NSW GOVERNMENT

NSW Resources Regulator

PLANNED INSPECTION PROGRAM
Ground or strata failure - underground coal

CONSOLIDATED REPORT: MANAGING GROUND OR STRATA FAILURE RISKS IN UNDERGROUND COAL MINES

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Contents

Executive summary

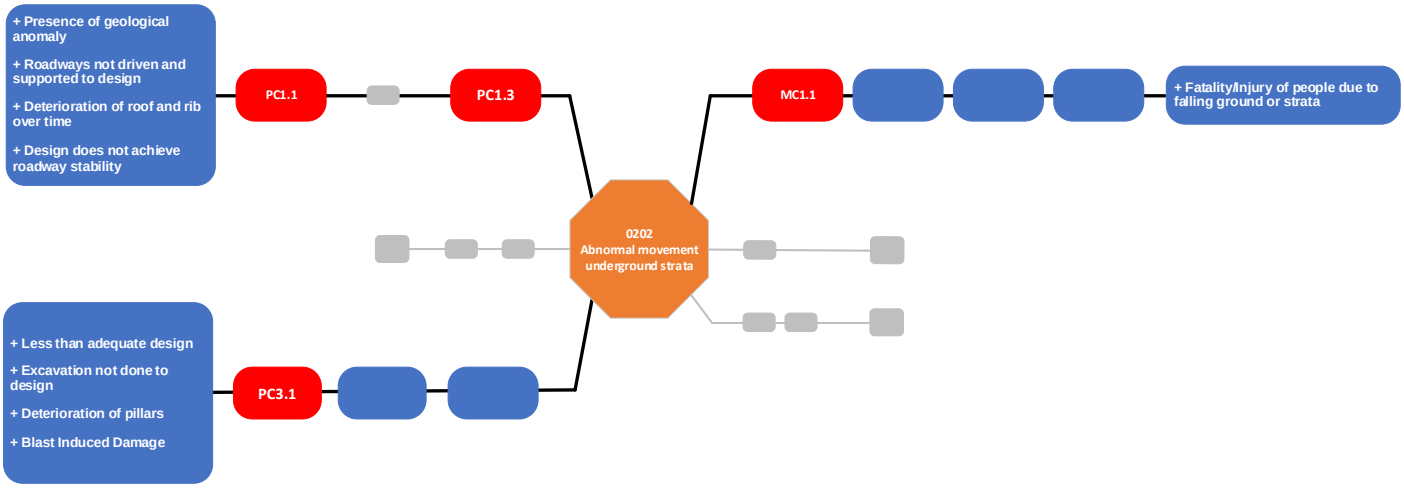
A crucial part of the NSW Resources Regulator's Incident Prevention Strategy involves targeted assessment and planned inspection programs for mines and petroleum sites. This is a focus on assessing an operation's control of critical risks through evaluating the effectiveness of control measures in the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

To this end the NSW Resources Regulator developed a bowtie hazard management framework to develop standardised assessment templates 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 critical controls and control supports.

This final report summarises assessment results from 19 mines in relation to the hazard of ground or strata failure in underground coal mines during the period from April to September 2019. Figure 1 below identifies the critical controls that were assessed in this program. It is worth noting that this is not a definitive list of controls for all ground and strata risks, rather a selection of critical controls that were appropriate to assess in an underground development panel. The critical controls assessed were:

- PC1.1 Roadways driven, and strata supports installed as per approved design/plans
- PC1.3 Strata Monitoring
- PC3.1 Stable pillars
- MC1.1 Workers to avoid positioning themselves within fall zone of unsupported strata.

Figure 1. Bowtie diagram for abnormal movement of underground strata



Legislative requirements and published guidance relating to the management of ground or strata failure risks is at **Appendix A**.

It also presents safety compliance findings for each deidentified mine and critical control. Explanatory notes on the assessment system are at **Appendix B**.

Recommendations

Mine operators should ensure a comprehensive risk assessment is conducted by a team of participants that are suitably qualified and experienced. The risk assessment should:

- identify the ground or strata failure risks at their mine
- identify appropriate controls to eliminate the risk or reduce as low as reasonably practicable (as per hierarchy of controls)
- outline the relevant components of the safety management system which address the risk and detail the implementation of the associated controls.

Mine operators should also ensure that appropriate resources are made available to adequately manage the ground or strata failure risks, as well as validate and verify control effectiveness. These processes should be regularly reviewed to not only confirm compliance but also identify any deficiencies which may exist within the controls.

It is recommended that mine operators, upon reading this consolidated report, review their site's relevant risk assessment, principal hazard management plan, and associated documents to manage the ground or strata failure risks that are unique to their site.

Introduction

The NSW Resources Regulator's planned assessment programs provide a planned, risk-based and proactive approach to assessing how effective an operation is when it comes to controlling risk. These programs apply the following principles:

- A focus on managing prescribed 'principal hazards' from the Work Health and Safety (Mine & Petroleum Sites) Regulation 2014.
- Evaluation of the effectiveness of control measures implemented through an organisation's safety management system.
- Consideration of the operation's risk profile.

The objective of risk profiling is to identify the inherent hazards and the hazard burden that exist at individual operations in each mining sector in NSW. The information is then used to develop the operational assessment and inspection plans that inform the program.

Scope

Planned inspection programs include two assessment types:

- **Targeted assessments**, incorporating:
  - desktop assessment of:
    - compliance against legislation with respect to the management of health and safety risks associated with ground or strata failure – see Appendix A for details
    - the definition of the controls the mine utilises to prevent and mitigate the risks to health and safety associated with the prevention, detection and suppression of ground or strata failure
  - a workplace assessment of the implementation of those controls through the inspection of plant and worker interviews.
- **Planned inspections**, which involve a workplace assessment of the implementation of controls through the inspection of plant and worker interviews.

The process

The process for undertaking an assessment under a planned inspection program generally requires:

- preliminary team meetings, preparation and review of documents
- execution of an on-site assessment involving:
  - a site desktop assessment of relevant plans and processes measuring legislative compliance of the relevant plans (targeted assessments only)
  - the inspection of relevant site operations (both targeted assessments and planned inspections)
- discussion and provision of feedback to the mine management team on the findings and actions that need to be taken by the mine operators in response.

Assessment findings

Summary findings

Compliance action was taken at multiple sites due to various contraventions of the relevant regulations and acts. One mine was found to require immediate intervention and was issued with a prohibition notice under section 195 of the *Work Health and Safety Act 2011*. This required the mine to immediately cease operations and install roof support that conformed to the mines support plans in the panel workings.

A common theme identified throughout the assessments was the lack of verification to ensure that controls were implemented and operating effectively. Several operations were found to have sub-standard risk management systems in place and various work areas were found to be neglected or poorly managed. As a result, these sites received improvement notices and\or notice of concern. A specific area of concern which was identified by inspectors at multiple operations was pertaining to ground or strata monitoring. This is explained further within Table 3.

Conversely, several mines were found to have effective and mature management systems in place to control ground or strata failure risks. These sites provided evidence that controls were being regularly implemented, reviewed, and refined. Further to this, upon discussions with workers and inspections of active work areas, there was a strong knowledge of the risk at the operation and a high standard of compliance. These sites performed strongly in the assessments and as a result no compliance actions were required.

Controls assessed

Threat: Issues with driven roadways

Critical control: Roadways driven, and strata supports installed as per approved design/plans

The practise of driving roadways is common with the underground environment and is a part of the operation which presents considerable risk. To ensure the safety of the workplace, it is expected that mines have implemented effective processes for the installation of strata supports. Various criteria were assessed as part of this critical control and included:

- strata failure risks identified with a suitable level of controls
- procedures outlined how controls are implemented
- strata support plans defined excavation limits with minimum support requirements
- trigger action response plans (TARPs) described conditions which warrant predefined minimum support requirements
- use of fit for purpose support installation equipment and consumables
- procedures detailed safe and effective excavation and support installation methods
- mining and support installation tasks were performed by competent workers.

With regard to the implementation of this critical control, the following issues were identified:

- Intersection support within development panels was determined to be inadequate and non-conformant to the support plan.
- Principal hazard management plans were not being complied with in relation to supervisors auditing the standards of installed support.
- Roadways were observed to have been driven in excess of the planned width.
- No additional support installed in roadways that were driven in excess of the planned width.
- Inspectors were advised by supervisors and workers that equipment was not always available for supporting corners and other areas unable to be supported by miner during development operations.
- Inspectors also observed at some mines that tolerance measures for roadways driven offline were not documented or documents were inconsistent in referencing limits and actions.

Threat: Issues with driven roadways

Critical control: Strata monitoring

Underground coal mines are subjected to variable strata conditions and it is essential for the health and safety of workers that monitoring systems are appropriately implemented. Mines should also be able to react accordingly to changes of strata conditions and have processes in place that assist identifying areas of increased risk. The below requirements were assessed in relation to strata monitoring.

- Strata monitoring identified as a control for the principal hazard.
- Procedures described how strata monitoring is implemented and how it reflected the level of hazard within specific areas.
- TARPs described strata conditions and behaviour that warrant predefined action.
- Strata monitoring devices were appropriately placed.
- The condition of roadways and installed support were inspected and monitored by appointed people.
- Monitoring data was collected, recorded, analysed, and reported.
- Identified secondary support requirements were prioritised by qualified personnel.
- Installation and reading of monitoring devices was undertaken by competent workers.

With regard to this specific critical control, the following issues were identified:

- Some mines were assessed to have inadequate documented response to damaged or failed rib supports and very few addressed the cause of the damage.
- Strata Monitoring Device (SMD) data was found to be unavailable for persons to reference or analyse, whether it be on recording sheets at the SMD, within crib room/deputy stations, or in the deputy inspection reports.
- In some cases, recording sheets were observed to be installed near the SMD, however, these were unable to be reached or retrieved.
- Inspectors also observed some SMD's were difficult to read, as the measuring scale was covered in dust as well as some instances where SMD's were obscured by services installations.
- A number of SMD's were observed to have the reading indicator set at less than zero on the gauge, which was non-compliant to OEM requirements. Some SMD's were observed to be set at up to negative 10mm, which effectively meant the ground or strata would have to

move in excess of 10mm before the device would register any movement in the roof and therefore presented a false/inaccurate reading. Consequently, this information was then used within the trigger action response plan to coordinate any action response.

- Some assessments found that persons tasked with installing the SMD's indicated they had not had any training to install the devices.
- Several mines did not have the installation instructions available.
- SMD's were not installed where required by the monitoring plan.
- Some mines had installed SMD's which were inappropriate and not fit for purpose.
- Some older mines did not have a documented process for installation or recording frequencies of SMD's in historical areas of the mine that are still accessed.
- Perhaps the most frequent issue observed by inspectors was that SMD's were not being read and recorded at the nominated frequencies, regardless of whether there was any measured strata movement.
- Some mines failed to have an installation plan for SMD's in a roadway widening area or in general mining areas

Threat: Issues with pillars

Critical Control: Stable pillars

A critical element within underground coal strata management is ensuring that pillars support the surrounding strata for the intended purpose and lifecycle. Mines were assessed on the basis of ensuring that the risk of pillar failure was identified and suitable controls were implemented. As part of this process, it was an expectation that the principal hazard management plan described how pillar failure controls are implemented with due consideration for the geological and geotechnical conditions as outlined within the mine design. Specific information regarding pillar strength requirements and subsequent pillar dimensions were also evaluated, along with the requirements to properly communicate this information to workers conducting mining activities. Following this, pillar dimensions and spacing were verified to ensure that documented standards were being applied.

Upon completion of the planned inspection program, it was determined that when specific ground conditions presented an increased risk of strata failure, some mines had not adequately addressed the risk or implemented a suitable level of controls regarding pillar design and construction. In particular, some inspectors observed a lack of stability monitoring processes for pillars in high roadway areas adjacent to geological structures. However, this was only applicable to a minority of the sites assessed and the majority had effective systems in place to manage pillar stability and ensure they were

constructed in accordance to the design parameters. This included conducting pillar stability calculations which was completed by internal and/or external geotechnical engineers and incorporated influencing factors such as geological conditions. Inspectors also observed that pillar dimensions generally complied with design dimensions and these were then subsequently verified through survey plans.

Consequence: Fatality/injury due to falling rib/roof

Critical control: Workers to avoid positioning themselves within fall zone of unsupported strata

Although defined as a mitigating control, underground coal mines should have processes in place to prevent workers from being exposed to areas of unsupported strata. Primary roof and rib supports should obviously be installed in the first instance, however due to the dynamics of an underground environment this cannot always be feasible and can potentially result in areas being unsupported for some periods of time. This can pose a risk to the health and safety of workers when working in and around such zones. The specific performance requirements which mines were assessed on included:

- The risk of people being struck by unsupported strata was identified with suitable controls.
- Procedures were developed to prevent people from being exposed to unsupported strata.
- The procedures, tools, and equipment required to protect people from unsupported strata were functional and available.
- Workers were educated and trained on the risks associated with unsupported strata as well as the implementation of relevant controls.
- Supervision was provided to ensure controls for unsupported strata were effectively implemented.

During the assessments, inspector observations and discussions with workers indicated there was a good understanding of the required controls to prevent workers from being exposed to unsupported strata. The majority of workers indicated they had been trained in strata management processes and could identify unsupported strata and the controls required to manage the associated risk. In most cases the supervision, tools and equipment required to protect people from being exposed to unsupported strata were available when required. That said, there were occasions where inspectors were advised by supervisors and workers that equipment was not always available for supporting corners and other areas unable to be supported by the miner during development operations. In addition to this, there were a few occurrences whereby the site standard for restricting access to areas of unsupported strata was inadequate or insufficient.

Assessment findings by mine

This table presents aggregate assessment findings by critical control providing a summary view of the status of each mine's hazard management system. The system recognises the value of fully implemented and documented controls. More details explaining the assessment system are found in Appendix B.

Table 1. Assessment findings for ground or strata failure in the underground coal sector

	Threats			Consequences
	Issues with driven roadways		Issues with pillars	Fatality/Injury due to falling rib/roof
	Preventing Controls		Preventing Controls	Mitigating Controls
	PC1.1 - Roadways driven, and strata supports installed as per approved design/plans	PC1.3 - Strata monitoring	PC3.1 - Stable pillars	MC1.1 - Workers to avoid positioning themselves within fall zone of unsupported strata
Mine A				
Mine B				
Mine C				
Mine D				
Mine E				
Mine F				
Mine G			Not Assessed	
Mine H				
Mine I				
Mine J				
Mine K				
Mine L				
Mine M				
Mine N				
Mine O				
Mine P				
Mine Q				
Mine R				
Mine S				

Assessment Result < 65%
65% <= Assessment Result < 80%
80% <= Assessment Result < 100%
Assessment Result = 100%

Notices issued

Of the 19 sites inspected under the program plan, 14 separate mines received notices relating to the principal hazard of ground or strata failure, while some mines received notices in relation to other matters. However, for the purposes of this report, contraventions related to other matters have been 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 for ground or strata failure

NOTICE TYPE	TOTAL ISSUED	NUMBER OF MINES
s.195 prohibition notice	1	1
s.191 improvement notice	8	7
s.23 notice of concerns	15	12
Total	**24**	14

Of the 24 notices issued, there were common themes identified across the mines assessed under the program plan. Table 3 summarises the type of contraventions and also outlines the total occurrences encountered. These themes can be related back to the critical controls outlined previously and identify some trends which are of concern.

Table 3. Notices issued - prevalence of categories of concern

IDENTIFIED CONCERN CATEGORY	TOTAL OCCURRENCES IN NOTICES
Supervisors not routinely collecting, recording, and analysing information from strata monitoring devices	3
Supervisors not auditing, verifying, or accurately reporting roadways are driven in compliance to strata support designs and standards	4
Measurement information for strata monitoring devices either not current or not available	8
Strata monitoring devices either not positioned appropriately or installed as per site standards	6
Workers not trained adequately on the principals of strata monitoring devices or strata support standards	2
Strata support installed to a poor standard or not to design	6

IDENTIFIED CONCERN CATEGORY	TOTAL OCCURRENCES IN NOTICES
Documentation relating to controls for ground or strata failure (PHMP, TARPs etc.) not relevant, current, or readily available	10
Equipment that is used to implement strata support is not readily available or maintained appropriately	8
Inadequate site standard for restricting access to areas of unsupported strata	2

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@planning.nsw.gov.au
Incident reporting	To report an incident or injury call 1300 814 609 or log in to the Regulator Portal
Website	resourcesregulator.nsw.gov.au
Address	NSW Resources Regulator 516 High Street Maitland NSW 2320

Appendix A. Legislative requirements and published guidance relating to the management of ground or strata failure risks

The following is a list of 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 2014. In addition, several guidance documents are also noted which have been published and are available for industry distribution.

Work Health and Safety (Mines and Petroleum Sites) Regulation 2014.

- Clause 52 - Ground and strata support.
- Clause 85 Inspection Plan, (5) (g), (5) (h).
- Schedule 1, Part 1 Mines, 1 Ground or strata failure

NSW Code of Practice - Strata control in underground coal mines.

- 3.2.7 Pillar design methodologies
- 5.1 Monitoring.
- 5.2 TARPs.

MDG 1005 - Manual on Pillar Extraction in NSW Underground Coal Mines.

Appendix B. Assessment system explained

The NSW Resources Regulator uses a bowtie framework to develop the assessment templates used to 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

During each mine's onsite assessment, inspectors rate each control support and record the findings. Points are awarded depending on whether there was evidence that the control support had been documented and / or implemented.

For the finding outcomes in this report, points were awarded for each control support identified within a critical control. An effective control support is allocated four points where the control is assessed as fully implemented and documented. An overall assessment result for the critical control is 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%.

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

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

Critical control calculations also take 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.

Assessment results 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