ENGINEERING

MPONENG LOWER COMPARTMENT TAILINGS STORAGE FACILITY PRE-FEASIBILITY STUDY REPORT

HARMONY GOLD MINING COMPANY

ATTENTION: Ruan Breytenbach

EMAIL: ruan.breytenbach@harmony.co.za

PROJECT NUMBER: 23-2486-5B-WMF

PROJECT: Mponeng Lower Compartment Pre-feasibility study

VERSION 4.0

AUTHOR: Riaan le Roux

riaanlr@ecoe.co.za

DATE: 2025/11/26

ecoe INNOVATIVE CONSULTING

PRE-FEASIBILITY DESIGN REPORT

Document and Quality Control:

DOCUMENT NO	PROJECT NAME: MPONENG LOWER COMPARTMENT PRE-FEASIBILITY STUDY			
AA – draft	2025/06/11	Riaan le Roux		First draft for review/comments
BB – draft	2025/06/13	David Smith		Technical Review
CC – draft	2025/06/18	Leoni le Roux		Quality Review
APPROVED FOR DISTRIBUTION				
0.0	2025/06/18	David Smith		Final Report
1.0	2025/06/30	David Smith		Revision 1.0
2.0	2025/07/18	David Smith		Approved
3.0	2025/11/25	David Smith		Approved
4.0	2025/11/26	David Smith		Approved

Quality Control By:

NATURE OF SIGNOFF	RESPONSIBLE PERSON	ROLE / RESPONSIBILITY	QUALIFICATION / ENTITY
Author	Riaan Le Roux	Lead Designer Civil Engineer	BEng (Civil) Pr Eng
Technical Reviewer	David Smith	Project Lead Civil Engineer	BEng (Civil) Pr Eng
Final Reviewer	Chris Fourie	Associate Director	BEng (Civil) Pr Eng

Client Approval:

NATURE OF SIGNOFF	RESPONSIBLE PERSON	ROLE / RESPONSIBILITY	DATE	SIGNATURE
Operations				
Central Projects				

Legal Notice:

This is a legally binding document, and many of the actions and recommendations remain the responsibility of the Client (as the owner/lessee of the property).

Eco Elementum and Engineering (Pty) Ltd (EcoE) and the authors of this report are protected from any legal action, possible loss, damage, or liability resulting from the content of this report. This document is considered confidential and remains so unless requested by a court of law. Please consider the environment and only print this document if necessary.

The findings, results, observations, conclusions, and recommendations given in this report are based on the author's best scientific and professional knowledge, as well as the available information. The information utilised and contained in this report is based on data/information supplied to EcoE by the Client and other external sources (including previous site investigation data and external specialist studies).

EcoE exercises due care and diligence in rendering services and preparing documents; however, it has been assumed that the information provided to EcoE is correct, and as such, the accuracy of the conclusions made is reliant on the accuracy and completeness of the data supplied.

No responsibility is accepted by EcoE for incomplete, or inaccurate data supplied by the Client and/or other external sources. Opinions expressed in this report apply to the site conditions and features that existed at the time of the start of the investigations and the production of this document. For this reason, EcoE accepts no liability, and the Client, by receiving and therefore accepting this document, indemnifies EcoE and its directors against all actions, claims, demands, losses, liabilities, costs, damages, and expenses arising from or in connection with the services rendered, directly or indirectly.

The document may not be altered or added to without the prior written consent of the author. This also refers to electronic copies of the report, which are supplied for the purposes of inclusion as part of other reports.

EXECUTIVE SUMMARY

INTRODUCTION

Eco Elementum (Pty) Ltd, hereinafter referred to as 'EcoE', was appointed by Harmony Gold Mining Company Limited, hereinafter referred to as 'Harmony', to undertake a Pre-Feasibility Study for the re-commissioning of the existing Mponeng Tailings Storage Facility (TSF) Lower Compartment.

BACKGROUND

The Savuka tailings facility has reached the end of its lifecycle and is undergoing a short-term extension of two years. Following this period, tailings from Savuka will need to be diverted to an alternative facility. The Lower Compartment has been identified as a viable solution to accommodate tailings until the end of life of the Savuka plant and thereafter accommodate tailings from the Mponeng plant.

The Lower Compartment was previously licensed, commissioned, and operated, as noted during the site investigation and survey contours. Tailings were deposited up to 25m on the southern half of the footprint, but deposition was ceased after a natural spring was identified within the footprint. Harmony plans to re-commission the Lower Compartment after the spring is diverted to reduce groundwater contamination.

DESIGN

The Mponeng Lower Compartment TSF will store approximately 43 Mt. It is anticipated to accommodate tailings deposition for a period of 10 years at a rate of 350 kilotonnes per month (ktpm). The end of life limiting factors considered were a rate of rise below 4 meters per annum and a final facility height of 60 meters, ensuring safe and sustainable deposition over the operational life of the facility.

The underflow material (coarse, dewatered tailings) is separated from the slurry by the hydrocyclones and deposited at the outer core. The overflow material (fine tailings and slurry water) is deposited in the basin.

The leachate collection system comprises a network of 110 mm and 160 mm perforated HDPE sub-soil drainage pipes installed within a graded gravel drainage layer, all enclosed in a geotextile separation fabric to prevent the migration of the tailings fines. Additionally, a toe blanket drain exists at the downstream toe of the facility, and a curtain drain is proposed to be constructed at the interface with the Mponeng Upper compartment.

At the upstream side of the footprint, two reverse filter packs are strategically positioned at the current existing spring and holding dam locations to serve as seepage interception points. These reverse filters comprise a thick waste rock layer with non-woven needle-punched geotextile encapsulating the drain. If the Lower Compartment footprint is dried out before construction works begin then the necessity of the filter packs will be reassessed.

All leachate drains discharge into trapezoidal concrete-lined channels within the existing paddocks. These channels will serve to collect and convey dirty water in a controlled manner, minimising seepage and preventing contamination of the surrounding environment. The channels will discharge into concrete silt traps before entering the RWD.

Supernatant water is decanted by a gravity penstock system through a flanged steel pipe encased in concrete. The penstock outfall pipe discharges water into the concrete-lined channels.

Contamination from the facility is expected to be relatively low as previous studies have shown very low seepage rates below/around the facility (mainly due to low permeability bedrock and artesian conditions). Additionally, unique geotechnical conditions are present at the site, including contaminated tailings below the level a liner can be safely stored, landfill waste and previously saturated zones, create a risk of differential settlement and localised weak zones affecting stability. These conditions hinder the safe and effective installation of an HDPE liner.

The proposed re-commissioning concept therefore comprises an unlined facility supported by a robust seepage control system, with the objective of maintaining global stability and limiting seepage impacts to an acceptable level during operation and post-closure.

This pre-feasibility design is submitted to DWS to support a performance-based motivation for an unlined re-commissioned facility on an existing tailings footprint, and to obtain feedback on the acceptability of this approach within the NWA / NEM:WA regulatory framework.

RECOMMENDATIONS

Updated hydrogeological modelling is currently underway by others. Once this is completed a pre-submission meeting with DWS will be arranged to review the predicted impact of an unlined facility. Thereafter, the feasibility level design for the unlined option will be developed for the Water Use License and Environmental Authorisation process.

Concurrently, planning for the spring diversion and relocation of the holding dam water should be prioritised. This will allow for the most cost-effective construction and ensure the stability of the Upper Compartment is not negatively affected.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ABBREVIATION	TERM
ANCOLD:	Australian National Committee on Large Dams
AEP:	Annual Exceedance Probability
CDA:	Canadian Dam Association
DWS:	Department of Water and Sanitation
EDL:	Earthquake Design Level
ELL:	Electric Leak Location Survey
EoR	Engineer of Record
GISTM:	Global Industry Standard on Tailings Management
GM:	Geomembrane
GN:	General Notice
GRI:	Geosynthetic Research Institute
GT:	Geotextile
HDPE:	High-Density Polyethylene
ICOLD:	International Commission on Large Dams
LOM:	Life of Mine
MAMSL:	Metres Above Mean Sea Level
MAP:	Mean Annual Precipitation
MCE:	Maximum Credible Earthquake
NEMWA:	National Environmental Management Waste Act
NWA:	National Water Act
OBE:	Operating Basis Earthquake
OMC:	Optimum Moisture Content
PSD:	Particle Size Distribution
RM:	Rational Method
RWD:	Return Water Dam
SANCOLD:	South African National Committee on Large Dams
SANAS:	South African National Accreditation System
SANS:	South African National Standards
SEE:	Safety Evaluation Earthquake
SWMP:	Stormwater Management Plan
TDBA:	Tailings Dam Breach Analysis
TSF:	Tailings Storage Facility
TST:	Total Solute Transport
WMA:	Water Management Area

ABBREVIATION	TERM
WRC:	Water Research Commission
Zol:	Zone of Influence

1 INTRODUCTION

1.1 BACKGROUND

Eco Elementum (Pty) Ltd (hereinafter referred to as 'EcoE') was appointed by Harmony Gold Mining Company Limited (hereinafter referred to as 'Harmony') to undertake a Pre-Feasibility Study for the re-commissioning of the Mponeng Lower Compartment Tailings Storage Facility (TSF). This report sets out the infrastructure required to support the re-commissioning of the lower compartment.

The current Upper Compartment of the TSF is approaching the end of its operational life, with capacity expected to be exhausted by 2031. Similarly, the Savuka tailings facility has reached the end of its lifecycle and is undergoing a short-term extension of two years. Following this period, tailings from Savuka will need to be diverted to an alternative facility. The Lower Compartment has been identified as a viable solution to accommodate tailings until the Savuka end of life and thereafter accommodate tailings from the Mponeng plant.

The Lower Compartment was previously licensed, commissioned, and operated, as noted on the site investigation and survey contours. Tailings were deposited up to 25m on the southern half of the footprint, but deposition was ceased after a natural spring was identified within the footprint. Harmony plans to re-commission the Lower Compartment after the spring is diverted to reduce groundwater contamination.

Contamination from the facility is expected to be relatively low as previous studies have shown very low seepage rates below/around the facility (mainly due to low permeability bedrock and artesian conditions). Nonetheless, the geotechnical and hydrogeological investigations have highlighted several critical site-specific risks, including heterogeneous legacy materials (landfill waste and previously saturated tailings), a spring daylighting within the footprint, and zones of soft, saturated tailings. These conditions introduce the potential for differential settlement, localised softening and elevated pore water pressures if not adequately mitigated. In this context, the current pre-feasibility study develops and assesses a re-commissioning concept for an unlined facility on an existing tailings footprint, supported by targeted ground improvement, a comprehensive seepage interception network

The facility is expected to accommodate tailings deposition for a period of 10 years at a rate of 350 kilotonnes per month (ktpm).

1.2 SCOPE OF WORK

The following outlines the scope of work undertaken during the prefeasibility study:

- Assess and determine the facility's maximum life when assuming a deposition rate of 350 kt per month (Current Savuka TSF complex deposition rate).
- Evaluation of proposed early works is required before deposition can commence.
- Evaluate the stability and safety factors to ensure an acceptable risk of failure.

- Evaluate the required Return Water Dam (RWD) capacity to accommodate the proposed TSF expansion.

1.3 LEGISLATION AND GUIDANCE DOCUMENTS

The key South African policies and guidance documents used for this pre-feasibility are shown below:

- South African National Standards, Code of Practice for Mine Residue (SANS 10286:1998), and consideration of the new revised version, currently issued for final comment.
- Department of Water and Sanitation, 2016: Guideline for the Development and Implementation of Water Conservation and Water Demand Management Plans for the Mining Sector.
- The National Water Act (Act number 36 of 1998) as amended by the General Notice number 704 of 1999.
- WRC – Guidelines on Freeboard of Dams Volume I and II (2011), WRC Report No. 1759/1/11 and 2/11.
- Department of Water Affairs and Forestry (2008). Best Practice Guideline A2: Water Management for Mine Residue Deposits.
- Department of Water Affairs and Forestry (2007). Best Practice Guideline A4: Pollution control dams.
- Department of Water and Sanitation (2020). Title: Construction Quality Assurance Plan for Government Waterworks Waste Disposal Facility Pollution Control Works.
- National Environmental Management: Waste Act, 2008 (Act 58 of 2009) (NEMWA).
- National Waste Information Regulations, 2012 (published under GN R625 in GG 35583 of 13 August 2012).
- Regulations Regarding the Planning and Management of Residue Stockpiles and Residue Deposits from a Prospecting, Mining, Exploration or Production Operation, 2015 (published under GN R632 in GG 39020 of 24 July 2015 as amended by the Planning and Management of Residue Stockpiles and Residue Deposits Amendment Regulations, 2018 published under GN 990 in GG 41920 of 21 September 2018).
- Waste Classification and Management Regulations, 2013 (published under GN R634 in GG 36784 of 23 August 2012).
- National Norms and Standards for the Assessment of Waste for Landfill Disposal (published under GN R635 in GG 36784 of 23 August 2013) (GN R635) as amended on 7 November 2024.
- National Norms and Standards for Disposal of Waste for Landfill Disposal (published under GN R636 in GG 36784 of 23 August 2013).
- List of Waste Management Activities that have or are likely to have a detrimental effect on the environment (published under GN 921 in GG 37083 of 29 November 2013 as amended).
- SANS 1936-3:2012 Development of dolomite land, Part 3: Design and construction of buildings, structures, and infrastructure.

The following international guidelines were referenced to supplement the South African guidelines above:

- ICOLD bulletins in terms of TSFs, Embankment dams, and filter design.
- ANCOLD Guidelines on Tailings Dams, Planning, Design, Construction, Operation, and Closure. May 2019.
- ANCOLD Guidelines on The Consequence Categories for Dams. October 2012.
- GISTM Global Industry Standard on Tailings Management. August 2020.

2 DESIGN CRITERIA

Design criteria and parameters adopted for the study are summarised in Table 2-1.

Table 2-1: Design Criteria

PARAMETER	VALUE	SOURCE
TSF Design		
Pertinent Standards and Guidelines	SANS 10286	EcoE
Tailings Ore body	Gold	Harmony
Tailings Waste Classification	Type-3	EcoE – Based on other, similar Gold Tailings Projects.
Life of TSF	10 Years (minimum)	EcoE – Based on current LoM.
Deposition Rate	350 ktpm	Harmony (Current Savuka deposition rate).
Total Tailings Produced	43Mt (Current LoM)	EcoE – As per capacity assessment.
Total Volume	27.9 Mm^3 (Current LoM)	EcoE – Calculated
Hazard Rating	High	EcoE – Annual report for the Upper compartment at a similar height.
Deposition strategy	Upstream construction with hydrocyclone deposition	EcoE – Based on other, similar Gold Tailings Projects with a high RoR.
Particle size distribution	85% Passing 75 µm	Mponeng Upper Compartment Lab Test Results (23-2486-WMF-5-HARMONY MPONENG TSF 2024 ANNUAL REPORT).
Particle Specific Gravity	2.7 (t/m^3)	Mponeng Upper Compartment Lab Test Results (23-2486-WMF-5-HARMONY MPONENG TSF 2024 ANNUAL REPORT) .
Dry density (average)	1.54 (t/m^3)	EcoE – Triaxial tests done on Savuka tailings
Maximum Rate of Rise	4 m per annum	Capacity assessment.
Maximum TSF Height	60m	EcoE – To be confirmed with slope stability calculations.
Bench widths	8m	EcoE – Best Practice
Lift height	8m	EcoE – Best Practice
Interim side slopes	1 (V):2.5 (H)	EcoE – Best Practice
Overall side slope	1 (V):3.5 (H)	EcoE – Best Practice
Stormwater Management Plan		
Temporary diversion structures during construction. 1:2 year	1:2 year	GNR 704

PARAMETER	VALUE	SOURCE
Stormwater diversion channels and their erosion protection.	1:50-year storm event / 72-hour drawdown from TSF and drain seepage outflow.	GNR 704
Penstock design	1:100 year 72-hour drawdown on top of TSF	Best practice
RWD sizing	1:50 year 24-hour storm event	GNR 704
RWD Lining	Type 3 waste	EcoE – Based on other, similar Gold Tailings Projects.
Groundwater Management		
Spring Water to be Diverted	1 611 m^3 per annum	AngloGold Ashanti Limited EMP report (2009)
Embankment Stability / Earthquake Criteria		
Earthquake Loading	1:2,475-year return period = 0.148 g (0.108 + 0.040 g) PGA (OBE) = 0.074 g (0.148 g / 2).	
Minimum Stability Factors of Safety (SANS 10286, 2022)	After construction: 1.30. Static drained conditions: 1.50. Short-term undrained (peak) 1.30. Short-term undrained earthquake: 1.10. Short-term undrained post-earthquake (liquefied): 1.10. Damage and deformation allowed (<freeboard allowance) - No release of tailings or water.	Best Practice

3 DESCRIPTION OF THE CURRENT ENVIRONMENT

3.1 LOCALITY AND PHYSICAL CHARACTERISTICS

The Mponeng TSF is located approximately 9 km southwest of Carletonville, Johannesburg, Gauteng Province. The TSF is situated on portion RE/23/115 of the farm Elandsfontein 115 IQ, covering an area of approximately 712.4 hectares. Figure 3-1 below indicates the layout of the TSF and the relative infrastructure pertinent to the site.

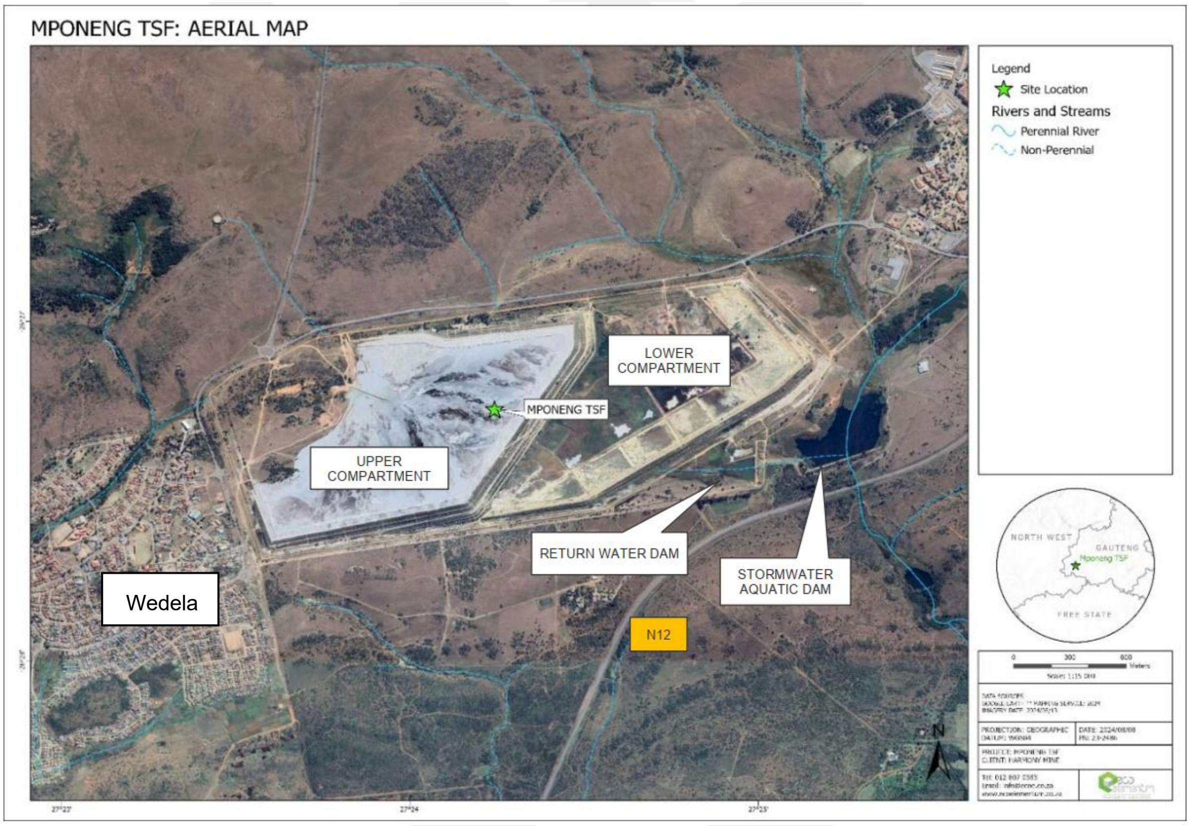


Figure 3-1: Mponeng TSF locality map

3.1.1 Topography and Drainage of the Site

The Mponeng TSF falls within the Upper Vaal Water Management Area (WMA), specifically within the C23J quaternary catchment. The position of the site in relation to the relevant quaternary catchment is shown in Figure 3-2.

The site is located on the northern section of the quaternary catchment and generally slopes from north to south, eventually draining into the Klipdrift Dam, on the western edge of the catchment. A floodline Map indicating the 1–100-year flood elevation still needs to be provided by the client to ensure all proposed infrastructure is out of the flood zone.

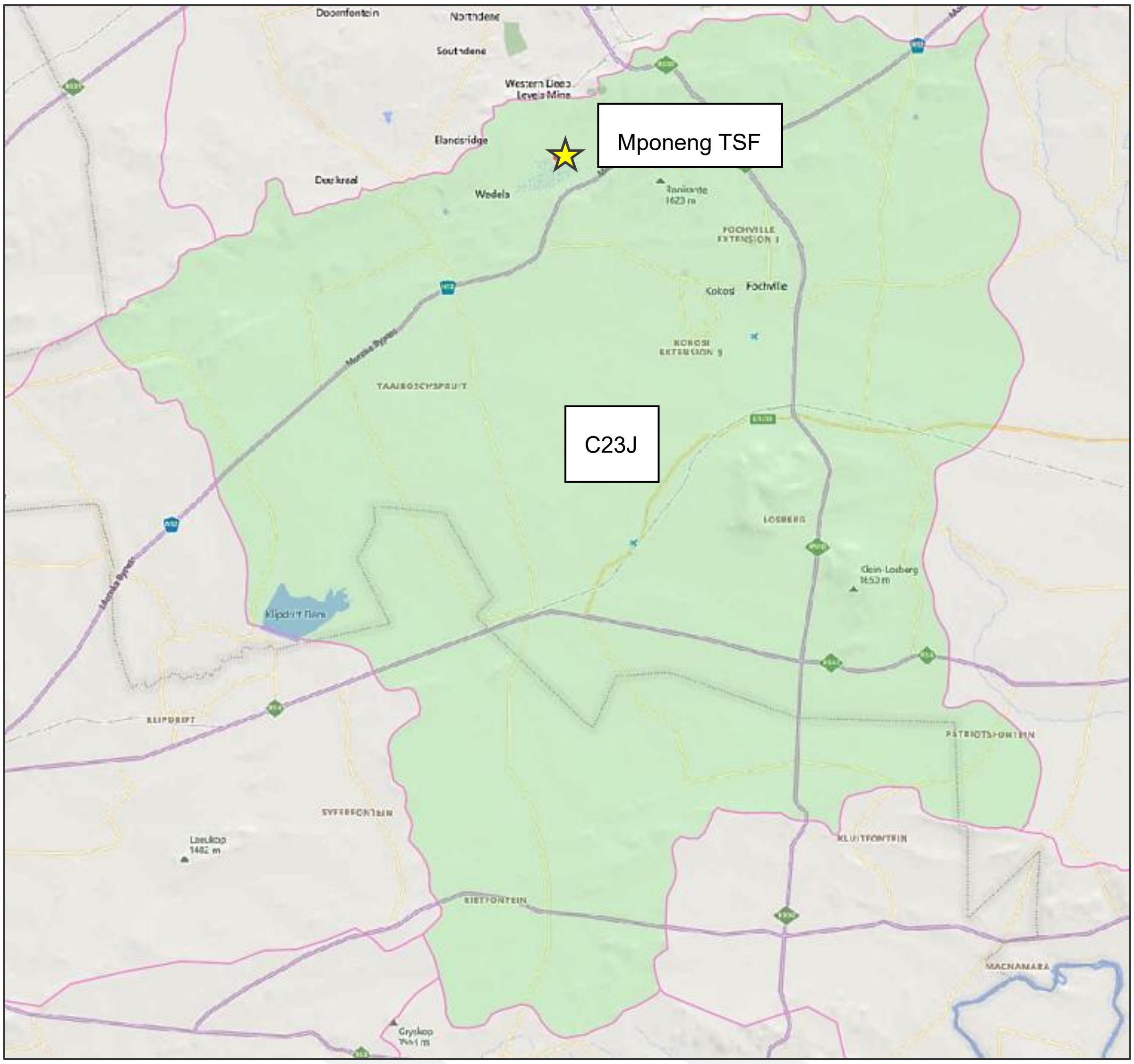


Figure 3-2: C31J Quaternary Catchment

3.2 GEOLOGY

According to the published geological map (2626 Wes Rand), the site is situated at the contact between the andesites of the Hekpoort Formation and the shales and quartzites of the Timeball Hill Formation, both part of the Pretoria Group within the Transvaal Supergroup. Figure 3-3 shows the site's location on an extract from the geological map (Kipaji, 2025).

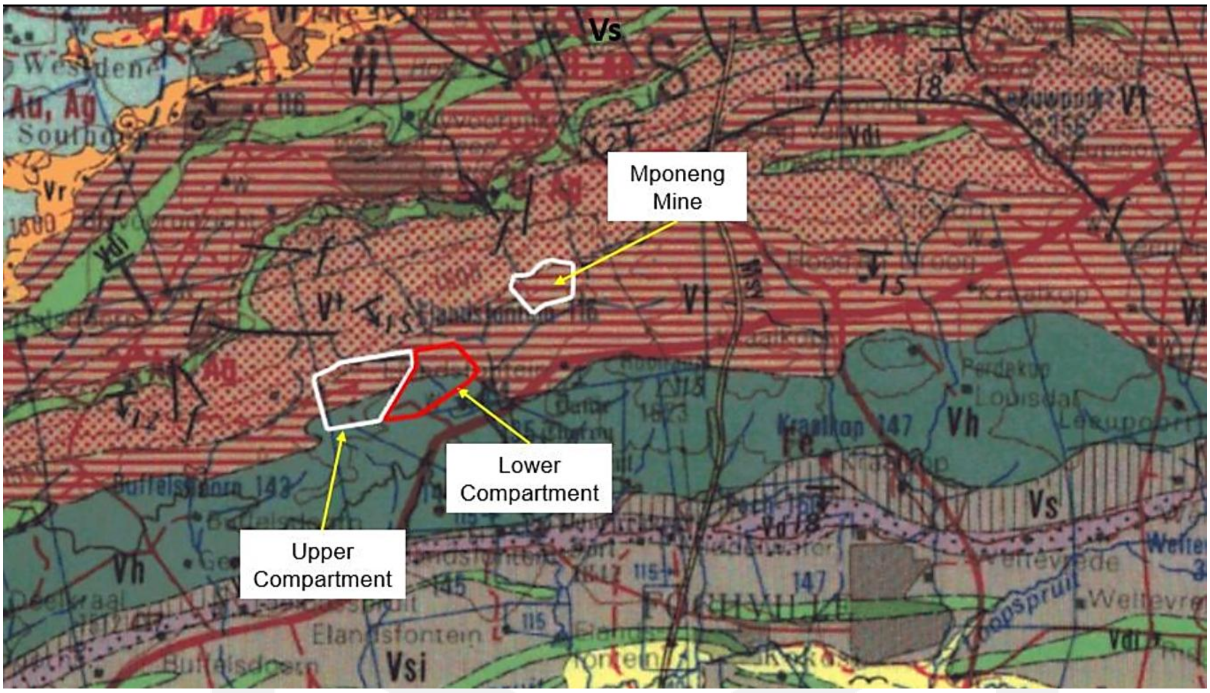
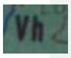


Figure 3-3: Regional Geology Map (Kipaji, 2025)

Geological Legend:

Vh – andesite, agglomerate & tuff (Hekpoort Formation)	
Vt – ferruginous shale & quartzite (Timeball Hill Formation)	

} Pretoria Group, Transvaal Sequence.

This contact runs in a northeast-southwest direction across the site. The residual shale soils derived from the Timeball Hill Formation are described as generally thin. Shale-derived soils are typically susceptible to slaking and deterioration under wetting-drying cycles and often display moderate to high plasticity with potential for a shrink-swell behaviour. The thin profile may limit the extent of problematic traits, but should still be considered.

Meanwhile, the weathering profile of the andesites (igneous rocks) follows a typical pattern where initial weathering produces coarse-grained soils, but with continued weathering, these transition to fine-grained soils with increasing depth. Fine-grained weathered andesite soils may contain clay minerals that could exhibit expansive properties, and a gradational weathering profile may create zones of differing engineering properties and permeability that need to be accounted for in the designs.

Refer to **Annexure B** for the full Geotechnical Investigation Report and Results.

3.3 GROUNDWATER

GCS Water & Environmental Consultants conducted hydrogeological investigations for the Mponeng TSF in January 2019 and April 2025 to support designs for water management. The investigations focused on identifying the source of a spring at the northeastern corner, characterising the underlying hydrogeological regime, commenting on the hydrogeological impact and management options, reviewing methods to manage the spring in terms of water quality and flow, and informing seepage management strategies.

The January 2019 report concluded that seepage rates are currently low—ranging from 12 to 20 mm/year—but are expected to increase moderately with the proposed elevation of the TSF. Seepage rates will remain fairly low for gold tailings, due to the foundation geology (shales and andesites) and characteristics of the tailings material.

Furthermore, most monitoring points show sulphate levels below 100 mg/L, with only two boreholes exceeding 500 mg/L. A calibrated groundwater model predicted a sulphate plume of 200–600 mg/L remaining largely confined to the TSF and return water dam areas by the year 2060. However, the Aquatic Dam is already showing elevated sulphate levels, which could rise further if seepage is not effectively managed.

Both reports confirmed that the spring is a natural groundwater discharge point, distinguished by its ambient water quality and surface flow. However, the spring water currently mixes with contaminated TSF seepage in a downstream control dam, raising environmental concerns. The April 2025 report recommended three key mitigation strategies:

1) Implementing a spring capture system to divert clean groundwater away from the TSF;
2) Diverting clean stormwater runoff from the northern area to prevent it from entering the seepage control infrastructure;
3) And installing a series of scavenger boreholes along the TSF's southern toe to intercept contaminated seepage caused by groundwater mounding.

These interventions aim to significantly reduce the environmental impact of the TSF during both operational and post-closure phases. The groundwater profile was subsequently modelled from the available data and is illustrated in Figure 3-4.

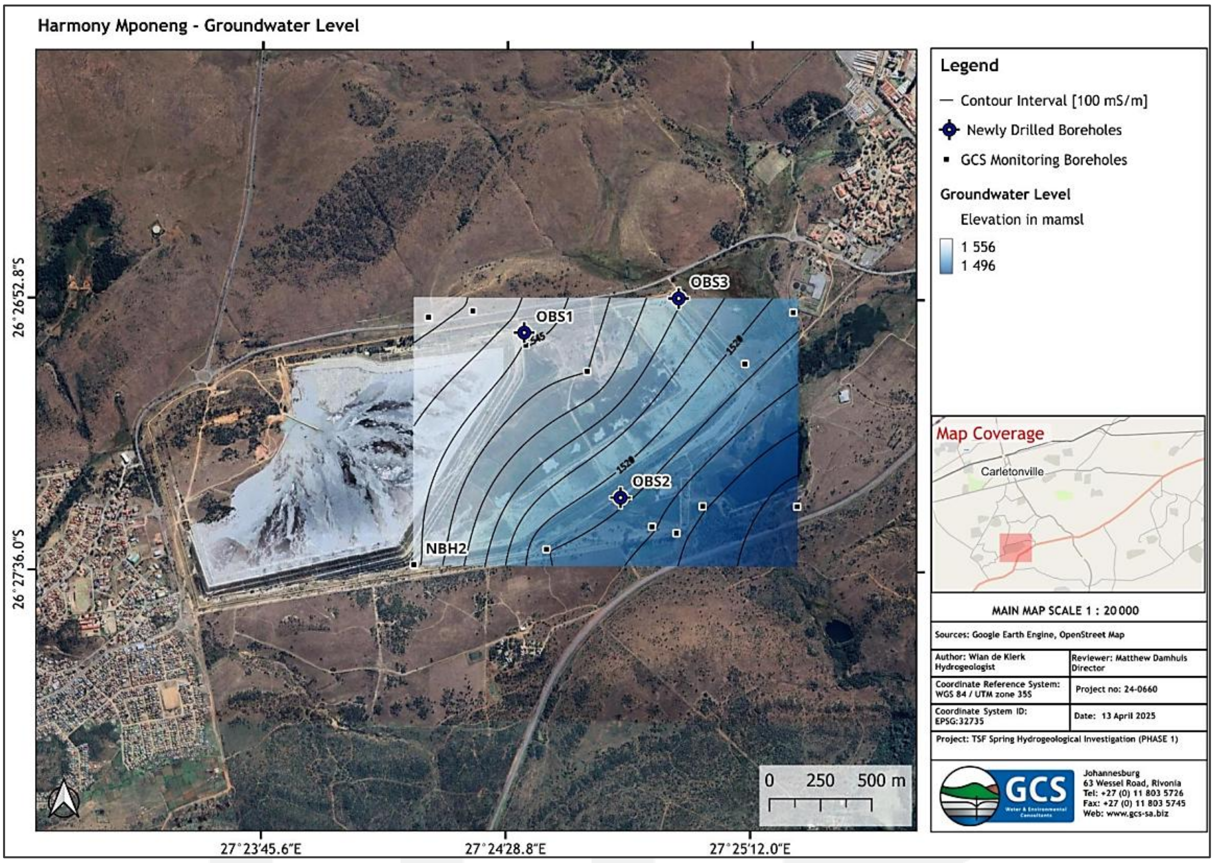


Figure 3-4: Groundwater level map (GCS, 2025)

Most test pits on the original ground level showed no seepage during the geotechnical investigation, except TP32, which may be influenced by the upper compartment's embankment. Moderate to strong seepage was observed at the base of the landfill site due to its permeable waste material, though downstream test pits showed no seepage, suggesting localized infiltration. Additionally, significant seepage was found at the southeast corner of the starter wall, potentially sourced from the lower compartment's catchment area or along bedrock lineations.

Refer to **Annexure B and C** for the full Geotechnical and Geohydrological Investigation Reports and Results.

3.4 SEISMICITY

As part of this design, the effect of an earthquake event on the TSF must be considered. The global tailings dam design guidelines generally differentiate between 3 levels of earthquakes:

- Operating Basis Earthquake (OBE) - there are different meanings to it, but it typically refers to a seismic event with an annual exceedance probability (AEP) of 1/145, i.e., 50% probability of exceedance in 50 years.
- Safety Evaluation Earthquake (SEE) - with AEP of 1/475, i.e., 10% probability of exceedance in 50 years.

- Maximum Credible Earthquake (MCE) - with AEP of 1/10,000, 0.5% probability of exceedance in 50 years.

For TSFs, it is preferable to use international best practices, which in this instance would entail the ICMM's Global Industry Standard for Tailings Management (GISTM, 2020). The GISTM recommends different annual exceedance probabilities based on the consequence classification of the mine waste facility. This is similar to the CDA (2019) and ANCOLD (2019) approaches. SANS 10286 also provides seismic design guidelines, which are based on those provided by the GISTM. The GISTM, CDA, ANCOLD, and SANS seismic design criteria are summarised in Table 3-1 below.

Table 3-1: Summary of Different Seismic Design Criteria for New and Active Tailings Facilities

CONSEQUENCE CLASSIFICATION	ANNUAL EXCEEDANCE PROBABILITY (AEP)		
	GISTM (2020) & SANS 10286 (2022)	CDA (2019)	ANCOLD (2019)
Low	1 / 200	1 / 100	1 / 50 (OBE) 1 / 100 (SEE)
Significant	1 / 1,000	Between 1 /100 and 1 / 1,000	1 / 100 (OBE) 1 / 1,000 (SEE)
High	1 / 2,475	1 / 2,475	1 / 1,000 (OBE) 1 / 10,000 (SEE)
Very High	1 / 5,000	Between 1 / 2,475 and 1 / 10,000	
Extreme	1 / 10,000	1 / 10,000	

In 2024, Prof Andrzej Kijko from Natural Hazard Assessment Consultancy conducted a site-specific probabilistic seismic hazard assessment (PSHA) for Harmony's Kusasalethu Plant area. This study is valid for a radius of 15 km around Kusasalethu Plant, meaning that it is also valid for the Mponeng TSF and hence this design.

The study aimed to determine peak ground accelerations (PGA) resulting from earthquake design levels (EDL) of different return periods. These are 145, 200, 475, 1,000, 2,475, 5,000, and 10,000 years. The results of this assessment are shown in Table 3-2.

Table 3-2: Estimated earthquake design levels for Mponeng Gold Mine (Kijko, 2024)

EARTHQUAKE DESIGN LEVELS	PGA (mean ± standard deviation)
EDL$_{145}$ (Return period 145 years) (OBE)	$0.032 \pm 0.010\ g$
EDL$_{200}$ (Return period 200 years)	$0.037 \pm 0.012\ g$
EDL$_{475}$ (Return period 475 years) (SEE)	$0.054 \pm 0.016\ g$
EDL$_{1,000}$ (Return Period 1,000 years)	$0.073 \pm 0.023\ g$

EARTHQUAKE DESIGN LEVELS	PGA (mean ± standard deviation)
$EDL_{2,475}$ (Return Period 2,475 years)	0.108 ± 0.040 g
$EDL_{5,000}$ (Return Period 5,000 years)	0.153 ± 0.068 g
$EDL_{10,000}$ (Return Period 10,000) (MCE)	0.221 ± 0.115 g

The consequence classification for the Mponeng TSF has been determined as “high” according to SANS 10286 (2022, draft standard). Hence, according to Table 3-1 the TSF stability must be assessed against an earthquake of a 1:2 475-year return period. This is the smallest earthquake likely to cause a collapse of structures and loss of confinement in TSFs, resulting in catastrophic consequences (Fourie et al., 2022).

As a conservative approach, the PGA for the Mponeng TSF area for the 1:2,475-year return period earthquake has been taken as 0.148 g (0.108 + 0.040 g) (Table 3-2), i.e., the mean plus one standard deviation. However, research by Hynes-Griffin and Franklin (1984) concluded that the acceleration (PGA) should be halved when applied in a limit equilibrium analysis. These authors did, however, state that this technique must not be applied when any of the following three conditions prevail in the area of interest (note that none of these are relevant to this site area).

- Where areas are subject to great earthquakes (of magnitude 8.0 or greater).
- Where materials in either the embankment or foundation are susceptible to liquefaction under the design cyclic loading.
- Where the available freeboard is small or where the dam has safety-related features that are vulnerable to small deformations.

A PGA (for OBE) = 0.074 g (0.148 g / 2) was hence used for the TSF design and its slope stability assessment (see report section 7).

3.5 REGIONAL CLIMATE

3.5.1 Rainfall and Evaporation

The Blyvooruitsig (GM) Weather Station (0474684_W) is the closest station (6.5 km) to the study area with extremely reliable (97%) and medium-term (59 years: 1941 – 2000) historic rainfall data that correlates with the recorded rainfall readings. The Mean Annual Precipitation (MAP) at this weather station is 705 mm per annum. Daily rainfall depths were extracted using the daily rainfall data extraction utility developed by Richard Kunz, from the Institute for Commercial Forestry Research (ICFR), in conjunction with the School of Bioresources Engineering and Environmental Hydrology (BEEH) at the University of KwaZulu-Natal, Pietermaritzburg, South Africa. This utility assists the user in extracting observed and infilled daily rainfall values from a database that was developed by Steven Lynch during a Water Research Commission (WRC) funded research project (K5/1156) awarded to BEEH. The project, titled “The development of a raster database of annual, monthly and daily rainfall for southern Africa”, was completed in March 2003.

Evaporation data were obtained from the closest DWS meteorological station (C2E009). Moderately high levels of evaporation occur in the area. The maximum evaporation rate occurs from October until January, with a mean rate of 6.4 mm per day. Evaporation is greater than rainfall for all months of the year, resulting in a marked moisture deficit in the region. The average monthly rainfall and average monthly evaporation figures are shown in Table 3-3.

Table 3-3: Summary of Regional Rainfall and S-Pan Evaporation Data

MONTH	MEAN PRECIPITATION (mm)	MEAN EVAPORATION (mm)
January	115.8	188.4
February	98.6	159.8
March	91.7	147.8
April	60.7	114.4
May	20.2	95.4
June	9.0	76.6
July	5.6	85.3
August	6.9	119.7
September	20.6	160
October	71.9	186.9
November	97.7	189.9
December	106.0	198.7
Mean Annual Total	**705**	**1 723**

3.5.2 Historical Site Rainfall

In addition to regional rainfall data, site-specific rainfall records have been collected over the past 17 years, indicating consistently higher precipitation levels compared to regional measurements.

Historical monthly rainfall data for the study area have been integrated into the calibration of the water balance model. This dataset offers a long-term record of precipitation patterns, supporting a detailed analysis of seasonal and interannual variability. It will be used to identify wet, dry, and average conditions, ensuring the model accurately represents real-world hydrological behaviour. The dataset spans from January 2008 to the present.

Table 3-4: Summary of Site Rainfall

MONTH	MEAN PRECIPITATION (mm)
January	154.8
February	147.6
March	105.6
April	75.9
May	28.4
June	11.5

MONTH	MEAN PRECIPITATION (mm)
July	5.8
August	5.9
September	16.9
October	58.1
November	99.2
December	170.2
Mean Annual Total	**880**

3.5.3 Storm Rainfall Depths

The design storm rainfall depths were obtained from the design rainfall software (Smithers and Schulze, 2002). The programme can extract the storm rainfall depths for various recurrence intervals from the six closest South African Weather Service (SAWS) rainfall stations, as shown below in Table 3-5.

The adopted storm rainfall depth used in the peak flow calculations is based on the gridded rainfall depths from the six closest stations. The summary of the rainfall depths for the 5-minute duration up to the 1-day storm duration for various recurrence intervals is shown below in Table 3-6.

Table 3-5: List of Regional SAWS Rainfall Measurement Stations

STATION NAME	SAWS	DISTANCE (km)	RECORD (years)	MAP	ALTITUDE (masl)
ELANDSFONTEIN	0474749_W	4.0	38	592	1462
BLYVOORUITSIG (GM)	0474684_W	7.4	58	689	1622
FOCHVILLE (POL)	0474899_W	9.7	72	611	1479
WONDERFONTEIN	0474680_W	12.7	38	660	1495
WELVERDIEND (POL)	0474502_W	14.5	93	620	1480
LEEUWPOORT	0475056_W	14.5	64	644	1580

Table 3-6: Summary of Rainfall Data (Schulze and Smithers,2002)

RETURN PERIOD							
Duration	**2**	**5**	**10**	**20**	**50**	**100**	**200**
5 min	8.9	11.90	13.90	15.80	18.30	20.30	22.20
10 min	12.90	17.20	20.10	22.90	26.50	29.30	32.10
15 min	16.00	21.30	24.90	28.40	32.90	36.30	39.80
30 min	20.40	27.20	31.80	36.20	42.10	46.50	50.90
45 min	23.60	31.40	36.70	41.80	48.50	53.60	58.70
60 min	26.10	34.80	40.60	46.30	53.70	59.40	65.00
90 min	30.10	40.20	46.90	53.50	62.00	68.50	75.00
120 min	33.40	44.50	51.90	59.20	68.70	75.90	83.10

RETURN PERIOD							
240 min	39.70	52.90	61.80	70.40	81.70	90.30	98.80
360 min	43.90	58.60	68.40	78.00	90.50	99.90	109.40
480 min	47.20	63.00	73.50	83.80	97.20	107.40	117.60
600 min	50.00	66.60	77.80	88.60	102.80	113.60	124.40
720 min	52.30	69.70	81.40	92.80	107.60	118.90	130.20
960 min	56.20	74.90	87.50	99.70	115.70	127.80	139.90
1200 min	59.40	79.20	92.50	105.50	122.40	135.10	148.00
24-Hour	62.20	83.00	96.90	110.40	128.10	141.50	154.90

4 GEOTECHNICAL INVESTIGATION

4.1 SITE INVESTIGATION

The first phase of the geotechnical investigation of Mponeng TSF Lower Compartment was conducted by Kipaji on 14 to 20 May 2025. This phase of the investigation focused on assessing the shallow ground profile of the TSF compartment basin. Previous site investigations conducted by other consultants focused on determining the ground profile of the foundation surrounding the TSF.

A second investigation phase is planned for later, comprising piezocone (SCPTu) probing of the tailings strata on the Lower Compartment to assess its insitu state and phreatic conditions.

The phase 1 investigation comprised the excavation of 32 test pits (TP1 to TP32) with a 20-ton excavator provided by the client. The test pits were excavated to the maximum reach of the machine or until excavation refusal occurred. It is noted that the excavator was fitted with a smooth blade bucket and that excavation refusal noted on the test pit logs generally occurred on soil/rock material softer than would typically have been excavatable with a toothed bucket. The soil profiles were logged by an engineering geologist according to South African standards (Brink and Bruin, 2002).

For the excavations deeper than 2,0m, the test pits were initially dug to approximately 2,0m and profiled in situ. Thereafter, the remaining depth was excavated and logged from the surface due to the presence or risk of unstable sidewalls (Kipaji, 2025).

Figure 4-1 below indicates test pit locations and the geotechnical zoning along the TSF embankment.

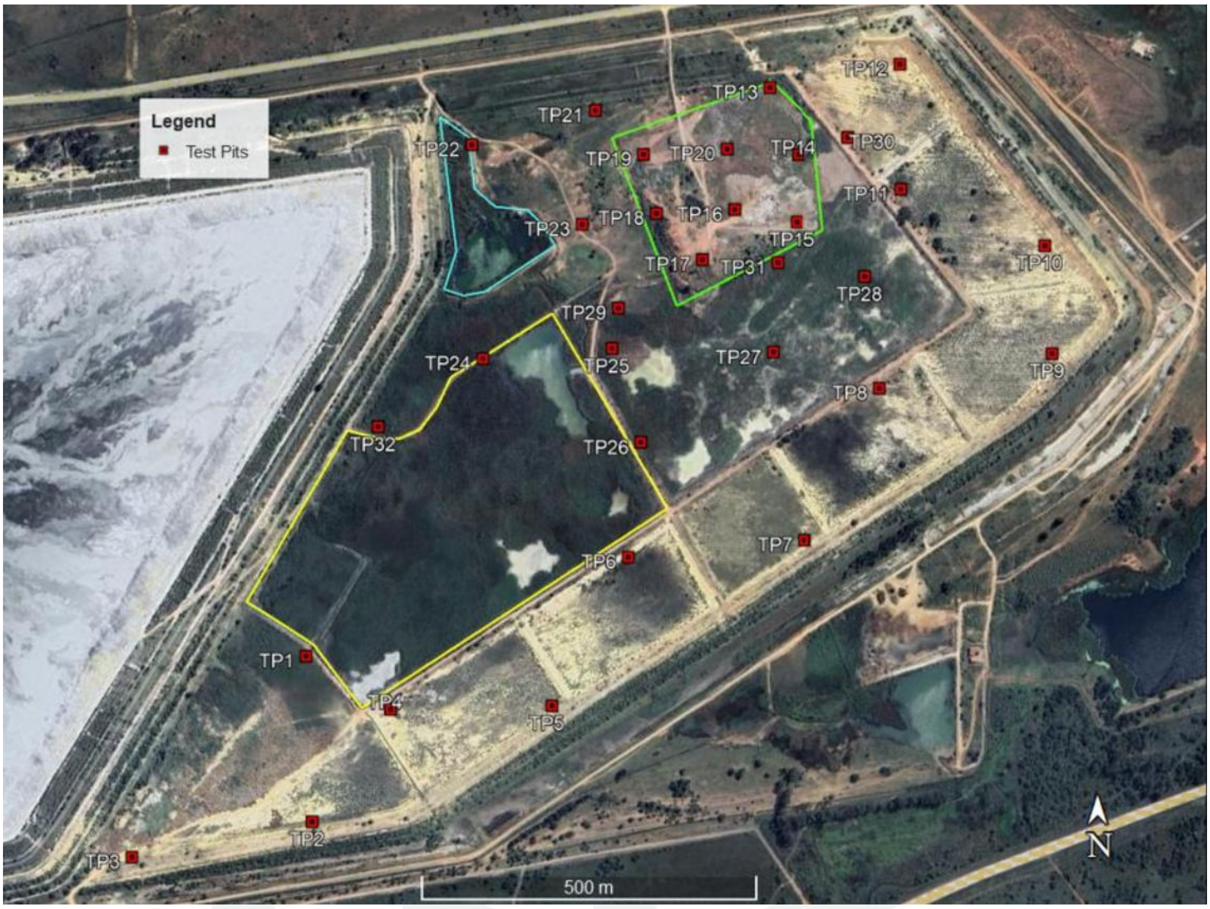


Figure 4-1: Test pit locations on Mponeng Lower Compartment (Kipaji, 2025)

The geotechnical investigation identified four distinct subsurface conditions across the site. In the north-western portion of the TSF, the area is mostly underlain by the original ground profile (natural soil and rock). This section, including test pits TP21 to TP23 and TP32, generally consists of a thin fill layer overlying residual shale soils and shallow, highly weathered shale bedrock. Bedrock was encountered at varying depths (0.9–3.8 m), with TP32 indicating possible shallow bedrock along the upper compartment toe. Seepage was also observed at TP32.

The client is operating a solid waste landfill site on the north-eastern portion of the TSF compartment. No organics or municipal waste are allowed to be disposed of on this site. The landfill extent is outlined in green in Figure 4-1. The test pits excavated in this area show varying waste material thickness, with the eastern and southern portions containing extensive rubble layers up to 5 m thick, particularly at TP20. In contrast, the western portion (e.g., TP18 and TP19) has thinner waste cover (0.3–1.3 m) and is directly underlain by residual shale or bedrock. Bedrock was generally deeper in the eastern/southern sections, found between 3.0 and 4.2 m. Groundwater seepage was commonly observed across the western and southern parts, occurring at similar depths and following the natural bedrock slope. Localised seepage was also noted at TP31 at the interface of the landfill and tailings.

In the area used as a dirty water dam, outlined in yellow in Figure 4-1, excavations at TP1 and TP24 to TP26 revealed an upper layer of oxidised tailings underlain by very moist to wet fresh tailings with very soft consistency. Excavation proved challenging due to collapsing sidewalls and strong water inflow, particularly at TP24 and TP25. Shale bedrock was encountered below the tailings at TP24 at a depth of 3.1 m. The conditions in this area suggest persistent saturation and poor soil stability.

The southern and eastern TSF area, underlain by tailings material (represented by TP2 to TP12), exhibited relatively uniform profiles. A surface layer of oxidised tailings (1.0–2.0 m thick) displayed firm to soft consistency and was underlain by fresh (unoxidized) tailings, which were moist to wet and very soft. The grading varied slightly but did not show obvious signs of coarsening toward the embankments, likely due to paddock deposition. Groundwater seepage was minimal, only noted at TP6 between the oxidised and fresh tailings. Despite limited seepage, excavation was hindered by the wet, unstable nature of the tailings, with many pits collapsing during the test pit excavation.

4.2 GEOTECHNICAL RISKS IDENTIFIED

The geotechnical risks identified for the site include several key concerns. Firstly, the presence of landfill material presents a challenge, with shallow fill on the western side that deepens towards the east due to the natural topography. This variation may cause differential settlement owing to the inconsistent composition and depth of the fill. Secondly, much of the basin currently contains water, leading to saturated and soft tailings beneath. These conditions render the area inaccessible for heavy equipment, posing a significant limitation on construction and operational activities. Additionally, there are concerns regarding groundwater and seepage, particularly the spring observed in the northwestern corner, suggesting artesian conditions. Seepage from the Upper Compartment is also expected, and as the load from the increasing height of the compartment grows, it is anticipated that groundwater pressures will rise and be released unpredictably.

5 CLEAN AND DIRTY WATER MANAGEMENT

5.1 BASIS OF DESIGN AND LEGAL REQUIREMENTS

The surface water management infrastructure must be designed, managed, and operated to comply with the requirements contained in the NWA, Regulation no 7 of 1999 (GN 704):

- Clean and dirty water are to be separated as far as reasonably possible, with a dedicated clean and dirty water system.
- Polluted water, which includes seepage, must be contained within the dirty water system.
- The reuse (process water, dust suppression, etc.) of dirty water will be maximised within the mining area.
- Clean and dirty water systems must be designed, constructed, and maintained to ensure that these systems do not spill into each other more than once in 50 years.
- No residue deposit, dam, reservoir, or associated infrastructure may be located within the 1:100-year flood line of any watercourse, estuary, borehole, or well. This excludes monitoring boreholes.
- All dams will have a minimum freeboard of 0.8 metres.

5.2 CATCHMENT AREAS

The catchment areas were delineated based on the localised catchments that influence the extended TSF area and the clean water diversion controls required in and around the site, as shown in Figure 5-1.

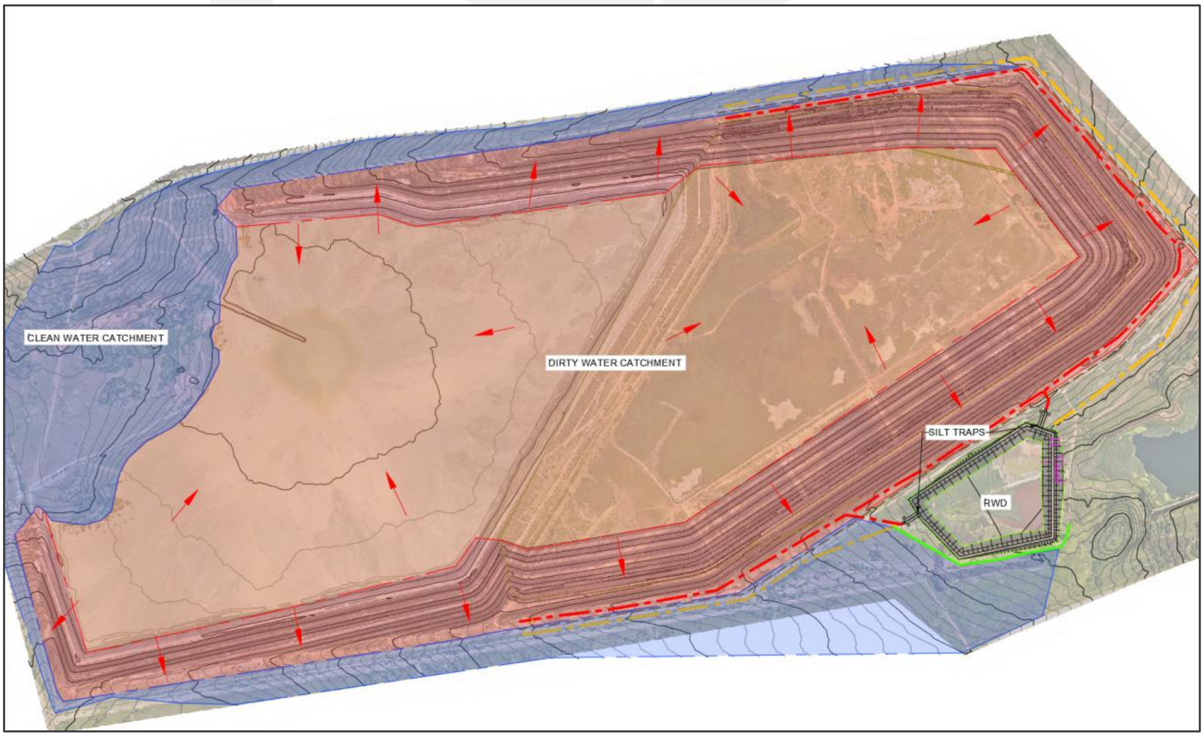


Figure 5-1: Mponeng overall site Catchment Layout

5.3 DIRTY WATER COLLECTION

5.3.1 Surface Water Conveyance

In support of the potential Water Use Licence Application (WULA) for the re-commissioning of the lower compartment, this study focuses solely on the direct infrastructure upgrades required on the lower TSF compartment to ensure regulatory compliance, particularly with respect to water management systems as prescribed under Government Notice 704 (GN704) of the National Water Act.

GN704 requires that all dirty water collection and conveyance systems associated with mining-related activities be designed to prevent seepage of polluted water and promote the reuse of water.

To achieve both regulatory compliance and cost efficiency, trapezoidal concrete-lined channels (Figure 5-2) are planned to be installed within the existing, unlined paddocks. These channels will serve to collect and convey dirty water in a controlled manner, minimising seepage and preventing contamination of the surrounding environment. The channels will discharge into concrete silt traps before entering the RWD.

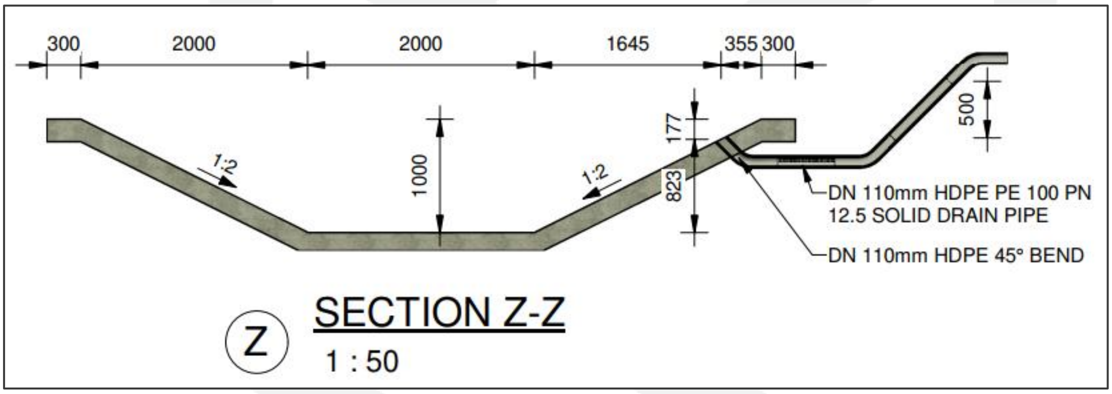


Figure 5-2: Typical Trapezoidal Concrete-lined Channel Detail

Importantly, this proposed system strategically utilises existing infrastructure to minimise capital expenditure. The outer paddock bund wall and the existing earth-lined solution trench, both of which are already in place and in suitable condition with minor repairs, will be repurposed to function as components of the clean and dirty water separation system. The bund wall acts as a physical barrier, delineating clean runoff areas from the TSF, while the existing solution trench will continue to serve as a means of intercepting and directing water away from the facility.

5.3.2 Leachate Collection

The leachate collection system has been set out to efficiently capture and convey leachate generated within the impoundment area, thereby reducing hydraulic head buildup and minimise seepage of contaminated water. This system plays a critical role in the environmental performance and geotechnical stability of the facility by promoting unsaturated conditions in the outer structural zone.

The leachate collection system comprises a high-permeability drainage layer, consisting of a network of perforated HDPE collector pipes embedded in free-draining gravel (as shown in Figure 5-3).

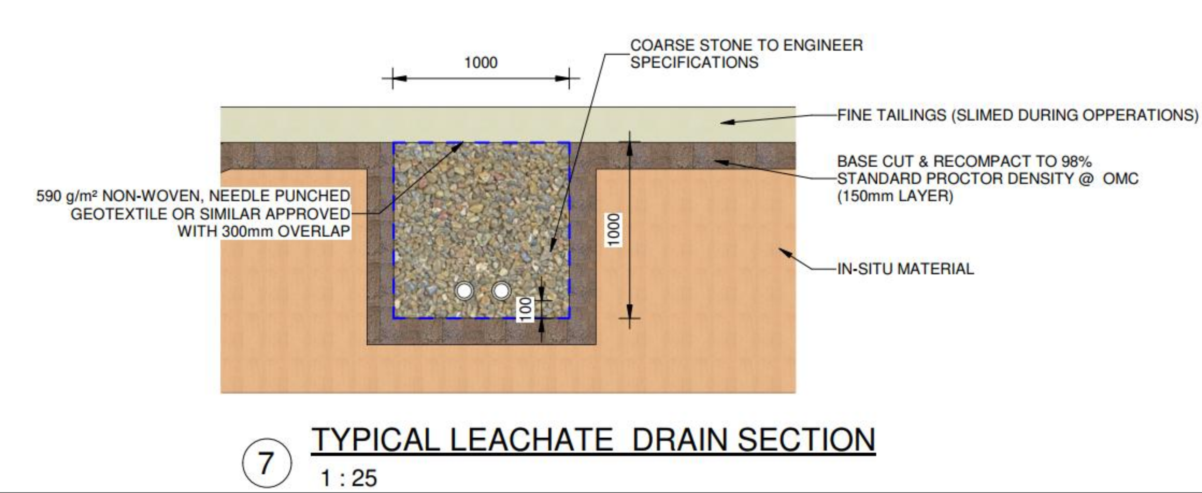


Figure 5-3: Typical Leachate Drain Detail

In addition to the leachate drainage network, the Lower Compartment of the TSF is equipped with a toe blanket drain (Figure 5-4) at the downstream toe of the facility. This drain serves as a secondary seepage control measure, capturing any leachate or seepage that migrates toward the outer limits of the impoundment. The toe blanket drain enhances the overall seepage control capacity of the TSF by providing an additional pathway for water interception before it can accumulate or emerge at the downstream slope, thereby reducing pore pressures and improving long-term slope stability.

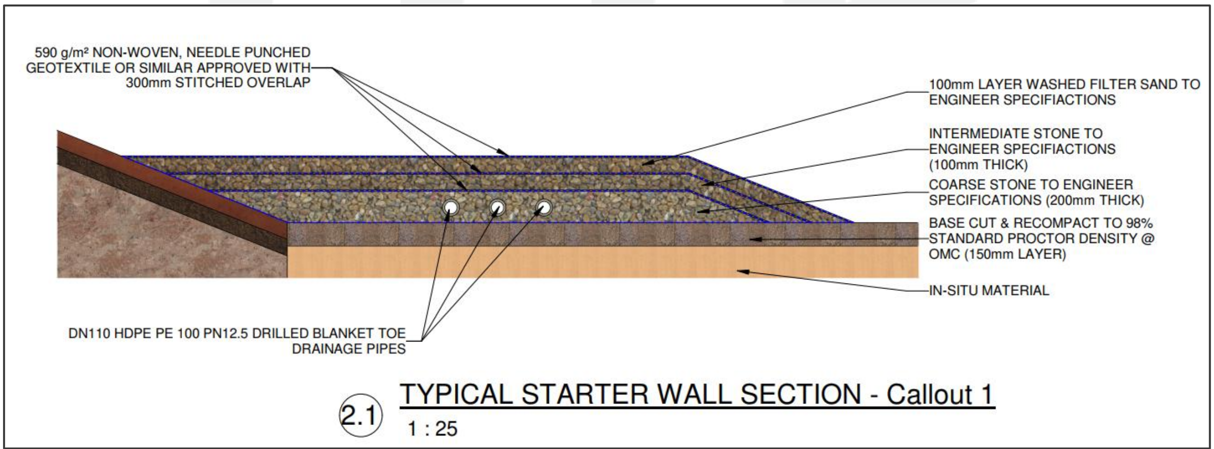


Figure 5-4: Typical Toe Drain Detail

To maintain geotechnical stability and minimise the risk of seepage-induced failure, an interface curtain drain will be installed along the slope separating the Upper Compartment from the proposed Lower Compartment of the TSF.

The curtain drain (as shown in Figure 5-5) has been designed to intercept and convey seepage emerging from the advancing Lower Compartment tailings before it can migrate laterally into the previously deposited, more permeable materials of the Upper Compartment. The interface drain will reduce the risk of increased pore water pressures within the coarser tailings zone, reducing effective stress and possibly triggering localised instability.

It is envisaged that the initial construction will establish a 4-meter-high curtain drain at the slope interface. However, because tailings deposition in the Lower Compartment will continue throughout the TSF's operational life, the curtain drain will need to be progressively extended upward by the operational contractor.

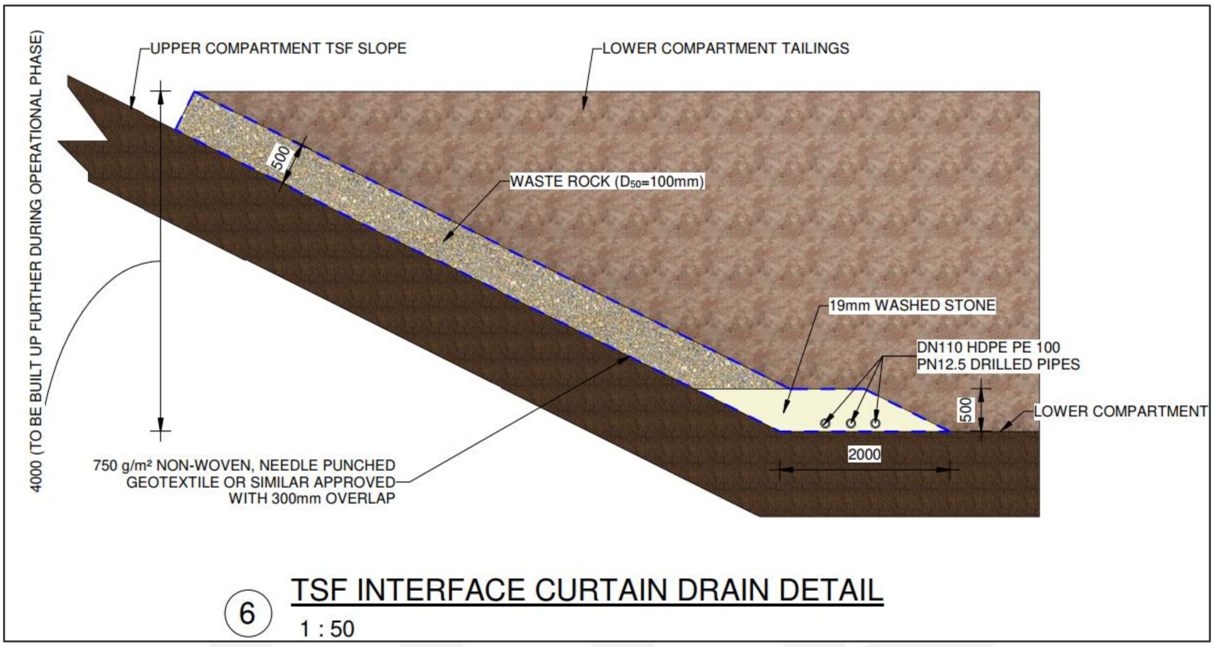


Figure 5-5: Typical Detail of the Interface drain

At the upstream side of the footprint, two reverse filter packs are strategically positioned at the current existing spring and holding dam locations to serve as seepage interception points. These reverse filters comprise a thick waste rock layer with non-woven needle-punched geotextile encapsulating the drain. If the Lower Compartment footprint is dried out, and time is allowed for the subsurface water to dissipate, before construction works begin, then the necessity of the filter packs will be reassessed.

It should also be noted that the lower compartment currently has ten leachate collection outlet pipes that discharge into the existing unlined solution trenches. However, based on data from the HMS, no measurable flow has been recorded from these outlets for over a year. Therefore, it is proposed that these outlet points be intercepted and fitted with monitoring manholes. These manholes will be designed to either overflow or allow for controlled pumping into the solution trenches in the event that leachate accumulates within them. Figure 5-6 below illustrates the proposed leachate and dirty surface water management system. Refer to the drawings in **Annexure A** for more detailed information on the planned infrastructure.

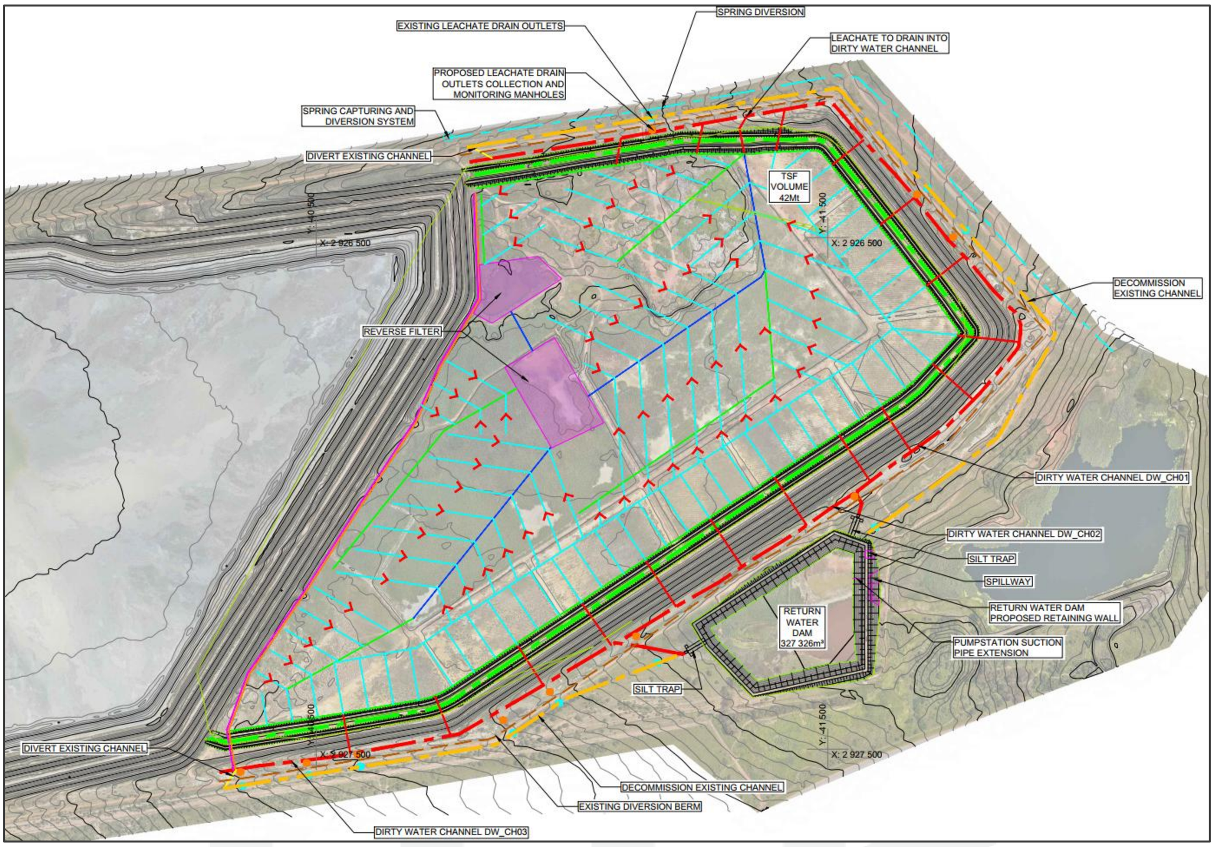


Figure 5-6: Proposed Stormwater and Leachate Collection System

5.4 CLEAN WATER DIVERSION SYSTEM

In addition to the repurposed clean water channels and berms discussed in Section 5.3.1, the spring water currently daylighting in the northern portion of the proposed footprint will also require diversion around the TSF.

5.4.1 Spring Diversion

A dedicated spring capturing and diversion system will be required before the installation of sub-surface drains. This system must be implemented on the upstream side of the currently active spring located along the northern boundary of the proposed lower compartment footprint (as shown in Figure 5-6**Error! Reference source not found.**). The purpose of this spring capturing system is to intercept and manage any clean groundwater emerging from the surrounding higher-elevation areas before it enters the TSF footprint. By doing so, it prevents this clean water from contributing to groundwater recharge beneath the tailings facility, which could otherwise elevate pore water pressures and compromise the integrity of not only the proposed lower compartment but also the foundation of the upper compartment toe.

As noted in Section 3.3, CGS Water and Environmental Consultants investigated the origin of the spring and provided preliminary recommendations for capturing and diverting the water around the facility. These measures include vertical shafts with horizontal drains (as shown in Figure 5-7). It was recommended by GCS in the January 2019 report that a trial study be initiated where the spring is intercepted by borehole MB20 and a potential 2nd borehole about 20 to 50m to the north-east. Once these have been established, further investigation will be necessary to determine the optimal placement of the capture system to effectively drain and redirect clean water away from the facility.

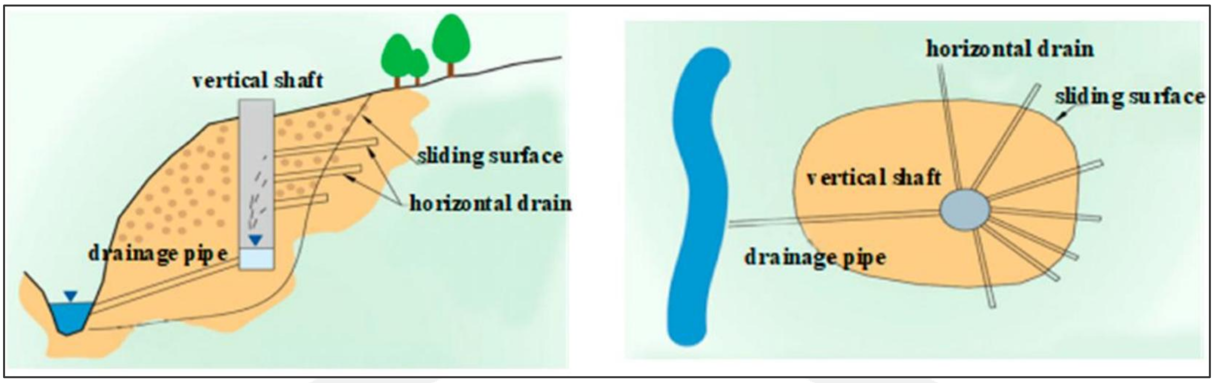


Figure 5-7: Schematic Detail of the proposed capturing system (GCS, 2025)

5.5 RETURN WATER DAM

5.5.1 RWD Design

The current RWD does not have sufficient capacity to accommodate both current and future operational demands. Therefore, the existing dam will need to be enlarged to provide adequate capacity to contain the 1:50-year, 24-hour storm event above the mean operating level. The RWD is designated for the runoff, TSF pool drawdown, leachate, and sub-surface water of both the upper and lower compartments of the TSF. The RWD will be equipped with two silt traps (on the eastern and western sides of the dam, respectively) and an emergency spillway.

The RWD will be of the earth fill embankment type, with an upstream and downstream slope of 1:3 (V:H). To prevent seepage and groundwater contamination, the RWD will be constructed with a Class C performance barrier system. The RWD will also be provided with a minimum freeboard of 800 mm and an overflow spillway capable of safely passing the 1:100-year flood event.

A Class C performance barrier system has been opted for the RWD. The geomembrane was changed from a general Class C 1.5 mm HDPE to a 2 mm HDPE to improve the liner performance as well as to negate the use of a clay layer below. Due care should be taken when installing the barrier on top of the founding soil, which is to comply to SANS 10409 (2020), receiving face of reworked foundation soil.

Soilcrete as a ballast layer and soilcrete-filled geocells are to be placed on the floor and wall area, respectively. Care should be taken when placing these layers above the liner. An Electric Leak Location (ELL) survey has been specified for the covered geomembrane in the RWD by means of Dipole testing according to ASTM D7007 to ensure that no damage has been caused to the barrier system after installation. Refer to **Annexure A** for more information on the proposed RWD layout and liner detail.

5.5.2 RWD Sizing (Water Balance)

A water balance was conducted to ensure that the size of the dirty water management infrastructure is adequate and that the mine complies with the requirements set out in the National Water Act (NWA), Act 36 of 1998, as well as the regulations on water usage for mining activities stated in Government Notice Nr. GN704 dated June 1999.

The results of the water balance model are summarised below:

- Excess water in the RWD is at risk of overflowing into the downstream environment when both the Upper and Lower TSFs are operational, with the potential to degrade the surface and groundwater qualities of surrounding areas. Excess water from Mponeng operations must be sent to the Savuka Operations to ensure that the proposed RWD is adequately sized to accommodate all the dirty water inflows.
- The proposed capacity of Mponeng TSF RWD is 327,000 m3. This capacity is sufficient to contain all dirty water inflows without the dam spilling more than once in 50 years.
- Average of 3.03 Ml/day needs to be pumped back to the Savuka plant.
- Average of 6.16 Ml/day needs to be pumped back to the Mponeng plant.
- Roughly 40% of the RWD capacity was allowed for the operating level of the RWD.

Refer to **Annexure D** for more details on the Water Balance Report.

6 TAILINGS STORAGE FACILITY DESIGN

6.1 OVERVIEW

The lower compartment was designed to meet the client's minimum capacity requirement of 40.3 million tonnes (Mt). The current design exceeds this target, providing a total storage capacity of approximately 43 Mt. This design was developed with operational and geotechnical constraints in mind, specifically aiming to limit the rate of rise to a maximum of 4 meters per annum and to cap the final facility height at 60 meters, ensuring safe and sustainable deposition over the operational life of the facility.

The facility will include a starter wall and a toe wall as part of its initial construction phase. The TSF will be raised in successive 8 m high lifts, each separated by 8 m wide benches. This stepped configuration not only aids in structural stability and erosion control but also provides access for construction and inspection activities as the facility is developed over time.

The delivery system will consist of hydrocyclones. The underflow material (coarse, dewatered tailings) is separated from the slurry by the hydrocyclones and deposited at the outer core. The overflow material (fine tailings and slurry water) is deposited in the basin. The facility will be served by hydrocyclones on three sides (north, east, and south) with a proposed spigot system to deposit tailings at the interface of the upper and lower compartments.

Supernatant water is decanted by a gravity penstock system through a flanged steel pipe encased in concrete beneath the pollution control barrier. The penstock outfall pipe discharges water into the solution trench from where the water is conveyed via the concrete-lined dirty canal system and silt trap to the RWD.

6.2 PROPOSED GROUND IMPROVEMENTS

In addition to the presence of a spring within the footprint and the proposed groundwater-intercepting sub-surface drainage network designed to manage seepage and maintain slope stability, there is also a landfill site located on the northern portion of the facility that poses a significant geotechnical and environmental risk. The landfill site contains heterogeneous and potentially compressible waste materials, which introduces the possibility of uneven settlement over time, especially under the loading conditions imposed by the overlying tailings. To mitigate this risk, long-term ground improvement measures are necessary.

Ground improvement, such as dynamic compaction, is recommended to densify the underlying landfill material, reduce voids, and improve uniformity in stiffness and bearing capacity across the area. To further support the foundation and distribute applied loads evenly, a load-distribution platform should be constructed. This platform should incorporate a high-strength geogrid (at least 100KN/m) to provide tensile reinforcement and interlock with the granular material, combined with a 1 m thick rockfill layer to act as a bridging and load-spreading medium. Together, these measures will help ensure structural stability and reduce the potential for differential settlement.

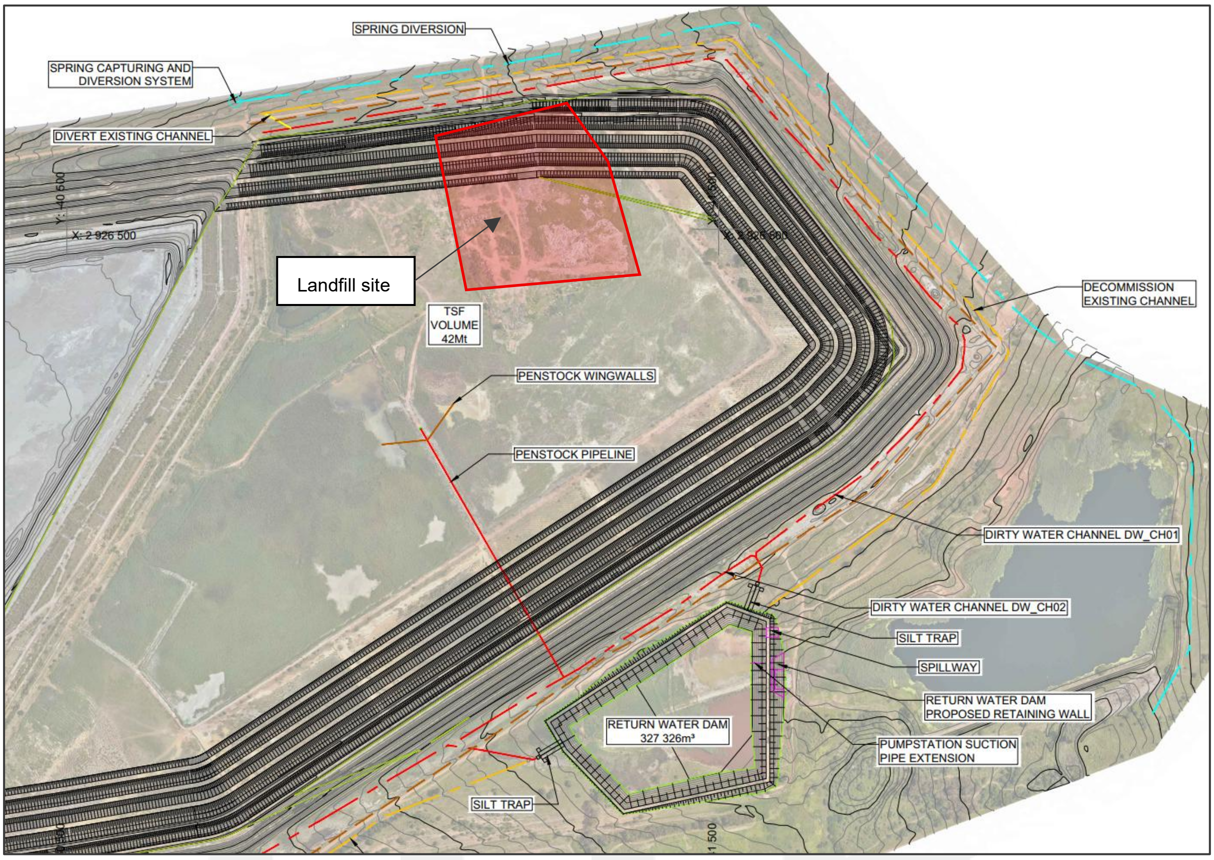


Figure 6-1: Existing Landfill site within the TSF footprint.

6.3 BARRIER DESIGN

6.3.1 Material Classification and Barrier Type

Under the current requirements of the National Water Act (NWA) and associated regulations, facilities intended for the storage or disposal of Type 3 waste must be designed and constructed with a Class C equivalent barrier system. Seepage losses through a traditional Class C barrier are primarily determined based on the number of holes intersecting wrinkles, as reflected in the Casagrande lecture 2012 by RK Rowe.

At the time of writing this report, no formal waste classification information has been made available. In the absence of this data, the waste material is assumed to fall under Type 3 waste, in accordance with the National Environmental Management: Waste Act (NEM:WA) classification system. This assumption is based on similarities with tailings produced by other gold mining operations, which typically exhibit geochemical and physical characteristics consistent with Type 3 waste.

6.3.2 Expected seepage losses

Contamination from the facility is expected to be relatively low as previous studies have shown very low seepage rates below/around the facility (mainly due to low permeability bedrock and artesian conditions). Furthermore, the sulphate concentrations within existing monitoring boreholes are considered low with neutral pH values. This implies that limited acid mine drainage has occurred at the

Mponeng TSF and that limited metal mobilization is in progress (report reference: *Groundwater Assessment for the Mponeng TSF Complex, GCS 2019*).

Additionally, unique geotechnical conditions are present at the site, due to the heterogeneous legacy materials (including the landfill waste and previously saturated tailings). These conditions create a high risk a risk of differential settlement and localised weak zones affecting stability. Where differential settlement occurs, the liner experiences elevated strains, and any compromise in its integrity promotes the formation of concentrated seepage flow paths.

The proposed re-commissioning design therefore comprises an unlined facility supported by a robust seepage control system, with the objective of maintaining global stability and limiting seepage impacts to an acceptable level during operation and post-closure.

6.4 TSF CAPACITY

The stage capacity of the new TSF is based on the Civil3D model contours. The stage capacity curves for the lower compartment are shown in Figure 6-2. The supplied delivery rate for deposition is 350 000 t/m (tonnes per month) at an average dry density of 1.54 tonnes/m³.

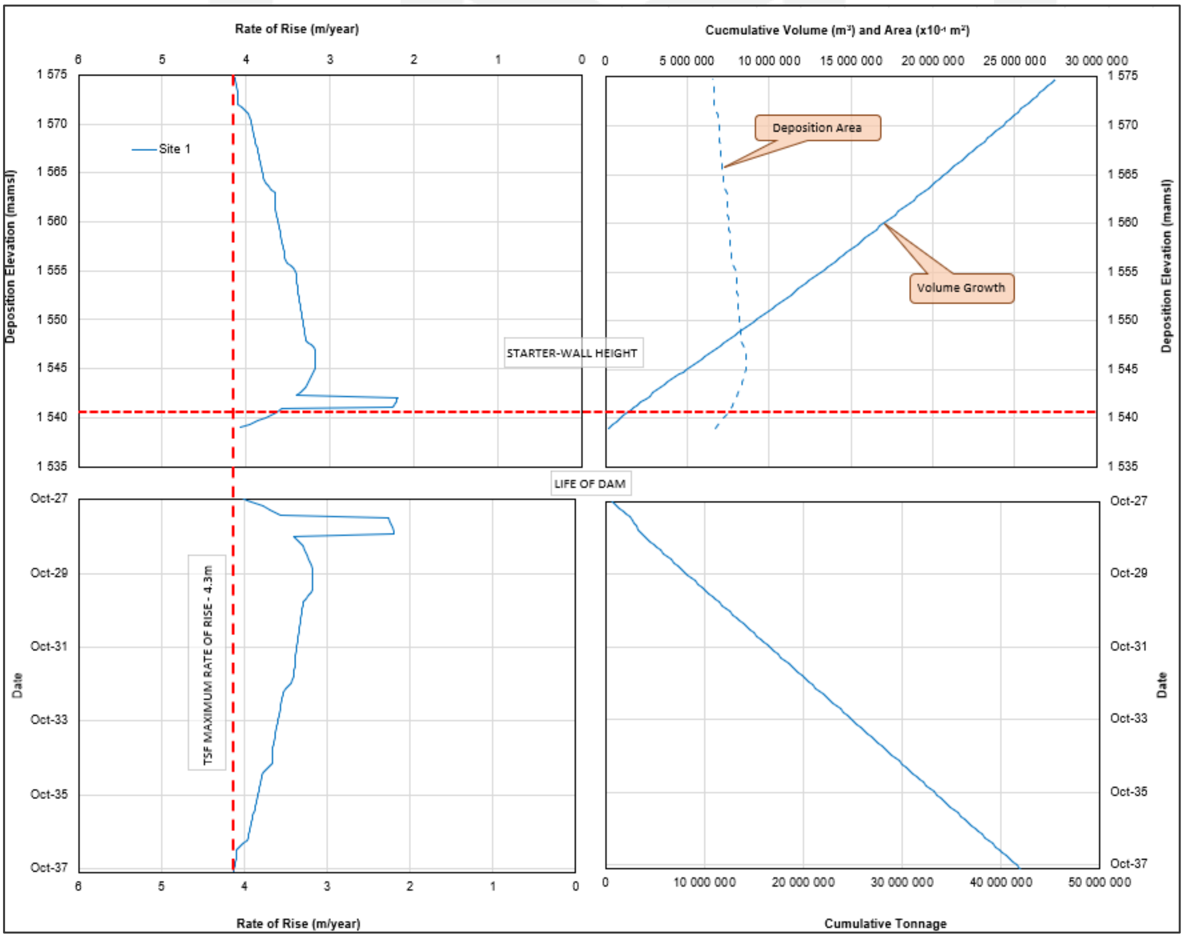


Figure 6-2: (Mponeng Lower Compartment Stage Storage Curves)

7 SEEPAGE AND STABILITY ANALYSIS

7.1 BACKGROUND

This section of the report covers the stability assessment of the Mponeng TSF Lower Compartment raising design to determine its compliance with the South African regulatory minimum stability requirements.

7.2 GEOLOGY

The results of the Kipaji 2025 test pit investigation are briefly discussed in Section 4. Refer to the Kipaji investigation report for a more detailed discussion on the fieldwork findings.

For this stability assessment, four relevant sections are considered. The test pits relevant to each cross-section are summarised in Table 7-1. These profiles are utilised to compile the ground model for each section.

The typical strata encountered in the test pits are:

- Solid Waste.
- Fill.
- Tailings.
- Residual shale.
- Shale bedrock.

These are discussed in greater detail below.

7.3 SEISMICITY

The seismicity of the Mponeng TSF area is discussed in Section 3.4. In short, a peak ground acceleration of 0.074 g is utilised in the stability assessment. This acceleration relates to a seismic event with a return period of 2,475 years. This is in line with current international best practice guidelines for a tailings facility with a “high” hazard rating.

7.4 MATERIAL STRENGTH PARAMETERS

This chapter discusses the strength parameters for the tailings and foundation materials used in the slope stability assessment.

7.4.1 NATURAL SOIL AND ROCK

The test pit profiles show that where the excavations proceeded into the natural foundation profile, shale material was encountered. The shale bedrock is in places overlain by a thin cover of clayey silt residual soil. The shale bedrock was found to be highly weathered, soft rock.

7.4.2 LANDFILL WASTE

The waste material at the landfill facility consists of industrial solid waste. Due to the variability in the composition of the waste body, it is very difficult to test for its shear strength. No testing on the solid waste has yet been conducted by either the landfill operator or during any historical geotechnical investigations. Hence, a literature study was conducted to determine a representative set of parameters for typical industrial solid waste. The study revealed that this type of waste typically has a cohesion ranging from 0 to 100 kPa, with Bray et al. (2009) recommending a characteristic value of c’ = 15 kPa for slope stability purposes. A value of 25 kPa is recommended by Edincliler et al (1996) and 10 kPa by Naveen et al (2014).

Similarly, for the friction angle, the values ranged from 36°, 35°, and 25° for the aforementioned three sources, respectively. To maintain a modicum of conservancy, the average of the above values was adopted, with c’ = 15 kPa and ϕ’ = 32°.

7.4.3 TAILINGS

No formal geotechnical laboratory testing of the Mponeng tailings was conducted as part of this design. Several historical reports are available for this TSF, all showing drained strength parameters of the coarser daywall and finer basin tailings in the order of ϕ’ ranging from 30° to 34°. This aligns well with the detailed laboratory testing conducted recently on tailings from Harmony’s neighbouring Kusasalethu and Savuka TSFs.

The historical stability reports did not consider undrained strength conditions within the TSF. As such, the undrained strength parameters determined from the Kusasalethu and Savuka tailings testing are again used for both the existing tailings as well as the tailings to be deposited in the future on this compartment.

Table 7-1: Summary of relevant test pit profiles (Kipaji, 2025)

STABILITY SECTION NO.	TP NO.	SOLID WASTE (LANDFILL)	FILL (TAILINGS)	FILL (SOIL)	TAILINGS	RESIDUAL SHALE SOIL	SOFT ROCK SHALE	DEPTH TO GROUNDWATER (mbgl)
A-A	TP1			0 – 0.4	0.4 – 3.8+			-
	TP4				0 – 4.7+			-
	TP2				0 – 5.0+			-
B-B	TP25			0 – 1.4+				0.0
	TP26				0 – 4.5+			1.2
	TP7				0 – 4.0+			-
C-C	TP28				0 – 4.0+			-
	TP11				0 – 4.8+			-
D-D	TP31		0 – 1.9	1.9 – 2.9			2.9+ R	2.8
	TP15	0 – 2.3	2.3 – 3.0	3.0 – 3.5		3.5 – 4.2	4.2+ R	4.0
	TP14	0 – 2.2		2.2 – 4.2+				3.3
	TP13				0 – 0.9		0.9 – 1.3+ R	-

"+" denotes that the same layer continues further down, but the excavation was stopped at that specific depth.

"R" indicates that refusal was encountered at the specific depth with the excavator.

Table 7-2: Material strength parameters

Material Type	Unit weight		Mohr-Coulomb Drained			Undrained shear strength			
						Peak Short-term and during earthquake		Residual Post-seismic (liquefied)	
	Bulk	Saturated	Cohesion	Friction angle	Dilation angle	Undrained strength ratio	Undrained strength, min	Undrained strength ratio	Undrained strength, min
	γ'	γ_{sat}	c'	Φ'	ψ	$S_{u(peak)}/\sigma'_{vo}$	$S_{u(peak,min)}$	$S_{u(res)}/\sigma'_{vo}$	$S_{u(res,min)}$
	kN/m³	kN/m³	kPa	deg	deg	-	kPa	-	kPa
Insitu soil/rock									
Solid waste (landfill)	16.0	17.0	15	32	0	N/A			
Fill (tailings)	17.5	18.3	0	32	0	N/A			
Fill (soil)	17.0	17.5	0	27	0	N/A			
Residual shale (clayey silt)	17.0	17.5	2	30	0	N/A			
Weathered shale bedrock (soft rock)	23.0	23.0	Generalized Hoek-Brown model UCS = 6.5 MPa ; GSI = 35 ; mi = 6 ; D = 0 ; MR = 200						
Tailings									
Tailings – Daywall (coarse)	17.5	18.3	0	34	0	N/A			
Tailings – Basin (fine)	17.5	18.3	0	30	0	0	0.31	0	0.07

7.5 LOADING CONDITIONS

SANS 10286 (2022, draft standard) for tailings facilities aligned with GISTM (2020) specifies different loading conditions against which the stability of mine residue deposits must be assessed. These loading conditions are listed below and are thoroughly described in Table 7-3. However, the first loading condition applies only to new tailings storage facilities, not to existing ones such as the lower compartment.

1) Embankments before tailings deposition.
2) Long-term drained loading.
3) Short-term peak undrained.
4) Pseudo-static (earthquake) (peak undrained).
5) Liquefied / Residual shear strength.

Table 7-3: Relevant loading conditions for Mponeng TSF Lower Compartment

SCENARIO	LOADING CONDITIONS	DESCRIPTION	MINIMUM FOS
2	Long-term (peak drained strength conditions, steady-state seepage)	This scenario considers the long-term stability of the facility when steady-state seepage has been achieved during operation and closure. This scenario also assumes drained effective strength conditions, with no rapid change in phreatic surface or dam geometry.	1.50
3	Short-term (peak undrained strength)	This scenario considers the short-term stability of the facility when a trigger event (apart from an earthquake) results in the tailings and in-situ materials behaving in an undrained manner. Typical trigger events that are considered in the stability analyses are a rapid change in the phreatic surface, loss of confinement in the wall geometry.	1.30
4	Earthquake - pseudo-static (peak undrained strength)	At any given time, a regional earthquake may impose energy waves onto the facility. Probabilistic seismic hazard assessment must be done for better determination of site seismic response, and if not done, then the estimation of peak ground acceleration is determined from regional seismic maps. The ground acceleration is applied to the facility as a pseudo-static force in the limit equilibrium software. During an earthquake, the loading conditions within the facility change rapidly enough that there is not enough time for drainage of induced excess pore water pressures. Peak undrained strength conditions are therefore assumed for all fine-grained materials	1.10

SCENARIO	LOADING CONDITIONS	DESCRIPTION	MINIMUM FOS
		situated below the water table (i.e., saturated) and expected to behave in a contractive manner. All other materials are taken to behave in a drained manner.	
5	Post-liquefaction (residual undrained strength)	This scenario considers the stability of the facility after a flow liquefaction event has occurred due to one of the aforementioned trigger events. Hence, it is assumed that the saturated, contractive materials have liquefied during the trigger event, and one now wants to verify the stability of the embankment post-liquefaction. The strengths of all contractive materials that are fully saturated (i.e., below the water table) are thus reduced from their peak to residual (post-liquefaction) values. All contractive materials above the water table are assumed to behave in an undrained manner without being prone to liquefaction, i.e., peak undrained strength. All other dilative materials are assumed to still behave in a drained manner.	1.10

7.6 SLOPE STABILITY ASSESSMENT

7.6.1 ASSESSMENT PROCEDURE

Four representative cross-sections were taken around the TSF for the slope stability assessment. The section locations are shown in Figure 7-1.

A seepage analysis was conducted using the proposed drainage layout to estimate the phreatic surface used in the stability models. The stability assessment was performed with Rocscience's Slide2 v9.0 (2025) limit equilibrium software using the Morgenstern-Price method of slices to determine safety factors (FoS) for the critical failure surfaces.

Figure 7-1: Google Earth aerial image showing slope stability section locations

7.6.2 ASSESSMENT RESULTS

Table 7-4 presents the results of the slope stability assessment. Detailed analysis outputs, including the corresponding critical failure surfaces, are provided in **Annexure E**. As indicated in Table 7-4, the calculated FoS values comply with the minimum stability criteria outlined in Table 7-3. Accordingly, the raised design of the Mponeng TSF Lower Compartment is considered safe and stable for the intended function.

Table 7-4: Slope stability results – Mponeng TSF Lower Compartment

SECTION NO.	LOADING CONDITION	REQUIRED FOS	OBTAINED FOS
A-A	Long-term drained	1.5	1.5
	Short-term peak undrained	1.3	1.4
	Pseudo-static	1.1	1.1
	Residual shear strength	1.1	1.4
B-B	Long-term drained	1.5	1.5
	Short-term peak undrained	1.3	1.4
	Pseudo-static	1.1	1.1
	Residual shear strength	1.1	1.4
C-C	Long-term drained	1.5	2.0
	Short-term peak undrained	1.3	1.7
	Pseudo-static	1.1	1.3
	Residual shear strength	1.1	1.1

SECTION NO.	LOADING CONDITION	REQUIRED FOS	OBTAINED FOS
D-D	Long-term drained	1.5	2.0
	Short-term peak undrained	1.3	1.7
	Pseudo-static	1.1	1.3
	Residual shear strength	1.1	1.1

8 CONCLUSION

The Upper Compartment of the Mponeng TSF is nearing the end of its operational life, with capacity expected to be exhausted by 2031. The Savuka facility has also reached its limit and is undergoing a short-term two-year extension, after which an alternative is needed. The facility is expected to operate for 10 years at 350 ktpm.

Recommissioning the Lower Compartment has been identified as a suitable replacement. The works, in brief, would involve the regrading and shaping of the basin, the construction of a toe and starter wall, and the installation of a new drainage network, outfall pipelines, and an RWD.

The facility was designed to accommodate approximately 43 Mt of tailings, with key limiting parameters including a maximum height of 60 meters and a rate of rise limited to a maximum of 4 meters per annum. The deposition strategy, utilising hydrocyclone separation of coarse and fine tailings, promotes stable construction and efficient water management.

Contamination from the facility is expected to be relatively low as previous studies have shown very low seepage rates below/around the facility (mainly due to low permeability bedrock and artesian conditions). Additionally, unique geotechnical conditions are present at the site, including contaminated tailings below the level a liner can be safely stored, landfill waste and previously saturated zones, create a risk of differential settlement and localised weak zones affecting stability. These conditions hinder the safe and effective installation of an HDPE liner.

The proposed re-commissioning concept therefore comprises an unlined facility supported by a robust seepage control system, with the objective of maintaining global stability and limiting seepage impacts to an acceptable level during operation and post-closure.

The site poses challenges due to an existing landfill and a natural spring; however, the design incorporates appropriate mitigation measures, including differential settlement management (such as dynamic compaction and a reinforcing geogrid) and spring interception, to address these conditions.

To comply with Regulation GN704 and the Waste Act, the stormwater management infrastructure has been designed to ensure the separation of clean and dirty water. The system will ensure that dirty water is contained within the dirty water system, and the clean water, generated from the catchment upstream of the dirty areas, will be diverted past the dirty water areas and released into the environment. The dirty water containment system and clean water diversion system have been designed for a fifty-year (1:50) reoccurrence period.

The leachate collection system comprises a network of 110 mm and 160 mm perforated HDPE sub-soil drainage pipes installed within a graded gravel drainage layer, all enclosed in a geotextile separation fabric to prevent the migration of the tailings fines. Additionally, a toe blanket drain exists at the downstream toe of the facility, and a curtain drain is proposed to be constructed at the interface with the Mponeng Upper compartment.

All leachate drains discharge into trapezoidal concrete-lined channels within the existing paddocks. These channels will serve to collect and convey dirty water in a controlled manner, minimising seepage and preventing contamination of the surrounding environment. The channels will discharge into concrete silt traps before entering the RWD.

Supernatant water is decanted by a gravity penstock system through a flanged steel pipe encased in concrete. The penstock outfall pipe discharges water into the concrete-lined channels.

The raised design of the Mponeng TSF Lower Compartment is deemed safe and stable for its intended function, as indicated by the slope stability analysis conducted.

Once the geohydrological seepage model has been completed and analysed, the Feasibility level design will be initiated. Making a timely decision on the proposed way forward is critical so that the overall project schedule can be aligned with water management strategies to remove the existing water on site.

9 REFERENCES

- Bray, J.D., Zekkos, D., Kavazanjian Jr, E., Athanasopoulos, G.A., and Riemer, M.F. 2009. Shear Strength of Municipal Solid Waste. Journal of Geotechnical and Geoenvironmental Engineering, Volume 135, Issue 6, June 2009.
- Canadian Dam Association (CDA), 2013. Dam Safety Guidelines 2007 (2013 edition). Canadian Dam Association.
- Edincliler, A., Benson, C.H. and Edil, T.B. 1996. Shear Strength of Municipal Solid Waste – Interim Report Year 1. Environmental Geotechnics Report 96-2, University of Wisconsin.
- GCS. (2025). *Harmony Mponeng- TSF Spring Hydrogeological.* Johannesburg: GCS Water & Environmental Consultants.
- Hoek, E. and Diederichs, M.S., 2006. Empirical estimation of rock mass modulus. International Journal of Rock Mechanics and Mining Sciences, 43, pp.203–215.
- Howell G.C. and Kirsten A.H. 2016. Interface Shear: Towards understanding the significance in Geotechnical Structures. Proceedings of the first Southern African Geotechnical Conference.
- Kipaji. (2025). Mponeng Mine Tailings Storage Facility Lower Compartment Geotechnical Investigation. Pretoria: Kipaji Geotechnical Consulting.
- Morgenstern, N.R. and Price, V.E., 1965. The analysis of the stability of general slip surfaces. Géotechnique, 15(1), pp.79–93.
- Naveen, B.P., Sivapullaiah, P.V., and Sitharam, T.G. 2014. Compressibility and Shear Strength of Dumped Municipal Solid Waste. Journal of Solid Waste Technology and Management, Volume 40, No. 4, November 2014.
- Rocscience, 2025. Slide2 version 9.0. 2D Limit Equilibrium Analysis for Slopes. Toronto: Rocscience Inc.
- Vunganai Midzi, B. M. (2020). Probabilistic seismic hazard maps for South Africa. *Journal of African Earth Sciences*, 11.

ANNEXURE A: DRAWINGS

ANNEXURE B: GEOTECHNICAL INVESTIGATION REPORT

ANNEXURE C: GEOHYDROLOGICAL INVESTIGATION

ANNEXURE D: WATER BALANCE REPORT

ANNEXURE E: SLOPE STABILITY SECTIONS