Geotechnical guideline for terminal and rehabilitated slopes

Extractive industry projects

September 2020

VICTORIA State Government | Jobs, Precincts and Regions

Disclaimer

The information presented in this publication is distributed by the State of Victoria as a source of information for applicants only. The State of Victoria makes no statements, representations or warranties about the accuracy, completeness or reliability of any of the information contained in this publication. The information in this publication is provided on the basis that all persons accessing the publication undertake responsibility for assessing the relevance and accuracy of its content. The State of Victoria its instrumentalities, employees, contractors and agents disclaim all responsibility and all liability which may arise from relying on any information in this publication, including without limitation, liability in negligence, for all expenses, losses, damages and costs that may be incurred as a result of the information being inaccurate or incomplete in any way and for any reason.

This guideline is authorised for publication by Earth Resources Regulation, Department of Jobs, Precincts and Regions, 1 Spring Street, Melbourne, Victoria.

Enquiries

All enquiries should be addressed to the Principal Geotechnical Engineer, Technical Services, Earth Resources Regulation, Department of Jobs, Precincts and Regions, 1 Spring Street, Melbourne, Victoria (email: TechnicalServices.err@ecodev.vic.gov.au)

CONTENTS

FIGURES

TABLES

Abbreviations

Abbreviation	Term
ASTM	American Society of Testing and Materials
DEDJTR	Department of Economic Development, Jobs, Transport and Resources (Vic.)
DJPR	Department of Jobs, Precincts and Regions (Vic.)
ERR	Earth Resources Regulation (the principal regulator of mines and quarries in Victoria)
FOS	Factor of Safety
POF	Probability of Failure
GCMP	Ground Control Management Plan
ISRM	International Society of Rock Mechanics
Minister	Minister for Resources (Vic.)
MRSDA	*Mineral Resources (Sustainable Development) Act 1990*
NA	Not Applicable
RPO	Recognised Professional Organisation
TARP	Trigger Action Response Plan
Work Plan Guideline	*Preparation of Work Plans and Work Plan Variations: Guideline for Extractive Industry Projects* (DEDJTR 2018)

1. Introduction

1.1 Purpose and scope of this guideline

The purpose of this guideline is to provide the extractive industry in the State of Victoria with clarity on the regulator's expectations on the geotechnical design of terminal and rehabilitated slopes in the submission of work plans or work plan variations. Design of embankments for slimes dams are covered under the Technical Guideline: Design and Management of Tailings Storage Facilities (DEDJTR, 2017).

Best practice slope management design has been adopted from similar guidelines published by other regulatory agencies within Australia and New Zealand. Aligned principles should also be applied to working operational faces that are regulated by WorkSafe Victoria. This guideline applies to applications for work plans or work plan variations for extractive industry projects.

This guideline must be read in conjunction with *Preparation of Work Plans and Work Plan Variations: Guideline for Extractive Industry Projects* (DEDJTR 2018) or any updated versions of this guideline, referred to subsequently in this document as the "Work Plan Guideline".

1.2 Legislative and administrative framework

One of the objectives of the *Mineral Resources (Sustainable Development) Act 1990* (Vic.) (MRSDA) is to ensure that risks posed to the environment, to members of the public, or to land, property or infrastructure by work being done under a licence or extractive industry work authority are identified and are eliminated or minimised as far as reasonably practicable.

Before stone can be extracted, a work authority must be granted, subject to a work plan[1] being approved under the MRSDA[2], and relevant planning permission. Approval processes under the MRSDA are administered by Earth Resources Regulation (ERR) within the Department of Jobs, Precincts and Regions (DJPR).[3]

Further information about work plans, work authorities and other related matters is available on the ERR website at http://earthresources.vic.gov.au/earth-resources-regulation.

WorkSafe Victoria and ERR have a Memorandum of Understanding, with related responsibilities in areas of quarry stability; fire prevention, mitigation and suppression; and explosives, including blasting. WorkSafe Victoria has responsibility for preventing workplace injuries, illnesses and fatalities by monitoring and enforcing compliance with Victoria's occupational health and safety laws and regulations.

---

[1]Quarries that are less than five hectares in area and less than five metres in depth, provided that no blasting or native vegetation clearance occurs, are exempt from the requirement to work to an approved work plan (section 77G of MRSDA) and are, consequently, outside the scope of these guidelines. Sometimes referred to as "code-of-practice quarries", such small quarries are instead required to comply with the *Code of Practice for Small Quarries* (DPI 2010), which is made under sections 89A through 89H of the MRSDA.

[2] Quarries that are less than one hectare in area and less than two metres in depth are exempt from work plan submissions under the MRSDA.

[3] Prior to 1 January 2019, Earth Resources Regulation was under the Department of Economic Development, Jobs, Transport and Resources.

1.3 Geotechnical aspects of an extractive industry operation

Geotechnical risks at an extractive industry site are defined as those risks associated with ground movements in and around the quarry. Ground movements may vary from minor to significant (such as subsidence or natural rebound) or catastrophic (such as batter collapse). Irrespective of the type of ground movements, it is possible for persons, the environment, land or property or infrastructure to be harmed. It is essential that the risks of harm arising from ground movements and erosion are minimised.

Geotechnical aspects of the excavation should be assessed and monitored throughout the life of the project. This should start in the planning and design phase, continue through the construction and operations phases, and extend to the decommissioning, rehabilitation, closure, monitoring, maintenance and relinquishment phase.

In particular, the design of safe, stable and sustainable terminal and rehabilitated slopes must take into consideration the intended post-closure end land use of the site. As such geotechnical designs of these slopes must be included in the work plan.

2. Work plan requirements

2.1 Preparing geotechnical information for a work plan

The framework involved for preparing geotechnical information for a work plan is described below.

1. **Preliminary assessment**—during the initial planning and design phase (prior to submission of the work plan) determine under what category the proposed terminal slopes fall as defined in Section 3.1
2. **Competent Person's letter**—For excavations where the terminal slopes are categorised as requiring a letter from a Competent Person, this letter setting out the reasons for their determination should be included with the work plan. The scope of the letter is described in Section 3.3 and an example is provided as Appendix A1.

   Geotechnical assessment—If it is an excavation where the total height of any of the terminal slopes is more than 15m, a full geotechnical assessment of the proposed project should be performed by a Competent Person during the initial planning and design phase (prior to submission of the work plan).
3. **Risk management plan** —The competent person's letter or geotechnical assessment informs the geotechnical aspects of the project's risk management plan, which is required to be included with the work plan. The key geotechnical requirements of the risk management plan is outlined in Section 3.8. The risk management plan should include an appropriate risk treatment plan, which sets out the processes by which the stability of slopes are monitored, the frequency at which geotechnical risks need to be reassessed, and the methods employed to control potential ground instability.
4. **Rehabilitation Plan –** the Geotechnical guideline should be read alongside any guidelines developed for preparing rehabilitation plans under Regulation 11 of MRSDEI Regs. Refer to Section 3.9 for further detail.

2.2 Work plan changes

There are two ways an authority holder can make changes to an operation, either through an 'administrative update' or a 'work plan variation'. An administrative update can take place if the changes result in no new risks, or residuals risks are low or medium and there are no planning permit changes required. Refer to the Work Plan Guideline for further detail on making changes to an existing work plan or operation.

Where changes to work plans (through the work plan variation process) impact on geotechnical aspects of the approved work, geotechnical assessments may be required to be included with the application. Examples of work plan variations (resulting in a significant increase in risk) that might require geotechnical assessments include, but are not limited to, the following:

- Change in depth or rock/soil type.
- Ground conditions are less favourable than the expected conditions.
- Where there is a change in the quarrying method, e.g. from dry extraction to wet extraction (dredging).
- A slope may exhibit movement that is larger or more extensive than designed for, due to crest loading from proposed/new infrastructure such as a waste dump, building or containment structure.
- The terminal slope geometry changes, including overall slope angle, berm width, or bench height.
- Where rehabilitation will not be undertaken immediately after extraction.
- Where there is a change in the intended end use of the site approved in the work plan.

3. Work plan geotechnical assessment

3.1 Preliminary assessment

The purpose of the preliminary assessment is to determine the terminal and rehabilitated slope categories, and subsequent work plan documentation requirements as defined in Table 1. Note that the preliminary assessment does not require the involvement of a Competent Person (as defined in section 3.2).

Table 1: Documentation required for terminal and rehabilitated slopes

	Hard rock (buffer greater than 20m plus final depth of excavation)[1]	**Hard rock (buffer less than 20m plus final depth of excavation)**	**Soft rock - flatter than or equal to 1V:3H**[2]	**Soft rock – steeper than 1V:3H**
Total Height: >15m	Geotechnical Assessment	Geotechnical Assessment	Geotechnical Assessment	Geotechnical Assessment
Total Height: 5-15m	None, but requires public safety measures in rehabilitation plan	Competent Person's Letter	None[3]	Competent Person's Letter
Total Height: 0-5m	None	None	None	None

[1] Consideration of buffer between extraction limit and work authority boundary to remain intact. For 5m high slope, this would be a 25m buffer. For a 10m high slope, this would be a 30m wide buffer. For a 15m high slope this means a 35m buffer. This allows space for terminal slopes to be reprofiled if necessary, to achieve a safe and stable slope without impacting on the 20m minimum allowed buffer.

[2]The slope configuration of 1V:3H considered due to the fact that revegetation and maintenance of rehabilitation slopes are improved at such an angle.

[3] Where final landform is a lake or the site is considered as a floodplain quarry, a geotechnical assessment is required.

As a guide:

- **None -** Slopes where no competent person's letter or geotechnical assessment is required include those slopes where:
  - the quarry falls in the Code of Practice category, provided the quarry slopes are not located in close proximity to any sensitive receptors
  - hard rock or soft rock/soil slopes where the overall final slope height is no greater than 5m
  - hard rock slopes (5-15m) where the buffer distance between the extraction limit and the work authority boundary is greater than or equal to 20m plus final depth of excavation. Due to the public safety risk of falls over 5m, measures are required to protect public safety after rehabilitation with these sites.
  - soft rock slopes where the final terminal slope height is between 5m and 15m and the overall slope configuration is flatter than or equal to 1V:3H.

- **Competent Person's Letter -** Slopes where a competent person's letter is required, but no geotechnical assessment report is required (unless specified in the competent person's letter). These include slopes where:
  - hard rock slopes are between 5m and 15m in height and the buffer between the extraction limit and the work authority boundary is less than 20m plus the final depth of excavation.
  - soft rock slopes are between 5m and 15m in height. If the overall slope configuration is steeper than 1V:3H.

  In these cases the competent person also determines whether the slope design is safe, stable and sustainable in the long term (i.e. multi-generational) and the justification for no geotechnical assessment required needs to be provided in writing (see Appendix A1 as a guide).

- **Geotechnical Assessment -** Slopes where a geotechnical assessment report is required (also refer to Section 3.2.4 for Acceptance Criteria to be considered in the geotechnical assessment report), include slopes where:
  - soft rock slopes are more than 15m in overall depth (regardless of whether the overall slope configuration is steeper or flatter than or equal to 1V:3H).
  - hard rock slopes where the overall depth is more than 15m (regardless of the buffer).

3.2 Who can prepare a 'Competent Person's Letter' or a 'Geotechnical Assessment'?

'Competent Person's Letters' and 'Geotechnical Assessments' must be prepared by a "Competent Person", defined as a qualified geotechnical engineer able to competently and professionally undertake the task.

A Competent Person must be either a full member or fellow of a recognised professional organisation (RPO), such as AusIMM or Engineers Australia.

Geotechnical assessments forms part of the overall geotechnical engineering required for a quarry design. Appropriate experience and competency are required due to potentially complex geotechnical issues which may arise during the life of the quarry.

3.3 Competent Person's Letter

Where the terminal slope is categorised to include a Competent Person's letter, the Competent Person conducting the assessment should prepare a letter, for inclusion in the work plan, which should contain the following:

- Preliminary assessment confirming whether the site is categorised as:
    - None – in which case no further work is required
    - Competent Person's Letter - where a site specific Ground Control Management Plan is recommended; or
    - Geotechnical Assessment - which require further geotechnical assessment.
- A summary of the available data and expertise used in the assessment.
- A record of the site inspection log, including photographic evidence of observations.
- A preliminary slope stability analysis using the available data.
- Whether the design acceptance criteria are appropriate for the intended end land use.
- A determination of geotechnical risk of terminal slope design
- A determination of geotechnical risk of rehabilitated slope design
- The reasons for the determination of level of geotechnical risk for terminal slopes.
- The reasons for the determination of level of geotechnical risk for rehabilitated slopes.
- Geotechnical considerations and recommendations for the rehabilitation plan (e.g. decommissioning, stabilisation, rehabilitation, monitoring, maintenance surface water control).

An example assessment letter is provided as Appendix A1, while an example of a geotechnical checklist to assist the preliminary geotechnical assessment, is provided in Appendix A2.

3.4 Geotechnical Assessment

Geotechnical assessments are iterative, where the operation's understanding of ground stability is progressively informed by the information collected over the life of the operation, starting at the planning phase for the operation.

The purpose of a geotechnical assessment is to inform the quarry planning and risk assessment processes. The assessment also informs development of the GCMP and rehabilitation plan. The scope of the geotechnical assessments for work plan and work plan variation submissions are restricted to the design of terminal and rehabilitated slopes.

An assessment considers the issues listed in Table 2, where applicable, based on the available information, which is sourced from some or all of the following activities:

Table 2: Key issues for consideration in a geotechnical assessment (adapted from source: DPE(NSW) 2018)

Issue	Considerations
Slope status	Terminal or rehabilitated
Slope geometry	Overall slope height, overall slope angle, batter angle, bench height, berm width
Engineering characteristics	Rock or soil, structurally controlled, alteration materials present, material strength, discontinuity shear strength
Proximity of existing infrastructure	Property or services adjacent to crest or toe of slope, located externally or on site
Surcharge loading	Top-loading of slope by e.g. Stockpile, dumps or dams.
Proximity of dams, dumps and voids	Potential for adjacent structures to be impacted by slope failure, or potential for the excavation to be impacted by a dam failure or dump wall failure

Proximity of general public	Proximity of public access, roads, footpaths, walkways
History of failure	History of instability, rock falls, unexpected slope movement
Slope condition	Active failure (visible signs of failure: rockfalls, bulging, tension cracks), stabilised, stable
Failure mechanism	Planar, wedge, toppling, rotational, liquefaction, toe bulge, crest damage, complex
Size of failure	Minor, significant (requires stabilisation), major (impacts on sensitive receptors)
Speed of failure	Rapid (flows, rockfall), slow (rotational), very slow (rotational)
Design acceptance criteria	Acceptability of failure based on consequence or probability of failure and the inherent uncertainty of the design data
Surface water	Control of surface water and detrimental effects on slope stability (e.g erosion)
Groundwater	Visible signs of seepage or discharge, pore pressures
Frequency and size of rockfall	The size of the rockfall and ejection distance
Blast impacts	Blast performance and the damage induced into the rock mass (back break, crest damage)
Dispersive soils and clays	Soils rapidly erode due to water
Time	Effect of time on engineering characteristics of the soil and rock mass and degradation of ground support, and factor of safety over the life of the slope
Existing remedial measures	Reorientation, regrading, dewatering, buttresses, trenches, reprofiling, exclusion zones
Monitoring	Extensometers, piezometers, closure meters, EDM targets, radar, UAV, pin and prism survey, etc.
Seismic history	Whether the region is seismically active or subject to significant crustal stress
Land end uses	End-use considerations on design acceptance criteria, terminal and rehabilitated slope designs, slope monitoring, and slope stabilisation

3.5 Design Acceptance Criteria selection

Quarry slopes should be stable for the operational life of the quarry and through the rehabilitation and closure stages of the site. In an open pit, the Design Acceptance Criteria (Factor of Safety and Probability of Failure) includes consideration of:

- available data and its reliability
- regulatory, stakeholder and industry acceptance criteria for the pit slopes, and
- design based on conventional engineering methodologies and criteria.

The design of quarry slopes can sometimes be difficult due to the uncertainties in the geological data, uncertainty in geotechnical parameters and geotechnical model assessment uncertainty. Having a good understanding of how these factors may impact on any slope instability is critical for the work authority holder in developing a robust slope stability management system specific for the site.

Natural materials such as rock and soil in geotechnical and rock engineering projects need to be considered in the design due to the following aspects:

- The materials characteristics are variable and may not be well understood since site investigations comprising drilling, mapping and testing only sample very small portions of the material.
- Strength characteristics of known intact materials have variability in compression, tension and shearing. Strengths can vary significantly within a site.
- The intact materials are separated by geological structures which have variable:
    - strength and stiffness properties.
    - location and orientation.
    - occurrence as it is currently impossible to discretely model and understand each, individual geological structure both from a site investigation and modelling point-of-view.
    - complex influences from groundwater and other external factors such as in-situ stresses and environmental effects (e.g. rainfall, freeze-thaw, seismicity).
    - time dependence of material characteristics (e.g. strength loss due to exposure following extraction).

Slope design is essentially governed by two factors: the consequence of failure and the degree of inherent uncertainty/sensitivity as listed above. It is usual practice within the quarry industry to apply a factor of safety (FOS) to the slope design geometry. Even with an appropriate Factor of Safety, all designs have a “probability of failure”. Probabilistic geotechnical analysis involves using tools that attempt to quantify this risk using a statistical approach. This method is called the Probability of Failure (POF) method and the benefits of applying this method include the following:

- POF output can be used as an input into economic optimization of the slope.
- Probabilistic analysis is able to provide a more precise description of the slope design parameters.
- Probabilistic design allows for comparison of the strengths of several elements within the slope system and can accordingly indicate which element to improve.

Note. Applying both the FOS and POF methods are good practice and as such can be applied in the slope design process. Providing PoF values are not mandatory in the geotechnical assessment report.

When the consequence of failure or the level of uncertainty is high, the design criteria should be altered accordingly, resulting in a more conservative design.

The FOS and POF values in 3 are indicative of accepted industry practice but should always be adjusted to account for local conditions, confidence level in the geotechnical model and the owner’s risk acceptance policy. The person undertaking the slope design should ensure that the FOS and POF values used are verified against local ground conditions, the potential modes of failure, the amount and quality of information available, and the likely worst-case outcome. For example, more conservative criteria should be adopted at sites that have:

- limited geotechnical information (e.g. greenfield site)
- limited testing of rock mass properties (unrepresentative values)

- limited knowledge on ground control management
- unverified failure mechanisms
- limited ability (financially or otherwise) to suitably manage ground movements
- potential for sudden falls of ground causing harm to sensitive receptors
- significantly variable ground conditions
- important infrastructure in close proximity.

As the potential negative impact of using assumed values can be significant, sensitivity analyses should be conducted to determine the effect of uncertainty for both the design assumptions being used and the various geotechnical design methods being used.

The basis for adopting any design method, strategy, and design acceptance criteria must be justified and documented in the assessment report. All assumptions must also be documented. Similarly, a higher FOS or lower POF should be used if the samples used for engineering property testing are not representative of the rock mass.

For further guidance on determining an acceptable FOS and POF values, refer to Read & Stacey (2009).

Table 3: Example of acceptance criteria for slope stability analysis of terminal and rehabilitated slopes (adapted from Read & Stacey 2009)

Consequence of failure impacting on public safety, infrastructure, environment, land or property	Acceptable (Mean) FOS	Acceptable Minimum PoF
Not serious	1.3	10%
Moderately serious	1.6	1%
Very serious	2.0	0.5%

3.6 Upper slope configuration for rehabilitated slopes

To protect public safety post closure, where steep slopes remain after rehabilitation, treatment and management of the upper slopes is likely to be required. This treatment of needs to consider the following criteria:

- Rehabilitation of the site in a manner that guarantees the long term safety, stability and sustainability of the area, especially reducing the risk to public safety posed by large heights.
- Minimising the area of disturbance.
- Designing the batters within the overburden and highly weathered material to minimise erosion and enhance rehabilitation opportunities both during operation and post closure.
- Minimising impacts generated by the operation during the life of operation as well as post closure, and
- Progressively rehabilitating disturbed areas.

Figure 1 is an example of upper slope treatment within overburden and highly weathered material.

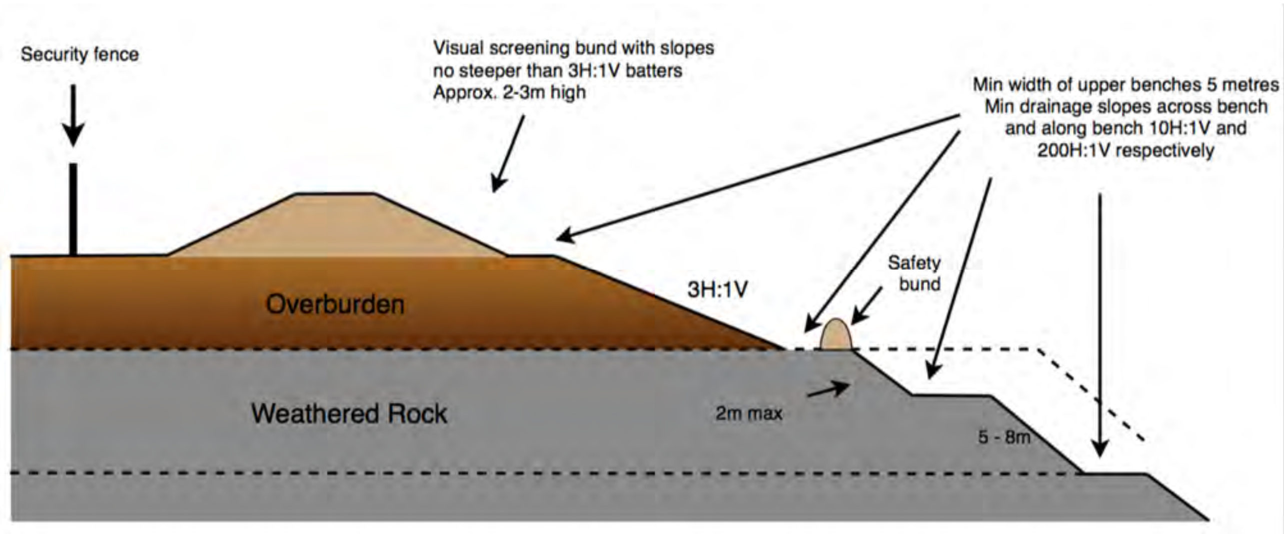

Figure 1: Example of upper slope treatment within overburden and highly weathered material

3.7 Geotechnical Risk Assessment

Geotechnical risk assessment is informed by the geotechnical assessments, described in sections 3.1-3.4. The assessment of geotechnical risks follows the process set out in Appendix A of the Work Plan Guideline (DEDJTR 2018), which is summarised in Figure 2.

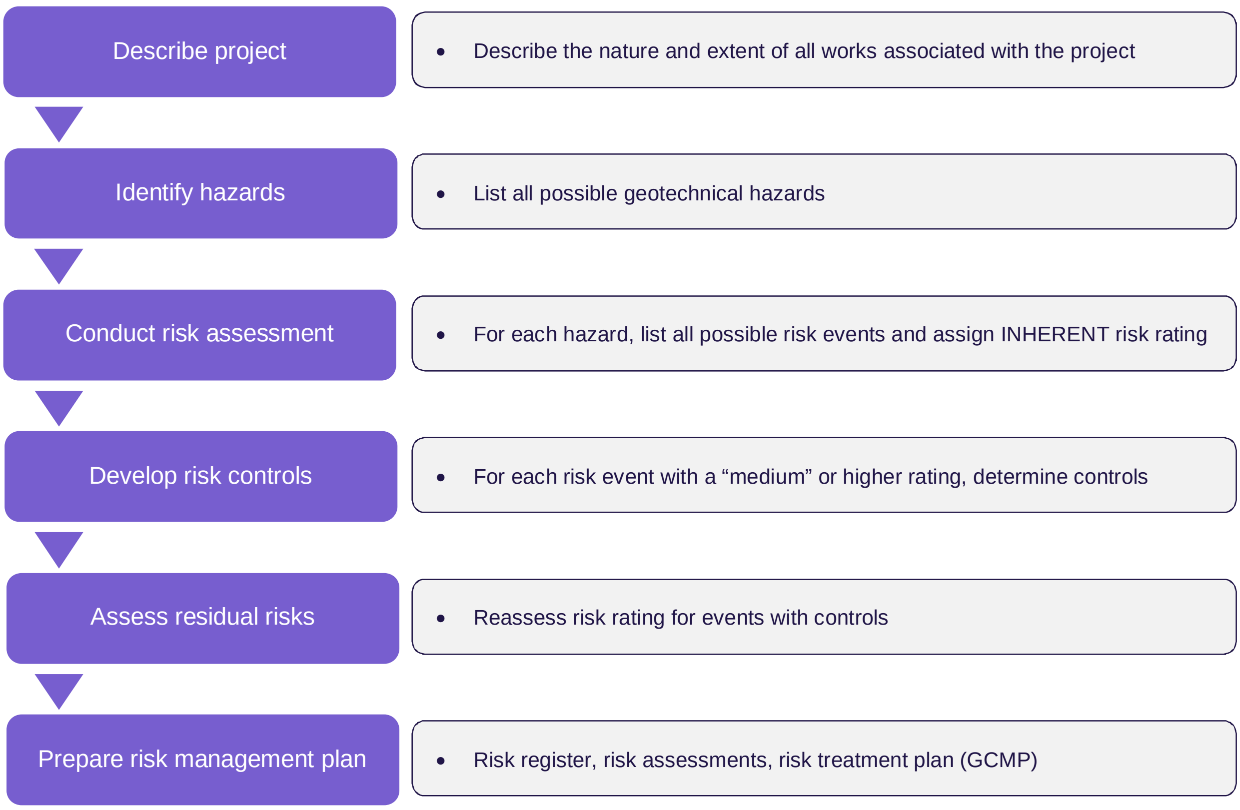

Figure 2: Risk assessment process overview (source: DEDJTR 2018)

The hazards, consequences of failure, and potential control measures during the operations phase are likely to be different to the post-closure phase. Consequently, separate geotechnical risk assessments should be conducted for each phase of the project.

3.8 Risk Management Plan

A work plan is required to include a ‘risk management plan’ consisting of a risk register and risk treatment plan(s). The risk management plan should demonstrate that the control measure(s) are able to reduce the likelihood(s) and/or consequence(s) such that the residual risk is minimised as far as reasonably practicable. A ‘risk treatment plan template’ is provided in the Work Plan Guideline that can be used for providing details of geotechnical risks.

For sites requiring a ‘Competent Persons Letter’ or a ‘Geotechnical Assessment’, the information in theses assessments can be used for completing the risk treatment plan.

For sites that don’t require a ‘Competent Persons Letter’ or a ‘Geotechnical Assessment’, the risk treatment plan is covered in the risk assessment within the Work Plan. Refer to the Work Plan Guideline.

The controls to be developed and documented within the ‘risk treatment plan’ need to reflect acceptable industry practice for the geotechnical hazards. Where necessary, additional controls may be required to minimize the risk rating as far as reasonably practicable.

3.9 Rehabilitation Plan

Work plans must include rehabilitation plans (Schedule 1 of MRSDEI Regs). If the plans are not sufficient, conditions can be imposed (section 77J of the MRSDA) to ensure that at closure the site is left in a safe, stable and sustainable condition. Planning for closure, and what rehabilitation should be undertaken at what stage, is a critical component of managing stability for an extractive industry project including design of the rehabilitated slopes and providing suitable factors of safety (refer to table 3). The Geotechnical guideline should be read alongside any guidelines developed for preparing rehabilitation plans under Regulation 11 of MRSDEI Regs.

References

DEDJTR 2018, *Preparation of work plans and work plan variations: Guideline for extractive industry projects,* Department of Economic Development, Jobs, Transport and Resources (Vic.), December 2018, available <http://earthresources.vic.gov.au/earth-resources-regulation>, last viewed 31 May 2019.

Department of Mines (WA) 2018, *Ground control management in Western Australian mining operations: Guideline*, Department of Mines (WA), Industry Regulation and Safety, 100 Plain Street, East Perth WA 6004, available from SafetyComms@dmirs.wa.gov.au

DPE(NSW) 2018, *Health and safety at quarries: Good practice guidelines*, Department of Planning and Environment (NSW), NSW Resources Regulator, November 2018, available https://www.resourcesregulator.nsw.gov.au/safety-and-health/topics/small-mines-and-quarries , last viewed 31 May 2019.

DPI 2010, *Code of practice for small quarries*, Department of Primary Industries (Vic.), Earth Resources Regulation, 2010, available https://earthresources.vic.gov.au/legislation-and-regulations/guidelines-and-codes-of-practice/code-of-practice-for-small-quarries

DJPR 2019, *Rehabilitation plans and other environmental aspects of work plans*, Department of Jobs, Precincts and Regions (Vic.), Earth Resources Regulation, available https://earthresources.vic.gov.au/legislation-and-regulations/guidelines-and-codes-of-practice/rehabilitation-plans

Read, J & Stacey, R 2009, *Guideline for Open Pit Slope Design*, CRC Press, https://www.crcpress.com

Commissioner for Better Regulation 2017, *Getting the Groundwork Right – Better regulation of mines and quarries.*, available https://earthresources.vic.gov.au/__data/assets/pdf_file/0009/456246/Getting-the-groundwork-right-better-regulation-of-mines-and-quarries.pdf

WorkSafe (New Zealand) 2015, *Health and Safety at Opencast Mines, Alluvial Mines and Quarries*, available https://worksafe.govt.nz/topic-and-industry/extractives/guidance-position-statements/health-and-safety-at-opencast-mines-alluvial-mines-and-quarries/

Bar, N & Heweston, A. 2018, *Considerations for Effectively Using Probability of Failure as a Means of Slope Design Appraisal for Homogeneous and Heterogeneous Rock Masses.* World Academy of Science, Engineering and Technology International Journal of Geological and Environmental Engineering Vol:12, No:2, 2018

Kanji, M.A 2014 *Critical issues in soft rocks.* Journal of Rock Mechanics and Geotechnical Engineering 6 (2014) 186 -195

Glossary

Derived from DEDJTR (2018) and DPE(NSW) (2018).

Term	Description
Closure	A life-of-operation process which ultimately can culminate in relinquishment. It broadly includes planning, decommissioning, rehabilitation, monitoring and maintenance.
Competent Person (geotechnical)	A suitably qualified and experienced geotechnical professional as defined in Section 3.2.
End of quarry life	The date at which production is proposed to cease under the currently approved work plan.
Extractive industry	Any activity involving the extraction or removal of stone from land for sale or commercial use in construction, building, road or manufacturing works.
Ground Control Management Plan (GCMP)	A framework for the management of geotechnical hazards.
Hard rock	Hard rock are those rock with an uniaxial compressive strength of more than 25MPa and therefore has a greater ability to withstand stress/loading. Typical hard rock are: Igneous/volcanic rocks such as granite, gabbro, rhyolite , basalt , pegmatite , syenite , diorite , dolerite. Metamorphic rock such as quartzite, hornfels, amphibolite and sedimentary rocks such as sandstone.
Quarry	(a) A pit or excavation made below the natural surface for the purpose of extracting or removing stone if a primary purpose of the extraction or removal is the sale or commercial use of the stone or the use of the stone in construction, building, road or manufacturing works. (b) Any place or operation involving the removal of stone from land, declared by the Minister by notice published in the Government Gazette to be a quarry, and includes access ways on private land and the works, machinery, plant, equipment, buildings and structures above or below ground used for or in connection with making, enlarging or deepening the pit or excavation; or carrying on the operation; or the extraction or removal of stone from the pit or excavation; or the treatment on or adjacent to the land in which the pit or excavation is made of stone extracted or removed from the land or the manufacture on or adjacent to that land of bricks, tiles, pottery or cement products substantially from stone so extracted or removed.
Quarry hazard	Any quarrying activity and circumstance that may pose a risk to the environment, to any member of the public or to land, property or infrastructure in the vicinity of work carried out at a quarry.

Term	Description
Reasonably practicable	“As far as reasonably practicable” under MRSDA section 77G(3)(c) and Regulations Schedule 1, Part 1, 4.1(a) based on the approach to precaution-based risk analysis under the Occupational Health and Safety Act 2004. Under section 20(2) of the Occupational Health and Safety Act 2004, reasonably practicable means: that which is, or was at a particular time, reasonably able to be done to ensure health and safety, taking into account and weighing up all relevant matters including: the likelihood of the hazard or the risk concerned eventuating the degree of harm that would result if the hazard or risk eventuated what the person concerned knows, or ought reasonably to know, about the hazard or risk, and any ways of eliminating or reducing the hazard or risk the availability and suitability of ways to eliminate or reduce the hazard or risk the cost of eliminating or reducing the hazard or risk.
Regulations	Mineral Resources (Sustainable Development) (Extractive Industries) Regulations 2019 (MRSDEI Regs)
Rehabilitated slope	A slope that has been returned to a safe, stable and sustainable condition in accordance with the rehabilitation plan approved for the work authority.
Rehabilitation	Rehabilitation – the return of disturbed land to a safe, stable, and sustainable condition to an agreed end use. It broadly involves landform design, construction and shaping; materials characterisation, handling and placement; surface water management and revegetation.
Risk management plan	Schedule 1 of the Mineral Resources (Sustainable Development) (Extractive Industries) Regulations 2010 (as revised) states that a risk management plan is required in a work plan for a quarry. The risk management plan consists of a risk treatment plan for each quarrying hazard that is identified and a risk register.
Risk register	A risk register is a summary table of the risks identified for the hazards and includes the inherent and residual risk ratings. It is a component of the risk management plan.
Risk treatment plan	A risk treatment plan addresses the risks associated with one of the quarrying hazards identified. It specifies the control measures to eliminate or minimise, as far as reasonably practicable, the identified risks associated with the particular hazard, the objectives, intermediates or acceptance criteria for those control measures, the monitoring program that will measure performance against all the specified objectives, intermediates and acceptance criteria, the arrangements for reporting on performance against all the specified objectives, intermediates and acceptance criteria, risk treatment plans for each of the identified quarrying hazards and a risk register form the risk management plan.

Term	Description
Recognised Professional Organisation (RPO)	An RPO is a self-regulatory organisation covering professionals in the mining or extractive industries, which admits members primarily on the basis of their academic qualifications and professional experience, and require compliance with the professional intermediates of competence, code of conduct and ethics established by the organisation anywhere in the world, and have disciplinary powers, including the power to suspend or expel a member for breaches of professional intermediates of competence or ethics. RPOs include but are not limited to the Australasian Institute of Mining and Metallurgy and Engineers Australia
Sensitive receptor	Sensitive receptors are people or other organisms that may have an increased sensitivity or exposure to an emission by virtue of their age and health (e.g. schools, day care centres, hospitals, nursing homes), status (e.g. sensitive or endangered species), proximity to the contamination, dwelling construction, or the facilities they use (e.g. water supply). For the purposes of a work plan the sensitive receptors are described in relation to the environment, any member of the public, or land, property or infrastructure in the vicinity of the proposed work.
Soft rock	Several authors have classified intact rocks according to their strength in different scales and terms. However, there is a practical coincidence that the upper limit of the strength of what is considered soft is about 25 MPa as unconfined compressive strength (UCS). Typical soft rock includes: • Sedimentary rocks such as mudstones, shales, siltsones, s, conglomerates and beccias, and marl, salt rock, carnallite, limestone, dolomite, and gypsum and coal. • Igneous rocks such as volcanic conglomerates, breccias, and lahar, basaltic breccia, pyroclastic deposits, volcanic ash, tuff and ignimbrite and weathering products of crystalline rocks • Metamorphic rocks such as slate, phyllite, schists, metavolcanic deposits. Soft rock also include sand and gravel.
Stone	Sandstone, freestone or other building stone; or basalt, granite, limestone or rock of any kind ordinarily used for building, manufacturing or construction purposes; or quartz (other than quartz crystals); or slate or gravel; or clay (other than fine clay, bentonite or kaolin); or peat; or sand, earth or soil; or other similar materials.
Terminal slope	The final (as-designed or as-built) operational pit slope.
Work Authority (WA)	A work authority relating to an extractive industry granted under MRSDA section 77I.

Term	Description
Work plan	The work plan is the primary document describing the permitted activities to be undertaken on a work authority. It is intended to provide guidance to operations staff at the quarry as well as informing other interested parties such as council or government officers in order to facilitate decisions, approvals, compliance, and enforcement functions. It must be clear, concise and contain sufficient detail to enable a reader to understand the activities proposed to be undertaken at the site, their potential risks and impacts, and the control or management actions required.

Appendices

A1. Example Competent Person’s letter

[Date]

[Name]
[Position Title]
[Company]
[Address]

Dear [Name]

Re: Preliminary geotechnical assessment of [Site Name]

[This letter report should be kept as brief as possible. Its purpose is to assure ERR that geotechnical issues have been reviewed by a competent person and that the geotechnical risk is low./medium The letter accompanies the work plan, and so it can rely on more detailed descriptions provided there, such as the project description and intended end use.]

1. INTRODUCTION

[Consultant] was engaged by [Company] to undertake a preliminary geotechnical assessment of the stability of the proposed slope design at [Site Name] near [Town], Victoria. The scope of the assessment was to:

- conduct a site inspection
- conduct a desktop review of available geotechnical information
- make a preliminary risk assessment of slope stability in accordance with the ERR risk rating matrix
- determine if the proposed excavation is “intermediate” or “complex” as defined by the Victorian Geotechnical Guideline for Extractive Industries[4].

2. COMPETENT PERSON’S STATEMENT (Below is an example only – refer to Section 3.2)

The information presented in this letter is based on information compiled by [Name] of [Consultant]. [Name] is registered to practice as a geotechnical engineer in the State of Victoria, is a Member of the Australasian Institute of Mining and Metallurgy (AusIMM), and is

[4] Add documentary note to the published geotechnical guideline.

accredited by the AusIMM as a Chartered Professional (CP) in the discipline of Geotechnical Engineering.

3. PROJECT DESCRIPTION

[Briefly describe the location, deposit type, current land use, size of operation, and intended end land use. Refer reader to more detailed descriptions in work plan]

4. SITE INSPECTION

An inspection of the site was undertaken by [Name] on [Date]. The site area contains several granite outcrops. The outcrops are shown on the aerial photograph in Figure X. The site inspection log is provided at attachment B and includes a detailed photographic record of outcrops and other geographical features.

[Provide summaries of the following, as appropriate:

- *Aerial photograph and site map*
- *Outcrop description with selected photographs*
- *Structural mapping and stereonets]*

5. DESKTOP STUDY

An initial literature review was undertaken; covering the geology, geomorphology, landslide hazards, plus the location and examination of relevant borehole and report data that was publicly available.

[Provide summaries of relevant data considered in the study, as appropriate:

- *Local infrastructure, water courses, dams*
- *Geology data*
- *Geomorphology data*
- *Landslide data*
- Drill core data
- *Bore data]*

6. PRELIMINARY GEOTECHNICAL RISK ASSESSMENT

[Provide brief descriptions of the following, as appropriate:

- *Terminal slope designs*
- *Rehabilitated landform designs*
- *Preliminary slope stability assessment*
- *Suitability of design acceptance criteria*
- *Closure considerations]*

7. CONCLUSIONS AND RECOMMENDATIONS

The main conclusions from the site investigation, desktop study and preliminary slope stability analysis are:

[Example only, adapt to suit actual site]

- Subsoil and weathered rock exposures are expected to be stable at the design batter angle of X°.
- Structural domains (for terminal and rehabilitated slopes) in the unweathered rock mass are not conducive to toppling or wedge failures and the design overall slope angle of Y° is expected to be stable.
- The intact, unweathered rock strength is very high.
- There is no evidence of structurally significant folding, shearing or fault displacement in the site area.
- Historical seismic activity in the area is low.
- The design acceptance criterion used in the slope design is appropriate for the intended end use.

The following recommendations are made concerning the GCMP and closure planning:

- Visual monitoring of the working and rehabilitated slopes should be at a four-week interval and continue for at least six months after closure.
- Measures should be taken during operations to prevent blast damage to terminal faces.
- Measure should be taken post closure to stabilise rehabilitated faces and manage surface water flows.

8. DETERMINATION

[Name] of [Consultant], as a Competent Person for the purpose of geotechnical assessments, considers that the risk of instability of terminal and rehabilitated slopes at the [Site] project is “low/medium”, as defined by the ERR risk rating matrix. The proposed excavation is therefore deemed “simple”, as defined by the Victorian Geotechnical Guideline for Extractive Industries.

Yours sincerely

[Name] BEng Melb, MAusIMM CP(Geotech - Mining)

Senior Geotechnical Engineer

[Consultant]

A2. Example geotechnical inspection checklist

Name	
Date	
Location	
Description	Notes
Operation	□ Active □ Inactive □ Drill-and-blast □ Loader/Excavator/Truck □ Hydromining/sluicing □ In-pit conveyor Years in operation: Expected year of closure:
Slope geometry	□ Maximum overall slope height and angle □ Maximum bench height and batter angle
Engineering characteristics	□ Weakly cemented gravel or sand □ Soil or highly weathered or friable rock □ Fresh rock or well-cemented gravel
Existing infrastructure	Property or services adjacent to both crest and toe of slope, both external and located on site
Dumps and dams	Proximity of waste dumps, slimes dams, and settling dams
Water courses and bodies of water	Proximity of natural and manmade water courses and bodies of water.
Proximity of workers	Vulnerability, location relative to potential failure
Proximity of general public	Proximity of public access, roads, footpaths, walkways and so on
Visible or recorded failure mechanisms	□ Planar □ Ravelling □ Wedge □ Circular (toe bulge) □ Step-path □ Circular (face slip) □ Toppling □ Rubble at toe □ Liquefaction □ Tension cracks
History of failure	□ Rapid (flows, rockfall) □ Slow (rotational) Size of rockfall: Roll-out distance:
Description	Notes
Water (surface water and groundwater)	□ Visible signs of seepage or discharge □ Pore pressures behind high walls □ Surface water management installed (describe)

Blast impacts	Blast performance and the damage induced into the rock mass (i.e. back break, crest damage):
Dispersive soils and clays	□ Eroded
Remedial measures (comment on effectiveness)	□ Regraded slopes □ Dewatered □ Reprofiled berms □ Bunding/Buttresses □ Exclusion zones
Monitoring	□ Extensometers □ Piezometers □ EDM □ Radar □ UAV
Seismic history (comment on history)	□ Seismically active □ No recorded activity
Other factors (comment)	

B1. Ground control management plan

The GCMP is a tool for stability management, which documents the history and evolution of the geotechnical aspects of the quarry, describes the geotechnical setting, and explains the way in which ground-related hazards are managed. The GCMP should be a single, living and logical document. Importantly, it should be easy-to-follow by anyone who needs to understand the factors influencing geotechnical risk at the site and how the risk is to be managed over the life of the quarry. The GCMP encompasses identification, assessment and control of operational slopes, post-closure hazards, and the design and rehabilitation of terminal slopes and dumps in sympathy with the intended end uses.

Note. The GCMP may not form part of the work plan, but may be relied upon to inform ERR and WorkSafe Victoria how the operator intends to reduce risks of both working and terminal slopes to as low as reasonably practicable.

Examples of information that might be included in a GCMP, depending on the nature and complexity of the site, are provided in this section. An example table of contents is provided as Appendix 1. The level of detail provided in the GCMP should be appropriate for the scale and complexity of the operation and potential consequences of ineffective or inadequate ground control. For example, a large, complex stone quarry requires a more detailed GCMP than a shallow, simple sand pit.

The following matters should be considered when developing the GCMP:

- Frequency of geotechnical assessments
- Frequency of geotechnical risk assessments
- Local geological structure, hydrogeological environment, effect of water and time on slope stability
- Dumps, stockpiles and emplacement areas, fill materials and filling requirements
- Proximity of dumps, dams and voids to the excavation
- Proximity of major infrastructure to the excavation
- The intended end uses of the land and its impact on slope design and rehabilitation
- Suitable slope stabilisation, repair and support methods, including appropriate design criteria
- Appropriate equipment and procedures for monitoring, recording, and analysing seismic activity
- Appropriate equipment and procedures for monitoring, recording, and analysing wall movement
- Collection, analysis and interpretation of relevant geotechnical data
- Use of appropriate equipment and procedures for scaling
- Continual reviews and verification of controls to ensure that the plan is controlling the hazard.

The GCMP should be reviewed to validate the data and strategies involved with the issues listed above. The frequency of reviews should be stated on the document control page of the plan. The GCMP should also be reviewed:

- After unexpected ground movement events
- Before proposed changes are made to quarry planning and design strategies
- After changes are noted in ground conditions or local geology
- When new risk management methods are implemented.

The GCMP may contain some or all of the elements listed in

Table , depending on its geotechnical complexity and geotechnical risk profile.

Table B1: Example of GCMP elements (sources: Department of Mines (WA) 2018; DPE(NSW) 2018)

Element	Description
Data sources	Slope design and stability analysis is informed by published literature; natural outcrops; existing local or neighbouring surface and underground excavations; drilling, chip drilling logs and geotechnical samples; trial pits and costeans; geophysical, geochemical and seismic surveys; pump and field tests.
Geological and structural models	The importance of the geological environment and geological structure and its potential for adverse influence on rock stability cannot be over-emphasised. Geological influences on ground stability typically include geological structure (joints, shears, bedding, etc.), lithology, weathering and erodibility. Development of a structural model is generally required to assist with developing a geotechnical model. Conversely, some quarries (e.g. sand pits where ground movement is largely controlled by the strength of the ground mass, rather than being structurally controlled), will not require a structural model.
Hydrogeology model	The hydrogeological environment can significantly affect the stability of geotechnical infrastructure and safety of operations. The impact is greater in quarries where the expected failure mechanisms are more influenced by water pressure or where groundwater quality impacts on the integrity of any ground reinforcement being used to stabilise slopes. Competent persons should develop and maintain a hydrogeological database to help evaluate the characteristics of regional and local aquifer systems and thereby assist with determining factors such as zones of hydrological influence, the relationship between groundwater, lithology and geological structures, recharge mechanisms, groundwater abstraction (withdrawal), monitoring strategies, impacts on ground movement, groundwater corrosion of ground support, and the influence of water-filled voids.

Element	Description
Engineering properties and rock mass model	The extent to which ground is expected to move towards a quarry void primarily depends on the engineering properties of the ground mass under given stress/loading conditions. Examples of the potential range of ground movements include small scale elastic relaxation, plastic squeezing of the ground and brittle failure causing ground ejection. The competent person needs to understand the potential movement and failure mechanisms of the ground under the given loading conditions. Engineering properties are commonly derived by various tests on samples of ground; however, back analysis of ground movements is another reliable method when the correct failure mechanism is known. With respect to laboratory testing, published recognised testing procedures are readily available to determine relevant engineering properties (e.g. Intermediates Australia, ASTM, ISRM Suggested Methods).
Geotechnical model	The geotechnical model must be representative of the areas to be excavated and pertinent to the planning and design processes. Competent persons should undertake adequate research of available literature to establish which approach is best suited to their local conditions. They should understand the need to continuously improve the degree of confidence in the geotechnical model and thereby the terminal slopes.
Geotechnical domains	The data collated within the geotechnical model is typically used for direct input into engineering design methods and to divide the ground mass into groups or domains of similar attributes and expected behaviour. Examples of geotechnical domains include weathering zones, lithology, zones affected by groundwater or water pressure, and ground classification (e.g. SMR, Q -Slope, Global slope performance index). Geotechnical domaining helps to identify specific areas of the quarry that may require specific attention or modification to a intermediate design. The procedure used for data collection and analysis for interpretation of domains should form part of the GCMP.
Incident register	A permanent record of all slope failures and observations shall be maintained to assist competent persons with site inspections and formal assessments.
Surface-related issues	Databases on topography, water courses and standing bodies of water, rainfall and evaporation data, historical records of flooding, and ecologically sensitive areas are needed to develop and maintain the geotechnical model and as inputs into ground stability analyses.

Element	Description
Stability assessment	Before any excavation begins, a competent person shall undertake an assessment of the site ground conditions to determine all factors likely to affect the stability of the ground and the limitations that should be imposed on the excavation site design. This assessment shall be documented. The assessment shall be reviewed and revised when necessary after a material change has occurred in the ground conditions or the excavation methods. Effective ground control relies on geotechnical information obtained at different stages of the life of the site including planning and design, implementation of the design and day-to-day operations such as surveying, installation, maintenance and inspections.
Design acceptance criteria	The basis for adopting any design method, strategy, and design acceptance criteria needs to be formally justified and documented in the GCMP. Design acceptance criteria should be adopted that reflect the level of uncertainty and the perceived risks in each area of the operation. More conservative planning and design strategies need to be adopted at quarries with limited geotechnical information, limited knowledge of slope stability and ground control, highly variable ground conditions, important infrastructure in close proximity.
Planning and design	The quarry shall have a well-considered and practical quarry plan. Following assessment of ground conditions, a design shall be prepared setting out the measures to control ground instability. Where an existing design has already been proven, it may be used as the basis for the design of a new excavation if the ground conditions at both sites are not significantly different. This requires ongoing assessment of the ground conditions as incremental changes can occur over time, resulting in different ground conditions from those originally excavated. Slope designs shall be suitable for the ground conditions and, where necessary, include the design and implementation of ground support or reinforcement. The ongoing maintenance of supports and continuous monitoring for any indication of movement or potential for failure are also important components of a systematic approach.
Excavation control	Adequate excavation control and scaling of faces are critical elements in achieving and maintaining safe slopes. A structured program of inspections shall be put in place to check and verify that slopes are excavated to design. Where batters are excavated by free digging, it is critical that slopes are not undercut, resulting in instability and potential over topping failures. Adequate surface water runoff control measures shall be implemented to minimise water infiltration and batter degradation as necessary. In strong, unweathered ground, care must be taken to prevent over-digging where there is blast damage or fractured rock.

Element	Description
Scaling	Scaling of the batter crest and face following excavation is an important component of the implementation of the design. Scaling helps preserve the catch capacity of benches needed to retain loose rock material falling (rilling/ravelling) from above. In soils and weak and weathered rock, scaling is not generally required. Scaling from the bench above is normally done by chaining the face. Scaling from the bench below is generally performed by specialised units equipped with long booms holding small buckets or rock picks. The debris accumulated at the toe of the batter after scaling must be removed before access to the toe is lost. This will ensure adequate catchment volume on the safety bench is maintained. Supplementary bench cleaning will depend on whether access is maintained to the bench.
Slope movement monitoring	The collection, analysis and interpretation of relevant geotechnical data, including the monitoring of slopes, must be considered when developing control measures for the GCMP. The selection of the most appropriate technique depends on site-specific conditions and the characteristics of the feature to be monitored. Regardless of the technique used, if there is an adequate level of monitoring and a good understanding of the ground conditions, the onset of major slope failure can be detected in advance. The safety risks can then be managed to an acceptable intermediate.
Monitoring methods	A comprehensive monitoring system may include instruments capable of measuring rock mass displacement, ground water parameters and seismicity. When selecting monitoring instruments, incorporate some level of redundancy in the system to cross-check instrument performance and eliminate errors. Automated equipment is generally more accurate, provides added flexibility in the sampling rate, and can trigger alarms. Common monitoring methods include visual inspection (tension cracks, abnormal water flows, creep, and rubble at the toe), extensometers and crack monitoring, terrestrial geodetic surveys, GPS stations with prisms, radar, seismic monitoring, and groundwater pressure.
Instrumentation data	A detailed draft of monitoring and reporting procedures should be prepared during the planning phase and finalised after the instruments have been installed. It is extremely important that procedures specify what actions are to be taken if any collected data indicates a safety issue. A competent person should be responsible for collection of instrumentation data.
Dams, dumps and voids	Dumps, overburden storage areas, dams and voids should also be covered by a GCMP, particularly when they are large structures with a serious consequence of failure e.g. large overburden storage areas or tailings dams. To determine if dumps, dams or voids are hazards post-closure, consideration should be given to how a dump, dam or void might feasibly fail, the proximity to the excavation, the likely scale of the failure, and the potential to impact on sensitive receptors. Dumps and dams identified as hazards typically require a formal geotechnical assessment to develop effective remediation and monitoring programs.

B2. Example GCMP table of contents

Section	Notes
1. Introduction	Provide a general guide on the purpose of the document and how to use it. Comment on the structure or flow of the document. Note that the GCMP should contain or provide easy and accurate reference to all information relevant to its development and effective ground control.
2. Relevant documents	Provide a list of published documents (e.g. legislative, site-specific, corporate) that are relevant to the GCMP.
3. GCMP document control and review	Define the processes, strategies, scheduling and timing to be used and personnel responsible for maintaining the GCMP to ensure its currency at all stages of mining.
4. Responsibilities	List of persons and their titles responsible for ensuring all aspects of the GCMP are understood and are being implemented within accepted tolerance limits to an accepted intermediate.
5. Geological and geotechnical setting (geotechnical model)	Describe qualitatively and quantitatively the physical characteristics of the site that can have an impact on ground control. Describe methods to be used to collate and formally document relevant geotechnical data. Examples of the types of geotechnical data required to develop effective ground control include: • Terrain and geology • Geotechnical characteristics (e.g. unconfined compressive strength, uniaxial tensile strength, elastic modulus, Poisson's ratio, shear strength (including cohesive strength, friction angles), bulk density, plasticity, porosity, permeability, slake durability, linear shrinkage, swelling, creep). • Geological structure (e.g. joints, faults, shears, cleavage, bedding planes, foliation, dykes and sills, veins, folds, schistosity, fissures) • Ground stress - define pre-mining and potential mining-induced stresses and loads • Hydrology and climate • Hydrogeology.
6. Safe planning and design	Describe the general process used when developing and implementing safe quarry planning and designs. It is recommended that a flowchart be developed to ensure all aspects of the design process are captured and can be used as a quick check when scheduling relevant works. Simplistically, the information provided in this section can be divided into the following subsections:

Section	Notes
6.1 Geotechnical model data analysis	Including geotechnical domaining and modes of failure of unwanted ground movement (e.g. surface and groundwater influences, structural block analysis, material types).
6.2 Design specifics	Provide details on the design process to be used for each type of geotechnical infrastructure expected at a quarry. This is to include acceptance criteria for specific design methods. Examples include the following: • Void excavation strategies and design (e.g. void profiles, free dig or drill and blast) • Catch berms • Batter angles • Development geometry and sequencing (underground) • Slope geometry and sequencing • Waste landforms.
6.3 Geotechnical design methods and relevant acceptance criteria for each geotechnical structure	The basis for adopting any design method, strategy, and design acceptance criteria needs to be formally justified and documented in the GCMP. All assumptions made for this justification should also be included. Conversely, if the samples of ground used for engineering property testing are not representative of the full range of geotechnical materials to be mined (e.g. only the best drill core recovered is tested), then higher factors of safety should be adopted for the quarry design criteria.
7. Design implementation and quality control	Describe actions to be taken to ensure that safe quarry planning and designs have been implemented within the intermediates and tolerances required. This is to include safe work procedures, OEM requirements, responsibilities. Examples of issues requiring quality control and assurance actions include those listed in 6.2 above and other matters.
8. Performance monitoring, data recording and review, including inspections (daily/weekly) of site (e.g. active work areas, dumps, dams).	
8.1 Monitoring methods and safe implementation	Establishing safe processes for required monitoring. These processes (observational or by instrumentation) will need to meet with the hazards imposed by various forms of ground movement and potential exposure to these hazards by the mining method.

Section	Notes
8.2 Monitoring and review of monitoring data	All performance monitoring data is reviewed with respect to the adopted safe planning and design process and geotechnical model. This is a form of quality assurance for the safe planning and design processes in place. The performance monitoring process is developed to allow for early identification of ground movement indicating that the initial safe design has not resulted in effective ground control or is trending towards ineffective ground control unless a change is implemented.
9. Managing unstable ground	Safe work procedures must be developed for managing unstable ground or ground that may become unstable. Unstable ground includes ground movement that has become "plastic", blast damaged rock, loosening of blocks of rock defined by geological structure, and loose rock collected by catch berms and behind mesh. Suitable records should be kept of the areas requiring some form of remedial work to manage unstable ground. Define limits for methods used to control or contain loose rock (e.g. catch berm capacity and crest profile and remedial actions, mesh bagging limits and remedial actions). Define movement limits for various modes of failure in various geology and provide triggered action response plans (TARPs).
10. Communication, training and supervision	
11. Emergency response	