profile into the underlying bedrock is the dominant flow direction. These soils can either be shallow on fractured rock with limited contribution to evapotranspiration or deep freely drained soils with significant contribution to evapotranspiration.	Shallow	
		Deep	
Interflow (a/b)	Duplex soils where the textural discontinuity facilitates build-up of water in the topsoil. Duration of drainable water depends on rate of ET, position in the hillslope (lateral addition/release) and slope (discharge in a predominantly lateral direction).	A/B	
Interflow (soil/bedrock)	Soils overlying relatively impermeable bedrock. Hydromorphic properties signify temporal build of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction.	Soil/Bedrock	
Responsive (shallow)	Shallow soils overlying relatively impermeable bedrock. Limited storage capacity results in the generation of overland flow after rain events.	Shallow	
Responsive (saturated)	Soils with morphological evidence of long periods of saturation. These soils are close to saturation during rainy seasons and promote the generation of overland flow due to saturation excess.	Saturated	
Stagnating	In these soils outflow of water is limited or restricted. The A and/or B horizons are permeable but morphological indicators suggest that recharge and interflow are not dominant. These includes soils with carbonate accumulations in the subsoil, accumulation and cementation by silica, and precipitation of iron as concretions and layers. These soils are frequently observed in climate regions with a very high evapotranspiration demand. Although infiltration occurs readily, the dominant hydrological flow path in the soil is upward, driven by evapotranspiration.		

4 Results and Discussions

4.1 Desktop Background Findings

4.1.1 Climate

The climate for the Rand Highveld Grassland is characterised by a summer rainfall with a mean annual precipitation of 654 mm which is slightly lower in the western parts of this vegetation type (see Figure 4-1). These areas are known to have warm-temperate conditions with dry winters. The likelihood of frost however is greater in the western parts with the incidence of frost ranging from 30 to 40 days compared to the east which has a frost incidence of 10 to 35 days (Mucina & Rutherford, 2006).

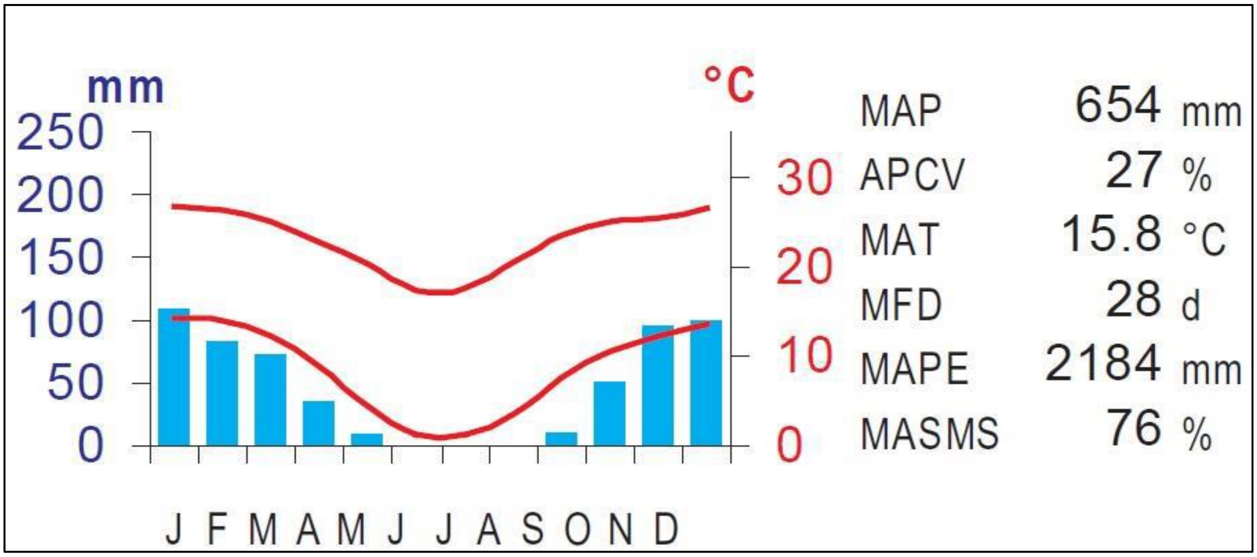

Figure 4-1 Summarised climate for the region (Mucina & Rutherford, 2006)

4.1.2 Vegetation

The distribution of the KwaZulu-Natal Coastal Belt vegetation type (CB 3) ranges from Mtunzi to Margate as a broad coastal strip. The altitude of this vegetation type is between twenty meters above sea level to 450 meters above sea level (Mucina & Rutherford, 2006).

Undulating coastal plains cover this vegetation type with historic signs of dense subtropical coastal forests being present. Primary grasslands still dominate areas protected from veld fires, especially in high altitude areas with high rainfall. These grasslands are dominated specifically by *Themeda triandra*. This vegetation type is affected by timber plantations, vast amounts of sugarcane fields and infrastructure related to tourism. Secondary grasslands dominated by *Aristida* as well as thickets and patches of coastal thornveld is still present in between disturbed areas (Mucina & Rutherford, 2006).

This vegetation type is endangered with only small patches of land being conserved. These conservation areas include the Ngoye, Vernon Crookes and Mbumbazi nature reserves. Approximately 50% of this vegetation type is transformed by cultivation, road building and urban sprawl. Alien species include *Solanum mauritianum, Melia azedarach, Lantana camera* and *Chromolaena odorata* (Mucina & Rutherford, 2006).

4.1.3 Geology & Soils

According to the land type database (Land Type Survey Staff, 1972 - 2006), the project area is characterised by the Ba 5, Ba 13, Bb 11 and Bb 16 land types which is illustrated in Figure 4-5. The Ba 5 land type is commonly dominated with the Hutton and Willowbrook soil forms according to the Soil classification working group, (1991), with the occurrence of other soils within the landscape. The Ba 13 land type mostly has Hutton and Katspruit soil forms within the landscape. The Bb 11 land type is characterised with the occurrence of Avalon and Katspruit soil forms with also other associated soils being present within the terrain. The Bb 16 land type mainly has the Clovelly soil forms and stream beds within the landscape with the possibility of other soils occurring in the terrain. The Ba and Bb land types consists of duplex and margalitic soils which tend to be dystrophic or mesotrophic. The subsoils consist of widespread red soils and according to Mucina & Rutherford (2006), Glenrosa as well as Mispah soil forms tend to dominate these areas. These soil forms are predominantly formed on rocky ridges. The land terrain units for the featured Ba 5 land type are illustrated in Figure 4-2; the Ba 13 land types are illustrated in Figure 4-3; the Bb 11 land types in Figure 4-4; the Bb 16 and Table 4-4.

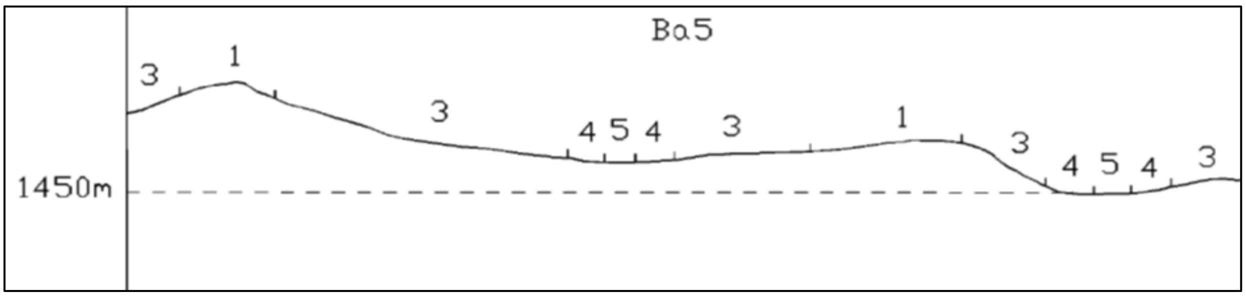

Figure 4-2 Illustration of land type Ba5 terrain units (Land Type Survey Staff, 1972 - 2006)

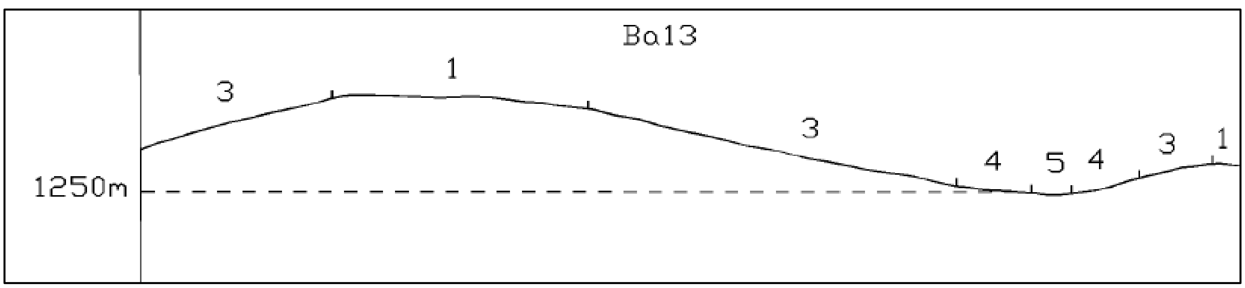

Figure 4-3 Illustration of land type Ba13 terrain units (Land Type Survey Staff, 1972 - 2006)

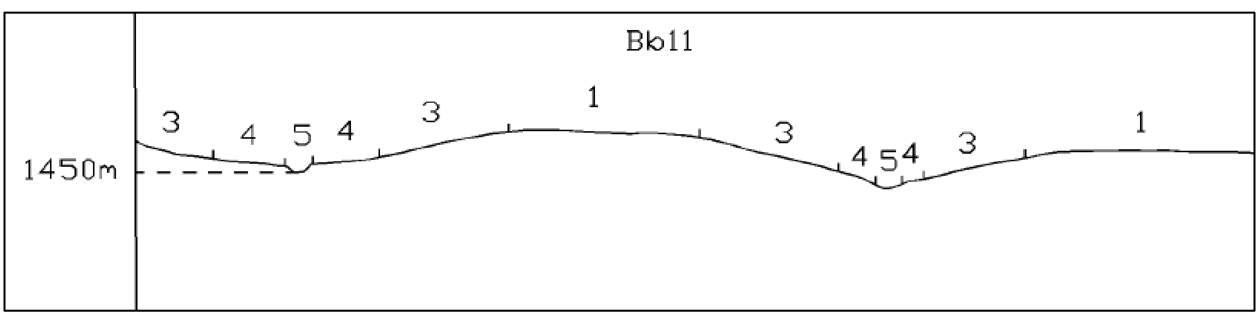

Figure 4-4 Illustration of land type Bb11 terrain units (Land Type Survey Staff, 1972 - 2006)

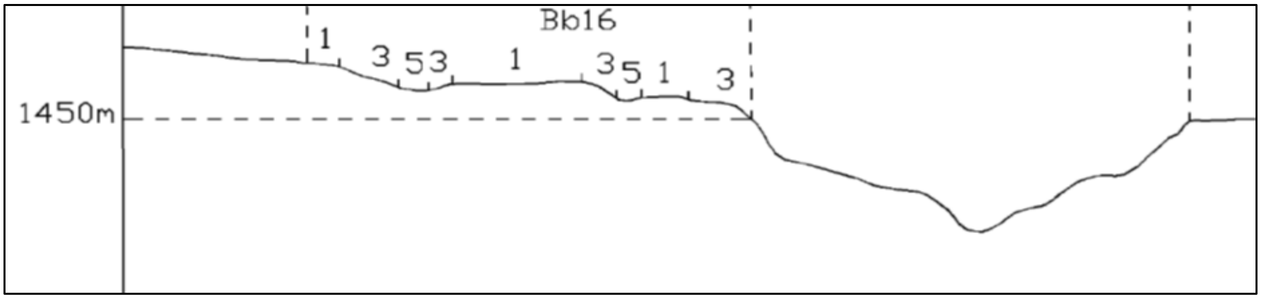

Figure 4-5 Illustration of land type Bb16 terrain units (Land Type Survey Staff, 1972 - 2006)

Table 4-1 Soils expected at the respective terrain units within the Ba5 land type (Land Type Survey Staff, 1972 - 2006)

Terrain Units							
1 (20%)		**3 (60%)**		**4 (15%)**		**5 (5%)**	
Hutton	50%	Hutton	40%	Hutton	25%	Willowbrook	50%
Glenrosa	20%	Avalon	15%	Avalon	15%	Katspruit	30%
Clovelly	10%	Glenrosa	10%	Longlands	15%	Longlands	20%
Bare rock	10%	Glencoe	10%	Kroonstad	10%		
		Clovelly	5%	Bonheim	10%		
		Longlands	5%	Clovelly	10%		
		Swartland	5%	Swartland	5%		
		Wasbank	5%	Glencoe	5%		
		Mispah	5%	Wasbank	5%		

Table 4-2 Soils expected at the respective terrain units within the Ba13 land type (Land Type Survey Staff, 1972 - 2006)

Terrain Units							
1 (30%)		**3 (55%)**		**4 (13%)**		**5 (2%)**	
Hutton	50%	Hutton	45%	Hutton	30%	Katspruit	50%
Avalon	12.5%	Avalon	12.5%	Longlands	25%	Longlands	30%
Glencoe	12.5%	Glencoe	12.5%	Avalon	12.5%	Dundee	10%
Glenrosa	10%	Glenrosa	10%	Glencoe	12.5%	Oakleaf	10%
Clovelly	10%	Clovelly	10%	Swartland	10%		
Mispah	5%	Longlands	5%	Clovelly	5%		
		Swartland	5%	Glenrosa	5%		

Table 4-3 Soils expected at the respective terrain units within the Bb11 land type (Land Type Survey Staff, 1972 - 2006)

Terrain Units							
1 (40%)		**3 (30%)**		**4 (28%)**		**5 (2%)**	
Avalon	30%	Avalon	35%	Avalon	40%	Katspruit	60%
Hutton	25%	Hutton	20%	Clovelly	15%	Longlands	20%
Clovelly	25%	Clovelly	20%	Glencoe	15%	Hutton	10%
Glencoe	15%	Glencoe	15%	Hutton	10%	Dundee	10%
Wasbank	5%	Wasbank	5%	Wasbank	10%		
		Longlands	5%	Longlands	10%		

Table 4-4 Soils expected at the respective terrain units within the Bb16 land type (Land Type Survey Staff, 1972 - 2006)

Terrain Units					
1 50%)		**3 (45%)**		**5 (5%)**	
Clovelly	35%	Clovelly	35%	Stream beds	30%
Mispah	15%	Bare Rock	10%	Katspruit	30%
Hutton	15%	Mispah	15%	Longlands	15%
Avalon	15%	Cartref	15%	Wasbank	15%
Cartref	5%	Hutton	10%	Swartland	10%
Glenrosa	5%	Avalon	10%		
Glencoe	5%	Longlands	5%		
Bare Rock	5%				

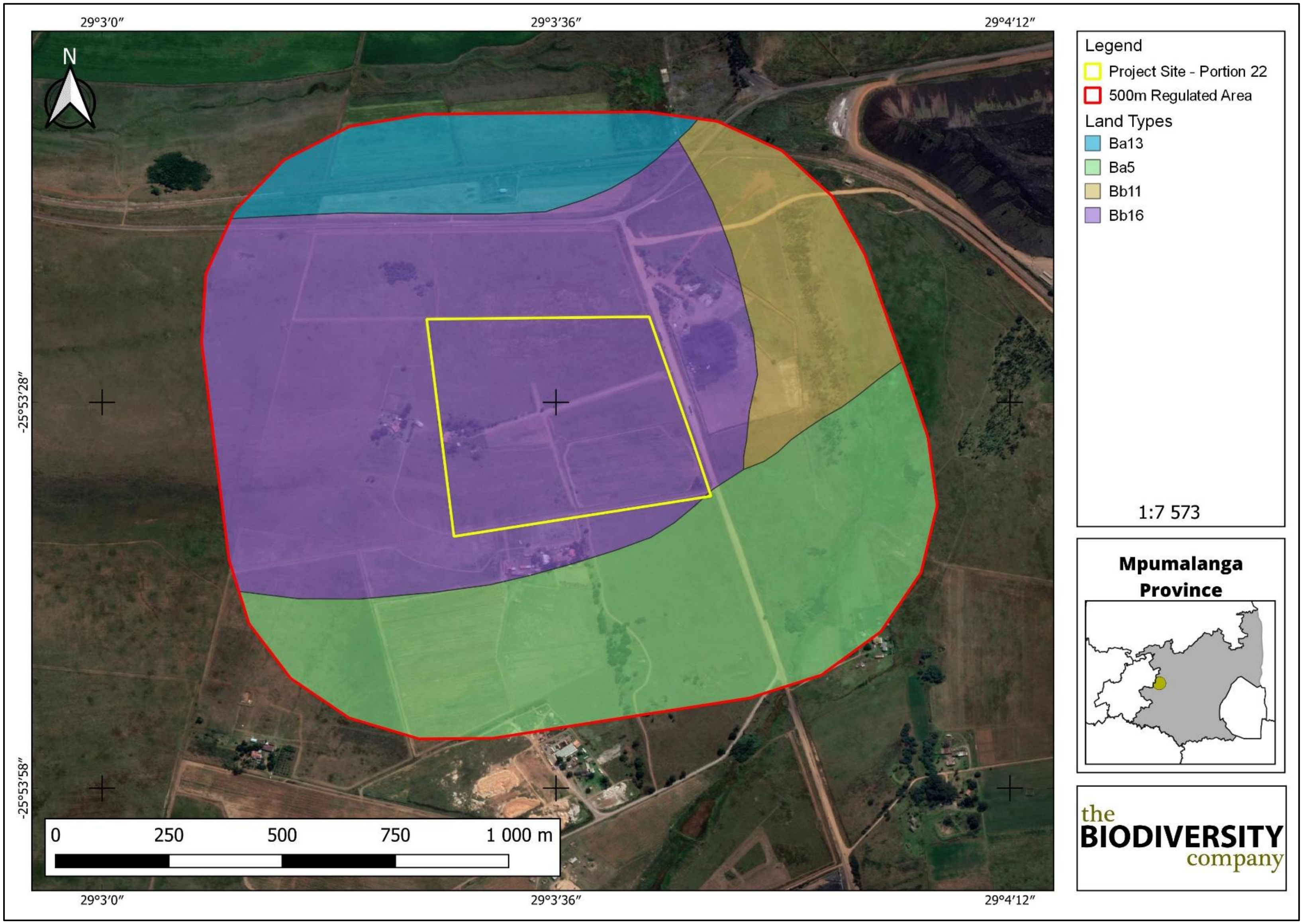

Figure 4-5 Land types present within the proposed Burial Estate

4.2 Soil Forms Identified on-site

The following soil forms were identified on-site whilst surveying the relevant transects;

- Mispah (Orthic topsoil, over Hard rock);
- Glenrosa (Orthic topsoil, over lithic); and
- Kroonstad (Orthic topsoil, over albic, over gley).

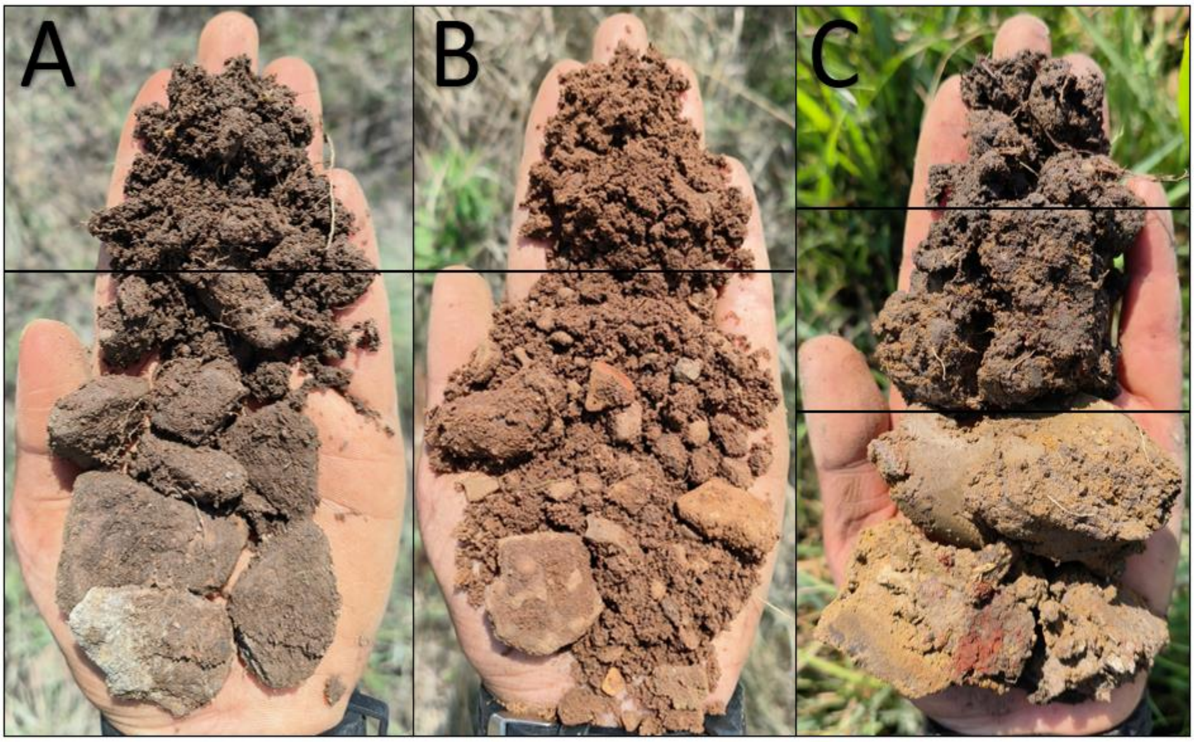

Figure 4-6 Diagnostic soil horizons identified on-site: A) Orthic over hard rock B) Orthic over lithic C) Albic over gley

4.3 Hillslope Hydrology

The survey was conducted to obtain information regarding the soil morphology and hydropedological flow paths relevant to the hillslope by means of several transects. The hillslope hydrology of slopes intersected by the proposed Su Casa Burial Estate and associated infrastructure components are characterised by two distinct hydropedological patterns. Most of the slopes for the first distinctive hydropedological patterns are characterised by shallow recharge (see Figure 4-6) hydropedological types. These patterns occur from the crest to the upper mid-slope, after which a transition occurs from recharge to a responsive (saturated) section at the lower mid-slope to the valley bottom.

The second distinctive hydropedological pattern includes a shallow recharge soil forms in the crest to lower mid-slope area with a transition to a small responsive saturated hydropedological types. At the crest to lower mid-slope section, an increased Saturated Hydraulic Conductivity (*Ks*) occurs in the soil profile. Waterflow restrictions can also occur between the soil and the underlying parent material only if the substratum is impermeable.

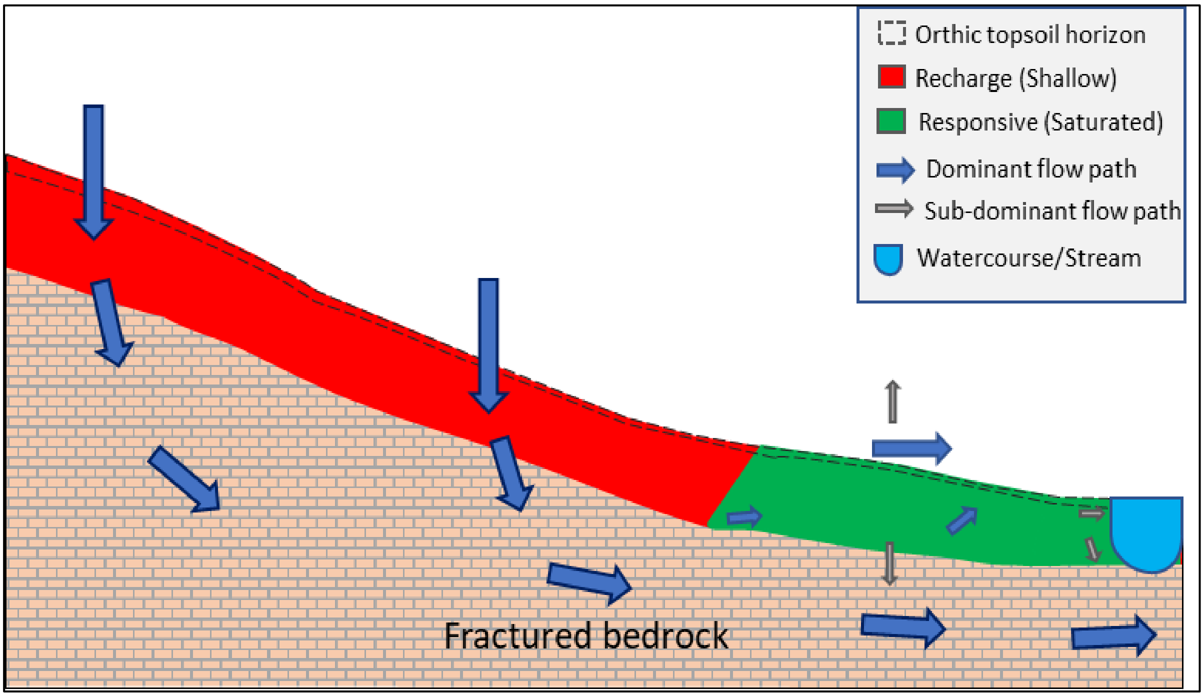

Figure 4-6 Hillslope hydrology of one of two distinct hydropedological patterns prior to cemetery construction.

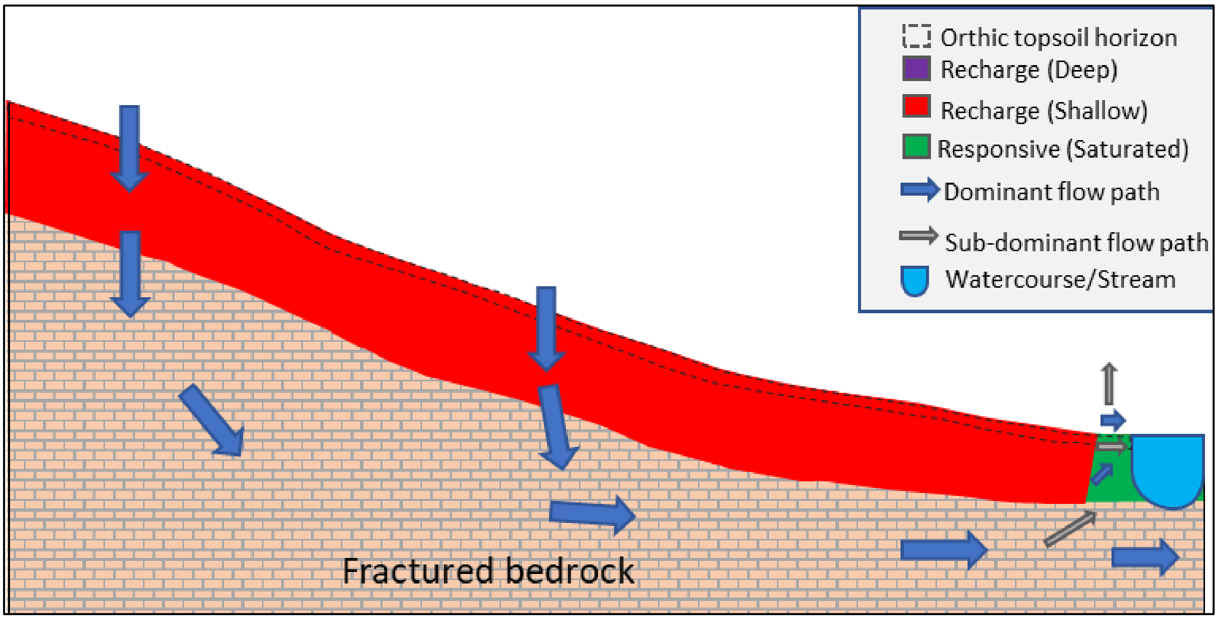

Figure 4-7 Hillslope hydrology of the second of two distinct hydropedological patterns prior to cemetery construction.

The shallow Glenrosa and Mispah soil forms identified on-site are characterised with well drained profiles. The Glenrosa soil forms consist of an orthic topsoil profiles which include the presence of a fractured lithic horizon at the rock interface. The Mispah soil forms are characterised with orthic topsoil profiles merging into a fractured substratum. These profiles are characterised by extremely high *Ks* rates, including the lower lithic horizon.

No signs of leaching or oxidation/reduction processes were identified throughout the soil profile, which, together with the high *Ks* emphasises rapid vertical recharge of the groundwater stores as being the dominant flow path.

The valley bottom regions are characterised by a responsive (wet) hydropedological type. The soil form relevant to this observation point is that of the Kroonstad soil from. This soil form is characterised by an albic horizon subsoil with a gley horizon below, which is indicative of prolonged/permanently saturated soils which result in the formation of "responsive soils." Responsive soils will be subject to overland/return flow during precipitation events (due to the naturally high-water content which will ensure rapid saturation). Between rainfall events, these soil forms will steadily feed watercourses and will lose moisture by means of Evapotranspiration (ET).

Albic horizons are often characterised by uniform white-greyish colours from the residual clay and quartz particles making up the matrix of the horizon. The main characteristic of this diagnostic horizon is a bleached colouration, which is a resultant product of distinct redox and ferrolysis pedological processes combined with eluvial processes. According to the Soil Classification Working Group (2018), albic horizons often receive lateral sub-surface flows from hillslope processes.

Gley horizons that are well developed and have homogenous dark to light grey colours with smooth transitions. Stagnant and reduced water over long periods is the main factor responsible for the formation of a gley horizon and could be characterised by green or blue tinges due to the presence of a mineral called Fougerite which includes sulphate and carbonate complexes. Even though grey colours are dominant, yellow and/or red striations can be noticed throughout a gley horizon. The structure of a gley horizon mostly is characterised as strong pedal, with low hydraulic conductivities and a clay texture, although sandy gley horizons are known to occur. The gley soil form commonly occurs at the toe of hillslopes (or benches) where lateral water inputs (sub-surface) are dominant and the underlaying geology is characterised by a low hydraulic conductivity. The gley horizon usually is second in diagnostic sequence in shallow profiles yet is known to be lower down in sequence and at greater depths (Soil Classification Working Group, 2018).

4.4 Conceptual Impact Prediction

The proposed Su Casa Burial Estate and associated infrastructure components will have very little impact on the hydropedology of the relevant hillslopes, regardless of the position of the grave sites (crest, mid-slope or valley bottom). For recharge soils (which are dominant), recharge won't be affected at all given the fact that infiltration will only be impeded for the width of the grave site, which has been deemed insignificant given the size of the catchments as the dominant flow paths will remain vertical recharging groundwater stores (see Figure 4-8; Figure 4-9; for a conceptual example of interferences via the proposed grave sites).

The responsive (saturated) hydropedological types, are usually not recommended for most activities as their interface can affect the total streamflow of sensitive receptors (e.g., the lower valley bottoms in Figure 4-8). Also, responsive (saturated) hydropedological soil types tend to promote migration of contaminates towards water resources. In the case of the burial site body decomposition will occur.

The proposed Su Casa Burial Estate and associated infrastructure components located within the recharge hydropedological type is not expected to affect the hillslope hydrology in any manner. Limited impacts can occur due the impeded vertical flows on the burial coffins and caskets are expected. These effects are however expected to have negligible impacts towards the total streamflow of sensitive receptors.

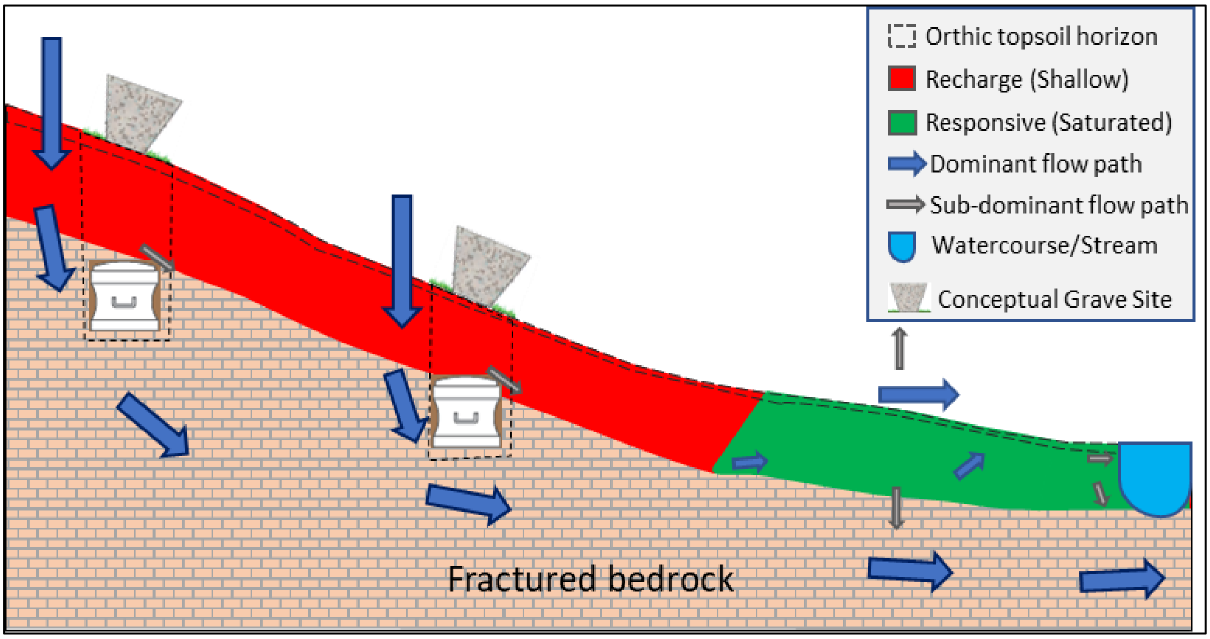

Figure 4-8 Hillslope hydrology of one of two distinct hydropedological patterns after the establishment of the burial estate and associated infrastructure.

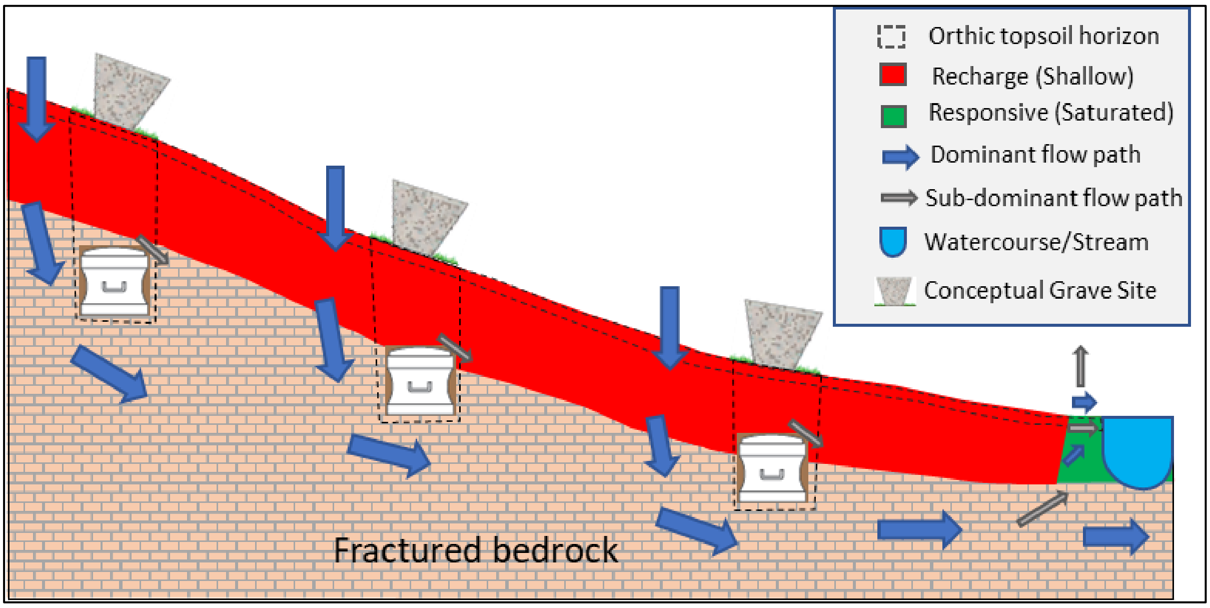

Figure 4-9 Hillslope hydrology of two of two distinct hydropedological patterns after the establishment of burial estate and associated infrastructure.

5 Conclusion and Impact Statement

Two main hillslope types were identified, which includes the presence of recharge (shallow) and responsive hydropedological types. The proposed Su Casa Burial Estate and associated infrastructure components will have no effect on the hillslope hydrology due to the extent of the grave sites (diameter), the fact that recharge dominates even though shallow throughout as well as the size of the greater catchment. Also, no impacts on the total streamflow of watercourses as both lateral and vertical flow paths will occur in response to the flow impediment.

Therefore, it is recommended that the proposed activities may proceed as have been planned due to negligible impacts expected on most of the identified hillslopes. Measures can be set on soils with some expected changes in flow paths prior to the burial estate establishment. Development should avoid areas with responsive (saturated) hydropedological soil types as they can promote contaminates migration and also act as receptors for groundwater stores.

5.1 Surface Water Monitoring Programme

The limits prescribed in this monitoring programme are stipulated in the Target Water Quality Range (TWQR) for aquatic ecosystems (DWAF, 1996). This prescribed monitoring programme should be conducted in conjunction with other aspects of riverine monitoring in the form of aquatic biomonitoring which addresses macroinvertebrate and ichthyofauna assemblages on a bi-yearly basis. The surface water monitoring programme will require monthly monitoring of the adjacent valley bottom wetland at two sites, upstream (control site) and a downstream monitoring site. The watercourse should be monitored for the prescribed aspects below (Table 5-1).

Contaminants emanating from burial practices are typically based on the following:

- Their sources (whether from the body's decomposition, accessory burial materials, or associated activities)
- The rate at which they are released to the subsurface
- Their mobility and persistence in the subsurface, and
- Their toxicity or health effects on receptors.

Table 5-1 Proposed water quality parameters

Parameters	pH	Conductivity (µS/cm)	Dissolved Oxygen (mg/l)	Temperature (°C)
TWQR*	6.5-9.0	-	>5.00	5-30*
Metals	Ti, Cr, Cd, Pb, Fe, Mn, Ni, Zn, As			
Nutrients	NO3, PO4, Cl, salts of Ca, Na, K, Mg			
Organics	Formaldehyde, Methanol			
Pathogens	Bacteria, Viruses, Microorganisms, Fungi			
***TWQR – Target Water Quality Range (DWAF, 1996)**				

6 References

Land Type Survey Staff. (1972 - 2006). Land Types of South Africa: Digital Map (1:250 000 Scale) and Soil Inventory Databases. Pretoria: ARC-Institute for Soil, Climate, and Water.

Mucina, L., & Rutherford, M. C. (2006). The Vegetation of South Africa, Lesotho, and Swaziland. Strelitzia 19. Pretoria: National Biodiversity Institute.

Soil Classification Working Group. (1991). Soil Classification A Taxonomic system for South Africa. Pretoria: The Department of Agricultural Development.

Soil Classification Working Group. (2018). Soil Classification A Taxonomic system for South Africa. Pretoria: The Agricultural Research Council.

Van Tol, J.J., Le Roux, P.A.L. & Hensley, M. 2013. Pedological criteria for estimating the importance of subsurface lateral flow in E horizons in South African soils. *Water SA* (39):1

Van Tol, J.J., Le Roux, P.A.L., Lorentz, S.A., Hensley, M. 2013. Hydropedological classification of South African hillslopes. Vadose Zone Journal.

Van Tol, J., Le Roux, P. & Lorentz, S. 2017. The science of hydropedology- Linking soil morphology with hydrological processes. *Water Wheel* 16(3).

Van Tol, J.J. & Le Roux, P.A.L., 2019. Hydropedological grouping of South African soil forms. South African Journal of Plant and Soil.

Van Tol., JJ., Bouwer, D. and Le Roux, P.A.L. 2021. Guideline for hydropedological assessments and minimum requirements.