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Department of Regional NSW

Consolidated report

Ground or strata failure – slope stability – small mines

February 2022 – August 2022

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Executive summary

A crucial part of the NSW Resources Regulator's *Incident prevention strategy* involves targeted assessment and planned inspection programs for mines and petroleum sites. This is a focus on assessing an operation's control of critical risks through evaluating the effectiveness of control measures in the mine's safety management system.

The Regulator has developed a bowtie hazard management framework and standardised assessment checklist for each program plan. Under each program plan, the effectiveness of the safety management system at each mine site is assessed against a standard set of control supports and critical controls.

This report summarises the assessment findings from the program, which covered 35 mines between February 2022 and August 2022.

The threats and critical controls assessed for the material unwanted event (ground or strata failure – slope stability) are shown in Table 1.

Table 1: Threats and critical controls for the material unwanted event (ground or strata failure - slope stability – small mines)

Threat/consequence		Critical control
Threat	• Ground conditions • Natural or induced seismic event	PC 1.4 – Drilling and blasting practices
Threat	• Ground conditions • Unconsolidated material • Natural or induced seismic event	PC 1.5 – Excavate to design
Threat	• Ground conditions • Unconsolidated material • Water	PC 1.6 – Water management
Threat	• Ground conditions • Voids or other workings beneath wall • Unconsolidated material • Water • Natural or induced seismic event	PC 1.7 - Separate people from the ground or strata hazard
Threat	• Unconsolidated material	PC 3.4 Dump to design

Legislative requirements and published guidance relating to the principal hazard of ground or strata failure is listed in Appendix A. Figure 1 presents safety compliance findings for each de identified mine and critical control assessed for the material unwanted event of ground or strata failure. Explanatory notes on the assessment system are also listed in Appendix B.

Key findings

Throughout the inspection program, there were several examples where sites could demonstrate a good application in controlling the principal hazard of ground or strata failure – slope stability.

Improvement areas were also identified and discussed with the sites during the assessments for managing their ground or strata hazards.

Resource Regulator inspectors were able to share information from other mine sites of work that was being done well to manage the hazards associated with ground or strata failure, as well as any incidents that had occurred within the mining industry and what controls were applied to prevent a similar type of incident from reoccurring.

Levels of compliance for the nominated controls for this assessment program were found to be modest.

Key findings included:

- Some mines documentation relating to controls for ground or strata failure (risk assessment, PHMP, TARPs, etc.) were not relevant, up-to-date, readily available, and did not address site-specific issues. This included the design, layout, operation, construction and maintenance of dump, stockpile or emplacement area(s) at the mine.
- Excavations on some sites generally did not meet the design set out in the mine plan leaving unstable or overhanging strata.
- There was lack of understanding the importance of checking blast hole logs for anomalies before loading, leading to poor fragmentation, unstable geological structures and deviations from the design excavations. This could lead to poor change management process, including a risk assessment addressing impacts on slope stability, not being undertaken when the blast or shot has be altered from the original plan
- Water management practices were not documented, implemented or linked to the PHMP for Ground or Strata Instability, and did not identify how water might enter the mine, the procedures for removing water from the mine, and the effect the procedures had on rock stability over time.
- Working adjacent to geological structures such as high walls, slopes, stockpiles, dumps, etc, was not a risk-based procedure and did not include equipment setup for excavating such as excavator pads, scaling, catch bunds, etc.
- Most quarry managers could explain the key features of the blasting plan and implemented exclusion zones where remedial geological work was required.

In addition, it was identified that:

- inspections of geological conditions and safeguarding features as per the mine design were not relevant, current, implemented or readily available
- documentation relating to assessment by competent person (geotechnical engineer) relating to rock/soil characteristics (support/stability) was not relevant, current, implemented or readily available
- training or information for supervisors and workers was not clearly defined or detailed in relation to the hazard and controls for the hazard
- reported defects were not actioned or reviewed
- the mine operator relied on the blasting contractor to implement the blast management plan or a significant part of it with no reference to the mine design
- there were failures in incident reporting to the Resources Regulator.

Recommendations

The planned inspection program identified varying levels of control implementation and effectiveness across all the sites was assessed. This highlighted several practices that could be improved to assist in protecting the health and safety of workers when exposed to this hazard. Based on the assessments completed, the recommendations are as follows:

- Mine operators should ensure that documentation relating to controls for ground or strata failure (risk assessment, PHMP, TARPs, etc.) are relevant, current, readily available, and address site specific issues.
- Excavations - where there is unstable or overhanging strata, should be identified, reported and controlled or made inaccessible until controls are put in place. This may require the advice of a geotechnical engineer.
- Mine operators should record and ensure they understand the impacts on the mine design when any abnormalities occur with drill and blast activities, or any changes required to manage ground or strata conditions. A change management process should be completed, including a risk assessment with all relevant stakeholders before making the change.
- Mine operators should train and communicate to all workers what controls are developed from their ground or strata risk assessments, such as the requirements for accessing exclusion zones in vehicles or on foot.
- Quarry managers, supervisors, and workers must be trained to undertake regular inspections of work areas for geotechnical hazards prior to commencing work in their area and ensure all identified hazards are reported and controlled prior to commencing work.
- Mine operators should ensure access or remote monitoring is provided for workers to safely conduct inspections of the work areas to establish the condition of walls. Where areas cannot be properly inspected this must be reported and action on.
- Where any changes are required to the sites drill and blast processes, a change management process should be completed, including a risk assessment with all relevant stakeholders prior to making the change.
- Control of water drainage is also an important aspect of the implementation of the slope design. Surface water drainage paths through and around the site should be designed, constructed and maintained so that water does not dam at the crest or toe of critical slopes.
- To stop scouring on a face, water should not be discharged over a face except at controlled points. If possible, the water should be directed along the bench to the roadway, and along an open drain to a collection point, sump or settling dam. Surface water management is an aspect that requires consideration and input into the whole of mine site design.
- Mines or quarries excavated below the groundwater table may need some form of dewatering and depressurisation. Water pressure in structural defects in the rock mass, and pore spaces in rock material reduces effective stress, and consequently shear strength. The approach to groundwater control can be by means of water abstraction methods such as:
  - production bores
  - sumps or trenches
  - sub-horizontal drainage holes drilled into the slopes.
- Dumping and storage of waste materials is a requirement for most operations. Storage design activities should be proactive and occur at the initial planning of the project, and not rely solely on reactionary and unoptimized design. Mines should be aware of the properties of the overburden, and the influence of the local environment, especially rainfall on dump stability.

- A risk based approach should be undertaken when working adjacent to geological structures. Managing hazards from individual rocks falling from a slope (highwall or face) may be achieved through a combination of four techniques. These are:
  - supporting or controlling the fall path of potentially loose rock
  - scaling the loose rock, with appropriated plant fitted with operator protective devices
  - providing rock catching berms or benches or both
  - limiting workers' exposure to areas where loose rock is on the slope.

Assessment findings

Threats, consequence and controls assessed

Threats:

- Ground conditions
- Natural or induced seismic event
- Critical control: PC 1.4 – Drilling and blasting practices
  - Control objective: Achieve stable wall conditions
  - Performance requirement:
  1. Blast holes are drilled to design
  2. Blasts are completed to design

Specific findings for this critical control included:

- There was lack of understanding the importance of checking blast hole logs before loading for anomalies, leading to poor fragmentation, unstable geological structures and deviations from the design excavations. This could lead to poor change management process, including a risk assessment addressing impacts on slope stability, not undertaken when the blast or shot has be altered from the original plan
- The mine operator relies on the blasting contractor to implement the blast management plan or a significant part of it with no reference to the mine design.

Threats:

- Ground conditions
- Unconsolidated material
- Natural or induced seismic event
- Critical control: PC 1.5 – Excavate to design
  - Control objective: stable walls. Walls are excavated to the design and cleaned back to hard.
  - Performance requirement:
  1. Walls are excavated to design.
  2. Loose material is cleared from the wall.

Specific findings for this critical control included:

- Documentation relating to controls for ground or strata failure (risk assessment, PHMP, TARPs, etc.) were not relevant, current, readily available, and does not address site specific issues. This includes the design, layout, operation, construction and maintenance of dump, stockpile or emplacement area(s) at the mine.

- The excavations on site generally did not meet the design set out in the mine plan leaving unstable or overhanging strata.
- Working adjacent to geological structures such as high walls, slopes, stockpiles, dumps, etc, was not based on a risk based procedure and does not include equipment setup for excavating such as excavator pads, scaling, catch bunds, etc.
- Inspections of geological conditions and safeguarding features as per the mine design were not relevant, current, implemented or readily available.
- Documentation relating to assessment by competent person (geotechnical engineer) relating to rock/soil characteristics (support/stability) were not relevant, current, implemented or readily available

Threats:

- Ground conditions
- Unconsolidated material
- Water
- Critical control: PC 1.6 – Water management
  - Control objective: Water is diverted or removed to prevent ground or strata failure.
  - Performance requirement:
  1. Control measures for ground or strata water damage risks are implemented.

Specific findings for this critical control included:

- Water management practices were not documented, implemented or linked to the PHMP for ground or strata Instability, and does not identify how water may enter the mine, the procedures for removing water from the mine, and the effect the procedures have on rock stability over time.

Threats:

- Ground conditions
- Voids or other workings beneath wall
- Unconsolidated material
- Water
- Natural or induced seismic event
- Critical control: PC 1.7 – Separate people from the ground or strata hazard
  - Control objective: People are separated from identified ground or strata failure hazards.
  - Performance requirement:
  1. Ground or strata failure is identified as a hazard.
  2. Indicators of potential ground or strata failure are identified.
  3. People are protected from ground or strata failure hazards.

Specific findings for this critical control included:

- Working adjacent to geological structures such as high walls, slopes, stockpiles, dumps, etc, was not based on a risk based procedure and did not include equipment setup for excavating such as excavator pads, scaling, catch bunds, etc.
- Inspections of geological conditions and safeguarding features as per the mine design were not relevant, current, implemented or readily available

Threats:

- Unconsolidated material
- Critical control: PC 3.4 – dump to design
  - — Control objective: dumps remain stable.
  - — Performance requirement:
  1. Factors that affect dump stability were identified.
  2. Dumps were constructed to design.
  3. Dumps were inspected and monitored to ensure compliance with the design and dumping standards.

Specific findings for this critical control included:

- Documentation relating to controls for ground or strata failure (risk assessment, PHMP, TARPs, etc.) were not relevant, current, readily available, and does not address site specific issues. This includes the design, layout, operation, construction and maintenance of dump, stockpile or emplacement area(s) at the mine.

Findings by mine

Figure 1 presents aggregate assessment findings by critical control, providing a summary view of the status of each mine's hazard management processes. Importantly, the system recognises the value of fully implemented and documented controls by awarding an additional point if both elements were assessed as present. More details explaining the assessment system are found at Appendix B.

Figure 1: Assessment findings for the planned inspection program – ground or strata failure – slope stability – small mines –– overall results < 80%

Mine	Threat				
	1. Ground conditions 5. Natural or induced seismic event	1. Ground conditions 3. Unconsolidated material 5. Natural or induced seismic event	1. Ground conditions 3. Unconsolidated material 4. Water	1. Ground conditions 2. Voids or other workings beneath wall 3. Unconsolidated material 4. Water 5. Natural or induced seis..	3. Unconsolidated material
	PC1.4	PC1.5	PC1.6	PC1.7	PC3.4
	Drilling & blasting practices	Excavate to design	Water managment	Separate people from the ground or strata hazard	Dump to design
Mine A	Red	Red	Red	Red	Grey
Mine B	Red	Red	Red	Red	Red
Mine C	Red	Red	Red	Orange	Grey
Mine D	Green	Red	Red	Red	Red
Mine E	Green	Red	Red	Red	Red
Mine F	Orange	Red	Red	Orange	Grey
Mine G	Red	Orange	Red	Red	Orange
Mine H	Orange	Red	Orange	Red	Grey
Mine I	Green	Red	Red	Green	Red
Mine J	Yellow	Red	Green	Red	Grey
Mine K	Grey	Orange	Orange	Orange	Red
Mine L	Grey	Red	Orange	Green	Red
Mine M	Red	Orange	Orange	Green	Grey
Mine N	Red	Orange	Orange	Green	Green
Mine O	Grey	Red	Green	Orange	Green

Green (=100%)
Yellow (>= 80% and <100%)
Orange (>= 65% and <80%)
Red (<65%)

Figure 21: Assessment findings for the planned inspection program – ground or strata failure – slope stability – small mines –– overall results ≥ 80%

Mine	Threat				
	1. Ground conditions 5. Natural or induced seismic event	1. Ground conditions 3. Unconsolidated material 5. Natural or induced seismic event	1. Ground conditions 3. Unconsolidated material 4. Water	1. Ground conditions 2. Voids or other workings beneath wall 3. Unconsolidated material 4. Water 5. Natural or induced seis..	3. Unconsolidated material
	PC1.4	PC1.5	PC1.6	PC1.7	PC3.4
	Drilling & blasting practices	Excavate to design	Water managment	Separate people from the ground or strata hazard	Dump to design
Mine P	Green	Red	Green	Orange	Green
Mine Q	Yellow	Orange	Orange	Orange	Green
Mine R	Green	Orange	Green	Red	Green
Mine S	Red	Orange	Green	Green	Green
Mine T	Green	Green	Orange	Green	Red
Mine U	Yellow	Green	Orange	Green	Green
Mine V	Green	Red	Green	Green	Grey
Mine W	Grey	Red	Green	Green	Green
Mine X	Green	Green	Green	Red	Green
Mine Y	Green	Green	Green	Red	Green
Mine Z	Green	Orange	Green	Green	Grey
Mine AA	Green	Green	Green	Orange	Green
Mine AB	Green	Green	Orange	Green	Green
Mine AC	Green	Green	Green	Green	Red
Mine AD	Green	Green	Orange	Green	Green
Mine AE	Green	Green	Green	Orange	Green
Mine AF	Green	Orange	Green	Green	Green
Mine AG	Green	Green	Orange	Green	Green
Mine AH	Green	Green	Green	Green	Green
Mine AI	Grey	Green	Green	Green	Green

Green (=100%)
Yellow (>= 80% and <100%)
Orange (>= 65% and <80%)
Red (<65%)

Notices issued

Of the 35 sites assessed under the inspection program, 35 separate mines were issued notices relating to the principal hazard of ground or strata failure, while some mines were given notices in relation to other matters. For the purposes of this report, contraventions related to other matters were removed from the analysis. The notices issued for ground or strata failure were examined in detail and Table 2 below lists the notices issued by type and details.

Table 2: Notices issued for the planned inspection program – ground or strata failure – slope stability -small mines

NOTICE TYPE	TOTAL ISSUED	NUMBER OF MINES
s.195 prohibition notice	4	4
s.191 improvement notice	27	22
s.23 notice of concerns	18	18
Total	**49**	**35**

Of the combined 49 notices issued, there were some common themes that were apparent throughout the program plan. Table 3 summarises the type of contraventions and also outlines the total occurrences encountered. These themes can be related to the critical controls outlined earlier and identify some trends, which are of concern.

Table 3: Notices issued for the planned inspection program – ground or strata failure – slope stability -small mines - prevalence of categories of concern

IDENTIFIED CONCERN CATEGORY	TOTAL OCCURRENCES IN NOTICES
Documentation relating to controls for ground or strata failure (Risk Assessment, PHMP, TARPs, etc.) not relevant, current, readily available, and does not address site specific issues	30
The survey/mine plan for the mining operations was not current, accurate, approved, implemented, regularly reviewed or readily available.	21
Working adjacent to geological structures such as high walls, stockpiles, dumps, etc, is not based on a risk based procedure including equipment setup for excavating such as excavator pads, scaling, catch bunds, etc	20
Blast drill hole logs were incomplete, not readily available, or use to determine alterations to the final blast which may lead to non-conformance with slope design and stability	12
Water management practices are not documented, implemented or linked to the PHMP for Ground or Strata Instability, and does not identify how water may enter the mine, the procedures for removing water from the mine and the effect the procedures have on rock stability over time	12
Inspections of geological conditions and safeguarding features as per the rock support/stability design not relevant, current, implemented or readily available	8
Documentation relating to assessment by competent person (geotechnical engineer) relating to rock/soil characteristics (support/stability) not relevant, current, implemented or readily available	8
Training information for workers not clearly defined or detailed in relation to the hazard	6
The PHMP for Ground or strata failure did not include the design, layout, operation, construction and maintenance of dump, stockpile or emplacement area(s) at the mine.	6
No formal requirement for supervisors to be trained in the relevant controls nominated for site	4
Reported defects not actioned or reviewed	2

IDENTIFIED CONCERN CATEGORY	TOTAL OCCURRENCES IN NOTICES
The mine operator relies on the blasting contractor to implement the blast management plan or a significant part of it	2
Failings in incident reporting to the Resources Regulator	1
Change management process, including a risk assessment addressing impacts on slope stability, not undertaken when the blast or shot has be altered from the original plan	1
The existing mining excavations and infrastructure (stockpiles, tailings, roads, etc) have exceeded the area consented for mining	1

Further information

For more information on safety assessment programs, the findings outlined in this report, or other mine safety information, please contact the NSW Resources Regulator:

CONTACT TYPE	CONTACT DETAILS
Email	cau@regional.nsw.gov.au
Incident reporting	To report an incident or injury call 1300 814 609 or log in to the Regulator Portal
Website	www.resourcesregulator.nsw.gov.au/
Address	NSW Resources Regulator 516 High Street Maitland NSW 2320

Appendix A -Legislative requirements and published guidance relating to the principal hazard of ground or strata failure

The following is a list of certain legislative requirements for the management of ground or strata failure risks referred to in this report, as provided by the Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 and Work Health and Safety Regulation 2017.

- Work Health Safety Regulation 2017
  - Part 3.2 General workplace management Division 10 Falling objects
  - Clause 214 The person with management or control of powered mobile plant at a workplace must in accordance with Part 3.1, manage risks to health and safety associated with the following —
  - (b) things falling on the operator of the plant,
  - Clause 215 (2) The person must ensure, so far as is reasonably practicable, that a suitable combination of operator protective devices for the plant is provided, maintained and used.
- Work Health and Safety (Mines and Petroleum Sites) Regulation 2022
  - Division 2 Principal hazard management plans and principal control plans
  - Section 39 Inspections
  - Section 47 Mining induced seismic activity
  - Section 116(4) The mine operator of a mine, other than an underground mine or coal mine, must conduct a risk assessment to determine if a survey plan is necessary for the mine.
  - Section 122 Other mine plans
  - Schedule 1 Principal hazard management plans Part 1 Mines Section 1(1)(a), (b), (c), (d), (e), (f), (g), (h), (i), (j), (k), (l), (m), (o), (p), (q), (r), (s), (x)
  - Schedule 1 Principal hazard management plans Part 1 Mines Section 4
- NSW Resources Regulator Guide Health and safety at quarries November 2018
- Fact sheet assessment program - Ground or strata failure – slope stability Small mines
- Safety Bulletins
  - SB22-03 Impacts of severe weather on slope stability
  - SB20-01 Failure of highwalls
  - SB19-09 Lack of bunding on accessible edges
  - SA18-13 Dangerous incident involving excavator on edge of highwall
  - SB18-11 Windrow management and demarcation
  - SB17-03 Rocks breach catch bund

Appendix B. Assessment system explained

The NSW Resources Regulator uses a bowtie framework to proactively assess how mine sites manage their principal hazards. Bowties are a widely used risk management tool that integrates preventative and mitigating controls onto threat lines that relate to a material unwanted event.

As part of program planning, controls were categorised by the NSW Resources Regulator's Mine Safety Inspectorate in accordance with the ICMM handbook. Only controls deemed critical[1] are assessed under a planned inspection program. For a control to be assessed as effective, each of its control supports must be in place and operational.

Assessment findings results calculation

During the program, each control support assessed at each mine was rated and the findings recorded. Points were awarded depending on whether there was evidence that the control support had been documented and / or implemented. Importantly, the system recognises the value of fully implemented and documented controls by allocating four points if both these elements were present.

For finding outcomes, points were awarded for each control support identified within a critical control. An overall assessment result for the critical control was then calculated as a proportion of the maximum possible points for that critical control. For example, if a critical control comprises ten control supports and five were assessed as fully implemented ('documented and implemented') and five were found to be 'not documented and not implemented' then the overall assessment result for that critical control would be 50%.

Table 3: Finding outcome and points

FINDING OUTCOME	POINTS
Documented and implemented	4
Implemented but not documented	2
Documented but not implemented	1
Not documented and not implemented	0

Critical control calculations also took into account instances where control supports were not applicable to the mine being assessed or when control supports were not able to be assessed during a site visit.

[1] Critical Control Management Implementation Guide, International Council on Mining and Metals (ICMM), 2015.

The overall assessment result for each critical control has been assigned a colour based on the assessment bands presented in the table below. The colour band results are then used to identify industry focus areas requiring improvement.

Table 4: Assessment results and colour code

CRITERIA	COLOUR
An assessment result of 100% of possible points	Green
An assessment result of ≥ 80% but < 100% of possible points	Yellow
An assessment result of ≥ 65% but < 80% of possible points	Orange
An assessment result of < 65% of possible points	Red