

HYDROPEDOLOGICAL IMPACT ASSESSMENT

HYDROPEDOLOGICAL IMPACT ASSESSMENT FOR THE SOUTH DEEP GOLD MINE, SITUATED WITHIN THE WEST RAND DISTRICT MUNICIPALITY, GAUTENG PROVINCE.



Prepared for: South Deep Gold Mine (Pty) Ltd
Prepared by: Environmental Assurance (Pty) Ltd
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EXECUTIVE SUMMARY

Environmental Assurance (Pty) Ltd (hereafter referred to as “ENVASS”) was appointed by Gold Fields Operations Limited (GFO) and GFI Joint Venture Holdings (Pty) Limited (GFI Holdings) acting jointly in their capacities as participants in an unincorporated joint venture (JV) known as South Deep JV: South Deep Gold Mine (herein referred to as “the client”) to undertake a Hydropedological Impact Assessment for the existing operations at South Deep, (hereafter referred to as “the proposed development”) on various portions of the farms Modderfontein 345 IQ, Doornpoort 347 IQ, Wildebeestkuil 360 IQ, Kalbasfontein 365 IQ, Cardoville 647 IQ, and Cardoville 364 IQ outside of Westonaria in the Gauteng Province. In addition to the existing and proposed new water uses, three (3) discharge points were assessed [located in two (2) areas] from a hydropedological perspective, and the most preferred point was suggested. This hydropedology report will be used in support of a Water Use License Application (WULA).

As the operation has been in existence for many years, a pre-operational baseline could not be established. However, the existing landscape and hydropedological interactions will be used as a current status baseline. The hydropedology report indicates the hillslopes and hydropedological soils present, the existing flow path and flow drivers (conceptual hillslope models) and potential impacts on soils (specifically wetland soils) and wetland flow drivers if any changes are to be made. A site visit was conducted on the 17th and 18th of September 2025 (dry season).

The study area is situated on a generally gentle slope (3.5% from north to south), with instances of higher gradients over the study area. The Leeuspruit is located to the south of the TSF, and an unnamed tributary of the Leeuspruit flows along the eastern boundary of the MR. A stream called the “Kariegarivier” flows through the centre of the MR area. The study area lies in a part of the Highveld where plains with low relief (0 – 130 m) and open hills, lowlands and mountains with moderate to high relief are present. The study area is located on various terrain units and ranges from 1635 metres above sea level (masl) in the north to 1501 masl at the Leeuspruit in the south. The general area is characterised by a mixture of developments (mining, residential and agricultural areas) as well as open areas that have had an impact on the various streams and their associated wetlands. The study area falls within quaternary catchment C22J of the Vaal River Water Management Area (WMA).

The study area was further derived into 15 sub-catchments/ basins (which in turn was used for the hydrological response units – HRUs) using a 30 m Digital Elevation Model (DEM) and SWAT+. Of these 15 sub-catchments (SC), only seven (7) are affected directly by the operational area and the TSF. These seven (7) sub-catchments/ basins assist in describing the natural drainage of the site. Sub-catchments one (1), two (2) and five (5) drain via surface/ subsurface flow into the unnamed tributary of the Leeuspruit and its associated wetlands, however, surface flow in these catchments are collected in the stormwater drains and channelled to the PCDs. Sub catchment three (3), predominantly via surface flow, flow towards the Kariegarivier. As with the other catchments, large amounts are channelled to the PCDs. Sub-catchments four (4) and ten drains to the Leeuspruit and only a small area is affected by the TSF, this is also the case for Sub-catchment eight (8) that drains into an unnamed tributary of the Leeuspruit.

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 2.4), which were used to determine the hydrological soil types (HSTs). The following soil forms and families were identified during the site visit and their hydrological soil groups are also given:

- | | |
|--------------------------|---------------------------|
| • Johannesburg (Jo) 2200 | Responsive (Hortonian) |
| • Glenrosa (Gs) 2110 | Recharge (Shallow) |
| • Vaalbos (Vb) 1221 | Recharge (Deep) |
| • Clovelly (Cv) 1221 | Recharge (Deep) |
| • Glencoe (Gc) 1220 | Recharge (Deep) |
| • Hutton (Hu) 1220 | Recharge (Deep) |
| • Bainsvlei (Bv) 1220 | Interflow (Soil/ Bedrock) |
| • Willowbrook (Wo) 1000 | Responsive (Wet) |
| • Rensburg (Rb) 1000 | Responsive (Wet) |
| • Mispah (Ms) 1120 | Responsive (Shallow) |
| • Witbank (Wb) 1200 | Responsive (Shallow) |
| • Witbank (Wb) 1300 | Responsive (Shallow) |
| • Witbank (Wb) 2100 | Responsive (Shallow) |
| • Witbank (Wb) 2200 | Responsive (Shallow) |

Eight (8) Conceptual Hydrological Response Models (CHRM) were identified using the 30 m SRTM data, contours and SWAT+. These CHRMs indicate the flow of water through the soils to the watercourses downstream and will be used to determine the change in surface and lateral flow and the impacts on the associated sections of the wetlands. The interplay of topography, soils, climate, and vegetation gives rise to discernible, repeating patterns and laws that offer valuable insights into their functioning (Van Tol, *et al.* 2023).

In conclusion, the modelling and hydrological response models indicate that a low volume of water will be lost in each of the hillslopes (as long as the surface flow is not intercepted and diverted away from the wetland and stream). The proposed discharge points associated with the South Deep Gold Fields mining and processing activities have already been constructed but is not yet being used. This entire area has already been severely impacted upon by industrial activities, infrastructure and agricultural activities. The mining operation and processing activities occur predominantly on deep recharge soils and soil/ bedrock interflow soils, which either flows vertically

into the groundwater regime or on the soil/ bedrock interface to the downstream watercourses. Eight (8) hillslopes were identified that form part of seven (7) sub-catchments over the study area. Based on the assessment and location of the discharge points, it was found that due to the water being directly discharged into the streams/ wetlands, the impact on hydrogeological flow paths will be negligible. This is due to pipelines being constructed overland with no water (except for leaks) being discharged directly onto the soil further up the hillslope. Ultimately, the discharge points will have a net positive impact on water quantity entering the stream and surrounding wetlands. The mitigation measures must be implemented to prevent surface flow from being intercepted and diverted away from the wetlands.

Based on the findings of this assessment, ENVASS believes that the proposed development poses a low risk to the hydrogeological environment, and with the implementation of the specified mitigation measures, impacts can be mitigated. This is due to the mining and processing operation existing for many years and resulting in a new “baseline” environment, and the fact that discharge water will enter watercourses directly and not higher on the hillslopes where it may have affected hydrogeological processes. With regards to the discharge points, it is recommended that discharge point one (1) be used as the infrastructure is already in place (in the form of aboveground pipes), the impact on hydrogeological flow paths/drivers is negligible due to the water being directly discharged into the Leeuspruit and the presence of clayey soils that prevent unnecessary infiltration back into the soils. The approval of the activity should be considered to enable South Deep Gold Mine to continue with its mining and processing operations.

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LIST OF ABBREVIATIONS

Term	Expansion
CHRM	Conceptual Hydrological Response Models.
DEA	Department of Environmental Affairs (now the DFFE).
DFFE	Department of Forestry, Fisheries and the Environment.
DEM	Digital Elevation Model.
DSM	Digital Soil Mapping.
DWS	Department of Water and Sanitation.
EA	Environmental Authorisation.
EIA	Environmental Impact Assessment.
GPS	Global Positioning System.
HRU	Hydrological Response Unit.
HS	Hillslope.
HST	Hydrological Soil Type.
LoO	Life of Operation.
MAE	Mean Annual Evaporation.
MAR	Mean Annual Runoff.
masl	Meters above Sea Level.
NEMA	National Environmental Management Act, 1998 (Act No. 107 of 1998, as amended).
NGO's	Non-Governmental Organisations.
QGIS	Quantum Geographic Information System.
RoM	Run-of-Mine.
SASCS	South African Soil Classification System: A Natural and Anthropogenic System for South Africa (Soil Classification Working Group, 2018).
SAGA	System for Automated Geoscientific Analysis.
SANS	South African National Standards.
SWAT	Soil and Water Assessment Tool.
TMU	Terrain Morphological Unit
WRB	World Reference Base for Soil Resources.

GLOSSARY OF TERMS

Term	Expansion
Activity	An activity is any water use or related activity which requires a water use licence in terms of section 40 of the National Water Act, 1998 (Act No. 36 of 1998, as amended) (NWA), and includes mines, industries, and related processes.
Aquifer	A geological formation which has structures or textures that hold water or permit appreciable water movement through them.
Baseflow	The contribution to runoff from previous rainfall events where rainfall percolates through the soil horizons into the vadose and groundwater zones and then contributes a very slow delayed flow to streams whose channels are 'connected' to the groundwater. These constitute the 'dry weather' flows which are significant in sustaining flows in non-rainy seasons.
Catchment	The area from which any rainfall will drain into the watercourse or watercourses or part of the watercourse, through surface flow to a common point or common points.
Catena	A series of soils linked by their topographic relationship (typically from crest to valley floor).
Confining Layer	A body of relatively impermeable or distinctly less permeable material stratigraphically adjacent to one or more aquifers that restricts the movement of water into or out of those aquifers.
Erosion	Erosion is the act in which the earth is worn away, often by water, wind, or ice. The process of erosion moves bits of rock or soil from one place to another. Most erosion is performed by water, wind, or ice (usually in the form of a glacier). These forces carry the rocks and soil from the places where they were weathered.
Flow path	Zones where water flows in the unsaturated zone, between the soil surface and the groundwater table.
Groundwater	All subsurface water that fills voids between highly permeable ground strata comprised of sand, gravel, broken rocks, porous rocks, etc. and move under the influence of gravitation.
Hydraulic Conductivity	Measure of the ease with which water will pass through porous media.
Hydrological Hillslope	Areas that have distinct hydrological regimes which are both cause and consequence of a particular combination of plant cover, soil, slope characteristics (e.g. gradient, curvature and aspect) and slope position.
Hydropedology	Study of the hydrological interaction of water with soil and the fractured rock zone.
Impact	The potential effect or consequence of an aspect of the development on a specified component of the biophysical, social or economic environment within a defined time and space.
Infrastructure	The network of facilities and/ or services that are required for economic activities e.g., roads, railways, electricity, water, and sewerage.
Interflow	Lateral movement of water through the unsaturated zone.
Mitigation Measures	Measures designed to avoid, reduce, or remedy adverse impacts.
Natural Environment	Our physical surroundings, including plants and animals, when they are unspoiled by human activities.
Overland Flow	Water flowing on the soil surface.
Pedology	The branch of soil science dealing with soils as a natural phenomenon, including their morphological, physical, chemical, mineralogical and biological constitution, genesis, classification and geographical distribution.

Pedon	The smallest three-dimensional portion of the soil mantle needed to describe and sample soil in order to represent the nature and arrangement of its horizons.
Permanent Saturation or Inundation	Wetland area characterised by saturation within 50 cm of the soil surface for most of the year, for most years.
Pollutant	A contaminant at a concentration high enough to endanger the environment or the public health.
Pollution	National Water Act, 1998 (Act No. 36 of 1998, as amended): “<i>Water pollution means the direct or indirect alteration of the physical, chemical or biological properties of a water resource to make it –</i> (a) <i>less fit for any beneficial purpose for which it may reasonably be expected to be used; or</i> (b) <i>harmful or potentially harmful –</i> (aa) <i>to the welfare, health or safety of human beings;</i> (bb) <i>to any aquatic or non-aquatic organisms;</i> (cc) <i>to the resource quality; or</i> (dd) <i>to property”.</i> National Environmental Management Act (Act No. 107 of 1998, as amended): - “<i>pollution means any change in the environment caused by –</i> (i) <i>substances;</i> (ii) <i>radioactive or other waves; or</i> (iii) <i>noise, odours, dust or heat emitted from any activity, including the storage or treatment of waste or substances, construction and the provision of services, whether engaged in by any person or an organ of state, where that change has an adverse effect on human health or well-being or on the composition, resilience and productivity of natural or managed ecosystems, or on materials useful to people, or will have such an effect in the future.”</i>
Protection	In relation to a water resource, means – i. maintenance of the quality of the water resource to the extent that the water resource may be used in an ecologically sustainable way; ii. prevention of the degradation of the water resource; and iii. the rehabilitation of the water resource;
Recharge	Filling-up zones that can be replenished including soil horizons, saprolite, fractured rock or groundwater with water.
Regulated Area of a Watercourse	in terms of the Water Act means: (a) the outer edge of the 1 in 100 year flood line and/ or delineated riparian habitat, whichever is the greatest, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam; (b) In the absence of a determined flood line or riparian area within 100 m from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench; or (c) A 500 m radius from the delineated boundary (extent) of any wetland or pan.
Runoff	Surface runoff is water that finds its way into a surface water body without infiltration into the soil and may include overland flow, return flow, interflow, and base flow.

Saturated	All voids filled with water. This is seldom reached in natural conditions. Related to exclusion of air to the point where soil has anaerobic conditions.
Seasonal Saturation or Inundation	Wetland area characterised by saturation within 50 cm of the soil surface for three to nine months of the year, usually during the wet season.
Significant Impact	The activity that results in substantial breach of statutory regulations under abnormal conditions.
Surface Water	All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.); also refers to springs, wells, or other collectors that are directly influenced by surface water.
Stormwater	Water that accumulates on land as a result of precipitation events and includes runoff from areas such as roads and roofs.
Temporary Saturation or Inundation	Wetland area characterised by saturation within 50 cm of the soil surface for less than three months of the year.
Unsaturated Zone	Includes soil horizons, saprolite and fractured rock above the surface of the regional groundwater table.
Vadose Zone	The unsaturated zone, part of earth's mantle between the land surface and the top of the phreatic zone (groundwater aquifer). This includes soil, fractured rock and saprolite.
Waste Management	Classifying, recycling, treatment and disposal of waste generated during operational activities.
Water Balance	The regulation or rationalisation of human activity to match the sustainable local water supply, rather than base, or a process of balancing water supply and demand to ensure that the water use does not exceed supply.
Watercourse	i. A river or spring; ii. A natural channel in which water flows regularly or intermittently; iii. A wetland, lake, or dam into which, or from which, water flows; and iv. Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.
Water Resource	A water resource includes any watercourse, surface water, estuary, or aquifer. Watercourses include rivers, springs, and natural perennial and non-perennial channels. Wetlands, lakes, dams, or any collection identified as such by the Minister in the Government Gazette.
Wetland	Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.

STRUCTURE OF THE SPECIALIST REPORT

NEMA Regulations (2014) (as amended) – Appendix 6	Relevant Section in this Report
(1) A specialist report prepared in terms of these Regulations must contain-	
(a) details of-	Page ii and Appendix A
(i) the specialist who prepared the report; and	
(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Page ii
(c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 1
(cA) an indication of the quality and age of base data used for the specialist report;	Section 1
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 2
(d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Sections 1, 2 and 3
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 3
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Sections 1.2 and 6.1
(g) an identification of any areas to be avoided, including buffers;	Section 5
(h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Sections 1 and 2
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.4
(j) a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Sections 5 and 6
(k) any mitigation measures for inclusion in the EMPr;	Section 6.3
(l) any conditions for inclusion in the environmental authorisation;	Section 6.3
(m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 6.3
(n) a reasoned opinion-	
(i) whether the proposed activity, activities or portions thereof should be authorised; and	
(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, any avoidance, management and mitigation measures that should be included in the EMPr, and the closure plan in the case of a closure activity;	Section 7.1
(o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	N/A
(p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	N/A
(q) any other information requested by the competent authority.	N/A
(2) Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	N/A

1. INTRODUCTION

1.1. PROJECT BACKGROUND

South Deep Gold Mine is an existing gold mine and processing operation currently applying for a Water Use License (WUL) for the update and consolidation of all water uses. Two (2) possible discharge areas have been selected for treated water from the RO plants and have also been included in this report. As part of the WUL application, the Department of Water and Sanitation (DWS) requested that a hydrogeological impact assessment be conducted over the footprint area of the mining and processing operations. As the mining operation has been in existence for many years, no pre-mining/ operational baseline can be accurately established. This study will focus on the current “baseline” and hydrogeological interactions. As part of this study, four (4) possible discharge points were also assessed from a hydrogeological point of view. Impacts and mitigation measures have been developed not only for the entire operation as a whole, but for the preferred discharge point as well.

Figure 1-1 below indicates the extent of the mining right (MR) area with the study area focused on the operational sections and the South Deep Doornpoort Tailings Storage Facility (TSF). It is important to note that certain sections of the study area have already been developed. **Figure 1-2** indicates the two (2) areas for the proposed discharge points [a total of three (3), with two (2) located at discharge point two (2)].

1.2. SCOPE OF WORK

The scope of work completed was as follows:

Desktop study:

- All available reports (which were provided by the client) relating to the site were assessed; and
- Evaluation of soil occurrences in the study area, based on available South African databases (i.e. land types identified by the Land Type Survey Staff, 1972 – 2006).

Site walkover assessment and sampling:

- ENVASS undertook a site walkover assessment and drilled several soil observation holes using a hand-held auger. Auger holes were drilled up to 1.5 m or refusal depending on the soil profile intercepted and logged with GPS;
- Photographs were taken at each observation location and of the general area;
- Visual observations with regards to soil degradation, land-use and wetland health were made; and
- The soils identified in the study area were screened per the Soil Classification guidelines for South Africa (Department of Agricultural Development, 1991) and Soil Classifications Working Group (2018) to derive hydrogeological flow regimes.

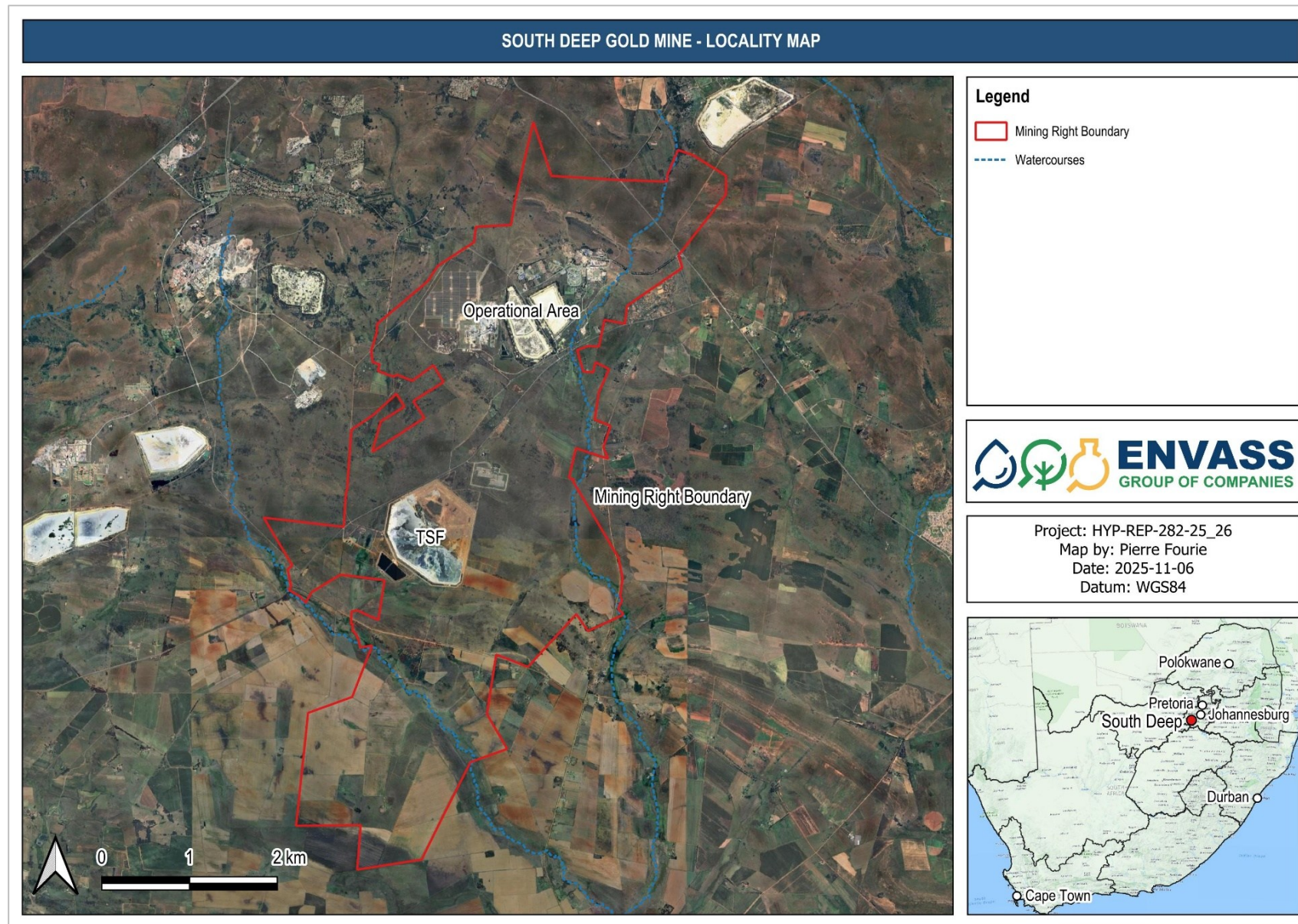


Figure 1-1: South Deep MR area.

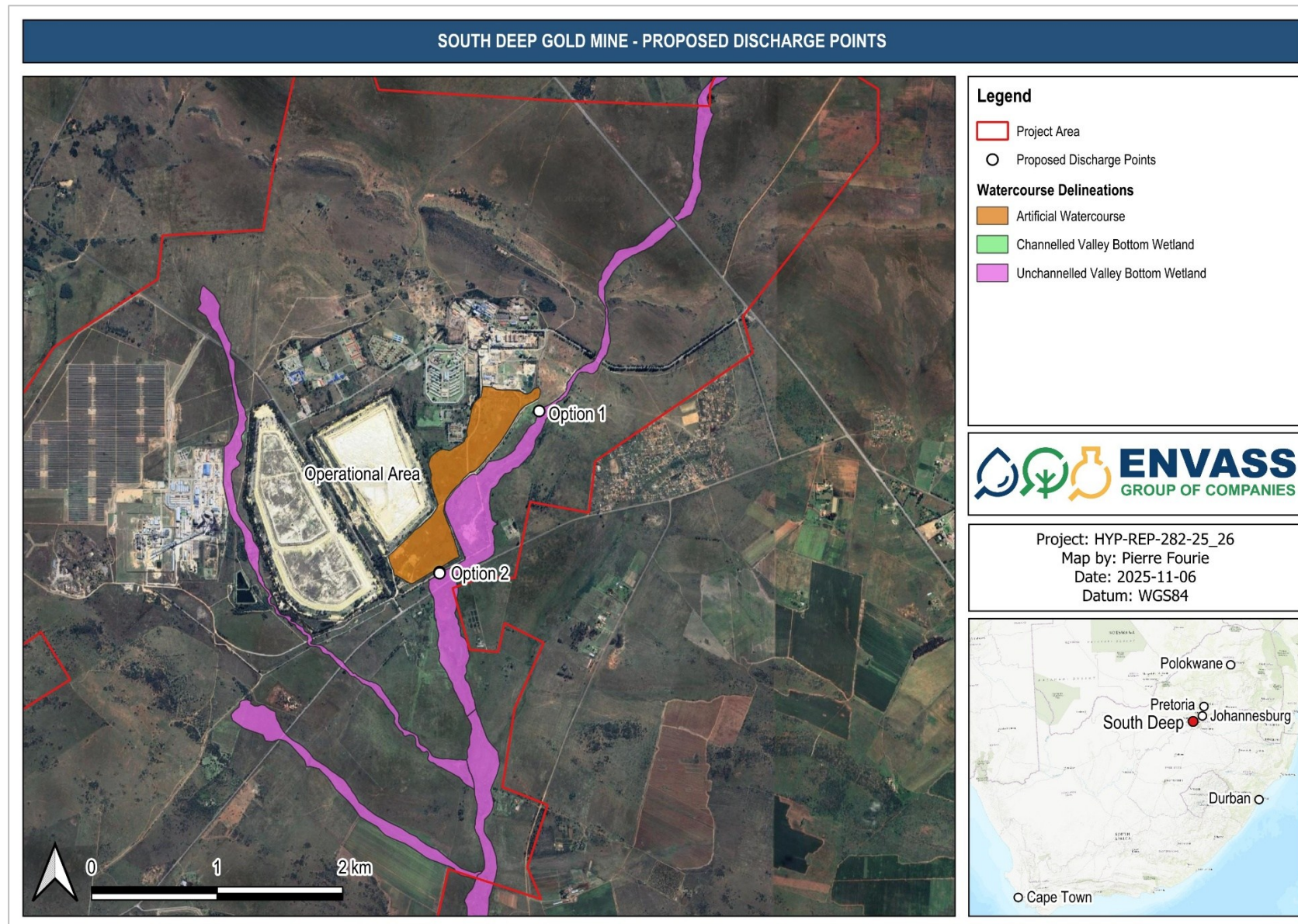


Figure 1-2: Proposed discharge points.

Hydropedological assessment:

- Meteorological evaluation;
- Catchment delineation (using available contour lines and SWAT+ modelling software);
- Conceptualise the hillslope hydrological responses based on field observation and desktop data;
- Determining the hydropedological soil forms as developed by van Tol and Bouwer (2024); and
- Determining sub-catchments (watersheds) and hydrological response units (HRU's) within the project area using topography and SWAT+.

Modelling:

- Quantify and model the change in flow of surface and subsurface water through the soil using SWAT+; and
- Determine impacts based on the model output.

Risk assessment and mitigation measures:

- The risk and impact criteria were applied to the study area, to evaluate hydropedological risks;
- Natural flow losses were estimated using SWAT+ (as indicated above); and
- Mitigation measures and potential hydropedology buffers were estimated.

Mapping and report:

- Several hydrological hillslope profiles (hillslope hydrological responses), soil distribution and hydrological soil type maps were produced; and
- This report was compiled based on the relevant information. The Hydropedological Assessment Guidelines (Van Tol, *et al.* 2023) were used to develop this report.

1.3. OBJECTIVES

The objectives of this hydropedological assessment are summarised as follows:

- Evaluate the soils in the study area;
- Derive hydropedological flow regimes and interaction areas;
- Conceptualise the water flow dynamics and derive hydrological hillslope profiles;
- Quantify the change in flow and/ or existing flow using SWAT+ modelling software;
- Identify potential hydropedological impacts per standard Department of Water and Sanitation (DWS) and Environmental Impact Assessment (EIA) impact criteria;
- Determine mitigation measures to decrease the impact of the proposed activities; and

- Define potential hydropedological buffer areas, based on the flow driver assessment.

1.4. LIMITATIONS AND ASSUMPTIONS

- Sampling, by definition, means that not all areas are assessed, and therefore some aspects of soil and hydropedological characteristics may have been overlooked in this assessment. However, it is the opinion of the specialist that this assessment was carried out with sufficient sampling and in sufficient detail to enable the proponent, the Environmental Assessment Practitioner (EAP) and the regulating authorities to make an informed decision regarding the proposed development.
- The SWAT+ model mainly models surface processes and does not entail processes relating to ground water recharge. Impacts on groundwater need to be considered on the broader landscape and drainage regime.
- The main limitation of the model is the spatial representation of the Hydrological Response Units (HRUs) within each sub-catchment (watershed). This approach ignores flow and pollutants routing between the HRUs. However, the results presented as landscape units (LSU's) are considered sufficient to guide the decision-making process.
- Modelled weather data (obtained from online sources) in the absence of measured weather data is not 100% accurate especially with respect to precipitation data thus inaccuracies can be expected.
- The effects of climate change dynamics were not considered as part this assessment; however, it is acknowledged that this might exacerbate the anticipated impacts associated with a reduction in water inputs and the resultant hydrological function of the remaining wetlands beyond the extent of the proposed development.
- Per requirements for hydropedology studies published by the Department of Water and Sanitation (DWS) and the Water Research Commission (WRC) (Van Tol, *et al.* 2023), this "Level 3" study (field investigation, conceptualisation of hillslopes impact discussion and quantification) was undertaken as the proposed development triggers the conditions given in this report.
- As water will be discharged directly into either a stream or onto the soil close to the stream, modelling did not include the increase of water volume on flow drivers/ paths. This is because water will not be allowed to enter the soil and affect flow drivers/ paths. Mitigation measures were provided, as well as a preferred discharge location.

2. SITE OVERVIEW AND BASELINE

2.1. STUDY AREA

The study area is located approximately 5 km south of Westonaria and 17 km east of Fochville, within the Gauteng Province (**Figure 2-1**).

The study area is situated on a generally gentle slope (3.5% from north to south), with instances of higher gradients over the study area. The Leeuspruit is located to the south of the TSF and an unnamed tributary of the Leeuspruit flows along the eastern boundary of the MR. A stream called the “Kariegarivier” flows through the centre of the MR area. The study area lies in a part of the Highveld where plains with low relief (0 – 130 m) and open hills, lowlands and mountains with moderate to high relief are present. The study area is located on various terrain units and ranges from 1635 metres above sea level (masl) in the north to 1501 masl at the Leeuspruit in the south. The general area is characterised by a mixture of developments (mining, residential and agricultural areas) as well as open areas that have had an impact on the various streams and their associated wetlands. The study area falls within quaternary catchment C22J (**Figure 2-1**) of the Vaal River Water Management Area (WMA).

2.2. SUB-CATCHMENTS

The study area was further derived into 15 sub-catchments/ basins (which in turn was used for the hydrological response units – HRUs) using a 30 m Digital Elevation Model (DEM) and SWAT+ (**Figure 2-2**). Of these 15 sub-catchments (SC), only seven (7) are affected directly by the operational area and the TSF. These seven (7) sub-catchments/ basins assist in describing the natural drainage of the site. Sub-catchments one (1), two (2) and five (5) drain via surface/ subsurface flow into the unnamed tributary of the Leeuspruit and its associated wetlands, however, surface flow in these catchments are collected in the stormwater drains and channelled to the PCDs. Sub catchment three (3), predominantly via surface flow, flow towards the Kariegarivier. As with the other catchments, large amounts are channelled to the PCDs. Sub-catchments four (4) and ten drains to the Leeuspruit and only a small area is affected by the TSF, this is also the case for Sub-catchment eight (8) that drains into an unnamed tributary of the Leeuspruit. **Table 2-1** indicates the size and slope percentage of each of the sub-catchments/ basins.

Table 2-1: Summary of sub-catchment characteristics.

Sub-catchment/ Basin	Area (ha)	Longest Drainage Line (m)	Average Slope (%)	Infrastructure Surface Area Percentage of Sub- Catchment/ Basin (%)
SC 1	776.14 ha	818 m	5.1%	2.8%
SC 2	671.14 ha	905 m	2.5%	14.28%
SC 3	807.13 ha	1393 m	2.5%	28.63%
SC 4	1693.58 ha	1313 m	2.2%	13.58%
SC 5	421.77 ha	697 m	1.2%	24.65%

Sub-catchment/ Basin	Area (ha)	Longest Drainage Line (m)	Average Slope (%)	Infrastructure Surface Area Percentage of Sub- Catchment/ Basin (%)
SC 8	398.05 ha	1284 m	1%	5.72%
SC 10	433.76 ha	1912 m	1.8%	40.7%

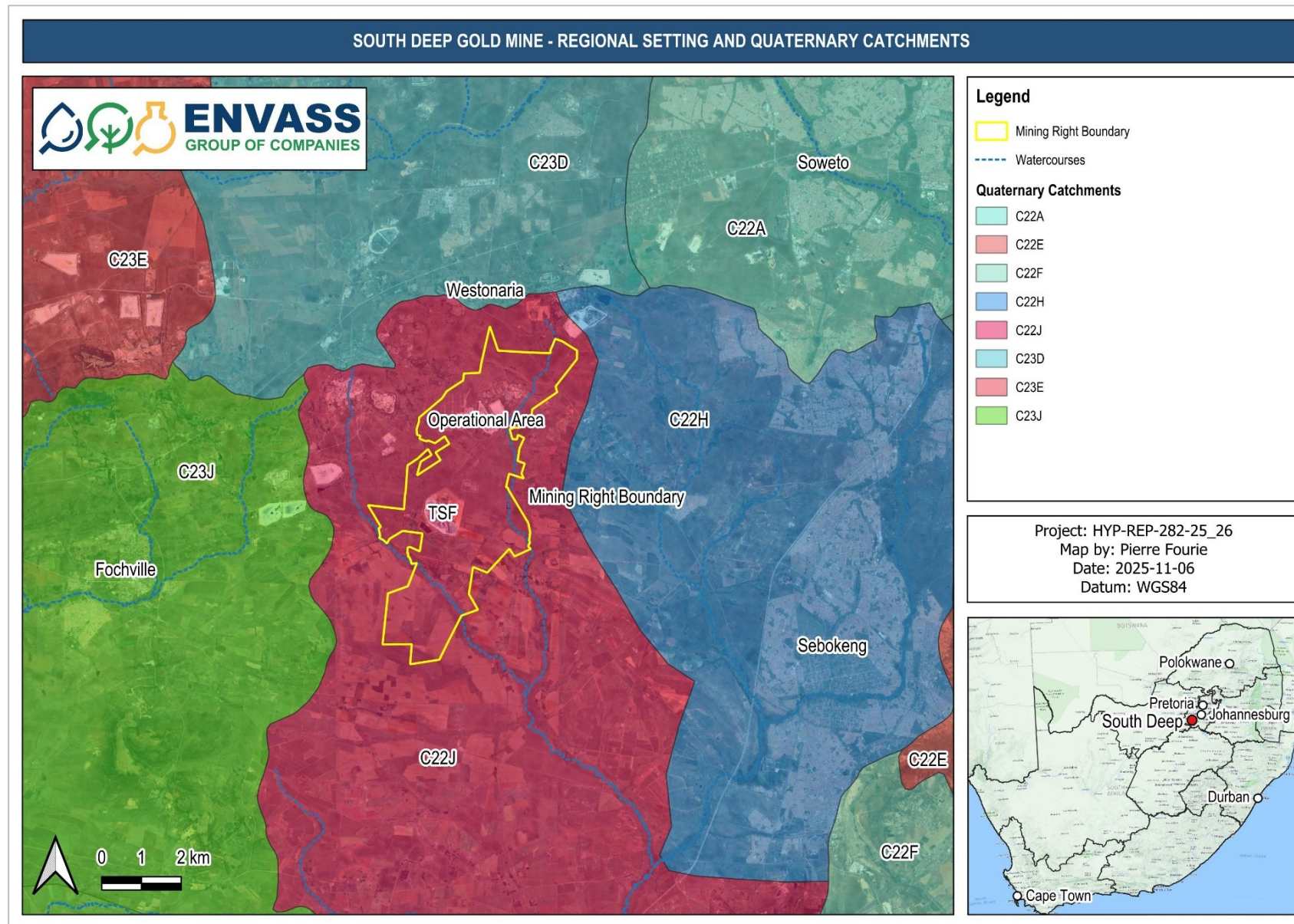


Figure 2-1: Regional setting and quaternary catchments associated with South Deep Gold Mine.

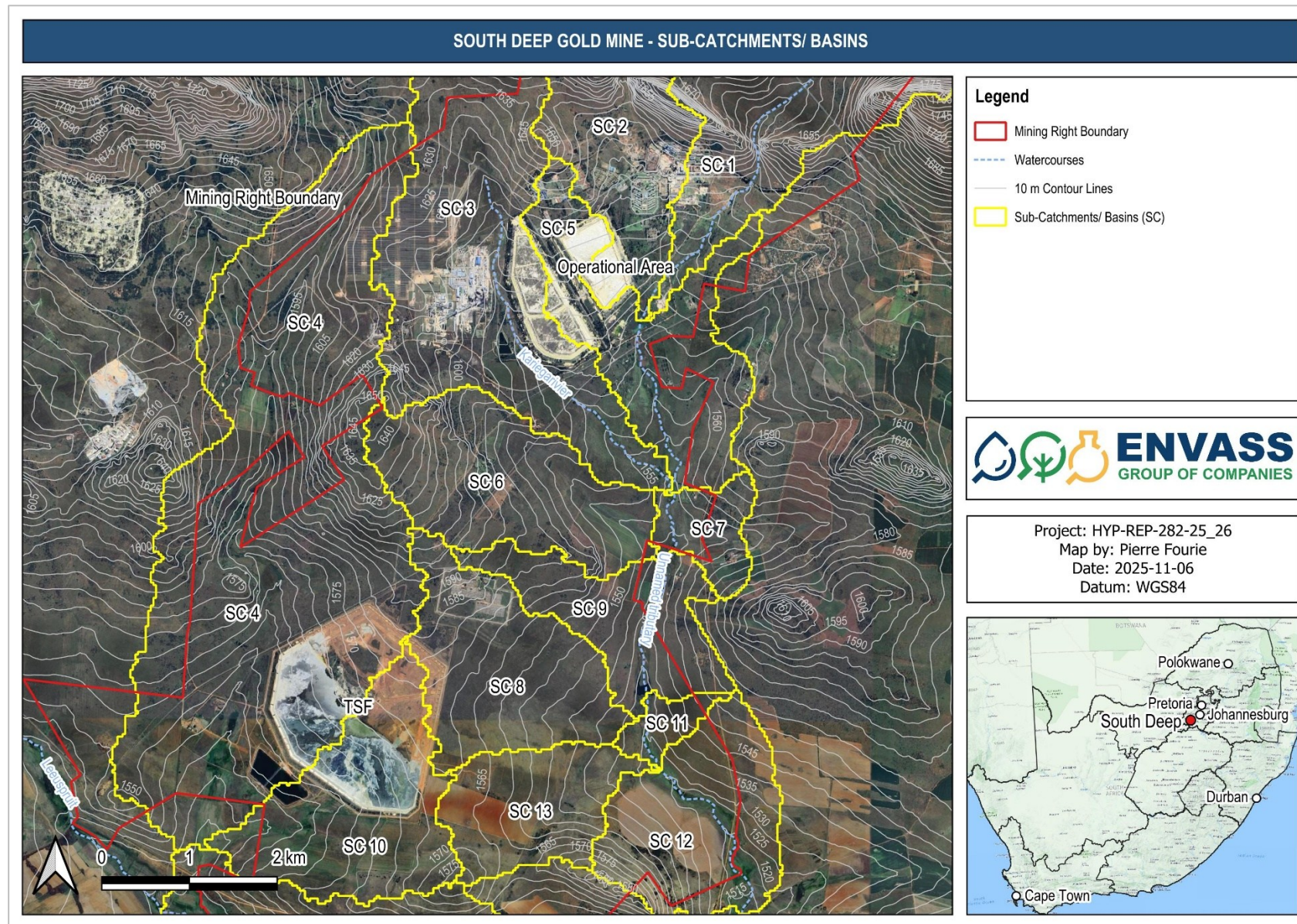


Figure 2-2: Sub-catchments/ basins for the study area.

2.3. CLIMATE

Climate, amongst other factors, influences soil-water processes, runoff, and groundwater recharge. 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.

2.3.1. Temperature

The study area falls within the boundary of South Africa's cold interior (SANS 204, 2011). The area experiences warm summers with an average daily high temperature of 26 °C and cool winters with an average low of 5 °C. The hottest month of the year is January with July experiencing the coldest temperatures (WeatherSpark, 2025). **Figure 2-3** indicates the average maximum and minimum temperatures throughout the year.

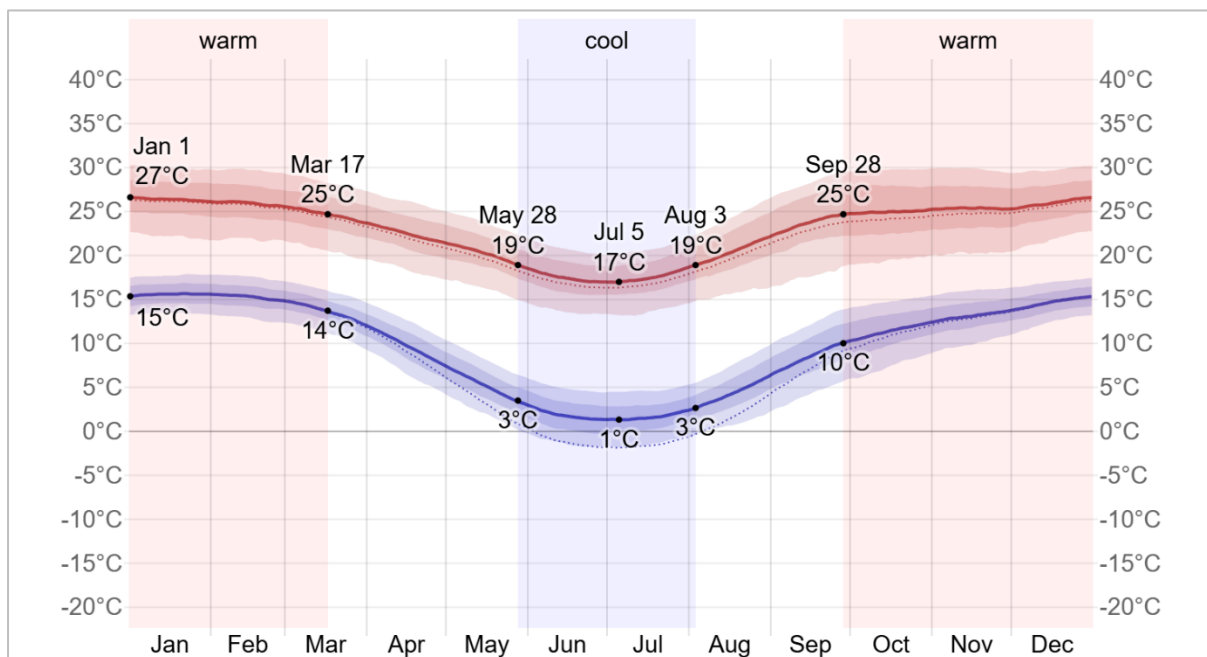


Figure 2-3: Average temperature in Westonaria (WeatherSpark, 2025).

2.3.2. Rainfall

The area experiences its rainy period from October to late March (WeatherSpark, 2025) with an average annual precipitation of 42.80 mm per month. The average annual rainfall for the project area is 513.5 mm (**Figure 2-4**). The dry period is from May to September with very few rainfall events occurring over this period. The S Class Pan evaporation for the area (DWS weather station C2E007-MET located at Zuurbekom) is on average 1520 mm per annum (DWS, 2025) with October to January experiencing the highest evaporation rates.

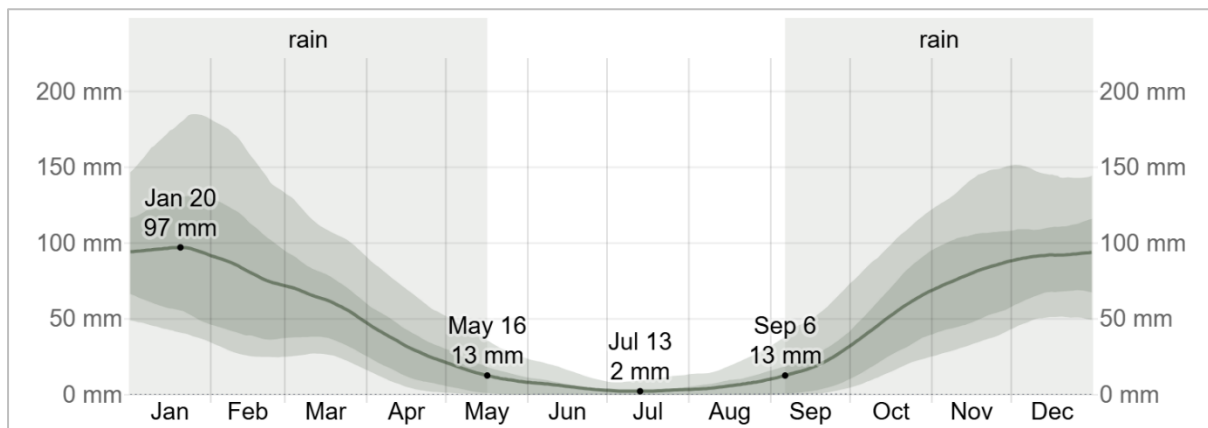


Figure 2-4: Average rainfall in Westonaria (WeatherSpark, 2025).

2.4. SOILS AND GEOLOGY

2.4.1. 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. The Terrain Morphological Units (TMU) are illustrated within **Figure 2-5** with the crest (1), scarp (2), midslope (3), secondary midslope [3(1)], footslope (4), and valley floor (5). The terrain in the project area is generally on a gentle slope (3.5% for length of site – middle footslopes to valley floor), with soil depths ranging from 100 mm to > 1.2 m generally with clay content ranging from 4% - 15% and some areas with shallow horizons underlain by rock.

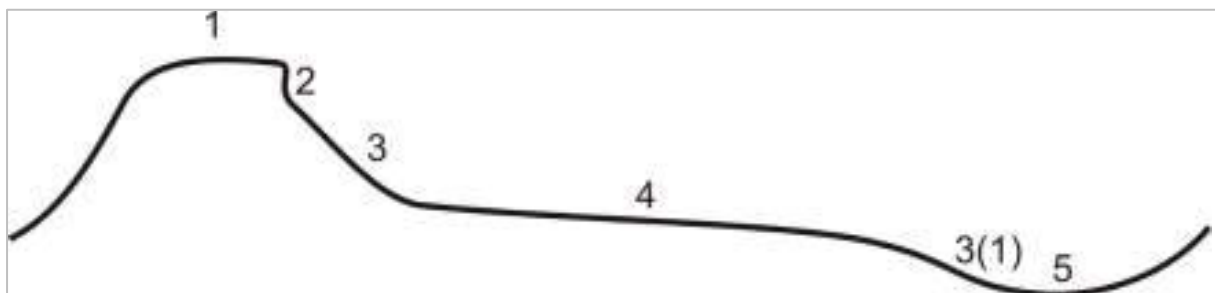


Figure 2-5: Terrain Morphological Units (LTSS, 1972 – 2006).

According to the World Reference Base for Soil Resources (WRB, 2022) world soil map, the majority of the study area is located within the Lixisols (LX) or Group 7 area. This area consists of: “Soils with clay enriched subsoil. A further subdivision can be made depending on the base status and/ or type of clay minerals. Contains soils with retic properties; soils with low-activity clays and low base status; soils with low-activity clays and high base status; soils with high-activity clays and low base status, and soils with high-activity clays and high base status” (Caspari and Schad, 2022).

The study area (where the operational activities and TSF are situated) is located within the Fb5 and Ba1 land types (LTSS, 1972 – 2006) which is characterised by a plinthic catena: upland duplex and marginalitic soils rare (ARC, 2006); red soils widespread and can consist of dystrophic and/ or mesotrophic materials with shallow soils also present. **Figure 2-6** indicates the Fb5 land type and **Figure 2-7** the Ba1 land type as well as the general position of specific soil forms within this land type. The terrain units are described in **Table 2-2** below.

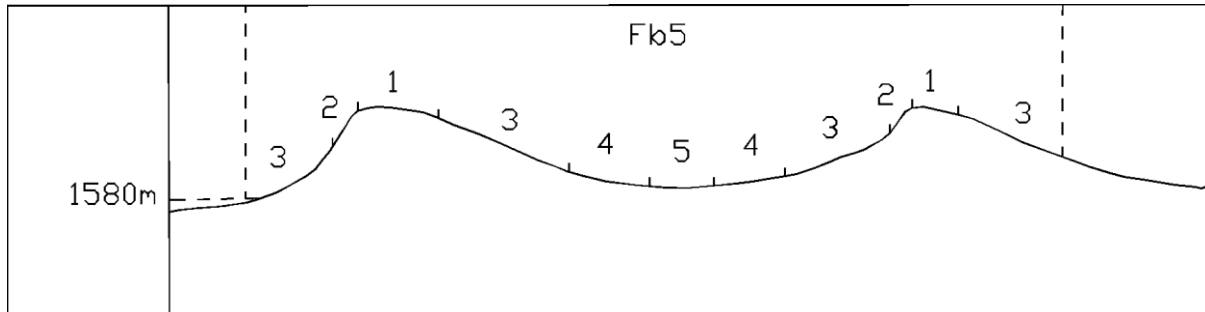


Figure 2-6: Fb5 land type (ARC, 2006).

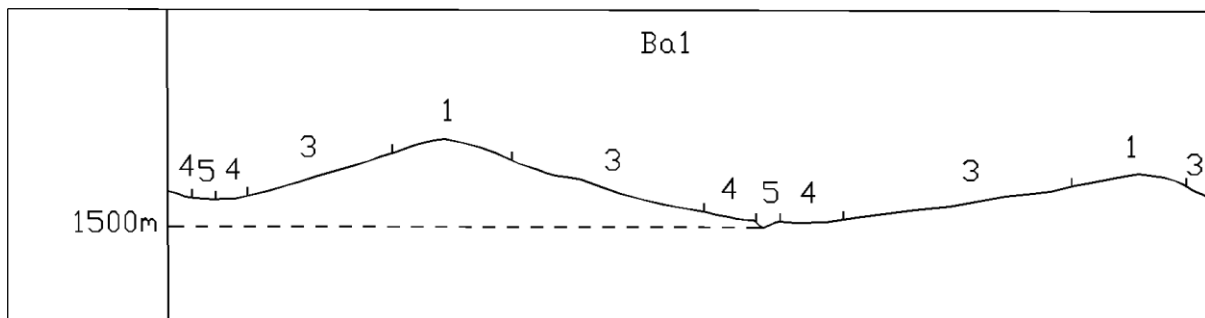


Figure 2-7: Ba1 land type (ARC, 2006).

Table 2-2: Fb5 terrain units (ARC, 2006).

Soil Form/ Identifier	Terrain Unit									
	1		2		3		4		5	
	ha	%	ha	%	ha	%	ha	%	ha	%
Rock	1948	40	1136	70	2249	21	682	5	192	12
Mispah (Mispah Ms10)	1607	33	325	20	2678	25	1500	11	260	16
Glenrosa (Williamson Gs16, Trevanian Gs17)	1120	23	162	10	3106	29	1636	12	-	-
Hutton (Msinga Hu26, Hutton Hu16)	195	4	-	-	2464	23	6543	48	-	-
Oakleaf and Dundee (Leeufontein Oa16, Jozini Oa36, Highflats Oa17, Dundee Du10)	-	-	-	-	-	-	1227	9	162	10
Arcadia and Rensburg (Gelykvlakte Ar20, Rensburg Rg20)	-	-	-	-	-	-	-	-	844	52

Soil Form/ Identifier	Terrain Unit									
	1		2		3		4		5	
	ha	%	ha	%	ha	%	ha	%	ha	%
Clovelly (Southwold Cv26, Oatsdale Cv16)	-	-	-	-	-	-	818	6	-	-
Shortlands (Doveton Hu27, Glendale Sd21)	-	-	-	-	214	2	409	3	-	-
Clovelly (Ofazi Cv23, Vidal Cv13)	-	-	-	-	-	-	545	4	-	-
Avalon (Avalon Av26)	-	-	-	-	-	-	273	2	-	-
Stream beds	-	-	-	-	-	-	-	-	162	10

Table 2-3: Ba1 terrain units (ARC, 2006).

Soil Form/ Identifier	Terrain Unit							
	1		3		4		5	
	ha	%	ha	%	ha	%	ha	%
Rock	2292	5	-	-	-	-	-	-
Hutton (Msinga Hu26, Shorrocks Hu36, Makatini Hu37)	4583	10	-	-	-	-	-	-
Mispah (Mispah Ms10)	4583	10	-	-	-	-	-	-
Hutton (Msinga Hu26, Shorrocks Hu36)	4583	10	33610	40	6111	40	-	-
Hutton (Msinga Hu26, Shorrocks Hu36)	9166	20	16805	20	-	-	-	-
Mispah (Mispah Ms10, Klipfontein Ms11)	9166	20	8402	10	764	5	-	-
Hutton (Makatini Hu37, Doveton Hu27)	4583	10	8402	10	1528	10	-	-
Glencoe (Glencoe Gc26, Leslie Gc36)	2292	5	4201	5	764	5	-	-
Clovelly (Southwold Cv26, Blinkklip Cv36)	2292	5	4201	5	764	5	-	-
Glenrosa (Trevanian Gs17, Williamson Gs16)	2292	5	4201	5	-	-	-	-
Avalon (Avalon Av26, Soetmelk Av36, Bezuidenhout Av37)	-	-	4201	5	1528	10	-	-
Valsrivier (Lindley Va41)	-	-	-	-	1528	10	764	10
Rensburg and Willowbrook (Rensburg Rg20, Sarasdale Wo20, Chiyika Wo21)	-	-	-	-	-	-	2291	30
Oakleaf and Dundee (Jozini Oa36, Dundee Du10)	-	-	-	-	-	-	2291	30
Bonheim (Glengazi Bo31, Bonheim Bo41)	-	-	-	-	764	5	764	10

Soil Form/ Identifier	Terrain Unit							
	1		3		4		5	
	ha	%	ha	%	ha	%	ha	%
Kroonstad (Mkambati Kd14, Kroonstad Kd13, Avoca Kd17)	-	-	-	-	764	5	382	5
Westleigh (Sibasa We13)	-	-	-	-	764	5	382	5
Champagne (Champagne Ch11)	-	-	-	-	-	-	764	10

The largest areas, as per the LTSS (1972 – 2006), consist of red-yellow apedal and shallow soils. A red-yellow apedal horizon has defined red/ yellow colours and has a structure weaker than moderate on the moist state (SCWG, 2018). The essential uniform, red pigmentation is due to the presence of evenly distributed hematite which, even when it is not necessarily the dominant iron oxide present, typically indicates well aerated swell conditions in warmer climates. The clay mineral suite of red apedal horizons is similar to its yellow-brown apedal counterparts. Kaolinite is the dominant clay mineral. Poorly ordered or amorphous clay minerals are also present in the clay fractions of soils in humid climates, while limited proportions of 2:1 clay minerals can be present in semi-arid climates, with increasing quartz contents in sandy textured horizons. The apedal or weak structure forms in sandy textured soils, while within clay textured horizons it results either from the low activity, non-swelling clay minerals or from a soil moisture regime lacking severe desiccation. The horizon may experience only short durations of water saturation, while at greater depths, water saturation may last for longer periods. The sandy loam and finer textured horizons have a strong micro-aggregate structure resulting in stable pores and a moderately high infiltration rate (SCWG, 2018).

The shallow soils within this land type are characterised by a shallow A horizon (between 100 mm – 400 mm thick) overlying a hard rock horizon. The hard rock horizon comprises hard country rock where primarily physical weathering has taken place, ranging from a fractured rock horizon variant with numerous closely aligned fractured planes, but lacking soil development between fractures, to a solid rock horizon variant with limited and widely spaced fractures. It includes all igneous, sedimentary and metamorphic rock types (SCWG, 2018).

2.4.2. Geology

The regional geological map (2626 Wes Rand - 1:250 000 Geological Map Series) indicates that the project area is underlain by the Timeball Hill, Hekpoort and Strubenkop formations of the Pretoria Group of the Transvaal Supergroup (DMEA, 1998). Dolomite, subordinate chert, minor carbonaceous shale, limestone and quartzite form the base of this geological area (refer to **Figure 2-8**).

In the West Rand, the Timeball Hill formation (~300–500 m thick) comprises lower and upper ferruginous shales and mudstones (~150–250 m each), with an intervening arenaceous Klapperkop Quartzite Member (~50 m) of sandstones, siltstones, and iron-rich quartzites. It includes laminated, graded, and ripple-marked sediments, indicating marine deposition, with occasional diamictites. Under subtropical climates, it weathers to shallow (< 2 –

4 m) residual soils of clayey silt to silty clay, often compressible and occasionally expansive, with instability in cut slopes due to bedding planes.

The Hekpoort formation (~280 m thick in West Rand) consists of subaerial basaltic andesite lavas, with volcanoclastic bases, brecciated tops, and amygdalites (filled vesicles). Composition includes plagioclase, hornblende (altered to chlorite), quartz, and accessories like epidote. It overlies Timeball Hill sharply. Weathering produces variable-depth clayey soils, compressible and often expansive, forming rich loams under moist conditions but requiring drainage control to mitigate heave.

The Strubenkop formation comprises of ferruginous shales, interlayered shaly sandstones, and hornfels (~100–200 m thick), this unit transitions from Hekpoort volcanics to overlying mudstones and siltstones. In West Rand, it's similar to Timeball Hill shales, with fine-grained textures. It weathers to shallow, poor soils if dry, or deeper, richer clays if moist, similar to Timeball Hill: clayey silt/ silty clay, compressible, with slope instability risks.

Weathering in South Africa's variable climate, with wet summers and dry winters, produces soils with iron oxide enrichment, influencing local agriculture and erosion patterns. These rocks' durability and iron content shape the region's distinctive reddish landscapes.

2.5. TOPOGRAPHY

The study area is situated on a generally gentle slope (3.5% from north to south), with instances of higher gradients over the study area. The study area lies in a part of the Highveld where plains with low relief (0 – 130 m) and open hills, lowlands and mountains with moderate to high relief are present. The study area is located on various terrain units and ranges from 1635 metres above sea level (masl) in the north to 1501 masl at the Leeuspruit in the south. The project area is divided into smaller HRUs, and the overall topography is illustrated by the DEM in **Figure 2-9**.

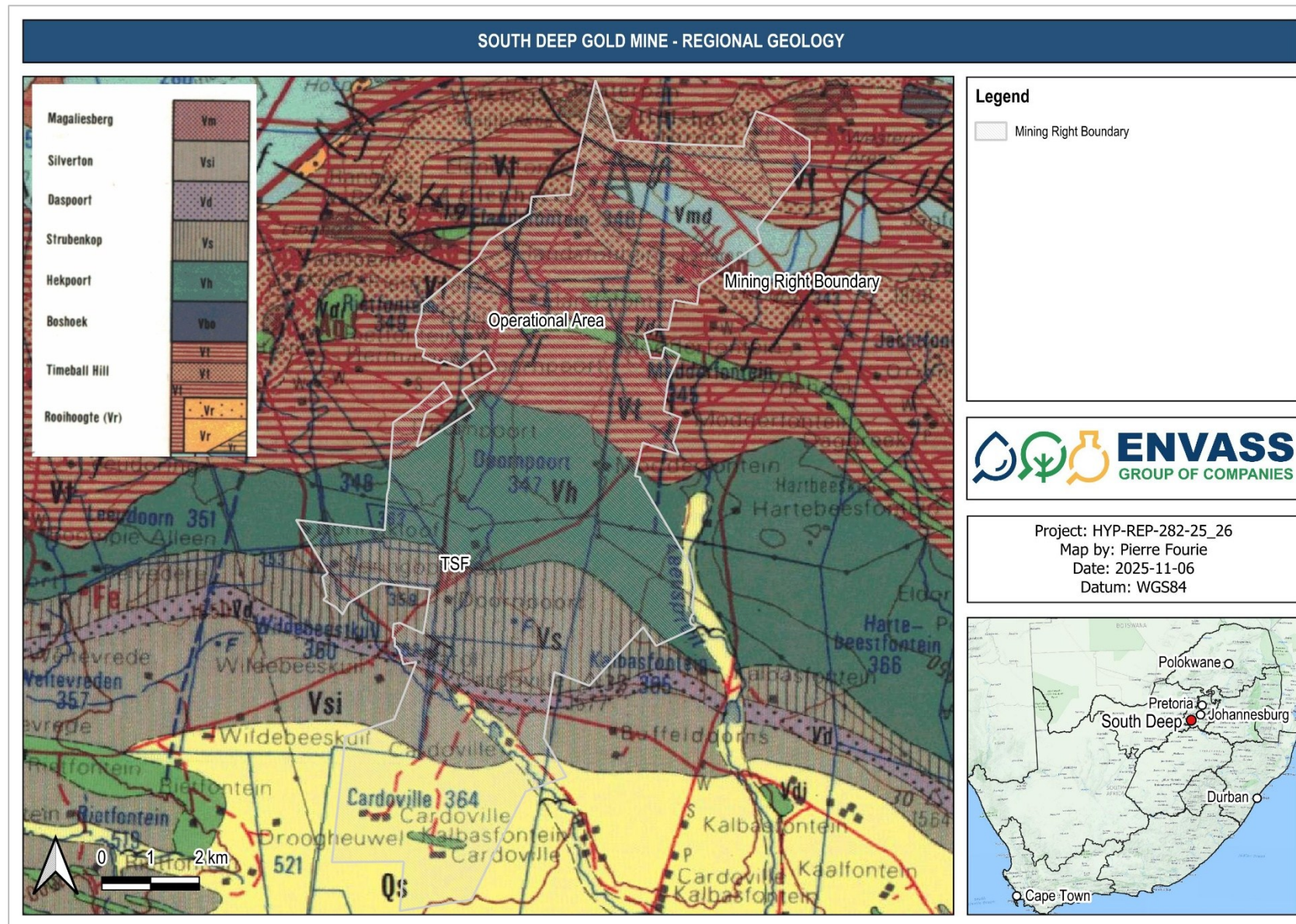


Figure 2-8: Regional geology.

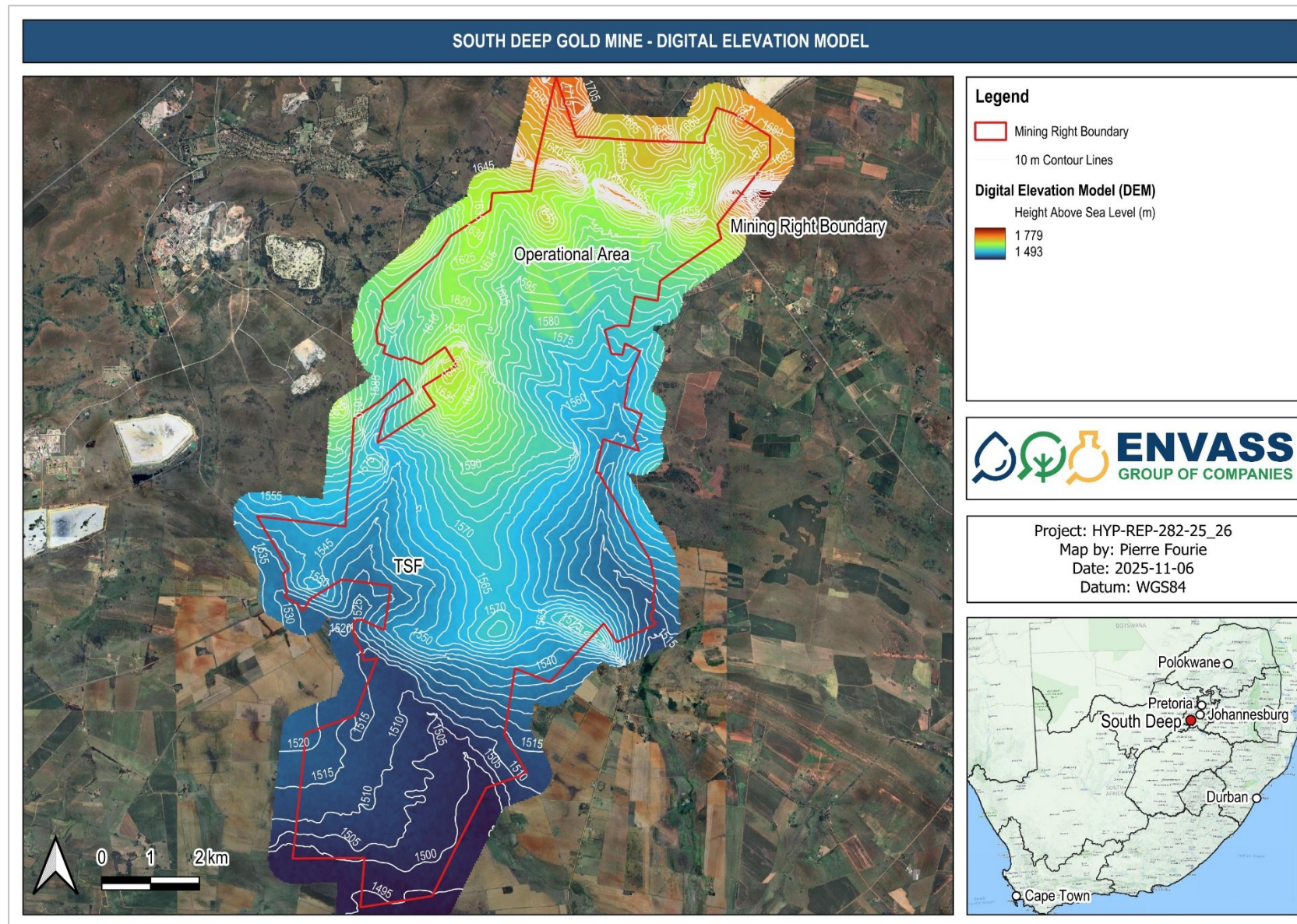


Figure 2-9: DEM of the study area.

3. METHODOLOGY

3.1. SOIL-LANDFORM ASSESSMENT AND HYDROPEDOLOGICAL ASSESSMENT

A hydro pedological survey and sampling activities were conducted in September 2025 (during the dry season) to assess the hydro pedological characteristics of the landscape and associated soils within the project area. A soil sampling exercise was undertaken at selected representative points, considering the various soil types, hillslopes and catena's in order to deduce the wetland recharge mechanisms and identify the anticipated hydro pedological impacts of South Deep Gold Mine on the wetland resources. Subsurface soil observations were made by means of a standard hand auger (until 1.5 m or refusal) and investigation methods.

Identification of the Various Hillslopes:

Prior to the site visit a desk-based exercise was undertaken which included the following:

- Identification of land types (LTSS, 1972 – 2006) within the study area; and
- Identification of dominant hillslopes (from crest to stream) of the study area using terrain analysis (SWAT).

Conceptualise Hillslope Hydro pedological Responses:

- A transect soil survey was conducted on each of the identified hillslopes (Van Tol, *et al.* 2023);
- Soil observations were made at predetermined positions based on the landscape, on the transect; and
- Analysis of soil was made by means of a hand auger (until 1.5 m, or refusal) as well as analysis of exposed profile areas which depict the diagnostic horizon sequence.

Field assessment data included description of physical soil properties including the following parameters, in order to characterise the various recharge mechanisms of the investigated wetlands:

- Diagnostic soil horizon sequence;
- Landscape position in relation to the investigated wetlands (recorded on GPS); and
- Depth to saturation (water table), if encountered.

Conceptual Hillslope Hydro pedological Response:

The occurrence, sequence, and coverage of the different hydro pedological groups on a transect was used to describe the hydrological behaviour of the hillslope. This includes a graphical representation of the dominant and sub-dominant flow paths at hillslope scale prior to development. This will include:

- Overland flow;
- Subsurface lateral flow;
- Bedrock flow;

- Return flow; and
- Storage mechanisms.

Field assessment data was subsequently used to carry out the following assessments and investigation:

- Verify the spatial extent of the identified soil forms using a GIS software programme (QGIS);
- Identify the potential impacts of the proposed development on the unsaturated flow processes, and implications to the functionality of the wetland systems;
- Compile a brief report on the conceptual hydropedological regime of the assessed wetlands based on the soil types within the study area under current conditions; and
- Recommend suitable mitigation and management measures to alleviate the identified impacts on the wetland hydropedological conditions.

Identification of Soil Forms and Hydropedological Counterparts:

The dominant soil forms were identified within the investigated transects and at strategic locations. Soil auger observations were used to classify and describe the soils and to ensure that the variation within the soil distribution patterns were captured. The profile descriptions and soil classifications were done according to the Soil Classification Working Group (2018). Soil morphological properties were then related to a specific hydrological behaviour (van Tol and Bouwer., 2024). The soils were further ascribed to their hydropedological soil groups recognised as recharge (deep, shallow, and slow), interflow (soil/ bedrock, shallow, and slow), and responsive (shallow, wet, and Hortonian). Soil chemical properties were then used to verify the soil morphological interpretations of hydrological behaviour, since chemical trends can indicate recent soil hydrological behaviour. It is important to note that, for modelling purposes, a high-level extrapolation of the soils was done over the model area. Sub-catchments and hillslopes specific to the project is thus modelled at a higher accuracy in comparison to sub-catchments where soils were extrapolated to. Ultimately, it does not affect the outcome of the modelling exercise over the targeted areas.

Figure 3-1 indicates the hillslopes that were identified within the sub-catchments/ basins as well as the location of the sampling points.

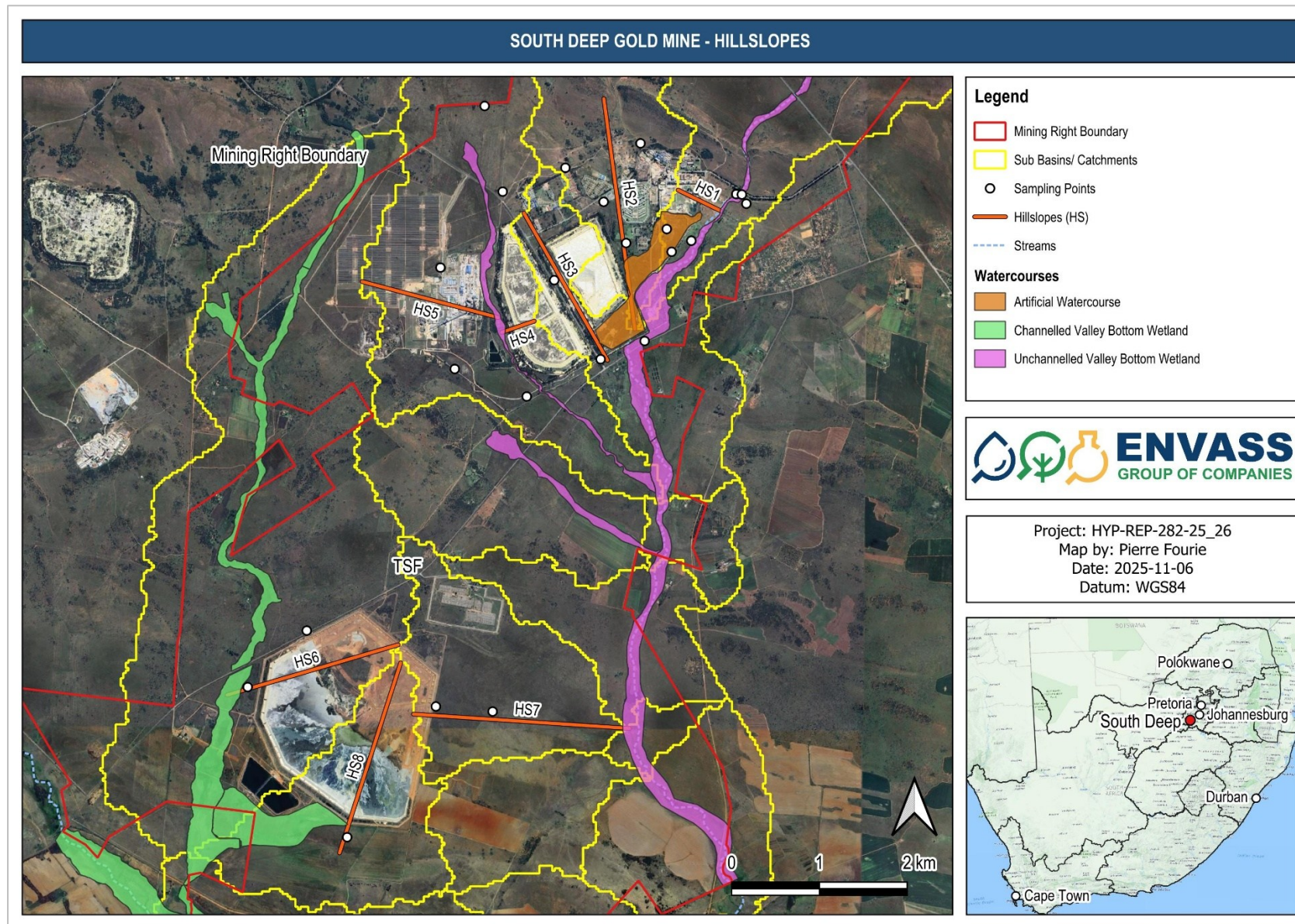


Figure 3-1: Identified hillslopes and sampling points.

3.2. MODELLING

The hydrological model SWAT+ (v 3.0.5) was used for the modelling process with QSWAT+ (v. 3.0.5) to set up the watersheds. SWAT+ is a revised version of the well-known Soil and Water Assessment Tool. SWAT is a widely used small watershed to river basin-scale model. It is typically used to simulate the quality and quantity of surface and groundwater and predict the environmental impact of land use, land management practices, and climate change. The aim of the hydrological modelling was to quantify the dominant hydrological processes as well as the impact of the proposed development on these processes and the wetlands (at a HRU level) associated with the project area. The existing operation will be used as a baseline to model existing flow paths and flow rates. Although modelling and reporting was undertaken on simulated percolation volumes, the impact of the proposed development on groundwater resources is beyond the scope of this study.

The watershed area was determined from a 30m DEM and subdivided into sub-basins, with Landscape Units (LSUs) and HRUs. These LSUs were consequently the focus of this modelling. The current land use was obtained from the South African National Land-Cover Database (DFFE, 2021) and visual inspection with predefined parameters for each of the uses. To simulate the current status of the development, the various infrastructure areas were assigned an “industrial” class (Arnold, *et al.*, 2012).

The soils identified from the soil survey were reclassified and regrouped into hydropedological classes according to (Van Tol and Bouwer, 2024): Interflow soil/ bedrock (ISB), responsive Hortonian (RHo), responsive shallow (RS), responsive wet (RW); recharge shallow (ReS) and recharge deep (ReD). These abbreviations were used within the model with certain properties assigned to each horizon of the soil. The soils were further extrapolated to cover the areas outside the study area using the Land Type soil information and thus enabling the modelling to take place at a larger catchment scale. Soil physical parameters such as bulk density, particle size distribution affecting the water content and the hydraulic conductivity were based on field observations.

A 39-year simulation period was selected (January 1985 – January 2024) of which the first three (3) years were used as a warm-up period. WeatherGen in SWAT+ Editor used daily precipitation, temperature (minimum and maximum), wind speed, solar radiation and relative humidity from selected stations to generate daily climatic variables for the simulations. The daily precipitation was adjusted so that the annual rainfall was comparable with the measured rainfall for the site. Results are reported only as yearly averages for the affected HRUs, LSUs and the basin, before, and after the proposed development.

The key parameters used in the modelling process are summarised in **Table 3-1** below and base raster data represented in **Figure 3-2** to **Figure 3-4**.

Table 3-1: Model input parameters.

Input Parameter	Description
Digital Elevation Model (DEM)	30m STRM
Landcover	South African National Land-Cover Database (2013 – 2014) and visual observations
Weather data	Weather Gen (SWAT+ editor)
Soil data	In-situ soil data and land type (land cover and urban areas) data
Vegetation cover	Generic plant data from SWAT+
Project footprint size (modelled area)	10 486.253 ha
Sub-catchment/ basin size (a total of 15 were identified by SWAT)	8 304.059 ha

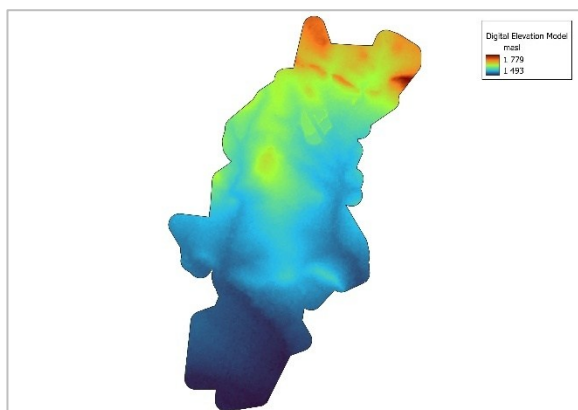


Figure 3-2: DEM.

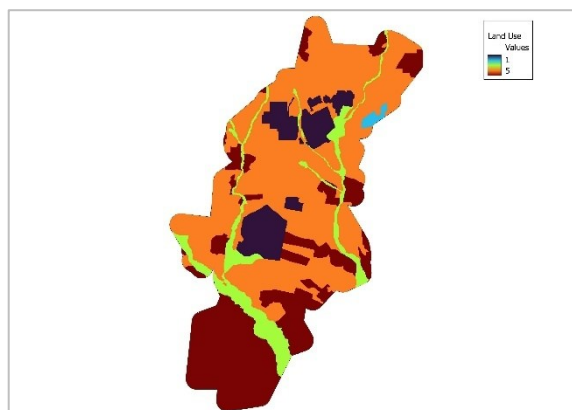


Figure 3-3: Current land cover.

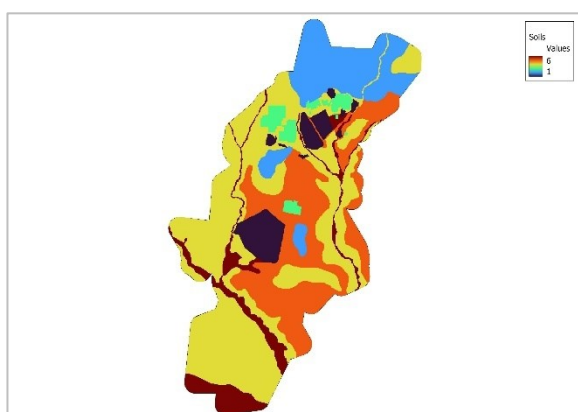


Figure 3-4: Hydropedological soils.

4. HYDROPEDOLOGICAL SOIL TYPES AND HILLSLOPES

4.1. SITE SPECIFIC SOILS

ENVASS undertook a site visit in September 2025 to determine the soil forms present on the identified hillslopes. **Figure 4-5** indicates the dominant soil forms identified over the project area within each hillslope (then extrapolated over the entire project area), where **Table 4-1** provides information regarding the diagnostic horizons of the soil families. **Figure 4-1** to **Figure 4-4** provides a photographic record of selected soil properties used to identify the various soil forms and families.

Table 4-1: Soils identified on-site.

Soil Form and Family	1 st Horizon	2 nd Horizon	3 rd Horizon	Size (ha)	Percentage of Study Area
Bainsvlei (Bv) 1220	Orthic A	Red apedal	Soft plinthic	2 450.449 ha	23.34%
Clovelly (Cv) 1222	Orthic A	Yellow-brown apedal	Lithic	3 323.154 ha	31.69%
Glencoe (Gc) 1220	Orthic A	Yellow-brown apedal	Hard plinthic	21.242 ha	0.20%
Glenrosa (Gs) 2110	Orthic A	Lithic	-	1 434.352 ha	13.68%
Hutton (Hu) 1220	Orthic A	Red apedal (thick)	-	1 238.324 ha	11.81%
Johannesburg (Jo) 2200 (Urban technosol)	Exposed subsoil, asphalt, infrastructure and other urban areas	Where present, exposed red/yellow apedal, gley material, hard rock and lithic material	-	313.422 ha	2.99%
Mispah (Ms) 1120	Orthic A	Solid rock	-	72.449 ha	0.69%
Pollution Control Dams (PCD's)	-	-	-	42.893 ha	0.41%
Rensburg (Rg) 1000	Vertic A	Gley	-	920.15 ha	8.77%
Vaalbos (Vb) 1221	Orthic A	Red apedal	Hard rock	13.964 ha	0.13%
Witbank (Wb) 1200 (Transported technosol)	Ex-natural soil	Tailings material	-	156.32 ha	1.49%
Wb 1300	Ex-natural soil	Backfilled material	-	79.338 ha	0.76%
Wb 2100	Anthropogenic material	Undisturbed natural soils	-	6.296 ha	0.06%
Wb 2200	Anthropogenic material (TSF)	Anthropogenic material (TSF)	-	383.988 ha	3.66%
Willowbrook (Wo) 1000	Melanic A	Gley	-	29.912 ha	0.29%
Total				10 486.253 ha	100%

The study area primarily comprises of natural soils that have not been impacted by agricultural land scattered throughout. The soils that form part of the hillslopes, on the contrary, consists largely of anthropogenic soils from mining and processing activities. The topsoil has been extensively removed, and/ or covered as a result of construction and operations typical of underground mining and processing in regions like Gauteng or Mpumalanga. The subsoil is characterised by yellow and red apedal soils, alongside gley material indicative of periodic waterlogging, hard rock formations, and lithic/ plinthic material often found in the Highveld and other geologically diverse areas. In some sections of the study area, subsoil has been excavated (or covered by the TSF's) and used as backfill and subsequently transported through alluvial processes during seasonal rains or aeolian processes during dry, windy conditions. This material has been deposited into adjacent wetlands and streams, potentially impacting hydro pedological functions such as water retention and filtration. These disturbances may exacerbate soil erosion and sedimentation, further affecting the ecological integrity of local wetland systems, which are vital for biodiversity conservation and water resource management.



Figure 4-1: Red apedal B horizon.



Figure 4-2: Yellow-brown B horizon.



Figure 4-3: Shallow, rocky soils.



Figure 4-4: Lithic material in the subsoil horizon.

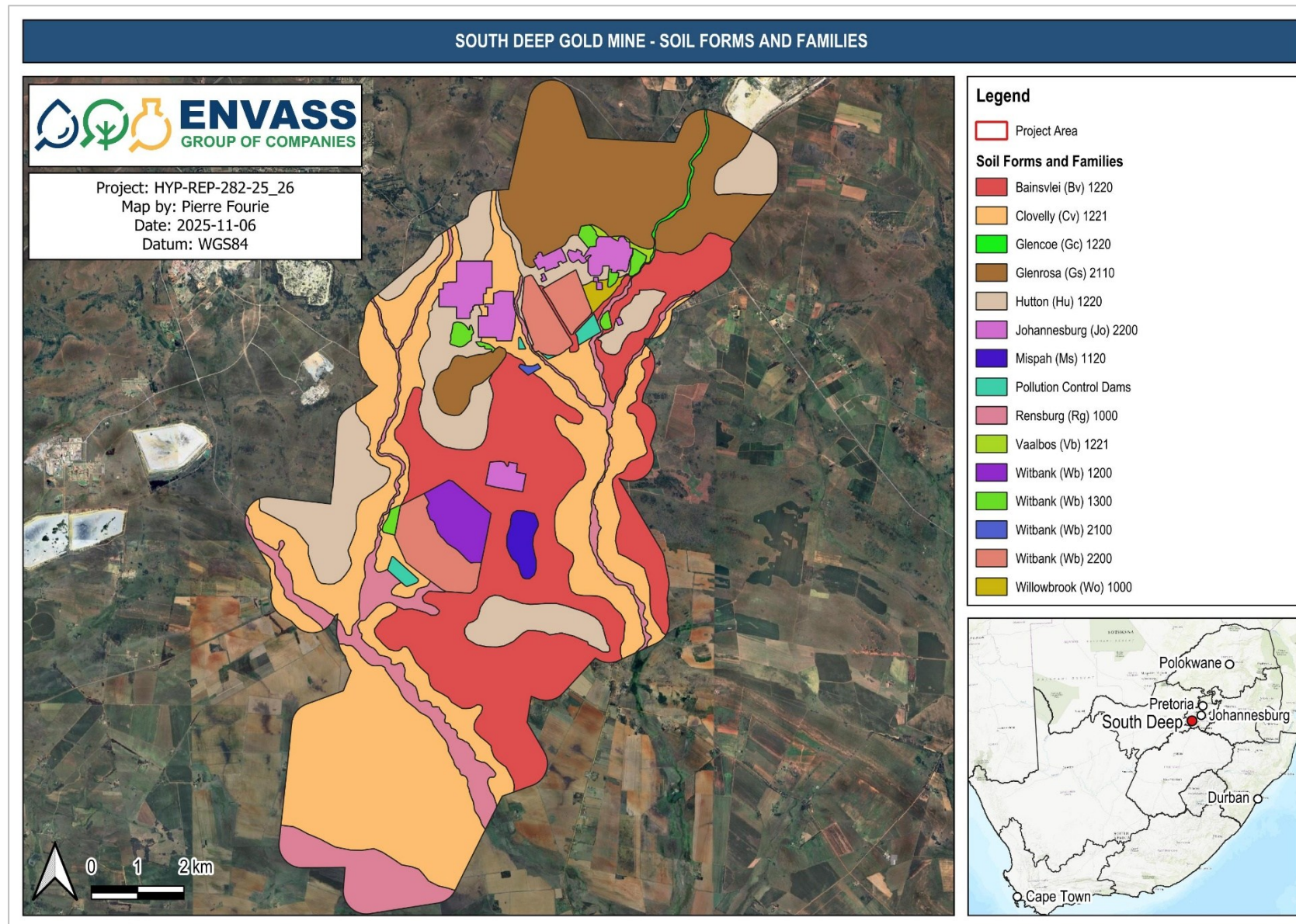


Figure 4-5: Soil forms and families present on site.

4.2. HYDROPEDOLOGICAL SOIL TYPES

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 2.4), which were used to determine the hydrological soil types (HSTs). Finally, a conceptualisation of hydrological processes (Van Tol, *et al.* 2023) that occur on the various hillslopes, based on HST was undertaken. **Table 4-2** indicates the identified soil forms and their hydrological soil counterpart (Van Tol and Bouwer, 2024) and is illustrated in **Figure 4-6**.

Table 4-2: Hydropedological soil groups present on site.

Soil Form and Family	Hydrological Counterpart	Area (ha)	Percentage of Study Area (%)
Jo 2200	Responsive (Hortonian).	313.422 ha	2.99%
Gs 2110	Recharge (Shallow).	1 434.352 ha	13.68%
Vb 1221	Recharge (Deep)	4 639.577 ha	44.24%
Cv 1221			
Gc 1220			
Hu 1220			
Bv 1220	Interflow (Soil/ Bedrock).	2 450.449 ha	23.37%
Wo 1000	Responsive (Wet).	950.062 ha	9.06%
Rg 1000			
Ms 1120	Responsive (Shallow).	698.391 ha	6.66%
Wb 1200			
Wb 1300			
Wb 2100			
Wb 2200			
Total		10 486.253 ha	100%

4.2.1. Responsive (Hortonian) Soils

Soils with vertic horizons will swell and close during wet periods. The hydraulic conductivity/ infiltration rate of these soils with high 2:1 clay content is less than the rainfall intensity and will therefore generate overland flow due to infiltration excess. This is often referred to as Hortonian overland flow. Degraded soils with surface crusting or sodic soils will behave similarly. (Van Tol and Bouwer, 2024).

4.2.2. Recharge (Shallow) Soils

These are freely drained topsoil horizons overlying fractured rock or saprolite. The contribution of these soils to transpiration is lower than that of 'recharge (deep)' soils. Due to the relatively short residence time in the biological zone (solum), water exiting 'recharge (shallow)' soils has a lower reduction potential (oxygenized) (Van Tol and Bouwer, 2024).

4.2.3. Recharge (Deep) Soils

These are deep, freely drained soils without any indication of saturation overlying fractured rock or deeply weathered saprolite. In drier areas, the underlying bedrock might not be permeable, and the absence of hydromorphic properties is due to insufficient rainfall to cause saturation for significant periods (Van Tol and Bouwer, 2024). 'Recharge (deep)' soils contribute significantly to transpiration, but downward ET excess flow is the dominant flowpath.

4.2.4. Interflow (Soil/ Bedrock) Soils

In this group lateral flow is generated, either due to low permeability of the bedrock which restricts vertical drainage, or due to return flow from the bedrock flow path to the soils. The flow rate via this pathway is determined by the slope and conductivity of the interflow horizon. Flow is normally maintained on a seasonal basis, but it depends on the length and recharge area of the bedrock-return flow path (Van Tol and Bouwer, 2024).

4.2.5. Responsive (Wet) Soils

These are soils marked by saturation close to the surface layers for extended periods, especially during the wet season (Van Tol and Bouwer, 2024). Additional precipitation will not infiltrate but overland flow will be generated. These soils respond quickly to rain events, resulting in high peak flows.

4.2.6. Responsive (Shallow) Soils

These are soils with limited depth and hence small storage capacity. Underlying rocks are slowly permeable and rapid recharge of bedrock flowpaths is not likely. When significant rainfall is received, the storage capacity of the soil is exceeded, and overland flow is then generated (Van Tol and Bouwer, 2024). These soils 'respond' quickly to rain events.

4.3. CONCEPTUAL HYDROLOGICAL RESPONSE MODELS

Eight (8) Conceptual Hydrological Response Models (CHRM), one (1) per hillslope, were identified using the 30 m SRTM data, contours and SWAT+ (**Figure 4-6**). These CHRMs, although not taken from the crest of the larger hill, indicate the flow of water through the soils to the watercourses below and will be used to determine the "baseline"

flow paths of the operation. The interplay of topography, soils, climate, and vegetation gives rise to discernible, repeating patterns and laws that offer valuable insights into their functioning (Van Tol, *et al.* 2023).

These hillslopes can be broadly classified as a Class 9 hillslope (keeping in mind that variations are present on site) as per Van Tol, *et al.* 2023 (**Figure 4-7**). The reason being that surface infrastructure and TSF stockpiles react quickly during rain events and result in surface water flow that then enters the soil further downstream. The flowpaths have adapted to the current environment due to the many years that the infrastructure has been in place.

Risk to wetland from catchment development: These are generally low risk hillslopes as wetlands predominantly have short hydroperiods and are relatively self-contained. Depression wetlands often also generally have small wetland catchments, limiting the potential cumulative intensity of impacts. However, natural overland flow does contribute to the hydroperiod of wetlands in this class. Wetlands may be rich in biodiversity in wet years, although they may lie dormant for many dry years in between. Increased overland flow in a fully developed catchment can completely change the hydroperiod of a naturally seasonal or temporary wetland to more permanent.

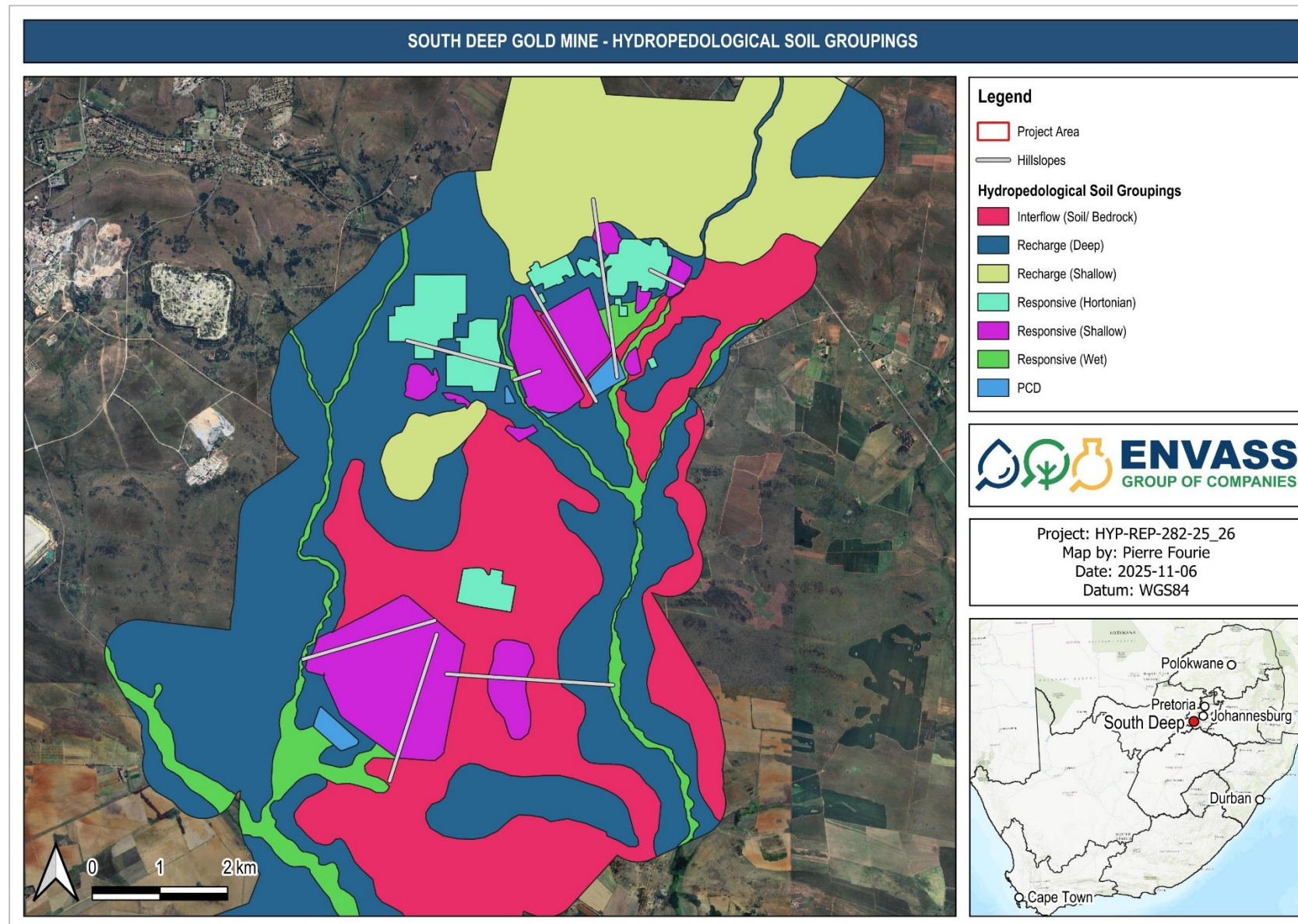


Figure 4-6: Hydro-pedological soil groups present on site.

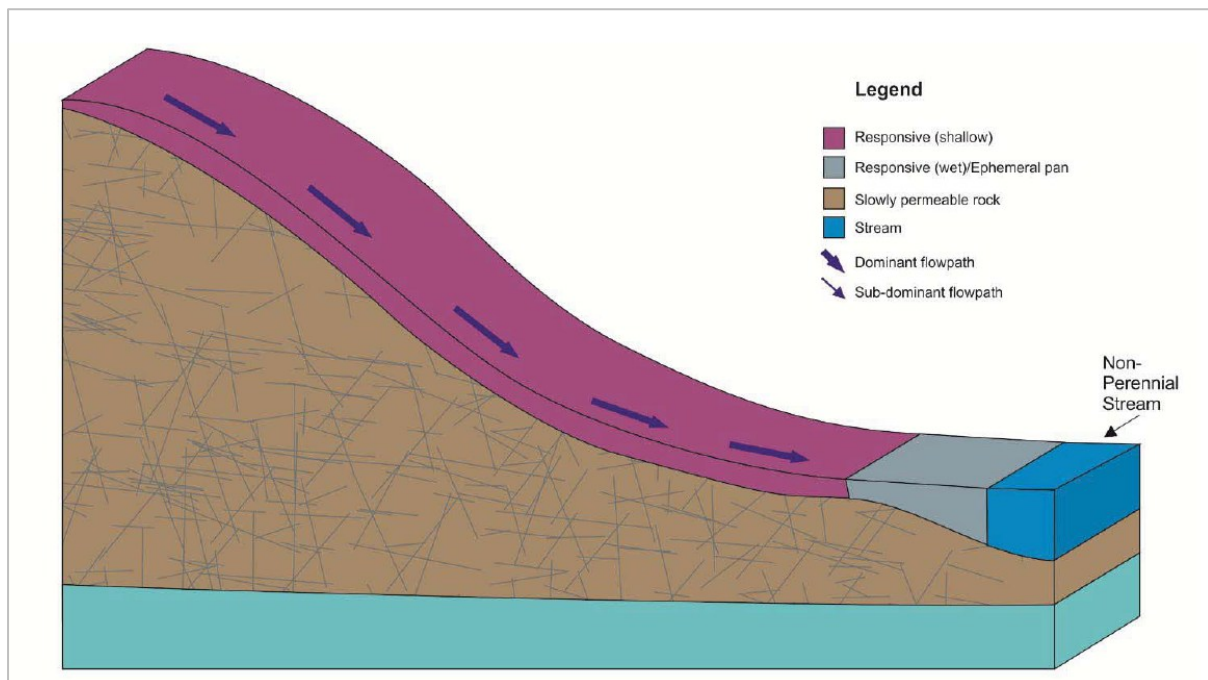


Figure 4-7: Conceptual hydrological response of a Class 9 hillslope (Van Tol, *et al.* 2023).

4.3.1. Conceptual Hydrological Response Model 1

Conceptual Hydrological Response Model (CHRM) 1 is characterised by mostly responsive soils (Hortonian and shallow, respectively) on the majority of the hillslope, with deep recharge soils just before the unnamed tributary. The responsive soils are due to infrastructure and an old, backfilled pit. The predominant flow path for this hillslope will be overland surface flow due to compacted surfaces preventing water infiltration (due to infrastructure and backfilled material). Surface flow associated with the infrastructure areas enter stormwater trenches and is channelled to the PCDs. Surface flow and secondary vertical flow from the backfilled area will enter the deep recharge soil at the bottom of the hillslope and predominantly flow vertically into the groundwater regime. The flow will move into the groundwater and continue downslope until it reaches the stream. **Figure 4-8** illustrates this CHRM with the dominant flow paths as it is currently (anthropogenic activities included). This is the current flow drivers and paths as a baseline could not be established. This will account for all of the CHRMs. Discharge area one (1) [which includes discharge point one (1)] is located downstream of this hillslope. The soils associated with this discharge area are classified as interflow (soil/ bedrock) and responsive (wet) soils. Both limit vertical flow into the groundwater regime. However, as the pipeline to the discharge point is above ground, the impact on the flow drivers/ paths will be negligible.

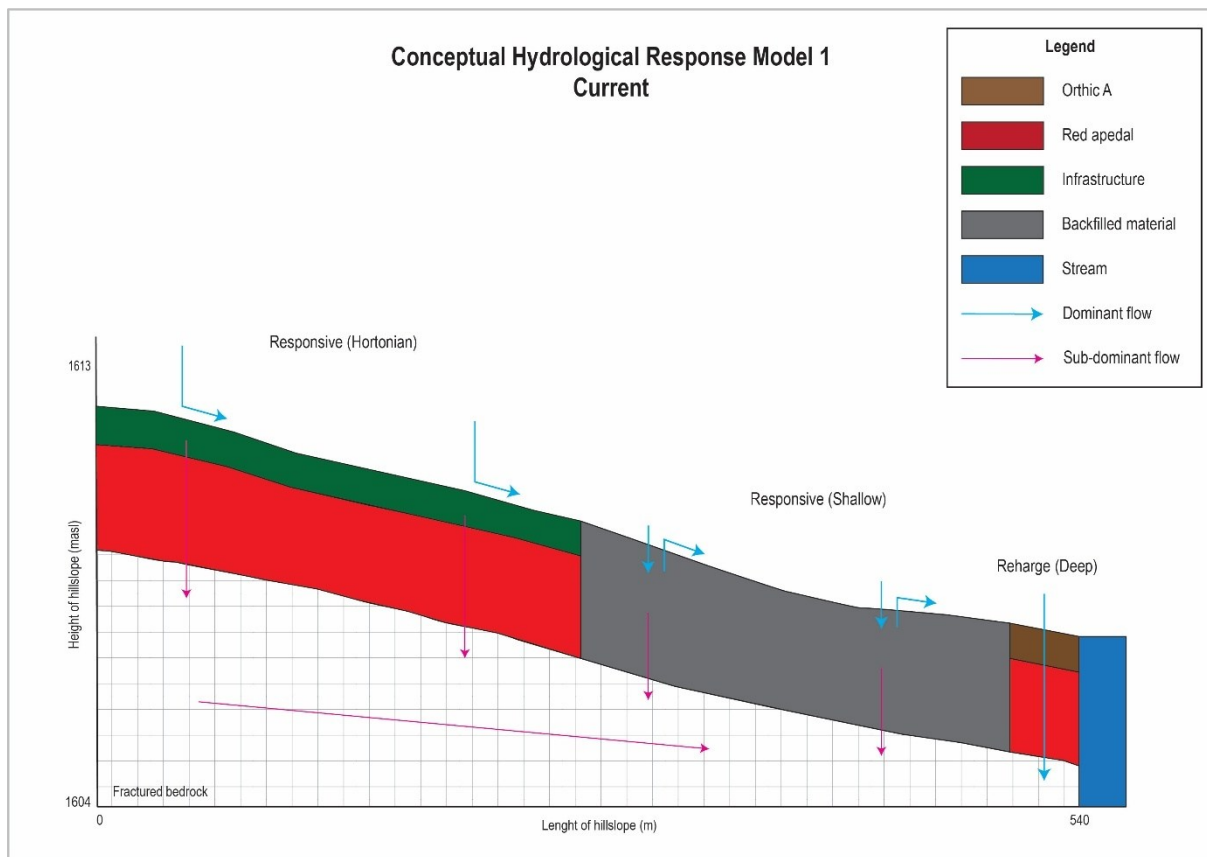


Figure 4-8: CHRM 1.

4.3.2. Conceptual Hydrological Response Model 2

The length of this hillslope (2 660 m) resulted in various hydropedological soil groupings. This CHRM is characterised by predominantly recharge soils (shallow at the top of the hillslope with deep sections further down the hillslope). As with CHRM 1, responsive soils (Hortonian and shallow) are a result of the infrastructure and old backfilled pits. A large wetland is located within this hillslope that consists of responsive wet soils before a small interflow (soil/ bedrock) area. The main PCD is located at the bottom of this hillslope. The main flow driver for this hillslope will be vertical into the groundwater regime with surface water flow the secondary flow driver over the responsive soils. Surface flow associated with the infrastructure areas (if not channelled into stormwater trenches) enter the deep recharge soils. The wetland associated with this hillslope has a clayey A horizon that swells during rain events and results in surface flow. Water flows laterally within interflow soils (as found at the bottom of this hillslope) and in this instance, flows around the PCD until the unnamed tributary. Soil/ bedrock interflow soils result in generally lateral water flow (this occurs after the water has moved horizontally through the red/ yellow apedal horizon and reaches the layer of impendence, which is a lithic horizon in the Bainsvlei soil form) **Figure 4-9** illustrates this CHRM with the dominant flow paths as it is currently (anthropogenic activities included).

Discharge area two (2) [which includes discharge points two (2) and three (3)] is located at the bottom of this hillslope (just below the PCD). The soils associated with this discharge area are classified as interflow (soil/ bedrock) and responsive (wet) soils (keep in mind that this area has been severely impact upon by anthropogenic

activities and this has affected flow paths/ drivers). Both limit vertical flow into the groundwater regime. However, as the pipeline to the discharge point is above ground, the impact on the flow drivers/ paths will be negligible. Water from this discharge point will also enter directly into the watercourse.

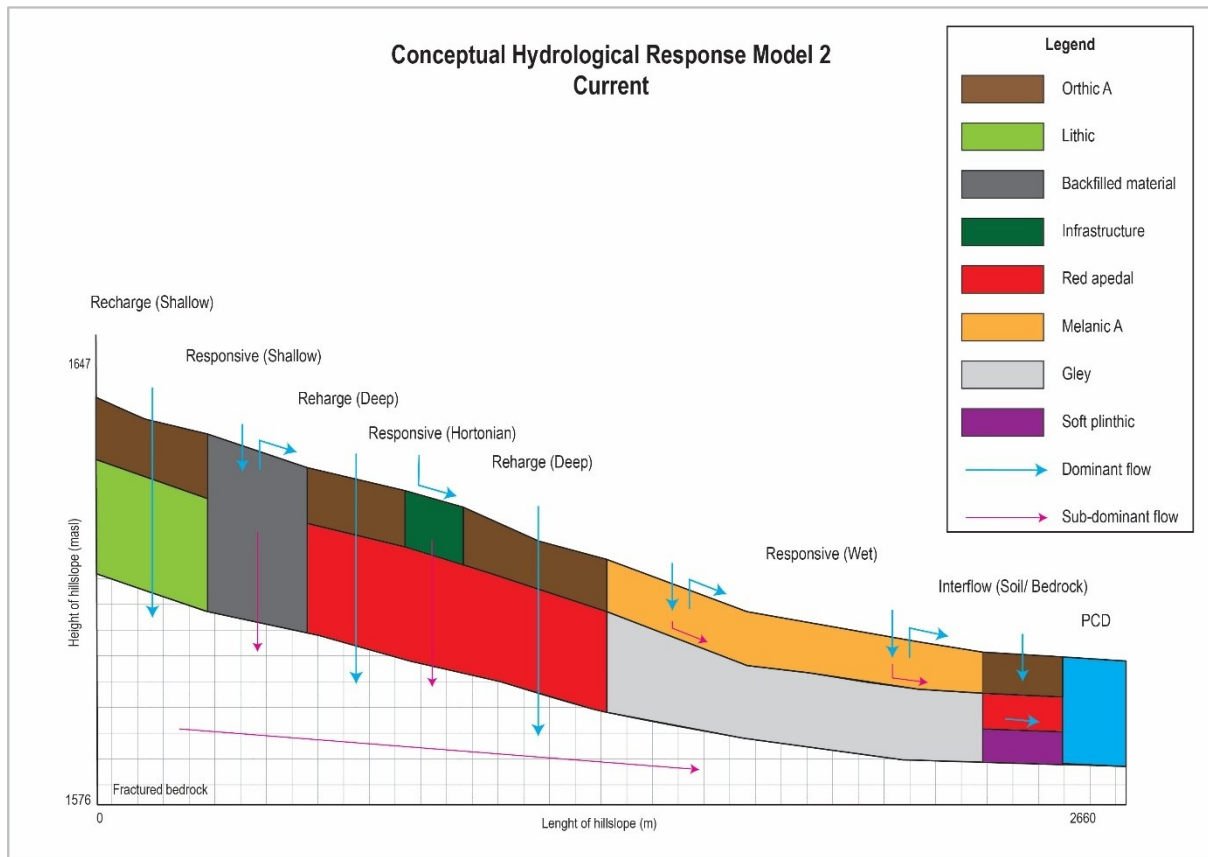


Figure 4-9: CHRM 2.

4.3.3. Conceptual Hydrological Response Model 3

CHRM 3 is mostly covered with tailings material (TSF) while the rest of the hillslope is divided into areas with deep recharge and interflow (soil/ bedrock) soils. Deep recharge soil allows water to flow vertically into the groundwater regime from where it makes its way to streams and rivers downstream. Water flows laterally through the interflow soils on the soil/ bedrock horizon until the limiting horizon changes and water flow vertically within the recharge soils. Rainwater that falls onto the TSF does not enter the natural soil and is collected via stormwater drains and channelled to the PCDs. **Figure 4-10** illustrates this CHRM with the dominant flow paths as it is currently (anthropogenic activities included). The impact of the proposed new infrastructure will be discussed in Section 5.

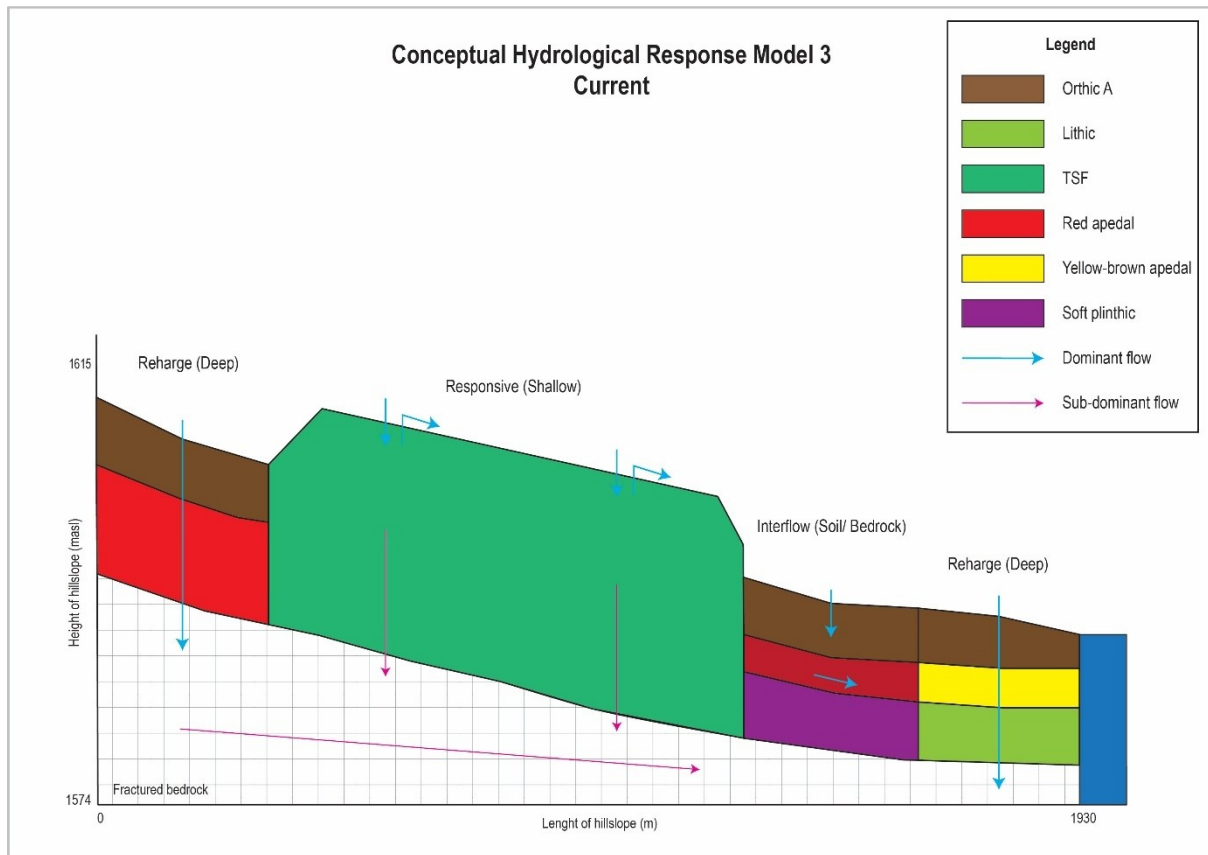


Figure 4-10: CHRM 3.

4.3.4. Conceptual Hydrological Response Model 4

As with CHRM 3, CHRM 4 is characterised by mostly shallow responsive soils associated with the TSF, followed by a section of deep recharge soils, and finally a responsive wet soil associated with the wetland of the Kariagarivier. Surface water runoff associated with the TSF is collected and channelled to the PCDs. The predominant flow path for this hillslope will be vertical flow through the soil horizons into the underlying bedrock and groundwater regime. The flow will move into the groundwater and continue downslope until it reaches the stream. The responsive wet soils (Vertic A and Gley horizons) will become saturated quickly during wet periods and overland flow will be the main flow path. **Figure 4-11** illustrates this CHRM with the dominant flow paths as it is currently (anthropogenic activities included).

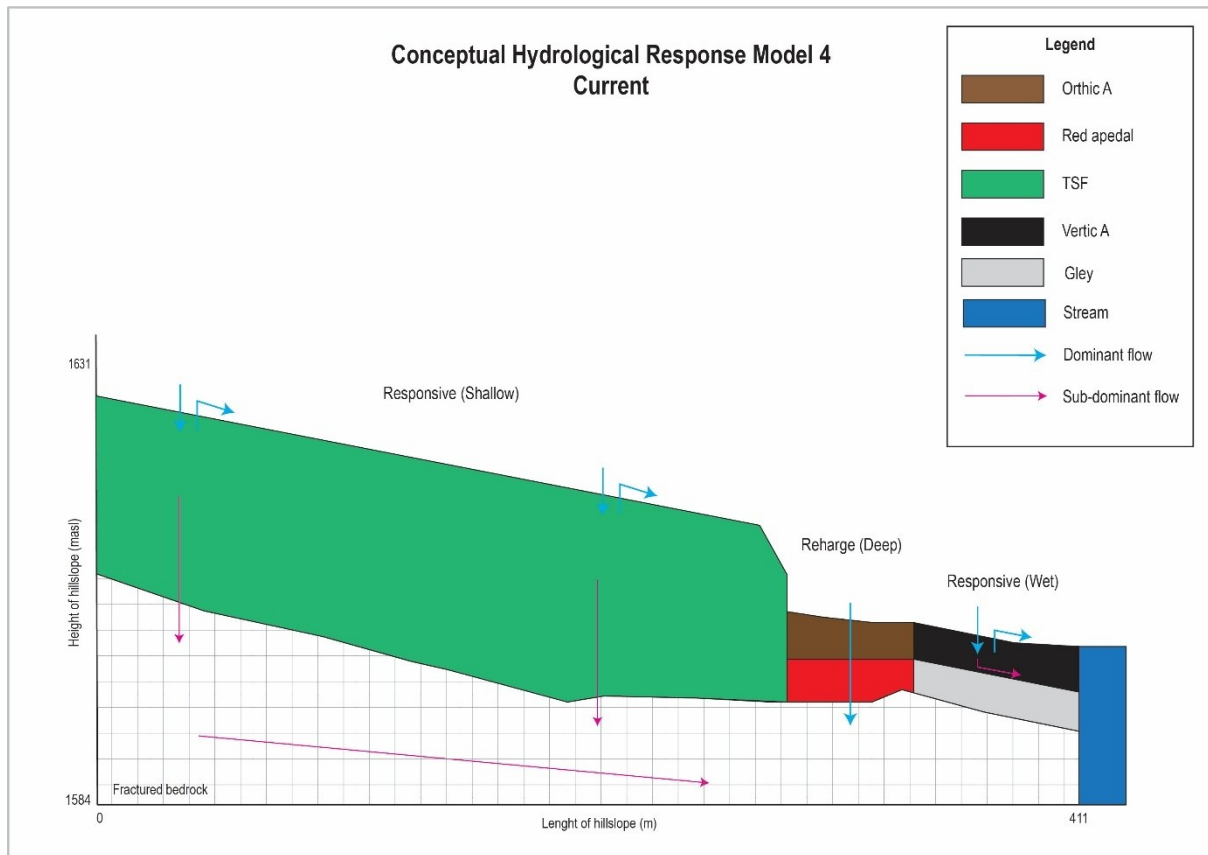


Figure 4-11: CHRM 4.

4.3.5. Conceptual Hydrological Response Model 5

As with CHRM 2, this hillslope consists of various hydropedological soil groupings due to its length and the anthropogenic activities. The largest section of this CHRM is characterised by Hortonian soils. As with CHRMs 1 and 2, Hortonian soils are a result of the infrastructure in the area and result in surface flow (due to compaction). The rest of the hillslope consist of deep recharge soils in which water flows vertically into the groundwater regime. Further down the hillslope the soils consist primarily of clay material (which swells when saturated and prevent infiltration) and thus flows via the surface to the stream. **Figure 4-12** illustrates this CHRM with the dominant flow paths as it is currently (anthropogenic activities included). The impact of the proposed new infrastructure will be discussed in Section 5.

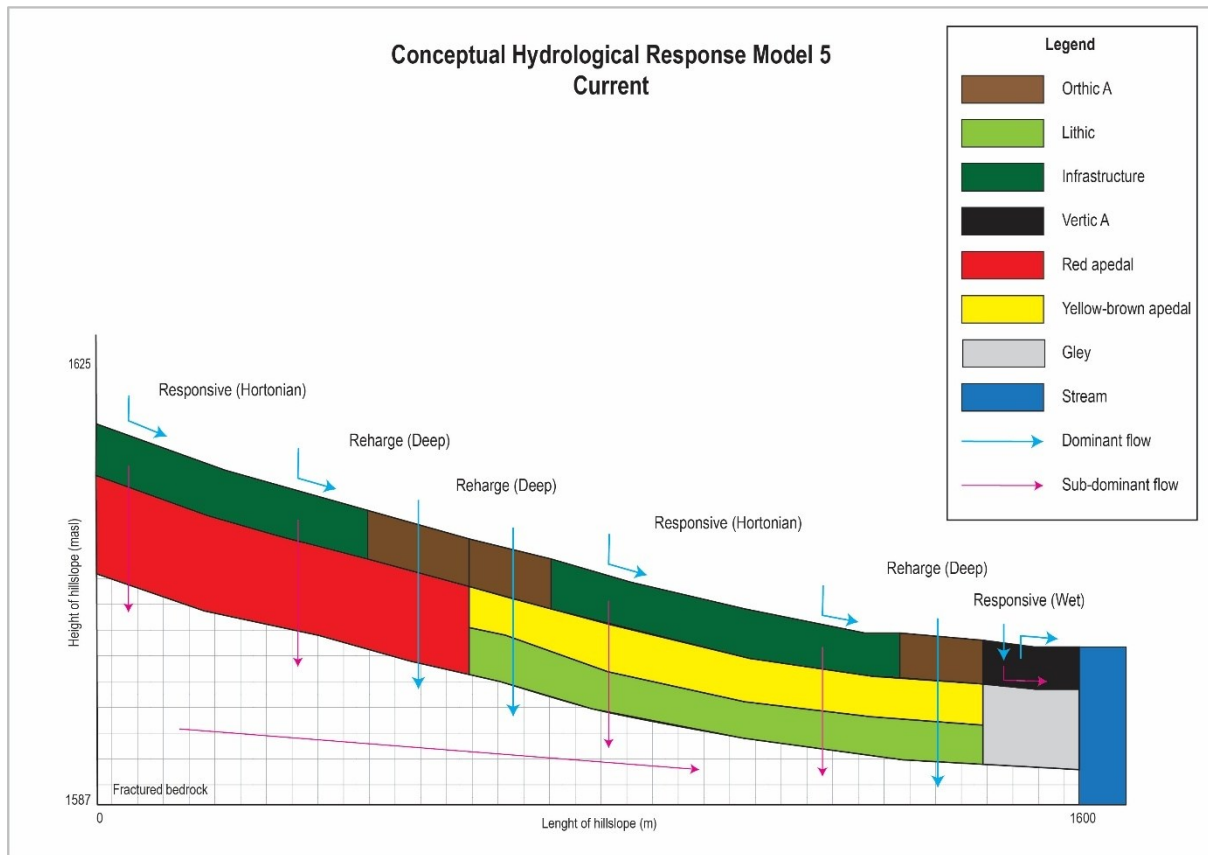


Figure 4-12: CHRM 5.

4.3.6. Conceptual Hydrological Response Model 6

As with CHRM 4, CHRM 6 is characterised by mostly shallow responsive soils associated with the Doornpoort TSF, followed by a section of deep recharge soils, and finally a responsive wet soil associated with the wetland of the Leeuspruit. Surface water runoff associated with the Doornpoort TSF is collected and channelled to the PCDs. The predominant flow path for this hillslope will be vertical flow through the soil horizons into the underlying bedrock and groundwater regime. The flow will move into the groundwater and continue downslope until it reaches the stream. The responsive wet soils (Vertic A and Gley horizons) will become saturated quickly during wet periods and overland flow will be the main flow path. **Figure 4-13** illustrates this CHRM with the dominant flow paths as it is currently (anthropogenic activities included).

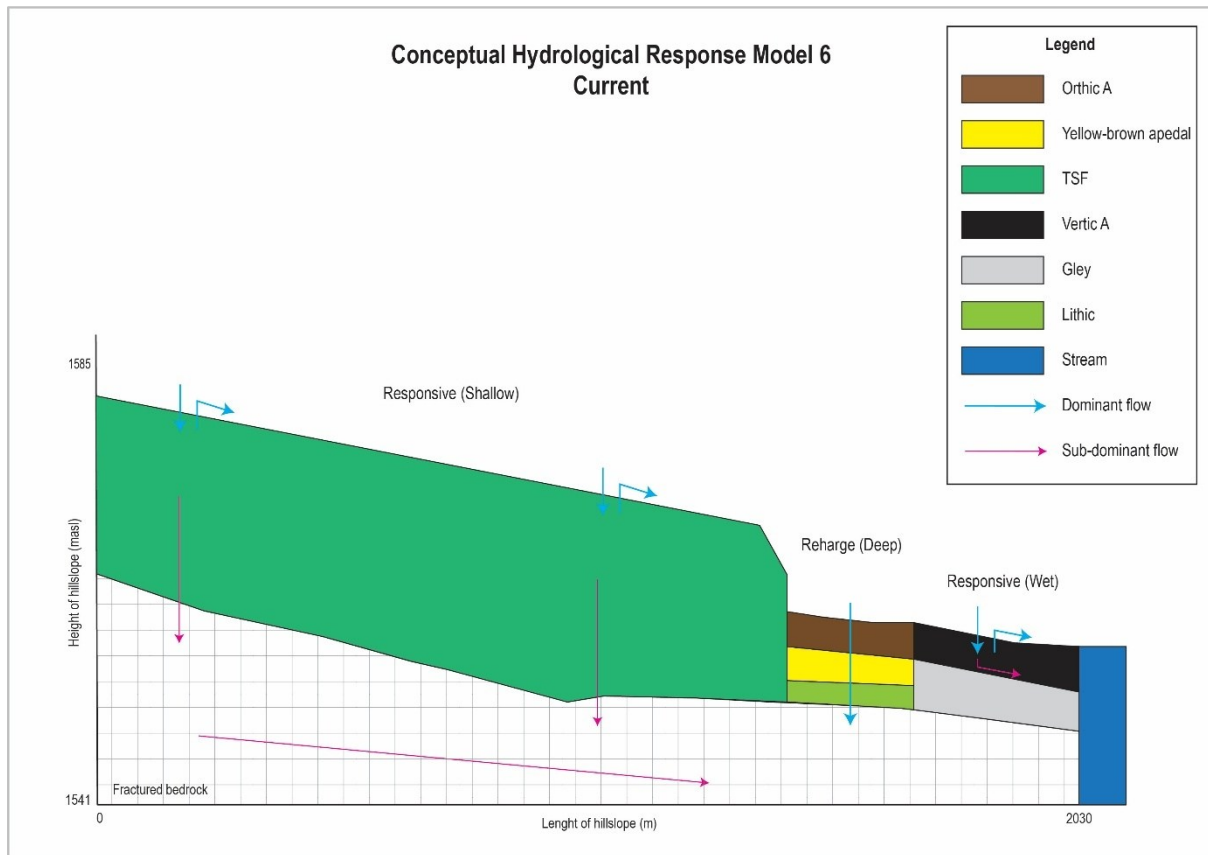


Figure 4-13: CHRM 6.

4.3.7. Conceptual Hydrological Response Model 7

CHRM 7 is another long (2 460 m) hillslope with very little anthropogenic related disturbance. The top of the hillslope consists of shallow responsive soils (that of the Doornpoort TSF) which results in surface water flow (collected by stormwater channels and routed to the PCD). The majority of the rest of the hillslope consists of interflow soils (soil/ bedrock) which encourage lateral flow down the hillslope into either a shallow soil area or deep recharge soils. As mentioned above, water enters deep recharge soils and flows vertically until it enters the groundwater regime and finally a stream of river. The section of shallow responsive soils (shallow Orthic A overlying hard rock material) becomes saturated quickly during a rainfall event and thus the water flows over the surface until it can penetrate the soil further. **Figure 4-13** illustrates this CHRM with the dominant flow paths as it is currently (anthropogenic activities included).

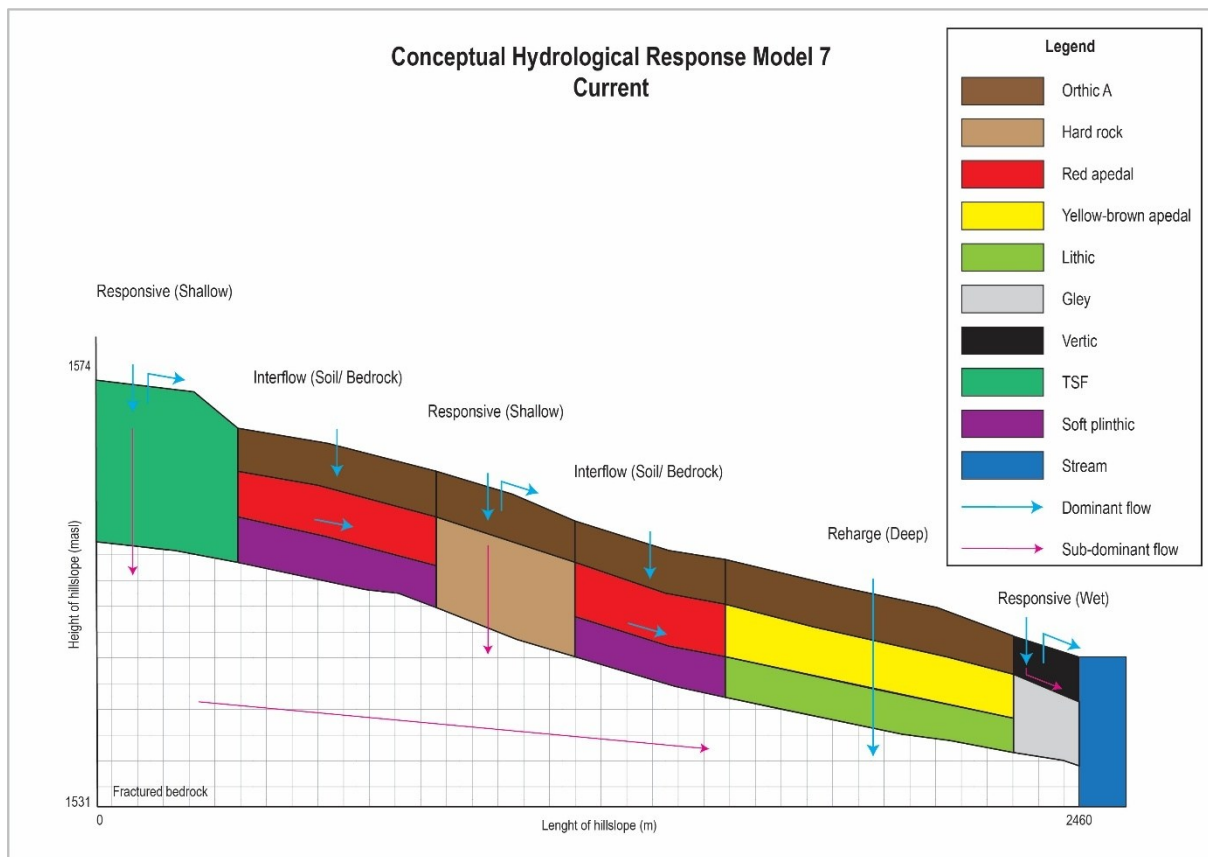


Figure 4-14: CHRM 7.

4.3.8. Conceptual Hydrological Response Model 8

As with CHRM 6, CHRM 8 is characterised by mostly shallow responsive soils associated with the Doornpoort TSF, followed by interflow soils (soil/ bedrock) until a drainage line associated with the Leeuspruit. Surface water runoff associated with the Doornpoort TSF is collected and channelled to the PCDs. The predominant flow path for this hillslope will be lateral flow through the A and B soil horizons onto the soil/ bedrock interface (soft plinthic material associated with the Bainsvlei soil form). Water will then flow laterally on this limiting layer until it reaches the drainage line and wetland. **Figure 4-15** illustrates this CHRM with the dominant flow paths as it is currently (anthropogenic activities included).

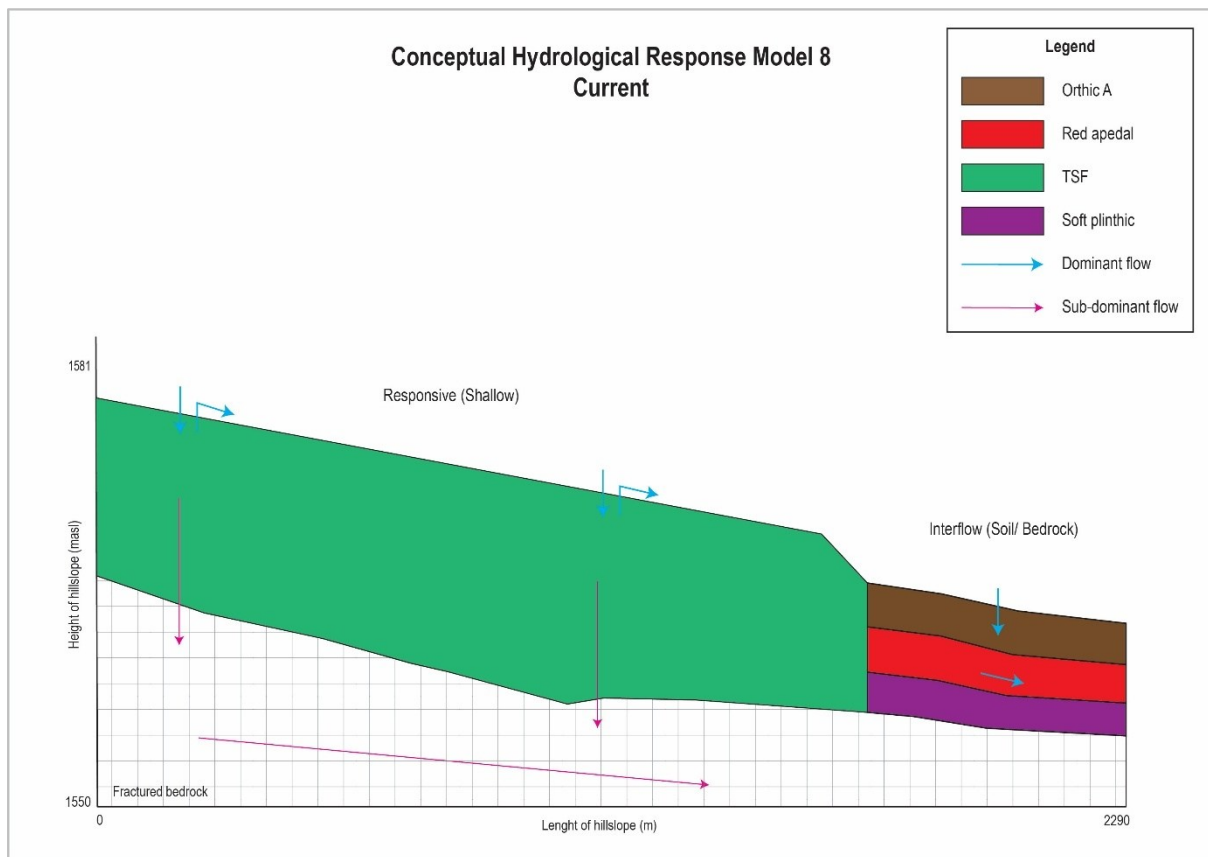


Figure 4-15: CHRM 8.

5. MODELLING RESULTS AND IMPACTS

The SWAT+ model was used to determine the baseline flow of water through the various watersheds associated with the CHRM (and hillslopes). The outputs below are given as an annual volume and/ or percentage (Arnold, *et al.*, 2012) for each of the watersheds (which consists of various HRU's). HRU's are portions of a subbasin that possess unique land use/ management/ soil attributes. An HRU is not synonymous to a field, rather it is the total area in the subbasin with a particular land use, management and soil. While individual fields with a specific land use, management and soil may be scattered throughout a subbasin, these areas are lumped together to form one HRU.

5.1. MODELLING RESULTS

The results (current situation) given in **Table 5-1** indicate three (3) major flow paths associated with the study area, namely: (1) surface flow (due to the large quantities of clayey soils and compacted soils within the industrial areas), (2) lateral flow and (3) vertical flow. These observations were based on modelled weather data from 1985 – 2024. The modelling results indicate the current flow paths and flow drivers associated with the sub-catchments associated with South Deep Gold Mine. The proposed discharge points will have an insignificant impact on the hydrogeology as the discharge will take place into the streams and not onto any soils. There will be no flow loss to the wetlands due to the proposed discharging and impacts, and mitigation measures are given in the Sections below. **Figure 5-1** visually represents the various flow paths as well as the modelled volumes.

Table 5-1: Summary of surface flow on an HRU scale before and after the extension.

Sub-Catchment (SC)	Surface Flow (mm/ month)	Lateral Flow (mm/ month)	Recharge (mm/ month)
SC 1	37.63	2405.48	2435.3
SC 2	214.00	2296.32	2297.97
SC 3	328.00	2981.5	2848
SC 4	248.25	5875	5978.4
SC 5	72.94	1364.33	1535.16
SC 8	100.75	1387.76	1496
SC 10	104.50	1421	1389.64

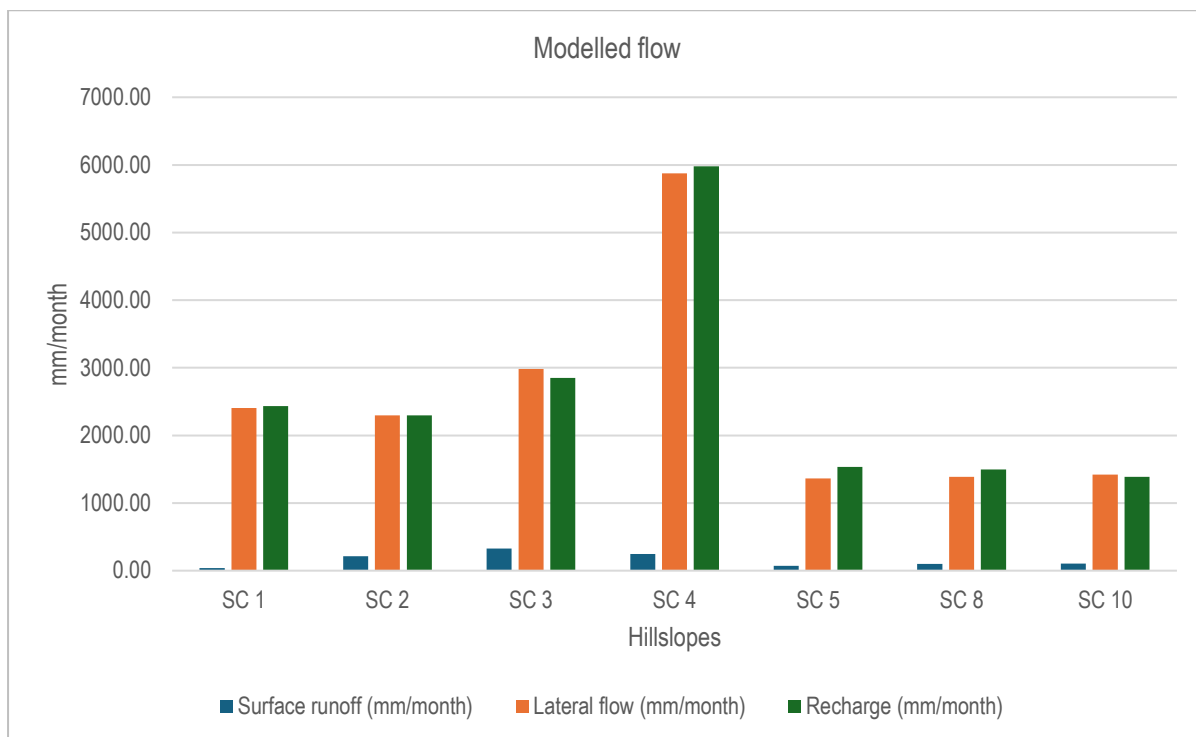


Figure 5-1: Modelled flow of various flow drivers within the relevant sub-catchments.

5.2. WATER LOSS AND IMPACTS ON HILLSLOPES

5.2.1. Water Loss

The main flow drivers for the sub-catchments are via vertical flow into the groundwater regime followed closely by lateral flow. As the operation has been in existence for many years it is impractical to establish a pre-operational baseline, and the current state is used as the “baseline”. Based on this information the proposed discharge points (irrespective of the location) will have no impact on water loss to the wetlands via subsurface water flow. This is as a result of water being directly discharged into the streams and/ or wetlands. The modelled information can be used if any additional infrastructure is planned in the future.

5.3. OUTCOME OF MODELLING ASSESSMENT

In conclusion, the modelling and hydrological response models indicate that the main flow drivers of the eight (8) hillslopes (and the associated sub-catchments) are via vertical flow into the groundwater regime and lateral flow on the soil/ bedrock interface to the downstream watercourses. Surface and sub-surface water flow was observed during the site visit (despite taking place late in the dry season), which indicates that flow to the stream and wetlands have settled and adapted to the current state of affairs. This is expected, given that the mining operation has been in place for many years. The proposed discharging of water will have a negligible impact on hydro-pedological flow drivers, as water will be directly discharged into the watercourses and not onto the soils. General mitigation measures will be provided to improve subsurface flow in general.

6. IMPACT ASSESSMENT AND MITIGATION MEASURES

The perceived impacts associated with the activities were assessed using a quantitative impact assessment methodology, which was formalised to comply with Regulation 31(2)(l) of the National Environmental Management Act, 1998 (NEMA) (Act No. 107 of 1998, as amended). This assessment aimed to identify and assess the significance of all the perceived impacts, which may arise as a result of the activities. The methodology employed makes use of the following procedure:

- i. Identification and assessment of potential impacts;
- ii. Prediction of the nature, duration, extent, likelihood and significance;
- iii. Identification of mitigation measures that could be implemented to reduce the significance of the potential impact; and
- iv. Evaluation of the significance of the potential impacts following the implementation of mitigation measures.

Potential impacts were assessed using the following factors and associated score ratings.

Table 6-1: Factors considered when determining the significance of each potential impact.

Measure	Rating	Definition of Rating	Score
Magnitude (M)	Zero	Natural and/ or social functions and/or processes remain unaltered.	1
	Very low	Natural and/ or social functions and/or processes are negligibly altered.	2
	Low	Natural and/ or social functions and/or processes are slightly altered.	3
	Medium	Natural and/ or social functions and/or processes are notably altered.	4
	High	Natural and/ or social functions and/or processes severely altered.	5
Extent (E)	Site	Only the site and/or 500 m radius from the site will be affected.	1
	Local	Local area/ district (neighbouring properties, transport routes and adjacent towns) is affected.	2
	Regional	Entire region / province is affected.	3
	National	Country is affected.	4
	International	World	5
Duration (D)	Short term	Less than 2 years	1
	Short to medium-term	2 – 5 years	2
	Medium term	6 – 25 years	3
	Long term	26 – 45 years	4
	Permanent	46 years or more	5
Consequence (C)		See next table	-
Probability (P)	Improbable	<40% chance of occurring	N/A

Measure	Rating	Definition of Rating	Score
	Possible	40% - 70% chance of occurring	N/A
	Probable	>70% - 90% chance of occurring	N/A
	Definite	>90% chance of occurring	N/A

Table 6-2: Consequence of Impacts.

Combined Score (M + E + D)	3 – 4	5 – 7	8 – 10	11 – 13	14 – 15
Consequence Rating	Very Low	Low	Medium	High	Very High

Table 6-3: Impact assessment determination (Consequence and Probability).

Probability	Consequence				
	Very Low	Low	Medium	High	Very High
Definite (D)	Low (L)	Medium (M)	High (H)	Very high (VH)	Unacceptable (U)
Probable (Pr)	Very Low (VL)	Low	Medium	High	Very High
Possible (P)	Insignificant (I)	Very Low	Low	Medium	High
Improbable (I)	Insignificant	Very Low	Low	Medium	High

Table 6-4: Significance of the impacts.

Impact Significance (S)	Flow Driver Reduction	Definition
Very High	22.6% - 60%	The proposed development should only be approved under special circumstances.
High	16% - 22.5%	The potential impact will affect the decision regarding the proposed development.
Medium	11% - 15%	The potential impact should influence the decision regarding the proposed development.
Low	6% - 10%	The potential impact may not have any meaningful influence on the decision regarding the proposed development.
Very Low	2.6% - 5%	The potential impact is very small and should not have any meaningful influence on the decision regarding the proposed development.
Insignificant	0% - 2.5%	The potential impact is negligible and will not have an influence on the decision regarding the proposed development.

6.1. ALTERNATIVES

Based on the nature of the proposed project and the infrastructure that is already in place, alternatives are limited to the proposed three (3) discharge points. It is recommended that discharge point one (1) be used as this will have the lowest impact for the following reasons:

- Infrastructure is already in place and above ground (which prevents disturbance of soils and allows easy inspections to identify leaks);
- Soils are responsive (wet) soils that prevent infiltration when saturated, resulting in discharge water flowing overland to the Leeuwspruit and associated wetlands;
- Larger sections of the watercourse experience an increase in water quantity; and
- Closer to the main operational site, which reduces any disturbances of the soils and possibility of leaks.

6.2. IMPACTS ON THE HYDROPEDOLOGICAL CYCLE

This impact assessment presents the findings of a hydropedological investigation conducted to evaluate the potential impacts of proposed discharge points on soil-water interactions within the study area. Hydropedology, an interdisciplinary field integrating soil science and hydrology, provides critical insights into the movement, distribution, and storage of water in the vadose zone and its interaction with soil properties and landscape features.

The assessment aims to characterise the hydropedological behaviour of dominant soil forms, determine the hydrological sensitivity of the terrain, and assess how anticipated alterations, such as vegetation clearance, infrastructure development, or changes in land cover, may affect soil water dynamics, infiltration capacity, lateral flow, and groundwater recharge potential. Emphasis is placed on identifying hydrological flow paths, surface and subsurface connectivity, and areas of potential saturation or runoff generation.

Data collection involved field-based soil profiling, in situ infiltration testing, and a qualitative evaluation of morphological indicators relevant to water movement. These findings are interpreted within a hydropedological framework to inform risk mitigation strategies and guide sustainable land management decisions. The outcome of this assessment is intended to support compliance with environmental legislation and contribute to integrated water resource planning and conservation practices.

6.2.1. Impacts on Hillslopes

Table 6-5 below indicates the impact on the hydropedology associated with the proposed discharging activities. It is assumed that the infrastructure is already in place and that the only impact will be related to the operational phase. The impact is negligible as the water will be directly discharged into the watercourses and not directly affect the hydropedological activities.

Table 6-5: Impact assessment.

Potential Impact	Without Mitigation						With Mitigation
	M	E	D	C	P	S	S
Operational Phase							
Soil erosion and bank instability due to increase in water flow.	2	1	4	L	Pr	L	VL
Contamination of soil and water due to leaks from the infrastructure and from water being discharged.	2	1	4	L	Pr	L	VL

6.3. MITIGATION MEASURES

The following mitigation measures can be considered as part of the Environmental Management Programme (EMPr) and to the operational area in general:

- Investigate engineering options to improve bank instability and prevent soil erosion associated with the discharge points and watercourses (i.e. gabions);
- Regular monitoring the quality of the water being discharged;
- Rip and revegetate compacted areas over the general operational area. This will improve filtration into the soil;
- Ensure that stormwater infrastructure is maintained to prevent contaminated water from entering the clean environment;
- Exposed soils must be protected by revegetating it to prevent erosion and allow water to infiltrate (grass can be donated to community members, which will also assist in reducing sedimentation runoff);
- TSFs to be covered, with vegetation, to minimise windblown dust and prevent contaminated dust deposition onto the surrounding clean environment;
- Regular inspections of the area to ensure mitigation measures are correctly implemented and remain effective;
- Remove alien invasive species;
- All infrastructure that are not in use is to be removed and disposed of at a licensed facility;
- Contaminated soil must be removed and disposed of correctly; and
- Rip and revegetate all rehabilitated areas. Regular inspections must be carried out to identify possible erosion and remediation to take place as soon as possible.

7. CONCLUSIONS AND RECOMMENDATIONS

ENVASS was appointed by South Deep Gold Mine (Pty) Ltd to undertake a Hydropedological Impact Assessment for the existing operations at South Deep, on various portions of the farms Modderfontein 345 IQ, Doornpoort 347 IQ, Wildebeestkuil 360 IQ, Kalbasfontein 365 IQ, Cardoville 647 IQ, and Cardoville 364 IQ outside of Westonaria in the Gauteng Province. This hydropedology report will be used in support of a Water Use License Application (WULA).

The proposed discharge points associated with the South Deep Gold Fields mining and processing activities have already been constructed but is not yet being used. This entire area has already been severely impacted upon by industrial activities, infrastructure and agricultural activities. The mining operation and processing activities occurs predominantly on deep recharge soils and soil/ bedrock interflow soils, which either flows vertically into the groundwater regime or on the soil/ bedrock interface to the downstream watercourses. Eight (8) hillslopes were identified that form part of seven (7) sub-catchments over the study area. The impact from the proposed discharge will be very low as the water will be pumped directly into the watercourses and not onto the land where it may affect hydropedological flow paths and flow drivers. With regards to the discharge points, it is recommended that discharge point one (1) be used as the infrastructure is already in place (in the form of aboveground pipes), the impact on hydropedological flow paths/drivers is negligible due to the water being directly discharged into the Leeuspruit and the presence of clayey soils that prevent unnecessary infiltration back into the soils. It is important that the mitigation measures are implemented to prevent surface flow from being intercepted and diverted away from the wetlands.

7.1. SPECIALIST OPINION

Based on the findings of this assessment, ENVASS believes that the proposed development poses a low risk to the hydropedological environment, and with the implementation of the specified mitigation measures, impacts can be mitigated. This is due to the mining and processing operation existing for many years and resulting in a new “baseline” environment, and the fact that discharge water will enter watercourses directly and not higher on the hillslopes, where it may affect hydropedological processes. The approval of the activity should be considered to enable South Deep Gold Mine to continue with its mining and processing operations.

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9. APPENDICES

APPENDIX A – CV OF THE SPECIALIST



Pierre Fourie
Divisional Unit Head - Authorisations

QUALIFICATIONS

- M.Sc. Environmental Science.
University of South Africa – 2020.
- B.Sc. Hons. in Environmental Management.
University of South Africa – 2018.
- Model Maker – DTM
Model Maker Systems – 2017.
- Model Maker – Introduction Course.
Model Maker Systems – 2017.
- B.Sc. General – Archaeology and Geography.
University of South Africa – 2014.
- ISO 14001:2004 – EMS Understanding and Implementation
SABS – 2011.
- ISO 14001:2004 – EMS SAATCA Auditors Examination.
SABS – 2011
- Matric.
Reynopark Highschool – 2006.

PROFESSIONAL HISTORY

Pierre earned his M.Sc. in Environmental Science with research focused on predictive soil mapping in Phinda Private Game reserve. He has six years of experience as an Environmental Consultant working on projects such as Basic Assessment Reports, Scoping and Environmental Impact Assessment Reports, Water Use Licenses, Environmental Auditing, Soil and Hydropedological Assessments, GIS and ECO work.

At present, he is employed at ENVASS as the Divisional Unit Head for Authorisations as well as an Environmental Consultant where he undertakes environmental and water related authorisations. Pierre also uses his pedological skills in the development of soil and hydropedological assessments.

DEVELOPMENTAL HIGHLIGHTS

- DWS Hydropedological Courses.
DWS and DSA – 2019.
- IWRM, the NWA, and Water Use Authorisations, focusing on WULAs and IWWMPs.
Carin Bosman Sustainable Solutions – 2018.
- IAIA International Conference.
Durban – 2018.

CRITICAL SKILLS

- Basic Assessment Reports
- Water Use License Applications
- Environmental Impact Assessments
- Environmental Management Programmes
- Public Participation Process
- Environmental Compliance Auditing
- Environmental Officer
- GIS
- Soil and Hydropedological Reports

MEMBERSHIPS

- EAPASA (Candidate EAP – 2019/1213)
- SACNASP (Pr. Sci. Nat – 120289)
- IAIA (7980)



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herewith certifies that
Petrus Johannes Fourie
 Registration Number: 120289
is a registered scientist

in terms of section 20(3) of the Natural Scientific Professions Act, 2003
 (Act 27 of 2003)
 in the following field(s) of practice (Schedule 1 of the Act)

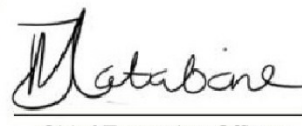
Soil Science (Candidate Natural Scientist)
 Environmental Science (Professional Natural Scientist)

Effective **31 March 2019**

Expires **31 March 2027**




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