# Discussion Paper

# Safety of Persons in Proximity to Underground Coal Mine Openings

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# Executive Summary

Following the Pike River underground coal mine explosion in New Zealand, 2010, rescue workers were prevented from entering the mine due to a risk of further explosions. However, rescuers were allowed to enter areas around mine entrances which presented similar risks, it was only luck that prevented them from being killed from subsequent explosions. Historically, numerous mine workers and rescuers have been killed in proximity to mine entrances from mine explosions. Sadly people around the world are still being killed today.

A review of past events was undertaken to assess the nature of the potential consequences. A survey of current underground coal mines operations was also undertaken to determine industry risk profile and the implementation of suitable controls.

Despite the introduction of formalised risk management practices into legislative requirements for coal mines over a decade ago, adequate controls have not been established around mine entrances to ensure the safety of persons at coal mines. This is arguably a result of Human Factors, Perceptional and Cognitive Errors and a level of organisational (industry) maturity. Whilst there is an obvious risk to underground workers from an explosion, this focus has potentially resulted in a perceptive failure to identify the risk to persons on the surface or in proximity of mine openings. As a consequence coal mine workers are exposed to an unacceptable level of risk.

The survey of current underground coal mines found:

- There are some mines with surface infrastructure in close proximity to mine openings.
- Where mine infrastructure is in proximity to mine openings there is no explosion protection for persons or infrastructure.
- A limited number of mines have clearly defined exclusion zones around mine openings.
- QMRS has defined High Risk Zones around mine openings for GAG operations, but is not clearly referenced for other operations.
- NSWMR have identified but not quantified requirements for safety of persons from secondary explosions.
- Few mines have CCTV monitoring of mine entrances.

In order to reduce the risk to an acceptable level a regulatory amendment is required to:

- Require mines to clearly define and establish risk zones around mine openings
- Install protection barriers for infrastructure within high risk zones.
- Install monitoring on mine openings to assist with analysis of underground incidents.
- Pre-install monitoring equipment that ensures rescue workers are not required to enter zones around mine openings.

An industry standard would be of value to all mines. It would be of benefit if the standard were based on scientific data and documented risk management practices. Action must be taken to ensure that coal mine workers are not exposed to an unacceptable level of risk.

Cover Photo. An illustration of the 1956 Springhill Mine Explosion, Nova Scotia, Canada.

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## Discussion

In reviewing the Pike River Royal Commission Report, it was apparent that whilst rescuers were prevented from entering the mine, rescue and recovery workers were allowed in close proximity to mine openings. There were 3 subsequent explosions. It appears to have been only luck that prevented further fatalities from those explosions. Adequate controls had not been established to ensure the safety of persons around mine openings.

A study of Australian and international disasters highlights that it is an area of emergency management which is not adequately controlled. Evidence of this is provided in this discussion paper.

This discussion paper is intended as a point of reflection, consideration, discussion and opportunity for improvement for our industry. We don't need another disaster to remind us of the risks associated with underground coal mining.

I urge you to consider the potential risks on the surface from underground explosions. Don't ever think that this couldn't happen at your mine. I believe that we all collectively need to improve the safety of persons on the surface around underground coal mine openings. I appreciate your consideration and discussion of this topic.

Mark Parcell.

# Hypothesis

The Australasian underground coal mining industry does not adequately manage the risks associated with injury to people and damage to equipment/infrastructure in proximity to mine openings, in the event of, or as the result of the risk of an underground coal mine explosion.

Photo 1 – On the 31st of July 1972 the Box Flat Colliery, near Ipswich Queensland, exploded killing 17 men. Three of them were standing at the surface near the mine opening.

# Introduction

Underground coal mines have been exploding around the world for hundreds of years[1]. When explosions propagate through mine openings, or are vented, significant explosive force and irrespirable gases are expelled through the mine opening. These explosive forces and gases have the potential to result in fatal injuries to personnel, either in the immediate vicinity or some distance from the blast. Further, there is a risk that blast debris may be propelled significant distances potentially resulting in fatal injuries or catastrophic infrastructure damage.

These risks continue to be present today. Evidence of this is clearly apparent in the report of the Royal Commission on the Pike River Coal Mine Tragedy[2] in New Zealand in 2010. Immediately following the first explosion, mine employees were authorised to go to the return shaft[3].

> "*During the early evening of 19 November Mr White authorised employees to fly to the main vent shaft with handheld monitoring devices and sample bags to obtain atmospheric samples. This was hazardous, as the men had to enter the fan housing to gain access to the top of the shaft"[3].*

Despite rescuers not entering the mine following the initial explosion on the 19th of November 2010, rescue workers were in close proximity of mine openings and further fatalities were lucky not to occur during subsequent explosions. Figure 8.10 from Volume 2 of the Pike River Royal Commission Report[2] (below) shows three men standing in close proximity to the return shaft at Pike River (and another person taking the photo), already damaged by the first explosion.

Figure 8.10: The surface fan after the first explosion

The shaft collar area and infrastructure was subsequently destroyed by additional explosions. It was only luck that rescuers were not in the area at the time of subsequent explosions. Video footage of the 4th Pike River explosion.

Despite the international assistance provided to Pike River, including assistance from Australia, exclusion zones were not consistently established around mine entrances and rescue workers were exposed to unacceptable levels of risk. In her book, Tragedy at Pike River Mine, Rebecca

Macfie describes the moment an explosion is vented up the slim line Shaft at Pike, only luckily not injuring or killing rescuers working in the area.[4] This is a multiple fatality risk.

There are approximately 50 underground coal mines in Australasia (15 in Queensland, 32 in New South Wales, 3 in New Zealand – and a number under care and maintenance). This discussion paper applies to all of those mines, and organisations who provide services to those mines in the event of an emergency (including Mines Rescue Services).

The discussion applies in two general concepts:

a. Mine design and construction,
b. Mine operations. Mine operations can be further divided into:
    i. Normal operations,
    ii. When there is an identified explosion risk.

The outcomes from the discussion will be universally applicable to all underground coal mines, locally and internationally.

# Method of Research

## Literature Review

A review of mine disaster inquiry reports from around the world (Appendix 1) found evidence of a significant history of fatal injuries and significant infrastructure damage around mine entrances resulting from mine explosions for at least the last century (it would be reasonable to assume that it has occurred for centuries before that, but reports are less readily available).

Reports were reviewed from explosions in Queensland, New South Wales, New Zealand, Zimbabwe, Japan, India, Canada, Russia and Turkey. The failure to adequately manage the risk around underground coal mine openings, around the world, over a century is staggering.

Further investigation of local arrangements included a review of Queensland and New South Wales legislative requirements, Queensland and New South Wales Mines Rescue Service Operational Guidelines, including GAG Operational Guidelines and a review of Level 1 Emergency Exercise Reports.

The safety of mines rescue personnel, or mine workers involved in emergency activities has been highlighted following the Box Flat explosion in 1972[9], where seven members of the Queensland Mines Rescue Brigade were killed during operations and 13 men were killed sealing a fire at Kianga No.1 Colliery, near Moura in 1975[10]. The safety of rescuers is highlighted in the withdrawal of rescuer workers from the Moura No.4 Mine explosion in 1986[11] and the prevention of rescue workers entering the mine following the Moura No.2 explosion in 1994[12] and Pike River, 2010[2].

The risk has been explicitly identified in the following inquiry reports

- The Kianga No.1 accident Report[10]:

  *Where possible mine surface buildings should be positioned out of the direct path of any underground explosion.*


- The Moura No.2 accident report stated[12]

*The second explosion occurred at approximately 1220 hours on Tuesday 9 August 1994 and was observed by many of the people on site. The observed effects indicated that it was more violent than the first explosion. The ducting linking the mine fan to the shaft was destroyed, some sections being reportedly launched into the air. Large volumes of dust, smoke and gases, including carbon monoxide, were forcefully emitted from each of the entry tunnels into the mine. The surface facilities including the emergency control room, the gas monitoring room and the bathroom, although being over 250 metres away and to the side of the mine openings were covered with dust. The prevailing wind brought products of combustion from the mine to the surface facilities. Carbon monoxide levels around the surface facilities rose to over 400 ppm and required the use of self-rescuers and immediate evacuation of the area.*

*Contamination of the atmosphere around the surface buildings continued after the main blast with smoke continuing to issue from the underground tunnels. This made the Emergency Control Room unfit to use and, as a result, gas analysis equipment was relocated to a safe position several kilometres away in the open cut mine office complex.*


Despite these recommendations, mines today continue to construct buildings in proximity to mine openings.

## Legislative requirements

The Queensland Coal Mining Safety and Health Regulation (QCMSHR) requires mines to be able to be sealed without personnel to travel in front of the entrance to seal it (Section 156 1ai) but this is quite limited in scope. If the entrance is not being sealed, there is no requirement to prevent persons from travelling in front of the mine entrance. It is arguable that the intent is that persons are prevented from travelling in front of mine entrances (assumedly when there is an explosion risk – particularly at the time of sealing the mine, but this is not expressly stated). The section is also limited by the fact that no distances are stated or suggested, potentially allowing an assumption that the limitation is just immediately in front of the mine entrance.

Logically, this requirement is in direct response to the past disasters (Box Flat and Kianga and the inability to safely seal Moura 2 and allow for re-entry) which resulted in the deaths of men involved in sealing operations. However, the requirement is narrow in scope and unfortunately neglects the circumstance when there is an explosion risk and sealing is not taking place. The remedy is an adjustment to the Regulation that requires the exclusion of persons from a high risk zone when there is an explosion risk, including persons involved in sealing operations (or GAG, or sampling, or rescue or whatever, not just sealing).

The New South Wales Coal Mine Health and Safety Regulation 2006 does not provide any advice in relation to the safety of persons on the surface of the mine in vicinity of mine openings. The Underground Mine Emergency Management System (Clause 45 b x) requires the mine to be able to be sealed whilst allowing for re-entry to the mine, but provides no guidance in relation to the safety of persons involved in sealing operations. MDG 1020 and

1022 do not provide any guidance in relation to places of safety in respect of exclusion zones around mine openings.

The Draft for Comment WHS (Mines) Regulation 2014 provides requirements in line with the existing Queensland legislative requirements, but does not completely address the risks involved, Clause 69 2c.

> (c) that each entrance from the surface to the underground mine is capable of being sealed remotely so that, for the purposes of the sealing, no person will be required to be in front of, or above, the entrance or the point at which the seal is to be placed, and

It prevents people from being in front of the entrance when being sealed, but for how far? What about if there was an explosion risk in the mine, but it wasn't being sealed? Are people still allowed to stand in front of the entrance? The draft NSW Regulation is limited in the same manner as the existing QLD legislation.

### Mines Rescue Operational Guidelines.

A number of operational guidelines were reviewed from the Queensland Mines Rescue Service (QMRS) and Coal Services (New South Wales) Mines Rescue (NSWMR). The current QMRS Operational Guideline (QMRS OPS0001CD Revision 2, April 2014) does not make any reference to exclusion zones around mine entrances. Section 2 of the Guideline, Mines Rescue Team Deployment, requires an Authority to Enter a mine before undertaking rescue operations, but does not identify high risk zones around mine entrances. It is recommended that the Guideline be updated to include high risk zones around mine openings and the Authority to Enter process applied to persons entering high risk zones.

Superseded QMRS Operational Guideline (MRS001GUIDS September 2006) clearly identified the risk of explosion and proximity to mine entrances. Section 6.3 of the Guideline, Escape, Rescue or Extrication (Part 8) required:

> *Before establishing the control centre and operations base in existing surface infrastructure, due consideration must be given to the possible occurrence, magnitude and effects of any secondary event.*
>
> *If possible, barriers should be erected on the surface to prevent unauthorised access into blast windows of all surface entries.*
>
> *To obtain atmosphere samples from surface entries, after initial establishment of the sampling point, the sample line should extend at least 100m minimum from the entry with due regard given to blast direction.*

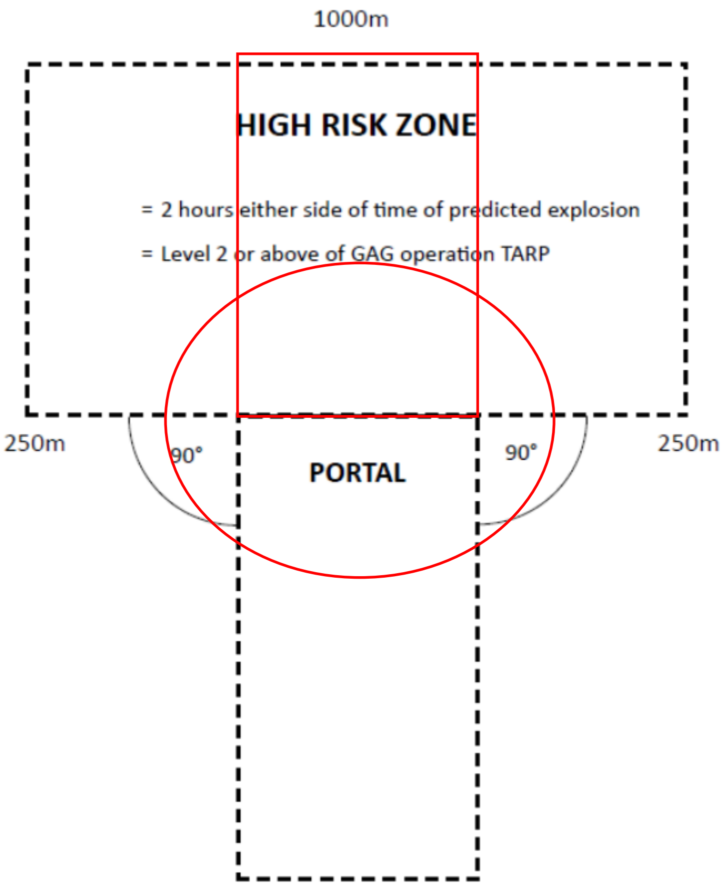
The current NSWMR Operational Guideline (Emergency Preparedness and Mines Rescue Guidelines – Review by July 2014) identifies the risk to surface personnel in Section 6.9 (below).

> *6.9 Can personnel on the surface be safely and effectively deployed and what measures need to be introduced to ensure their safety?*
>
> - *Before establishing the control centre and operations base in existing surface infrastructure, due consideration must be given to the possible occurrence, magnitude and effects of any secondary event.*
> - *Evacuation procedure to designated muster points should be established and made familiar to all required personnel.*

- *Barriers should be erected on the surface to prevent unauthorised access into blast windows of all surface entries.*
- *To obtain atmosphere samples from surface entries, after initial establishment of the sampling point, the sample line should extend at least 100m minimum away from the entry with regard given to blast direction.*
- *Due consideration should be given to direction of prevailing winds over a 24 hour period in relation to atmospheric contaminants from surface entries with continuous monitoring points (audible alarm) established at appropriate locations.*
- *Consideration should be given to surface personnel having access to adequate protection from potential atmospheric contamination.*
- *Consideration should be given to safety of neighbours and public roads*
- *All exposed non-mining personnel should receive instruction in the use of escape breathing apparatus.*

Whilst this is the best example found of awareness of risk in proximity of surface entrances. It is limited by the fact that no guidance is given with respect to the size of potential blast zones and persons are required to enter a blast window to establish a sampling point and then extend it 100m from the entry. Quite simply, mines must establish the sample point outside of the blast window. It would be more proactive if the blast window had been previously established and that it is automatically recognised when the explosion risk is identified.

In 2008, the Queensland Chief Inspector of Coal Mines required QMRS to demonstrate that GAG operations were being undertaken in a place of safety[13]. Following industry consultation QMRS established High Risk Zones around mine entrances for GAG operations. These zones are defined in the QMRS GAG Operating Guidelines (JIU0056CD Revision 6 24 April 2013). High risk zones are established around mine portals and shafts, but only for GAG operations. The unfortunate part about this is that the explosion risk is most likely present well before the GAG operations are likely to commence. The high risk zones are described and diagrammatically represented in the QMRS GAG Operating Guideline.




Without scientifically or critically analysing the dimensions of the high risk zones, based on information from the review of historical events, the zone dimensions appear adequate. The only point for consideration is that the diagram is disproportional and potentially misleading. It is twice as long as it is wide, but this is not represented in the diagram. The portal width is excessive and the location of the 1000m distance is potentially confusing. It is recommended that the QMRS update this diagram in order to reduce any potential confusion. It is also recommended that the industry adopt this standard as an interim industry standard.

## Level 1 Emergency Exercise Reports

Following the Moura No.2 Inquiry, the Queensland Mines Inspectorate established the Approved Standard for the Conduct of Emergency Exercises[14]. This approved standard has been updated to Recognised Standard 08 Conduct of Mine Emergency Exercises[15] under the Coal Mining Safety and Health Act. Level 1 Emergency Exercises are conducted as State Level Exercises at a Queensland coal mine each year.

The 2012 Level 1 exercise was conducted at Oaky North Mine on the 7th of October 2012[16]. The exercise involved a simulated gas explosion at the mine on the Longwall face. Given the potential for a secondary explosion the Incident Control Team declared a No-Go zone around the shafts on the surface but this was not followed at the main fan site.

> workers. Ratios such as Tricket's ratio or the ratio of hydrogen to carbon were not computed to evaluate the nature of the explosion. Because of the likelihood of a second explosion, the ICT declared a no-go zone around the shafts on the surface, but this was not followed at the main fan site.

Whilst the historical incident reports provide information on past events, they provide no basis for an assessment of current risks for operating mines. In order to assess the risk to operating mines a survey was developed (Appendix 2) and forwarded to current mines in Queensland. Consultation with the Queensland Department of Natural Resources and Mines Inspectorate (DNRM) was undertaken as part of the project and assistance was provided with the distribution of the survey. The interest and involvement of the DNRM is of critical importance to the project with respect to the implementation of actions resulting from the findings of the project.

# Industry Survey

The survey results are included in Appendix 3. 11 out of 15 surveys have been completed and returned.

The survey aimed to consider four key risk factors.

1. The risk to persons from a mine explosion on the surface during normal operations.
2. The identification of exclusion zones around mine openings once an explosion risk had been identified.
3. Secondary explosion risks.
4. Monitoring of mine openings for assessment of underground events. (Given the value gained from the video footage from the portal camera in the Pike River explosions)

The survey results found:

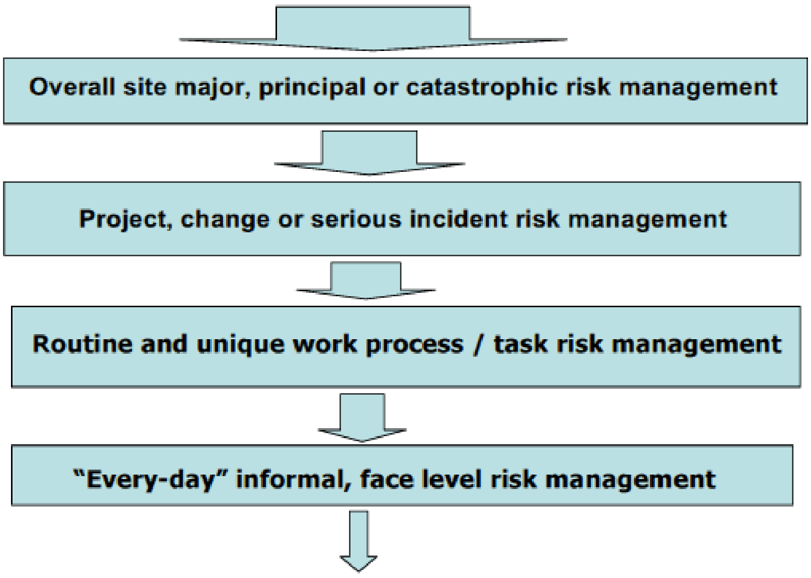
- There are some mines with surface infrastructure in close proximity to mine openings.
- Where mine infrastructure is in proximity to mine openings there is no explosion protection for persons or infrastructure.
- Very few mines have clearly defined exclusion zones around mine openings.
- Very few mines have CCTV monitoring of mine entrances, but do not have any trigger to review the monitoring in the event of an incident.

# Risk Management

Despite the introduction of risk management practices into coal mining legislation over a decade ago, the industry has failed to adequately manage risks associated with the proximity of personnel and infrastructure to mine entrances, even after the identification of an explosion risk.

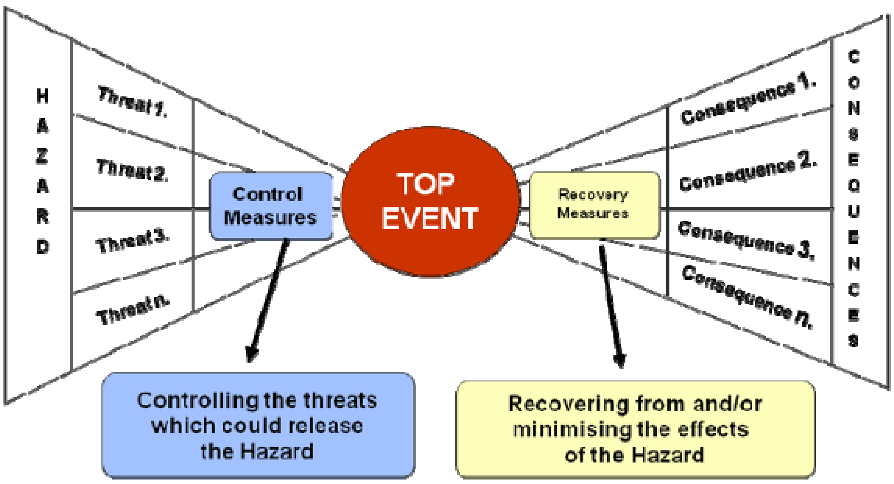
The 4 layer model of minerals industry best practice risk management[5] identifies a cascading hierarchy of risk. The model considers the strategic, tactical and operational decisions made with respect to management of risk at the mine surface. With further consideration of human behaviour and decision making, additional controls are required to provide a reliable, quality controlled process to ensure the safety of persons, equipment and infrastructure. The risk to persons around mine openings should be identified in each layer of the 4 layer model.

**The 4 layer model of minerals industry best practice risk management**

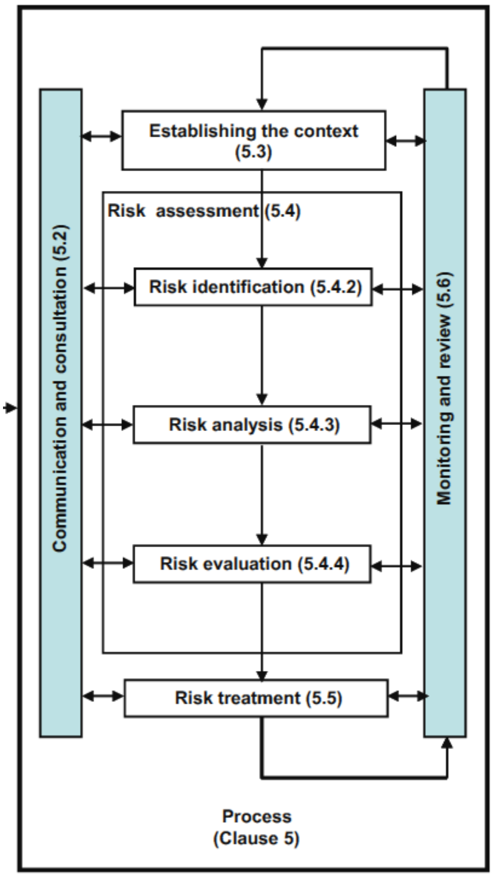



An underground coal mine explosion is clearly a catastrophic risk, based on any assessment of risk dimension.

Based on the potential consequence, effective controls are required to both prevent surface damage from a mine explosion and mitigate the consequences should it occur. Protection of persons on the surface from an underground explosion is a mitigating control and should be identified on the right hand side of the Bow Tie Risk Assessment Model. The model is represented in the diagrammatically below[5].




The risk management process[6] (diagrammatically represented below) requires the identification, analysis, evaluation and risk treatment. Evidence from historical events and the survey of existing underground coal mines indicates that the risk has not been adequately identified, analysed or evaluated, resulting in ineffective risk treatment.




Given the long history of tragic and catastrophic consequences, it is almost incomprehensible that this risk has not been more effectively managed across the Australasian and international coal mining industry.

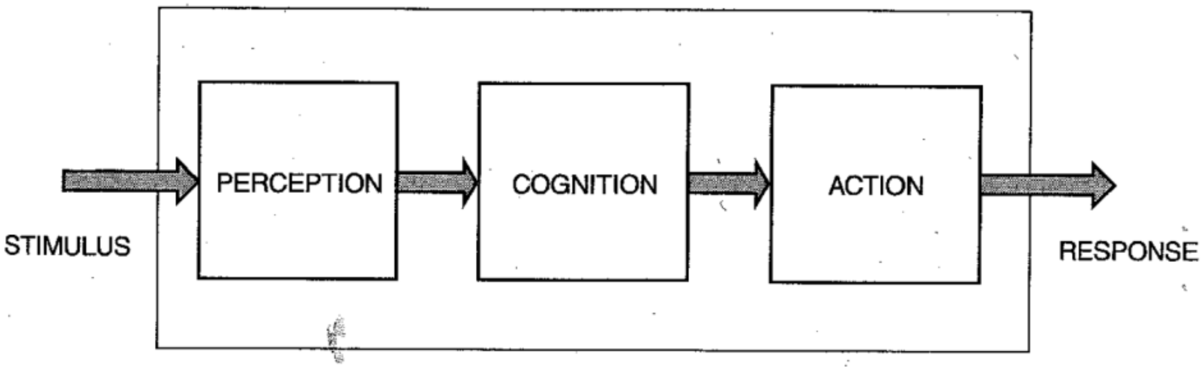
Some of the worst mine explosions have occurred in mines that have never detected methane. These include, Mt Mulligan (Queensland 1921) in which 75 men and boys were killed and the Mitsui Miike Mine (Japan 1963), killing 458 and injuring 839. The Mitsui Miike inquiry found

> *There is very little methane gas in the coal seams of the Miike mine. Thus, the possibility of a gas explosion is relatively low and, even if such an explosion came about, the possibility of its initiating a coal-dust explosion is likewise low.*
>
> *The Miike mine owners were very careless in relation to coal-dust prevention procedures during mining operations.*

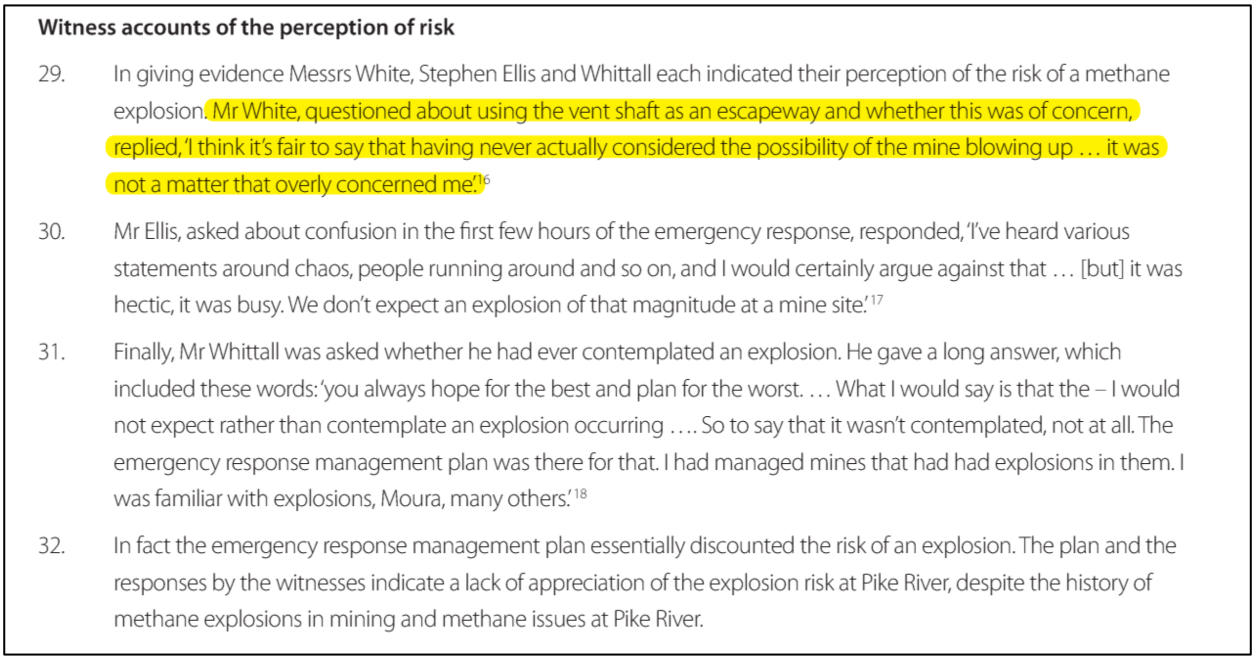
The risk to persons around mine openings applies equally to gassy and non-gassy mines. A coal dust explosion does not need to be detonated by a methane explosion.

## Human Factors

Perceptual and cognitive human limitations[7] are arguably responsible for the failure to provide effective control for mine explosion surface risks. Whilst the risk does not involve individual tasks, it is significantly influenced by the organisational and industry perspective.




The extent of the failure challenges the existing models. Reasons Latent Pathogen model is applicable to workplace accidents, however, in this case, the failure of an industry to address a risk must consider the application of the model beyond an organisation to an industry. The inadequate perception is illustrated by the comments of Pike River Mine Manager, Doug White, when questioned as part of the Pike River Royal Commission[2]:



**Witness accounts of the perception of risk**

29. In giving evidence Messrs White, Stephen Ellis and Whittall each indicated their perception of the risk of a methane explosion. Mr White, questioned about using the vent shaft as an escapeway and whether this was of concern, replied, 'I think it's fair to say that having never actually considered the possibility of the mine blowing up … it was not a matter that overly concerned me.'[16]

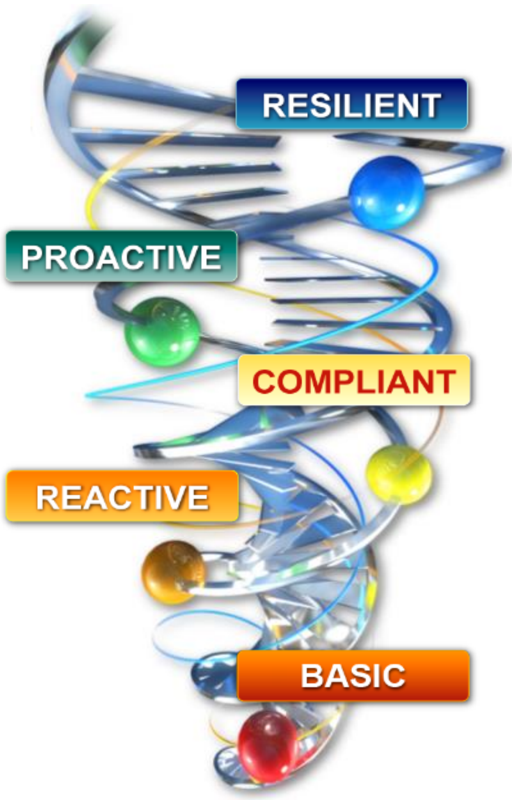
30. Mr Ellis, asked about confusion in the first few hours of the emergency response, responded, 'I've heard various statements around chaos, people running around and so on, and I would certainly argue against that … [but] it was hectic, it was busy. We don't expect an explosion of that magnitude at a mine site.'[17]

31. Finally, Mr Whittall was asked whether he had ever contemplated an explosion. He gave a long answer, which included these words: 'you always hope for the best and plan for the worst. … What I would say is that the – I would not expect rather than contemplate an explosion occurring …. So to say that it wasn't contemplated, not at all. The emergency response management plan was there for that. I had managed mines that had had explosions in them. I was familiar with explosions, Moura, many others.'[18]

32. In fact the emergency response management plan essentially discounted the risk of an explosion. The plan and the responses by the witnesses indicate a lack of appreciation of the explosion risk at Pike River, despite the history of methane explosions in mining and methane issues at Pike River.

It is unreasonable to suggest that the perception of one person at one mine could be representative of an entire industry, although It is difficult to explain how such a risk could be so widely ignored, by so many for so long.

Consideration may be given to the model for organisational maturity[8] if the model were applied to the industry instead of a single organisation. The coal mining industry has emerged from a long history of prescriptive legislation, and although it has an opportunity to manage risks, perhaps the absence of controls for mine surface risks is a function of a basic level of risk management maturity.




Consequently, in order to improve the level of risk to persons throughout the industry in relation to explosion risks around mine openings, some prescribed controls are required by way of legislative amendment, combined with education and motivation. In the longer term, a more resilient industry would have identified and managed the risks without government intervention (which has also apparently failed to establish adequate control for the risks).

## Summary of findings

The evidence from the literature review illustrates that the risk to persons around mine openings is clearly identified, but sadly neglected by mines around the world for centuries. The current Queensland regulatory requirements (whilst at least making a reference to the safety of persons during mine sealing) specifically address past events but fail to give adequate guidance to risks outside the scope of past events (limited to persons involved in sealing).

The industry survey highlights that reasonable controls have not been reliably or consistently applied at current underground coal mines. Mines with surface infrastructure that may be impacted by an underground explosion have not installed effective controls and few mines have established a defined exclusion zone around the mine openings.

The QMRS has established high risk zones for GAG operations, as it was required to do, but not for other operations (at least not clearly defined in the Operational Guideline). NSWMR have established requirements for the assessment of safety of personnel on the surface but provide little guidance on the size of the exclusion zones.

The highly regarded, widely heralded risk management process has not been effective to ensure the safety of persons in proximity to mine openings. The cause of this failure may be attributed to a perceptive failure, or limited industry maturity, or even the fact that the surface risks are obscured by the larger underground risks.

# Limitations on Findings

There is sufficient evidence from historical events to clearly establish that this is a risk with the potential for multiple fatalities. If the review was based only on one mining jurisdiction, say just New South Wales, whilst there has been significant infrastructure damage on the surface, there haven't been any fatalities (at least in the past 50 years). It may be possible to establish a diminished scale of potential consequence.

From the completed surveys, clear industry trends have been established. It is unlikely that the outstanding surveys will significantly alter the project findings. For mines that have not completed the survey, Google Maps and Google Earth were utilised to review the mine opening arrangements. Whilst of limited value, the full details of the survey were not able to be assessed.

The project findings can be extended to other underground coal mining states and countries. A survey in other states or countries would be of value to support any initiative to implement actions to reduce the risk. Personal experience in other coal mining jurisdictions is consistent with the findings from this project, arguably worse.

# Conclusion

The long history of fatalities, injuries and infrastructure demolition resulting from underground coal mine explosions around mine openings is not being adequately controlled in current mining operations. The consequences from past disasters would appear likely to be repeated without some reforms or intervention. The exposure and near misses that were experienced at Pike River are likely to be experienced in Australasia in the absence of more clearly defined controls.

The risk management process has failed to implement adequate controls consistently across the industry. Whether the failure results from a perceptive failure (Human Factors) or lack of industry maturity (Journey Model), the fact is that mine and rescue workers are exposed to unacceptable levels of risk.

A range of fairly simple actions will significantly reduce the risk to persons around mine openings. These controls should not be delayed for another fatality to prompt appropriate action.

# Recommendations

Given current legislative reviews, it is recommended that underground coal mining legislation is amended to ensure the safety of persons in the vicinity of mine openings, not just specifically during sealing operations.

The following recommendations are categorised in the key areas of the survey.

Buildings in proximity of mine openings:

1. New mines must not construct infrastructure in high risk zones.
2. Consideration should be given to an approval process for mine construction to ensure mines are not developed with infrastructure in high risk zones around mine openings.
3. For existing mines with infrastructure in high risk zones around mine openings some form of explosion barrier must be constructed between the opening and infrastructure.

All mines – Establishment of High Risk Zones around mine openings:

1. All mines must establish an exclusion zone around mine openings. It would be of value if there was an industry standard. In the interim, the industry adopt the QMRS GAG Operations High Risk Zone dimensions.
2. High risk zones must be clearly delineated around mine openings.
3. In order to minimise the size of high risk zones, consider installation of some form of explosion barrier around mine openings, such as bunding around explosive magazines.
4. Monitoring infrastructure for mine openings must be pre-installed outside of the high risk zone so that persons do not have to enter the zone to establish monitoring when an explosion risk occurs.
5. Update the Emergency Management Plans to prevent access into high risk zones.
6. Establish a process to permit persons to enter high risk zones.

Monitoring of Mine Openings

1. Install CCTV monitoring for mine entrances to assist with incident analysis.
    a. Include some monitoring device to show normal airflow into the mine (like the innocuous piece of tape on the rib in the Pike River portal).
2. Include a trigger to review monitoring data following potential emergency situations.

Risks about the safety of persons in the vicinity of mine openings be included in industry inductions in order to educate persons of the potential risk.

# Future work

- Validation of the QMRS GAG Operations high risk zone be undertaken to support the adoption of that standard as an industry standard. This validation should not prevent that standard being adopted as an immediate interim measure.
- Communication of these findings should be made to the industry at appropriate forums, including the Ventilation Officer meeting in July 2014, Mine Manager Association of Australia meetings, or perhaps a Safety Alert.

# Acknowledgement

The assistance of the Queensland Mines Inspectorate has been of significant value in the distribution and completion of the surveys at operating mines.

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# Appendix 1 Extracts from Past Inquiry Reports

Coal mine explosions have been occurring for hundreds of years[1]. Inquiry reports detail an almost unbelievable trail of repeated circumstances and disastrous consequences from around the world. Some of which are detailed below.

### Mitsubishi Hojyo Coal Mine Disaster (1914) - Japan

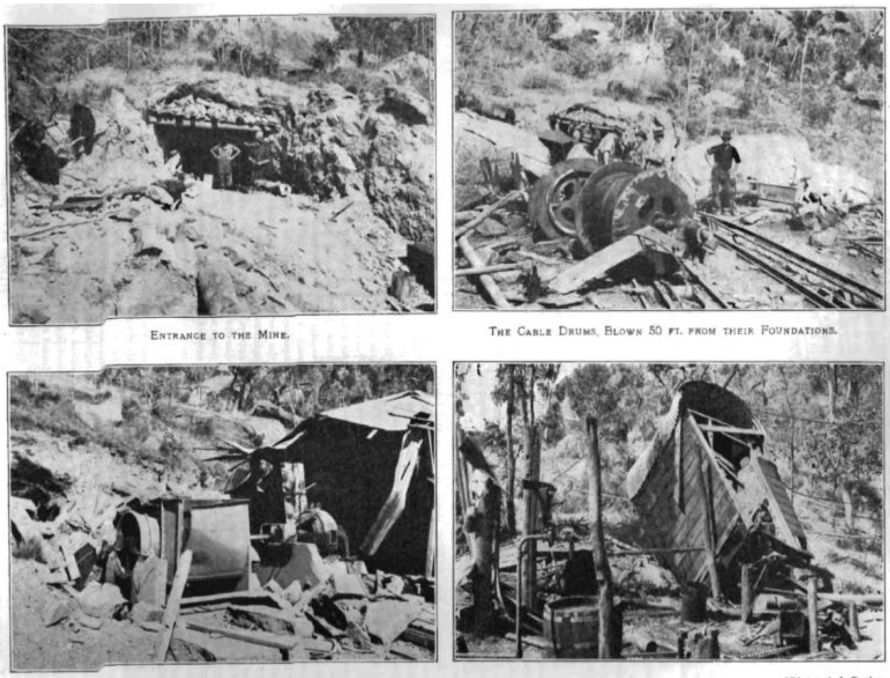
Mitsubishi Hojyo coal mine disaster, the deadliest mining accident in Japan, caused 687 deaths. It was caused by a gas explosion at the Mitsubishi Hojyo coal mine located in the Kyushu Island of Japan. The disaster took place on 15 December 1914.

The gas explosion, which occurred underground, caused thick black smoke to come gushing out of the air vents before it finally blew the elevator cage 15m up into the air with a massive blast. People within a 200m radius of the mine entrance were also impacted by the explosion

### Mt Mulligan Mine, Mt Mulligan Queensland, 19th September 1921.

A pair of jig drums, with shafting, bearings, and foundation, weighing approximately 3 tons, and placed immediately above the tunnel entrance, were hurled from their positions down the incline way for a distance of 50 ft. The switch-house, standing about 25 yds. from the pit mouth and to the left of the road, was overturned, and the switchboard was moved from its foundations. The smithy adjoining was completely demolished. The grass for some distance further away was burned, probably by the flame from the explosion.

George Morrison was working On the surface near the pit month when he was slightly injured by the blast coming from the tunnel mouth.



ENTRANCE TO THE MINE. THE CABLE DRUMS, BLOWN 50 FT. FROM THEIR FOUNDATIONS.

WRECK OF THE EXHAUST FAN, AT OUTLET OF THE FAN TUNNEL. SMITHY AND ELECTRIC SWITCHBOARD, 100 FT. FROM THE ENTRANCE.

[Photos. A. L. Taylor.

MOUNT MULLIGAN COLLIERY AFTER THE EXPLOSION.

Exhibit 16.

## Dobson Colliery, Greymouth New Zealand, 3rd of December 1926.

**STONE CRASHES THROUGH ROOF.**

Friday night's explosion was preceded by a warning rumble. One man hurried away, called to his mates to follow, and they just got to a point of safety when a terrific explosion hurled debris hundreds of yards and a rock of about 150lb weight a distance of a quarter of a mile. Near the hotel another big stone crashed through the roof of Mr. Roberts's house, and fell close to a sleeping child. About ten houses were then vacated in North Dobson.

The first explosion blew one block of concrete of twenty tons weight from the entrance of the mine, and last night's explosion blew the same block a further ten feet. Friday afternoon's explosion at 2.55 o'clock was not so severe.

## Springhill No.4 Colliery Explosion, Nova Scotia, Canada 1st of November 1956

The resulting explosion blew the slope up to the surface where the additional oxygen created a huge blast which levelled the bankhead on the surface - where the coal is hauled out from the mine in an angled shaft into a vertical building. Most of the devastation was sustained by the surface buildings, but many miners were trapped in the shaft along with the derailed train cars and fallen support timbers and other items damaged by the explosion.

An eyewitness account described: “She looked up and saw men in the distance somersaulting high in the air”. Margie Guthro hurried to the pit, learned instantly that her two uncles, surface workers, had been caught and burned to death.

All the buildings that covered the No.4 mine portal were burning. The wives of some of the men trapped in the burning buildings had always corrected anyone who referred to their husbands as “miners” – as if to emphasize, “No, dear, my Leonard is a surface worker”, she could keep her man out of danger. But, this time, surface workers were killed.

## Wankie Colliery Explosion, 6th June 1972, Zimbabwe.

The policeman was blown fifty yards, his box nearly demolished. A heavy trolley used for carrying miners in and out of the shaft shot out like a missile and smashed into a wall lining the top.

Four Africans near the top of the shaft were killed and eight injured, one of whom Fred Bezuidenhout pulled away. The injured man died later.

## Box Flat Colliery, Ipswich Queensland. 31st July 1972.

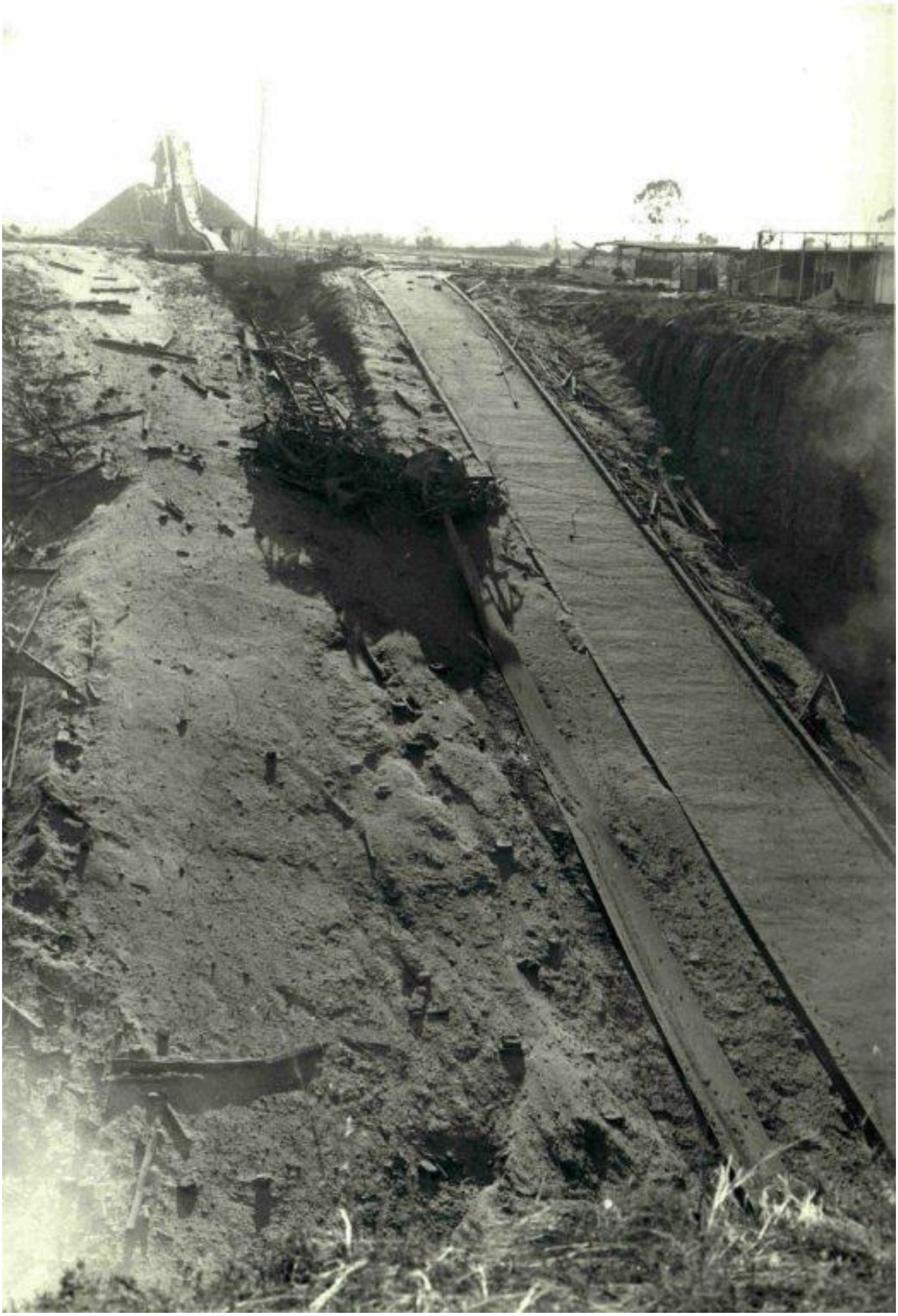
On the 31st of July 1972 3 men were killed standing in proximity of a mine entrance at the time of the Box Flat mine explosion near Ipswich. The explosion also killed 14 men underground.

## Kianga No. 1 Underground Mine explosion 20th September 1975

In 1975 surface equipment and infrastructure was destroyed in the Kianga disaster, near Moura in Central Queensland which claimed the lives of 13 men underground.

The Kianga No.1 Underground Mine Accident Warden's inquiry specifically recommended:

| | |
|---|---|
| (f) | Where possible mine surface buildings should be positioned out of the direct path of any underground explosion. |



## West Wallsend, NSW, 8th of January 1979.

In January 1979 surface infrastructure was severely damaged in the West Wallsend mine explosion. Fortunately no one was killed in the explosion, either on the surface or underground. However, significant infrastructure damage occurred.

Persons were engaged in a range of activities following the explosion in close proximity to mine entrances. Had there been a secondary explosion, multiple fatalities would almost certainly have resulted.

Huntly West Mine, New Zealand 23rd of September1992.

The Huntly West Mine is probably the most graphic example of what not to do. Mine infrastructure was constructed in direct line with the mine openings. Fortunately the risk of explosion had been identified prior to the explosion and the surface buildings (and the mine) evacuated prior to the explosion (by order of the Chief Inspector).

## Westray Mine, Nova Scotia, Canada. 9th May 1992

An explosion at the Westray mine in Nova Scotia, Canada killed 26 miners. Substantial damage occurred at the surface of the mine.

## Moura No.2 Underground Mine. 7th of August 1994.

In 1994 at the Moura No.2 Mine disaster, emergency coordinators were forced to evacuate from the surface buildings following the second explosion.

The following information has been extracted from the inquiry report:

> The second explosion occurred at approximately 1220 hours on Tuesday 9 August 1994 and was observed by many of the people on site. The observed effects indicated that it was more violent than the first explosion. The ducting linking the mine fan to the shaft was destroyed, some sections being reportedly launched into the air. Large volumes of dust, smoke and gases, including carbon monoxide, were forcefully emitted from each of the entry tunnels into the mine. The surface facilities including the emergency control room, the gas monitoring room and the bathroom, although being over 250 metres away and to the side of the mine openings were covered with dust. The prevailing wind brought products of combustion from the mine to the surface facilities. Carbon monoxide levels around the surface facilities rose to over 400 ppm and required the use of self-rescuers and immediate evacuation of the area.
>
> Contamination of the atmosphere around the surface buildings continued after the main blast with smoke continuing to issue from the underground tunnels. This made the Emergency Control Room unfit to use and, as a result, gas analysis equipment was relocated to a safe position several kilometres away in the open cut mine office complex.
>
> Smoke and dust were emitted continuously from the entry tunnels after the explosion. Mine ventilation was reversed with the upcast shaft becoming the fresh air intake for the mine. These observations led to an assumption that active fires remained underground.

## Upper Big Branch, West Virginia, USA 5th of April 2010

Following the explosion at Upper Big Branch in April 2010, large numbers of mines rescue members were sent into the mine for body recovery of the victims. Existing protocols were not followed and large numbers of rescue workers were exposed to unacceptable risk.

> *The decision of the Upper Big Branch Command Center to send large numbers of mine rescue teams underground to recover the bodies, despite the fact that the entire mine had not been inspected by rescue team members and all possible ignition sources had not been determined to be extinguished, and more significantly the lack of adequate back-up teams, was a departure from mine rescue protocol.*
>
> *By proceeding in this manner, the Command Center decided that if the recovery of the victims' bodies was accomplished quickly (i.e., with as many mine rescuers underground as possible) the overall risk would be lower than the standard, more methodical approach. Their decision was further complicated by the fact that victims were spread over such a large area.*
>
> *During this "quick" approach, there was one large movement of air in the Headgate 22 section. Investigators were unable to determine what caused the event. Although there were no injuries or deaths, the potential existed for disastrous consequences. There were large numbers of mine rescue teams underground, but they were not backed up by an equal number of teams on the surface.*
>
> *One major coal company, CONSOL Energy, deemed the risk to their mine rescue team members unacceptable because a safer alternative recovery scheme was available. This plan would have included a complete preshift examination, which would have ensured that all possible ignition sources were extinguished prior to entry and adequate backup teams made available. Although this plan would have taken longer and the recovery of the victims' bodies could have been significantly delayed, the mine rescue teams would have been in a much less precarious situation.*
>
> *The Command Center decided to forego standard mine rescue protocols – procedures designed to safeguard the lives of rescue team members – in an effort to remove the bodies more expeditiously. The decision scales were tipped toward speed, not security and safety.*
>
> *This issue needs to be carefully examined by the mine rescue community and new technology developed which provide improved information upon which to make judgments affecting the lives of mine rescuers.*

## Anjan Hills Mine, Chhattisgarh Koriya, India. 7th of May 2010.

Thirty two miners were standing at the mouth of the mine when it exploded. Four miners were killed and 28 injured.

Six members of a technical team were still trapped in the mine, and rescue workers were unable to make contact with them. The mine, operated by South Eastern Coalfields Limited, an undertaking of the Coal Authority of India, is located 50 km from Chirmirri, district headquarters.

"Of the 28 injured, 14 are being treated in the district hospital at Chirmirri, while 14 have been shifted to the Apollo Hospital at Bilaspur," Collector Alok Awasthi said. "S.K. Goswami, deputy general manager, operations, was among the dead."

While the exact cause of the explosion, which occurred at about 11.30 a.m., is yet to be ascertained, Mr. Awasthi told The Hindu that it happened probably when carbon monoxide gas leaked into a mine shaft and caught fire under high pressure and temperature that prevailed in the mine.

The leak and the rise in temperature were detected on Wednesday, and there was no mining operation on Thursday. In the morning, a rescue team and a technical team entered the mine for a safety check.

However, they were trapped in the explosion that spewed scalding fumes to the surface.

Raspadskaya Mine Russia, 8th of May 2010

Most people are familiar with the second explosion at Raspadskaya due to the almost unbelievable video footage of the explosion. Video of Raspadskaya second explosion

The first blast occurred at 20:55 Moscow Summer Time (16:55 UTC) with the second at 01:00 MST (21:00 UTC). The explosions were confirmed by investigators to have been caused by methane gas. A secondary explosion was reported approximately four hours later, with 20 rescue workers now among those missing. The second explosion caused a collapse of the mine's ventilation shaft, drastically reducing the flow of fresh air into the mine.

Rescue efforts were suspended after the second blast. By 18 May 2010, 66 people were confirmed to have died, at least 99 injured and 24 remained trapped underground. Mine infrastructure around mine openings was also destroyed.

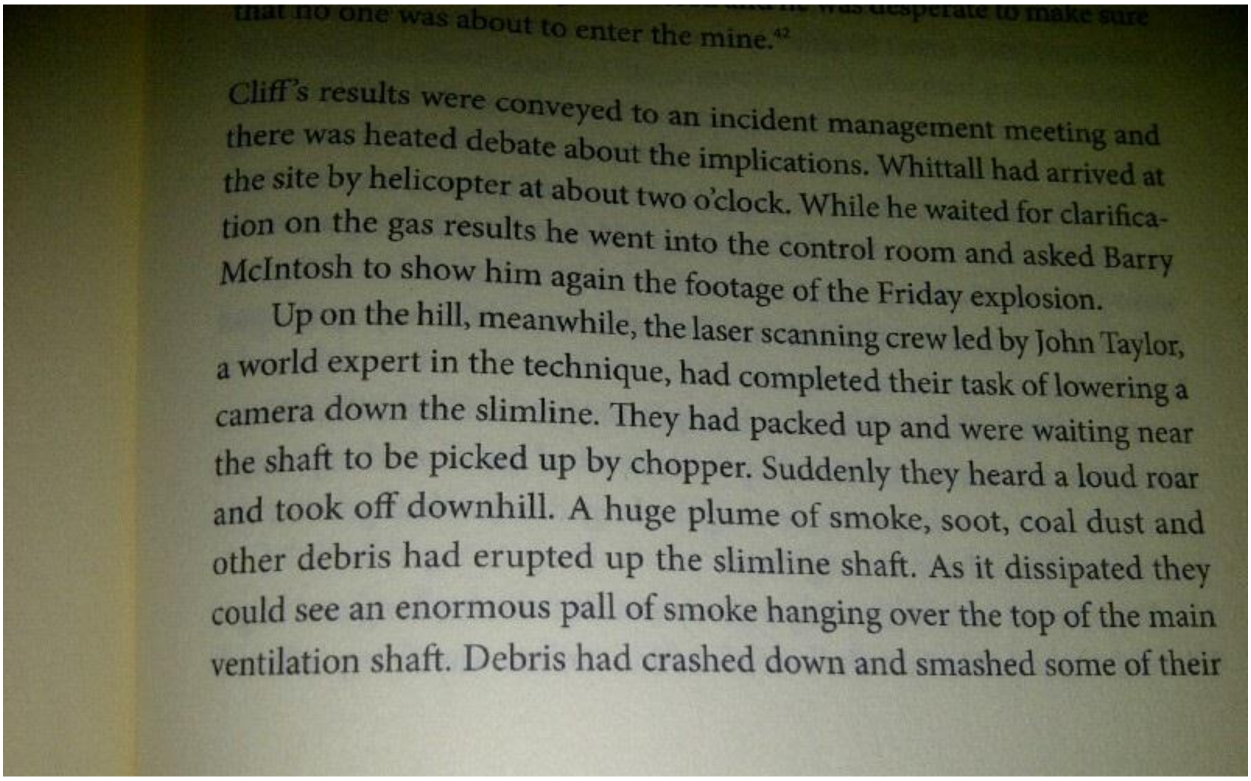
## Pike River, Greymouth New Zealand, 19th November 2010.

In the Pike River Mine Disaster, mine rescuers were prevented from entering the mine but people were not restricted from being in proximity to mine entrances. It is arguable that it was only luck that prevented fatalities of persons on the surface at Pike River.

Figure 8.10: The surface fan after the first explosion

## Pike River 4th Explosion

In the book Tragedy at Pike River Mine, Rebecca Macfie recounts the near miss of the Cal Scan specialist's lucky escape from one of the mine explosions.



that no one was about to enter the mine.[42]

Cliff's results were conveyed to an incident management meeting and there was heated debate about the implications. Whittall had arrived at the site by helicopter at about two o'clock. While he waited for clarification on the gas results he went into the control room and asked Barry McIntosh to show him again the footage of the Friday explosion.

Up on the hill, meanwhile, the laser scanning crew led by John Taylor, a world expert in the technique, had completed their task of lowering a camera down the slimline. They had packed up and were waiting near the shaft to be picked up by chopper. Suddenly they heard a loud roar and took off downhill. A huge plume of smoke, soot, coal dust and other debris had erupted up the slimline shaft. As it dissipated they could see an enormous pall of smoke hanging over the top of the main ventilation shaft. Debris had crashed down and smashed some of their

Of Critical importance of the assessment of the events at Pike River was the portal video camera and the innocuous piece of tape on the opposite rib. This allowed an analysis of the potential cause of the explosion and of the survivability of the persons in the mine.

It was unfortunate that there was no trigger to review the footage when there was a concern for the safety of persons in the mine. This should be an automatic trigger for mines today. Every mine should have a camera on the mine opening and a trigger to review the footage should any concern be raised about an event in the mine.

## Soma Turkey May 2014

Whatever the cause of the disaster, 301 miners died following a fire in the mine. Hundreds of people gathered around the mine entrance to wait for news of rescued miners. Had there been a mine explosion, the death toll could have easily doubled.


Even better, without any sealing capability, mine workers stand in front of the portal to seal the mine.


Queensland Coal Mining Safety and Health Regulation (1999)

Section 156 of the CMSHR
(1) The site senior executive must ensure—
(a) each entrance from the surface to the underground mine is capable of being sealed—
(i) at the surface without requiring persons to travel in front of the entrance to seal it; or
(ii) if the entrance is a vertical shaft—
(A) in the way mentioned in subparagraph (i); or
(B) in a roadway at the bottom of the
shaft;
and (b) at least 1 entrance from the surface to the
underground mine has a mine entry airlock.

So whilst the Regulation requires no one to go in front of the entrance to seal it, there is no specific requirement for the establishment of an exclusion zone. The requirement is very narrow in scope. It is limited by a number of factors.

a. The Regulation is limited to mine sealing. If there was an explosion risk at the mine and sealing was not being carried out, the Regulation does not prohibit persons travelling in front of the entrance.
b. If sealing was being carried out, the limitation is for persons not to travel in front of the entrance, but there is no guidance on how far the restriction extends. Evidence above shows that the effects can be 100’s of meters from the entrance.

# Appendix 2 Mine Survey

The following survey was developed in consultation with the Queensland Department of Natural Resources and Mines. The Survey was distributed on behalf of the Chief Inspector of Coal Mines to Site Senior Executives of coal mines for completion.

Survey - Surface Risks from an Underground Coal Mine Explosion

The purpose of this survey is to assess the level of risk and consider the availability of appropriate controls for persons on the surface who may be exposed to risks from an underground coal mine explosion (either gas or dust).

**Situation 1.** Normal Operations

Normal operations means that the mine is operating normally. There is no detection of an increased risk of an explosion.

Examples of explosions which occurred during the normal operations of the mine include:

- Blakefield South (Initial explosion).
- Pike River (Initial explosion),
- Upper Big Branch
- Moura 4,

| | | | | |
|---|---|---|---|---|
| 1. | How many mine openings are at the mine? This includes any borehole in excess of 0.5m diameter. | Drifts | Shafts | Other |
| | | | | |
| 2. | Are there surface buildings in proximity of mine openings (likely to be damaged in the event of an explosion or affected by contaminants ejected from the mine – gas cloud)? | | | |
| 3. | Are there any barriers between the mine openings and surface buildings to minimise the damage from an explosion? (if applicable) | | | |
| 4. | What risk controls are in place on the surface to protect the safety and health of personnel in these areas i.e. self-rescuers. | | | |

**Situation 2**. Identified Explosion Risk

An identified explosion risk means that there is an increased risk of an explosion (either source of ignition or accumulation of fuel) and has resulted in the withdrawal of personnel to a place of safety, (most likely the surface and preferably outside of a high risk zone).

| | | |
|---|---|---|
| 1. | Does the mine have a TARP to withdraw persons to a place of safety in this situation? | |
| 2. | Is there a specific exclusion zone around all mine openings? | |
| 3. | Is there an exclusion zone around the mine fan? | |
| 4. | Are the zones clearly defined for each opening? | |
| 5. | What are the dimensions of the exclusion zones? | |
| 6. | Is emergency infrastructure pre-installed outside of the exclusion zones? (such as gas sampling points) Or does someone have to enter the exclusion zone to establish monitoring. | |
| 7. | Is a sentry allocated to prevent unauthorised access to mine openings? | |
| 8. | Is there any advice for the location of the sentry to ensure that they are not at risk? | |

**Situation 3**. Post Explosion Emergency Response

An explosion has occurred and the mine is undertaking emergency response.

Examples of mines that have suffered an explosion and there is a risk of secondary explosion:

- Just about all of them until it is proven that there is no fuel or ignition source, including:
- Blakefield South,
- Pike River,
- Moura 2.

| | | |
|---|---|---|
| 1. | Are persons restricted from entering all exclusion zones or just entering the mine? | |
| 2. | Does a person have to enter the exclusion zone to initiate mine sealing? | |
| 3. | Are the entrances to the mine within the confines of a box cut or opencut excavation? If so does the exclusion zone preclude personnel from the confines of the boxcut or opencut excavation? | |
| 4. | Does a person have to enter the exclusion zone for gas sampling? | |
| 5. | Is there any other reason for a person to enter an exclusion zone? | |
| 6. | Can the emergency portal sealing doors be closed from a position outside of the exclusion zone? | |
| 7. | Is there an existing process to allow a person to enter an exclusion zone? | |

## Monitoring of Mine Openings

The video footage of the explosions at Pike River was vital for assessing the magnitude of the explosion in order to determine what may have occurred at the mine.

| | | |
|---|---|---|
| 1. | Does the mine have CCTV monitoring of mine openings?<br>(Portals and fan – or other). | |
| 2. | Is there a trigger to review CCTV monitoring in the event of concern of a possible explosion? | |

# Appendix 3 Survey Results

| | Mine | Ideal response | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section A | Normal Operation s - s | | | | | | | | | | | | | | | | |
| | Number of Drifts | | 1 | 2 | 2 | 2 | 6 | 2 | 3 | 4 | | | 0 | 2 | 4 | 1 | 2 |
| | Number of Shafts | | 2 | 2 | 10 | 5 | 1 | 3 | 4 | 5 | | | 1 | 0 | 1 | 0 | 1 |
| | Number of other openings | | 1 GAG connecti on | 0 | 0 | 0 | 2 | 0 | 0 | | | | 13 | 0 | 1 | 0 | 1 |
| | Surface Buildings likely to be damaged. | Surface buildings away from mine entrances and away from line of blast | Yes | No | Possible | No | No | Yes | >500m | Possible buildings 175 m from portal | | | No | No | Not sure of location | Yes | Gas |
| | Surface buildings in proximity that may be affected. | If surface buildings are in proximity to mine entrances have appropriate protection (gas - including self-rescuers) | Not in direct line but in proximity . | Yes | Possible | No | No | Yes | >500m | No | | | Yes Gas | Nil | In pit substation | Yes | No |
| | Any barriers for buildings likely to be damaged | A barrier is installed similar to an earth bund around an explosives magazine | No | NA | No | NA | NA | No | No | No | | | No | NA | No | No | No |
| | Other risk controls | Self-rescuers to protect people from a gas cloud | Rescuers are available | Multiple egress routes | Evacuation procedure and MR building out of exclusion zone | Buildings in close proximity | NA | Explosion barrier UG | Rescuers are available | Portal faces away from buildings | | | Remote facilities | NA | NA | Nil | Rescuers available |

| Section B | Identified or increased risk of explosion | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Does the mine have a TARP to withdraw persons to a place of safety in this situation? | The TARP withdraws people from the mine and also any exclusion zone. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | | | Yes | Yes | Yes | Yes | Yes |
| 2 | Is there a specific exclusion zone around all mine openings? | Specific exclusion zones established around all mine entrances / openings. | No | Says one would be established | No | Yes | No but gates are 1000m away | Yes | No | No | | | Yes | NA | No | Yes | No |
| 3 | Is there an exclusion zone around the mine fan? | A clear exclusion zone is established around the mine fan - see West Wallsend Photos | No | Says one would be established | Yes and no | Yes | No | Yes | Not really | No | | | Yes | NA | 150m | No | No |
| 4 | Are the zones clearly defined for each opening? | Clearly defined zones for each mine entrance | No | No | No | Yes (Unsure) | No | No | No | No | | | On plan | NA | No | On a plan | No |
| 5 | What are the dimensions of the exclusion zones? | To be determined and documented | Not determined | Not determined | Not determined | Yes | QMRS | Not determined | Not determined | | | | QMRS | NA | Portal 50 Fan 150 | $60^0$ | Not determin ed |
| 6 | Is emergency infrastructure pre-installed outside of the exclusion zones? (such as gas sampling points) | Sampling tubes preinstalled on the surface from the fan and portal to outside of the exclusion zones. | Pre-installed | Tube bundle as installed | Tube bundle as installed | Tube bundle as installed | Tube bundle as installed | Tube bundle as installed | Yes | No | | | No | NA | No<br>Yes | NA | No |
| 7 | Is a sentry allocated? | Sentry located outside the exclusion zone. | Yes duty card 2.1 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | | | No | Yes | Yes | Yes | Yes |
| 8 | Is there any advice for the location of the sentry to ensure that they are not at risk? | The sentry needs to know if they are at risk or not. | No | No, but are remote | Yes | Yes | Yes | Yes | Yes | No | | | No | Yes | Yes | Yes | No |

| Section C | Post explosion (possible secondary explosion) | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Are persons restricted from entering all exclusion zones or just entering the mine? | Clearly definition that persons not to enter the exclusion zones. | Security to prevent unauthorised access. But not for the exclusion zones. | Exclusion zones | Just the mine, zones not established | Exclusion zones | Exclusion zones | Just the mine, zones not established | Exclusion zones | Mine only | | | Mine only | NA | Exclusion zones | Yes | Yes |
| | Does a person have to enter the exclusion zone to initiate mine sealing? | Initiate mine sealing without entering an exclusion zone. | Yes | No | Yes | No | ? Unsure | No | No | Yes, for now | | | Yes for now | NA | No | NA | No |
| | Are the entrances to the mine within the confines of a box cut or opencut excavation? | Persons prevented from entering the excavation. | No | In open cut but multiple egress | Yes - | No | Yes. | No | Yes | Yes, No | | | Yes Yes | NA | Yes Yes | No | No |
| | Does a person have to enter the exclusion zone for gas sampling? | Gas sampling points outside of the exclusion zone. (Preinstalled). | No | No | YES | No | Yes. | No | No | Yes | | | Yes | NA | Yes | No | Yes |
| | Is there any other reason for a person to enter an exclusion zone? | | No | No | Possibly | No | No | No | No | No | | | Yes | NA | No | No | No |
| | Sealing from a position outside of the exclusion zone? | Mine sealing completed without entering the exclusion zone. | Not currently but planned | Yes | No | Yes | Yes. | Yes. | Yes. | No, but being corrected | | | No but being correct ed | NA | Yes | Yes | Yes |
| | Is there an existing process to allow a person to enter an exclusion zone? | A risk management process for allowing re-entry of the high risk zone | Stated as a risk assessment but not sure this is formalised with pre-set considerations. | No | Yes | No | Yes. | No | Yes | No, just the mine | | | No | NA | Yes | No | Would be but not defined |

| Section D | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Does the mine have CCTV monitoring of mine openings? (Portals and fan – or other). | A mine should have portal monitoring. | No | No, but in process | Yes | Yes | No | No | No, but in process | No | | | Yes | No | Partial | Plan ned | No |
| | Is there a trigger to review CCTV monitoring in the event of concern of a possible explosion? | There should be a prompt to review portal video footage. | No | No | No | No | No | No | No | No | | | NO | No | No | No | No |