Appendix 2

Conceptual Design Report - RSF2 Stages 1 and 2

prepared by

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Tomingley Gold Operations Pty Ltd

TGO RSF 2
Concept Design Report

November 2020

Executive summary

Tomingely Gold Operations (TGO) engaged GHD to provide engineering services to undertake concept design for the new Residue Storage Facility (RSF).

TGO are preparing a project modification for Tomingley Gold Operations to permit construction of Stages 1 and 2 of RSF 2 and to extend TGO's project life to 31 December 2025. It is GHD's understanding that a further application may be prepared for the Tomingley Gold Extension Project, comprising two additional deposits to the south of the existing Mine. This application would result in an additional 10 years of mining operations and would require RSF2 Stages 3 to 9 to be developed.TGO will confirm this following mining studies work. However, based on the outcomes of the recent options study a concept design is required to provide a preliminary overview of the required RSF and allow for planning of future design and investigations.

This report details the concept design for the new RSF including the engineering considerations made in the sizing of the facility, design of the stage 1 and 2 embankment, construction staging, residue management, operation and surveillance requirements and conceptual closure considerations.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.5 and the assumptions and qualifications contained throughout the Report.

The concept design includes preliminary consideration of consequence category, hydrology storage volume, embankment geometry and zoning, construction requirements, residue management, operation and surveillance requirements, risk assessment and conceptual closure considerations.

Based on the options assessment report outcomes, the new RSF is to be located adjacent to the existing RSF and has been designed as a dual cell facility with a common wall with the existing RSF embankment. Based on this arrangement a consequence category assessment has been undertaken which has identified the Dam Failure Consequence Category as Significant and the Environmental Spill Consequence Category as Low. The sizing of the facility has been undertaken such that the facility has the capacity to store the PMF rainfall event.

The conceptual design for the stage 1 and 2 dam has been has made allowances for both upstream and centreline raise requirements as such the upstream face will consist of a 2H:1V slope, whilst the downstream face will consist of a 3H:1V slope.

Recommendations for a pathway to progress the concept to construction of the new RSF have been provided.

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1. Introduction

1.1 Background

Tomingely Gold Operations (TGO) engaged GHD Pty Ltd (GHD) to provide engineering services to undertake an options study for a suitable location for the new Residue Storage Facility (RSF) and concept design for the preferred location.

TGO are preparing a project modification for Tomingley Gold Operations to permit construction of stages 1 and 2 of RSF 2 and to extend TGO's project life to 31 December 2025. It is GHD's understanding that a further application may be prepared for the Tomingley Gold Extension Project, comprising two additional deposits to the south of the existing Mine. This application would result in an additional 10 years of mining operations and would require RSF2 stages 3 to 9 to be developed.

TGO will confirm this post mining studies in mid 2020. An options study has been completed to identify the potential sites and assess each site's suitability through the use of a multi-criteria assessment (MCA), followed by development of a concept design for the preferred site.

1.2 Purpose of this report

The purpose of this report is to present the details of the conceptual design for TGO's proposed RSF 2 starter dam (stage 1) and stage 2 raise. The details for the conceptual design for stages 3 to 9 are to be provided at a later date but concepts for stage 3 to 9 have been considered and included in this report for reference.

1.3 Scope of works

The scope of work for the concept design comprises:

- Detailing of the design basis for the RSF 2,
- Undertake conceptual level Consequence Category assessment,
- Undertake suitable facility sizing to meet TGO requirements,
- Develop a conceptual residue management strategy to meet TGO's ongoing deposition requirements,
- Undertake conceptual embankment design,
- Undertake conceptual foundation seepage modelling,
- Undertake conceptual water balance modelling,
- Undertake conceptual construction scheduling and raise methodology to meet TGO's expected throughput,
- Develop a conceptual RSF staging strategy,
- Undertake a conceptual level closure design, and
- Undertake a safety in design risk assessment.

1.4 Assumptions

The following assumptions have been used in the development of this report:

- RSF 2 Stage 1 and 2 dam embankment construction material will be won from the dam footprint and existing waste rock dump on site. This will be confirmed in the preliminary design stage following geotechnical investigations.

1.5 Limitations

This report: has been prepared by GHD for Tomingley Gold Operations Pty Ltd and may only be used and relied on by Tomingley Gold Operations Pty Ltd for the purpose agreed between GHD and the Tomingley Gold Operations Pty Ltd as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Tomingley Gold Operations Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.4 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Tomingley Gold Operations Pty Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has not been involved in the preparation of the wider approval applications associated with RSF 2 and has had no contribution to, or review of the wider approval applications associated with RSF 2 other than in the RSF 2 Concept Design Report. GHD shall not be liable to any person for any error in, omission from, or false or misleading statement in, any other part of the approval application documentation.

2. Basis of design

2.1 Background

TGO currently store residue within twin paddock-style facilities that are known as the Residue Storage Facility (RSF) Cells 1 and 2, collectively referred to as RSF1.

The existing RSF is approved to Stage 9 Cell 1 and anticipated to be full by February 2022. As a result RSF 2 will be required to be available before that date to cater for the remaining known 1.4Mt of ore to be mined, plus additional ore that would be identified prior to December 2021. Additional capacity (Stages 3 to 9) will be required for the Tomingley Gold Extension Project subject to subsequent approvals.

The current site layout is presented in Figure 2-1

Figure 2-1 Current site layout

2.2 Design Basis

The design basis was collated from a number of sources, including TGO input, RSF Stage 6 Raise Design Report (GHD, 2018), Stage 7-9 Concept Report (GHD, 2019), industry guidelines, GHD's TGO site experience and GHD's industry experience.

Whilst the majority of the parameters and design basis remain consistent throughout the RSF life, it is important to note that some will vary over time and should be checked and verified at each stage of the design, construction and operation. In some cases, various values for the same parameter has been sourced and included as an example. In each case, the most recent source should be relied upon for current and future designs.

A summary of the basis of design for RSF 2 is presented in Table 2-1.

Table 2-1 RSF 2 Basis of Design

Design Aspect	Design Basis	Design Source
Storage Capacity		
Facility Duration	3 years (to Stage 2), extending to 10 years	TGO Requirement
Ultimate capacity	4.5 Mt (with potential expansion to 15 Mt)	TGO Requirement
Dam Capacity	2 years (Stage 1) then 1 year per 2m raise for the subsequent raises	TGO Requirement
Dam Crest RL	Stage 1 – RL 270m; Stage 2 – RL 272m; Potential to extent to the existing RSF Stage 9 height at RL 286.5 m for an extended design life.	TGO Requirement
Annual Residue Production Rate	1.5 Mtpa	TGO Requirement
Long-term Residue Stored Dry Density	1.4 t/m³	RSF Stage 6 Pre-Construction Report
Rate of Rise	Maximum 2 m raise/annum	RSF Stage 6 Pre-Construction Report Industry experience for upstream / centreline raising
Consequence Category (ANCOLD)	Significant	GHD assessed
Embankment Arrangement		
Upstream Face	2:1 (H:V)	GHD Proposed
Downstream Face	3:1 (H:V)	GHD Proposed
Crest Width	TGO to confirm minimum crest width including safety bunds for single or dual lane arrangement for mining vehicles.	TGO to confirm
Construction Material	The stage 1 and 2 embankments will be constructed using excavated material from the footprint of the RSF and existing waste rock at the site.	As discussed with TGO
Construction Fleet	The stage 1 and 2 embankments will be initially constructed utilising a civil construction fleet with following raises (Stage 3 onwards) via the mining fleet.	As discussed with TGO
Mining Fleet	TGO to confirm mining fleet.	TGO to confirm
Future Raise Arrangement	The embankment will be designed such that both upstream or centreline/downstream raise arrangements can be utilised during future raises.	As discussed with TGO
Liner	1 m Compacted Clay Liner (CCL)	Environmental Protection Authority Tailings Dam Liner Policy Letter (2016)
Hydrology and Catchment		
Catchment Area	Area of the RSF footprint of the chosen arrangement	GHD Assessed
Flood storage requirements	Facility to be designed as a non-release facility, conceptual design to be based storage for 1:1000 AEP 72 hr	GHD Assessed
Spillway	Emergency Spillway for 1:1000 AEP. Decant arrangement to be designed to manage inflows in accordance with existing RSF 1 and 2 requirements use Residue Decant Storage for excess water storage.	GHD Assessed RSF Stage 6 Pre-Construction Report

Design Aspect	Design Basis	Design Source
Residue Information and Infrastructure		
Residue Classification	Non-Acid Forming (NAF), pumped as a slurry at 45 – 50 % solids#	RSF Stage 6 Pre-Construction Report
Beach Angle	1V:140H	Based on a survey of the existing RSF
Deposition Infrastructure	Deposited from spigots on the perimeter pipe	Based on Existing RSF Design
Deposition Methodology	Sub-aerial tailings deposition	Based on Existing RSF Design
Water Recovery Infrastructure	Central Decant Tower. Decant pond kept as low as possible with water return to process water dam for re-use and excess to Residue Decant Storage dam	Based on Existing RSF Design

2.3 Design Standards

The design standards and technical references adopted for this project will be as follows:

- Australian National Committee on Large Dams (ANCOLD) Guidelines on Tailings Dams (2019) and related ANCOLD guidelines
- Relevant ICOLD Guidelines
- Dam Safety NSW Guidelines*
- NSW Environmental Protection Authority, Tailings Dam Liner Policy Letter (2016)

*Legislation has passed and commenced 1 November 2019 to replace NSW DSC with Dams Safety NSW. Updates on guidelines and requirements are currently under preparation, however are unlikely to impact the outcomes of this study, as Dam Safety NSW has indicated the changes will align with ANCOLD requirements.

3. Background

3.1 Preferred Site Arrangement

Based on the options assessment report outcomes, Option 1 was identified as the preferred location, as such the new RSF is to be located adjacent to the existing RSF. Due to the topography around the preferred location the new RSF has been designed as a turkey's nest arrangement minimising hydrological impacts and simplifying depositional and residue management requirements. The facility has been designed such that the southern wall of the existing embankment will be utilised as part of the new RSF to optimise earthworks and ensure a stable landform arrangement, this will also allow for a single closure landform at the end of mine life. The facility arrangement can be found in Figure 3-1.

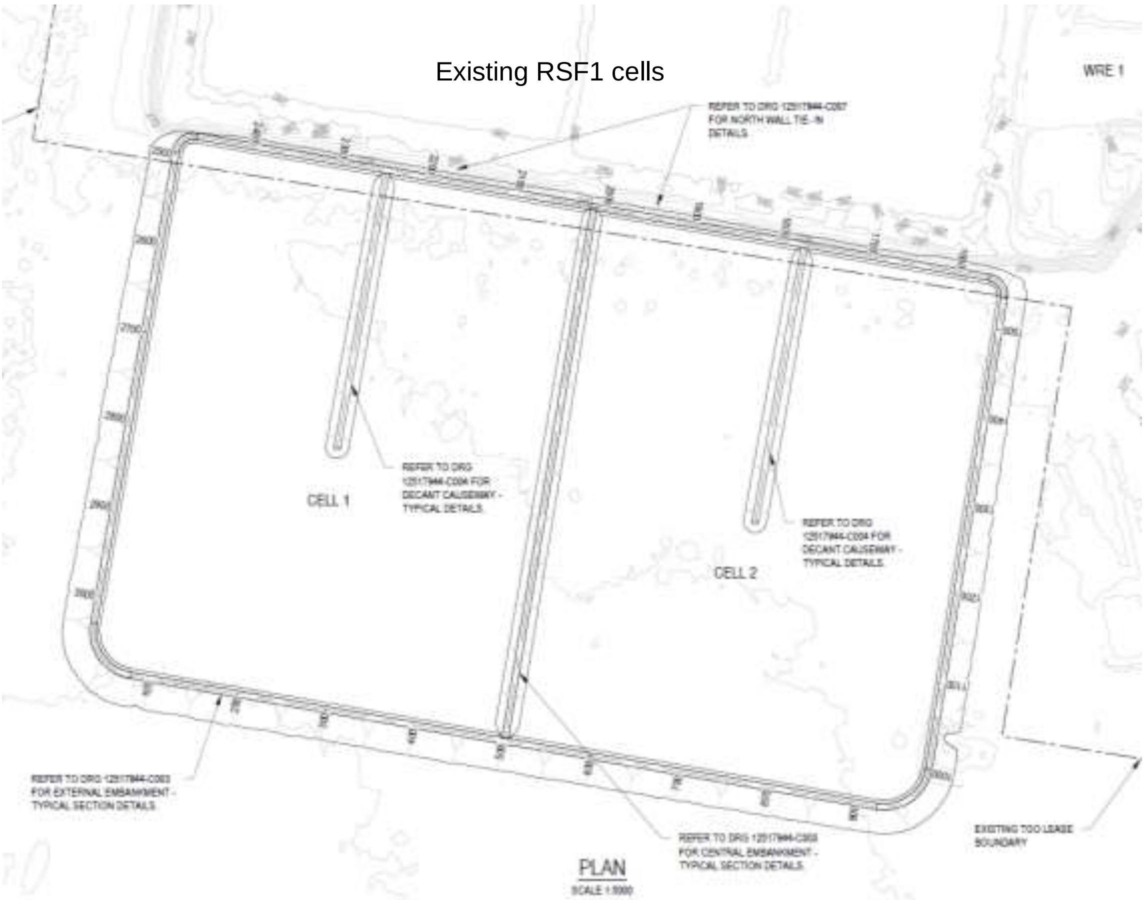


Figure 3-1 Preferred Site Arrangement – Stage 2 Plan

3.2 Climate

TGO mine is located on the south-western outskirts of Tomingley town and falls in a warm temperate climate zone. TGO have been recording daily rainfall data at the mine since 2013. Data prior to 2013 have been collected by the Bureau of Meteorology at the Peak Hill Post Office (Station Number 050031) with an average rainfall of 560 mm/year.

3.3 Geology

The local area geology map (refer Figure 3-2 and Table 3-1) was obtained from the NSW Department of Primary Infrastructure and indicates the following:

- A combination of alluvium deposits (Qa), Colluvium (Qv) undifferentiated sediments (Czs), and Ordovician sedimentary rocks (Os) are present.
- Multiple fault zones in close proximity to the mine location.

The map also includes the extents of the existing mining lease as sourced from Planning, Industry & Environment MinView and the proposed future mining lease extents as provided by TGO.

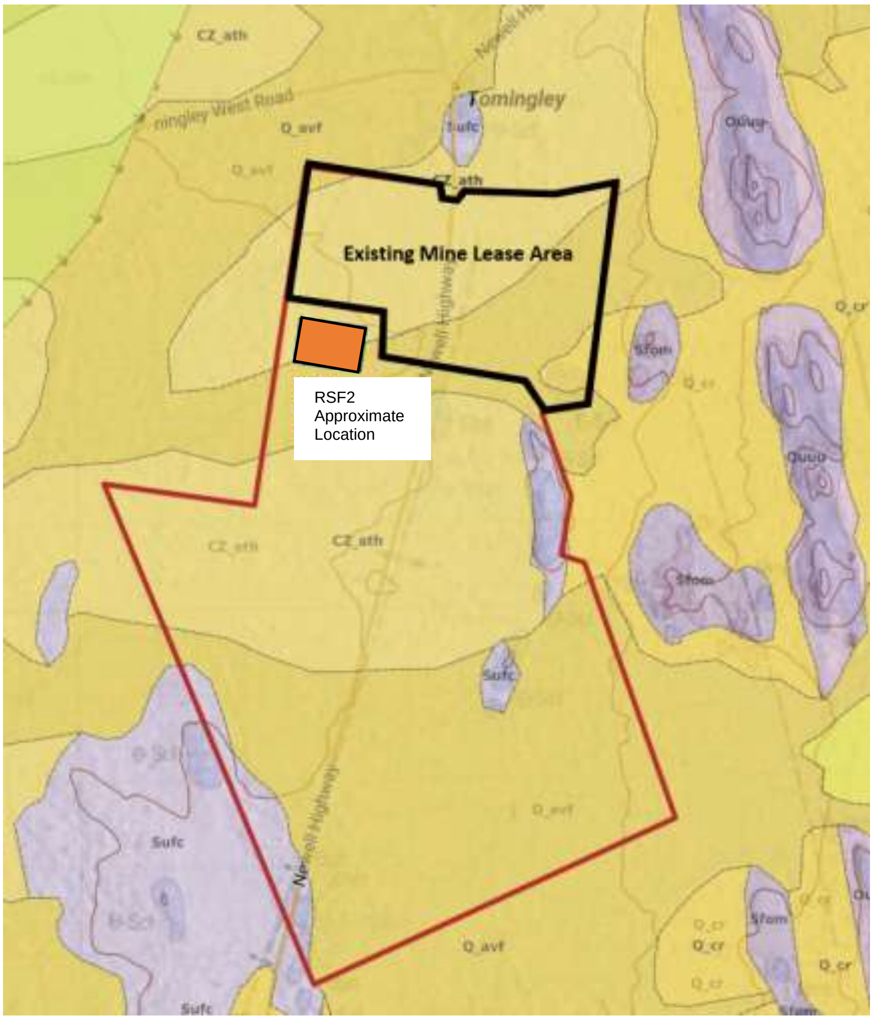


Figure 3-2 Local geology (image sourced from NSW Department of Primary Infrastructure)

Table 3-1 Local geological summary

Unit code	Unit name	Dominant Lithology
Q_avf	Alluvial Terrace deposits-high stand facies	Biogenic sediment
CZ_ath	Alluvial fan deposits	Mud
Sform	Mumbidgle Formation	Siltstone
Sufc	Cotton formation	Siltstone
Ouuu	Mugincoble Chert	Chert

A high level local geological review has been undertaken for the mine site previously as discussed in “Wyoming 3 In-pit Residue Storage Facility Preliminary Design Report” (GHD, 2016). Key findings from this review have been summarised below:

- In the vicinity of the Wyo3 pit (beyond the ore body), alluvial clay / sandy clay and saprolite clay generally extend up to 70 m below ground level (bgl); and
- The weathered zone is underlain by fractured siltstone, sandstone and shale extending beyond 100 m bgl.

3.4 Geotechnical Investigations

Previous geotechnical investigations for embankment materials and foundations were undertaken in during the initial embankment design and construction phases (Cooper and Associates, 2011) as well as the Stage 2-6 raises, which also included in-situ and laboratory testing for the residue. The previous investigations can be summarised as follows:

- Foundations for the current RSF 1 (cells 1 and 2) generally consisted of stiff clay with a high bearing capacity, with the only unsuitable material that required removal being topsoil. The foundations were found to be low permeability, between 2×10^{-8} m/s and 2×10^{-9} m/s.
- The residue geochemistry classified as Non-Acid Forming (NAF).
- Materials used in the embankment raise are generally low permeability (less than 1×10^{-9} m/s as per EPA requirements) sandy clay, won from mining operations.
- Investigations of the residue as foundations for upstream raises found they were generally low strength, low permeability, clayey silt, and the residue is susceptible to liquefaction with low residual shear strength.

3.5 Hydrogeology and Groundwater Investigations

A groundwater impact assessment report has been previously completed for Wyoming In-pit Tailings Study (GHD, 2016). Key findings from this study related to the existing groundwater conditions at the mine site have been summarised below:

- Perched groundwater occurs within the shallow alluvium, however it is generally not continuous across the mine site;
- The hydraulic conductivity of the upper clay is generally low to very low;
- A deeper confined saline groundwater system occurs within the fractured sandstone, siltstone and volcanics. This groundwater would be classified as less productive fractured rock groundwater under the NSW Aquifer Interference Policy; and
- Coffey (2007) investigated this groundwater system as a potential water supply for the mine and found it to be inadequate in terms of both yield and quality.

3.6 Hydrology

Surface water drainage surrounding the mine site typically flows to the southwest. Gundong Creek flows for the north of Tomingley before passing through the north-western section of the Mine Site. Other named creeks in the vicinity of the Mine Site include Fiddlers and Tomingley Creeks (upstream) to the north and Bulldog Creek to the south. Each of these, together with Gundong Creek, flow to the west and merge with the Bogan River approximately 11 km to the south-west of the Mine Site.

4. Consequence Category

4.1 Dam Failure Consequence Category (DFCC)

The Consequence Category assessment for the stage 1 and 2 of RSF 2 has been undertaken based on a high level assessment of the dam break consequence. Given the concentration of solids deposited into the RSF, the residue is considered to be susceptible to flow in a dam break due to previous observations of water retention in RSF 1 Cells 1 and 2 particularly through the winter months.

Given the location of the RSF, and the topography, it is considered that both the plant personnel and downstream residents would have adequate warning to reach a safe evacuation area in the event of a catastrophic Sunny Day or Flood failure. Therefore, the PAR has been assessed as <1.

In accordance with the ANCOLD guidelines, the highest 'Severity of Damage and Loss' level was assessed as being 'Major'. This is based on the impact it would have on the business as storage of the residue is considered essential to maintain operation of the facility, as well as the natural environment.

The dam failure consequence category for the RSF is 'Significant' for the stage 1 and 2 embankment of RSF 2 which is considered applicable for the subsequent lifts to the embankment although the flood depth would be higher due to the increase of residue volume stored in the RSF. Prior to further design stages TGO will review and workshop the Consequence Category assessment for the stage 1 and 2 dam and consider the impact of increased storage on the CCA in future raises.

4.2 Environmental Spill Consequence Category (ESCC)

The Environmental Spill Consequence Category has been reviewed for the RSF 2 stage 1 and 2 dam and assessed to be 'Low' due to the release of decant water stored in the RSF that would have a "Medium" impact on the environment with PAR<1. The main contributing factors to the ESCC is related to the potential contamination of water supplies used by stock and fauna with no anticipated health impacts and the short term impacts on the local ecosystems.

4.3 Implications of Consequence Category Assessment

Based on the Consequence Category assessment the following design and management requirements shall be incorporated throughout the life of the design, operation and closure of the RSF

4.3.1 Key design parameters

Flood Design

ANCOLD gives guidance on flood design parameters based on both the Dam Failure Consequence Category and the Environmental Spill Consequence Category of the dam. The design hydraulic performance parameters adopted based on ANCOLD Guidelines on Tailings Dams (ANCOLD, 2019) is as follows:

- Minimum wet season water storage allowance: 1:10 AEP wet season runoff
- Minimum extreme storm storage: 1:1,000 AEP, 72 hour flood event[1]
- Contingency freeboard: 300 mm

- Emergency spillway design capacity: 1:1,000 AEP flood event with sufficient freeboard for wave run-up during a 1:10 AEP wind event[1].

Note 1; Minimum extreme storm storage design event is only suggested in ANCOLD as 1:100 AEP 72 hour, however given TGO is a no-release site this has been increased to 1:1,000 AEP to reduce risk of spill. This design criterion shall reconsidered (increased) in future design given facility is a non-release facility as it is possible a 1:10,000 AEP could be contained. An emergency spillway is recommended even for no-release facilities such that should a spill occur in an extreme event it is controlled and does not result in a catastrophic failure.

Surveillance requirements

ANCOLD (ANCOLD, 2003) provides guidance on the surveillance requirements and frequency for dams based on their Dam Failure Consequence Category. For a 'Significant' Dam Failure Consequence Category dam considered to be in sound condition with no deficiencies, ANCOLD suggest the inspection and monitoring types and frequencies as shown in Table 4-1 and Table 4-2 respectively.

Table 4-1 Inspection Types and Frequencies

Inspection Type	ANCOLD Recommended Frequency
Routine Visual	Twice Weekly to Weekly
Intermediate	Annual to 2-Yearly
Comprehensive	On Commissioning then 5-Yearly
Special	As Required

Table 4-2 Monitoring Types and Frequencies

Monitoring Type	ANCOLD Recommended Frequency
Rainfall	Twice Weekly to Weekly
Storage Level	Twice Weekly to Weekly
Seepage	Twice Weekly to Weekly
Chemical Analysis of Seepage	Consider
Pore Pressure	3 Monthly to 6-Monthly
Surface Movement Control	Consider
Surface Movement Normal	Consider
Internal Movement / Stresses	Consider
Seismological	Consider

From a review of the ANCOLD guidelines (ANCOLD, 2003) and the design of the RSF, the following instrumentation is recommended at the site:

- Rainfall;
- Seepage;
- Vibrating Wire Piezometers;
- Settlement monitoring.

The details of this instrumentation will be determined in the subsequent stages of design.

4.3.2 Operation and maintenance

A RSF Operations Maintenance and Surveillance (OMS) Manual will be required in accordance with (ANCOLD, 2003) detailing specific requirements and frequency of dam monitoring. Specific designer requirements will need to be met to ensure on-going safety of the dam.

There is an existing OMS Manual for the RSF 1, this can be updated to include RSF 2 operation.

This manual should include but not be limited to the following:

- Design intent;
- Daily operations and inspections;
- Water and tailings management procedures;
- Criteria for mechanical works;
- Surveillance;
- Maintenance and on-going works.

4.3.3 Dam safety emergency planning

ANCOLD (ANCOLD, 2003) states a Dam Safety Emergency Plan (DSEP) be prepared where any persons, infrastructure or environmental values could be at risk if the dam were to fail. A DSEP will therefore be required for both the construction and operation of the RSF 2 impoundment. There is an existing DSEP for RSF 1, which can be updated to include RSF 2.

5. Storage capacity

5.1 Production

As discussed in Section 1.1, TGO are preparing a project modification for Tomingley Gold Operations to permit construction of stages 1 and 2 of RSF 2 and to extend TGO's project life to 31 December 2025. RSF 2 is required to store tailings production from 1.4Mt of ore to be mined, plus additional ore that would be identified prior to December 2021.

Based on the Options Study Report (GHD 2019), the stage 1 dam is required to store tailings for 2 years at an annual production rate of 1.5Mtpa. Based on the long term residue stored density of 1.4 t/m³ as described in Table 2-1, the stage 1 dam is required to contain 2.1 Mm³ of stored residue. This deposition will be required to remain below the maximum tailings level before the next dam raise is constructed and commissioned. The dam will then be raised by 2m (Stage 2) to provide additional 1 year of storage if required.

5.2 Hydrology and Water Management

As a 'Significant' Consequence Category dam, the RSF has been designed to have a minimum capacity as outlined in Section 4.3.1 as required by ANCOLD guidelines *Guidelines to Tailings Dams* (ANCOLD, 2019). The flood water will be temporarily stored in RSF 2 with the residue water and will be pumped back into the plant via the decant structure for reuse.

The conceptual arrangement for the RSF 2 has been designed as a store and release facility capable of maintaining a PMF rainfall event, the stage 1 and 2 dam will need to be designed to store the estimated total rainfall based on the associated surface area.

The design rainfall events have been estimated by using *Very Rare to Extreme Flood Estimation* (ARR 2016) as shown in Table 5-1.

Table 5-1 Storm events for various AEP (2 cells)

AEP (years)	1:100	1:1,000	1:2,000	1:10,000	1:200,000	PMP
Design Rainfall (mm)	192	310	347	470	676	996
RSF 2 Storage Volume (54 ha)	103 (ML)	167 (ML)	187 (ML)	254 (ML)	365 (ML)	538 (ML)

It should be noted that the storage requirements estimations are indicative only and are based on 54 Ha footprint

Given the internal cell dimensions of 460 m x 590 m for each cell, and assuming a beach slope of 1V : 140H based on previous survey undertaken on RSF1 Cell 1 and 2, assuming the decant pond is kept to a maximum level of 1 m below the maximum beach level, and the crest height is 0.7 m above the tailings beach, the storage availability for each separate cell is summarised in Table 5-2.

Table 5-2 RSF storage capacity

Storage Area	Single Cell Volume (ML)	Dual Cell Volume (ML)
With decant pond limits	7	14
Within minimum beach width	76	152
Top of the tailings beach	84	168
Embankment crest (including 300 mm freeboard)	189	378
TOTAL	**356**	**712**

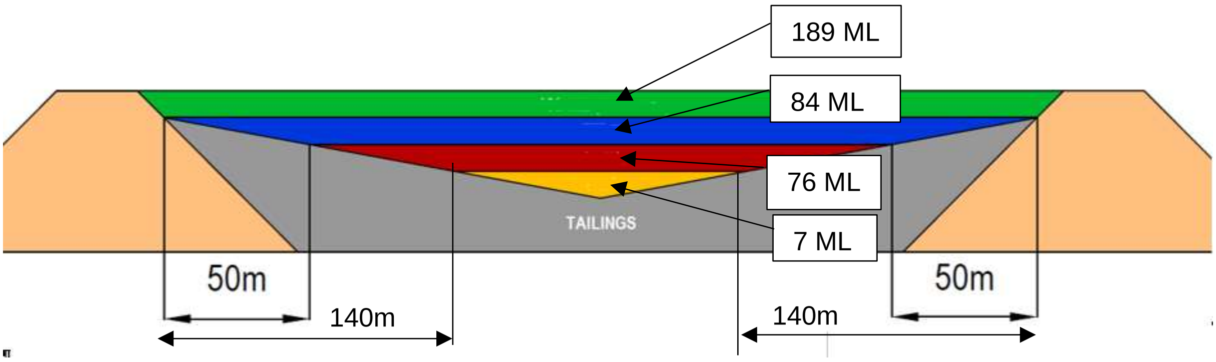


Figure 5-1 Stylised Section of water storage volumes for single cell

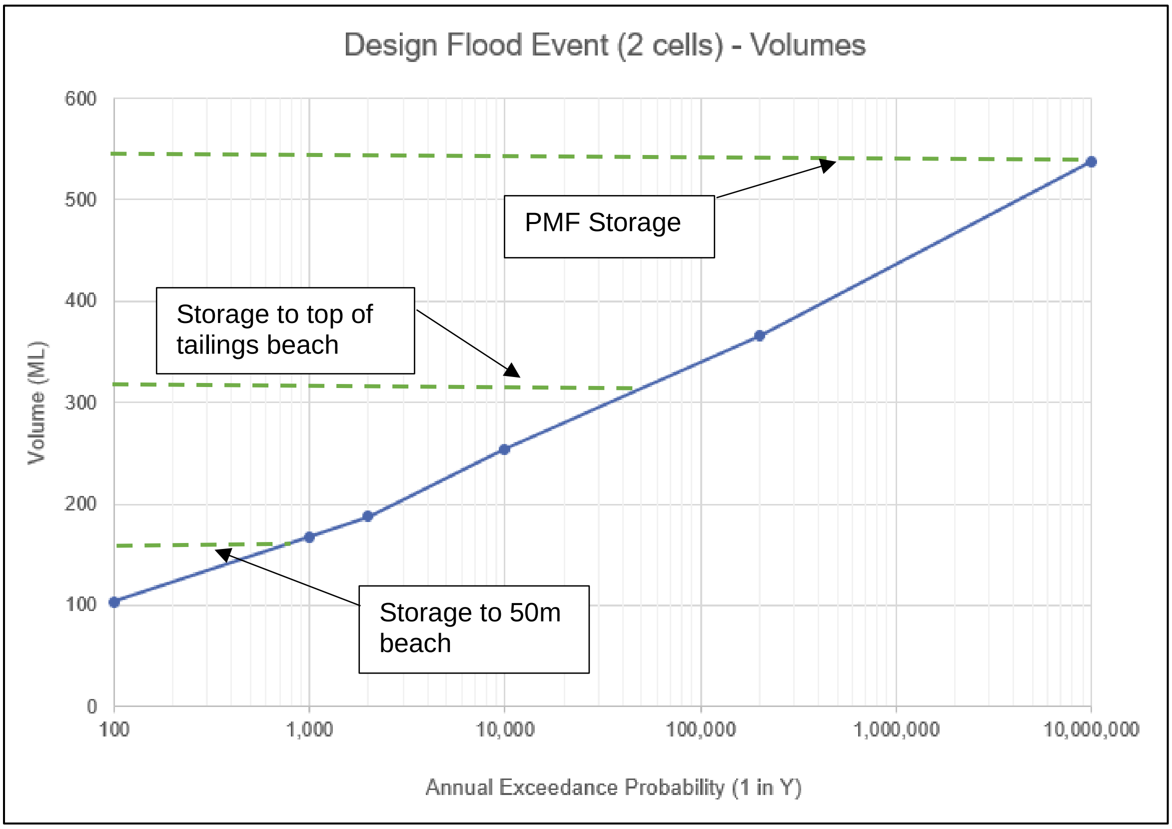


Figure 5-2 Design Flood Events

Based on the above analysis, the following is determined:

- There is sufficient storage capacity to store both the 1:1,000 AEP and 1:10,000 AEP events within the tailing beach area (refer Figure 5-2).
- If a minimum of 0.7 m freeboard is maintained above the tailings beach, the RSF 2 will be capable of containing the PMF event (including 300 mm freeboard). However, in accordance with ANCOLD (2019) and industry good practise an emergency spillway will be investigated during the next stage of the design to ensure the safety of the RSF during flood events.

Note these are high level calculations and exact values will be confirmed during the detailed design stage when the dam footprint is finalised.

Therefore, a total volume of 712 ML is required to handle flood events (which includes 300 mm freeboard) for both stages.

5.3 Storage capacity

Based on the requirements as discussed in Sections 5.1 and 5.2 the total storage volume required for the RSF 2 stage 1 dam for the stored tailings and design flood event is 2.1 Mm^3 and 0.712 Mm^3 respectively which gives a total of 2.812 Mm^3 (to the top of the dam crest which allows for 300 mm freeboard). This requires RSF 2 stage 1 crest to be RL 270m, the 2 m stage 2 lift will lift take the crest to RL 272 m.

The stage 1 storage curve as shown in Figure 5-3.

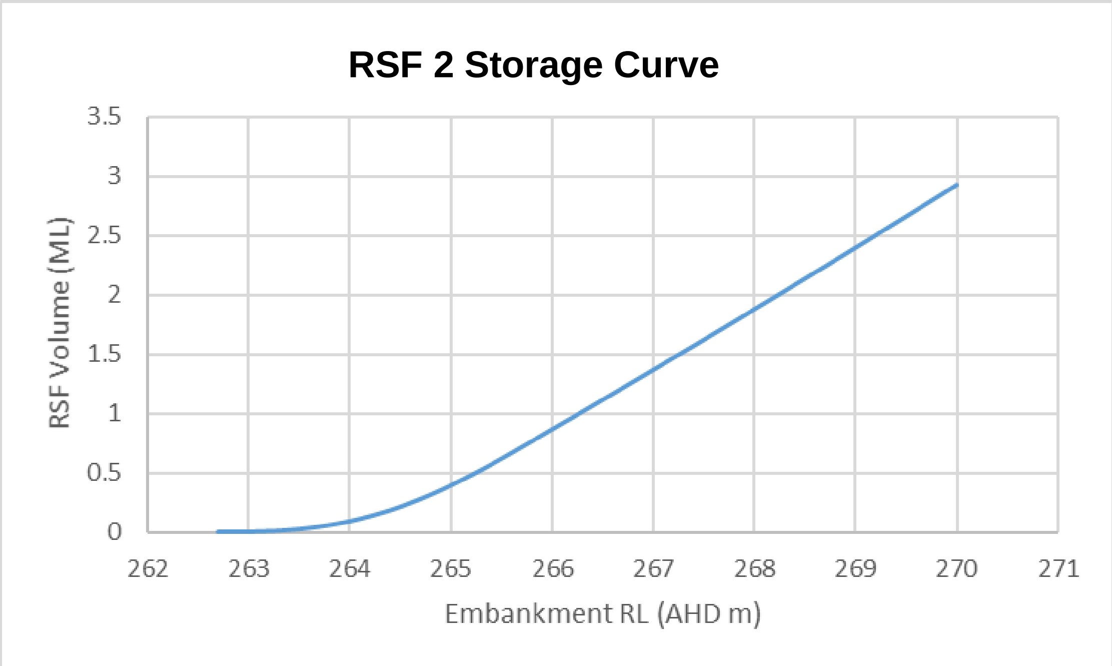


Figure 5-3 Storage Curve

6. Concept RSF Design

6.1 RSF Arrangement

Given the size and arrangement of the outer RSF shell there are two RSF arrangement options which may be utilised in the design, a single cell arrangement consisting of a single decant location or a dual cell arrangement consisting of two separate cells and decants. Each option can be operated effectively however there are a number of advantages and disadvantages to each arrangement outlined below in Table 6-1.

Table 6-1 RSF arrangement options assessment

	Single Cell Arrangement	Dual Cell Arrangement
Strength	Single decant location Single emergency spillway location if required No dividing wall required Increased stormwater capacity	Simplification in tailings deposition Increased consolidation ability through deposition efficiency Ability to effectively stage embankment raises Operational contingency Improved ability for closure staging
Weaknesses	Increased complexity in materials deposition Increased difficulty in consolidation management No operational contingency during extreme events Increased difficulty in closure staging	Dual decant locations Dual emergency spillway location if required Dividing wall required between cells Significantly less stormwater storage capacity

From Table 6-1 it can be seen that both cell arrangements have their strengths and weaknesses. Based on this assessment a dual cell arrangement has been utilised in the development of the conceptual design however a single cell arrangement may be used in future design stages with minimal alteration required.

6.2 External Embankment Geometry

The use of both centreline and upstream raise methodologies have been assessed to allow for comparison of the options. As such the concept for the stage 1 and 2 embankment has been designed to allow for stability and constructability in both scenarios. The stage 1 dam geometry will consist of upstream embankment slopes of 2H:1V which allows for an increased depositional capacity whilst allowing for sufficient stability on the upstream side of the embankment. The downstream slope of the stage 1 embankment is 3H:1V which allows for increased stability in the stage 1 dam and throughout the life of the facility should upstream construction be utilised for Stage 2 raise and future raises.

Given that upstream construction is highly reliant on strength of the residue, and buttressing has been required for the existing RSF to address liquefaction risk, a reliance on upstream raising for the new RSF 2 is not considered justifiable. The adoption of centreline construction does require more embankment volume however, this is not seen as a constraint or significantly increased capex given the new RSF 2 raises can be efficiently constructed using mine waste from the existing operations. For this reason it is considered that centreline construction is a more geotechnical stable and efficient method of raising the embankment safely as the reliance on the residue strength is reduced.

The centreline raise methodology enables additional Zone 3 material to be placed on the downstream embankment to form 2H:1V batter slopes and to support the subsequent future centreline raises. The centreline raise method will also provide benefit of having slightly higher storage capacity than upstream raise method as the surface area will be maintained for the subsequent raises.

The downstream batter slopes for the centreline raises shall be confirmed in the preliminary design stage, following geotechnical investigations including confirmation of available material properties and stability analyses.

The design of the stage 1 embankment allows for a 6 m wide crest which will allow for 2 way light vehicle traffic, tailings deposition line, safety bunding on each side and sufficient space to undertake operational and maintenance tasks on the pipeline. This will also be adopted for Stage 2 raise.

6.3 Internal Embankment Zoning

Internal zoning of the embankment will consist of Zone 1 (Core and Liner), Zone 2 (filter material), and Zone 3 (General Fill).

6.3.1 Zone 1 Core

The Zone 1 core material will consist of low permeability material, nominally 5 m thick which shall be placed on the upstream side of the RSF 2 stage 1 dam embankment, reducing to 3m for Stage 2 and future raises.

The upstream Zone 1 slope will likely be 2H:1V and internal slope will be 1H:1V. The stage 1 dam Zone 1 will be keyed in to the foundation to minimise the risk of a seepage path forming beneath the embankment.

6.3.2 Zone 1 Liner

Zone 1 Liner will comprise of 1000 mm thick zone of in-situ material which will be ripped and recompacted to form a low permeability layer (of 1×10^{-9} m/s minimum) across the foundation of the RSF to limit seepage through the foundation during both operation and closure of the facility.

6.3.3 Zone 2 Transition Material

Zone 2 transition material will be used as a filter layer between the RSF northern wall and the existing buttressing on the downstream side of the Cell 1 and Cell 2 (as discussed in Section 6.4). Investigations for suitable Zone 2 filter material will be undertaken during the preliminary design and investigation phase of the project. However if the material is not readily available onsite this material may be required to be imported in order to meet the required filter gradings which will be developed during the preliminary design.

6.3.4 Zone 3 General Fill

Zone 3 material will consist of general fill material. The foundation will need to be stripped to nominally 300 mm to remove topsoil and organic matter and ensure a strong competent foundation material. The Zone 3 material will be selectively placed such that the finer material will be placed against the Zone 1 core and the coarser material will be on the downstream face. This placement methodology is to reduce the risk of fines migrating into the Zone 3 material and assist in stability and erosion protection.

The Zone 3 material is also proposed to be used on the upstream face of the embankment and foundation liner to protect the Zone 1 material from desiccation cracking increasing susceptibility to seepage.

6.3.5 Crest Wearing Course

The wearing course material to form the embankment pavement will likely consist of course durable material found onsite. Potential locations for the source of this material will be determined in the preliminary design and investigation stage and be dependent on local availability.

6.4 Embankment Connections

RSF 2 eastern and western embankments will abut to the existing RSF 1 Cell 1 and Cell 2 southern embankment and utilise the existing embankment to form RSF 2 northern embankment. A Zone 1 clay liner will be placed against the existing embankment following treatment of existing buttressing.

RSF 1 and RSF 2 includes buttressing on the downstream side of the south embankments which comprises of uncompacted material. The buttressing material, which contains a matrix of dispersible highly weathered to moderately weathered material, containing boulders up to an approximate size of 600 mm. This uncompacted material when loaded will likely settle resulting in cracking of the Zone 1 clay liner and presenting risk for piping failure or internal erosion.

To mitigate this risk, a filter zone will be required between the Zone 1 and the existing buttressing. An internal subsoil drain can be placed at the base of the filter layer to direct any the seepage to a monitored collection point.

There are 2 options to transition the filter zone to the existing buttressing. Option 1 consists of placing a layer of engineered fill against the existing buttress and retain the existing batter slope. The engineered fill would be required to comprise of appropriately graded material to allow for construction of a filter zone to be placed against it as per Drawing 12517944-C006.Option 2 would be to batter back the buttressing to nominal slope of 3H:1V, roll, and compact with a pad foot roller. Geofabric would then be used at the interface between the filter zone and the prepared buttress surface.

These options will be investigated in the preliminary design stage following completion of the geotechnical investigation and constructability considerations.

7. Construction staging and materials

7.1 Raise Methodology and Strategy

As discussed in Section 6.1, the stage 1 and 2 dam will allow for both upstream and centreline raises in the future. A comprehensive list of advantages and disadvantages for each dam raise methodology is listed in the RSF 2 Options Study Report (GHD, 2019). Whilst both options may be utilised for future raises, it is recommended the centreline method is adopted as an upstream raise will still likely result in a need for buttressing on the downstream face to ensure the stability of the facility.

7.1.1 Construction Considerations

Centreline raise construction utilises both the tailings surface adjacent to the upstream face and the existing ground surface at the downstream toe for support as such this option generally requires greater material volume. Centreline construction has the advantage of less reliance on the tailings beach for strength however a small amount of the upstream embankments will be required to be constructed on the tailings beach.

While there is more fill required for this raise option, the mine waste produced from the satellite operation may be used in the construction of the raise. Similarly suitable planning means that the foundation for the entire footprint up to the LOM extent can be built prior to the construction of the first raise utilising the mining fleet potentially reducing both construction timing and cost.

7.2 Construction staging

Based on the facility sizing requirements, the stage 1 dam is required to contain 2 years of tailings production which equates to 2.1 Mm^3 of stored tailings (at an assumed consolidated density of 1.4 t/m^3) and flood storage. The subsequent raise to Stage 2 RL 272m will be 2m. The The raises have been limited to 2m, this limitation on the rise rate has been set to allow for optimal material tailings placement and consolidation during operation prior to placement of materials required for the raise construction improving the overall stability of the raise structure.

Raise 7 for RSF 1 Cell 1 and Cell 2 will be constructed prior to construction of RSF 2 stage 1 dam. It is also noted that the existing buttress profile differs from the required buttressing as indicated in RSF stage 7 Concept Design Report. Therefore, stability analysis will need to be undertaken to confirm the existing buttressing will provide sufficient support for Stage 7 prior to construction of RSF 2 stage 1 dam.

7.3 RSF 2 Foundation

Preliminary site observations from the GHD geological investigation indicate that surface material includes alluvial deposits comprising of a low permeability sandy clay. This material will likely be utilised for embankment construction. Deeper deposits (>5m) generally consist of a gravelly clay to a depth of approximately 15m. At approximately 15m below ground level, there is a stiff weathered siltstone.

The foundation level will likely be founded on the stiff gravelly clay as per the existing cells. Confirmation of the foundation material will be made during the Preliminary Design following the geotechnical investigations.

7.4 Construction material borrow areas

7.4.1 Zone 1 – Core

Zone 1 material for the core will be sourced from excavations from the RSF 2 footprint during construction. This material will likely consist of low permeability Sandy Clay. GHD geological site investigations and geological desktop investigations undertaken in the RSF 2 Site Options Study (GHD, 2019), indicate that the surface material within the RSF 2 footprint consists of alluvial deposits comprising of a low permeability sandy clay.

7.4.2 Zone 1 – Liner

Zone 1 liner will comprise of in-situ sandy clay which will be ripped and recompacted in place to form the low permeability liner. As discussed in Section 6.3.2, insitu material will require multiple passes from vibratory roller to ensure sufficient compaction and a low permeability liner.

7.4.3 Zone 2 – Filter Material

As discussed in Section 6.3.3, it is not anticipated that Zone 2 filter material will be available from borrows on site, therefore Zone 2 material will have to be sourced from an existing commercial quarry operation, or crushed from fresh waste rock onsite. The gradings will be determined in the preliminary design stage when the treatment of the transition between the filter and the existing buttressing is determined.

7.4.4 Zone 3 – General Fill

Zone 3 General Fill will be sourced from overburden material from the RSF 2 foot print. The material properties will be confirmed following the geotechnical investigation.

For future raises, there is also potential to develop a new Waste Rock Emplacement (WRE) around the perimeter of the RSF 2 to form buttressing which would allow mining equipment to construct the embankment and improve stability of the dam.

8. Water Balance

A site water balance model has previously been prepared for TGO (GHD, 2019). The model was simulated from 1 July 2019 to 1 July 2029, with an initial inventory of process water volume of 50 ML and a mining water volume of about 800 ML. The water balance has been updated by including the catchment of the proposed RSF 2 commencing in January 2022 and reflecting the proposed production schedule with a nominal 1.5 Mtpa production commencing in May 2022 and continuing until July 2029. All other model parameters and inputs were as documented in GHD (2019).

8.1 Process water

The range of total process water inventory under various potential rainfall conditions are shown in Figure 8-1.

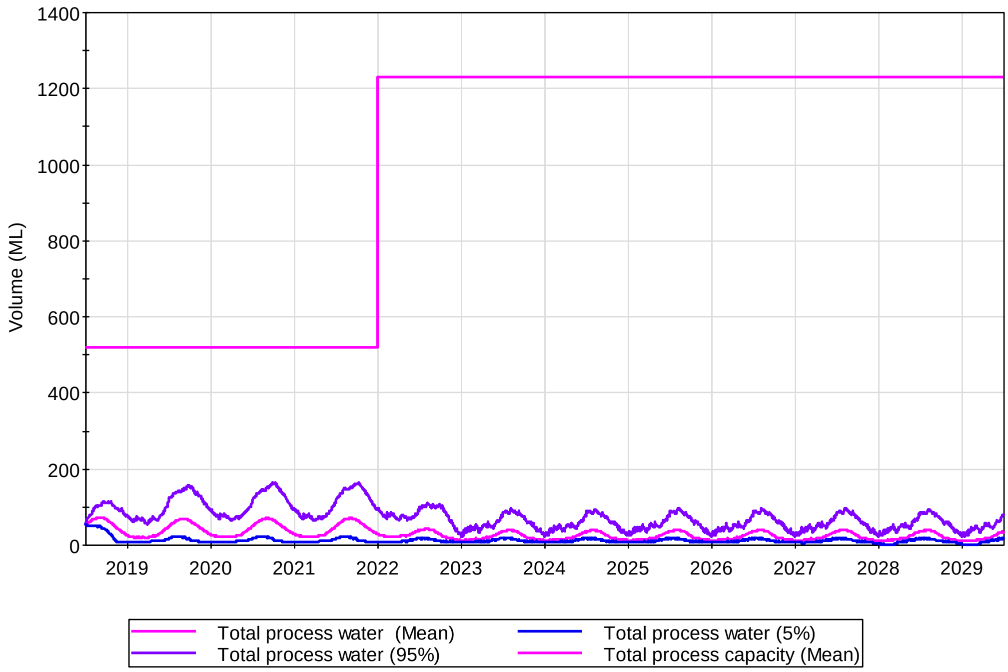


Figure 8-1 Total process water inventory

Figure 8-1 shows that process water inventory is likely to continue to vary, potentially exceeding the 110 ML capacity of the RSD in above average rainfall conditions. However, the total process water inventory is not expected to exceed the combined physical water storage capacity of RSD and the RSFs, especially following the commissioning of RSF 2. Figure 8-1 shows that the potential range of total process water inventory is expected to be similar to current conditions. This reflects that the process water demand with higher production rates is roughly sufficient to counter balance the additional process water from runoff of the additional RSF catchment area across RSF 1 and RSF 2.

A sensitivity run was performed, with minimal production demand. The results are shown in Figure 8-2.

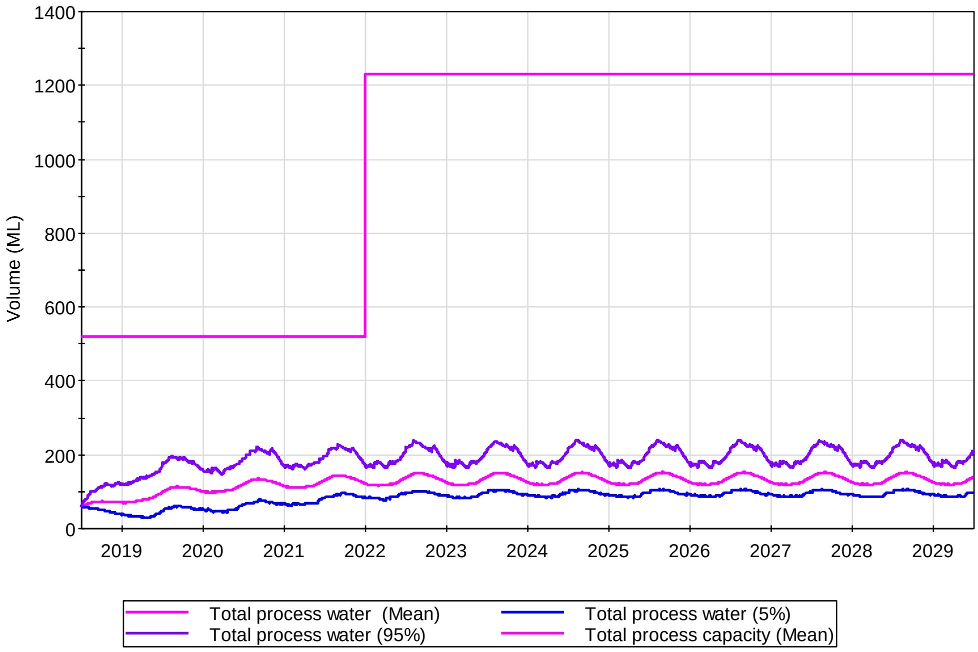


Figure 8-2 Total process water inventory – minimal production case

Figure 8-2 shows a potential higher process water inventory compared to Figure 8-1, but remains well within the total water storage capacity of the combined process water storages. Therefore, operating the proposed RSF 2 while the existing RSF1 remains uncapped is not expected to result in an unmanageable process water excess.

8.2 Mine water and water security

The overall forecast site water inventory is shown in Figure 8-3.

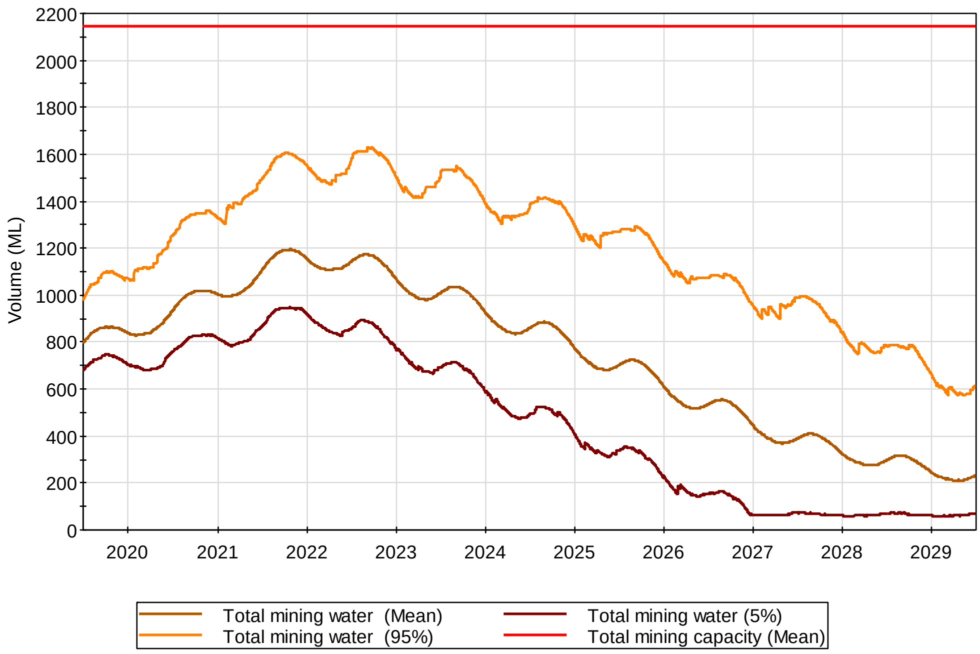


Figure 8-3 Forecast total mining water inventory

Figure 8-3 shows that mining water inventory is likely to increase until 2022, corresponding to the peak in predicted groundwater inflows, then starts to decline until mid 2029. Total mining inventory remains within the total water storage capacity.

The average annual water balance for year ending in June 2025 is summarised in Table 8-1 which is expected to be typical over the remainder of operations at TGO.

Table 8-1 Average annual water balance for TGO

Water flow	2024-2025 (ML/year)
Inputs	
Direct rainfall and catchment runoff	443
Supplied from Woodlands borefield	735
External water delivery	0
Moisture in ore	75
Secondary release from residue	22
Groundwater inflows	88
Total Inputs	1363
Outputs	
Evaporation from water storages	82
Discharge from sediment dams	2
Potable use	1
Water in residue	714
Evaporation from active residue	212
Losses from rewetting of inactive residue	246
Dust Suppression	249
Losses from underground workings	3
Total Outputs	1509
Change in Storage	-146

Table 8-1 shows that, on average, the largest inflow into the site water balance is coming from water supplied from Woodlands borefield, accounting for about 54% of total inflows. This may be attributable to the decline in groundwater inflows after year 2022. With higher production rate, the largest site demand is ore processing, where water ultimately remains entrained in residue or is lost to evaporation. Table 8-1 indicates an overall decrease in site water inventory on average.

The site water balance model simulated the available borefield allocation over the prediction period. A plot of allocation is shown in Figure 8-4.

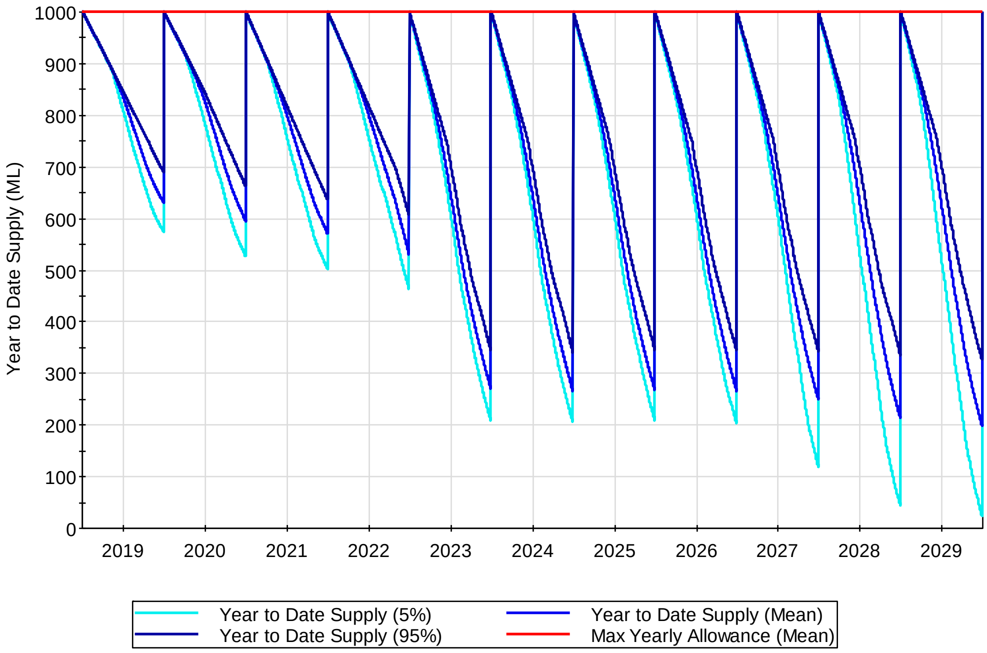


Figure 8-4 Forecast borefield allocation

Figure 8-4 shows that with higher production rate and lower forecast groundwater inflows, water demand from borefield allocation has the potential to be almost completely utilisied in the last two years of operations at TGO.

9. Groundwater and seepage analysis

9.1 Local hydrogeology

There are three distinct groundwater systems within the vicinity of TGO's mining leases, as identified by The Impax Group (2011):

- Shallow alluvium – discrete, shallow alluvium (less than 10-20 m deep) dissects the plains surrounding the mine site along creek flow paths. These aquifers are believed to be recharged from rainfall infiltration. Groundwater within these systems is of relatively good quality, however yields are relatively low and dependent on rainfall. Perched groundwater occurs within the shallow alluvium underlying the RSF, however it is generally not continuous across the mine site. Shallow groundwater appears to be more permanent along Gundong Creek to the northwest of the RSFs.
- Deep alluvium – up to 100 m deep and located approximately 10 km to the northwest and west of TGO. Groundwater yields are believed to be low and of poor quality. These systems may have some interaction with underlying bedrock however are believed to be primarily recharged from rainfall.
- Fractured rock – the area surrounding Tomingley is underlain by a confined saline groundwater system within the fractured sandstone, siltstone and volcanics at a depth of greater than 80 m. Groundwater yields range from 0-3 L/s, generally less than 1.5 L/s, and water quality is poor with high salinity (average electrical conductivity (EC) exceeds 20,000 µS/cm). Coffey (2007) investigated this groundwater system as a potential water supply for the mine and found it to be inadequate in terms of both yield and quality.

The hydraulic conductivity of the clay which comprises the foundation of the existing RSF is generally low to very low. Falling head tests on clayey strata between 1.55 and 42.5 m bgl at the existing RSF area indicate hydraulic conductivities of 0.0002 to 0.002 m/d or 2.3×10^{-8} to 1×10^{-9} m/s (DEC, 2011). Shallow perched groundwater, where it occurs throughout the TGO site, is typically at a depth of less than 10 m bgl.

The water bearing zone within the deep confined fractured rock groundwater system occurs at an elevation below 190 m AHD, based on observed groundwater inflows into the WYO3 pit and groundwater monitoring bore data. The groundwater is under pressure as indicated by the monitoring bore data showing groundwater levels ranging from approximately 200 m and 240 m AHD.

Groundwater usage is limited in the vicinity of the mine site. The closest active production bores (i.e. non test or monitoring bores), are over 3 km to the north of the mining lease area within shallow alluvium (GW034897, GW037395 and GW803148) with all reported yields less than 1.5 L/s. These bores are registered for stock and domestic, irrigation use and town water supply respectively.

9.2 Analysis of foundation seepage

Although seepage through the foundation from the existing RSF has not been detected by the existing shallow groundwater monitoring bore network, a conceptual analysis of potential seepage through the foundation of RSF 2 stage 1 and 2 has been undertaken.

9.2.1 Methodology

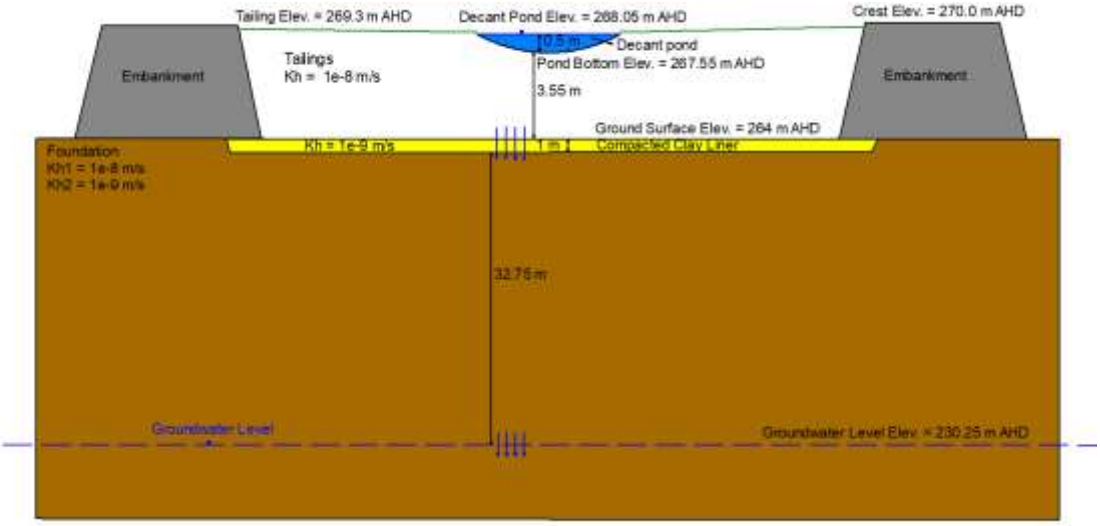
The seepage analysis involved a one-dimensional calculation of vertical advective flow from the RSF 2 decant pond into the underlying foundation. The calculation was based on the Darcy flow equation. For both RSF 2 stage 1 and stage 2, the rate of seepage and time for seepage to occur were calculated under three scenarios:

- Scenario 1: seepage to shallow strata through the residue and CCL only.
- Scenario 2: seepage to regional groundwater through the residue, CCL and high permeability foundation.
- Scenario 3: seepage to regional groundwater through the residue, CCL and low permeability foundation.

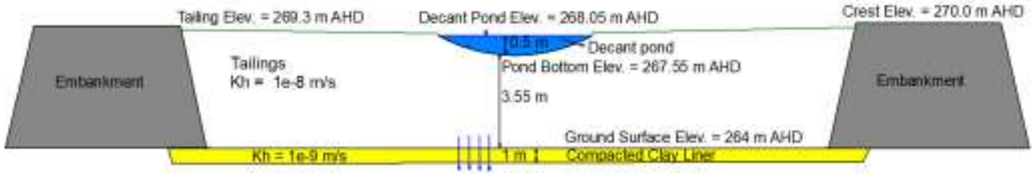
The conceptual analysis of the seepage through the foundation of RSF 2 stage 1 and stage 2 are shown schematically in Figure 9-1 and Figure 9-2.

The following inputs and assumptions were applied:

- For Stage 1, the decant pond water level was assumed to be managed at RL 268.05 m and 0.5 m deep, while for Stage 2 the decant pond water level was assumed to be managed at RL 270.05 m and 0.5 m deep.
- Maximum decant pond area of 0.49 ha (70 m x 70 m).
- The base of the residue was assumed to be RL 264.0 m.
- The residue has a permeability of 1 x 10^{-8} m/s (DEC, 2011).
- The CCL is 1 m thick and has a permeability of 1 x 10^{-9} m/s (refer Table 2-1).
- The influence of the embankment on seepage was not considered.
- Negligible water pressure at the base of the tailings.
- Foundation permeabilities of 1 x 10^{-8} m/s (Scenario 2) and 1 x 10^{-9} m/s (Scenario 3) were analysed (DEC, 2011).
- The average regional groundwater level at the RSF 2 of RL 230.25 m based on groundwater monitoring at bores WYMB01 and WYMB06. It should be noted that this is generally a conservative approach since regional groundwater occurs within a confined groundwater source at elevation below RL 190 m and recorded groundwater levels reflect water under pressure. However, it is noted that groundwater levels at WYMB06 are also influenced by water levels within the old McPhail workings.
- Seepage rates are calculated under steady-state conditions.

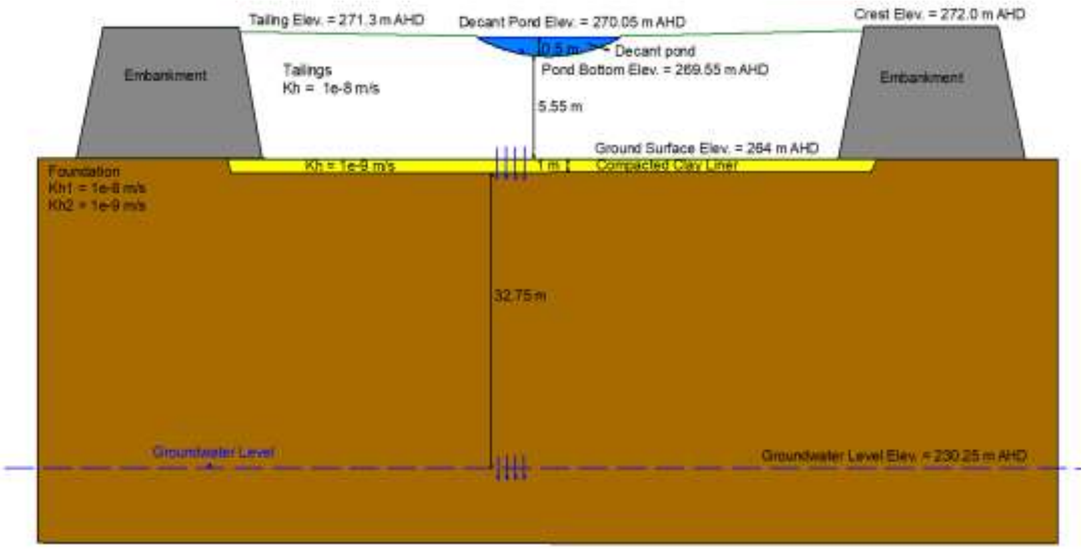


(a)

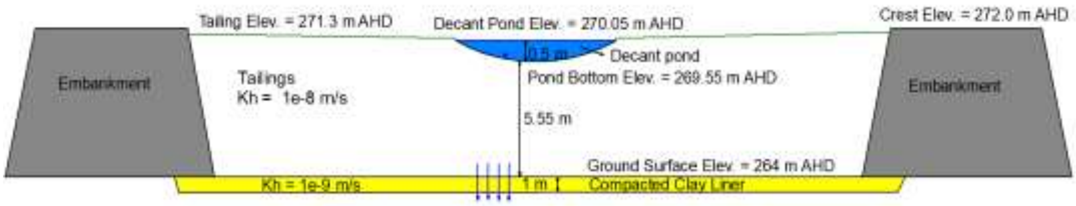


(b)

Figure 9-1 Stage 1 conceptual seepage cross-section through the (a) residue, CCL and foundation, and (b) residue and CCL



(a)



(b)

Figure 9-2 Stage 2 conceptual seepage cross-section through the (a) residue, CCL and foundation, and (b) residue and CCL

9.2.2 Results

The results of the seepage analysis are shown in Table 9-1. The calculated seepage rates below the CCL to shallow strata are 1.6 kL/day for stage 1 and 1.9 kL/day for stage 2. Seepage is calculated to occur after approximately 40 years. The calculated seepage rates to regional groundwater range from 0.5 to 3.5 kL/day and are predicted to occur after a timeframe of approximately 150 years up to over 1,000 years. These calculations are subject to the assumptions outlined in Section 9.2.1, however indicate a low risk of seepage of RSF decant through the CCL and RSF foundation throughout the 7 year life of the facility. Once the RSF is closed and rehabilitated and the residue is dewatered, the risk of seepage is further reduced.

The analysis suggests a negligible incremental change in seepage rate to regional groundwater and seepage time between stage 1 and the stage 2 raise.

This analysis will be updated, if required, following review of results from the geotechnical investigation at the RSF 2 site.

Table 9-1 RSF stage 1 and stage 2 seepage analysis results

Scenario	Stage 1		Stage 2	
	Calculated seepage volume (kL/d)	Seepage time (yrs)	Calculated seepage volume (kL/d)	Seepage time (yrs)
Scenario 1	1.6	39	1.9	46
Scenario 2	3.5	145	3.5	151
Scenario 3	0.5	1067	0.5	1074

9.3 Monitoring Program

Dam monitoring requirements are outlined in Section 4.3.1. In addition to this, it is recommended that shallow monitoring bores be installed around the outside of the embankment of RSF 2 to detect seepage through the foundation. Monitoring bores should be installed to depths of 10 m bgl and at an interval of approximately 250 m around the perimeter of the RSF. Bores should be screened between 2 m depth and the base of the bore. The new RSF monitoring bores should be incorporated into the monthly groundwater monitoring program at TGO. Ongoing monitoring of the regional bores near the site - WYMB01 and WYMB06 – should also occur.

RSFs can influence local groundwater pressure, which can be detected by increasing groundwater levels, however this does not necessarily mean that seepage is occurring. A line of evidence approach is necessary in interpreting monitoring data whereby the spatial and temporal trends in both groundwater levels and groundwater chemistry should be assessed to determine whether seepage is occurring.

10. Residue management strategy

10.1 Residue management strategy

Prior to the commissioning of the RSF, a detailed Residue Management Plan (RMP) will be developed to document all elements associated with the deposition and storage of residue within the dam. The RMP is critical to the effective operation of the facility.

The purpose of the RMP will be to achieve the following:

- Provide a management framework that allows for the RSF design intent to be met;
- Upholding environmental standards in terms of water quality and discharge;
- Provide a stable landform and maximise the residue storage capacity of the facility;
- Provide direction to allow the proposed closure strategy to be effectively realised.

10.1.1 Residue deposition

Residue deposition within the RSF 2 will involve perimeter loop discharge in frequent and uniform cycles around each of the cells at separate times with spigots nominally spaced at 15 m intervals. A rotational deposition cycle of nominally two weeks for each cell depositing an equally thick layer in each cell which allows for a consolidation and drying time of approximately one month at any one location.

During the initial stage of operation of the RSF, residue deposition will focus on quickly pushing the pond away from the main embankment to the proposed central decant tower location. This will allow decant water to be returned to the plant at the earliest opportunity whilst minimising ponding against the wall and encouraging consolidation of the material.

10.1.2 Decant management

The RSF decant area will capture residue bleed water and incidental run-off from the catchment area associated with each of the cells. This water will be returned to the plant for re-use as required.

The pumps required for the decant tower have been sized to allow for the expected runoff from the initial settlement of the material allowing for expected evaporation and seepage into the deposited residue profile as per Table 10-1 below.

Table 10-1 Decant Management Requirements

Parameter	Value	Unit
Production Rate	1.5	Mtpa
% solids in slurry	45	%
Particle density/ SG	2.7	t/m^3
Volume of water in slurry	1.83	Mm^3pa
Volume of solid in slurry	0.56	Mm^3pa
Dry density of slurry	0.63	t/m^3
Residue dry density	1.40	t/m^3
Saturated tails density	1.88	t/m^3
Water retained in residue	0.48	t/m^3
Water retained in residue (volume)	0.52	Mm^3pa
Water released (volume)	1.32	Mm^3pa
Water released (volume)	3,609	m^3pa
Water released (volume)	42	l/s
Estimated Required Pump Capacity Range for a Single Pump(Refer Note 1)	60 – 80	m^3/hour

Note 1 – The required pump capacity does not currently take seepage or evaporation into account

Decant towers in each of the cells will be accessed via a causeway constructed from readily available fill materials. Throughout the life of the RSF the decant causeway will be raised as part of the construction works utilising a centreline raise arrangement to meet the crest level of each raise.

The proposed decant tower will be a slotted concrete ring type of decant arrangement whereby ponded water decants through slots in the side of a concrete ring tower which is raised incrementally to remain elevated above the rising residue. A variable speed submersible pump will be installed at the base of the tower for water return to the plant. An additional pipeline to remove excess RSF decant water to the existing Residue Storage Dam (RSD) will also be required. The RSD is used in the existing RSF operation with its purpose being to ensure there is no need for excess water to be stored on the RSF at any time.

10.1.3 Thickener optimisation

The residue material is currently deposited into RSF 1 at 45% solids which is considered to be at the lower end of slurry deposition which has traditionally caused a number of issues including, increased site water usage, difficulties in consolidation, increased risk of liquefaction and increased difficulty during closure. Given the increased throughput from the new pit and ongoing difficulties in securing suitable water allocations at similar operations in the area, an assessment of the potential engineering value in further thickening the residue has been undertaken.

Based on the existing throughput of the processing facility and the proposed increased throughput, the increased water consumption has been calculated at varying solids percentages to understand the potential impact of an additional thickener, the results are shown below in Table 10-2.

Table 10-2 Water consumption assessment

Parameter	Current Value	RSF 2 Value	RSF 2 Value	RSF 2 Value	Unit
Production Rate	1	1.5	1.5	1.5	Mtpa
% solids in slurry	45	45	55	65	%
Particle density/ SG	2.7	2.7	2.7	2.7	t/m^3
Volume of water in slurry	1.22	1.83	1.23	0.81	Mm^3pa
	3,349	5,023	3,362	2,213	m^3/day
	39	58	39	26	l/s
Increased water consumption	**-**	**19**	**0**	**-23**	**l/s**

Based on the assessment it can be seen that an increase in the throughput in the processing facility without an additional thickener results in a 19 L/s increase in required water. However should an additional thickener be installed in the process circuit post cyanide detoxification, depending on the efficiency of the thickener and the percentage solids achieved, the water usage will either see no increase or may even begin to decrease thus eliminating the need to purchase additional water and improve the facilities ability to operate during extended drought periods. The thickener could be located at the RSF to reduce pumping cost for the higher solids contents.

Further review of potential thickener options and their impacts may be undertaken during the Preliminary Design.

10.2 Observational approach

In accordance with ANCOLD 2012, the design and management of the RSF shall utilise the observational approach. The observational approach allows the RSF to be optimised over time as monitoring information becomes available and the design and construction methodologies evolve. The observational approach allows any changes that might occur during the life of the RSF to be accommodated whilst meeting the design criteria and objectives over the entire life of the RSF.

The key risks that could result in design and operation modifications during commissioning and operation of the project are:

- Life of mine and tailings production rate
- Physical properties of the tailing including solids content and rheology
- Geochemical properties of the materials
- Variation in geological or hydrogeological conditions across the site
- Variations in geotechnical properties of embankment materials dependent on material source

Further studies and investigations to be carried out as part of further design stages will assist in mitigating the risks through greater understanding of the RSF area.

11. Conceptual closure design

11.1 General Requirements

Closure for the facility will conform to industry standards to develop a final landform that is:

- Physically safe to humans and animals;
- Geotechnically stable;
- Geochemically non-polluting/ non-contaminating;
- Capable of sustaining an agreed post-mining land use;
- Decommissioned and rehabilitated in an ecologically sustainable manner.

Based on these the aims of the closure design are as follows:

- Ancillary infrastructure associated with each of the cells shall be to be removed and each of the cells shall be made safe;
- The closure landform shall be free draining, stable and non-polluting;
- The cover and landform design shall require minimal ongoing surveillance and maintenance post closure;
- Vegetation used in the closure of the facility shall self-sustaining.

11.2 Concept design

Given the location of RSF 2 in relation to RSF 1, it is proposed that a single closure landform be developed to assist in the assimilation of the landform into the surround topography and optimise water management elements of the design.

11.2.1 Landform arrangement

The final landform will be developed such that a single closure structure encapsulating both RSF 1 and RSF 2 to improve visual amenity and reduce ongoing operation and maintenance costs associated with the landform. The closure landform will seek to incorporate the following elements in the design:

- Additional buttressing on the downstream face of the embankment using non-leachable, NAF waste rock utilising gentler slopes on the downstream face to minimise erosion and ongoing maintenance.
- The cap over the combined facility should be graded over the entire footprint such that all rainfall is released from single drainage outlet point.
- The hydraulic structures designed such that that they can sustain a PMP rainfall event as per ANCOLD Guidelines without erosion.
- The landform design should manage settlement to limit ponding and infiltration into the residue material.
- The capping design for the embankment should consider the following elements:
  - A waste rock layer directly over the residue to form a trafficable layer and assist in the profiling of the capping,
  - A low permeability layer placed over the waste rock to reduce the potential for infiltration, a 600 mm clay layer is currently proposed however alternatives including a

    geosynthetic liner systems or geo-composite liners should be considered during further design.
  – A growth medium / topsoil layer lain over the clay capping and downstream face of the buttressing layer to be revegetated using local occurring grassland species.

11.2.2 Closure staging

Following the completion of deposition of the material into RSF 2 following the stage 2 Raise, the closure phase will consist of the following staging:

- Following completion of deposition all decant water will removed from the facility utilising the existing infrastructure and evaporation.
- All ancillary structures used in the management of the facility including but not limited to deposition pipelines, decant equipment and water management structures will be decommissioned.
- Waste rock from the existing stockpiles would be used to buttress the downstream face of the embankment and ensure the batters are flattened to 4H:1V to assist in ensuring the stability of the embankment during and after the closure of the facility. Noting this could also be done during the operational phase if feasible.
- Waste rock from the existing stockpile would be dumped from the crest around the facility and pushed into the centre of each of the cells at a rate designed to manage the risk of residue displacement and static liquefaction.
- This waste rock would then be profiled to allow for suitable drainage across the crest whilst minimising erosion and damage to the landform.
- A 600 mm low permeability clay capping layer would then be lain across the waste rock to reduce the potential for infiltration and assist in the encapsulation of the residue.
- A 150-500 mm layer of growth medium and topsoil would then be lain across the clay capping layer and downstream batters and be revegetated utilising local occurring native grassland species.

12. Safety in design

Safety in design is a strategy aimed at preventing injuries by considering hazards as early as possible in the planning and design process, enhancing safety through choices in the design process. A safety in design approach considers the safety of those who construct, operate, maintain, clean, repair and demolish an asset (includes building, structure, plant or equipment). Parties involved in the planning and design stage of a project are in a position to reduce the risks that arise during the life cycle of the asset and have a legal requirement to do so.

At each design stage “designers” can make a significant contribution by identifying and eliminating hazards, and reducing likely risks from hazards where elimination is not possible. Often the most cost effective and practical approach is to avoid introducing a hazard to the workplace in the first place, by eliminating hazards at the design stage.

The definition of “designer” not only affects the actual designer but also those who are connected with the design (e.g. during construction), including parties where the end product is to be used, or could reasonably be expected to be used, as, or at a workplace (e.g. during end use, inspection, operation, cleaning, maintenance and demolition). Furthermore, the “designer” must ensure, so far as is reasonably practicable, that the plant, substance or structure is designed to minimise risks to the health and safety of workers where the design is for the purposes of a workplace.

It is therefore reasonable to consider the wider practical definition of “designer” to include:

- Design professionals
- Head contractors, project managers, clients, end- users and workers
- Quantity surveyors, insurers, quality assurance staff, work safety professionals and ergonomics practitioners
- Suppliers including manufacturers, importers, those who hire plant, constructors, installers and trades and maintenance people

GHD has been engaged to provide design services described in this report. As such GHD has undertaken a component of the designer’s role in this project. In this role GHD has identified and mitigated a number of potential risks within the limitations of our scope, in consultation with other members of the design team. The key risks identified throughout the risk assessment are identified below in Table 12-1 while the risk assessment is included as Appendix C.

Table 12-1 Key risks identified to be mitigated in further design

Item	Risk Description	Mitigating Action
1	Inadequate assumptions relating to the material properties on site impacting the construction and operation of the facility	Development of comprehensive geotechnical investigations to be undertaken prior to the detailed design of the facility. Undertake sensitivity analysis during the detailed design to assess impacts of varying material properties.
2	Insufficient materials available from the local area for the construction of the stage 1 embankment	Development of comprehensive geotechnical investigations to be undertaken prior to the detailed design of the facility and undertake material balance of the identified materials onsite.

3	Target tailings densities not achieved resulting in impacts to embankment raising and closure of the facility	Development of operational controls and Operation and Maintenance Manual to outline critical requirements for the management of the RSF. Ongoing engineering assessments to assess material densities and rectify where possible. It is likely further raises would be possible if required particularly if conservative boundary offsets are provided to the ultimate downstream toe.
4	Poor water management in the RSF cells increasing risk of piping, inability to sufficiently dewater, increased risk of overtopping.	Development of operational controls and Operation and Maintenance Manual to outline critical requirements for the management of the RSF. Installation of suitable decant infrastructure to allow for the efficient dewatering of the RSF. Use of RSD for excess water storage if required.

GHD formally hands responsibility of the residual risks to TGO for further mitigation, and trust that you will complete the safety in design review process for the phases of this project within your responsibility. The combined safety in design document should be provided to each of the parties who may be identified as being able to influence design. The safety in design risk assessment should be continually updated to reflect the current risks associated with all current activities associated with the asset.

13. Recommendations

To further develop the RSF 2 concept to a construction stage the following high level steps are required;

- TGO to confirm basis of design for tailings throughput, LOM tonnage, ore changes/types throughout LOM and mine waste schedule for RSF construction;
- Gain approvals to undertake geotechnical investigations on the new RSF foundation area, investigation is likely to comprise;
  - 20 test pits in storage area for bulk samples and laboratory testing;
  - 10 boreholes with U63 samples, insitu SPT and packer testing;
  - 4-6 groundwater monitoring bores;
- Preliminary design for submission of new RSF approvals
- Detailed design
- Develop tender documentation and run tender process
- Develop IFC documentation

14. References

ANZECC and ARMCANZ (2000) Guidelines for Fresh and Marine Water Quality, Volume 1, National Water Quality Management Strategy

Coffey Geotechnics (2007) Preliminary Groundwater Investigation, Alkane Exploration Limited, Tomingley NSW

DE Cooper and Associates Pty Ltd (2011) Tomingley Gold Project, Residue Management, Design Report, Rev 1, August 2011

Gagnon I, Zagury G J and Deschenes L (2004) Natural Attenuation Potential of Cyanide in Groundwater Newar SPL Landfill.

GHD (2015) Tomingely Gold Operations Modification 3. Water resource impact assessment

GHD (2019a) RSF2 Concept Study.

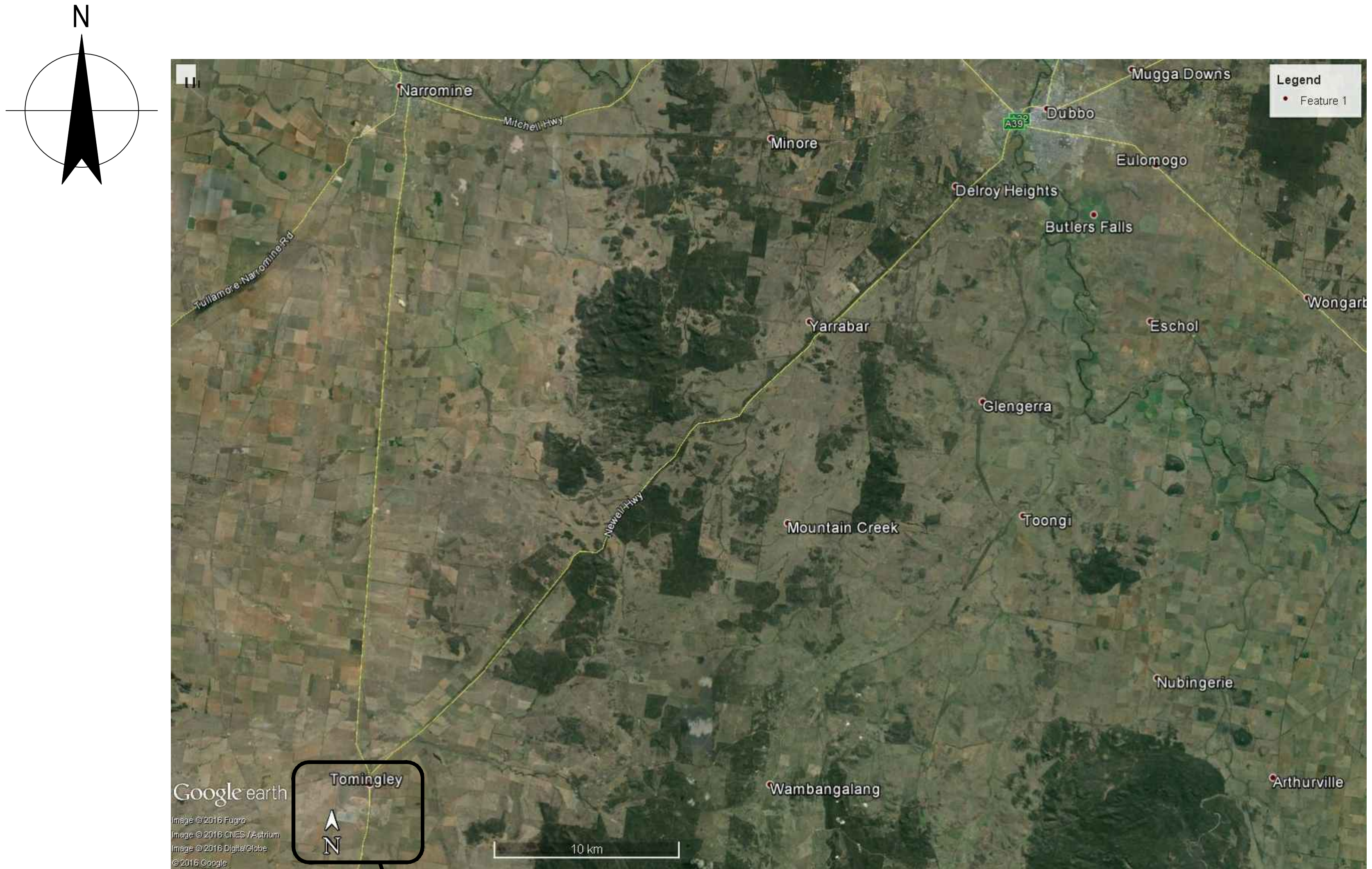
GHD (2019b) RSF1 Stage 6 Detailed Design.

GHD (2019c) RSF1 Stage 7-9 Concept Study.

Appendices

Appendix A – Concept Design Drawings

TOMINGLEY GOLD OPERATIONS
RSF 2 SITE OPTIONS
12517944



LOCALITY PLAN
NOT TO SCALE

SITE LOCATION

DRAWING LIST

DRG No.	DRAWING TITLE
12517944-C001	COVER PAGE AND DRAWING LIST
12517944-C002	STAGE 2 PLAN ARRANGEMENT
12517944-C003	TYPICAL SECTIONS - SHEET 1 OF 6
12517944-C004	TYPICAL SECTIONS - SHEET 2 OF 6
12517944-C005	TYPICAL SECTIONS - SHEET 3 OF 6
12517944-C006	TYPICAL SECTIONS - SHEET 4 OF 6
12517944-C007	TYPICAL SECTIONS - SHEET 5 OF 6
12517944-C008	TYPICAL SECTIONS - SHEET 6 OF 6

CONCEPT

No	Revision	Drawn	Job Manager	Project Director	Date
C	RE-ISSUED FOR CONCEPT DESIGN ONLY	RC	TR	RL	16.11.20
B	ISSUED FOR CONCEPT DESIGN ONLY	BH	TR*	RL*	22.06.20
A	ISSUED FOR CLIENT COMMENT	VGJ	TR*	RL*	22.05.20

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Drafting Check | Design Check
Approved (Project Director)
Date
Scale NOT TO SCALE
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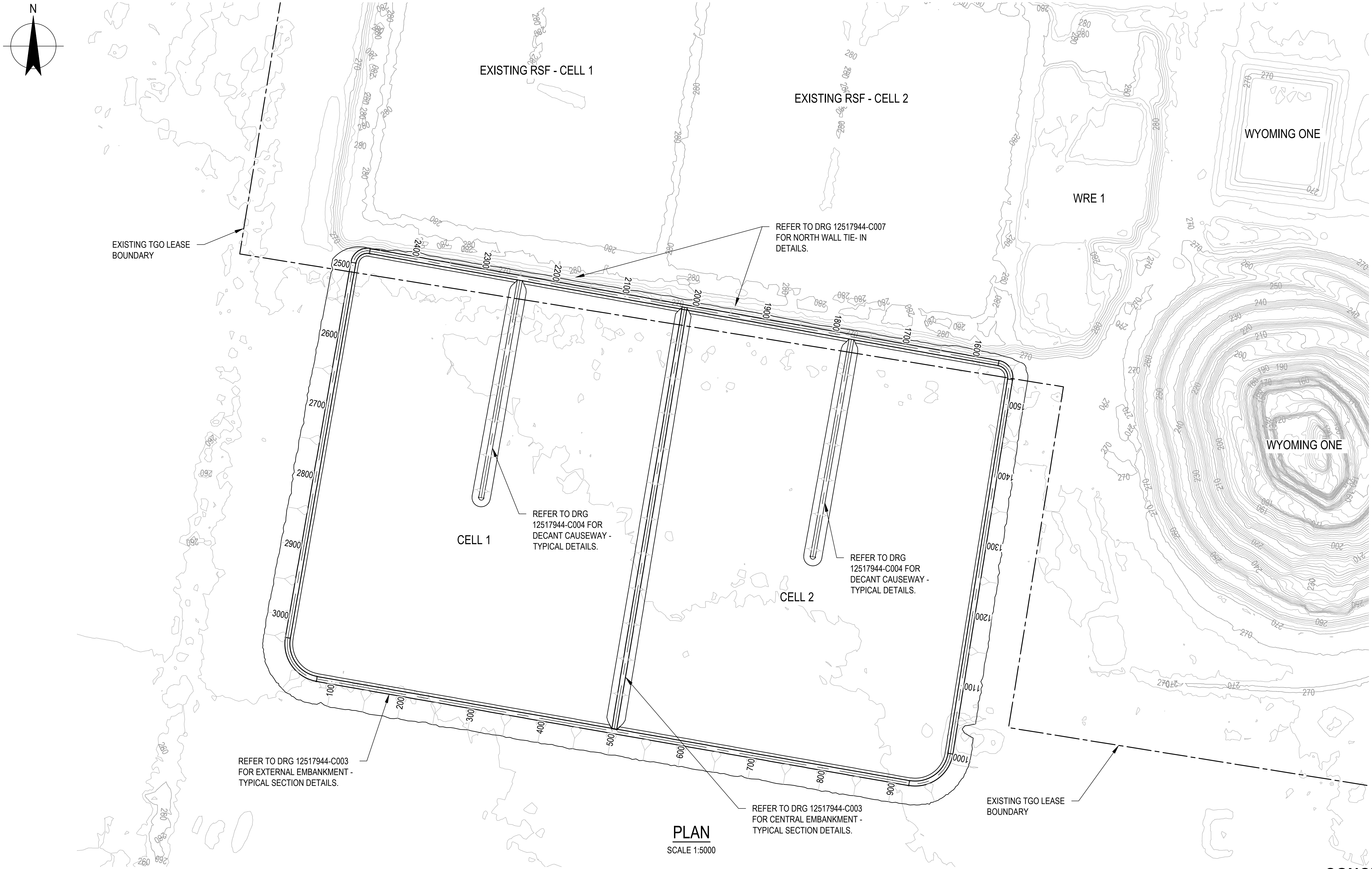
Client **TOMINGLEY GOLD OPERATIONS**
Project **RSF 2 SITE OPTIONS**
Title **COVER PAGE AND DRAWING LIST**

Original Size **A3** **Drawing No: 12517944-C001** **Rev: C**

Plot Date: 16 November 2020 - 3:37 PM Plotted By: Victoria Jenkins Cad File No: G:\32\12517944\CADD\Drawings\12517944-C001.dwg



PLAN

SCALE 1:5000

CONCEPT

No	Revision	Drawn	Job Manager	Project Director	Date
C	RE-ISSUED FOR CONCEPT DESIGN ONLY	RC	TR	RL	16.11.20
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0 50 100 150m

SCALE 1:5000 AT ORIGINAL SIZE

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Date

Scale 1:5000

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Client **TOMINGLEY GOLD OPERATIONS**

Project **RSF 2 SITE OPTIONS**

Title **STAGE 2 PLAN ARRANGEMENT**

Original Size A3 | Drawing No: **12517944-C002** | Rev: C

Plot Date: 16 November 2020 - 3:55 PM Plotted By: Victoria Jenkins Cad File No: G:\32\12517944\CADD\Drawings\12517944-C002.dwg

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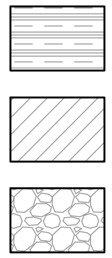
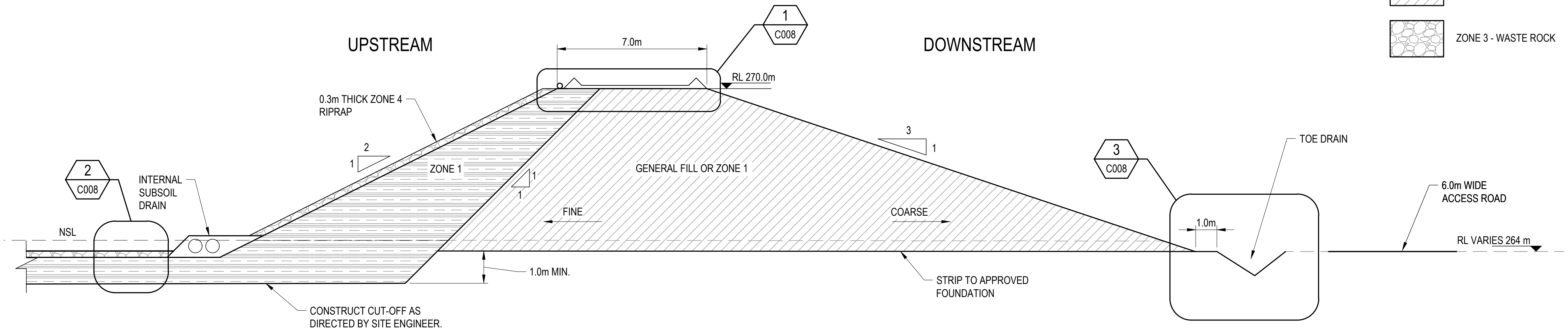


ZONE 1 - LOW PERMEABILITY RESIDUAL SOIL TO EXTREMELY WEATHERED ROCK

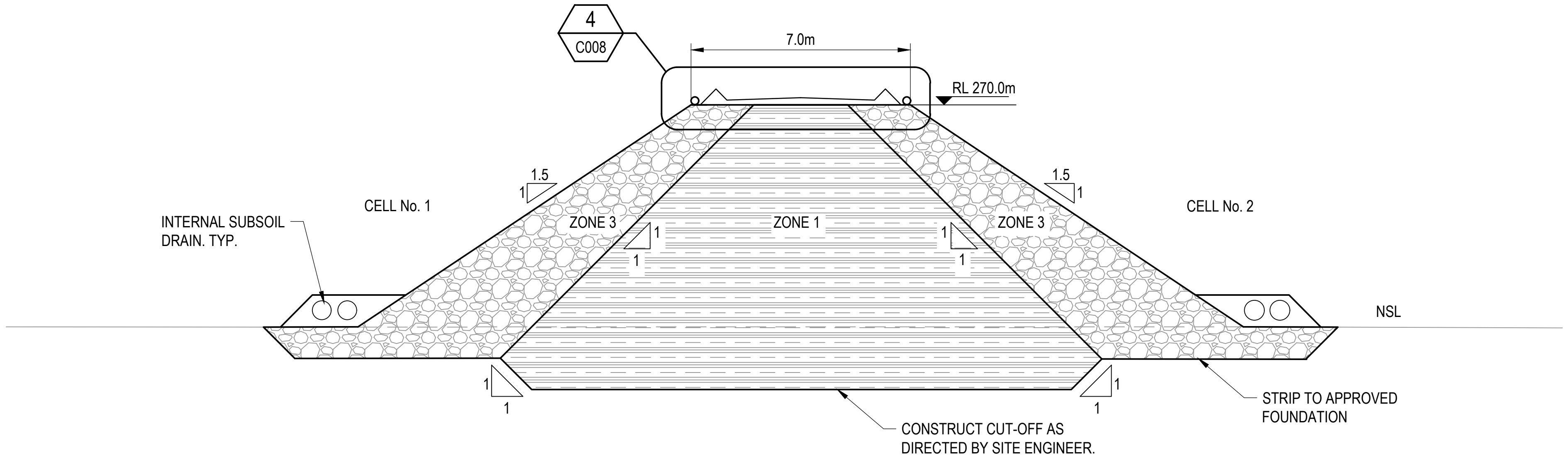
GENERAL FILL / ZONE 1

ZONE 3 - WASTE ROCK



TYPICAL SECTION - EXTERNAL EMBANKMENT - STAGE 1 DAM

SCALE 1:200



TYPICAL SECTION - CENTRAL EMBANKMENT - STAGE 1 DAM

SCALE 1:200

CONCEPT

No	Revision	Drawn	Job Manager	Project Director	Date
C	RE-ISSUED FOR CONCEPT DESIGN ONLY	RC	TR	RL	16.11.20
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0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

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Date
Scale 1:200
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Client **TOMINGLEY GOLD OPERATIONS**
Project **RSF 2 SITE OPTIONS**
Title **TYPICAL SECTIONS - SHEET 1 OF 6**

Original Size A3 Drawing No: **12517944-C003** Rev: C

Plot Date: 16 November 2020 - 4:50 PM Plotted By: Victoria Jenkins Cad File No: G:\32\12517944\CADD\Drawings\12517944-C003.dwg

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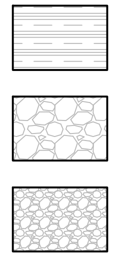
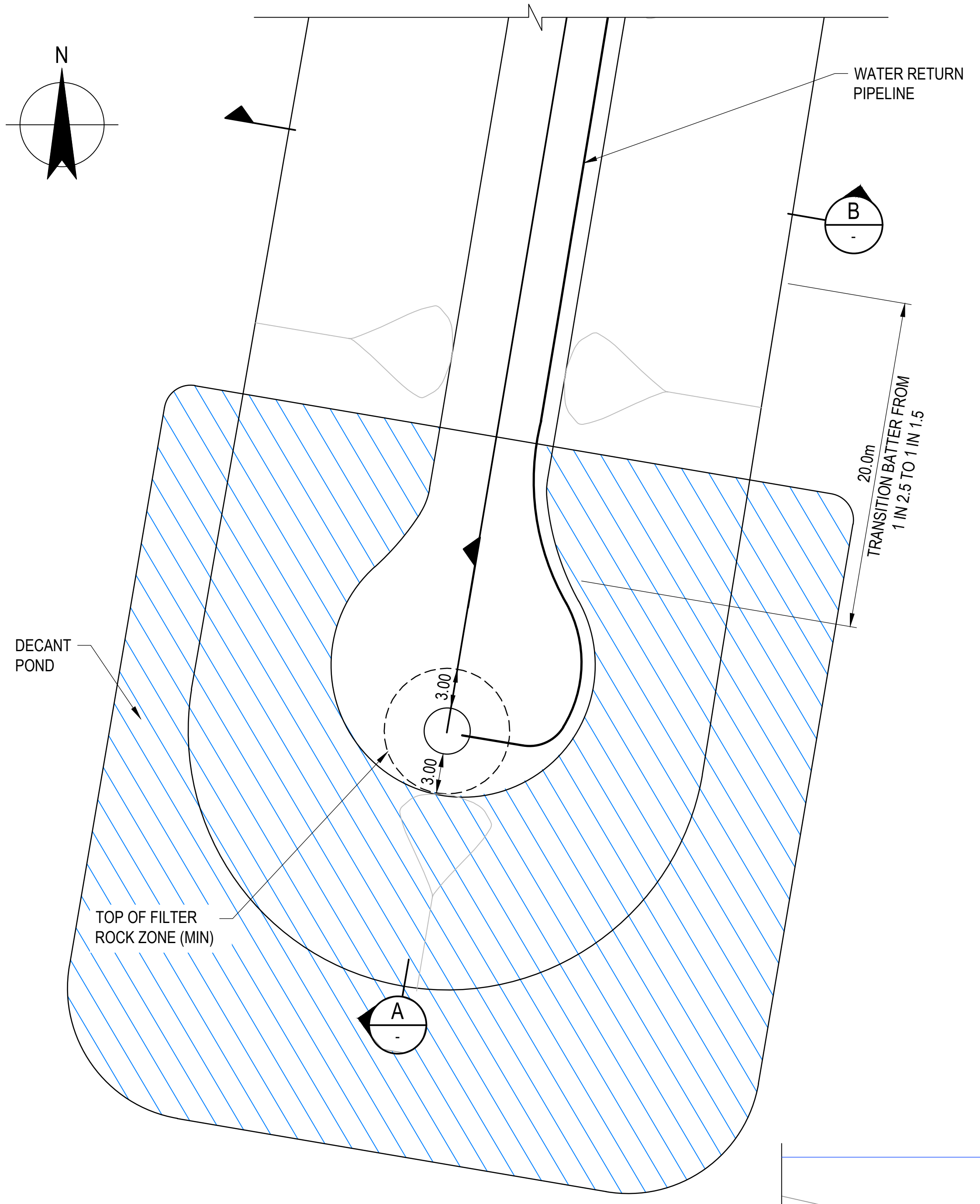
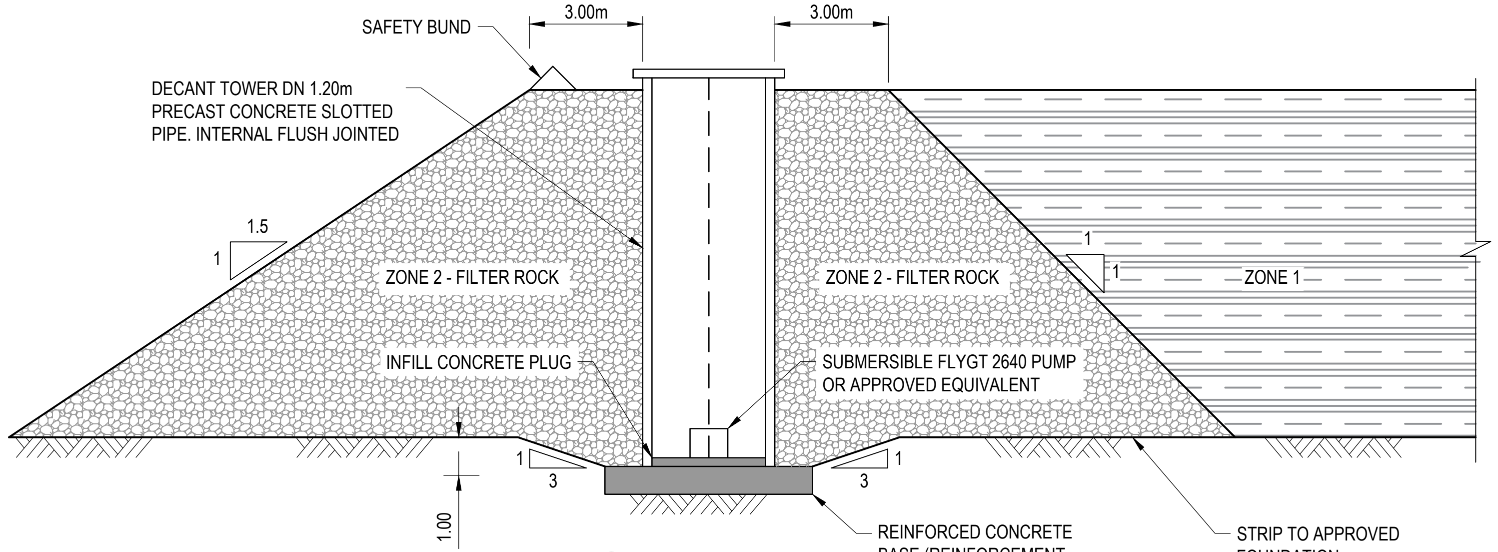




DECANT TOWER PLAN

SCALE 1 : 500



A SECTION
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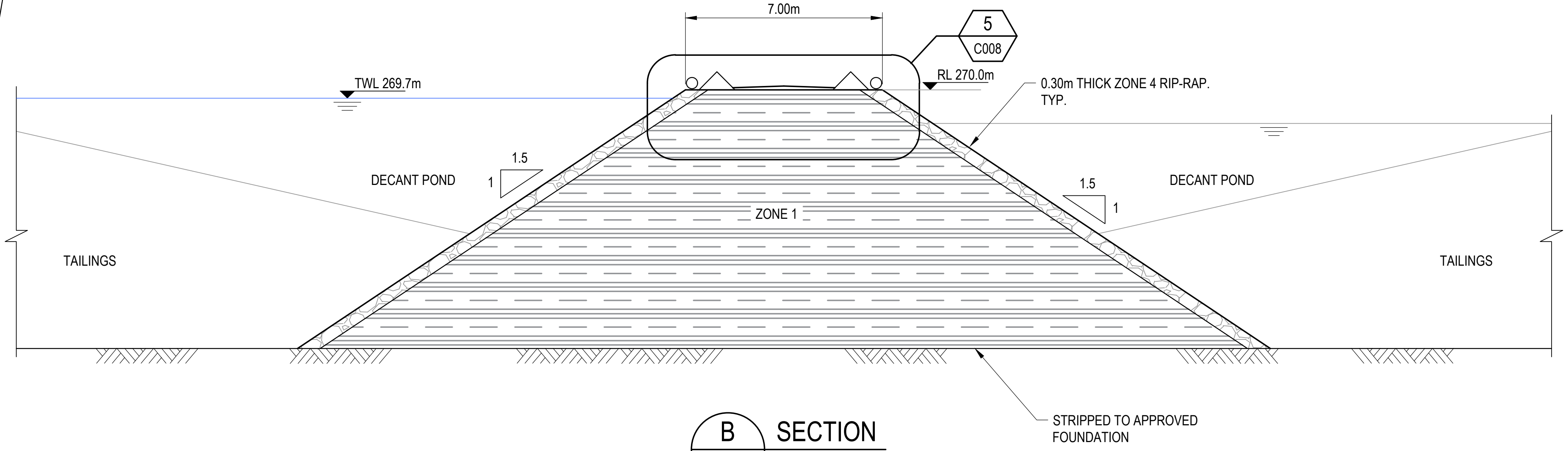
SCALE 1 : 200



B SECTION
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SCALE 1 : 200

CONCEPT

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0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 5 10 15m
SCALE 1:500 AT ORIGINAL SIZE

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Approved (Project Director)
Date
Scale AS SHOWN

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Client **TOMINGLEY GOLD OPERATIONS**
Project **RSF 2 SITE OPTIONS**
Title **TYPICAL SECTIONS - SHEET 2 OF 6**

Original Size **A3** | **Drawing No: 12517944-C004** | **Rev: C**

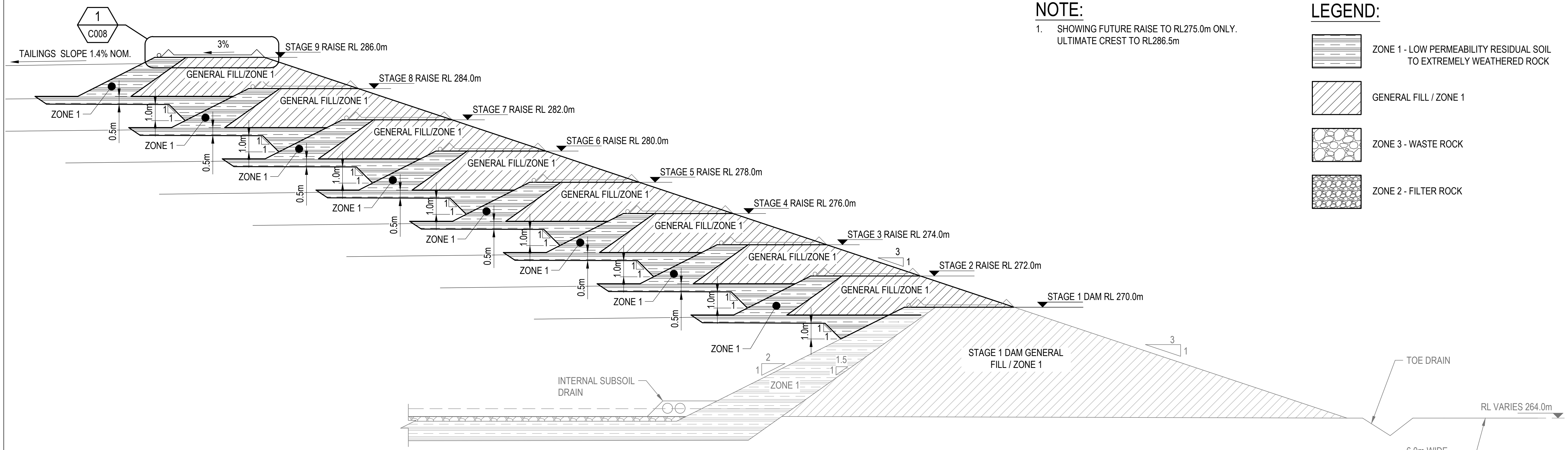
Plot Date: 16 November 2020 - 4:39 PM Plotted By: Victoria Jenkins Cad File No: G:\32\12517944\CADD\Drawings\12517944-C004.dwg

NOTE:

1. SHOWING FUTURE RAISE TO RL275.0m ONLY. ULTIMATE CREST TO RL286.5m

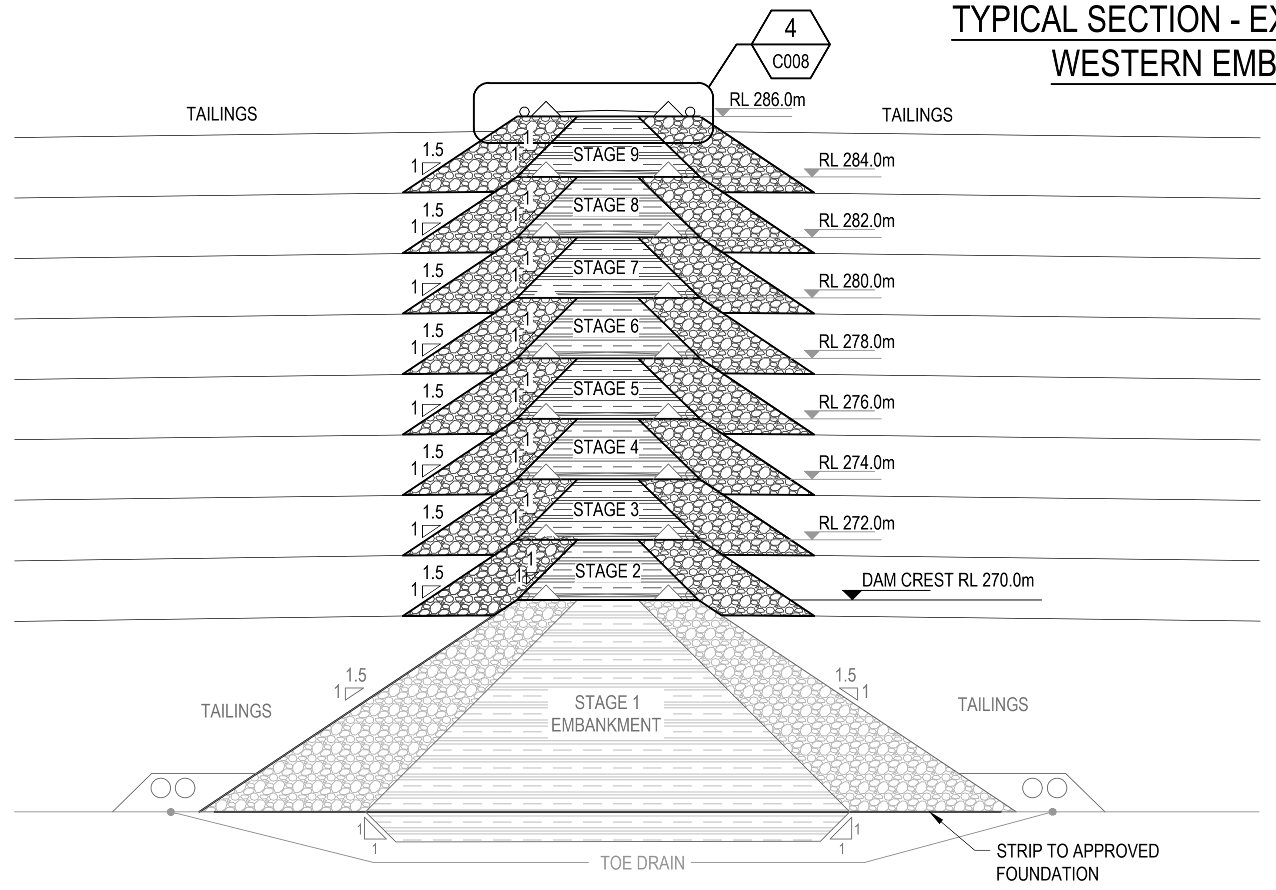
LEGEND:

- ZONE 1 - LOW PERMEABILITY RESIDUAL SOIL TO EXTREMELY WEATHERED ROCK
- GENERAL FILL / ZONE 1
- ZONE 3 - WASTE ROCK
- ZONE 2 - FILTER ROCK



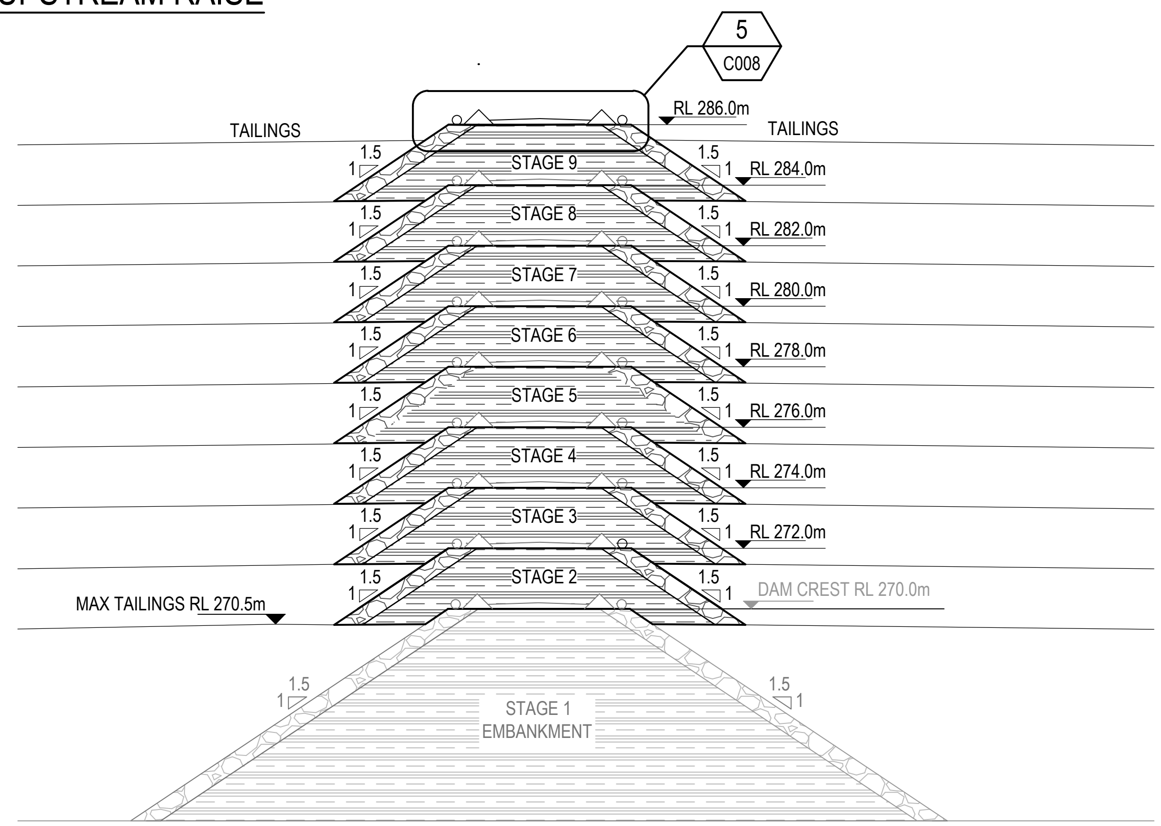
TYPICAL SECTION - EXTERNAL EASTERN, SOUTHERN AND WESTERN EMBANKMENT - UPSTREAM RAISE

SCALE 1:250



TYPICAL SECTION - CENTRAL EMBANKMENT

SCALE 1:250



TYPICAL SECTION - DECANT CAUSEWAYS

SCALE 1:250

CONCEPT

No	Revision	Drawn	Job Manager	Project Director	Date
C	RE-ISSUED FOR CONCEPT DESIGN ONLY	RC	TR	RL	16.11.20
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0 2.5 5.0 7.5m
SCALE 1:250 AT ORIGINAL SIZE

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Client **TOMINGLEY GOLD OPERATIONS**
Project **RSF 2 SITE OPTIONS**
Title **TYPICAL SECTIONS - SHEET 3 OF 6**

Original Size A3 Drawing No: **12517944-C005** Rev: C

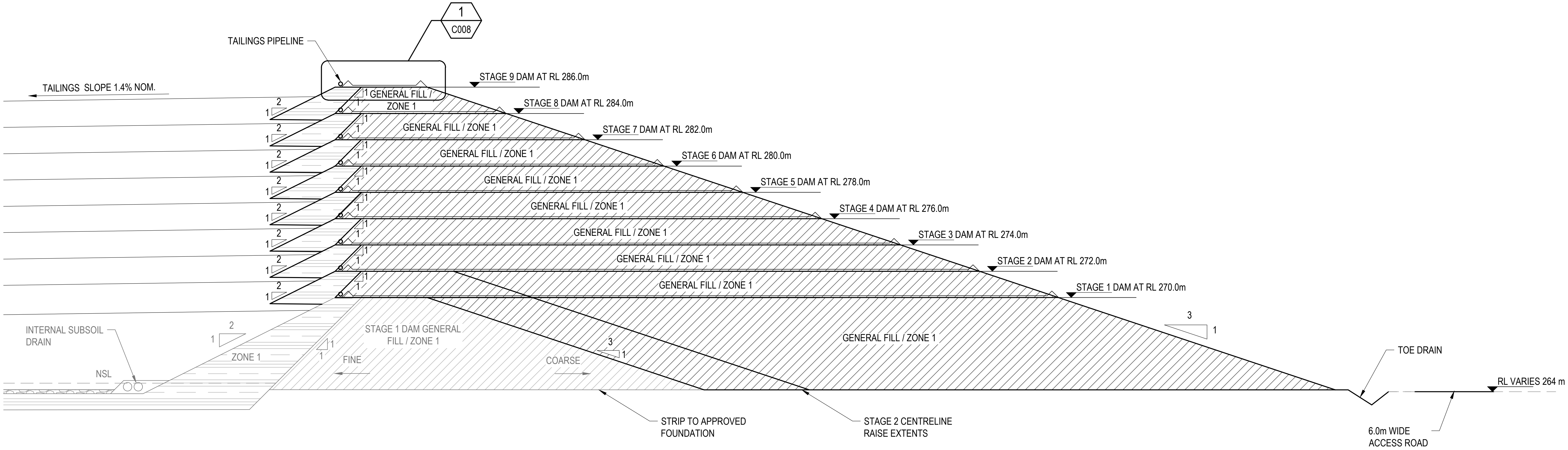
Plot Date: 16 November 2020 - 4:41 PM Plotted By: Victoria Jenkins Cad File No: G:\32\12517944\CADD\Drawings\12517944-C005.dwg

NOTE:

1. SHOWING FUTURE RAISE TO RL275.0m ONLY. ULTIMATE CREST TO RL286.5m

LEGEND:

- ZONE 1 - LOW PERMEABILITY RESIDUAL SOIL TO EXTREMELY WEATHERED ROCK
- GENERAL FILL / ZONE 1
- ZONE 3 - WASTE ROCK
- ZONE 2 - FILTER ROCK



TYPICAL SECTION - EXTERNAL EASTERN, SOUTHERN AND WESTERN EMBANKMENT CENTRELINE RAISE

SCALE 1:300

CONCEPT

No	Revision	Drawn	Job Manager	Project Director	Date
C	RE-ISSUED FOR CONCEPT DESIGN ONLY	RC	TR	RL	16.11.20
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A	ISSUED FOR CLIENT COMMENT	VGJ	TR*	RL*	22.05.20

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0 2 4 6 8 10m
SCALE 1:300 AT ORIGINAL SIZE

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Date
Scale 1:300
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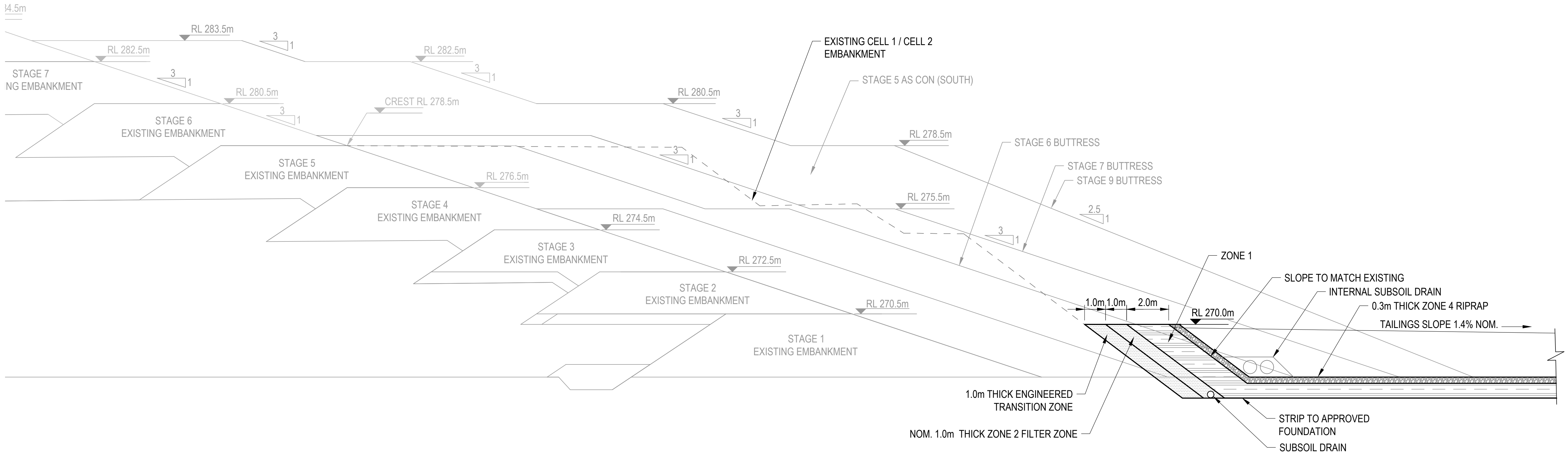
Client **TOMINGLEY GOLD OPERATIONS**
Project **RSF 2 SITE OPTIONS**
Title **TYPICAL SECTIONS - SHEET 4 OF 6**

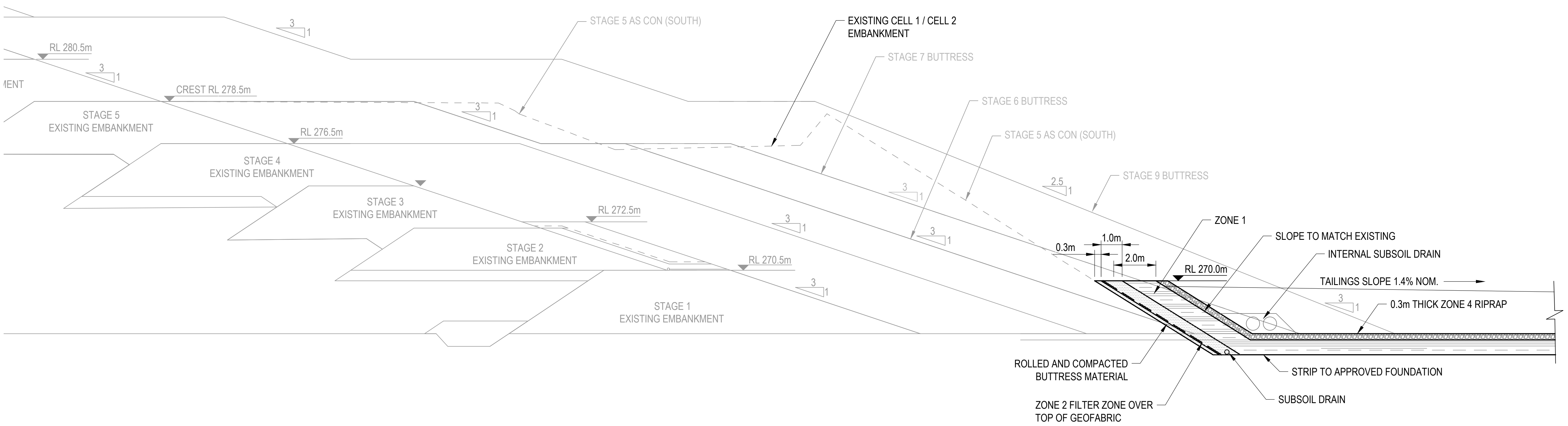
Original Size A3 | Drawing No: **12517944-C006** | Rev: C

Plot Date: 16 November 2020 - 4:44 PM | Plotted By: Victoria Jenkins | Cad File No: G:\32\12517944\CADD\Drawings\12517944-C006.dwg



RSF 3 NORTH WALL OPTION 1

SCALE 1:200



RSF 3 NORTH WALL OPTION 2

SCALE 1: 200

CONCEPT

No	Revision	Drawn	Job Manager	Project Director	Date
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B	ISSUED FOR CONCEPT DESIGN ONLY	BH	TR*	RL*	22.06.20
A	ISSUED FOR CLIENT COMMENT	VGJ	TR*	RL*	22.05.20

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

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Date
Scale 1:200 | This Drawing must not be used for Construction unless signed as Approved

Client **TOMINGLEY GOLD OPERATIONS**
Project **RSF 2 SITE OPTIONS**
Title **TYPICAL SECTIONS - SHEET 5 OF 6**

Original Size A3 | Drawing No: **12517944-C007** | Rev: C

Plot Date: 16 November 2020 - 4:46 PM Plotted By: Victoria Jenkins Cad File No: G:\32\12517944\CADD\Drawings\12517944-C007.dwg

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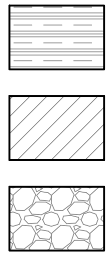
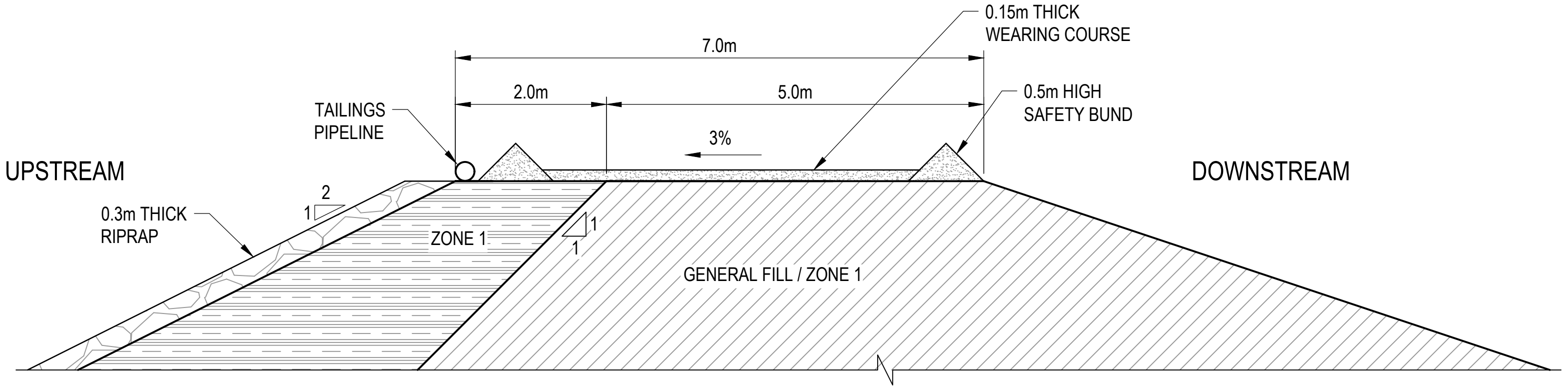


ZONE 1 - LOW PERMEABILITY RESIDUAL SOIL TO EXTREMELY WEATHERED ROCK

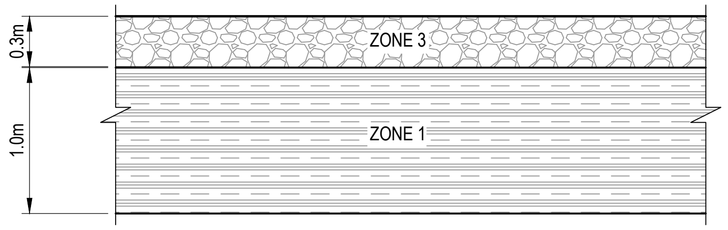
GENERAL FILL / ZONE 1

ZONE 3 - WASTE ROCK



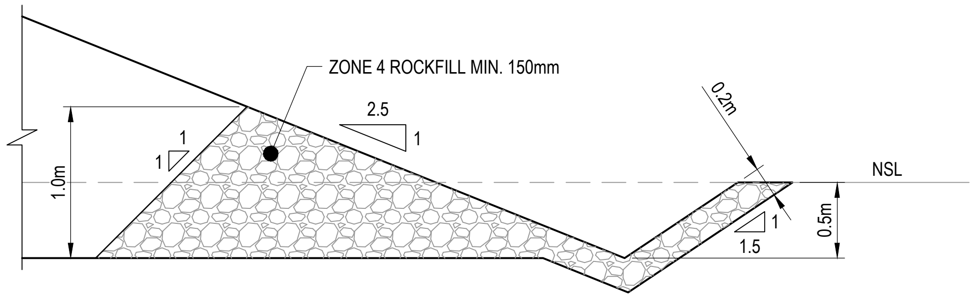
1 DETAIL - EXTERNAL EMBANKMENT

C003,C005,C006 SCALE 1 : 100



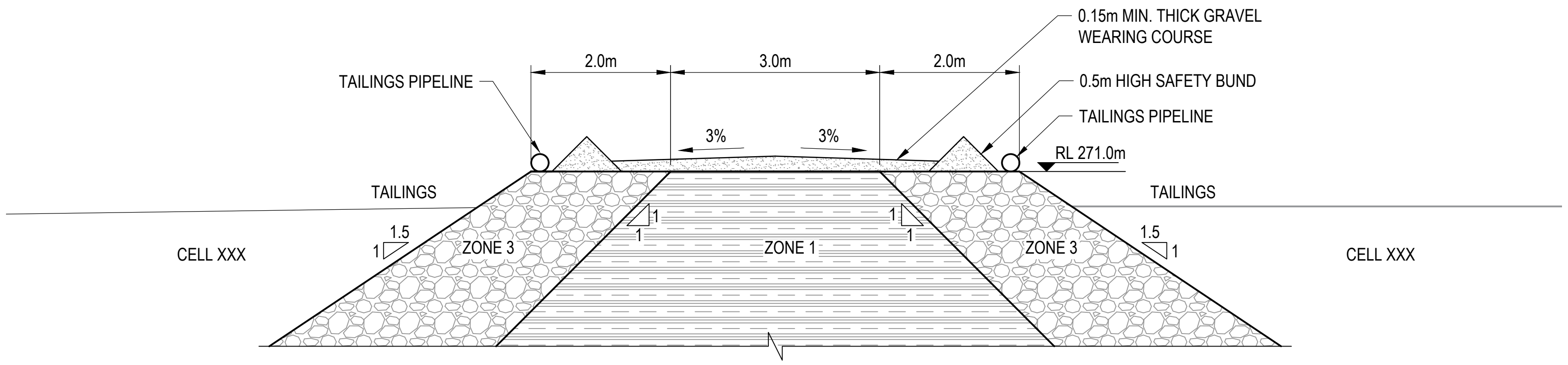
2 DETAIL - CLAY LINER

C003 SCALE 1 : 50



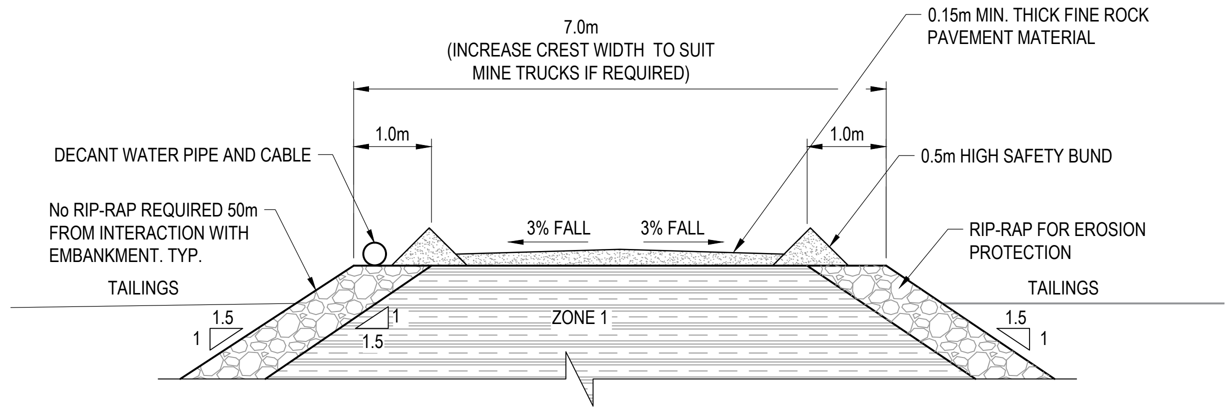
3 DETAIL -TOE DRAIN

C003 SCALE 1 : 50



4 DETAIL - CENTRAL EMBANKMENT

C003 SCALE 1 : C003



5 DETAIL - DECANT EMBANKMENT

C004,C005,C006 SCALE 1 : 100

CONCEPT

No	Revision	Drawn	Job Manager	Project Director	Date
A	RE-ISSUED FOR CONCEPT DESIGN ONLY	RC	TR	RL	16.11.20

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 0.5 1.0 1.5m — SCALE 1:50 AT ORIGINAL SIZE

0 1 2 3m — SCALE 1:100 AT ORIGINAL SIZE

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Drawn	V. JENKINS	Designer	T. RIDGWAY
Drafting Check		Design Check	
Approved (Project Director)			
Date			
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

Client **TOMINGLEY GOLD OPERATIONS**

Project **RSF 2 SITE OPTIONS**

Title **TYPICAL SECTIONS - SHEET 6 OF 6**

Original Size **A3** Drawing No: **12517944-C008** Rev: **A**

Plot Date: 16 November 2020 - 3:58 PM Plotted By: Victoria Jenkins Cad File No: G:\32\12517944\CADD\Drawings\12517944-C008.dwg

Appendix B – Consequence Category Assessment

CONSEQUENCE CATEGORY ASSESSMENT

Dam Failure Scenario

Client Name	Tomingley Gold Operation		
Dam Name	RSF 2		
Dam ID. No. (If existing dam)			
Stream Name			
Dam Height (Metres)	7	**Crest RL**	**270 m**
Estimated Capacity at FSL (Megalitres)			
Location	Tomingley Gold Mine		

Damage and Loss	**Estimate**	Minor	Medium	Major	Catastrophic
TOTAL INFRASTRUCTURE COSTS (costs are indicative only)					
Residential	<10M	YES	.	.	.
Commercial	<10M	YES	.	.	.
Community Infrastructure	<10M	YES	.	.	.
Dam replacement or repair cost	$10M - $100M	.	YES	.	.
TOTAL INFRASTRUCTURE COSTS severity level		**MEDIUM**			
IMPACT ON DAM OWNER'S BUSINESS					
Importance to the business	Essential to maintain supply	.	.	YES	.
Effect on services provided by the owner	Severe restictions would be applied for at least 1 yr	.	.	YES	.
Effect on continuing credibility	Extreme discontent	.	.	YES	.
Community reaction and political implications	Extreme discontent	.	.	YES	.
Impact on financial viability	Significant with considerable impact in the long term	.	YES	.	.
Value of water in storage (assessed by the owner in relation to the business)	Loss of income for at least 1 year	.	YES	.	.
IMPACT ON DAM OWNER'S BUSINESS damage and loss severity level		**MAJOR**			
HEALTH and SOCIAL IMPACTS					
Public health	<100 people affected	YES	.	.	.
Loss of service to the community	<100 people affected	YES	.	.	.
Cost of emergency management	1,000 - 10,000 person days	.	YES	.	.
Dislocation of people	<100 person months	YES	.	.	.
Dislocation of businesses	<20 business months	YES	.	.	.
Employment affected	<100 jobs lost	YES	.	.	.
Loss of heritage	Local facility	YES	.	.	.
Loss of recreational facility	Local facility	YES	.	.	.
HEALTH and SOCIAL IMPACTS damage and loss severity level		**MEDIUM**			
NATURAL ENVIRONMENT					
Area of Impact	<5km2	.	YES	.	.
Duration of Impact	<5 years	.	YES	.	.
Stock and Fauna	Discharge from dambreak would contaminate water supplies used by stock and fauna with contaminant uptake.	.	.	YES	.
Ecosystems	Discharge from dambreak would have significant impacts on ecosystems with natural recovery expected after several wet seasons. Remediation possible over many years.	.	.	YES	.
Rare and endangered fauna and flora	Rare and endangered species will be severely impacted. Recovery will take many years.	.	.	YES	.
NATURAL ENVIRONMENT damage and loss severity level		**MAJOR**			
HIGHEST DAMAGE AND LOSS SEVERITY LEVEL		**MAJOR**			

Population at Risk (PAR) PAR includes all those persons who would be directly exposed to flood waters within the dam break affected zone if they took no action to evacuate.	**<1** **CONSEQUENCE CATEGORY =**	**SIGNIFICANT**

Note 1: With a PAR in excess of 100, it is unlikely Damage will be minor. Similarly with a PAR in excess of 1,000 it is unlikely Damage will be classified as Medium.

Note 2: Change to 'High C' where there is the potential of one or more lives being lost. The potential for loss of life is determined by the charateristics of the flood area, particularly the depth and velocity of flow.

Reasons for recommending the consequence category (refer ANCOLD "Guidelines on the Consequence Categories for Dams", 2012) which MUST include comments on PAR, buildings, roads, other infrastructure and natural environment downstream of the dam and the potential impacts arising from a dambreak *(NOTE: Provide photographs to support reasons):*

As per Section 3 of Concept Design Report

Completed By	Tom Ridgway
Date	17/02/2020

CONSEQUENCE CATEGORY ASSESSMENT

Environmental Spill Scenario

Client Name	Tomingley Gold Operation		
Dam Name	RSF 2		
Dam ID. No. (If existing dam)			
Stream Name			
Dam Height (Metres)	7	**Crest RL**	**270 m**
Estimated Capacity at FSL (Megalitres)			
Location	Tomingley Gold Mine		

Damage and Loss	**Estimate**	**Severity Level** Minor	Medium	Major	Catastrophic
TOTAL INFRASTRUCTURE COSTS (costs are indicative only)					
Residential	<10M	YES	.	.	.
Commercial	<10M	YES	.	.	.
Community Infrastructure	<10M	YES	.	.	.
Dam replacement or repair cost	<10M	YES	.	.	.
TOTAL INFRASTRUCTURE COSTS severity level			**MINOR**		
IMPACT ON DAM OWNER'S BUSINESS					
Importance to the business	Restrictions needed during dry periods	YES	.	.	.
Effect on services provided by the owner	Minor difficulties in replacing services	YES	.	.	.
Effect on continuing credibility	Some reaction but short lived	YES	.	.	.
Community reaction and political implications	Severe widespread reaction	.	YES	.	.
Impact on financial viability	Able to absorb in 1 financial year	YES	.	.	.
Value of water in storage (assessed by the owner in relation to the business)	Can be absorbed in one financial year	YES	.	.	.
IMPACT ON DAM OWNER'S BUSINESS damage and loss severity level			**MEDIUM**		
HEALTH and SOCIAL IMPACTS					
Public health	<100 people affected	YES	.	.	.
Loss of service to the community	<100 people affected	YES	.	.	.
Cost of emergency management	<1,000 person days	YES	.	.	.
Dislocation of people	<100 person months	YES	.	.	.
Dislocation of businesses	<20 business months	YES	.	.	.
Employment affected	<100 jobs lost	YES	.	.	.
Loss of heritage	Local facility	YES	.	.	.
Loss of recreational facility	Local facility	YES	.	.	.
HEALTH and SOCIAL IMPACTS damage and loss severity level			**MINOR**		
NATURAL ENVIRONMENT					
Area of Impact	<5km2	.	YES	.	.
Duration of Impact	<5 years	.	YES	.	.
Stock and Fauna	Discharge from dambreak would contaminate water supplies used by stock and fauna. Health impacts not expected.	.	YES	.	.
Ecosystems	Discharge from dambreak would have short term impacts on ecosystems with natural recovery expected after 1 wet season. Remediation possible.	.	YES	.	.
Rare and endangered fauna and flora	Species exist with losses expected to be recovered over a number of years.	.	YES	.	.
NATURAL ENVIRONMENT damage and loss severity level			**MEDIUM**		

HIGHEST DAMAGE AND LOSS SEVERITY LEVEL	**MEDIUM**

Population at Risk (PAR) PAR includes all those persons who would be directly exposed to flood waters within the dam break affected zone if they took no action to evacuate.	**<1** **CONSEQUENCE CATEGORY =**	**LOW**

Note 1: With a PAR in excess of 100, it is unlikely Damage will be minor. Similarly with a PAR in excess of 1,000 it is unlikely Damage will be classified as Medium.

Note 2: Change to 'High C' where there is the potential of one or more lives being lost. The potential for loss of life is determined by the charateristics of the flood area, particularly the depth and velocity of flow.

Reasons for recommending the consequence category (refer ANCOLD "Guidelines on the Consequence Categories for Dams", 2012) which MUST include comments on PAR, buildings, roads, other infrastructure and natural environment downstream of the dam and the potential impacts arising from a dambreak *(NOTE: Provide photographs to support reasons):*

As per Section 3 of Concept Design Report

Completed By	Tom Ridgway
Date	17/02/2020

Appendix C – Safety in Design Risk Register

HSE040 Safety in Design Risk Assessment

Notes: *Designs with significant quantities of dangerous goods may require detailed risk assessments under Dangerous Goods or Major Hazard legislation
* Most industrial processes will require an industry specific assessment, e.g. HAZOP and/or Quantitative Risk Assessment for facilities that have chemical or high-pressure processes under Dangerous Goods or Major Hazard legislation.

Design Life Cycle:	Investigation and Design	Setup, Construction and Commissioning	Operation	Maintenance	Disposal		**Date:**	22/05/2020	**Revision No:**	0
Job Name:	TGO RSF 2 Site Options Study		**Job No:**	12517944	**Client**	Tomingley Gold Opperations (TGO)	**Design:**	RSF2 Stage 1		
People involved in Risk Assessment:	Rhys Koppelmann, Tom Ridgway									

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating C	Initial Risk Rating L	Initial Risk Rating RR	Potential Control Measures (Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating C	Residual Risk Rating L	Residual Risk Rating RR	Comments
R001	Investigation and Design	Inaccurate assumptions relating to material hydraulic properties (embankment, foundation and tailings), seepage behaviour and phreatic surface	Inadequate embankment stability as a result of higher than anticipated phreatic surface.	Sensitivity analysis on seepage and stability model to assess implications of varying material hydraulic properties on embankment stability.	E- Catastrophic	2 - Unlikely	Significant	Installation of piezometers in embankment, foundation and tailings to monitor seepage behaviour as the tailings beach rises. - Ongoing review of design assumptions using "observational approach" during detailed design of each embankment raise including provision for additional stabilisation or drainage if required to maintain acceptable embankment stability. - Review of design by independent peer reviewer.	GHD	Preliminary Design	To be investigated in the Preliminary Design Stage	E- Catastrophic	1 - Very Unlikely	Moderate	GHD/TGO
R002	Investigation and Design	Inaccurate assumptions relating to material hydraulic properties (embankment, foundation and tailings), seepage behaviour and phreatic surface	Inadequate hydraulic properties of liner/tailings leads to seepage through the embankment or foundation increasing environmental impact and piping risk. - Seepage through zones of potentially higher permeability tailings deposited on the valley floor.	CPTu investigation was undertaken on the RSF1 and RSF2. Geotechncial investigation to be undertaken on the starter dam alignemnt. Laboratory permeability testing of the foundation materials to be undertaken in include in design assumptions.	C- Severe	3 - Possible	Moderate	Installation of piezometers in embankment, foundation and tailings to monitor seepage behaviour as the tailings beach rises. - Installation of downstream monitoring bores to enable sampling and testing of groundwater quality. On site supervision during foundation excavations.	GHD	During Design Stage and during Construction	Ongoing	C- Severe	2 - Unlikely	Low	GHD/TGO
R003	Investigation and Design	Inaccurate assumptions relating to material hydraulic properties (embankment, foundation and tailings), seepage behaviour and phreatic surface	RSF failure as a result of incorrect design assumptions relating to loading conditions or material properties	Geotech investigations and testing to confirm material parameters within new borrow areas (dam footprint). - Review of any previous lab testing results to determine material parameters in existing proposed borrow area - Loading conditions assessed in accordance with ANCOLD Guidelines on Tailings Dams (2012) including undrained conditions as appropriate for foundation materials.	E- Catastrophic	2 - Unlikely	Significant	Ongoing review of design assumptions using "observational approach" during detailed design of each embankment raise. - Review of design by independent peer reviewer..	GHD	During Design stage of starter dam and subsequent raises	Ongoing	E- Catastrophic	1 - Very Unlikely	Moderate	GHD/TGO

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating			Potential Control Measures (Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating			Comments
					C	L	RR					C	L	RR	
R004	Investigation and Design	Inadequate understanding of foundation conditions	RSF failure as a result of incorrect design assumptions relating to foundation conditions (i.e. low strength foundation zone).	Geotechnical investigation to be undertaken during the design stage to assess the foundation conditions. Desktop review of the publicly available information and client supplied information.	E- Catastrophic	2 - Unlikely	Significant	Ongoing review of design assumptions using "observational approach" during detailed design of each embankment raise. - Adequate engineering supervision during foundation excavations. - Review of design by independent expert review panel	GHD	During Design stage of starter dam and subsequent raises	Ongoing	E- Catastrophic	1 - Very Unlikely	Moderate	GHD/TGO
R005	Investigation and Design	Settlement of buttressing on RSF1 and RSF2 causing instability and cracking of adjoining liner	Settlement of the buttressing causing instability and cracking of adjoining clay liner	Inclusion of a filter blanket along the downstream face of RSF1 and RSF2 under clay liner.	C- Severe	4 - Likely	Moderate	Investgate uncompacted buttressing treatment options prior to placement of the clay liner.	GHD	During the design stage	Ongoing	C- Severe	3 - Possible	Moderate	GHD/TGO
R007	Setup, Construction and Commissioning	Time delays in design/construction	In order to meet TGO increased tailings production needs, RSF3 ill need to be commissioned by mid 2021.	- Detailed project schedule to ensure key milestones are met within a suitable timeframe. - Active project management to ensure project schedule is met. - Ongoing review of project schedule. - Proactive management to ensure tasks are completed on time. - Time construction to maximise production during summer weather to minimise contractor delays.	D - Critical	2 - Unlikely	Moderate	Nil	GHD	During Design and Construction	Ongoing	D - Critical	1 - Very Unlikely	Moderate	GHD/TGO
R008	Setup, Construction and Commissioning	Insufficient availability of suitable embankment construction materials	- Insufficient construction materials to enable successful construction of embankment works results in compromised embankment quality, changes in design or increased cost to TGO. - Insufficient quaility of clay liner material - Availability of suitable filter materials on site.	- Design and material specification to be developed to enable use of as wide a range of material as possible. - Design utilises material from footprint to increase storage volume and reduce embankment quantity of borrow materials required. - Test pit investigations to identify and quantify potential borrow areas. - Importation of filter materials required. - Confirm extent of borrow sources for general fill zones (likely to be from dam footprint).	D - Critical	3 - Possible	Significant	- RSF construction to be a consideration in mine planning. - Future test pit investigations required to identify new borrow areas for future raises.	GHD	During Design Stage	Ongoing	D - Critical	2 - Unlikely	Moderate	GHD/TGO
R009	Setup, Construction and Commissioning	Instability of excavations in soil for the embankment and borrow areas	- Slope failure of excavation results in harm to staff and/or damage to plant and equipment.	Review of stability of slopes during construction. - Safe work method statement for excavations.	D - Critical	2 - Unlikely	Moderate	Site observations to be undertaken during Construction	GHD	During Construction	Ongoing	D - Critical	1 - Very Unlikely	Moderate	GHD/TGO
R010	Operation	Rising piezometric pressures in dam foundation of embakment.	- Instability of RSF3 Dam as a result of rising phreatic surface drainage zone. - Blockage of Megaflow drain due to build up sediments.	- Inclusion of drain within the filter blanket between RSF1/2 and RSF3 clay liner - Install piezometers in the foundation and embankemnt.	E- Catastrophic	2 - Unlikely	Significant	- Ongoing monitoring of RSF3 embankment piezometers during operation.	GHD	During Opertation	Ongoing	E- Catastrophic	1 - Very Unlikely	Moderate	GHD/TGO

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating C	L	RR	Potential Control Measures (Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating C	L	RR	Comments
R011	Operation	Intense rainfall in the early stages of operation	- Erosion of clay liner materials leads to breach of liner.	- Cover layer of clay liner to protect from erosion in areas where water will concentrate.	C- Severe	2 - Unlikely	Low	- Ongoing inspections of RSF to identify eroded areas. - Remediation of clay liner as required after intense rainfall events.	GHD	During Operation	Ongoing	C- Severe	1 - Very Unlikely	Low	TGO
R012	Operation	Poor tailings management practices	- Target tailings densities are not achieved resulting in RSF filling quicker than anticipated. -Reduced freeboard and flood storage leading to increased risk of uncontrolled spill.	- Tailings management to be addressed as part of design documentation. - Regular reviews of tailings management during periodic inspections. - Ongoing review of design flood storage allowance.	D - Critical	2 - Unlikely	Moderate	- Future CPTu testing and analysis to validate design assumptions and guide design of future raises. - Ongoing review of design flood storage allowance.	GHD	During Operation	Ongoing	D - Critical	1 - Very Unlikely	Moderate	TGO
R013	Operation	Decant structural failure	- Loss of tailings into decant resulting in minor contamination downstream - Blockage of decant due to tailings or structure, reduces decant capacity.	- Structural design for maximum expected tailings depth.	C- Severe	2 - Unlikely	Low	- Construct new decant in later stages	GHD	During Operation	Ongoing	C- Severe	1 - Very Unlikely	Low	TGO
R014	Operation	Water loading on embankment	- Instability of embankment in the direction towards the storage.	- Tailings managemet plan to ensure water is enclised within the tailings beach at all times.	D - Critical	2 - Unlikely	Moderate	- Ongoing inspections of RSF embankments to identify signs of distress.	GHD	During Operation	Ongoing	D - Critical	1 - Very Unlikely	Moderate	TGO
R015	Operation	High decant pond levels	- Potential for piping failure of RSF embankment due to increased hydraulic gradients. - Inadequate embankment stability as a result of high pond.	Regular reviews of piezometer data to validate assumptions made in determining phreatic surface in stability models. - Instrumentation (i.e. piezometers) -Tailings management plan to address water management	E- Catastrophic	2 - Unlikely	Significant	- Ongoing review of design flood storage allowance. - Undertake regular routine and intermediate surveillance inspections during operation. .	GHD	During Operation	Ongoing	E- Catastrophic	1 - Very Unlikely	Moderate	GHD/TGO
R016	Operation	Severe earthquake	-Foundation liquefaction or cyclic softening. - Loss of strength of embankment material. - Deformation or failure of embankment leads to loss of tailings/decant water.	- Stability modelling for post seismic to be undertaken during design stage.	E- Catastrophic	1 - Very Unlikely	Moderate	- Ongoing geotechnical assessment of embankment and foundation materials to verify design assumptions and guide future raise designs.	GHD	During Operation	Ongoing	E- Catastrophic	1 - Very Unlikely	Moderate	GHD/TGO
R017	Operation	RSF fills quicker than anticipated	- Production is greater than anticipated or tailings density is less than anticipated. - Raise schedule must be bought forward. - Production must be slowed or halted.	- Design based on TGO supplied production and forecasts and consolidated tailings density - Include provision in the design to commission RSF prior to RSF1/2 filling.	C- Severe	3 - Possible	Moderate	- Monitor RSF fill rate during operation. Tailings survey and density reconciliation. - Contingency for bringing forward future raises.	GHD	During Operation	Ongoing	C- Severe	2 - Unlikely	Low	GHD/TGO
R018	Operation	Extreme rainfall events	- Overtopping of RSF embankments leads to erosion and breach resulting in release of tailings to the receiving environment	RSF to be designed to accomdate the required design storm event.	D - Critical	2 - Unlikely	Moderate	- Regular inspections of decant to check it does not become blocked leading to reduced capacity.	TGO/GHD	During Operation	Ongoing	D - Critical	1 - Very Unlikely	Moderate	GHD/TGO

Design Ref	Design Life Cycle Stage (Select from Drop Down Box)	Hazards What could cause injury or ill health, damage to property or damage to the environment	Risk What could go wrong and what might happen as a result	Existing Control Measures	Initial Risk Rating C	L	RR	Potential Control Measures (Consider Hierarchy of Control - Elimination, Substitution, Isolation, Engineering Controls, Administrative Controls, PPE)	Responsibility	By When	Decision / Status	Residual Risk Rating C	L	RR	Comments
R019	Operation	Poor quality decant water	- Unable to release water resulting in build up of water inventory and reduced storage capacity increasing risk of flood overtopping. - Turbidity of water flowing through decant channel due to erosion in the channel.	- Existing water management controls have been acceptable.	B - Major	2 - Unlikely	Negligible	- Routine water quality monitoring as per Permit Requirements	TGO	During Operation	Ongoing	B - Major	1 - Very Unlikely	Negligible	TGO
R020	Operation	Tailings delivery and decant pipelines	- Failure of tailings delivery pipeline or decant pipeline results in erosion of embankment requiring remedial works.	- Ongoing inspections of tailings and decant pipelines	B - Major	1 - Very Unlikely	Negligible	- Ongoing inspections of tailings and decant pipelines	TGO	During Operation	Ongoing	B - Major	1 - Very Unlikely	Negligible	TGO
R021	Operation	Vehicle drives off crest road/ramps following construction	- Vehicle drives off crest road following construction	- Safety bunds proposed on either side of crest road and ramps. - Suitable speed limit implemented on crest road. - Crest width suitable for vehicles.	D - Critical	2 - Unlikely	Moderate	- TGO to review vehicle safety provisions on completion of construction to ensure they are adequate.	TGO	During Operation	Ongoing	D - Critical	1 - Very Unlikely	Moderate	TGO
R022	Disposal	Saturation levels are too low upon closure	- Leads to the potential for AMD and contamination to downstream environment.	- Appropriate tailings management so that the HST will be inundated on closure, whether it is planned or premature.	B - Major	2 - Unlikely	Negligible	- Instrumentation to monitor capping to ensure HST is suitably covered. - If required construct an additional low permeability cover layer using select clayey material. - If required, raise phreatic surface in areas with a long beach length. - Updating of closure plan where design changes	TGO	During Operation	Ongoing	B - Major	1 - Very Unlikely	Negligible	GHD/TGO

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