**Resources Regulator**
Department of Regional NSW

# Consolidated report

## Ground or strata failure – underground metalliferous mines

### June 2021 – December 2022

**Published by the Department of Regional NSW**

Title: Consolidated report – Ground or strata failure – Underground metalliferous mines

First published: February 2023

Department reference number: RDOC22/199083

**More information**

| Amendment schedule | | |
|---|---|---|
| Date | Version | Amendment |
| February 2023 | 1 | First published |
| | | |
| | | |

# Table of Contents

# 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 10 mines in relation to assessments for the hazard of ground or strata failure, conducted during the period between June 2021 and December 2022.

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

Table 1: Threats, Consequences and Critical Controls for the Material Unwanted Event (Ground or strata failure – underground metalliferous mines)

| THREAT/CONSEQUENCE | | CRITICAL CONTROL |
|---|---|---|
| Threat | • Ground conditions | PC 1.4 – Manage void formation |
| Threat | • Ground conditions<br>• Pillar overload<br>• Seismic event | PC 1.6 – Ground support |
| Threat | • Ground conditions | PC1.7 – Ground support lifecycle management |
| Consequence | • Crush injuries<br>• Impact injuries<br>• Asphyxia | MC1.1 – Control access to unsupported ground |

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 deidentified 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

Some general findings from the inspection program are listed below, as well as some specific findings for each of the critical controls assessed.

**General findings:**

- A variety of mining methods were in use, including:
  - block caving
  - sub-level caving
  - long hole open stoping

  - transverse sequential stoping
  - uphole pillar retreat stoping,
  - single entry decline.
- Most of the mines used the ground control management plan (GCMP) as the primary means of managing ground or strata failure risks, with varying levels of compliance with Schedule 1 to the Work Health and Safety (Mines and Petroleum Sites) Regulation 2022.
- All mines had formal processes for the design, implementation, monitoring and maintenance of ground or strata failure risk control measures but these were implemented at varying standards, with larger mines demonstrating higher standards in most cases.
- All mines had substantive geotechnical engineers, with other mines having access to corporate support, specialist contractors or consultants.
- At all mines, mineworkers spoken to by inspectors had on their person copies of the ground support standards. These workers indicated that they knew that the standards provided to them were the minimum and that they could install additional support as required.

**Critical control:** PC1.4 – Manage void formation

- Two mines had comprehensive arrangements in place for managing risks associated with airblast and material periodic weighting such as:
  - drawing of material or ore from the undercut blast occurs close to the next blast, to minimise the amount of time the void is exposed to localised material flow or drawn-down
  - drawing of material or ore to a certain maximum percentage of the tonnage or equivalent volume, to leave sufficient space or void for the next blast
  - monitoring material or ore draw, and carrying out tonnage or volume reconciliations.
- Two mines used void and ground movement monitoring techniques such as tracker beacons, extensometers, scanning of mine headings, convergence monitoring stations, and seismic sensors.
- Most of the mines used the cavity monitoring system (CMS) for surveying stopes, and in some cases, cameras for monitoring stope backfill operations.
- Where most of the mines had ‘voids’ being synonymous with stopes, a few mines went beyond stope voids to include the interconnectedness of ore-passes, raises, winzes and larger excavations in their void management plans.
- A few of the mines did not have a stand-alone trigger action response plan for incidents associated with voids, relying instead, on the existing arrangements for managing other emergencies at the mine.

**Critical control:** PC 1.6 – Ground support

- Most mines had ground support standards and installation procedures, as well as QA/QC processes to ensure that suitable and sufficient support elements were installed.
- One mine’s geotechnical domains had not been updated from structural mapping, and ground support regimes designed for the presenting conditions.
- Overdriven bolts and face plates were a common sight at the mines, including various ground support elements damaged by powered mobile plant without additional or replacement support.
- Two mines had areas of the mine which had not been supported as per the respective mines’ ground support standards.
- One mine provided a jumbo operator with a ground support standard that was impractical to install due to heading width, jumbo boom length, and bolt length constraints, resulting in the bolts being installed at the wrong dip and direction.
- One mine did not have arrangements for shotcrete depth application QA/QC.

- One mine's ground support standard specified a certain type of bolts, however a completely different type was installed, resulting in non-conformance to the mine's own ground support standard.
- One mine's perishable resin and cementitious products for ground support installation were found to have gone past their expiry date, and there were no arrangements for the proper management of these products.

**Critical control:** PC1.7 – Ground support lifecycle management

- Two mines developed and implemented clear and auditable ground support rehabilitation arrangements including mapping, technical assessments, action plans, ground support installation, verification, and close-out.
- All mines had some of the ground support elements damaged by powered mobile plant such as dump trucks and load haul and dump (LHD) units.
- All mines had check-scaling arrangements in place to prevent falls of ground involving shotcrete slabs and loose or fractured rocks, with varying standards for planning, implementation, monitoring and review,

**Critical control:** MC1.1 – Control access to unsupported ground

- All mines clearly defined 'unsupported ground', and had systems of work to prevent access to any unsupported ground, for example:
  - bunds or mounds (rocks and fine material)
  - chain barricades with signage reading "*Authorised Personnel Only*", "*No Entry, Unsupported Ground*"
  - other information, training and instruction.
- One mine had an unusually long distance (span) from the face to where ground support was installed and had conflicting maximum unsupported spans in their ground support documentation.

# Recommendations

The planned inspection program identified varying levels of control implementation and effectiveness across all the sites 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:

- Process-map the relevant ground or strata failure risk management activities and identify safety and quality critical stages for each activity,
- Design and implement suitable and sufficient monitoring arrangements that include safety and quality verification 'hold-points' for the mapped activities,
- Conduct a holistic assessment of the work environment, equipment, competency of operators and ground support elements to be used, and ensure that the recommended ground support can be, and is installed as required,
- Develop and implement suitable and sufficient trigger action response plans (TARPs) for mine voids-related occurrences and tie-in with the mine's overall emergency management plan,
- Assess and decide on the most suitable area(s) for the storage of ground support elements (includes perishables), having regard to the manufacturer's recommendations,
- Develop and implement suitable and sufficient arrangements for ensuring that all ground support elements (including perishables), have not been degraded or gone past their 'use-by' date,

- Design, construct and maintain headings that enable powered mobile plant such as trucks and load haul and dump units (LHDs) to negotiate corners and/or move about the mine without damaging ground support elements,
- Retrain and/or reassess as appropriate, personnel involved in ground or strata support installation, monitoring and maintenance, to ensure that they remain up to date with new technologies, procedures and related requirements.

## Findings by mine

Figure 1 presents aggregate assessment findings by threat/consequence and 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 at Appendix B.

Figure 1: Assessment findings for the planned inspection program – Ground or strata failure – underground metalliferous mines

| | Threat | | | Consequence |
|---|---|---|---|---|
| | 1. Ground conditions | 1. Ground conditions<br>3. Pillar Overload<br>4. Seismic event | 1. Ground conditions | 1. Crush injuries<br>2. Impact injuries<br>3. Asphyxia |
| | PC1.4 | PC1.6 | PC1.7 | MC1.1 |
| Mine | Manage void formation | Ground support | Ground support lifecycle management | Control access to unsupported ground |
| Mine A | Yellow | Green | Orange | Red |
| Mine B | Yellow | Red | Green | Green |
| Mine C | Green | Red | Yellow | Green |
| Mine D | Green | Yellow | Orange | Yellow |
| Mine E | Green | Yellow | Yellow | Green |
| Mine F | Green | Green | Yellow | Green |
| Mine G | Green | Green | Green | Green |
| Mine H | Green | Green | Green | Green |
| Mine I | Green | Green | Green | Green |
| Mine J | Green | Green | Green | Green |

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

# Notices issued

Of the 10 sites assessed under the inspection program, all 10 mines were given 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 – underground metalliferous mines

| NOTICE TYPE | TOTAL ISSUED | NUMBER OF MINES |
|---|---|---|
| s.195 prohibition notice | 1 | 1 |
| s.191 improvement notice | 7 | 5 |
| s.23 notice of concerns | 10 | 9 |
| **Total** | **18** | **10** |

Of the combined 18 notices issued, there were some common themes that were apparent throughout the program plan. Table 3 summarises the type of contraventions. These themes can be related to the critical controls outlined earlier and identify some trends that are of concern.

Table 3: Notices issued - prevalence of categories of concern

| IDENTIFIED CONCERN CATEGORY |
|---|
| Defining ground support systems without an assessment of the size of the working environment and equipment to be used |
| No arrangements for the storage and use of perishable products such as resin and cement |
| No arrangements for shotcrete thickness QA/QC |
| Conflicting maximum unsupported ground length or span |
| Poorly maintained ground support installation equipment |
| Ground support standard not followed |
| Over-driven bolts and face plates |
| Damage to ground support elements by powered mobile plant |
| Damaged ground support not replaced |
| Geotechnical domains not updated following structural mapping |
| Airblast plugs constructed with services (air, water, electrical) in-situ |

# 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<br>or log in to the Regulator Portal |
| Website | www.resourcesregulator.nsw.gov.au |
| Address | NSW Resources Regulator<br>516 High Street<br>Maitland NSW 2320 |

# Appendix A. Legislative requirements and published guidance relating to the principal hazard 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 and Safety (Mines and Petroleum Sites) Regulation 2022:

- Section 47 – Mining induced seismic activity
- Section 55 – Ground and strata support
- Schedule 1, Part 1 Mines, (1) Ground or strata failure.

Work Health and Safety Regulation 2017:

- Clause 37 – Maintenance of control measures
- Clause 38 – Review of control measures

NSW Resources Regulator publications:

- Investigation report: Report into the death of Lee Peters at the Ridgeway Mine, Cadia, NSW on 6 September 2015
- IIR17-02: Strainburst: E26 sublevel cave (SLC) ore drive 8
- IIR15-02: Fatality when crushed in pinch point
- SA10-07: Shotfirer hit by falling shotcrete
- Case Study: Northparkes Air Blast

# 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.

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 |

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