4a Old Main Road, Judges Walk, Kloof, Kwazulu-Natal, South Africa, 3610
PO Box 819, Gillitts, 3603, South Africa
Tel: +27 (0) 31 764 7130 **Fax:** +27 (0) 31 764 7140 **Web:** www.gcs-sa.biz

Hydropedology Assessment for the Proposed Cato Ridge Land Development and Release Project

Report

Version - Final 1

18 April 2023

Zutari

GCS Project Number: 22-1129

Client Reference: 162153 & 162151

HYDROPEDOLOGY ASSESSMENT FOR THE PROPOSED CATO RIDGE LAND DEVELOPMENT AND RELEASE PROJECT

Report
Version – Final 1

18 April 2023

Zutari

22-1129

DOCUMENT ISSUE STATUS

Report Issue	Final V1		
GCS Reference Number	GCS Ref - 22-1129		
Client Reference	162153 & 162151		
Title	Hydropedology Assessment for the Proposed Cato Ridge Land Development and Release Project		
	Name	**Signature**	**Date**
Author	Hendrik Botha (MSc, PriSciNat	18/04/2023 10:53:18	18 April 2023
Proof-reader	Lisa Botha (BSc, Hons)		18 April 2023
Director	Hendrik Botha (MSc, PriSciNat)	18/04/2023	18 April 2023

LEGAL NOTICE

This report or any proportion thereof and any associated documentation remain the property of GCS until the mandator effects payment of all fees and disbursements due to GCS in terms of the GCS Conditions of Contract and Project Acceptance Form. Notwithstanding the aforesaid, any reproduction, duplication, copying, adaptation, editing, change, disclosure, publication, distribution, incorporation, modification, lending, transfer, sending, delivering, serving, or broadcasting must be authorised in writing by GCS.

DECLARATION OF INDEPENDENCE

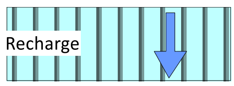
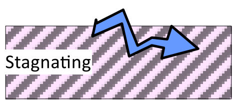
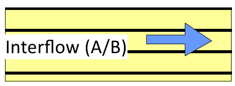
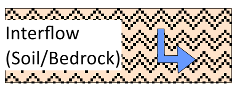
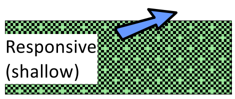
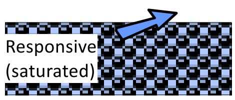
GCS (Pty) Ltd was appointed to conduct this specialist hydropedology study and to act as the independent specialist. GCS objectively performed the work, even if this results in views and findings that are not favourable. GCS has the expertise in conducting the specialist investigation and does not have a conflict of interest in the undertaking of this study. This report presents the findings of the investigations which include the activities set out in the scope of work.

EXECUTIVE SUMMARY

GCS Water and Environment (Pty) Ltd (GCS) was appointed by Assmang Manganese Cato Ridge Works, on behalf of Zutari to undertake a hydropedology assessment for the Proposed Cato Ridge Land Development and Release Project, in KwaZulu Natal. The project falls on the threshold of and within quaternary catchment U20J, U20L and U60C of the Pongola to Mtamvuna Water Management Area (WMA) (DWS, 2016).

Nineteen (19) hydrological response unit (HRU) describes the natural drainage for the study area. The proposed PH1 development entails the central portion of the proposed development and is situated in an eastern and southern sloping area. PH2 is situated on the crest of the project area, towards the north, and predominantly slopes towards the northeast, while being relatively flat towards the east. PH3 entails the southernmost boundary of the proposed development and is situated in a southeastern sloping area. Drainage is predominantly for the undulated hilltops associated with the project area.

Soil and hydrological data were evaluated for the project area to produce a soil distribution map. The soil map was used to categorise the hydrological soil types (HST), into the following categories:

Hydrological soil type	Description	Symbol
Recharge	The soils do not have any morphological indication of saturation. Vertical flow through and out of the profile into the underlying bedrock is the dominant flow path. These soils are deep and freely drained and are experiencing the leaching of nutrients to underlying soil horizons.	
Stagnating	Stagnating soils tend to act like interflow (soil/bedrock) soil types, however, due to the presence of abundant clays lateral discharge is slow. A build-up of water content in the soil profile leads to temporary perched groundwater after high rainfall events.	
Interflow (A/B)	The soils have a textural discontinuity which facilitates the build-up of water in the topsoil, the water that sits on the upper layer then flows laterally into the stream on the A/B horizon interface. The flow path is predominantly downslope in a lateral direction.	
Interflow (Soil/Bedrock) Or Interflow (A/ Bedrock)	Soils overlying relatively impermeable bedrock. Hydromorphic properties signify the temporal build of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction.	
Responsive (Shallow)	The soils are shallow, and they are over a relatively less permeable weathered rock or bedrock. They have limited storage capacity which results in the generation of overland flow after rainfall events.	
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.	

*Adapted from (Van Tol, et al., 2013)

Dominant hydropedology flow processes for the study area can be expressed by three (3) dominant hilltop types. The study area is primarily characterised by responsive (shallow) soils of the Swartland and Glenrosa types. However, in some areas (in flattened areas or areas where there has been significant hills wash) shallow/deep recharge soils of the Clovelly type were observed. Vertical flow through and out of the profile into the underlying bedrock is the dominant flow path. These soils are deep and freely drained and are experiencing the leaching of nutrients to underlying soil horizons. Recharge to the regional groundwater table is expected to occur via the saturated soils and will follow the hydraulic head associated with the regional water table.

On the crest to footslope position of the project area (typically hillslopes 1, 2 and 3) responsive (shallow) soils occur. In responsive soils, the build-up of water is expected in the B and upper A horizons after rain and overland discharge and minor lateral seepage are expected (due to saturation excess). Secondary vertical seepage to deeper soil zones from the saturated B horizon is expected. At the transition from one soil type to the other (upstream to downstream) overland flow may take place during wet seasons.

Some areas (typically Hillslope 1) have been developed, and here stagnating water conditions are expected (i.e., the soils have been compacted and altered). Stagnating soils tend to act like interflow (soil/bedrock) soil types, however, due to the presence of abundant clays lateral discharge is slow. A build-up of water content in the soil profile leads to temporary perched groundwater after high rainfall events.

Several hydropedological impacts were identified, and are available in Section 4. The predicted impact on the watercourses fed by the hydropedological process is estimated to range from 0% (no development HRUs) to 28% for the hydropedological sub-catchments. This translates to a “no impact” and “very high impact” about PES. If stormwater attenuation back to the environment is considered, the severity changes from ‘no impact” to “low,” except for HRU2 which shows a “low to moderate” potential impact.

The resource management objectives (RMO) for any wetland unit would be to maintain the current PES and EIS post-development or be improved by implementing dedicated stormwater features/structures. The table below shows how the severity of a sub-catchment scale can be improved by incorporating stormwater attenuation back into the environment. However, the way water is discharged into receiving wetland systems needs to be regulated, as high flow velocities could impact wetland health. HRU2 will have the largest impact post-development due to scale (i.e. the catchment area may become 80% impermeable based on the layout plan provided, with little open spaces). Development areas will likely have both stagnant and inherent soil flow properties.

A 15 m hydropedological buffer is proposed for wetlands, streams, and rivers, however, it is known that Eco-Pulse (2022) has proposed wetlands buffers that supersede the hydropedology buffers. The proposed buffers will limit direct disturbance/edge effects to the wetland and riparian habitats, will reduce sediment/erosion impacts through sediment trapping by vegetated buffer strips, and will contribute to dealing with water quality impacts (such as nutrient enrichment from surface runoff). The recommended buffer zones will also contribute to maintaining areas of terrestrial habitat as well as hydropedological soil flow processes.

It is further understood that the proposed stormwater management plan is to discharge accumulated stormwater back to the receiving environment, via 11 stormwater attenuation ponds. The discharge from the modular wastewater treatment plant (WTP) will likely not impact the hydropedology processes of the site, however, minor hydropedology process changes may occur at the discharge point (i.e. responsive shallow soils may become saturated, but will maintain similar flow processes).

This assessment cannot find any grounds or identify high hydropedological risks to not proceed with the development. This is grounded on the assumption that the proposed mitigation measures and EMPr recommendations are implemented during the construction and operational phase of the development

APPENDIX 6 OF THE EIA REGULATION – CHECKLIST AND REFERENCE FOR THIS REPORT

Table 1 - Requirements from Appendix 6 of GN 326 EIA Regulation 2017

Requirements from Appendix 6 of GN 326 EIA Regulation 2017	Chapter
(a) Details of: (i) The specialist who prepare the reports; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae	Page ii and Appendix F.
(b) Declaration that the specialist is independent in a form as may be specialities by the competent authority	Appendix D.
(c) Indication of the scope of, and purpose for which, the report was prepared	Page ii
(cA) Indication of the quality and age of base data used for the specialist report	Section 1.3.
(cB) A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 1.
(d) Duration, Date and seasons of the site investigation and the relevance of the season to the outcome of the assessment	Sections 1, 2 and 3.
(e) Description of the methodology adopted in preparing the report or carrying out the specialised process include of equipment and modelling used	Section 4.
(f) Details of an assessment of the specifically identified sensitivity of the site related to the proposed activity or activities and its associate's structures and infrastructure, inclusive of a site plan identifying alternative	Section 1.3.
(g) Identification of any areas to be avoided, including buffers	Section 1.2
(h) Map superimposing the activity and associated structures and infrastructure on environmental sensitivities of the site including areas to be avoided, including buffers	Sections 1, 2, 3 and 4
(i) Description of any assumptions made and uncertainties or gaps in knowledge	Section 5.1
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity including identified alternatives on the environment or activities	Sections 1, 2 and 3
(k) Mitigation measures for inclusion in the EMPr	Sections 2, 4, and 5.
(l) Conditions for inclusion in the environmental authorisation	Executive summary, Section 5.
(m) Monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 5.
(n) Reasoned opinion – (i) as to whether the proposed activity, activities or portions thereof should be authorised. (iA) regarding the acceptability of the proposed activity or activities; and (ii) if the opinion is that the proposed activity, activities, or portions thereof should be authorised, and avoidance, management, and mitigation measures should be included in the EMPr, and where applicable, the closure plan	Refer to Section 5.3
(o) Description of any consultation process that was undertaken during preparing the specialist report	None required.
(p) A summary and copies of any comments received during any consultation process and where applicable all responses thereto	None required.
(q) Any other information requested by the competent authority	None required.

CONTENTS PAGE

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

Acronym	Description
A	Diagnostic A horizon
A/B	Interflow soil type A/B
A/Bedrock	Interflow soil type A/Bedrock
B (B1, B2, B3 etc.)	Diagnostic B horizon
BA	Basic Assessment
BOD	Biological oxygen demand
COD	Chemical oxygen demand
CSWMP	A conceptual stormwater management plan
CVB	channel valley bottom wetland
CVB	Channelled valley bottom wetland
DEM	Digital Elevation Model
DWS	Department of Water and Sanitation
E	Diagnostic E horizon
G	G Horizon/soil
GCS	GCS Water and Environment (Pty) Ltd.
GN704	General Notice 704
ha	Hectare
HOSASH	Hydrology of South African Soils and Hillslopes
HRU	Hydrological Response Unit
HST	Hydrological Soil Type
IWULA	Integrated Water Use Licence Application
m^3	Cubic Metres
MAE	Mean annual evaporation
MAR	Mean Annual Runoff
MIPI	Midgley and Pitman
NEMA	National Environmental Management Agency
n-Value	Manning's Roughness Coefficients
NWA	National Water Act, 1998 (Act No. 36 of 1998)
O	Orthic Horizon/soil
PCD	Pollution Control Dam
PFD	Process flow diagram
RP	Riparian zone/wetland
S	Seepage wetland
SDF	Standard design flood
SW	Surface Water

TDS	Total dissolved solids
TIN	Triangulated Irregular Network
UCVB	Unchanneled valley bottom wetland
UVB	un-channelled valley bottom
V	Vertic Horizon/soil
WMA	Water Management Area
WR2012	Water Resources of South Africa 2012
WTW	Water Treatment Works
PES	Present Ecological State
EIS	Ecological Importance and Sensitivity

1 INTRODUCTION

GCS Water and Environment (Pty) Ltd (GCS) was appointed by Assmang Manganese Cato Ridge Works, on behalf of Zutari to undertake a hydropedology assessment for the Proposed Cato Ridge Land Development and Release Project, in KwaZulu Natal (refer to Figure 1-3). The project falls on the threshold of and within quaternary catchment U20J, U20L and U60C of the Pongola to Mtamvuna Water Management Area (WMA) (DWS, 2016).

1.1 Project background

The development is set to consist of mixed light industry, general industry, warehousing, and logistics land uses. The proposed development and land release project has been phased in line with bulk services provisioning over 25 years as follows:

- Phase 1: 1 -10 Years
- Phase 2: 11 -20 Years
- Phase 3: 21 - 25 Years

The total Footprint for the project is 358.4 ha divided between the three phases as follows:

- Phase 1: 138 ha
- Phase 2: 177 ha
- Phase 3: 49 ha

An onsite sewerage package plant will be established at the intersection of R103 and Eddie Hagen (within the Phase 1 area). The plant will be used to treat wastewater for all proposed development phases. The plant will have a treatment capacity of approximately 2 Mℓ / day. The effluent will be discharged into the environment via a pipeline, leading from Portion 50, across the R103, into the North-eastern corner of Phase 3. To service the sewerage requirements for Phases 2 and 3, a collection sump and pump station will be required in each of these project areas. These pump stations will deliver effluent to the packaging plant.

To meet the water requirements for the development, eThekwini Metro will need to construct a 38 Mℓ above ground reservoir within the central parts of the Phase 2 development area. This reservoir will be subject to its environmental authorisation process and has not been addressed in this assessment report. Although most of the development will be serviced by underground powerlines, a small section of above-ground powerlines will be required along the northern border of the Phase 1 development area. Stormwater management will be completed per site, with the required infrastructure.

This hydropedological study was requested to evaluate the potential impact relating to total development. This hydrological report is intended to supplement the Water Use License Application (WULA) for the site.

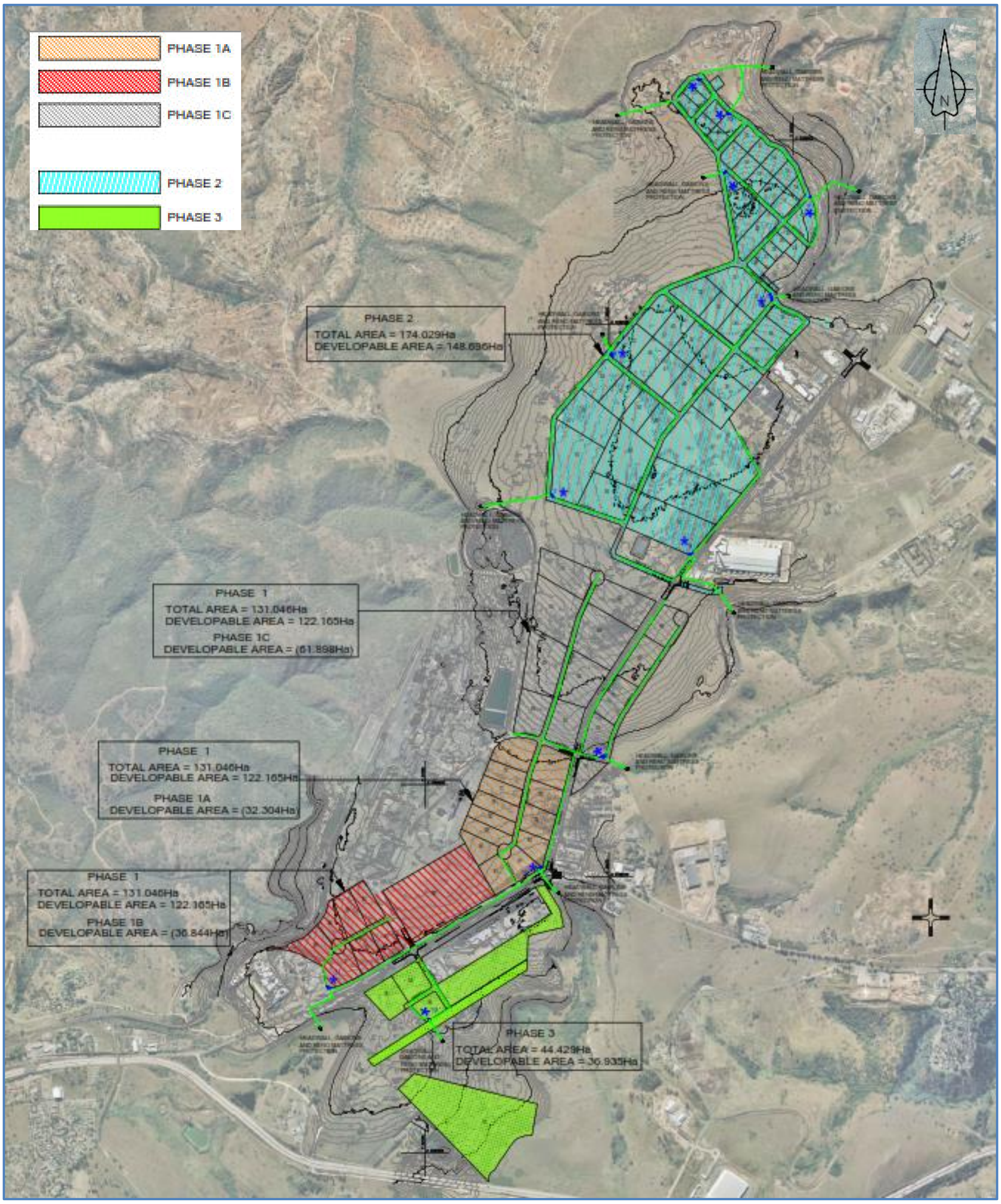


Figure 1-1: Proposed development layout area (Kantey & Templar, 2023)

1.2 Study Objectives and Methodology

Soils develop over time under the influence of chemical, physical, and biological processes (refer to Figure 1-2). Soils are predominantly the result of in-situ weathering of the host rock (i.e., has characteristics associated with the parent geological occurrence/rock). Soil has an interactive relationship with hydrology (i.e., climate, rainfall duration, runoff patterns, groundwater contribution to baseflow, evaporation etc.). It is a product of water-related processes (physical and chemical) and a first-order control of the destination of rainwater. Though hydrological processes change seasonally, soil characteristics and water transfer capabilities remain similar throughout the year. A once-off study was undertaken.

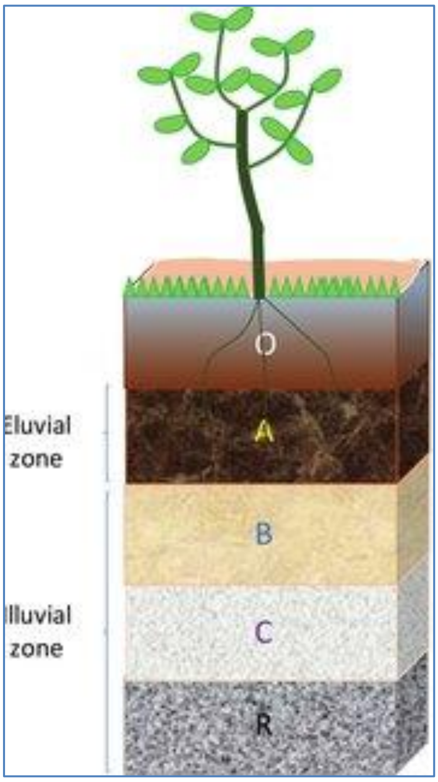


Figure 1-2: Typical soil genesis Invalid source specified.

The objectives of this hydropedological assessment were to:

1. Evaluate the soils in the study area:
    - Soils were classified per the taxonomic system for South Africa (Department of Agricultural Development, 1991); (SCWG, 2018)
    - Soil permeability was estimated based on available data (i.e. field characterised textures and public soil data) and according to best practice guidelines (FAO, 1980); and (DWS, 2011).
2. Derive hydropedological flow regimes and interaction areas:
    - In the determination of Hydrological Soil.
    - Types (HST), soils were divided into classes based on their expected hydrological responses (Van Tol, et al., 2013).
3. Conceptualise the water flow dynamics and derive hydropedological flow buffer areas (if required) for wetlands identified in the area.
    - Hydrological processes were perceived from traceable signatures in the soil matrix resulting from the soil's ability to transmit, store and react with water (Le Roux, et al., 2011).
4. Identify potential hydropedological impacts per standard DWS & EIA impact criteria and risk rating (refer to **Appendix B**).

1.3 Study relevance to the season in which it was undertaken

This study was undertaken as a once-off study and relies on historical hydrological and climate data for the site, as well as recognised hydrological and water resource databases for South Africa. Data generated during the time of this study is not seasonally bound as average yearly data was applied where required and as scientifically acceptable.

1.4 Scope of Work

The scope of work completed was as follows:

1. **Desktop study:**
    a. All available reports (which were provided by the client) relating to the site were assessed.
    b. Evaluation of soil occurrences in the study area, based on available South African databases.
2. **Site walkover assessment & sampling:**
    a. GCS undertook a site walkover assessment and drilled several hand augers to characterise the site soils.
    b. The soils identified in the study area were screened per the Soil Classification guidelines for South Africa (Department of Agricultural Development, 1991) and (SCWG, 2018) to derive hydropedological flow regimes.
3. **Hydropedological assessment:**
    a. Meteorological evaluation.
    b. Catchment delineation.
    c. Estimation of soil permeability and soil flow processes based on field observation and desktop data.
    d. HOSASH (Hydrology of South African Soils and Hillslopes) index.
4. **Risk assessment:**
    a. The risk and impact criteria (refer to **Appendix C**) were applied to the study area, to evaluate hydropedological risks.
    b. Natural flow losses were estimated, using a spreadsheet water balance developed for the site.
5. **Mapping and report:**
    a. Several hydrological hillslope profiles, soil distribution and hydrological soil type maps were produced; and
    b. This report was compiled.

1.5 Gaps and limitations

The following study limitations are recognised:

- The concepts presented are simplifications of the temporal variability of water transfer functions. Realistically, water transfer functions, such as throughflow and groundwater sources, may take a few months up to several years to recharge streams (Le Roux, et al., 2011) However, hydropedology hillslopes have been effectively applied to simulate runoff response mechanisms (Van Tol, et al., 2013).
- Per minimum requirements for hydropedology studies published by DWS (Van Tol, J.J., Bouwer, D. & Le Roux, P.A.L., 2021), this "Level 2" study was undertaken (field investigation, conceptualisation of hillslopes and soil flow suppression). No numerical unsaturated flow modelling (Level 3 and Level 4) was undertaken and was pre-determined by the project activity (i.e., a small development with limited activities that could potentially impact the soil flow regime).

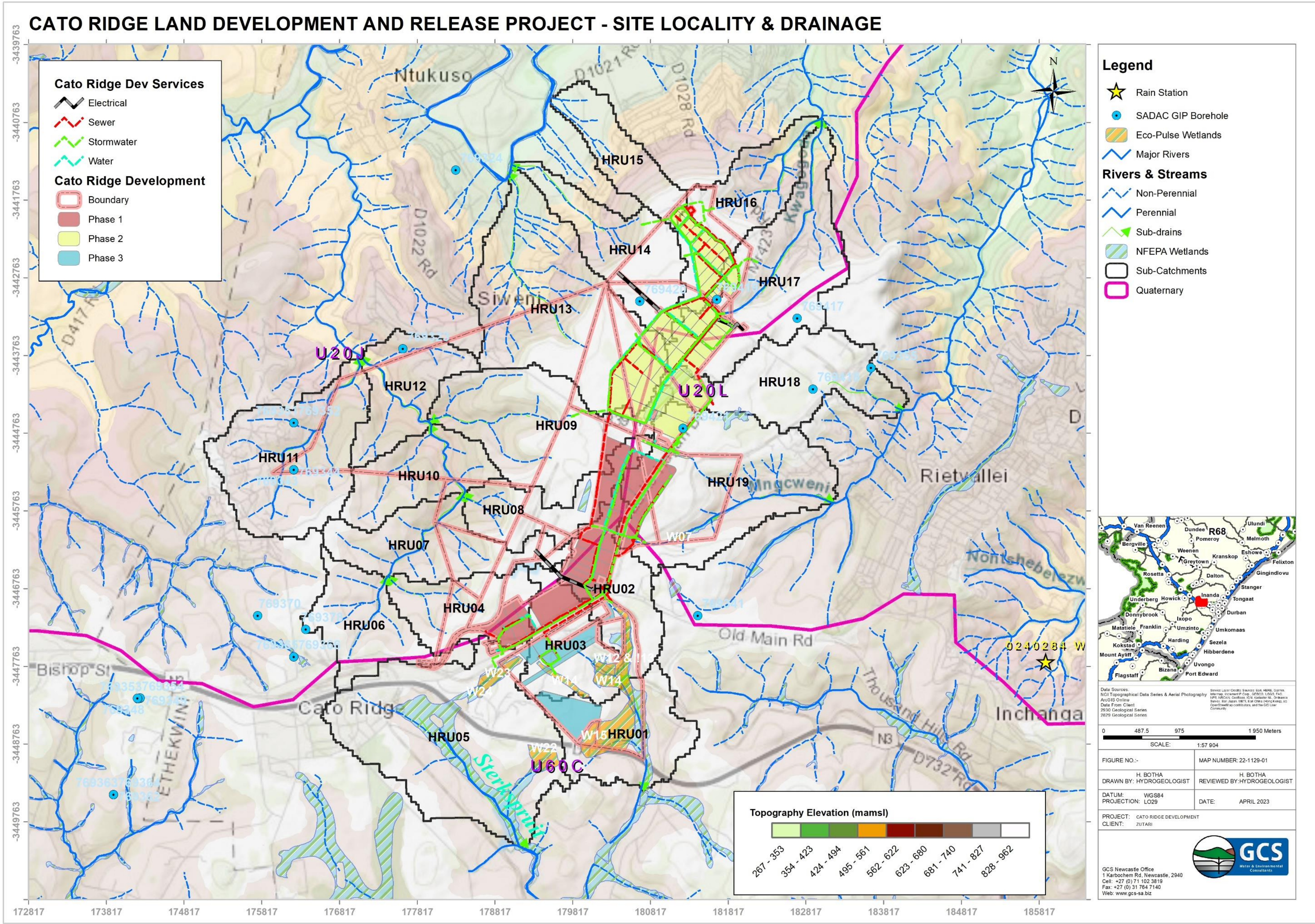


Figure 1-3: Site locality and drainage

2 SITE OVERVIEW AND HYDROLOGY

As mentioned previously, the site is situated in quaternary catchment U20J, U20L and U60C of the Pongola to Mtamvuna Water Management Area (DWS, 2016). The project falls within the headwater of the quaternary catchments. Elevations on the site typically range from 500 to 800 meters above mean sea level (mamsl).

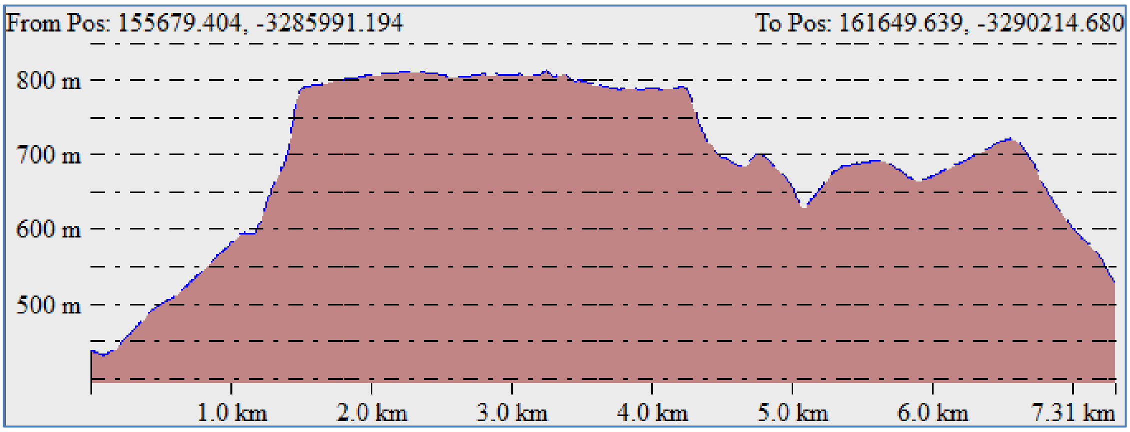


Figure 2-1: Typical cross-section of the study area topography

Nineteen (19) hydrological response unit (HRU) describes the natural drainage for the study area (using a 1:1 000 stream count and 30 m DTM fill) – refer to Figure 1-3. The proposed PH1 development entails the central portion of the proposed development and is situated in an eastern and southern sloping area. PH2 is situated on the crest of the project area, towards the north, and predominantly slopes towards the northeast, while being relatively flat towards the east. PH3 entails the southernmost boundary of the proposed development and is situated in a southeastern sloping area. Drainage is predominantly for the undulated hilltops associated with the project area.

2.1 Local geology

According to the 1:250 000 geological series (2930 Durban), the local surface geology is characterised by occurrences of Dwyka Tillite of the Karoo Sequence, as well as Natal Group Sandstone and granite from the Natal Structural and Metamorphic Group (refer to Figure 2-9).

2.2 Climate

Climate, amongst other factors, influences soil-water processes. The most influential climatic parameter is rainfall. Rainfall intensity, duration, evaporative demand, and runoff were considered in this study to indicate rainfall partitioning within the project area.

2.2.1 Temperature

The average yearly temperature (refer to Figure 2-2) for the project area ranges from 20 to 35°C (high) and 1 to 6°C (Low). The study area is situated in a humid subtropical climate or warm temperate climate (Cfa) area, as per the Köppen Climate Classification (Kottek, et al., 2006). The project area receives summer rainfall.

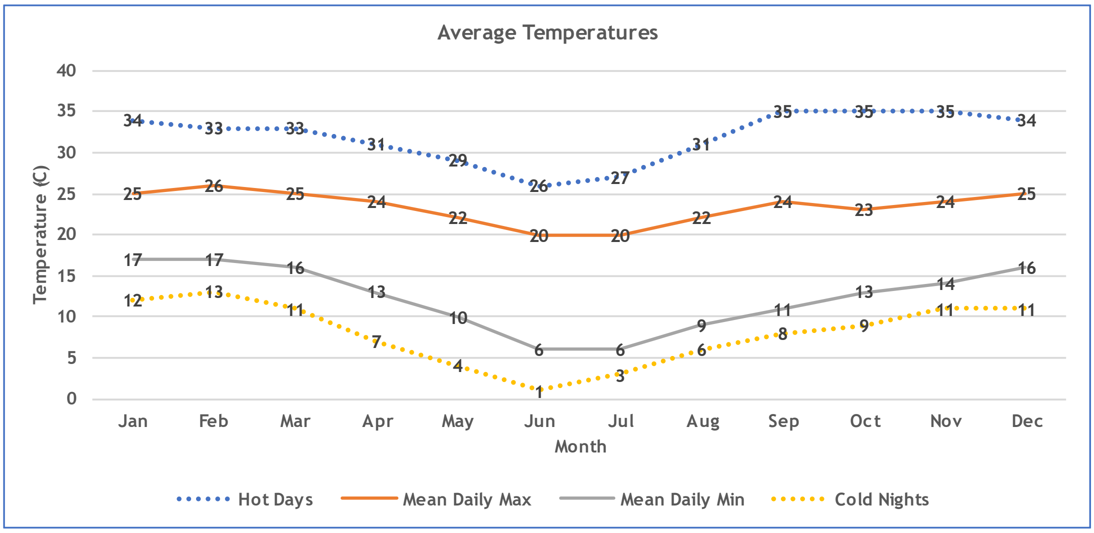


Figure 2-2: Average yearly temperatures (Meteoblue, 2023)

2.2.2 Wind speed and direction

Figure 2-3 shows the wind rose for the project area (Ballito used as reference) and presents the number of hours per year the wind blows from the indicated direction. The wind blows from ENE, E, NE, NNE, and SSE more often, at velocities > 19 km/hr; and from other directions but less frequently and at lower velocities (< 19 km/hr).

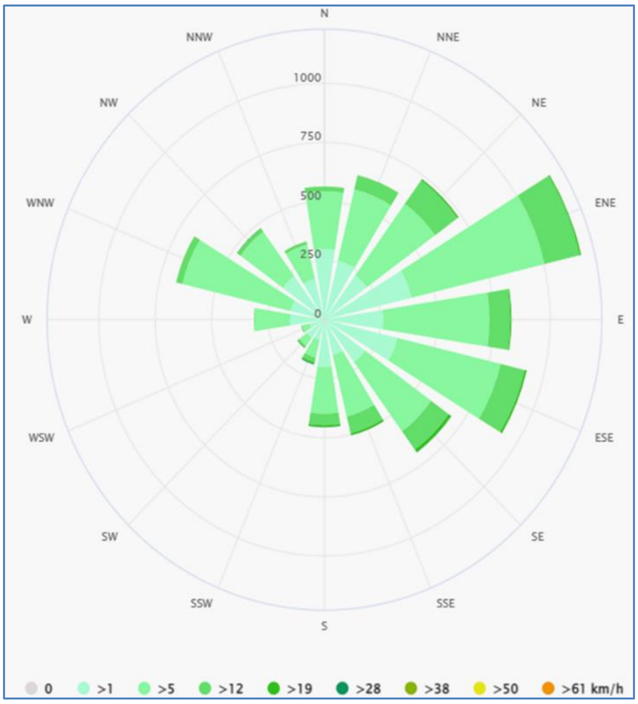


Figure 2-3: Wind rose (Meteoblue, 2023)

2.2.3 Rainfall and evaporation

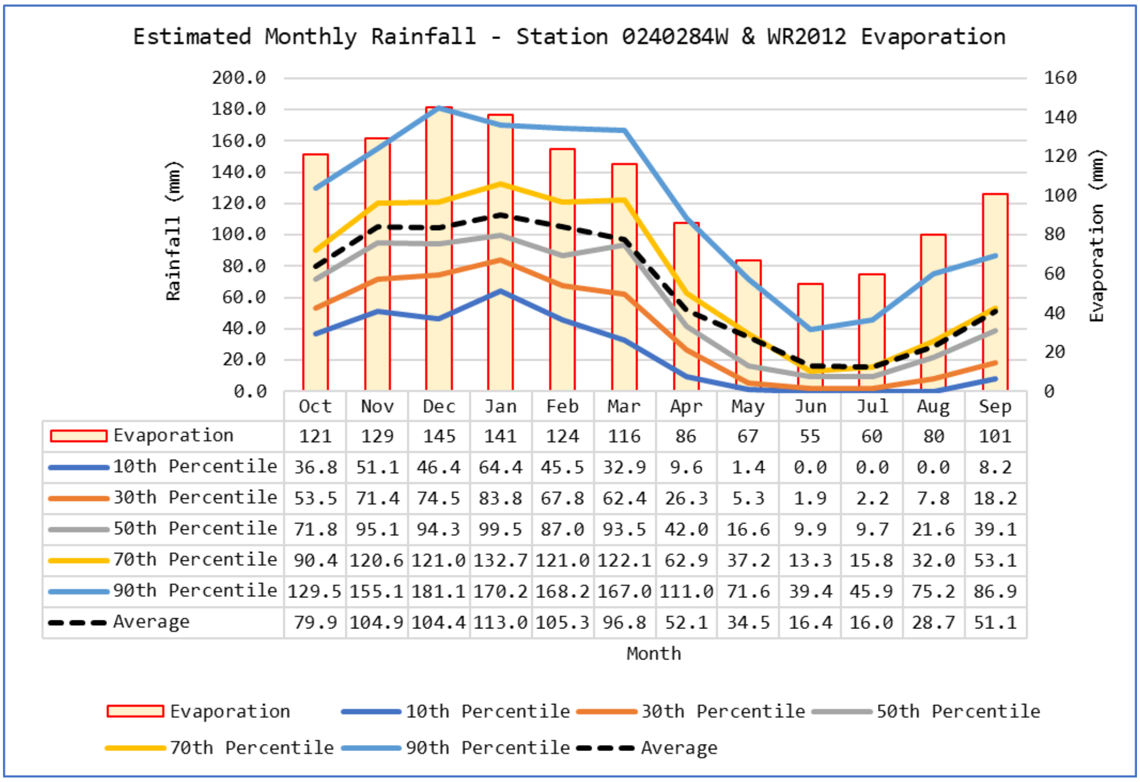
The project area is spread over rainfall zone U2D, U2E and U6B. The mean annual precipitation (MAP) measured at several rainfall stations that fall close to the site is summarised in Table 2-1, below.

Table 2-1: MAP of nearest rainfall stations

Station Name	Station ID	Rain Record (Yr)	MAP (mm/yr)
INCHANGA (SAR)	0240284_W	62	787
BOTHAS HILL	0240404_W	48	833
INTAKE	0240564_W	69	926
CAMPERDOWN	0240073_W	85	714
Average (mm)			**815**

The monthly rainfall data used to calculate MAP was obtained from rainfall station 0240284 – 1.5 km east of the site. The rainfall record is for the period 1928 to 1989 (62 years). Monthly rainfall for the site is likely to be distributed as shown in Figure 2-4, below.

Available rainfall data suggest a MAP ranging from 475 (30th percentile) to 1401 (90th percentile) mm/yr. The average rainfall is in the order of 803 mm/yr. The project area falls within evaporation zones 30B and 30A, of which Mean Annual Evaporation (MAE) ranges from 1 200 to 1 300 mm/yr. The MAE far exceeds the MAP for the site, which implies greater evaporative losses when compared to incident rainfall. Monthly evapotranspiration for the site is likely to be distributed as shown in Figure 2-4, below.

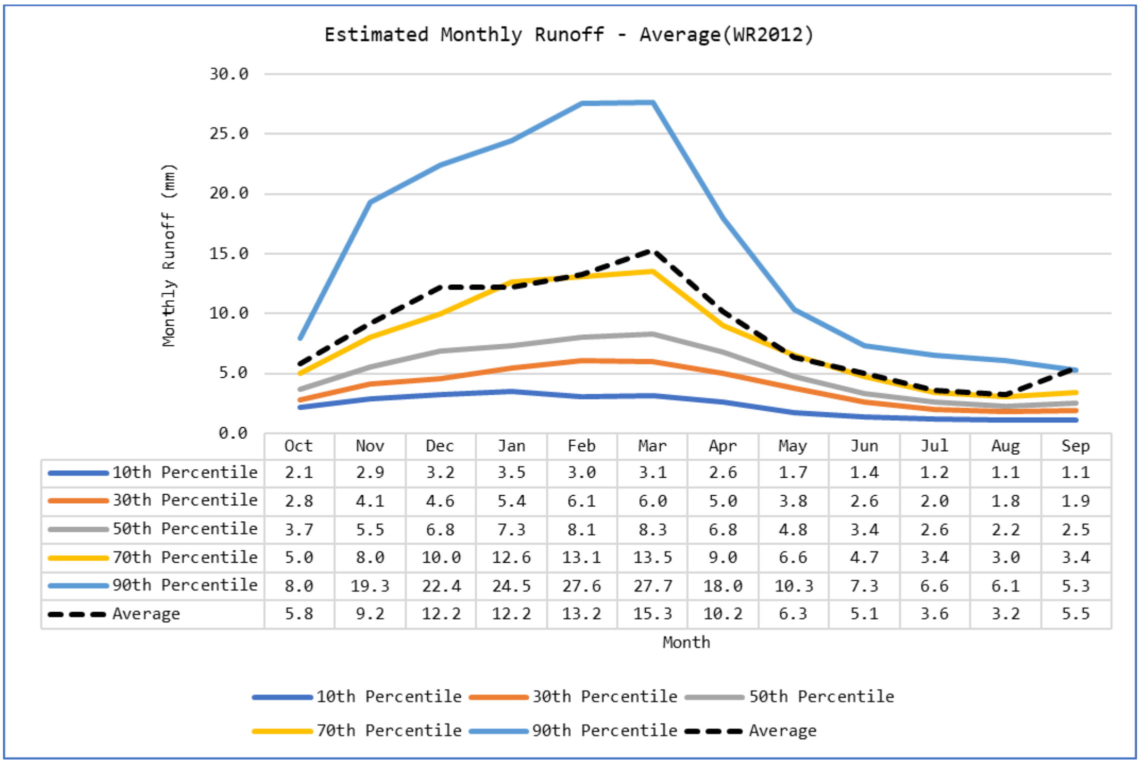


	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Evaporation	121	129	145	141	124	116	86	67	55	60	80	101
10th Percentile	36.8	51.1	46.4	64.4	45.5	32.9	9.6	1.4	0.0	0.0	0.0	8.2
30th Percentile	53.5	71.4	74.5	83.8	67.8	62.4	26.3	5.3	1.9	2.2	7.8	18.2
50th Percentile	71.8	95.1	94.3	99.5	87.0	93.5	42.0	16.6	9.9	9.7	21.6	39.1
70th Percentile	90.4	120.6	121.0	132.7	121.0	122.1	62.9	37.2	13.3	15.8	32.0	53.1
90th Percentile	129.5	155.1	181.1	170.2	168.2	167.0	111.0	71.6	39.4	45.9	75.2	86.9
Average	79.9	104.9	104.4	113.0	105.3	96.8	52.1	34.5	16.4	16.0	28.7	51.1

Figure 2-4: Average rainfall for Station 0240284W & WR2012 evaporation

2.2.4 *Runoff*

Average runoff from natural (unmodified) catchments for quaternary catchment U20J, U20L and U60C is simulated in WR2012 (WRC, 2015) as being equivalent to 57.8 mm/yr. The simulated average runoff is shown in Figure 2-5.



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10th Percentile	2.1	2.9	3.2	3.5	3.0	3.1	2.6	1.7	1.4	1.2	1.1	1.1
30th Percentile	2.8	4.1	4.6	5.4	6.1	6.0	5.0	3.8	2.6	2.0	1.8	1.9
50th Percentile	3.7	5.5	6.8	7.3	8.1	8.3	6.8	4.8	3.4	2.6	2.2	2.5
70th Percentile	5.0	8.0	10.0	12.6	13.1	13.5	9.0	6.6	4.7	3.4	3.0	3.4
90th Percentile	8.0	19.3	22.4	24.5	27.6	27.7	18.0	10.3	7.3	6.6	6.1	5.3
Average	5.8	9.2	12.2	12.2	13.2	15.3	10.2	6.3	5.1	3.6	3.2	5.5

Figure 2-5: Simulated average natural (unmodified) runoff from U20J, U20L and U60C

2.3 Local hydrogeology & depth to groundwater

The site is situated in an area associated with both argillaceous rock (sandstone) as well as acid/intermediate/alkaline intrusive rocks of various granitoid (King, et al., 1998). The aquifer has a low to medium hydraulic conductivity (K-value) and porosity (n-value). The aquifers in the project area are considered intergranular and/or fractured. The aquifer can be referred to as being primarily intergranular and fractured (King, et al., 1998).

Groundwater is typically encountered in:

- Fractures and bedrock contacts are recharged by overlying sedimentary rock.
- Fault zones.
- Contacts between lithologies and or at unconformities; and
- Dolerite contacts with the host rock, joints, and faults (King, et al., 1998).

Recharge to the underlying aquifer is estimated to be in the order of 6.8% of the MAP (803 mm) (DWAF, 2006). The aquifer's weathered zones are reported to be approx. 30 m thick, with the fractured zone approx. 130 m thick (DWAF, 2006). The combined aquifer thickness is estimated to be in the order of 160 m. The aquifers are important contributors to groundwater baseflow to streams and rivers (King, et al., 1998).

Fractured aquifers yields are estimated to range from 0.1 to 0.2 l/sec (Type B2 aquifers), and yields remain in the same order for mafic granitoid (Type D2 aquifers). Yields may increase to a range of > 5 l/sec for successful boreholes drilled into geological contacts, faults, or intrusive rock contacts (King, et al., 1998).

According to (Vegter, 1995) and (DWAF, 2006), the groundwater levels within the region are expected to range from 15 to 35 mbgl (meters below ground level). Available SADAC GIP borehole data (SADAC GIP, 2022) for the project area, and the geohydrology assessment report for the site (Geomeasure Group, 2023) suggest a water level range from 3 to 74 mbgl. Figure 2-6 plots available groundwater level data for the project area. There is a particularly good linear relationship between observed water levels and the topography (R^2 ~ 85%). The groundwater table mimics the topography and is shallower closer to perennial streams (i.e., these are prominent groundwater contributions to baseflow areas or areas where groundwater seepage from the resource into the aquifer units may take place).

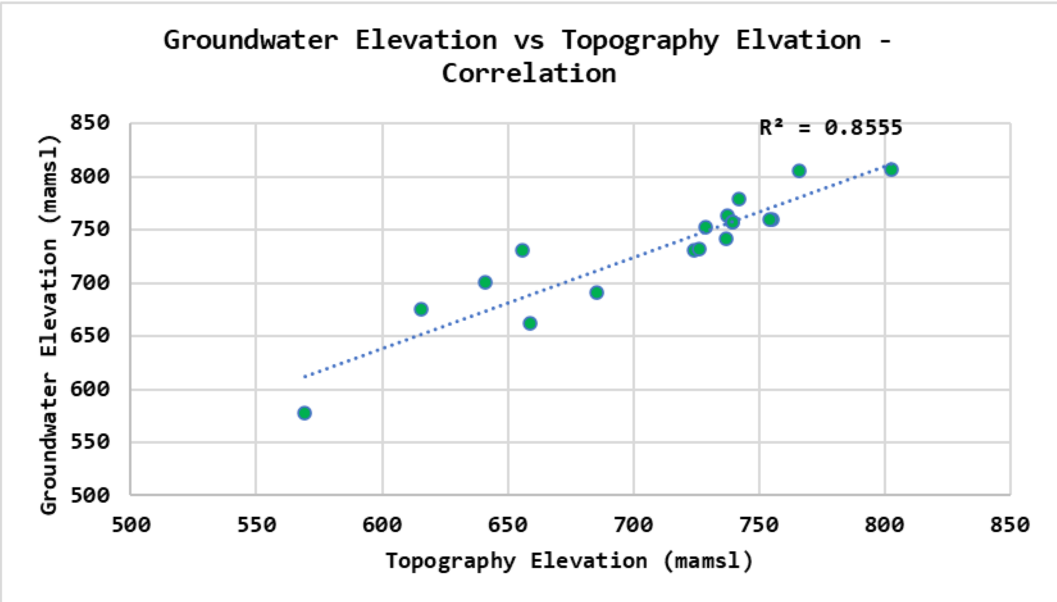


Figure 2-6: Groundwater elevations vs topography elevation - correlation

2.4 Desktop-identified wetland areas

Based on available National Wetland Freshwater Ecosystem Priority Areas (NFEPA) (Van Deventer, 2018) there are several unchanneled valley bottom and seepage wetlands in the study area (refer to Figure 1-3). Eco-Pulse (2022) further found that there are several wetland units and riverine systems in the project area, and focused on the south of PH3 and eastern boundaries of PH1 and PH2 (refer to Figure 2-7).

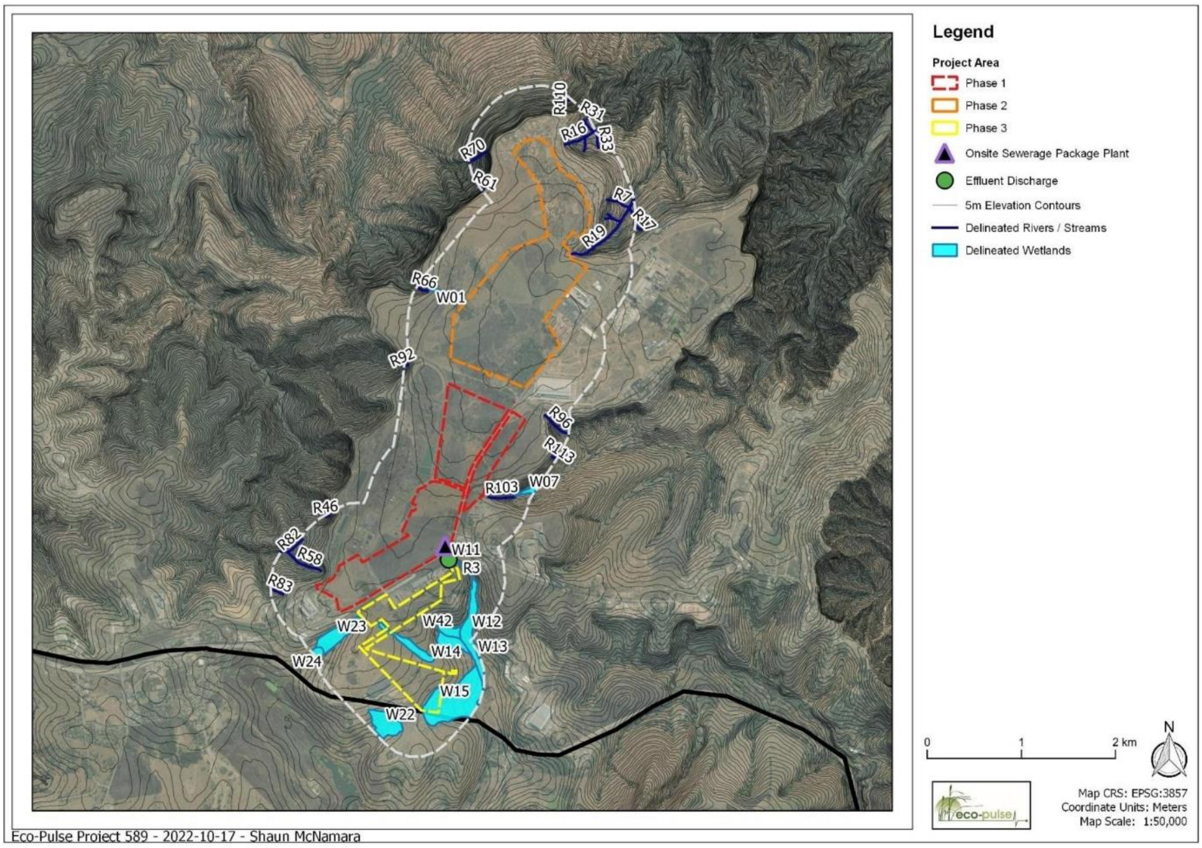


Figure 2-7: Eco-Pulse (2022) Identified wetland areas

In terms of wetland geo-hydrology, baseflow is considered the most important contributor to stream and wetland health. Baseflow (refer to Figure 2-8) is a non-process-related term to signify low amplitude high-frequency flow in a river during dry or fair-weather periods. Baseflow is not a measure of the volume of groundwater discharged into a river or wetland, but it is recognised that groundwater contributes to the baseflow component of a river or wetland flow.

Available literature (WRC, 2015; DWAF, 2006) suggests groundwater contribution to baseflow ranges from 20 mm/yr (PITMAN MODEL) to 87 mm/yr (HUGHES MODEL). This relates to approximately 2% to 8% of rainfall.

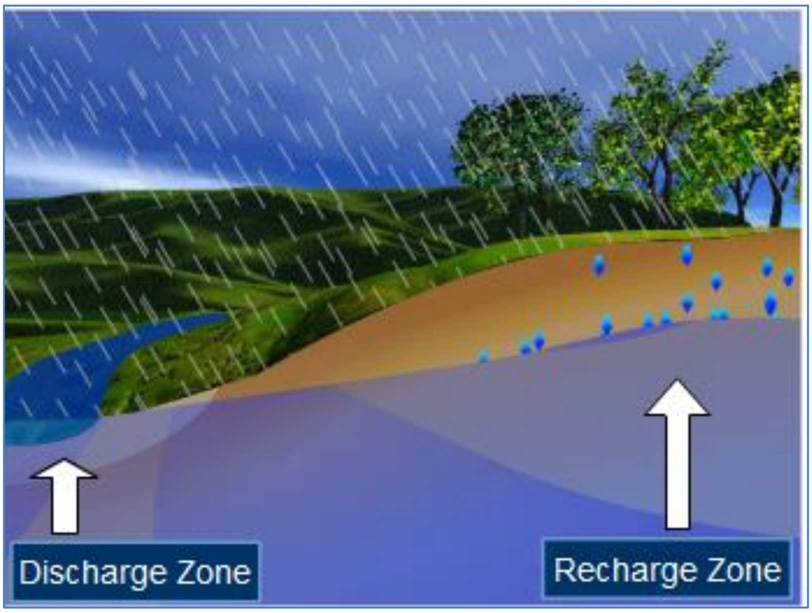


Figure 2-8: Groundwater baseflow concept (DWS, 2011)

2.5 Present ecological state (PES) and environmental sensitivity and ecological importance (EIS) – quaternary scale

Table 2-2 provides a summary of the PES and EIS for the quaternary catchment associated with the project area (WRC, 2015). Eco-Pulse (2022) EIS and PES ratings for wetlands and watercourses identified in the project area are listed in Table 2-3. The resource management objectives (RMO) for these wetlands need to maintain the current PES and EIS post-development. Some wetlands are proposed to be improved due to stormwater attenuation from the site (refer to Eco-Pulse (2022) report and Table 2-3).

Table 2-2: Summary of PES and EIS for the Quaternary Catchment

Quat	PES	EIS
U20J	Class D: Largely Modified	Moderate
U20L	Class C: Moderately Modified	Moderate
U60C	Class C: Moderately Modified	Moderate

Table 2-3: Eco-Pulse (2022) EIS and PES for identified freshwater resources

Process Unit	HGM Type	PES Class	EIS Rating	REC	RMO	Proposed Action
R3	Mountain Stream / Mountain Headwater Stream	D	Low	D	Maintain	Appropriate catchment management
R4	Mountain Stream / Mountain Headwater Stream	B	Mod	B	Maintain	Appropriate catchment management
S4	Seep	D	Low	D	Maintain	Appropriate catchment management
S9	Seep	C	Low	C	Maintain	Appropriate catchment management
S10	Seep	C	High	B/C	Improve	Appropriate catchment management and rehabilitation interventions
S11	Seep	D	Mod	D	Maintain	Appropriate catchment management
UCVB2	UCVB	C	High	B/C	Improve	Appropriate catchment management and rehabilitation interventions
UCVB3	UCVB	D	Low	D	Maintain	Appropriate catchment management
UCVB4	UCVB	C	High	B/C	Improve	Appropriate catchment management and rehabilitation interventions
	UCVB	D	High	C/D	Improve	Appropriate catchment management and rehabilitation interventions

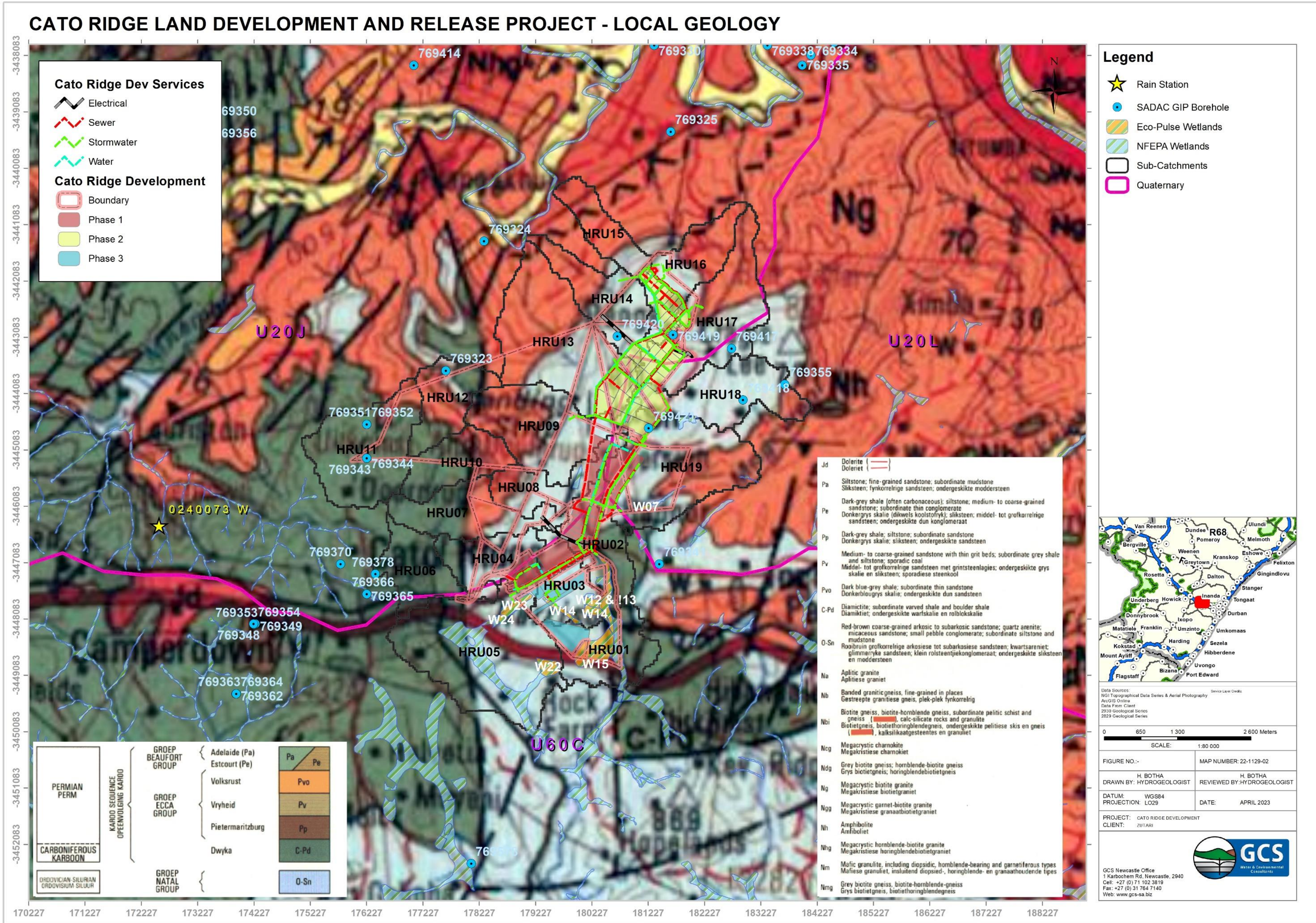


Figure 2-9: Local Geology

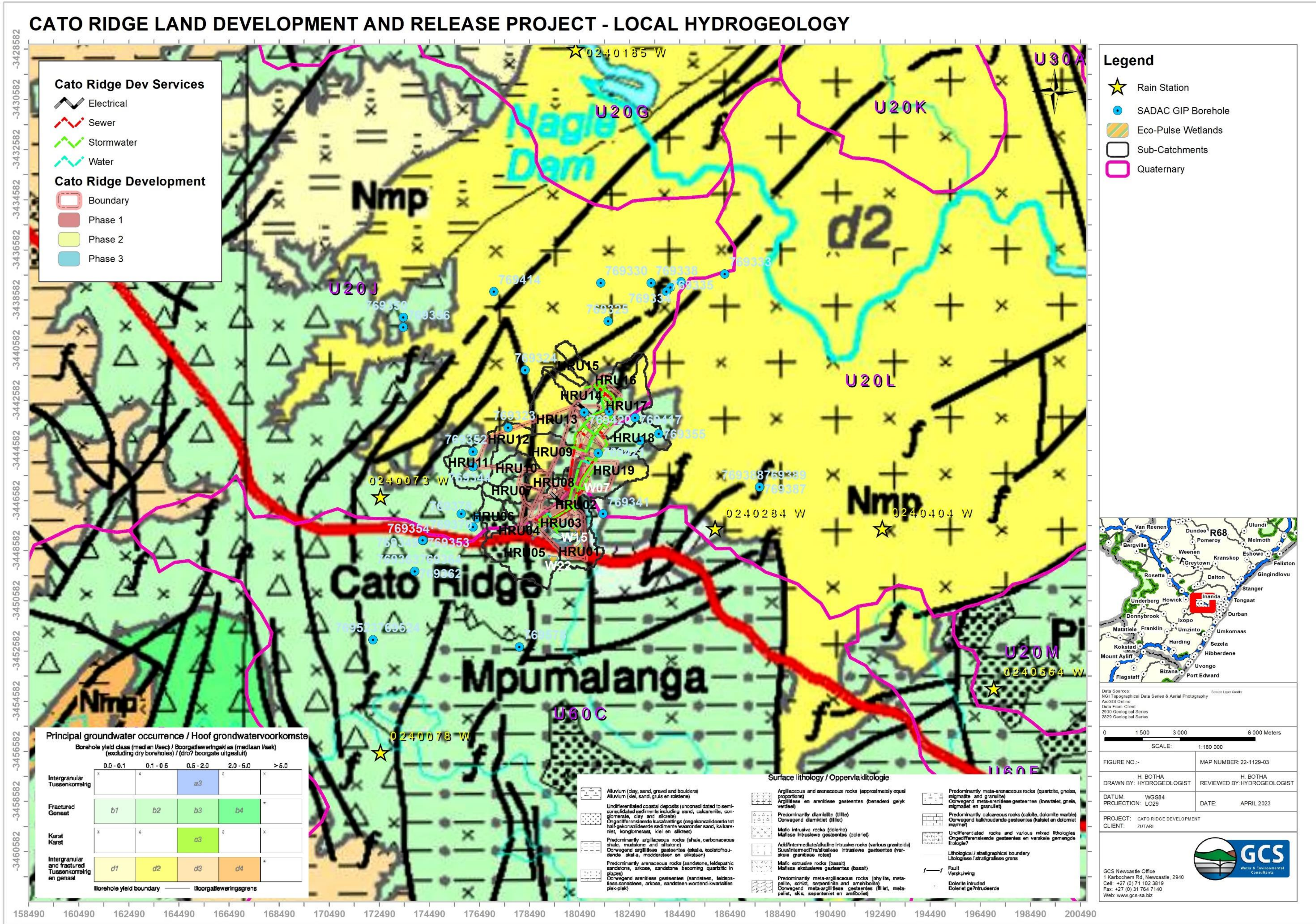


Figure 2-10: Local hydrogeology

2.6 Land morphology and soils

Different soil types are typically encountered within the shoulder, mid-slope and valley positions of the project area (referred to as soil hillslope) and are mainly due to sub-surface geology, products of weathering, degree of saturation, soil texture and slope position (refer to Figure 2-11). The terrain in the project area is moderately sloping (due to undulating hills), with soil depths ranging from 600 mm to > 2200 mm generally with clay content ranging from 15 - 60%.

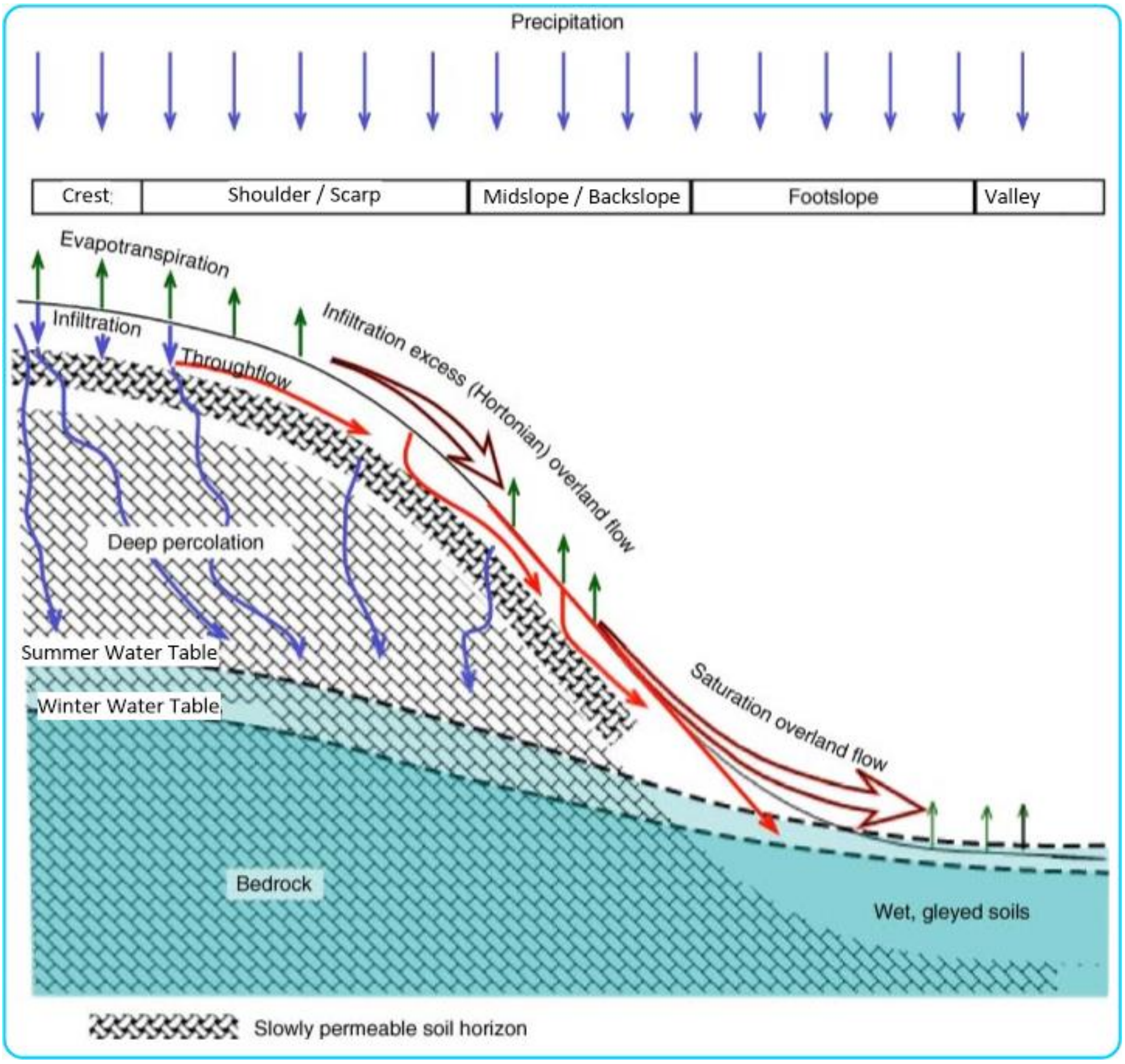


Figure 2-11: Land morphology concept (Almond, 2016)

According to the Land Types of South Africa databases (Land Type Survey Staff, 1972 – 2006c,), the soils in the area typically conform to land types of the Bd and Fa types (ARC, 2006) – refer to Figure 2-16. According to WR2012 soil data for the area, the erodibility of the soils for the area can be considered medium (WRC, 2015). These soils are described as follows:

- **<u>Bd49 – refer to Figure 2-12:</u>**

These are typically red and yellow, dystrophic/mesotrophic, apedal soils with plinthic subsoils (plinthic soils comprise > 10% of land type, red soils comprise < 33% of land type).

The moisture regime in these soils is often dominated by the presence of restricting rock and soil layers at a depth that leads to the perching of water in localised water tables and lateral seepage zones. The soils are therefore characterised by distinct zones of water fluctuation, zones of prolonged saturation with clearly expressed redox morphology features and zones where water manifests close or at the surface through return flow. The redox morphology indicative of the presence of the water is what is often used as the textbook description of mottling and grey colour as indicative of wetland conditions. It, therefore, follows that landscapes with plinthic soils have a large proportion of the soil-covered surface that qualifies as a wetland with distinct permanent, extensive seasonal/seepage and temporary wetland zones. Due to the generally accepted notion that the degree and duration of saturation are expressed increasingly through grey and bleached soil colours, it follows that the red soil-dominated plinthic landscapes (viz. Ba and Bc land types) tend to exhibit smaller wetland soil distributions than yellow and bleached soil dominated plinthic landscapes (viz. Bb and Bd land types). The Ba land type soil distribution can be considered the "modal" example of colour juxtaposition that is used for the identification of terrestrial and wetland zones in a landscape (Der Waals, 2019). The land capability of plinthic landscapes is very strongly linked to 1) the depth of the soil profiles and 2) the extent and degree of lateral seepage and water-feeding mechanisms at depth.

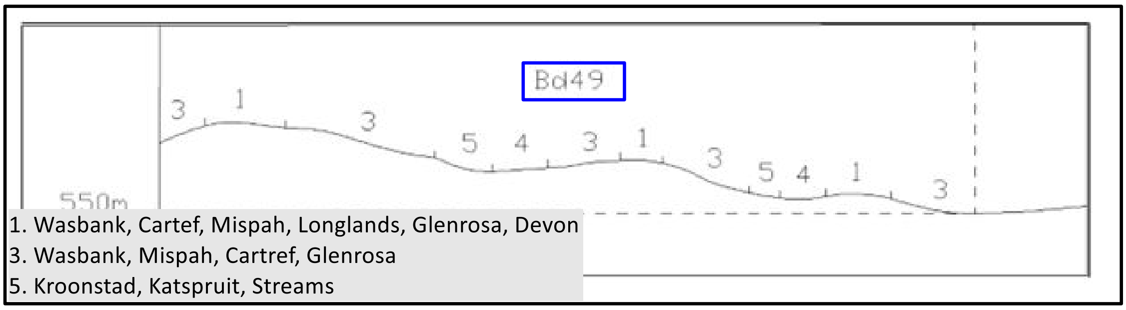


Figure 2-12: Bb49

- **<u>Fa461 & Fa468 – refer to Figure 2-13 and Figure 2-14:</u>**

These are typically shallow soils (Mispah & Glenrosa forms) predominate, with little or no lime in the landscape.

The dominant soil moisture regime in these soils is one of free drainage and leaching through the profiles to depth-limiting layers that may include geological materials (such as underlying shales and transported finer textured materials) or perched water tables on top of impermeable materials.

The formation of the podzol B horizon is usually associated with a slight change in the chemical equilibria in the soil profile. However, the formation of the E and podzol horizons is not primarily mediated by saturated conditions that usually lead to bleaching and sesquioxide depletion. In this regard, the colours of the E and podzol B horizons cannot be used as indicators of profile redox morphology. It is therefore challenging to identify redox morphology indicators as mottles are generally absent and colour variations are associated with other chemical processes. In general redox, morphology is readily observed in underlying finer texture layers in the form of redox depletions and accumulations (mottles). Another indicator is the organic C content of the A horizon as expressed in the colour. Generally, it can be assumed that a darker A horizon colour indicates a potentially wetter profile due to the retardation of organic matter breakdown under wetter conditions. This is a generalised assumption and the identification of wetland and wetland conditions remains very challenging in podzol-dominated landscapes, especially if a 50 cm mottle criterion is used and if the natural vegetation has been replaced by pasture grasses – as is the case in large areas characterised by podzol soils (Der Waals, 2019). The land capability of these soils is determined predominantly by climatic conditions and rainfall.

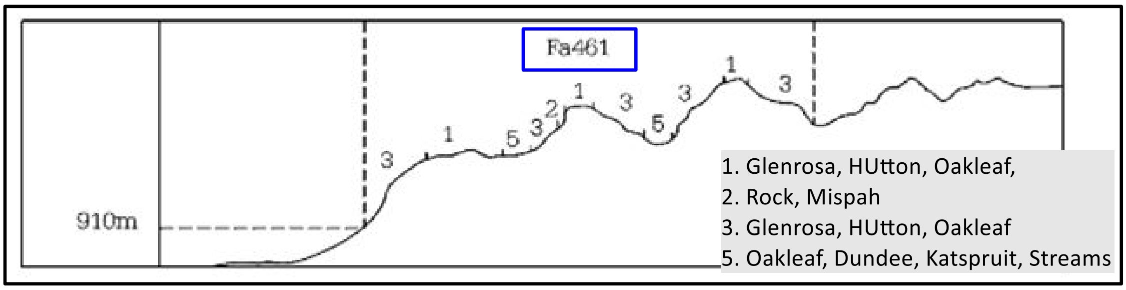


Figure 2-13: Fa461

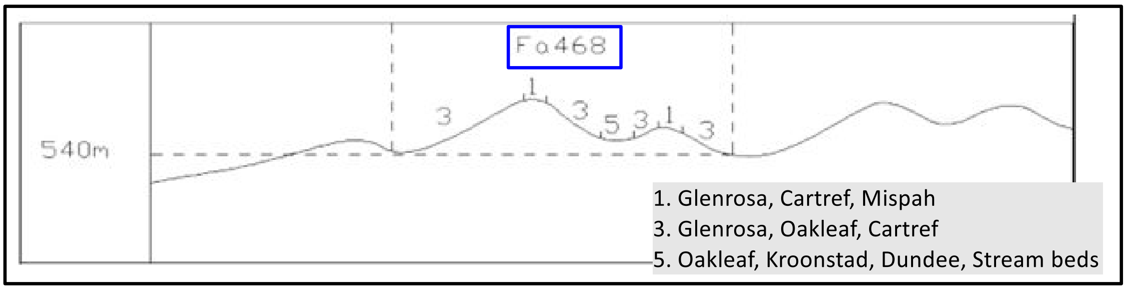


Figure 2-14: Fa468

2.6.1 *Site-specific*

GCS undertook a soil survey from 27 to 30 March 2023. the Test pit positions are shown in Figure 2-17. Auger field data and photographs are available in **Appendix A**. From the soil survey undertaken, the following is observed:

- A total number of 30 auger holes were developed with a bucket auger (named A1 to A30).
- The site is characterized by shallow and deep loamy-sandy soils, as well as occurrences of shallow rock and rock outcrops was noted. Soils associated with the Swartland, Glenrosa, Mispah and Clovelly types were encountered, with the Glenrosa type being the dominant soil form identified. The Clovelly soil type was typically encountered on flat plateau areas, and nearing rock outcrops the Mispah soil. It is clear from the soil investigation that overland runoff is the dominant flow path associated with the project site.
- Shallow groundwater was detected in auger holes A2 and A11. The water levels ranged from 0.2 to 0.5 mbgl (perched water table).
- The estimated soil distribution map for the area based on test pit data is shown in Figure 2-17.

2.7 Soil permeability

Based on available soil data for the project area (refer to Appendix B and Figure 2-15), it is anticipated that the area is characterised by loam to silty clay soil types. Samples were well sorted. As such, the anticipated permeability of the soils is estimated at 0.25 cm/hr to 1.3 cm/hr.

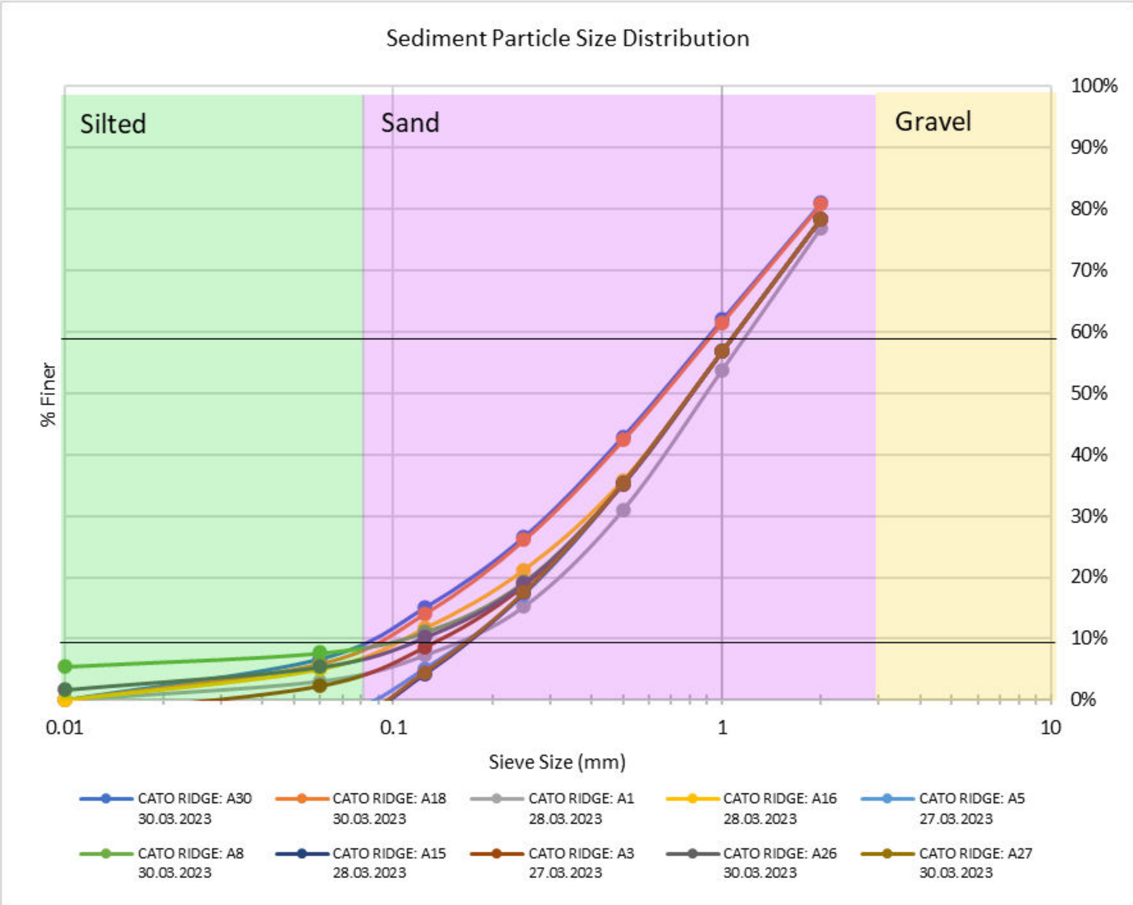


Figure 2-15: Sediment Particle Size Distribution for field samples

Table 2-4: Soil permeability classes for agriculture and conservation (Food and Agriculture Organization (FAO, 1980)

Soil Texture	Permeability (cm/hour)
Sand	5
Sandy Loam	2.5
Loam	1.3
Clay Loam	0.8
Silty Clay	0.25
Clay	0.05

Table 2-5: DWS range of hydraulic conductivities in different soil types (DWS, 2011)

Type	Saturated Hydraulic Conductivity, K_s (cm/s)
Gravel	$3x10^{-2}$ – 3
Coarse Sand	$9x10^{-5}$ – $6x10^{-1}$
Medium Sand	$9x10^{-5}$ – $5x10^{-2}$
Fine Sand	$2x10^{-5}$ – $2x10^{-2}$
Loamy Sand	$4.1x10^{-3}$
Sandy Loam	$1.2x10^{-3}$
Loam	$2.9x10^{-4}$
Silt, Loess	$1x10^{-7}$ – $2x10^{-3}$
Silt Loam	$1.2x10^{-4}$
Till	$1x10^{-10}$ – $2x10^{-4}$
Clay	$1x10^{-9}$ – $4.7x10^{-7}$
Sandy Clay Loam	$3.6x10^{-4}$
Silty Clay Loam	$1.9x10^{-5}$
Clay Loam	$7.2x10^{-5}$
Sandy Clay	$3.3x10^{-5}$
Silty Clay	$5.6x10^{-6}$
Un-weathered marine clay	$8x10^{-11}$ – $2x10^{-7}$

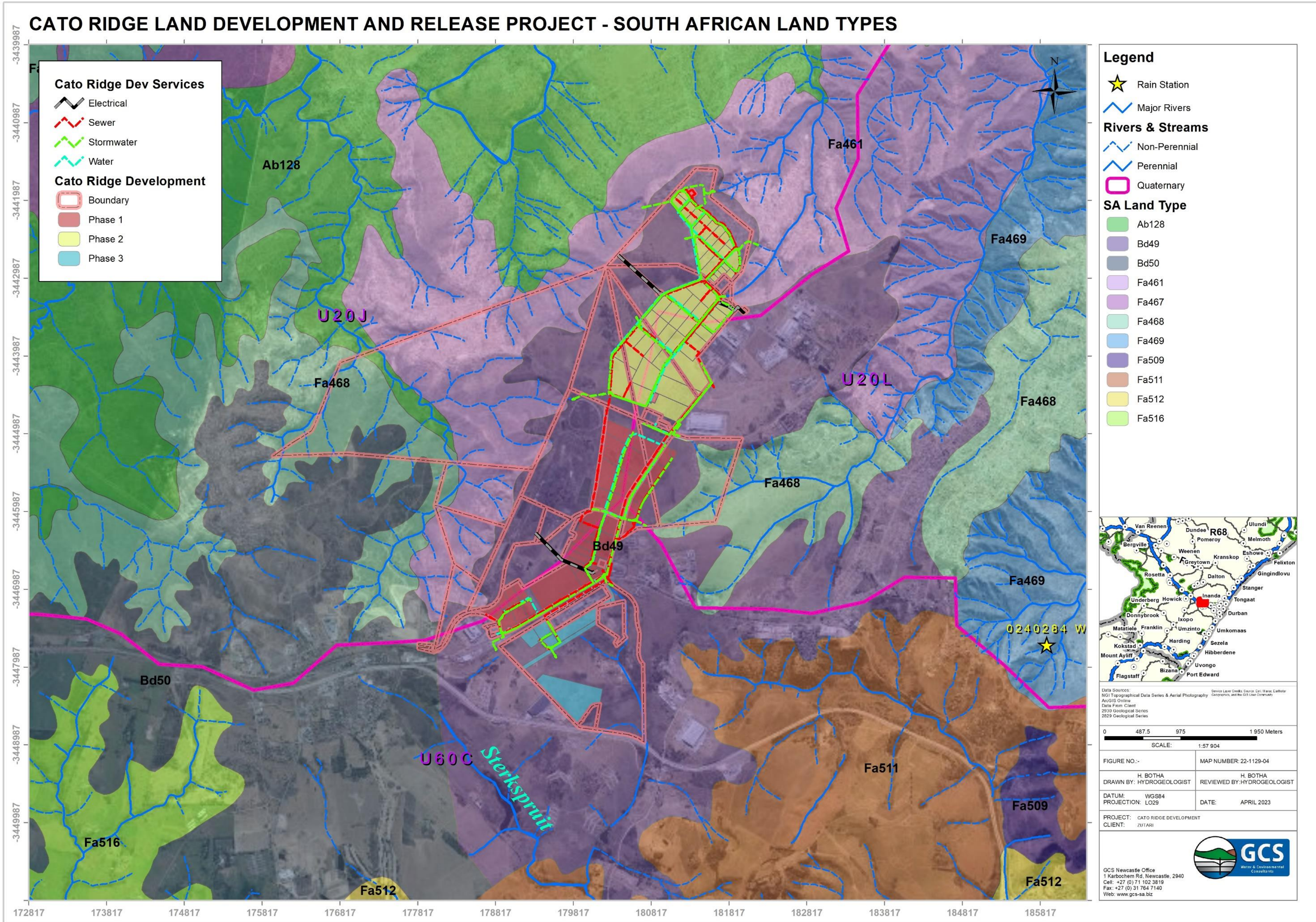


Figure 2-16: South African land cover types

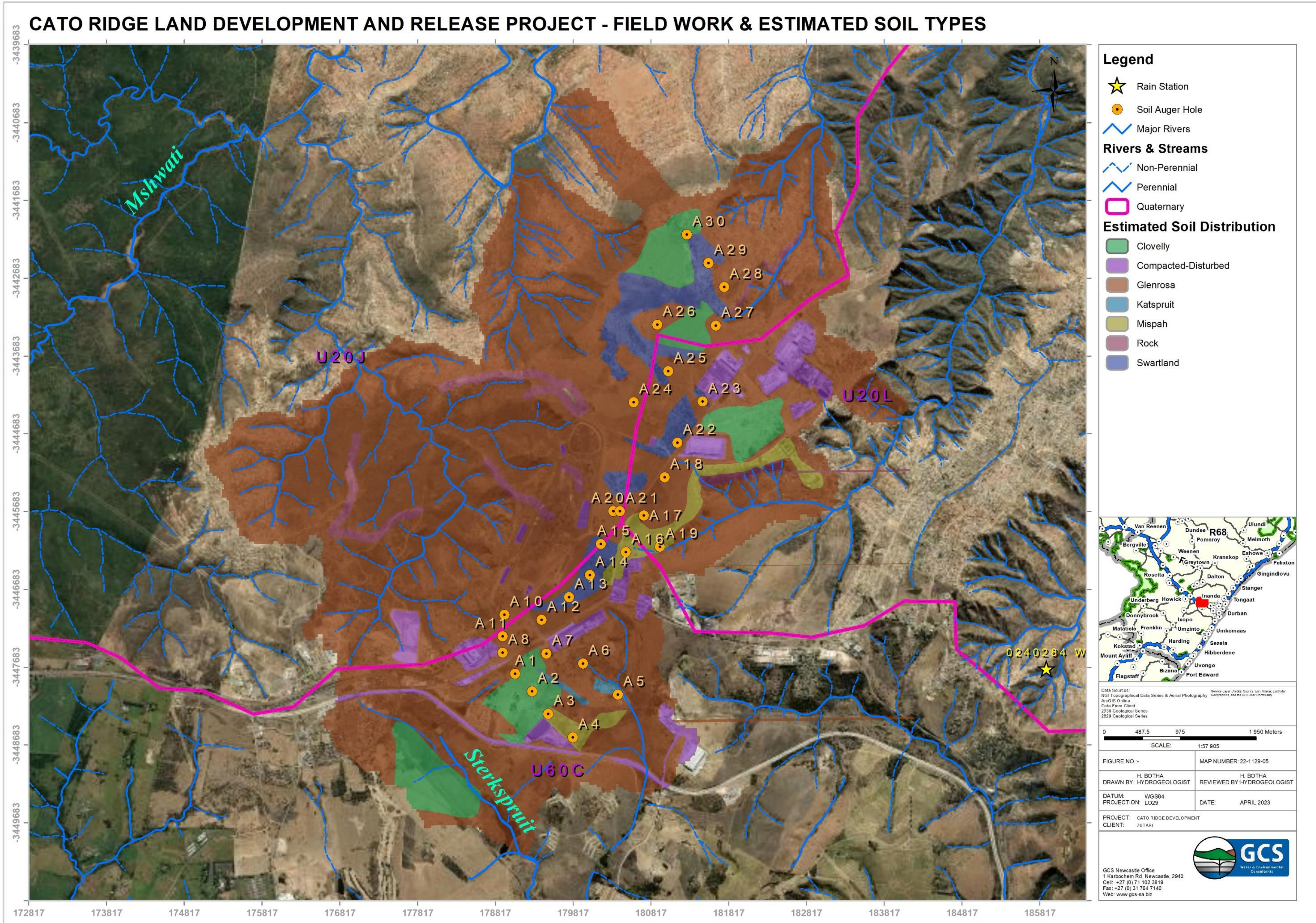


Figure 2-17: Estimated soil distribution map and field auger holes

3 HYDROPEDOLOGICAL ASSESSMENT

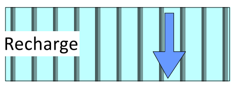
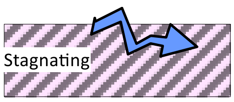
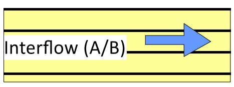
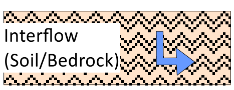
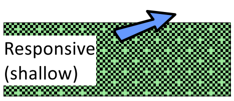
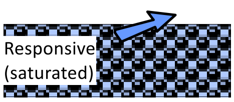
Soil genesis is influenced by physical and chemical water-related processes and soils are, therefore, the first-order control of hydrological processes. The water transfer function of soils varies on several factors including soil properties, topography, and climate.

Characteristic soil properties make it possible to conceptualise hillslope hydrological responses within catchments. The approach followed in this study includes the classification of hillslopes for the site, and the development of a soil map (refer to Section 2.6.1), which were used to determine the HST. Finally, a conceptualisation of hydrological processes that occur on the various hillslopes, based on HST was undertaken.

3.1 Hydrological Soil Types (HST)

In the determination of Hydrological Soil Types (HST), soils were divided into classes based on their expected hydrological responses (Van Tol, et al., 2013). Hydrological processes were perceived from traceable signatures in the soil matrix resulting from the soil's ability to transmit, store and react with water (Le Roux, et al., 2011). The HST descriptions and representative symbols are presented in Table 3-1, below.

Table 3-1: Hydrological soil types

Hydrological soil type	Description	Symbol
Recharge	The soils do not have any morphological indication of saturation. Vertical flow through and out of the profile into the underlying bedrock is the dominant flow path. These soils are deep and freely drained and are experiencing the leaching of nutrients to underlying soil horizons.	
Stagnating	Stagnating soils tend to act like interflow (soil/bedrock) soil types, however, due to the presence of abundant clays lateral discharge is slow. A build-up of water content in the soil profile leads to temporary perched groundwater after high rainfall events.	
Interflow (A/B)	The soils have a textural discontinuity which facilitates the build-up of water in the topsoil, the water that sits on the upper layer then flows laterally into the stream on the A/B horizon interface. The flow path is predominantly downslope in a lateral direction.	
Interflow (Soil/Bedrock) Or Interflow (A/ Bedrock)	Soils overlying relatively impermeable bedrock. Hydromorphic properties signify the temporal build of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction.	
Responsive (Shallow)	The soils are shallow, and they are over a relatively less permeable weathered rock or bedrock. They have limited storage capacity which results in the generation of overland flow after rainfall events.	
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.	

*Adapted from (Van Tol, et al., 2013)

3.2 Hillslopes and hillslope hydrology

Hillslopes and preferential soil flow paths were evaluated based on a 30 m ALOS digital terrain model (DTM) (JAXA, 2022), and can be seen in Figure 3-1. The hillslopes generally feed into responsive soil types or streams/rivers.

3.3 Conceptual hydrological flow processes

The hydrological processes associated with the land types and suspected soil types in the project area are discussed concerning the numbered arrows in Figure 3-2.

1. The study area is primarily characterised by responsive (shallow) soils of the Swartland and Glenrosa types. However, in some areas (in flattened areas or areas where there has been significant hills wash) shallow/deep recharge soils of the Clovelly type were observed.
    a. Vertical flow through and out of the profile into the underlying bedrock is the dominant flow path. These soils are deep and freely drained and are experiencing the leaching of nutrients to underlying soil horizons.
    b. Recharge to the regional groundwater table is expected to occur via the saturated soils and will follow the hydraulic head associated with the regional water table.
2. On the crest to footslope position of the project area (typically hillslopes 1, 2 and 3) responsive (shallow) soils occur. For responsive soil types, the following is likely:
    a. In responsive soils, the build-up of water is expected in the B and upper A horizons after rain and overland discharge and minor lateral seepage are expected (due to saturation excess).
    b. Secondary vertical seepage to deeper soil zones from the saturated B horizon is expected. At the transition from one soil type to the other (upstream to downstream) overland flow may take place during wet seasons.
3. Some areas (typically Hillslope 1) have been developed, and here stagnating water conditions are expected (i.e., the soils have been compacted and altered).
    a. Stagnating soils tend to act like interflow (soil/bedrock) soil types, however, due to the presence of abundant clays lateral discharge is slow. A build-up of water content in the soil profile leads to temporary perched groundwater after high rainfall events.

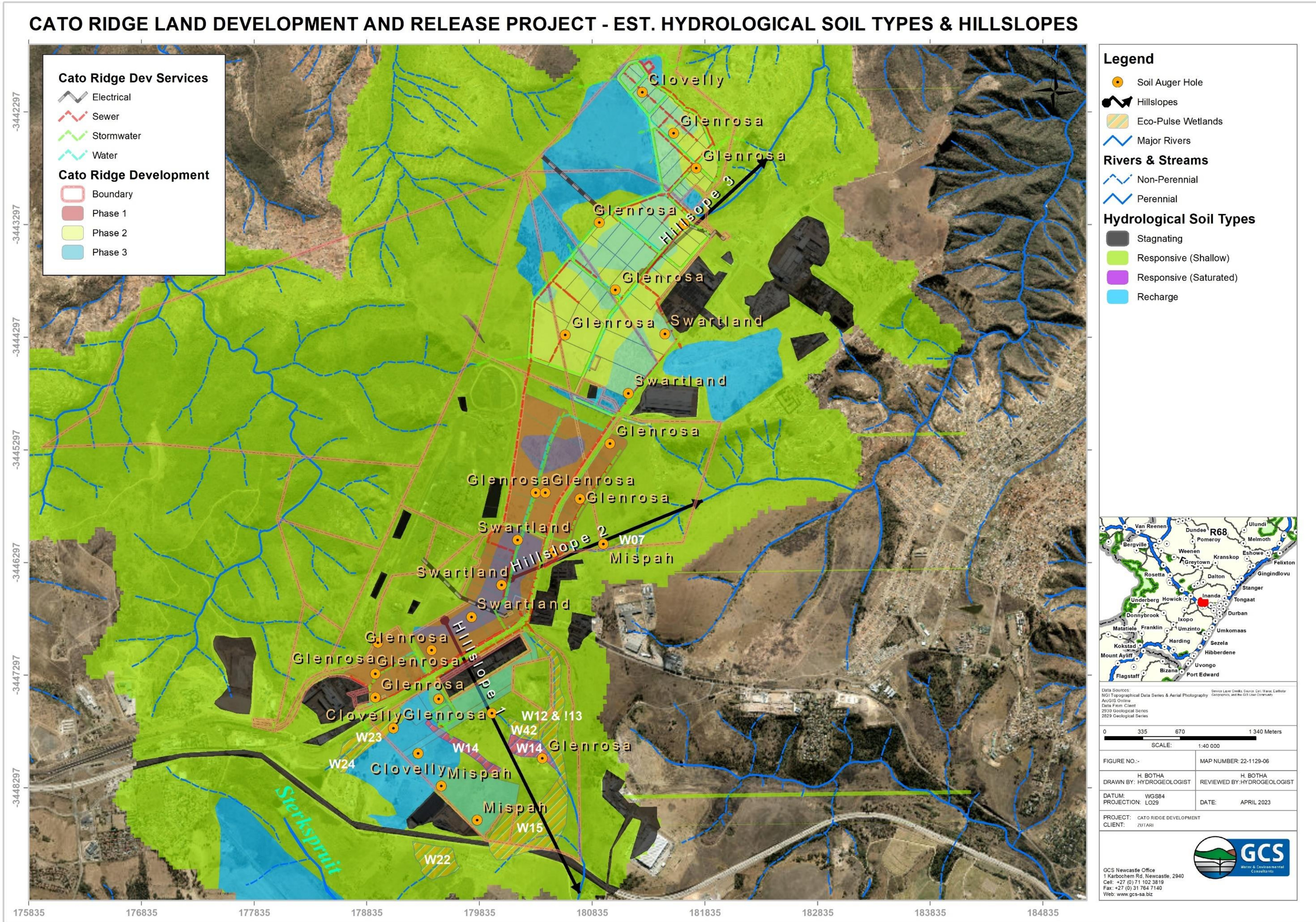


Figure 3-1: Hydrological soil types and hillslopes

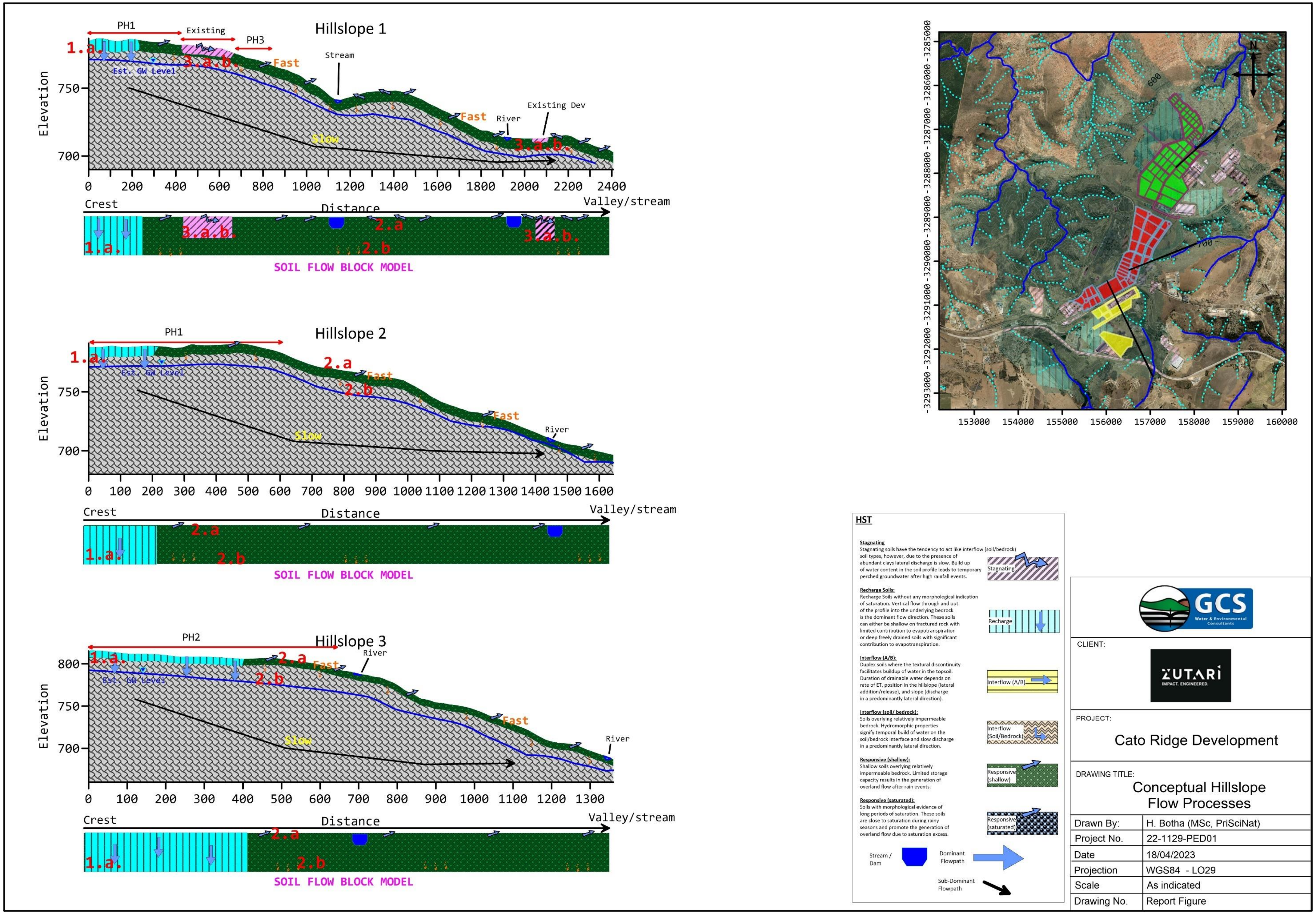


Figure 3-2: Conceptualisation of hydrological soil flow process

4 RISK ASSESSMENT & MITIGATION

The anticipated hydropedological risk concerning the construction and operational phase of the proposed Development was estimated. The source-pathway-receptor (SPR) model (DWAF, 2008) was used to evaluate potential pollution sources and primary receptors within the study area.

Risk assessment entails understanding the generation of a hazard, the probability that the hazard will occur, and the consequences if it should occur. The net consequence is established by the following equation:

Consequence = (Duration + Extent + Irreplaceability of resource) x Severity

And the environmental significance of an impact was determined by multiplying consequence by probability. The risk significance rating is summarised in Table 4-1.

Table 4-1: Risk rating scale

Criteria	Rating Scales
Significance	Very high - negative (-49 to -66)
	High - negative (-37 to -48)
	Moderate - negative (-25 to -36)
	Low - negative (-13 to -24)
	Neutral - Very low (0 to -12)
	Low-positive (0 to 12)
	Moderate-positive (13 to 24)
	High-positive (37 to 48)
	Very high - positive (49 to 66)

In terms of the proposed development, several risks during the construction and operational phase of the development were identified. The potential impacts identified and environmental significance for the construction and operational phase are listed in Table 4-2 and Table 4-3. No closure phase risks are anticipated, due to the project type.

Based on the available development layout plan the following will likely contribute to the impacts of hydropedological flow drivers, and soil quality and may compromise surface water quality in the nearby watercourse:

- **Construction:**
    - Site preparation, including placement of contractor laydown areas and storage (i.e., temporary stockpiles, bunded areas etc.) facilities.
    - Disturbing vadose zone during soil excavations/infilling activities.
    - In-situ placement of new soils, altering existing soil-flow processes (i.e., infilling of wetlands or cut-and-fill areas).
    - Soil compaction.

- Soil & surface water contamination and sedimentation from the following activities:
  - Leakages from vehicles and machines and building materials.
  - Erosion and sedimentation of watercourses if excavations are left open due to unforeseen circumstances (i.e., bad weather); and
  - Alteration of natural drainage lines may lead to ponding or increased runoff patterns (i.e., may cause stagnant water levels or increase erosion).
- Vegetation loss could decrease soil infiltration and increase runoff.

- **Operational:**
  - Reduced soil infiltration due to the residential development units and site access roads (i.e., areas which will potentially become impermeable).
  - Reduced rainfall runoff to wetland areas from drainage servitudes (i.e., this water will be captured in stormwater infrastructure).
  - Soil quality could be compromised if leakages occur from sewer lines. Moreover, oil & fuel spills from resident vehicles can cause soil contamination.
  - Stormwater discharge from the development may maintain or improve hydropedology functions.
  - Treated effluent discharge from the on-site WTP may impact soil quality if of poor quality. However, an overall improvement in the soils at the effluent outlet is anticipated.
- **Closure/decommission phase:**
  - Similar impacts as per the construction/preparation phase are anticipated.

The potential impact on hydropedological flow drivers and risk associated with the activities mentioned above were further investigated in the sub-sections below.

4.1 Cumulative impacts and impacts on the hydrological cycle.

As all activities will take place on the same property, there will be cumulative impacts. The operational phase risk table includes cumulative risk about the site, and activities thereon.

Table 4-2: Construction (preparation and development) phase hydropedology risk

			Pre- Mitigation								Post Mitigation						
Component being impacted	Activity Which May Cause the Impact	Activity	Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance	Recommended Mitigation Measures	Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance
Soil interflow processes: • Infilling of wetlands and watercourses inducing alternative flow paths (if infilling occurs). • Alteration to natural hydropedological flow paths. • Impacts on the macro-soil structure. • Impacts on the hydropedological processes supporting the watercourses. Soil structure & land capability: • Exposure of soils, leading to increased runoff from cleared areas and erosion of the watercourses, thus increasing the potential for sedimentation of the watercourses. • Vegetation loss. • Soil compaction; and Soil erosion. Soil quality: • Natural nutrient content decreases due to soil exposure. • Loss of natural bio-organisms essential to soil processes.	Site preparation, including placement of contractor laydown areas and storage (i.e., temporary stockpiles, bunded areas etc.) facilities.	Earthworks	Medium Term (4)	Site (2)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Definite (2)	Low (12 to -25) (-14)	• Only excavate areas applicable to the project area. • Backfill the material in the same order it was excavated to reduce contamination of deeper soils with shallow oxidised soils. • Cover excavated soils with a temporary liner to prevent contamination. • Keep the site clean of all general and domestic wastes. All development footprint areas are to remain as small as possible and vegetation clearing is to be limited to what is essential. • Retain as much indigenous vegetation as possible. • Exposed soils are to be protected using a suitable covering or revegetating. • Existing roads should be used as far as practical to gain access to the site, and crossing watercourses in areas where no existing crossing is apparent should be unnecessary, but if it is essential crossings should be made at right angles. • Have emergency fuel & oil spill kits on site. • Soil quality monitoring & visual assessments – monthly basis. If obvious pollution is noted (visually) then it is advised that soil screening be undertaken.	Medium Term (4)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (-0)	Probable (1)	Negligible (0 to -12) (0)
	Disturbing vadose zone during soil excavations/infilling activities.	Earthworks	Medium Term (4)	Site (2)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Definite (2)	Low (12 to -25) (-14)		Medium Term (4)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (-0)	Probable (1)	Negligible (0 to -12) (0)
	Vegetation clearing & soil stockpiling.	Earthworks	Medium Term (4)	Site (2)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Definite (2)	Low (12 to -25) (-14)		Medium Term (4)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (-0)	Probable (1)	Negligible (0 to -12) (0)
Soil quality	Seepage/leakages/overland flow from the sewer lines may cause soil degradation. Moreover, oil & fuel spills from vehicles parked at the site may compromise soil quality. Prolonged pollution may migrate to the nearby watercourse and/or percolate into the groundwater table.	Earthworks	Medium Term (4)	Site (2)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Definite (2)	Low (12 to -25) (-14)	Ensure the sewer system is monitored for leakages. Routine visual inspections of sewer infrastructure and resident parking areas for signs of soil contamination.	Medium Term (4)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (-0)	Probable (1)	Negligible (0 to -12) (0)

Component being impacted	Activity Which May Cause the Impact	Activity	Pre- Mitigation: Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance	Recommended Mitigation Measures	Post Mitigation: Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance
										Have emergency fuel & oil spill kits on site.							
Primary Surface Water Receivers > Non-perennial stream > Wetland units	Surface water contamination and sedimentation from the following activities: • Equipment and vehicles are washed in the water bodies (when there is water). • Erosion and sedimentation of watercourses due to unforeseen circumstances (i.e., bad weather); and • Alteration of natural drainage lines which may lead to ponding or increased runoff patterns (i.e., may cause stagnant water levels or increase erosion).	Earthworks	Medium Term (4)	Site (2)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Definite (2)	Low (12 to -25) (-14)	• Water quality monitoring and visual assessments. • Install a temporary cut-off trench to contain poor-quality runoff (if required). • Routine (monthly) inspections of all sewer-related infrastructure (hydraulic monitoring) • Ensure that stormwater systems conveying water to the nearby river are fitted with silt and oil traps, as well as that surface drains, are isolated from any potential surface pollution sources.	Medium Term (4)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (-0)	Probable (1)	Negligible (0 to -12) (0)
Perched Water Table Dewatering	Temporary dewatering of perched groundwater (only expected during intense storm events and shortly thereafter).	Earthworks	Medium Term (4)	Site (2)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Definite (2)	Low (12 to -25) (-14)	• Water quality monitoring and routine visual assessment for contamination. • Discharge dewatered / rainwater collected into the nearby stream. May require authorisation. If water is contaminated, discharge to the closest greywater system (depending on the extent of contamination)	Medium Term (4)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (-0)	Probable (1)	Negligible (0 to -12) (0)

Table 4-3: Operational phase hydropedology risk

Component being impacted	Activity Which May Cause the Impact	Activity	Pre- Mitigation							Recommended Mitigation Measures	Post Mitigation						
			Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance		Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance
Vadose zone soils and subsequent aquifer (groundwater table)	Site activities • Poor quality seepage and runoff from vehicles parked at the site and from ruptured sewer lines.	Site activities	Long-term (4)	Site (2)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Probable (1)	Negligible (0 to -12) (-7)	• Keep the site clean of all general and domestic wastes. • Water quality of the streams and sewer line monitoring.	Long-term (4)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (0)	Probable (1)	Negligible (0 to -12) (0)
Soil interflow processes: • Alteration to natural hydropedological flow paths. • Impacts on the macro-soil structure. • Impacts on the hydropedological processes supporting the watercourses.	Disturbing the inner-soil architecture of the original soil profile will disturb natural flow processes (i.e., a result of infilling or cut-and-fill activities). Excavated soil will be placed in other areas (i.e., on top of other soils) and will have an impact on the flow dynamics of the soil it is dumped on top of. This may reduce rainfall infiltration and induce runoff. Impermeable areas (urbanisation) may decrease rainfall infiltration into recharge soils, and hence reduce interflow (A/B and A/bedrock) or lateral flow to downstream wetland areas.	Site activities	Long-term (4)	Site (2)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Definite (2)	Low (12 to -25) (-14)	• Revegetate areas (with vegetation growing at the site) where heavy machinery movement takes place to prevent erosion. • Establish where excavated soils will be placed during the construction phase, and if the area is suitable to receive the excavated soils. • Cover excavated soils to be protected using a suitable covering.	Long-term (4)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (0)	Probable (1)	Negligible (0 to -12) (0)
	Treated effluent discharge into rivers/streams/wetland units, may improve or maintain hydropedological flow functions. Stormwater attenuation of accumulated rainwater back into the environment will help maintain or improve hydropedology functions.	Site activities	Long-term (4)	Site (2)	Yes (1)	High (3)	Highly beneficial (19 to 24) (21)	Definite (2)	High-positive (37 to 48) (42)	No mitigation is required.							

Component being impacted	Activity Which May Cause the Impact	Activity	Pre- Mitigation Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance	Recommended Mitigation Measures	Post Mitigation Duration (D)	Extent (E)	Potential for impact on irreplaceable resources (I)	Severity (S)	Consequence (C)	Probability (P)	Significance
Soil structure & land capability: • Exposure of soils, leading to increased runoff from cleared areas and erosion of the watercourses, thus increasing the potential for sedimentation of the watercourses. • Vegetation loss. • Soil compaction; and Soil erosion.	Areas which were backfilled with collapsible soils; water leakages from the stormwater system or sewer leakages may cause soil subsidence/erosion. Likely associated with soil structure comptonization.	Site Activities / Net Result of Earthworks and Development	Long-term (4)	Site (2)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Definite (2)	Low (12 to -25) (-14)	• Hydraulic monitoring of stormwater systems to ensure that the system operates as per design specifications. • Retain as much indigenous vegetation as possible. • Ensure the sewer system is monitored for leakages. • Routine visual inspections of sewer infrastructure and parking areas for signs of soil contamination. • Have emergency fuel & oil spill kits on site.	Long-term (4)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (0)	Probable (1)	Negligible (0 to -12) (0)
Soil quality	Seepage/leakages/overland flow from the sewer lines may cause soil degradation. Moreover, oil & fuel spills from vehicles parked at the site may compromise soil quality. Prolonged pollution may migrate to the nearby watercourse and/or percolate into the groundwater table.	Site activities	Long-term (4)	Site (2)	Yes (1)	Negligible (0)	Slightly detrimental (-7 to -12) (-7)	Definite (2)	Low (12 to -25) (-14)	Ensure the sewer system is monitored for leakages. Routine visual inspections of sewer infrastructure and resident parking areas for signs of soil contamination. Have emergency fuel & oil spill kits on site.	Long-term (4)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (0)	Probable (1)	Negligible (0 to -12) (0)
Primary Surface Water Receivers > Non-perennial stream > Wetland units	*Stormwater runoff* • Potential surface water contamination as a result of poor stormwater drainage on-site. • Increased erosion due to vegetation loss. • Contaminated runoff water into nearby streams from parked vehicles at the site. • Sedimentation of watercourses due to altered runoff patterns.	Net Result of Earthworks and Development	Long-term (4)	Site (2)	Yes (1)	Low (-1)	Slightly detrimental (-7 to -12) (-7)	Definite (2)	Low (12 to -25) (-14)	• Water quality monitoring and visual assessments. • Install a temporary cut-off trench to contain poor-quality runoff (if required and pre-determined by visual assessments). • Routine hydraulic monitoring of the stormwater system (monthly)	Long-term (4)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (-0)	Definite (2)	Negligible (0 to -12) (0)
	Sewer lines (waterborne sanitation) • Poor quality seepage into the subsoils from sewer lines may impact soil quality and eventually lead to poor quality seepage into the surroundings.	Net Result of the development	Long-term (4)	Site (2)	Yes (1)	Moderate (-2)	Negligible (0 to -6) (-14)	Definite (2)	Moderate (-25 to -36) (-28)	• Water quality monitoring and visual assessments. • Routine inspections of all sewer-related infrastructure (hydraulic monitoring	Long-term (4)	Site (2)	Yes (1)	Negligible (0)	Negligible (0 to -6) (-0)	Definite (2)	Negligible (0 to -12) (0)

4.2 Flow driver impact categories

Table 4-4 summarises the criteria used for the hydropedological flow driver impact assessment.

The flow driver impact assessment aims to characterise the likely impacts on the hydropedological flow drivers (i.e., what are the likely impacts of the development on the hydropedological flow drives sustaining a wetland or stream after the development has taken place).

Table 4-4: Impact categories for describing the impact on the wetlands and associated hydropedological drivers

Severity	Flow Driver Reduction	Change Class	Description
No Impact	0 - 2.5%	No change	The hydropedological process is predicted to be unmodified and the functionality of the wetland will remain unchanged
Low	2.5 - 5%	No Significant change	A small effect on the hydropedological process is predicted, however, the functionality of the wetland remains unchanged and no change in resource class is expected.
Low to Moderate	5 - 10%	Limited change with a change in the PES category is possible	A slight change in hydropedological processes is predicted and a small change in the wetland may have taken place but is changed to the (present ecological state) PES, EIS (ecological importance and sensitivity) or wetland functionality and eco service provision is limited with no more than one PES class predicted.
Moderate	10 - 15%	A significant change with a change in PES Category definite and possibly a change of more than one category	A moderate change in the hydropedological processes is predicted to occur, the change in PES may exceed one category but no change in EIS takes place. No loss of important eco-services is predicted to occur
High	15 - 22.5%	A very significant change with a change in PES of more than two categories	Modifications have reached a very significant level and the hydropedological processes are predicted to be largely modified with a large change in the PES, and EIS of the wetland feature as well as a significant loss in eco service provision.
Very High	22.5 - 60%	Serious to Critical change with a change in PES of more than three categories or a permanent complete loss of wetland resource	Modifications have reached a serious level and the hydropedological processes have been seriously modified with an almost complete loss of wetland integrity, functionality, and service provision.

4.3 Flow driver loss calculation/impact estimation

A water balance approach was adopted to estimate the potential impacts on the flow drivers. The equation used was as follows:

$$\text{Flow Loss \%} = \frac{FN\ (\mathrm{m^3/yr.})}{\mathrm{WT}\ (\mathrm{m^3/yr.})} \text{ x } 100 \text{ (convert to \%)}$$ Equation 1

Where:

- FN = Sum of Total Negative flow driver impacts in a given sub-catchment.
- WT = Total water in the system.

And:

$$FN = RRI + GBR + AII + NRF$$ Equation 2

- RRI = Est. direct rainfall runoff intercepted by the development (m^3/yr.).
- GBR = Est. reduced groundwater contribution to flow drivers/GW dewatering (m^3/yr.).
- AII = Est. aquifer and soil interflow intercepted by the development/activity (m^3/yr.); and
- NRF = Est. surface runoff intercepted which would naturally flow from upper catchments to the downstream environment (m^3/yr.) – estimated at 30% of the MAP.

Adding positive water releases to the flow driver system (i.e., diverting rainwater to the environment via stormwater systems) may offset the negative. The equation used, was as follows:

$$\text{Net Flow loss impact (\%)} = [\mathbf{\Sigma Total\ Negative}\text{ flow driver impacts } (\mathrm{m^3/yr.}) - \mathbf{Positive\ Adjustments}\ (\mathrm{m^3/yr.})\ ] \ / \text{ Total water in the system } (\mathrm{m^3/yr.}) \text{ x } 100 \text{ (convert to \%)}$$ Equation 3

Where:

The Sum of Positive Adjustments (m^3/yr.) are:

- Est. positive flow releases previously impacted (m^3/yr.); and
- Est. new positive flow releases not impacted on (m^3/yr.).

4.3.1 Assumptions

The following assumptions were made:

- Constant evaporation of 30% is assumed for the sub-catchments.
- No groundwater dewatering takes place.
- MAP is in the order of 803 mm/yr.
- Groundwater recharge is in the order of 6.5% (DWAF, 2006).
- Groundwater contribution to baseflow is assumed to be in the order of 20.82 mm/yr. (DWAF, 2006) – Hughes Model.
- No interception of upstream catchment overland flow paths is considered (i.e., as a result of other developments) – conservative approach.
- No artificial recharge, other than in the case of a mitigation measure (i.e., attenuated stormwater releases to wetlands/streams/drainage lines), is accounted for. Artificial recharge from dams is not considered.
- The existing setting and activities are evaluated. Built-up areas are assessed as being impermeable or no-flow boundaries. This was done to evaluate the likely impacts of PES/EIS.
- The above-mentioned assumptions were made to give a worst-case overview of the likely impacts on the hydropedological flow water balance, as a result of the activities at the site.

4.3.2 Calculations

The calculations for impact on the hydropedological flow drivers, pre- and post-mitigation, are shown in Table 4-5.

Table 4-5: Flow driver calculations

		Rainfall	HRU1	HRU2	HRU3	HRU4	HRU5	HRU6	HRU7	HRU8	HRU9	HRU10	HRU11	HRU12	HRU13	HRU14	HRU15	HRU16	HRU17	HRU18	HRU19
		mm/yr	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484	803.00484
		GW Recharge - DEEP	HRU1	HRU2	HRU3	HRU4	HRU5	HRU6	HRU7	HRU8	HRU9	HRU10	HRU11	HRU12	HRU13	HRU14	HRU15	HRU16	HRU17	HRU18	HRU19
		%	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
		mm/yr	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661	54.336661
		BF - SHALLOW	HRU1	HRU2	HRU3	HRU4	HRU5	HRU6	HRU7	HRU8	HRU9	HRU10	HRU11	HRU12	HRU13	HRU14	HRU15	HRU16	HRU17	HRU18	HRU19
		mm/yr	20.82	20.82	20.82	20.82	20.82	20.82	20.82	20.82	20.82	20.82	20.82	20.82	20.82	20.82	20.82	20.82	20.82	20.82	20.82
		Runoff	HRU1	HRU2	HRU3	HRU4	HRU5	HRU6	HRU7	HRU8	HRU9	HRU10	HRU11	HRU12	HRU13	HRU14	HRU15	HRU16	HRU17	HRU18	HRU19
		Stormwater factor (%)	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
		Runoff Factor (%)	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
		Sub-Catch Area	HRU1	HRU2	HRU3	HRU4	HRU5	HRU6	HRU7	HRU8	HRU9	HRU10	HRU11	HRU12	HRU13	HRU14	HRU15	HRU16	HRU17	HRU18	HRU19
Drivers	Status	km²	1.480	1.241	1.144	1.125	3.784	1.203	1.464	1.018	2.243	1.134	2.235	1.136	3.218	1.428	0.864	1.439	2.467	1.712	2.998
Natural Water Processes																					
	+	Total Rain Volume (m³/yr)	1188531.5	996875.9	919015.75	903709.68	3038540.6	966263.75	1175887.4	817198.75	1801430.5	910364.18	1794775.2	912361.25	2584024.6	1146606.6	694086.07	1155258.2	1981107.7	1374863.1	2407008.6
	-	Runoff (m³/yr)	950825.18	797500.72	735212.6	722967.74	2430832.5	773011	940709.89	653759	1441144.4	728291.34	1435820.2	729889	2067219.7	917285.28	555268.85	924206.53	1584886.2	1099890.5	1925606.9
	+	Re AQ - Deep / Shallow Percolation (m³/yr)	80423.963	67455.269	62186.732	61151.021	205607.91	65383.847	79568.378	55297.116	121896.8	61601.309	121446.46	61736.445	174852.33	77587.046	46966.49	78172.469	134054.95	93032.405	162874.25
	+	BF - Shallow Soil Interflow (m³/yr)	30815.786	25846.614	23827.886	23431.036	78782.11	25052.914	30487.954	21188.014	46706.797	23603.572	46534.241	23655.351	66997.594	29728.774	17995.996	29953.089	51365.397	35646.921	62407.992
	-	Evap (m³/yr)	126466.55	106073.3	97788.531	96159.878	323318.1	102815.99	125121.14	86954.621	191682.51	96867.955	190974.35	97080.454	274955	122005.5	73854.727	122926.08	210801.19	146293.3	256119.48
		Balance	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Description		Development	HRU1	HRU2	HRU3	HRU4	HRU5	HRU6	HRU7	HRU8	HRU9	HRU10	HRU11	HRU12	HRU13	HRU14	HRU15	HRU16	HRU17	HRU18	HRU19
The area that becomes impermeable or altered.		Est. Disturbance Area (km²) - Above Ground / Impermeable	0.2002	0.3492	0.1960	0.1700	0.0120	No Dev	No Dev	0.1750	0.0600	No Dev	No Dev	No Dev	0.4000	0.0790	0.0200	0.3360	0.4350	0.0162	0.1560
		Est. Disturbance Area (km²) - Soil Removal	0.0060	0.0105	0.0059	0.0051	0.0004	0.0000	0.0000	0.0053	0.0018	0.0000	0.0000	0.0000	0.0120	0.0024	0.0006	0.0101	0.0131	0.0005	0.0047
		Est. Disturbance Area (km²) - Underground	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		Est. Intercepted Flow Area (m²)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Est. Groundwater Dewatering (l/sec)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drivers	Status	Impact	HRU1	HRU2	HRU3	HRU4	HRU5	HRU6	HRU7	HRU8	HRU9	HRU10	HRU11	HRU12	HRU13	HRU14	HRU15	HRU16	HRU17	HRU18	HRU19
Impacted Processes	-	Rainfall Intercepted (m³/yr)	160761.6	280409.3	157388.9	136510.8	9636.1	0.0	0.0	140525.8	48180.3	0.0	0.0	0.0	321201.9	63437.4	16060.1	269809.6	349307.1	13008.7	125268.8
	-	Soil Zone Water Loss (m³/yr)	125.0	218.1	122.4	106.2	7.5	0.0	0.0	109.3	37.5	0.0	0.0	0.0	249.8	49.3	12.5	209.9	271.7	10.1	97.4
	-	Deeper Zone Water Loss (under soils) (m³/yr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	-	Deeper Vadose Zone & Water Table - DEWATER (m³/yr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Horizontal Interflow Removed (m³/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	+	Storm Water (m³/yr)	128609.3	224327.4	125911.2	109208.7	7708.8	0.0	0.0	112420.7	38544.2	0.0	0.0	0.0	256961.5	50749.9	12848.1	215847.7	279445.7	10406.9	100215.0
		Negative Impacts	160886.6	280627.4	157511.4	136617.0	9643.6	0.0	0.0	140635.2	48217.8	0.0	0.0	0.0	321451.8	63486.7	16072.6	270019.5	349578.8	13018.8	125366.2
		% Impact on Natural Flow System	13.54%	28.15%	17.14%	15.12%	0.32%	0.00%	0.00%	17.21%	2.68%	0.00%	0.00%	0.00%	12.44%	5.54%	2.32%	23.37%	17.65%	0.95%	5.21%
		% After Storm Water Convey	2.72%	5.65%	3.44%	3.03%	0.06%	0.00%	0.00%	3.45%	0.54%	0.00%	0.00%	0.00%	2.50%	1.11%	0.46%	4.69%	3.54%	0.19%	1.04%

4.4 Estimated flow losses and risk rating

Based on the sub-catchments delineated and the proposed development footprint, the overall impacts on the sub-surface natural flow systems were estimated. Table 4-6 summarises the estimated % loss ratings for the sub-catchments – pre- and post-mitigation.

The predicted impact on the watercourses fed by the hydropedological process is estimated to range from 0% (no development HRUs) to 28% for the hydropedological sub-catchments. This translates to a "no impact" and "very high impact" about PES. If stormwater attenuation back to the environment is considered, the severity changes from 'no impact" to "low," except for HRU2 which shows a "low to moderate" potential impact.

The resource management objectives (RMO) for any wetland unit would be to maintain the current PES and EIS post-development or be improved by implementing dedicated stormwater features/structures. The table below shows how the severity of a sub-catchment scale can be improved by incorporating stormwater attenuation back into the environment. However, the way water is discharged into receiving wetland systems needs to be regulated, as high flow velocities could impact wetland health. HRU2 will have the largest impact post-development due to scale (i.e. the catchment area may become 80% impermeable based on the layout plan provided, with little open spaces). Development areas will likely have both stagnant and inherent soil flow properties.

Table 4-6: Estimated % hydropedological flow loss rating for catchments

Sub-Catchment	Est. Flow Driver Impact (No Mitigation)	Severity	Est. Flow Driver Impact (Mitigation)	Severity
HRU1	14%	Moderate	3%	Low
HRU2	28%	Very High	6%	Low to Moderate
HRU3	17%	High	3%	Low
HRU4	15%	Moderate	3%	Low
HRU5	0%	No Impact	0%	No Impact
HRU6	0%	No Impact	0%	No Impact
HRU7	0%	No Impact	0%	No Impact
HRU8	17%	High	3%	Low
HRU9	3%	Low	1%	No Impact
HRU10	0%	No Impact	0%	No Impact
HRU11	0%	No Impact	0%	No Impact
HRU12	0%	No Impact	0%	No Impact
HRU13	12%	Moderate	2%	No Impact
HRU14	6%	Low to Moderate	1%	No Impact
HRU15	2%	No Impact	0%	No Impact
HRU16	23%	Very High	5%	Low
HRU17	18%	High	4%	Low
HRU18	1%	No Impact	0%	No Impact
HRU19	5%	Low	1%	No Impact

5 CONCLUSIONS

Soil and hydrological data were evaluated for the project area to produce a soil distribution map. The soil map was used to categorize the hydrological soil types (HST), into the following categories:

- Recharge.
- Stagnating.
- Responsive (shallow).
- Responsive (saturated).
- Interflow (A/B); and
- Interflow (soil/bedrock).

Dominant hydropedology flow processes for the study area can be expressed by three (3) dominant hilltop types. The study area is primarily characterised by responsive (shallow) soils of the Swartland and Glenrosa types. However, in some areas (in flattened areas or areas where there has been significant hills wash) shallow/deep recharge soils of the Clovelly type were observed. Vertical flow through and out of the profile into the underlying bedrock is the dominant flow path. These soils are deep and freely drained and are experiencing the leaching of nutrients to underlying soil horizons. Recharge to the regional groundwater table is expected to occur via the saturated soils and will follow the hydraulic head associated with the regional water table.

On the crest to footslope position of the project area (typically hillslopes 1, 2 and 3) responsive (shallow) soils occur. In responsive soils, the build-up of water is expected in the B and upper A horizons after rain and overland discharge and minor lateral seepage are expected (due to saturation excess). Secondary vertical seepage to deeper soil zones from the saturated B horizon is expected. At the transition from one soil type to the other (upstream to downstream) overland flow may take place during wet seasons.

Some areas (typically Hillslope 1) have been developed, and here stagnating water conditions are expected (i.e., the soils have been compacted and altered). Stagnating soils tend to act like interflow (soil/bedrock) soil types, however, due to the presence of abundant clays lateral discharge is slow. A build-up of water content in the soil profile leads to temporary perched groundwater after high rainfall events.

The predicted impact on the watercourses fed by the hydropedological process is estimated to range from 0% (no development HRUs) to 28% for the hydropedological sub-catchments. This translates to a “no impact” and “very high impact” about PES. If stormwater attenuation back to the environment is considered, the severity changes from ‘no impact” to “low,” except for HRU2 which shows a “low to moderate” potential impact.

The resource management objectives (RMO) for any wetland unit would be to maintain the current PES and EIS post-development or be improved by implementing dedicated stormwater features/structures. The table below shows how the severity of a sub-catchment scale can be improved by incorporating stormwater attenuation back into the environment. However, the way water is discharged into receiving wetland systems needs to be regulated, as high flow velocities could impact wetland health. HRU2 will have the largest impact post-development due to scale (i.e. the catchment area may become 80% impermeable based on the layout plan provided, with little open spaces). Development areas will likely have both stagnant and inherent soil flow properties.

5.1 Avoidance areas & buffers

A 15 m hydropedological buffer is proposed for wetlands, streams, and rivers, however, it is known that Eco-Pulse (2022) has proposed wetlands buffers that supersede the hydropedology buffers (refer to Table 5-1). The proposed buffers will limit direct disturbance/edge effects to the wetland and riparian habitats, will reduce sediment/erosion impacts through sediment trapping by vegetated buffer strips, and will contribute to dealing with water quality impacts (such as nutrient enrichment from surface runoff). The recommended buffer zones will also contribute to maintaining areas of terrestrial habitat as well as hydropedological soil flow processes.

It is further understood that the proposed stormwater management plan is to discharge accumulated stormwater back to the receiving environment, via 11 stormwater attenuation ponds. Therefore, the post-mitigation impact in Table 4-6 in terms of hydropedology suppression is anticipated. The discharge from the modular wastewater treatment plant (WTP) will likely not impact the hydropedology processes of the site, however, minor hydropedology process changes may occur at the discharge point (i.e. responsive shallow soils may become saturated, but will maintain similar flow processes).

Table 5-1: Proposed Eco-Pulse buffer zones (Eco-Pulse, 2022)

Watercourse Type	Project Phase	Recommended Buffer Width	
		Mitigation	
		Without	With
Rivers/ Streams	Construction	33 m	33 m
	Operation	29 m	29 m
	Final	**33 m**	**33 m**
Wetlands	Construction	31 m	31 m
	Operation	26 m	26 m
	Final	**31 m**	**31 m**

5.2 Mitigation measures for inclusion in the EMPr

The following mitigation measures can be considered as part of the EMPr:

- Ensure clean stormwater is conveyed to the natural environment (as per the stormwater managed to plan for the development).
- The outlets of stormwater attenuation structures should be associated with appropriate erosion protection measures.
- A series of small outlets from attenuation structures are preferred to a single large outlet.
- Measures to capture solid waste and debris entrained in stormwater entering the stormwater management system (inlet protection devices) will be incorporated into the design of the system and could include the use of either curb inlet/inlet drain grates and/or debris baskets/bags.
- Wherever possible, existing vegetation cover should be maintained during the construction phase. The unnecessary removal of ground cover from slopes must be prevented, especially on steep slopes.
- The recycling/reuse of dirty water is promoted; alternatively, this water will need to be directed into the sewer system.
- Ensure that treated effluent from the wastewater treatment plant achieves General Limit Values for wastewater discharge into a watercourse (DWS, 2016).
- Ensure fuel spill cleaning kits are on site.
- It is recommended that mitigation measures, as described in Section 4 be implemented during the construction and operational phase of this project.

5.3 Reasoned opinion on whether the activity should be authorized

This assessment cannot find any grounds or identify high hydropedological risks to not proceed with the development. This is grounded on the assumption that the proposed mitigation measures and EMPr recommendations are implemented during the construction and operational phase of the development.

6 BIBLIOGRAPHY

Almond, P. C. &. M. J. L., 2016. *Soils on Slopes: Catenas. International Encyclopedia of Geography: People, the Earth, Environment and Technology: People, the Earth, Environment and Technology, 1-12.,* s.l.: s.n.

ARC, 2006. *Lan Types of South Africa,* s.l.: Pretoria: Agricultural Research Council.

DEA, 2019. *South African National Land-Cover (SANLC) 2018,* South Africa: DEA on 1st October 2019.

Department of Agricultural Development, D., 1991. *Soil Classification - A Taxonomix System for South Africa,* s.l.: s.n.

Der Waals, J. G. A. P. D., 2019. *DEVELOPING WETLAND DISTRIBUTION AND TRANSFER FUNCTIONS FROM LAND TYPE DATA AS A BASIS FOR THE CRITICAL EVALUATION OF WETLAND DELINEATION GUIDELINES BY INCLUSION OF SOIL WATER FLOW DYNAMICS IN CATCHMENT AREAS VOLUME 3. WRC Report No. 2461/3/18.* s.l.:s.n.

DMEA, 1998d. *1:250 000 Geological Series - 2930 Durban,* s.l.: s.n.

DWAF, 2006. *Groundwater Resource Assessment II,* s.l.: s.n.

DWAF, 2008. *Best Practice Guidelines: Impact Prediction (G4),* s.l.: DWS.

DWS, 2011. *The Groundwater Dictionary - A Comprihensive Reference of Groundwater Related Terminology. 2nd Edition.,* s.l.: s.n.

DWS, 2011. *The Groundwater Dictionary - A Comprihensive Reference of Groundwater Related Terminology. 2nd Edition.,* s.l.: s.n.

DWS, 2016. *NATIONAL WATER ACT, 1998 (ACT NO. 36 OF 1998) - REVISION OF GENERAL AUTHORISATION FOR THE TAKING AND STORING OF WATER,* s.l.: STAATSKOERANT, 2 SEPTEMBER 2016 No. 40243.

DWS, 2016. *New Water Management Areas,* South Africa: Government Gazette No. 40279.

Eco-Pulse, 2022. *Cato Ridge Land Development & Release Project, Wetland & Aquatic Ecosystem Impact. Draft Repot V2,* s.l.: s.n.

FAO, 1980. *Food and Agriculture Organization (FAO) - Drainage design factors,* s.l.: FAO Irrigation and Drainage Paper No. 38. Rome.

Geomeasure Group, 2023. *Report on the Destkop Geohydrological Investigation in Support of an EIA for the Proposed Cato Ridge Land Development and Release Project - Ethekwini Municipality,* s.l.: s.n.

JAXA, 2022. *Advanced Land Observation Satellite (ALOS) Global Digital Surface Model (DSM),* Tokyo: Earth Observation Research Center (EORC), Japan Aerospace Exploration Agency (JAXA).

Kantey & Templar, 2023. *20207-DSW01-Stormwater Layout,* s.l.: s.n.

King, G., Maritz, E. & Jonck, F., 1998. *2829 Durban - 1:500 000 Hydrological Map Series of the Republic of South Africa,* s.l.: s.n.

Kottek, M. et al., 2006. *World Map of the Köppen-Geiger climate classification updated. Meteorol. Z.15, 259-263. doi:10.1127/0941-2948/2006/0130.* s.l.:s.n.

Le Roux, P. et al., 2011. *Hydropedological interpretation of the soils of selected catchments with the aim of improving efficiency of hydrological models,* s.l.: Pretoria: Water .

Meteoblue, 2023. *Climate Data.* s.l.:https://www.meteoblue.com.

SADAC GIP, 2022. *SADC Groundwater Information Portal,* s.l.: s.n.

SCWG, 2018. *Soil Classification - A Natural and Anthropogenic System for South Africa,* s.l.: ARC LNR.

Van Deventer, H. S.-A. L. M. N. P. C. S. A. C. N. G. M. J. N. L. M. O. D. S. P. S. E. &. S. K., 2018. *NBA2018 National Wetland Map 5.* s.l.:s.n.

Van Tol, J.J., Bouwer, D. & Le Roux, P.A.L., 2021. *Guideline for hydropedological Assessments and Minimum Requirements,* s.l.: DWS.

Van Tol, J., Le Roux, P. & Lorentz, S., 2013. *Hydropedological Classification of South African Hillslopes,* Vadoze Zone Journal, 2-10: s.n.

Vegter, J., 1995. *An explanation of a set of National Groundwater Maps. Water Research Commission. Report No TT 74/95..* s.l.:s.n.

WRC, 2015. *http://www.waterresourceswr2012.co.za/resource-centre/.* [Online].

APPENDIX A: SOIL AUGERING DATA & FIELD OBSERVATIONS

Auger hole logging data sheet

Hole ID:	A1	Latitude	-29.730516
Project:	Cato Ridge Hydroped	longitude	30.608621
Project No:	22-1129	Elevation (m amsl)	769
Province	KZN	Depth (m)	2.8
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.5	Orthic A: Moist; Dark Brown; Loose;soft; Granular; Fine grained loam soil
0.5	2.4	Yellow Brown Apedal B: Moist; Light Brown; Friable; loose; Fine-grained; Sandy Loam soil
2.4	2.8	Unspecified B/Saprolite: Moist; Reddish Brown; Slightly stiff; fine grained clayey loam soil.
Soil form		Clovelly

Hole ID:	A2	Latitude	-29.732268
Project:	Cato Ridge Hydroped	longitude	30.610583
Project No:	22-1129	Elevation (m amsl)	774
Province	KZN	Depth (m)	2.5
Logged by	Siphe	Water level (mbgl)	0.83

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.53	Orthic A: Moist; light grey; Loose;soft; Granular; Very Fine grained sandy loam soil
0.53	1.82	Yellow Brown Apedal B: Moist; Light Brown; Friable; loose; Fine-grained; Sandy Loam soil
1.82	2.5	Unspecified B/Saprolite: Wet; Yellowish Brown; Slightly stiff; medium grained loam soil with lithic fragment.
	collapse	
Soil form		Clovelly

Hole ID:	A3	Latitude	-29.734544
Project:	Cato Ridge Hydroped	longitude	30.612431
Project No:	22-1129	Elevation (m amsl)	769
Province	KZN	Depth (m)	0.63
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.63	Orthic A: Moist; light grey; Loose;soft; Granular; Fine grained sandy loam soil with lithic fragments
		Rock
Soil form		Mispah

Hole ID:	A4	Latitude	-29.736904
Project:	Cato Ridge Hydroped	longitude	30.615286
Project No:	22-1129	Elevation (m amsl)	760
Province	KZN	Depth (m)	0.7
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.7	Orthic A: Moist; light grey; Loose;soft; Granular; Fine grained sandy loam soil with lithic fragments
		Rock
Soil form		Mispah

Hole ID:	A5	Latitude	-29.732605
Project:	Cato Ridge Hydroped	longitude	30.620486
Project No:	22-1129	Elevation (m amsl)	719
Province	KZN	Depth (m)	1.59
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.25	soi;
0.25	1.59	Lithocunatic B: Moist; Reddish brown; Hard; Granular; medium grained soi
		Hard Weathered Rock
Soil form		Glenrosa

Hole ID:	A6	Latitude	-29.729479
Project:	Cato Ridge Hydroped	longitude	30.616471
Project No:	22-1129	Elevation (m amsl)	766
Province	KZN	Depth (m)	2.3
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.72	Orthic A: Moist; Reddish brown; Loose; Soft; Granular; Fine grained loam soi;
0.72	2.3	Lithocunatic B: Moist; Red; Hard; Granular; medium-grained soil with lithic fragments.
Soil form		Glenrosa

Hole ID:	A8	Latitude	-29.728374
Project:	Cato Ridge Hydroped	longitude	30.607182
Project No:	22-1129	Elevation (m amsl)	778
Province	KZN	Depth (m)	
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.5	Orthic A: Moist; Brown; Loose; Soft; Granular; Fine grained loam soil;
0.5	1.5	Lithocunatic B: Moist; Reddish brown; Hard; Granular; medium-grained soi with lithic fragments.
Soil form		Glenrosa

Hole ID:		A9	Latitude	-29.726971
Project:		Cato Ridge Hydroped	longitude	30.610602
Project No:		22-1129	Elevation (m amsl)	777
Province		KZN	Depth (m)	0.51
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.51	Orthic A: Moist; light grey; Loose;soft; Granular; Fine grained sandy loam soil with lithic fragments		
		Rock		
Soil form		Mispah		

Hole ID:		A10	Latitude	-29.724565
Project:		Cato Ridge Hydroped	longitude	30.607392
Project No:		22-1129	Elevation (m amsl)	781
Province		KZN	Depth (m)	1.6
Logged by		Siphe	Water level (mbgl)	0.2
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.57	Orthic A: Moist; Brown; Loose; Soft; Granular; Fine grained loam soil; with		
0.57	1.6	Lithocutanic B: Wet; Reddish brown; Hard; Granular; medium-grained soil with lithic fragments.		
		Weathered Shale		
Soil form		Glenrosa		

Hole ID:		A11	Latitude	-29.726726
Project:		Cato Ridge Hydroped	longitude	30.607181
Project No:		22-1129	Elevation (m amsl)	779
Province		KZN	Depth (m)	1.62
Logged by		Siphe	Water level (mbgl)	0.5
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.5	Orthic A: Moist; Brown; Loose; Soft; Granular; Fine grained loam soil; with		
0.5	1.62	Lithocutanic B: Wet; Reddish brown; Hard; Granular; medium-grained soil with lithic fragments.		
		Weathered Shale		
Soil form		Glenrosa		

Hole ID:		A12	Latitude	-29.725077
Project:		Cato Ridge Hydroped	longitude	30.611671
Project No:		22-1129	Elevation (m amsl)	784
Province		KZN	Depth (m)	1.57
Logged by		Siphe	Water level (mbgl)	-
From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size		
0	0.72	Orthic A: Moist; Brown; Loose; Soft; Granular; Fine grained loam soil; with		
0.72	1.42	Lithocutanic B: Moist; Yellowish brown; stiff; Granular; medium-grained soil		
Soil form		Glenrosa		

Hole ID:	A13	Latitude	-29.722785
Project:	Cato Ridge Hydroped	longitude	30.614857
Project No:	22-1129	Elevation (m amsl)	786
Province	KZN	Depth (m)	2.2
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.51	Orthic A: Moist; Brown; Loose; Soft; Granular; Fine-grained loam soil;
0.51	2.2	Pedocunatic B: Moist; Dark Brown to reddish brown; slightly stiff; Strongly developed Blocky structure; Clayey loam soil.
		Stiff Unit
Soil form		Swartland

Hole ID:	A14	Latitude	-29.720544
Project:	Cato Ridge Hydroped	longitude	30.617247
Project No:	22-1129	Elevation (m amsl)	786
Province	KZN	Depth (m)	1.56
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.72	Orthic A: Moist; Brown; Loose; Soft; Granular; Fine-grained loam soil;
0.72	1.56	Pedocunatic B: Moist; Dark Brown; stiff; Strongly developed Blocky structure; Clayey loam soil.
		Stiff Unit
Soil form		Swartland

Hole ID:	A15	Latitude	-29.717416
Project:	Cato Ridge Hydroped	longitude	30.618513
Project No:	22-1129	Elevation (m amsl)	792
Province	KZN	Depth (m)	2.1
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.54	Orthic A: Moist; Brown; Loose; Soft; Granular; Fine-grained loam soil;
0.54	1.72	Pedocunatic B: Moist; Dark Brown; stiff; Strongly developed Blocky structure; Clayey loam soil.
1.72	2.1	Unspecified B: Moist; brown; Very Stiff; Blocky; Loamy clay soil
Soil form		Swartland

Auger hole logging data sheet

Hole ID:	A16	Latitude	-29.718249
Project:	Cato Ridge Hydroped	longitude	30.621398
Project No:	22-1129	Elevation (m amsl)	790
Province	KZN	Depth (m)	0.6
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.6	soil
		Hard Rock
Soil form		Mispah

Photo

Hole ID:	A17	Latitude	-29.714544
Project:	Cato Ridge Hydroped	longitude	30.623479
Project No:	22-1129	Elevation (m amsl)	801
Province	KZN	Depth (m)	1.21
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.58	Orthic A: Moist; Reddish brown; Loose; Soft; Granular; medium grained loam soil;
0.58	1.21	Lithocunatic B: Moist; Reddish brown; Hard; Granular; medium grained soil
		Hard Weathered Rock
Soil form		**Glenrosa**

Hole ID:	A18	Latitude	-29.710702
Project:	Cato Ridge Hydroped	longitude	30.625888
Project No:	22-1129	Elevation (m amsl)	804
Province	KZN	Depth (m)	1.35
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.69	Orthic A: Moist; Dark brown; Loose; Soft; Granular; medium grained; Loam soil
0.69	1.35	Lithocunatic B: Moist;light brown; Hard; Granular; medium grained soil with lithic fragments.
		Hard Weathered Rock
Soil form		Glenrosa

Photo

Hole ID:	A19	Latitude	-29.717704
Project:	Cato Ridge Hydroped	longitude	30.625347
Project No:	22-1129	Elevation (m amsl)	761
Province	KZN	Depth (m)	
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
		soil
		Hard Rock
Soil form		**Mispah**

Hole ID:	A20	Latitude	-29.714119
Project:	Cato Ridge Hydroped	longitude	30.619963
Project No:	22-1129	Elevation (m amsl)	804
Province	KZN	Depth (m)	2.2
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.75	Orthic A: Moist; Dark brown; Loose; Soft; Granular; medium grained; Loam soil
0.75	2.2	Lithocunatic B: Moist;light brown; Hard; Granular; coarse grained soil with lithic fragments.
		Hard Weathered Rock
Soil form		**Glenrosa**

Photo

Hole ID:	A21	Latitude	-29.70772
Project:	Cato Ridge Hydroped	longitude	30.620727
Project No:	22-1129	Elevation (m amsl)	806
Province	KZN	Depth (m)	1.93
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.54	Orthic A: Moist; Dark brown; Loose; Soft; Granular; medium grained; Loam soil
0.54	1.93	Lithocunatic B: Moist;light brown; Hard; Granular; coarse grained soil with lithic fragments.
		Hard Weathered Rock
Soil form		Glenrosa

Hole ID:	A22	Latitude	-29.70722
Project:	Cato Ridge Hydroped	longitude	30.627353
Project No:	22-1129	Elevation (m amsl)	809
Province	KZN	Depth (m)	2.1
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.75	Orthic A: Moist; Brown; Loose; Soft; Granular; Fine-grained loam soil
0.75	2.1	Pedocunatic B: Moist; Dark Brown to reddish brown; slightly stiff; Strongly
		Stiff Unit
Soil form		Swartland

Hole ID:	A23	Latitude	-29.703065
Project:	Cato Ridge Hydroped	longitude	30.630264
Project No:	22-1129	Elevation (m amsl)	811
Province	KZN	Depth (m)	1.83
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.67	Orthic A: Moist; Brown; Loose; Soft; Granular; Fine-grained loam soil
0.68	1.83	Pedocunatic B: Moist; reddish brown; slightly stiff; Strongly developed Blocky structure; Clayey loam soil.
		Stiff Unit
Soil form		Swartland

Hole ID:	A24	Latitude	-29.703139
Project:	Cato Ridge Hydroped	longitude	30.622317
Project No:	22-1129	Elevation (m amsl)	811
Province	KZN	Depth (m)	2.42
Logged by	Siphe	Water level (mbgl)	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.6	Orthic A: Moist; Dark brown; Loose; Soft; Granular; medium grained; Loam soil
0.6	2.24	Lithocunatic B: Moist;light brown; Hard; Granular; medium grained loam soil with lithic fragments.
		Hard Weathered Rock
Soil form		Glenrosa

Hole ID:	A25	**Latitude**	-29.700002
Project:	Cato Ridge Hydroped	**longitude**	30.626301
Project No:	22-1129	**Elevation (m amsl)**	813
Province	KZN	**Depth (m)**	2.45
Logged by	Siphe	**Water level (mbgl)**	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.78	Orthic A: Moist; Dark brown; Loose; Soft; Granular; medium grained; Loam soil
0.78	2.45	Lithocunatic B: Moist;Dark brown; Hard; Granular; coarse-grained loam soil with lithic fragments.
		Hard Weathered Rock
Soil form		**Glenrosa**

Hole ID:	A26	**Latitude**	-29.695321
Project:	Cato Ridge Hydroped	**longitude**	30.625037
Project No:	22-1129	**Elevation (m amsl)**	812
Province	KZN	**Depth (m)**	2.38
Logged by	Siphe	**Water level (mbgl)**	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.36	soil
0.36	0.84	Orthic A2: Moist; Dark brown; Loose; Soft; Granular; medium grained; sandy Loam soil
0.84	2.38	Lithocunatic B: Moist;Reddish brown; Hard; Granular; coarse-grained loam soil with lithic fragments.
Soil form		**Glenrosa**

Hole ID:	A27	**Latitude**	-29.695415
Project:	Cato Ridge Hydroped	**longitude**	30.631788
Project No:	22-1129	**Elevation (m amsl)**	
Province	KZN	**Depth (m)**	1.8
Logged by	Siphe	**Water level (mbgl)**	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.6	Orthic A: Moist; Dark brown; Loose; Soft; Granular; medium grained; sandy Loam soil
0.6	1.8	Lithocunatic B: Moist;Yellow brown; Hard; Granular; coarse-grained loam soil with lithic fragments.
Soil form		**Glenrosa**

Hole ID:	A28	**Latitude**	-29.69152
Project:	Cato Ridge Hydroped	**longitude**	30.63276
Project No:	22-1129	**Elevation (m amsl)**	804
Province	KZN	**Depth (m)**	1.45
Logged by	Siphe	**Water level (mbgl)**	-

From (m)	To (m)	Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size
0	0.54	Orthic A: Moist; Dark brown; Loose; Soft; Granular; medium grained; sandy Loam soil
0.54	1.45	Lithocunatic B: Moist;Yellow brown; Hard; Granular; coarse-grained loam soil with lithic fragments.
Soil form		**Glenrosa**

Hole ID:		A29	Latitude	-29.689103
Project:		Cato Ridge Hydroped	longitude	30.630956
Project No:		22-1129	Elevation (m amsl)	802
Province		KZN	Depth (m)	1.25
Logged by		Siphe	Water level (mbgl)	-
From (m)	**To (m)**	**Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size**		
0	0.33	soil		
0.33	0.89	Orthic A2: Moist; Dark brown; Loose; Soft; Granular; fine grained; sandy Loam soil		
0.89	1.25	Lithocutanic B: Moist;Dark brown; Hard; Granular; coarse-grained loam soil with lithic fragments.		
Soil form		**Glenrosa**		

Hole ID:		A30	Latitude	-29.686238
Project:		Cato Ridge Hydroped	longitude	30.628461
Project No:		22-1129	Elevation (m amsl)	791
Province		KZN	Depth (m)	2.5
Logged by		Siphe	Water level (mbgl)	-
From (m)	**To (m)**	**Soil form; Moisture; Colour; Consistency; Structure; Origin: Grain size**		
0	0.46	Orthic A: Moist; light grey; Loose;soft; Granular; Very Fine grained sandy loam soil		
0.46	175	Yellow Brown Apedal B: Moist; Light Brown; Friable; loose; Fine-grained;		
1.75	2.5	Unspecified B/Saprolite: Moist; Yellowish Brown; Slightly stiff; fine grained loam soil with lithic fragment.		
Soil form		**Clovelly**		

APPENDIX B: LABORATORY CERTIFICATES

TALBOT
A Level 1 B-BBEE company

[002744/23], [2023/04/12]

Certificate of Analysis

Project details

Customer Details

Customer reference:	22-1129
Order number:	22-1129
Company name:	GCS (PTY) LTD DURBAN
Contact address:	P O BOX 819, GILLITS, 3603
Contact person:	HENDRIK BOTHA
Additional customer information:	CLIENT: ASMANG

Sampling Details

Sampled by:	CUSTOMER
Sampled date:	2023/03/30

Sample Details

Sample type(s):	SOIL SAMPLES
Date received:	2023/04/03
Delivered by:	CUSTOMER - GILLITTS DEPOT
Temperature at sample receipt (°C):	22.1

Report Details

Testing commenced:	2023/04/03
Testing completed:	2023/04/08
Report date:	2023/04/12
Our reference:	002744/23

Talbot Laboratories (Pty) Ltd Reg: 2016/334237/07
P.O Box 22598 Pietermaritzburg 3203 South Africa
+27 (0) 33 346 1444 www.talbot.co.za

Talbot Laboratories (Pty) Ltd

Analytical Results

Methods	Determinands	Units	W00736/23 CATO RIDGE: A30 30.03.2023	W00737/23 CATO RIDGE: A18 30.03.2023
Chemical				
-	Concentration*	%	0.0314#	0.0131#
-	Uniformity*	-	1.048#	1.101#
-	Specific Surface Area*	m^2/kg	542.0#	522#
-	D [3,2]*	µm	10.5#	10.9#
-	D [4,3]*	µm	211#	222#
-	Span*	-	3.134#	3.445#
-	Result Units*	-	volume#	volume#
-	Dv (10)*	µm	3.71#	4.23#
-	Dv (50)*	µm	163#	157#
-	Dv (90)*	µm	513#	545#
-	0.0100*	%	0.00#	0.00#
-	0.0114*	%	0.00#	0.00#
-	0.0129*	%	0.00#	0.00#
-	0.0147*	%	0.00#	0.00#
-	0.0189*	%	0.00#	0.00#
-	0.0215*	%	0.00#	0.00#
-	0.0278*	%	0.00#	0.00#
-	0.0315*	%	0.00#	0.00#
-	0.0358*	%	0.00#	0.00#
-	0.0407*	%	0.00#	0.00#
-	0.0463*	%	0.00#	0.00#
-	0.0526*	%	0.00#	0.00#
-	0.0597*	%	0.00#	0.00#
-	0.0679*	%	0.00#	0.00#
-	0.0771*	%	0.00#	0.00#
-	0.0876*	%	0.00#	0.00#
-	0.0995*	%	0.00#	0.00#
-	0.113*	%	0.00#	0.00#
-	0.128*	%	0.00#	0.00#
-	0.146*	%	0.00#	0.00#
-	0.166*	%	0.00#	0.00#
-	0.188*	%	0.00#	0.00#
-	0.214*	%	0.00#	0.00#
-	0.243*	%	0.00#	0.00#
-	0.276*	%	0.00#	0.00#

Methods	Determinands	Units	W00736/23 CATO RIDGE: A30 30.03.2023	W00737/23 CATO RIDGE: A18 30.03.2023
-	0.314*	%	0.00#	0.00#
-	0.357*	%	0.00#	0.00#
-	0.405*	%	0.00#	0.00#
-	0.460*	%	0.08#	0.09#
-	0.523*	%	0.24#	0.27#
-	0.594*	%	0.46#	0.53#
-	0.675*	%	0.75#	0.87#
-	0.767*	%	1.10#	1.29#
-	0.872*	%	1.51#	1.77#
-	1.00*	%	2.01#	2.32#
-	1.13*	%	2.52#	2.86#
-	1.28*	%	3.09#	3.44#
-	1.45*	%	3.73#	4.05#
-	1.65*	%	4.47#	4.71#
-	1.88*	%	5.27#	5.41#
-	2.13*	%	6.09#	6.09#
-	2.50*	%	7.19#	6.99#
-	2.75*	%	7.86#	7.52#
-	3.12*	%	8.76#	8.24#
-	3.55*	%	9.68#	8.98#
-	4.03*	%	10.60#	9.71#
-	4.58*	%	11.53#	10.46#
-	5.21*	%	12.49#	11.23#
-	5.92*	%	13.45#	12.00#
-	6.72*	%	14.43#	12.77#
-	7.64*	%	15.44#	13.57#
-	8.68*	%	16.47#	14.36#
-	10.00*	%	17.65#	15.25#
-	11.2*	%	18.62#	15.97#
-	12.7*	%	19.73#	16.79#
-	14.5*	%	20.95#	17.68#
-	16.4*	%	22.14#	18.56#
-	18.7*	%	23.46#	19.56#
-	21.2*	%	24.78#	20.61#
-	24.1*	%	26.20#	21.77#
-	27.4*	%	27.67#	23.04#
-	31.1*	%	29.17#	24.41#
-	35.3*	%	30.71#	25.86#

Methods	Determinands	Units	W00736/23	W00737/23
			CATO RIDGE: A30 30.03.2023	CATO RIDGE: A18 30.03.2023
-	40.1*	%	32.28#	27.42#
-	44.0*	%	33.42#	28.59#
-	45.0*	%	33.70#	28.88#
-	51.8*	%	35.41#	30.72#
-	58.9*	%	36.93#	32.46#
-	66.9*	%	38.38#	34.23#
-	76.0*	%	39.79#	36.08#
-	86.4*	%	41.18#	38.06#
-	98.1*	%	42.58#	40.16#
-	111*	%	44.02#	42.40#
-	127*	%	45.80#	45.09#
-	144*	%	47.74#	47.88#
-	163*	%	50.06#	50.92#
-	186*	%	53.04#	54.48#
-	211*	%	56.46#	58.19#
-	240*	%	60.55#	62.27#
-	272*	%	65.06#	66.47#
-	310*	%	70.21#	71.05#
-	352*	%	75.46#	75.60#
-	400*	%	80.74#	80.14#
-	454*	%	85.72#	84.47#
-	516*	%	90.20#	88.49#
-	586*	%	93.91#	91.99#
-	666*	%	96.74#	94.88#
-	756*	%	98.63#	97.05#
-	859*	%	99.72#	98.57#
-	976*	%	100#	99.44#
-	1110*	%	100#	99.82#
-	1260*	%	100#	99.98#
-	1430*	%	100#	100#
-	1630*	%	100#	100#
-	1850*	%	100#	100#
-	2100*	%	100#	100#
-	2390*	%	100#	100#
-	2710*	%	100#	100#
-	3080*	%	100#	100#
-	3500*	%	100#	100#

Methods	Determinands	Units	W00738/23 CATO RIDGE: A5 27.03.2023	W00739/23 CATO RIDGE: A8 30.03.2023
Chemical				
-	Concentration*	%	0.0113#	0.0209#
-	Uniformity*	-	0.918#	0.574#
-	Specific Surface Area*	m^2/kg	830.9#	275.4#
-	D [3,2]*	µm	6.88#	20.8#
-	D [4,3]*	µm	205#	290#
-	Span*	-	2.795#	1.952#
-	Result Units*	-	volume#	volume#
-	Dv (10)*	µm	1.93#	41.5#
-	Dv (50)*	µm	172#	265#
-	Dv (90)*	µm	483#	559#
-	0.0100*	%	0.00#	0.00#
-	0.0114*	%	0.00#	0.00#
-	0.0129*	%	0.00#	0.00#
-	0.0147*	%	0.00#	0.00#
-	0.0189*	%	0.00#	0.00#
-	0.0215*	%	0.00#	0.00#
-	0.0278*	%	0.00#	0.00#
-	0.0315*	%	0.00#	0.00#
-	0.0358*	%	0.00#	0.00#
-	0.0407*	%	0.00#	0.00#
-	0.0463*	%	0.00#	0.00#
-	0.0526*	%	0.00#	0.00#
-	0.0597*	%	0.00#	0.00#
-	0.0679*	%	0.00#	0.00#
-	0.0771*	%	0.00#	0.00#
-	0.0876*	%	0.00#	0.00#
-	0.0995*	%	0.00#	0.00#
-	0.113*	%	0.00#	0.00#
-	0.128*	%	0.00#	0.00#
-	0.146*	%	0.00#	0.00#
-	0.166*	%	0.00#	0.00#
-	0.188*	%	0.00#	0.00#
-	0.214*	%	0.00#	0.00#
-	0.243*	%	0.00#	0.00#
-	0.276*	%	0.00#	0.00#
-	0.314*	%	0.00#	0.00#
-	0.357*	%	0.00#	0.00#

Methods	Determinands	Units	W00738/23	W00739/23
			CATO RIDGE: A5 27.03.2023	CATO RIDGE: A8 30.03.2023
-	0.405*	%	0.12#	0.00#
-	0.460*	%	0.38#	0.06#
-	0.523*	%	0.78#	0.17#
-	0.594*	%	1.33#	0.33#
-	0.675*	%	2.01#	0.52#
-	0.767*	%	2.79#	0.76#
-	0.872*	%	3.65#	1.02#
-	1.00*	%	4.65#	1.32#
-	1.13*	%	5.58#	1.61#
-	1.28*	%	6.57#	1.93#
-	1.45*	%	7.59#	2.26#
-	1.65*	%	8.68#	2.61#
-	1.88*	%	9.78#	2.99#
-	2.13*	%	10.81#	3.36#
-	2.50*	%	12.07#	3.83#
-	2.75*	%	12.79#	4.11#
-	3.12*	%	13.68#	4.47#
-	3.55*	%	14.53#	4.82#
-	4.03*	%	15.30#	5.15#
-	4.58*	%	16.03#	5.47#
-	5.21*	%	16.73#	5.77#
-	5.92*	%	17.40#	6.05#
-	6.72*	%	18.04#	6.31#
-	7.64*	%	18.69#	6.56#
-	8.68*	%	19.33#	6.79#
-	10.00*	%	20.05#	7.03#
-	11.2*	%	20.63#	7.21#
-	12.7*	%	21.30#	7.40#
-	14.5*	%	22.03#	7.60#
-	16.4*	%	22.76#	7.79#
-	18.7*	%	23.60#	8.00#
-	21.2*	%	24.47#	8.22#
-	24.1*	%	25.43#	8.47#
-	27.4*	%	26.48#	8.75#
-	31.1*	%	27.58#	9.08#
-	35.3*	%	28.74#	9.45#
-	40.1*	%	29.97#	9.87#
-	44.0*	%	30.88#	10.21#

Talbot Laboratories (Pty) Ltd

Methods	Determinands	Units	W00738/23 CATO RIDGE: A5 27.03.2023	W00739/23 CATO RIDGE: A8 30.03.2023
-	45.0*	%	31.11#	10.30#
-	51.8*	%	32.51#	10.88#
-	58.9*	%	33.81#	11.49#
-	66.9*	%	35.10#	12.20#
-	76.0*	%	36.42#	13.07#
-	86.4*	%	37.82#	14.19#
-	98.1*	%	39.33#	15.63#
-	111*	%	41.00#	17.49#
-	127*	%	43.16#	20.14#
-	144*	%	45.60#	23.31#
-	163*	%	48.50#	27.23#
-	186*	%	52.19#	32.27#
-	211*	%	56.33#	37.93#
-	240*	%	61.14#	44.49#
-	272*	%	66.28#	51.47#
-	310*	%	71.96#	59.15#
-	352*	%	77.56#	66.73#
-	400*	%	83.01#	74.13#
-	454*	%	87.95#	80.92#
-	516*	%	92.22#	86.94#
-	586*	%	95.58#	91.83#
-	666*	%	97.96#	95.55#
-	756*	%	99.40#	98.04#
-	859*	%	99.95#	99.51#
-	976*	%	100#	100#
-	1110*	%	100#	100#
-	1260*	%	100#	100#
-	1430*	%	100#	100#
-	1630*	%	100#	100#
-	1850*	%	100#	100#
-	2100*	%	100#	100#
-	2390*	%	100#	100#
-	2710*	%	100#	100#
-	3080*	%	100#	100#
-	3500*	%	100#	100#

Talbot Laboratories (Pty) Ltd

Methods	Determinands	Units	W00740/23	W00741/23
			CATO RIDGE: A15 28.03.2023	CATO RIDGE: A3 27.03.2023
Chemical				
-	Concentration*	%	0.0168#	0.0164#
-	Uniformity*	-	1.184#	0.731#
-	Specific Surface Area*	m^2/kg	489.8#	438.4#
-	D [3,2]*	µm	11.7#	13.0#
-	D [4,3]*	µm	229#	288#
-	Span*	-	3.696#	2.335#
-	Result Units*	-	volume#	volume#
-	Dv (10)*	µm	4.62#	5.26#
-	Dv (50)*	µm	155#	262#
-	Dv (90)*	µm	578#	618#
-	0.0100*	%	0.00#	0.00#
-	0.0114*	%	0.00#	0.00#
-	0.0129*	%	0.00#	0.00#
-	0.0147*	%	0.00#	0.00#
-	0.0189*	%	0.00#	0.00#
-	0.0215*	%	0.00#	0.00#
-	0.0278*	%	0.00#	0.00#
-	0.0315*	%	0.00#	0.00#
-	0.0358*	%	0.00#	0.00#
-	0.0407*	%	0.00#	0.00#
-	0.0463*	%	0.00#	0.00#
-	0.0526*	%	0.00#	0.00#
-	0.0597*	%	0.00#	0.00#
-	0.0679*	%	0.00#	0.00#
-	0.0771*	%	0.00#	0.00#
-	0.0876*	%	0.00#	0.00#
-	0.0995*	%	0.00#	0.00#
-	0.113*	%	0.00#	0.00#
-	0.128*	%	0.00#	0.00#
-	0.146*	%	0.00#	0.00#
-	0.166*	%	0.00#	0.00#
-	0.188*	%	0.00#	0.00#
-	0.214*	%	0.00#	0.00#
-	0.243*	%	0.00#	0.00#
-	0.276*	%	0.00#	0.00#
-	0.314*	%	0.00#	0.00#
-	0.357*	%	0.00#	0.00#

Talbot Laboratories (Pty) Ltd

Methods	Determinands	Units	W00740/23	W00741/23
			CATO RIDGE: A15 28.03.2023	CATO RIDGE: A3 27.03.2023
-	0.405*	%	0.00#	0.00#
-	0.460*	%	0.09#	0.09#
-	0.523*	%	0.25#	0.24#
-	0.594*	%	0.47#	0.45#
-	0.675*	%	0.77#	0.73#
-	0.767*	%	1.11#	1.06#
-	0.872*	%	1.50#	1.44#
-	1.00*	%	1.96#	1.88#
-	1.13*	%	2.40#	2.32#
-	1.28*	%	2.88#	2.80#
-	1.45*	%	3.41#	3.32#
-	1.65*	%	3.99#	3.91#
-	1.88*	%	4.63#	4.55#
-	2.13*	%	5.28#	5.19#
-	2.50*	%	6.17#	6.03#
-	2.75*	%	6.71#	6.55#
-	3.12*	%	7.47#	7.23#
-	3.55*	%	8.27#	7.92#
-	4.03*	%	9.09#	8.60#
-	4.58*	%	9.94#	9.27#
-	5.21*	%	10.83#	9.95#
-	5.92*	%	11.74#	10.61#
-	6.72*	%	12.66#	11.26#
-	7.64*	%	13.61#	11.91#
-	8.68*	%	14.56#	12.55#
-	10.00*	%	15.64#	13.25#
-	11.2*	%	16.50#	13.80#
-	12.7*	%	17.48#	14.41#
-	14.5*	%	18.53#	15.05#
-	16.4*	%	19.55#	15.65#
-	18.7*	%	20.68#	16.31#
-	21.2*	%	21.83#	16.96#
-	24.1*	%	23.09#	17.65#
-	27.4*	%	24.45#	18.36#
-	31.1*	%	25.88#	19.10#
-	35.3*	%	27.40#	19.86#
-	40.1*	%	29.00#	20.65#
-	44.0*	%	30.20#	21.26#

Methods	Determinands	Units	W00740/23 CATO RIDGE: A15 28.03.2023	W00741/23 CATO RIDGE: A3 27.03.2023
-	45.0*	%	30.49#	21.40#
-	51.8*	%	32.35#	22.35#
-	58.9*	%	34.08#	23.25#
-	66.9*	%	35.82#	24.22#
-	76.0*	%	37.60#	25.26#
-	86.4*	%	39.46#	26.43#
-	98.1*	%	41.41#	27.74#
-	111*	%	43.45#	29.22#
-	127*	%	45.87#	31.12#
-	144*	%	48.36#	33.22#
-	163*	%	51.06#	35.68#
-	186*	%	54.21#	38.80#
-	211*	%	57.50#	42.33#
-	240*	%	61.14#	46.59#
-	272*	%	64.94#	51.37#
-	310*	%	69.16#	57.05#
-	352*	%	73.46#	63.12#
-	400*	%	77.90#	69.60#
-	454*	%	82.28#	76.11#
-	516*	%	86.53#	82.41#
-	586*	%	90.39#	88.04#
-	666*	%	93.73#	92.74#
-	756*	%	96.36#	96.25#
-	859*	%	98.26#	98.62#
-	976*	%	99.46#	99.83#
-	1110*	%	100#	100#
-	1260*	%	100#	100#
-	1430*	%	100#	100#
-	1630*	%	100#	100#
-	1850*	%	100#	100#
-	2100*	%	100#	100#
-	2390*	%	100#	100#
-	2710*	%	100#	100#
-	3080*	%	100#	100#
-	3500*	%	100#	100#

Talbot Laboratories (Pty) Ltd

Methods	Determinands	Units	W00742/23 CATO RIDGE: A1 28.03.2023	W00743/23 CATO RIDGE: A16 28.03.2023
Chemical				
-	Concentration*	%	0.0285#	0.0203#
-	Uniformity*	-	0.596#	0.821#
-	Specific Surface Area*	m^2/kg	243.4#	375.3#
-	D [3,2]*	µm	23.5#	15.2#
-	D [4,3]*	µm	317#	297#
-	Span*	-	2.040#	2.549#
-	Result Units*	-	volume#	volume#
-	Dv (10)*	µm	21.9#	6.68#
-	Dv (50)*	µm	294#	258#
-	Dv (90)*	µm	621#	665#
-	0.0100*	%	0.00#	0.00#
-	0.0114*	%	0.00#	0.00#
-	0.0129*	%	0.00#	0.00#
-	0.0147*	%	0.00#	0.00#
-	0.0189*	%	0.00#	0.00#
-	0.0215*	%	0.00#	0.00#
-	0.0278*	%	0.00#	0.00#
-	0.0315*	%	0.00#	0.00#
-	0.0358*	%	0.00#	0.00#
-	0.0407*	%	0.00#	0.00#
-	0.0463*	%	0.00#	0.00#
-	0.0526*	%	0.00#	0.00#
-	0.0597*	%	0.00#	0.00#
-	0.0679*	%	0.00#	0.00#
-	0.0771*	%	0.00#	0.00#
-	0.0876*	%	0.00#	0.00#
-	0.0995*	%	0.00#	0.00#
-	0.113*	%	0.00#	0.00#
-	0.128*	%	0.00#	0.00#
-	0.146*	%	0.00#	0.00#
-	0.166*	%	0.00#	0.00#
-	0.188*	%	0.00#	0.00#
-	0.214*	%	0.00#	0.00#
-	0.243*	%	0.00#	0.00#
-	0.276*	%	0.00#	0.00#
-	0.314*	%	0.00#	0.00#
-	0.357*	%	0.00#	0.00#

Talbot Laboratories (Pty) Ltd

Methods	Determinands	Units	W00742/23 CATO RIDGE: A1 28.03.2023	W00743/23 CATO RIDGE: A16 28.03.2023
-	0.405*	%	0.00#	0.00#
-	0.460*	%	0.00#	0.02#
-	0.523*	%	0.06#	0.13#
-	0.594*	%	0.16#	0.29#
-	0.675*	%	0.29#	0.50#
-	0.767*	%	0.46#	0.76#
-	0.872*	%	0.66#	1.05#
-	1.00*	%	0.90#	1.40#
-	1.13*	%	1.15#	1.73#
-	1.28*	%	1.42#	2.11#
-	1.45*	%	1.72#	2.52#
-	1.65*	%	2.05#	2.98#
-	1.88*	%	2.41#	3.50#
-	2.13*	%	2.77#	4.02#
-	2.50*	%	3.24#	4.74#
-	2.75*	%	3.52#	5.19#
-	3.12*	%	3.90#	5.81#
-	3.55*	%	4.29#	6.46#
-	4.03*	%	4.67#	7.13#
-	4.58*	%	5.05#	7.82#
-	5.21*	%	5.43#	8.55#
-	5.92*	%	5.81#	9.29#
-	6.72*	%	6.19#	10.04#
-	7.64*	%	6.57#	10.81#
-	8.68*	%	6.96#	11.60#
-	10.00*	%	7.39#	12.48#
-	11.2*	%	7.73#	13.19#
-	12.7*	%	8.13#	13.99#
-	14.5*	%	8.55#	14.85#
-	16.4*	%	8.96#	15.66#
-	18.7*	%	9.42#	16.56#
-	21.2*	%	9.88#	17.44#
-	24.1*	%	10.38#	18.38#
-	27.4*	%	10.91#	19.35#
-	31.1*	%	11.48#	20.35#
-	35.3*	%	12.08#	21.37#
-	40.1*	%	12.73#	22.42#
-	44.0*	%	13.23#	23.21#

Methods	Determinands	Units	W00742/23	W00743/23
			CATO RIDGE: A1 28.03.2023	CATO RIDGE: A16 28.03.2023
-	45.0*	%	13.35#	23.40#
-	51.8*	%	14.13#	24.61#
-	58.9*	%	14.87#	25.74#
-	66.9*	%	15.64#	26.90#
-	76.0*	%	16.45#	28.12#
-	86.4*	%	17.34#	29.43#
-	98.1*	%	18.36#	30.84#
-	111*	%	19.58#	32.35#
-	127*	%	21.28#	34.20#
-	144*	%	23.38#	36.16#
-	163*	%	26.08#	38.37#
-	186*	%	29.77#	41.08#
-	211*	%	34.19#	44.08#
-	240*	%	39.65#	47.65#
-	272*	%	45.79#	51.67#
-	310*	%	52.94#	56.49#
-	352*	%	60.34#	61.75#
-	400*	%	67.93#	67.52#
-	454*	%	75.23#	73.48#
-	516*	%	82.01#	79.49#
-	586*	%	87.84#	85.10#
-	666*	%	92.56#	90.06#
-	756*	%	96.03#	94.05#
-	859*	%	98.35#	97.02#
-	976*	%	99.67#	98.94#
-	1110*	%	100#	100#
-	1260*	%	100#	100#
-	1430*	%	100#	100#
-	1630*	%	100#	100#
-	1850*	%	100#	100#
-	2100*	%	100#	100#
-	2390*	%	100#	100#
-	2710*	%	100#	100#
-	3080*	%	100#	100#
-	3500*	%	100#	100#

Methods	Determinands	Units	W00744/23 CATO RIDGE: A26 30.03.2023	W00745/23 CATO RIDGE: A27 30.03.2023
Chemical				
-	Concentration*	%	0.0179#	0.027#
-	Uniformity*	-	0.623#	1.218#
-	Specific Surface Area*	m^2/kg	417.8#	574.0#
-	D [3,2]*	µm	13.7#	9.95#
-	D [4,3]*	µm	311#	229#
-	Span*	-	2.115#	3.668#
-	Result Units*	-	volume#	volume#
-	Dv (10)*	µm	7.44#	3.52#
-	Dv (50)*	µm	291#	156#
-	Dv (90)*	µm	623#	574#
-	0.0100*	%	0.00#	0.00#
-	0.0114*	%	0.00#	0.00#
-	0.0129*	%	0.00#	0.00#
-	0.0147*	%	0.00#	0.00#
-	0.0189*	%	0.00#	0.00#
-	0.0215*	%	0.00#	0.00#
-	0.0278*	%	0.00#	0.00#
-	0.0315*	%	0.00#	0.00#
-	0.0358*	%	0.00#	0.00#
-	0.0407*	%	0.00#	0.00#
-	0.0463*	%	0.00#	0.00#
-	0.0526*	%	0.00#	0.00#
-	0.0597*	%	0.00#	0.00#
-	0.0679*	%	0.00#	0.00#
-	0.0771*	%	0.00#	0.00#
-	0.0876*	%	0.00#	0.00#
-	0.0995*	%	0.00#	0.00#
-	0.113*	%	0.00#	0.00#
-	0.128*	%	0.00#	0.00#
-	0.146*	%	0.00#	0.00#
-	0.166*	%	0.00#	0.00#
-	0.188*	%	0.00#	0.00#
-	0.214*	%	0.00#	0.00#
-	0.243*	%	0.00#	0.00#
-	0.276*	%	0.00#	0.00#
-	0.314*	%	0.00#	0.00#
-	0.357*	%	0.00#	0.00#

Talbot Laboratories (Pty) Ltd

Methods	Determinands	Units	W00744/23 CATO RIDGE: A26 30.03.2023	W00745/23 CATO RIDGE: A27 30.03.2023
-	0.405*	%	0.04#	0.00#
-	0.460*	%	0.16#	0.11#
-	0.523*	%	0.35#	0.31#
-	0.594*	%	0.61#	0.58#
-	0.675*	%	0.93#	0.93#
-	0.767*	%	1.28#	1.34#
-	0.872*	%	1.68#	1.81#
-	1.00*	%	2.12#	2.36#
-	1.13*	%	2.55#	2.91#
-	1.28*	%	3.00#	3.51#
-	1.45*	%	3.48#	4.17#
-	1.65*	%	4.01#	4.92#
-	1.88*	%	4.57#	5.73#
-	2.13*	%	5.12#	6.54#
-	2.50*	%	5.83#	7.62#
-	2.75*	%	6.26#	8.27#
-	3.12*	%	6.80#	9.15#
-	3.55*	%	7.35#	10.07#
-	4.03*	%	7.86#	10.97#
-	4.58*	%	8.35#	11.90#
-	5.21*	%	8.82#	12.85#
-	5.92*	%	9.26#	13.80#
-	6.72*	%	9.68#	14.76#
-	7.64*	%	10.08#	15.74#
-	8.68*	%	10.47#	16.73#
-	10.00*	%	10.87#	17.85#
-	11.2*	%	11.19#	18.77#
-	12.7*	%	11.54#	19.82#
-	14.5*	%	11.91#	20.97#
-	16.4*	%	12.27#	22.09#
-	18.7*	%	12.67#	23.36#
-	21.2*	%	13.09#	24.64#
-	24.1*	%	13.55#	26.03#
-	27.4*	%	14.05#	27.49#
-	31.1*	%	14.59#	29.01#
-	35.3*	%	15.17#	30.58#
-	40.1*	%	15.79#	32.20#
-	44.0*	%	16.27#	33.39#

Methods	Determinands	Units	W00744/23	W00745/23
			CATO RIDGE: A26 30.03.2023	CATO RIDGE: A27 30.03.2023
-	45.0*	%	16.38#	33.68#
-	51.8*	%	17.12#	35.48#
-	58.9*	%	17.83#	37.10#
-	66.9*	%	18.55#	38.67#
-	76.0*	%	19.32#	40.22#
-	86.4*	%	20.17#	41.76#
-	98.1*	%	21.15#	43.29#
-	111*	%	22.30#	44.85#
-	127*	%	23.89#	46.70#
-	144*	%	25.83#	48.63#
-	163*	%	28.31#	50.83#
-	186*	%	31.69#	53.56#
-	211*	%	35.74#	56.61#
-	240*	%	40.77#	60.20#
-	272*	%	46.50#	64.12#
-	310*	%	53.26#	68.61#
-	352*	%	60.37#	73.23#
-	400*	%	67.76#	77.96#
-	454*	%	74.97#	82.53#
-	516*	%	81.76#	86.84#
-	586*	%	87.67#	90.61#
-	666*	%	92.51#	93.77#
-	756*	%	96.06#	96.20#
-	859*	%	98.42#	97.94#
-	976*	%	99.73#	99.07#
-	1110*	%	100#	99.64#
-	1260*	%	100#	99.87#
-	1430*	%	100#	99.98#
-	1630*	%	100#	100#
-	1850*	%	100#	100#
-	2100*	%	100#	100#
-	2390*	%	100#	100#
-	2710*	%	100#	100#
-	3080*	%	100#	100#
-	3500*	%	100#	100#

Refer to the “Notes” section at the end of this report for further explanations.

Specific Observations

None

Quality Assurance

Technical signatories

Inorganic Chemistry: Sipho Mgabhi

Notes to this report

Limitations

This report shall not be reproduced except in full without prior written approval of the laboratory.
Results in this report relate only to the samples as taken, and the condition received by the laboratory.
Any opinions and interpretations expressed herein are outside the scope of SANAS accreditation.
The decision rule applicable to this laboratory is available on request.
Sample preparation may require filtration, dilution, digestion or similar. Final results are reported accordingly.
Where the laboratory has undertaken the sampling, the location of sampling and sampling plan are available on request. Talbot Laboratories is guided by the National Standards SANS 5667-3:2006 Part 3 Guidance on the Preservation and Handling of Water Samples; SANS 5667-1:2008 Part 1 Guidance on the Design of Sampling Programmes and Sampling Techniques and SANS 5667-2:1991 Part 2: Guidance on Sampling Techniques.
Customers to contact Talbot Laboratories for further information.

Uncertainty of measurement

Talbot Laboratories' Uncertainty of Measurement (UoM) values are:

- Identified for relevant tests.
- Calculated as a percentage of the respective results.
- Applicable to total, dissolved and acid soluble metals for ICP element analyses.
- Available upon request.

Analysis explanatory notes

Tests may be marked as follows:

^	Tests conducted at our Port Elizabeth satellite laboratory.
*	Tests not included in our Schedule of Accreditation and therefore that are not SANAS accredited.
#	Tests that have been sub-contracted to a peer laboratory.
NR	Not required -shown, for example, where the schedule of analysis varied between samples.
σ	Field sampling point on-site results.
a	Testing has deviated from Method.

End of Report

APPENDIX C: RISK ASSESSMENT METHODOLOGY

As per GNR 982 of the EIA Regulations (2014), the significance of potential impacts was assessed. Due to the assessment forming part of a larger risk assessment for the study area, the potential impacts and the determination of impact significance were assessed. The process of assessing the potential impacts of the project includes the following four activities:

1. Identification and assessment of potential impacts.
2. Prediction of the nature, magnitude, extent, and duration of potentially significant impacts.
3. Identification of mitigation measures that could be implemented to reduce the severity or significance of the impacts of the activity; and
4. Evaluation of the significance of the impact after the mitigation measures have been implemented i.e., the significance of the residual impact.

Per GNR 982 of the EIA Regulations (2014), the significance of potential impacts was assessed in terms of the following criteria:

I. Cumulative impacts.
II. Nature of the impact.
III. The extent of the impact.
IV. Probability of the impact occurring.
V. The degree to which the impact can be reversed.
VI. The degree to which the impact may cause irreplaceable loss of resources; and
VII. The degree to which the impact can be mitigated.

Table 6-1 provides a summary of the criteria used to assess the significance of the potential impacts identified. An explanation of these impact criteria is provided in Table 6-2.

Consequence = (Duration + Extent + Irreplaceability of resource) x Severity

And the environmental significance of an impact was determined by multiplying consequence by probability.

Table 6-1: Proposed Criteria and Rating Scales to be used in the Assessment of the Potential Impacts

Criteria	Rating Scales	Notes
Nature	Positive (+)	An evaluation of the effect of the impact related to the proposed development.
	Negative (-)	
Extent	Footprint (1)	The impact only affects the area in which the proposed activity will occur.
	Site (2)	The impact will affect only the development area.
	Local (3)	The impact affects the development area and adjacent properties.
	Regional (4)	The effect of the impact extends beyond municipal boundaries.
	National (5)	The effect of the impact extends beyond more than 2 regional/ provincial boundaries.
	International (6)	The effect of the impact extends beyond country borders.
Duration	Temporary (1)	The duration of the activity associated with the impact will last 0-6 months.
	Short-term (2)	The duration of the activity associated with the impact will last 6-18 months.
	Medium-term (3)	The duration of the activity associated with the impact will last 18 months - 5 years.
	Long-term (4)	The duration of the activity associated with the impact will last more than 5 years.
Severity	Low (1)	Where the impact affects the environment in such a way that natural, cultural, and social functions and processes are minimally affected.
	Moderate (2)	Where the affected environment is altered but natural, cultural, and social functions and processes continue albeit in a modified way; and valued, important, sensitive, or vulnerable systems or communities are negatively affected.
	High (3)	Where natural, cultural, or social functions and processes are altered to the extent that the natural process will temporarily or permanently cease; and valued, important, sensitive, or vulnerable systems or communities are substantially affected.
Potential for impact on irreplaceable resources	No (0)	No irreplaceable resources will be impacted.
	Yes (1)	Irreplaceable resources will be impacted.
Consequence	Extremely detrimental (-25 to -33)	A combination of extent, duration, intensity, and the potential for impact on irreplaceable resources.
	Highly detrimental (-19 to -24)	
	Moderately detrimental (-13 to -18)	
	Slightly detrimental (-7 to -12)	
	Negligible (-6 to 0)	
	Slightly beneficial (0 to 6)	
	Moderately beneficial (13 to 18)	
	Highly beneficial (19 to 24)	
	Extremely beneficial (25 to 33)	
Probability (the likelihood of the impact occurring)	Improbable (0)	It is highly unlikely or less than 50% likely that an impact will occur.
	Probable (1)	It is between 50 and 70% certain that the impact will occur.
	Definite (2)	It is more than 75% certain that the impact will occur, or the impact will occur.
Significance	Very high - negative (-49 to -66)	A function of Consequence and Probability.
	High - negative (-37 to -48)	
	Moderate - negative (-25 to -36)	
	Low - negative (-13 to -24)	
	Neutral - Very low (0 to -12)	
	Low-positive (0 to 12)	
	Moderate-positive (13 to 24)	
	High-positive (37 to 48)	
	Very high - positive (49 to 66)	

Table 6-2: Explanation of Assessment Criteria

Criteria	Explanation
Nature	This is an evaluation of the type of effect the construction, operation, and management of the proposed development would have on the affected environment. Will the impact of change on the environment be positive, negative, or neutral?
Extent or Scale	This refers to the spatial scale at which the impact will occur. The extent of the impact is described as footprint (affecting only the footprint of the development), site (limited to the site), and regional (limited to the immediate surroundings and closest towns to the site). The extent of scale refers to the actual physical footprint of the impact, not to the spatial significance. It is acknowledged that some impacts, even though they may be of a small extent, are of very high importance, e.g., impacts on species of very restricted range. To avoid "double counting, specialists have been requested to indicate spatial significance under "intensity" or "impact on irreplaceable resources" but not under "extent" as well.
Duration	The lifespan of the impact is indicated as temporary, short, medium, and long-term.
Severity	This is a relative evaluation within the context of all the activities and the other impacts within the framework of the project. Does the activity destroy the impacted environment, alter its functioning, or render it slightly altered?
Impact on irreplaceable resources	This refers to the potential for an environmental resource to be replaced, should it be impacted. A resource could be replaced by natural processes (e.g., by natural colonization from surrounding areas), through artificial means (e.g., by reseeding disturbed areas or replanting rescued species) or by providing a substitute resource, in certain cases. In natural systems, providing substitute resources is usually not possible, but in social systems, substitutes are often possible (e.g., by constructing new social facilities for those that are lost). Should it not be possible to replace a resource, the resource is essentially irreplaceable e.g., red data species that are restricted to a particular site or habitat to a very limited extent.
Consequence	The consequence of the potential impacts is a summation of the above criteria, namely the extent, duration, intensity, and impact on irreplaceable resources.
Probability of occurrence	The probability of the impact occurring is based on the professional experience of the specialist with environments of a similar nature to the site and/or with similar projects. It is important to distinguish between the probability of the impact occurring and the probability that the activity causing a potential impact will occur. Probability is defined as the probability of the impact occurring, not as the probability of the activities that may result in the impact.
Significance	Impact significance is defined to be a combination of the consequence (as described below) and the probability of the impact occurring. The relationship between consequence and probability highlights that the risk (or impact significance) must be evaluated in terms of the seriousness (consequence) of the impact, weighted by the probability of the impact occurring. In simple terms, if the consequence and probability of an impact are high, then the impact will have a high significance. The significance defines the level to which the impact will influence the proposed development and/or environment. It determines whether mitigation measures need to be identified and implemented and whether the impact is important for decision-making.
Degree of confidence in predictions	Specialists and the EIR team were required to indicate the degree of confidence (low, medium, or high) that there is in the predictions made for each impact, based on the available information and their level of knowledge and expertise. The degree of confidence is not taken into account in the determination of consequence or probability.
Mitigation measures	Mitigation measures are designed to reduce the consequence or probability of an impact or to reduce both consequence and probability. The significance of impacts has been assessed both with mitigation and without mitigation.

APPENDIX D: DISCLAIMER AND DECELERATION OF INDEPENDENCE

The opinions expressed in this Report have been based on site /project information supplied to GCS (Pty) Ltd by Zutari and are based on public domain data and data supplied to GCS by the client. GCS has acted and undertaken this assessment objectively and independently.

GCS has exercised all due care in reviewing the supplied information. Whilst GCS has compared key supplied data with expected values, the accuracy of the results and conclusions are entirely reliant on the accuracy and completeness of the supplied data. GCS does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.

Opinions presented in this report, apply to the site conditions, and features as they existed at the time of GCS's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this report, about which GCS had no prior knowledge nor had the opportunity to evaluate.

APPENDIX E: DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

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

PROJECT TITLE

Hydropedology Assessment for the Proposed Cato Ridge Land Development and Release Project

SPECIALIST INFORMATION

Specialist Company Name:	GCS SA (Pty) Ltd			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	2	Percentage Procurement Recognition	
Specialist name:	Hendrik Botha			
Specialist Qualifications:	MSc Environmental Sciences (Geohydrology & Geochemistry) BSc Hons. Environmental Sciences (Hydrology) BSc. Geology and Chemistry			
Professional affiliation/registration:	PR SCI NAT 400139/17			
Physical address:	1 Karbochem Road, Newcastle, KZN			
Postal address:				
Postal code:	2940	Cell:		
Telephone:	071 102 3819	Fax:		
E-mail:	hendrikb@gcs-sa.biz			

DECLARATION BY THE SPECIALIST

I, _Hendrik Botha, declare that –

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

18/04/2023
9:32:46
Pr.Sci.Nat (400139/17)

Signature of the Specialist

GCS SA (Pty) Ltd

Name of Company:

18 April 2023

Date

APPENDIX F CV OF SPECIALIST

Hendrik Botha

Technical Director

LinkedIn:

CORE SKILLS

- Project management
- Analytical and numerical groundwater modelling
- Geochemical assessments and geochemical modelling
- Hydropedology, hydrological assessments & yield assessments
- Hydrology, floodline modelling & storm water management
- Groundwater vulnerability, impact, and risk assessments
- Technical report writing
- GIS and mapping

DETAILS

Qualifications

- BSc Chemistry and Geology (Environmental Sciences) (2012)
- BSc Hons Hydrology (Environmental Sciences) (2013)
- MSc Geohydrology and Hydrology (Environmental Sciences) (2014-2016)

Membership

- Groundwater Division of GSSA
- Groundwater Association of KwaZulu Natal Member
- International Mine Water Association (IMWA)

Languages

- Afrikaans – Speak, read, write.
- English – Speak, read, write.

Projects undertaken in

- South Africa
- Nigeria
- Namibia
- Liberia
- Malawi

PROFILE

Hendrik (Henri) Botha is currently the Technical Director at GCS Water and Environment. He holds an MSc in Environmental Science in Geohydrology & Geochemistry, and a BSc Hons. Degree in Hydrology. He is registered as a SACNASP Professional Natural Scientist in the Earth Science Field. Groundwater, geochemistry and surface hydrology, as well as knowledge of water chemistry together with GIS, and analytical and numerical modelling skills, are some of his sought-after expertise. General and applied logical knowledge are his key elements in problem-solving.

Professional Affiliations:

SACNASP Professional Natural Scientist (400139/17)

Areas of Expertise:

- Project Management of water and environmental projects for mining, industrial and agriculture sectors.
- Integrated Water Investigations
- Waste classification and Impact Assessments
- Aquifer vulnerability assessments
- Geochemical sampling, data interpretation and modelling
- Groundwater impact and risk assessments
- Numerical and Conceptual Visual Modelling (Visual Modflow, ModflowFLEX, Voxler, RockWorks, Surfer and Excel)
- Hydropedology (Hydrological Soil Types) & Soils Assessments
- Floodline Modelling (HEC-RAS)
- Conceptual Stormwater Management Assessments
- Surface Water Yield Assessments
- Water and Salt Balances

SCAN ME
PROJECT RECORD