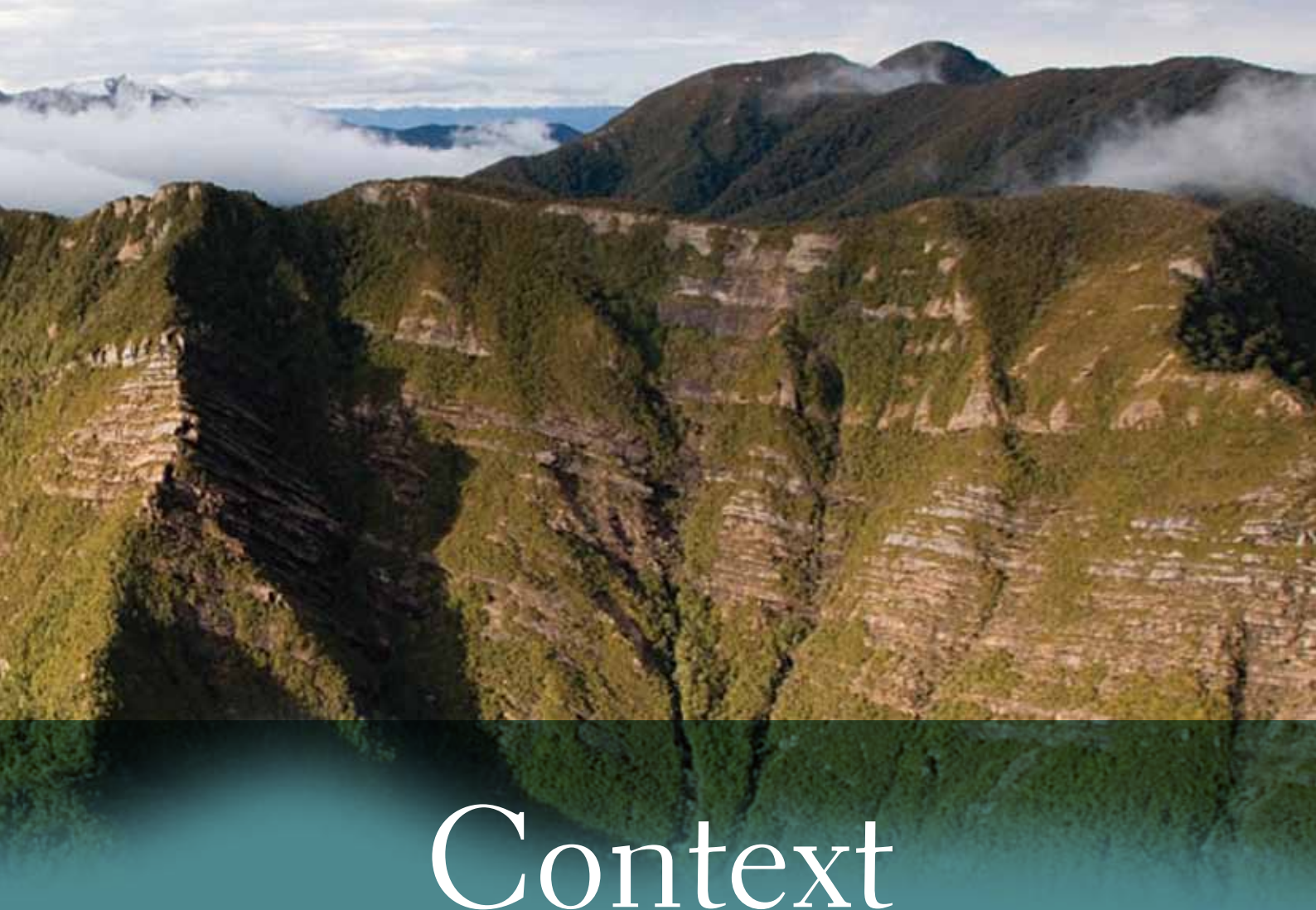


Part 1

+ What happened at Pike River



Context

- + Friday afternoon, 19 November 2010
- + Accident analysis - some concepts
- + The promise of Pike

CHAPTER 1

Friday afternoon, 19 November 2010

A tragedy unfolds: Friday afternoon, 19 November 2010

1. The Pike River coal mine lies under the rugged Paparoa Range on the West Coast of New Zealand's South Island. The mine was comparatively new, having shipped its first coal in February 2010, and the mine workings were not extensive. On the afternoon of Friday 19 November 2010 there were 31 men in the mine.
2. The three Pike mining crews, A, B and C, worked overlapping shifts. A crew worked the night shift, which began on Thursday night at 10:00pm and ended at 8:00am on Friday 19 November. B crew started the day shift at 7:00am and left the portal at 2:50pm to finish their shift at 3:00pm. C crew began the afternoon shift early, at 1:00pm. As recorded on closed-circuit television (CCTV), they entered the portal at 1:13pm.¹
3. Miners who manned the hydro monitor worked 12-hour shifts that ran from 7:00am to 7:00pm. The day shift crew of three men was underground at the time of the explosion.
4. In addition to Pike workers, seven companies had men working underground on contract during the day. Men from each of these companies, save for McConnell Dowell Constructors Ltd and Skevington Contracting Ltd, were in the mine when the explosion occurred.
5. Investigators endeavoured to reconstruct the likely locations of the men who perished.

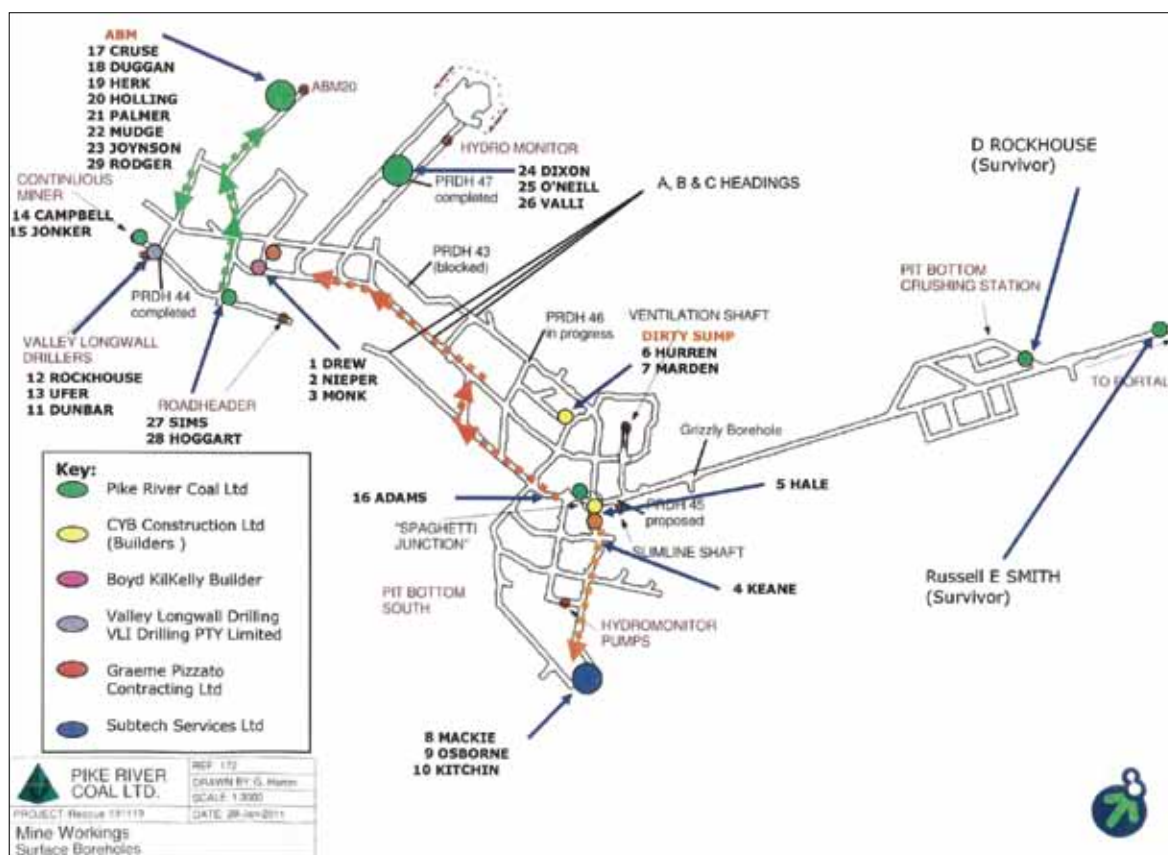


Figure 1.1: Last known position of the 29 deceased and two survivors²

6. The positions can only be indicative. They were fixed from the last sightings of the men by people who were also underground but left before the explosion, and also by reference to the work the men were to undertake that day.

7. Eight men from C crew, Glenn Cruse, Christopher Duggan, Daniel Herk, Richard Holling, Brendon Palmer, Stuart Mudge, William Joynton and Peter Rodger, were manning the alpine bolter miner (ABM), and driving a development road in the north-west corner of the mine. Daniel Rockhouse left the crew, driving a loader to uplift some gravel needed for the roadway. Conrad Adams, the acting C crew underviewer, was last seen near Spaghetti Junction, but could well have headed inbye to rejoin his men at the face.
8. Three men, Allan Dixon, Peter O'Neill and Keith Valli, were manning the monitor in the hydro panel at the most northern location in the mine. Because there were only two men, Blair Sims and David Hoggart, in the roadheader crew – too few to undertake roadway development – they were on maintenance duties near the roadheader. The continuous miner located at the westernmost point in the mine required servicing and engineer Malcolm Campbell and fitter Koos Jonker were undertaking this work.
9. VLI Drilling Pty Ltd employees, Joshua Ufer and Benjamin Rockhouse, were working at the in-seam drilling rig close to the continuous miner. Joseph Dunbar, aged 17, was in the mine on an orientation visit. He was to start work the following Monday, but he went into the mine with two of the company managers and elected to remain with the drilling crew until the end of their shift.
10. Three builders, Michael Monk, an employee of Graeme Pizzato Contracting Ltd, and Kane Nieper and Zen Drew, employees of Boyd Kilkelly Builder Ltd, were constructing a stopping in a cross-cut deep in the mine. Mr Drew, however, was last sighted in a nearby tool box area and could well have been walking back to the worksite at the time of the explosion.
11. John Hale, an employee of CYB Construction Ltd, was a permanent 'taxi driver', ferrying men in and out of the mine on a drifrunner. He was last seen at pit bottom in stone, but was understood to be en route to Spaghetti Junction. Other CYB employees, Andrew Hurren and Francis Marden, were inbye of the junction, preparing a sump area for concrete to be laid.
12. Terry Kitchin, Milton Osborne and Samuel Mackie, Subtech Services Ltd employees, were installing a water pipe in pit bottom south. Mr Kitchin, however, was last sighted in a roadway near Spaghetti Junction and could have been in transit at the time of the explosion. Riki Keane, an employee of Pizzato, was driving a loader used to remove spoil from the work site. His vehicle broke down near Spaghetti Junction sometime after 3:00pm and he was last seen there, trying to restart the vehicle. Daniel Rockhouse assisted him by obtaining hydraulic oil before he continued driving outbye into the drift.
13. As on any work day, others entered and left the mine at various times. A McConnell Dowell day crew of four men worked in stone, developing a stub to house equipment. The day shift finished at 4:00pm and the crew left the portal in a drifrunner at 3:41pm. The night crew of five workers was on the surface preparing to go underground when the explosion occurred.
14. Four employees of Skevington Contracting were also to finish work at 4:00pm and left the mine on the same drifrunner. Two surveyors, Callum McNaughton and Kevin Curtis, were walking out of the mine and flagged down the drifrunner. Earlier still, about 2:00pm, Lyndsay Main, a Coastline Roofing Ltd builder, finished work early and walked out of the mine about 70 minutes before the explosion. Pike technical staff had also been into the mine to undertake various tasks, but had returned to the surface before 3:45pm.
15. Chance played a big part in which men, and how many, remained underground at 3:45pm.

A planned maintenance shutdown

16. Water used in the mine was piped from the Pike River coal preparation plant 8km to the east of the mine, next to the main access road. Because there was to be planned maintenance work at the plant, beginning at midday, underground mining operations were to be halted until water became available again. In the meantime the miners were to undertake pit bottom maintenance tasks.

17. Daniel Duggan was in sole charge of the surface control room. He had started a 12-hour shift at 7:00am. Mid-afternoon he received a phone call from the coal preparation plant to confirm that the maintenance work had been completed and that water to the mine could be restored. He activated the start sequence for the fluming pump system supplying water to the working faces. At 3:44:12pm Mr Duggan used the digital access carrier (DAC) system, which provided simultaneous communication to the work areas at pit bottom, to advise that mining could be resumed.
18. This exchange occurred:

Daniel Duggan: 'Hello ABM or Road header.'

Malcolm Campbell: [Eight seconds later] 'Hey Dan, who you looking for?'

Daniel Duggan: [Three seconds later] 'I was just after ABM and Road header.'³

At this point an unidentified sound interrupted the conversation. Mr Duggan did not interpret it as an explosion at the time. He recognised the voice from underground as that of Malcolm Campbell, an engineer with a distinctive Scottish accent, who was doing maintenance work on the continuous miner.⁴
19. Mr Duggan continued to make calls using the DAC. Over the next almost four and a half minutes he made calls asking whether there were any 'sparkies' (electricians) underground, anyone at the 'monitor place' and, finally, whether there was 'anyone underground'.⁵ The DAC was functioning, but there was no response to his calls.

Signs that all was not well

20. At the same time as the unidentified noise was recorded on the DAC system, alarms in the control room were activated. This indicated that reporting from underground had ceased. Power, ventilation, pump and gas data were no longer being fed to the control room. Previously, when power to underground had been lost, miners would quickly contact the controller. On this day there were no callers. Mr Duggan also tried ringing different sites underground, using the telephone system which, like the DAC, had a back-up battery system, but there was no reply.
21. Meanwhile Douglas White, the statutory mine manager, Stephen Ellis, the production manager, and George Mason, the hydro-mining co-ordinator, were meeting in Mr White's office in the main administration building. At one point the office lights flickered but no one was concerned. At about 3:47pm Mr Duggan spoke to Mr White and told him they had lost power and communication to the mine. Mr Duggan added that he would contact the communications and monitoring engineer, or an electrician.
22. At 3:48pm Robb Ridl, the Pike engineering manager, and John Heads, a contract electrician, entered the control room. Mr Duggan spoke of his concerns and said, 'I've got a real bad feeling about this.'⁶
23. At 3:52pm Mr Duggan again spoke to Mr White and asked whether the Mines Rescue Service (MRS) should be placed on standby. Mr White replied, 'Oh, we won't go there yet, we'll get someone up there.'⁷ Mr White then left his office and went out to the car park near the administration building, where he spoke to Messrs Ridl and Heads. They noticed an unusual smell in the air, like excessive diesel exhaust fumes. Mr White then returned to his office and between 4:01 and 4:04pm he sent three emails on other matters.
24. The explosion had been recorded on CCTV footage taken by the portal camera. This footage was not seen until some time later. Beginning at 3:45:36pm and continuing for about 52 seconds, there was a pressure wave out of the portal. Movement of a tell-tale indicator tied to the rib opposite the camera showed the duration of the wave, and debris coming from the portal indicated the velocity of the explosion.

An electrician enters the mine

25. Following the car park discussion Mr Ridl approached electrician Mattheus Strydom, who was working nearby. Mr Ridl said there was a power outage in the mine and communications had also been lost. He requested Mr Strydom

to head up to the mine and investigate. Mr Strydom asked whether both 'power and communication' had been lost.⁸ He was concerned. Based on his 28 years of mining experience, he regarded this combination as significant. Messrs Ridl and Heads then drove to the mine and arrived at the portal at 4:03pm.

26. Mr Strydom obtained from the McConnell Dowell crew a drifrunner they had intended to use to enter the mine at 4:00pm. He commented to the crew deputy, 'I hope this isn't bad.'⁹ Strydom then obtained from the control room a hand-held gas monitor that could test only for methane. Other gas monitors could test for methane, carbon monoxide, hydrogen sulphide and oxygen.
27. Mr Strydom filled the drifrunner with water and set off to the portal, where he encountered Messrs Ridl and Heads. Mr Heads said that he had already checked the portal substation and that power was on there. This indicated to Mr Strydom that the power outage must have occurred at pit bottom in stone, 1900m into the mine. At 4:11pm Mr Strydom entered the portal, without a self-rescuer, and Messrs Ridl and Heads returned to the administration area.
28. After sending his third email at 4:04pm Mr White went to the control room. Mr Duggan told him the situation was unchanged: there had been no response from underground, and no telemetric communication. Mr White said he would drive to the mine and test whether the portal DAC was working. He arrived there at 4:16pm and successfully called the control room. Mr Duggan told him that Mr Strydom was on his way and that Mr Ridl was returning to the portal to check the ventilation. Mr White responded that there was ventilation going up the tunnel.¹⁰ At 4:18pm Messrs Ridl and Heads went back to the portal. The three men discussed the situation and satisfied themselves that there was a ventilation breeze entering the portal. At 4:23pm they left the portal area.¹¹
29. As Mr Strydom was driving up the drift, his first thought was that 'something just didn't feel right'.¹² He noted that reflector sticks, pieces of PVC pipe wrapped with reflector tape, were missing from the conveyor belt infrastructure to which they were ordinarily tied. He wondered whether the sticks had been removed by a fitter, as the belt was to be decommissioned the following week. He also noted a cordite-like smell, which he likened to diesel exhaust fumes. The smell became stronger as he continued up the drift. Also missing were signs that identified the position of fire hoses. Other items attached to the ribs were displaced. He drove past the decommissioned fresh air base (FAB) at 1500m into the drift. The substation at pit bottom in stone was a further 400m inbye. The air became increasingly thick and the engine of the drifrunner began to falter. Mr Strydom looked for a place where he could turn the vehicle around.
30. Then he saw a light in the distance. Relieved, he went on, and recognised a Jugernaut and, some metres outbye of it, the figure of a man lying on the roadway. The man was on his back, with arms outspread and his head pointing outbye. From Mr Strydom's training, he knew this was the typical position of a person killed by explosive forces. Breathing had become difficult and the engine of the drifrunner continued to splutter. This was a dangerous situation. In fear of his life, Mr Strydom put the drifrunner into neutral and it began to run backwards downhill.
31. Then the engine revived. He put the vehicle into reverse gear and continued backing as fast as he could. At one point he stopped and considered driving back up the drift to attempt a rescue. Then he recalled his previous breathing difficulties and he continued to reverse. At about the 1150m mark he backed into stub 2 and then drove forward towards the portal.
32. He reached the portal at 4:25pm, only a few minutes after the departure of Messrs White, Ridl and Heads, and immediately called the control room. He told Mr Duggan, 'You better call the Mine Rescue, we've had an explosion and I've seen a man lying on his back in the road'.¹³ He then spoke to Mr White who, thinking Mr Strydom was ringing from the FAB, instructed him to leave the mine and return to the surface.

Calls to emergency services

33. Mr White then accepted that there had been a major event underground and that emergency services must be

contacted. Mr Duggan phoned the MRS at 4:26pm. At 4:35pm he dialled 111 and spoke to a St John Ambulance operator. He reported a major underground incident, possibly an explosion, and requested as much emergency care as possible. He said 25–30 people were underground, with no one yet accounted for and that he had not heard from those underground 'for almost an hour now'.¹⁴ Mr Duggan then telephoned Coastwide Helicopters to order a helicopter so that Mr White could make a fly-over inspection of the main vent shaft.

34. At 4:45pm Mr Ridl phoned chief executive Peter Whittall in Wellington. He told him that there had been a major event underground and referred to Daniel Rockhouse's phone call from inside the mine, (see paragraph 39).
35. At 5:13pm Mr White flew by helicopter from the Pike River administration area to the top of the main vent shaft. He viewed the auxiliary fan site and returned to the administration area at 5:26pm. He saw smoke and damage and concluded that there had been an explosion.

Daniel Rockhouse

36. Nearing 3:45pm Daniel Rockhouse was in the drift en route to stub 2 to uplift the gravel required for road repairs at the ABM worksite. He stopped at the diesel bay at pit bottom in stone to fill his loader with diesel and water. The loader was parked with the engine running. While he was turning on a water valve there was a bright white flash and he felt an extreme pressure blast. Felled by the explosion, Daniel Rockhouse hit his head and ended up lying on his back. His first impression was that the loader had blown up, but he then realised that the engine was still running, although spluttering. He turned it off. Small amounts of debris fell from the roof and the ribs, although there was no cave-in. Within seconds a pungent strong smell, and dense smoke, reached the area. The atmosphere was warm and breathing became difficult.
37. To escape the effects, Daniel Rockhouse went inbye towards the crushing station (see Figure 1.1). It was clearer, but there was no place of refuge. He donned and activated his self-rescuer and moved back out to the main drift. The self-rescuer did not seem to be working properly so he discarded it. In the drift, next to his loader, he was overcome and fell to the ground again. He shouted for help, but there was no response. His eyes watered, his body tingled and he thought he was 'shutting down'.¹⁵ He lapsed into unconsciousness.
38. After some time he revived and sensed that feeling had returned to his fingers and toes. He was shivering with cold from lying in the mud. He tried to roll onto his stomach and push himself up, but he had no strength. Eventually he managed to stand, fell again and then was able to reach compressed air and water lines that ran along the rib. He turned on an outlet valve on the air line. There was only limited pressure, but enough flow to clear the smoke from around him. The fresh air was 'like gold'.¹⁶
39. After a minute or two breathing the fresh air and relieving the stinging of his eyes, Daniel Rockhouse looked for a telephone. Just inbye of his loader he located telephone 353 and rang the emergency number, 555. The telephone rang, but no one answered before the call was diverted to an answering service. He then dialled 410, the control room number. Mr Duggan answered the phone. Daniel Rockhouse said he was not injured, but that he could not see or breathe. At this point Mr White took the telephone, was told that the air seemed to be clearing and instructed Daniel Rockhouse to 'stay low', get to the FAB about 500m outbye and make contact from there.¹⁷
40. There is no record of the telephone call, or of its timing. However, it is apparent that Daniel Rockhouse made the call at approximately 4:40pm and that Mr Duggan answered it soon after his call to St John Ambulance. Immediately after Mr Strydom contacted him, Mr Duggan telephoned the MRS at 4:26pm. He then called and spoke to the St John operator until 4:39pm, twice mentioning he had not heard from anyone underground. Had Daniel Rockhouse already rung Mr Duggan, he would undoubtedly have said so.
41. It follows that Daniel Rockhouse was unconscious for a significant period, perhaps 50 minutes or so, after the explosion at 3:45pm until he made the phone call about 4:40pm.

A rescue

42. After the phone call Daniel Rockhouse followed the compressed air and water lines along the rib and proceeded outbye. As he found outlet valves he opened them and breathed in fresh air. He left the valves open, thinking this would improve the atmosphere. About 300m outbye he encountered a vehicle stationary in the drift. A few metres beyond it, he found Russell Smith lying semi-conscious on the ground, with his eyes open, but rolling back in his head. He could hardly speak. He was not wearing a helmet and light. Daniel Rockhouse removed Mr Smith's self-rescuer from his belt, opened it and tried to insert the mouthpiece into the other man's mouth. He could not do so. Daniel Rockhouse discarded the self-rescuer, lifted Mr Smith from behind and dragged him outbye towards the FAB.
43. Mr Smith was also in C crew. He had missed the bus to the mine and was late for the 1:00pm start of the shift. He was driving into the mine when the explosion struck. Minutes before he had passed the McConnell Dowell drifrunner heading outbye. He received no warning before there was a flash of bright light and a deafening noise, followed by a shock wave. The pressure was unrelenting. In an attempt to escape it, Mr Smith lowered himself to gain protection within the cabin of the vehicle. As breathing became difficult he attempted to remove a self-rescuer from his belt, but he was in an awkward position and could not do so.
44. Mr Smith could remember nothing after this. He had no recollection of his rescue by Daniel Rockhouse. He came to in an ambulance en route to Greymouth Hospital. Subsequently, he realised he had minor pitted abrasions to his face and back. His speech was affected in the short term, as was his respiratory system.
45. On reaching the FAB, Daniel Rockhouse propped Mr Smith up in a sitting position against the rib and said, 'I'll be back in a sec.'¹⁸ The FAB was a shipping container converted to include a two-door sealable entrance. Daniel Rockhouse thought it would provide a fresh air source, a telephone and spare self-rescuers. In fact, he found it had been decommissioned.
46. After venting his anger, Daniel Rockhouse returned to Mr Smith, got him to his feet and continued to drag him in an outbye direction. After a time he paused and asked Mr Smith whether he could walk. He tried, managed a few steps, but then fell. Daniel Rockhouse lifted him up again, and found that, if he supported Mr Smith, they could walk in tandem, with Daniel Rockhouse holding the rail of the conveyor belt to his left side for support. Periodically the pair stopped and looked inbye, hoping to see other lights coming down the drift. There were none. Daniel Rockhouse continued to open air valves as they went. To motivate Mr Smith, he told him to think of his family and to keep his legs moving for them.

Two miners walk out of the portal

47. As they progressed outbye, the atmosphere became clearer and it was easier to breathe. Natural ventilation provided a fresh air flow inbye from the portal. At 5:26pm the two men completed the 1500m walk from the FAB to the portal. From the time of the phone call at 4:40pm it had taken them 46 minutes to walk out of the mine. No one was there to meet them. Daniel Rockhouse used the DAC to call the control room for help. Vehicles arrived at the portal within minutes. Mr Smith was incoherent and Daniel Rockhouse broke down. Paramedics gave both men oxygen and they were taken by ambulance to Greymouth Hospital.

The emergency response

48. By 5:30pm the emergency response was well under way. Police, the New Zealand Fire Service, the MRS and St John Ambulance personnel were en route to or at the mine. Help from overseas would arrive over succeeding days, as a major search and rescue effort was launched to save the 29 missing men.

ENDNOTES

¹ References to times throughout this chapter are taken from various sources, including equipment at Pike and from other organisations. The sources are not synchronised. As a result, there may be minor discrepancies between the times quoted from different sources.

² Department of Labour, Last Known Position of Deceased and Two Survivors. Final Version, 28 January 2011 (DOL Investigation Report, Appendix 3), DOL3000130004/2. ('A, B, & C headings' locations added to the map by the commission)

³ Department of Labour: Transcription of the 'DAC' Underground Radio Communication System, 1 August 2011, INV.03.21043/32.

⁴ Daniel Duggan, transcript, p. 1581.

⁵ Department of Labour: Transcription of the 'DAC', INV.03.21043/32.

⁶ Daniel Duggan, transcript, p. 1585.

⁷ Ibid., p. 1586.

⁸ Mattheus Strydom, transcript, p. 1037.

⁹ Ibid.

¹⁰ Department of Labour: Transcription of the 'DAC', INV.03.21043/32.

¹¹ Video recording, 19 November 2010, CAC0018.

¹² Mattheus Strydom, transcript, p. 1040.

¹³ Ibid., p. 1047.

¹⁴ Audio recording, 19 November 2010, CAC0047.

¹⁵ Daniel Rockhouse, transcript, p. 1076.

¹⁶ Ibid., p. 1077.

¹⁷ Ibid., p. 1080.

¹⁸ Ibid., p. 1086.

CHAPTER 2

Accident analysis – some concepts

Introduction

1. The commission has sought the systemic reasons for the Pike River tragedy. The analysis, therefore, goes beyond the immediate cause to reveal the underlying causes and circumstances that allowed the tragedy to occur. In doing so, the commission has relied on expert evidence and international thinking. This chapter explains some concepts that have helped the commission in its evaluation and in preparing the report.

The ‘what/why’ distinction

2. Causation can be a vexing issue. In determining the cause of an event, it is possible to focus on the immediate or proximate cause or causes, or to look beyond the immediate to identify not just what happened, but why. The commission has taken the second approach.
3. The ‘what/why’ distinction can be illustrated by an example. A machine operator in a factory overrides a protective guard and is injured. The immediate and proximate cause is human error (or violation): but for the operator’s action the machine could have been operated safely and the accident avoided.
4. Identifying what happened, and the result, has the advantage of simplicity. It allows responsibility to be assigned to an individual and blame to be attributed. And then the quest for explanation can stop.¹
5. Until comparatively recently, accidents were routinely attributed to frontline operator error, and contributory causes were not considered, including the actions of those at management and governance level. The broader context, or setting, in which the operator acted was essentially ignored.²
6. If, by contrast, the question ‘why’ is asked – why did the operator act as they did? – a whole range of contributory factors may emerge. Perhaps the machine operator’s training was deficient, fatigue clouded their judgement, the machine guard inhibited production or overriding guards was commonplace in the factory.
7. The emergence of these factors prompts another level of inquiry. Why was operator training inadequate? Why was worker fatigue an issue? Why was the machinery not fit for purpose? Why was rule violation normalised? These questions invite greater scrutiny. Why were such problems not identified and addressed by management or at a governance level, where resources are allocated and an organisation’s direction is set?
8. The explosion and loss of 29 lives at Pike River demands a broad inquiry that extends to all levels of the company. Chapter 3, ‘The promise of Pike’, which examines the conception, approval and development of the mine, provides the backdrop for the examination of the mine and its systems in subsequent chapters.
9. But, as Dr Callaghan³ explained, the inquiry must extend further still: ‘to interrogate the strengths and weaknesses at all levels of the “system” – the company, the industry, the regulator and the wider government’, at least if ‘intervention is [likely] to be as efficacious and efficient as it could be.’⁴ The commission agrees.

Human factors

10. Dr Callaghan also stressed the need to consider ‘human factors’ in accident analysis. Human factors are the ‘environmental, organisational and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety.’⁵ The definition identifies three interrelated aspects: the job,

the individual and the organisation, each of which requires consideration. The job is the task to be performed in a specific workplace, including, in particular, the demands posed by that task. The notion of the individual captures the characteristics that influence human behaviour, such as competence, experience, attitude and personality. Some of these are fixed; others are adaptable. The organisation includes such things as resources, leadership and culture – all the company-related factors that influence individual and group behaviour in a workplace.

11. The aim of the human factors discipline is to ‘understand and improve competence and safety at work.’⁶ It seeks to answer such questions as:
 - Why do smart people do unsafe things?
 - Why don’t people do what they’ve been told?
 - Why are the same mistakes made over and over again?⁷

The questions expose the norm that error is a characteristic of human behaviour and therefore inevitable in any human system. It follows that any system relying on error-free human performance is fundamentally flawed. In any event, accidents are rarely the result of a single action, failure or factor, but rather of a combination of personal, task-related, environmental and organisational factors, some longstanding.⁸

Personal safety and process safety

12. These terms distinguish between two types of accidents widely recognised in the literature. As well as having different characteristics, personal safety and process safety accidents require different approaches to their prevention and investigation.
13. Personal safety accidents may involve one person who is both the cause and the victim. The damage may be significant, but is confined to an individual or a small group of people. Such accidents are relatively frequent because they occur as a result of human errors or violations in relation to hazards that are close at hand (as in the machine operator example). Often they can be described as slips, trips and falls. The defences or protections that guard against them are normally simple and few in number. Typically there is little time between the failure and the accident.
14. Process safety refers to the prevention of the unintended escape of toxic substances, flammable material or energy from a plant or other workplace. In a mining context the consequence may be an explosion or a fire. Process safety accidents can be catastrophic, causing multiple deaths and large-scale personal and property damage. Typically the organisations that suffer process safety accidents have complex and layered defence systems intended to eliminate workplace hazards. These systems comprise a mixture of hard and soft controls. Hard controls are physical barriers and devices that guard against, monitor or automatically warn of hazards. Soft controls are the organisation’s practices and procedures, including operating standards, supervisory oversight and worker training.⁹
15. A layered defence system makes it unlikely that one failure, human or mechanical, will trigger an event. Rather, a combination of failures is required before the multiple defence systems are penetrated, with potentially catastrophic results. Hence the term ‘low frequency, high consequence events’ is used with reference to process safety accidents. Because these events are often separated by a number of years, or decades, complacency may develop, even to the point where an organisation becomes blind to a known catastrophic risk.
16. The indicators of personal safety and process safety are also different. The occurrence of personal safety accidents has usually been measured by the lost time injury rate of the company. This is a lag indicator, a measure of performance made after the event, actually a measure of failure. Many companies place considerable store on their lost time injury rate figures. They may be used to measure performance and thereby affect a senior manager’s bonus payment. They may attract the attention of the regulator, or even of an insurer in fixing a premium.
17. A measure of injury rates is of limited use, however, as an indicator of a looming process safety failure. For this, a mixture of lag and lead indicators is required. Lead indicators, sometimes called positive performance indicators, are

obtained from routinely monitoring selected critical risk controls to ensure their continued effectiveness. The choice of risk controls is important. They must be of a kind to measure process safety performance in relation to the major hazards at the particular workplace.¹⁰

18. An example relevant to Pike River illustrates the interaction of lag and lead indicators. Methane explosions in mines are prevented by gas management, a key element of which is methane monitoring. This is done partly by using methane sensors, hard controls, strategically located in the mine. The sensors provide a warning of excessive methane levels, or spikes. A high-level spike is a warning sign, while a number or pattern of spikes may be a critical indicator of a potential process safety failure. An associated soft control may be a maintenance programme used to routinely test the calibration and reliability of the sensors. Data confirming that the maintenance programme is carried out on time, and effectively, gives the added assurance that the information supplied by the sensors is accurate. But all indicators are not equal. Failure data, such as a pattern of methane spikes, may demand an immediate response; other indicators may be less critical. What matters most is that there is a range of safety indicators, and that they are analysed and used to drive improvements in safety performance.¹¹
19. The explosion at Pike River was a process safety accident. Its occurrence raises many questions. Were the hard and soft controls at the mine adequate? How were the defence layers breached? Were lag indicators gathered and responded to? Were lead indicators used to check the effectiveness of hazard controls? Was there complacency about the existence of an explosion risk? These questions require the commission to look at the whole organisation, and to consider the actions of the regulator and others.

The ‘Swiss cheese’ model of causation

20. James Reason also devised a causation method, commonly referred to as the ‘Swiss cheese’ model, which is of particular relevance to process safety accidents.¹²

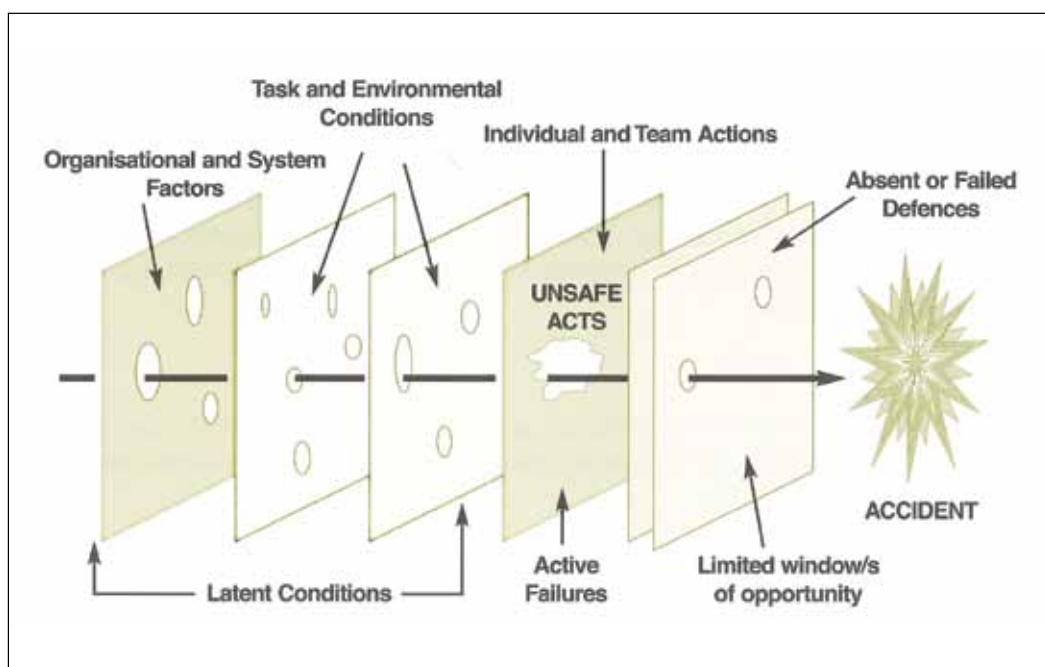


Figure 2.1: ‘Swiss cheese’ model of causation

Each slice of cheese represents one layer of an organisation’s defence system. These are labelled by type (at the top), and also divided into latent conditions and active failures, and windows of opportunity. The holes in each slice represent gaps in the defence system. Some arise from active failures, human errors or violations, which are short-lived. Latent conditions reflect the decisions and actions of the people who design, influence, implement and manage aspects of an organisation’s operational systems, such as equipment selection and monitoring, information

gathering or safe operation systems. These are latent because they can lie undiscovered and dormant for long periods until a combination of failures triggers a near miss or an actual event.¹³

21. An organisation's defence systems reduce the likelihood of major accidents because an accident occurs only when the holes in the multiple defences align, hence the reference in the model to limited windows of opportunity. Chance plays a part in the occurrence, and timing, of accidents. Defence systems are also difficult to understand and manage. No one person can be expected to oversee the entire system.
22. An organisation-wide safety culture can help to keep holes in the defence systems to a minimum. Active failures, worker errors and violations are likely to diminish in a workplace with a good safety attitude. Latent failures should be more readily discovered if those who design, establish, monitor and review the safety systems are also well motivated. And, most important of all, a safety culture should help to ensure that warning signs are not ignored, but heeded and addressed.¹⁴
23. The commission has had regard to this model in its analysis.

ENDNOTES

¹ Andrew Hopkins, *Failure to Learn: The BP Texas City Refinery Disaster*, 2008, CCH Australia, p. 10.

² Ibid.

³ The commission acknowledges the evidence provided by Dr Kathleen Callaghan, the director of the Human Factors Group, Faculty of Medical and Health Sciences, University of Auckland.

⁴ Kathleen Callaghan, witness statement, 31 October 2011, FAM00042/59, para. 213(f).

⁵ Health and Safety Executive (UK), *Introduction to Human Factors*, <http://www.hse.gov.uk/humanfactors/introduction.htm>

⁶ Kathleen Callaghan, witness statement, 31 October 2011, FAM00042/6, para. 9.

⁷ Ibid.

⁸ James Reason, 'Understanding Adverse Events: Human factors', *Quality in Health Care*, 1995, Vol. 4, No. 2, p. 85, <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1055294/pdf/qualhc00016-0008.pdf>. Reason, who was Professor of Psychology at the University of Manchester 1977–2001, is a prolific writer on many aspects of safety management, including *Managing the Risks of Organizational Accidents*, Ashgate, 1997.

⁹ BP U.S. Refineries Independent Safety Review Panel, *The Report of the BP U.S. Refineries Independent Safety Review Panel*, 2007, pp. 21–23, http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/SP/STAGING/local_assets/assets/pdfs/Baker_panel_report.pdf

¹⁰ Health and Safety Executive (UK), *Developing Process Safety Indicators: A Step-by-Step Guide for Chemical and Major Hazard Industries*, 2006, <http://www.hse.gov.uk/pubns/priced/hsg254.pdf>

¹¹ Andrew Hopkins, *Thinking About Process Safety Indicators* (Working Paper 53), May 2007, National Research Centre for OHS Regulation, Australian National University.

¹² Safety Wise Solutions Pty Ltd, 'Analyse Findings', in *Incident Investigation Reference Guide*, 2010, section 7, p. 2.

¹³ James Reason, 'Beyond the Organisational Accident: The Need for "Error Wisdom" on the Frontline', *Quality and Safety in Health Care*, 2004, Vol. 13, Suppl. 2, p. ii29, http://qualitysafety.bmj.com/content/13/suppl_2/ii28.full.pdf+html

¹⁴ James Reason, 'Achieving a Safe Culture: Theory and Practice', *Work & Stress*, 1998, Vol. 12, No. 3, pp. 293–306.

The promise of Pike

Introduction

1. This chapter describes the physical characteristics of the Pike River coal field and the history of the mine's development over the 28 years between 1982 and the explosion in 2010. In broad terms there were three relevant periods: exploration of the coal field to 1995, mining feasibility studies to a final investment decision in 2005 and mine development to November 2010.

Physical characteristics of the coal field

Location of the coal field

2. The Pike River coal field is in a remote location on the eastern side of the Paparoa Range, about 45km north-east of Greymouth. It lies between Mount Hawera (1190m) to the north and Mount Anderson (1069m) to the south. The coal field occupies an area of about 7km².



Figure 3.1: Location of the Pike River coal mine

3. Access to the coal field is from the Taylorville–Blackball Road on the western side of the Grey River, then up the Big River Valley on Logburn Road, from where an 11.7km private road leads to the mine.

The land

4. The coal field lies under conservation land, and partially under the Paparoa National Park. Its western boundary is a sheer 200m escarpment that is marginally within the eastern perimeter of the park. From the escarpment the coal field dips to the east and terminates at a major fault line, the Hawera Fault. The mine portal, situated more than 2km to the east of the fault, is on the true right bank of the White Knight Stream, 120m upstream from its confluence with the Pike Stream.
5. The land area under which the coal field lies is administered by the Department of Conservation (DOC), the western margin and an area to the north under the National Parks Act 1980 and the balance under the Conservation Act 1987. DOC granted an access arrangement that authorised coal mining under the conservation estate. Easements granted by the Crown and a private landowner enabled construction of the mine access road. Pike River Coal Ltd owned an area of 87ha where its coal preparation plant (CPP) was built near the northern end of Logburn Road. Because of its remoteness the land above the coal field contains areas of virgin rainforest.

Geology

6. The geology of the coal field is complex, as can be seen from the simplified cross-sectional figure below. There are two coal measures, the Brunner seam, which was mined, and, approximately 200m below it, much older Paparoa seams. The Brunner seam consists of the main seam and above it a narrower rider seam, separated by interburden of variable thickness. The seams outcrop on the western escarpment. The Hawera Fault not only marks the eastern margin of the coal field, but has also deformed the seam upwards adjacent to the fault line.

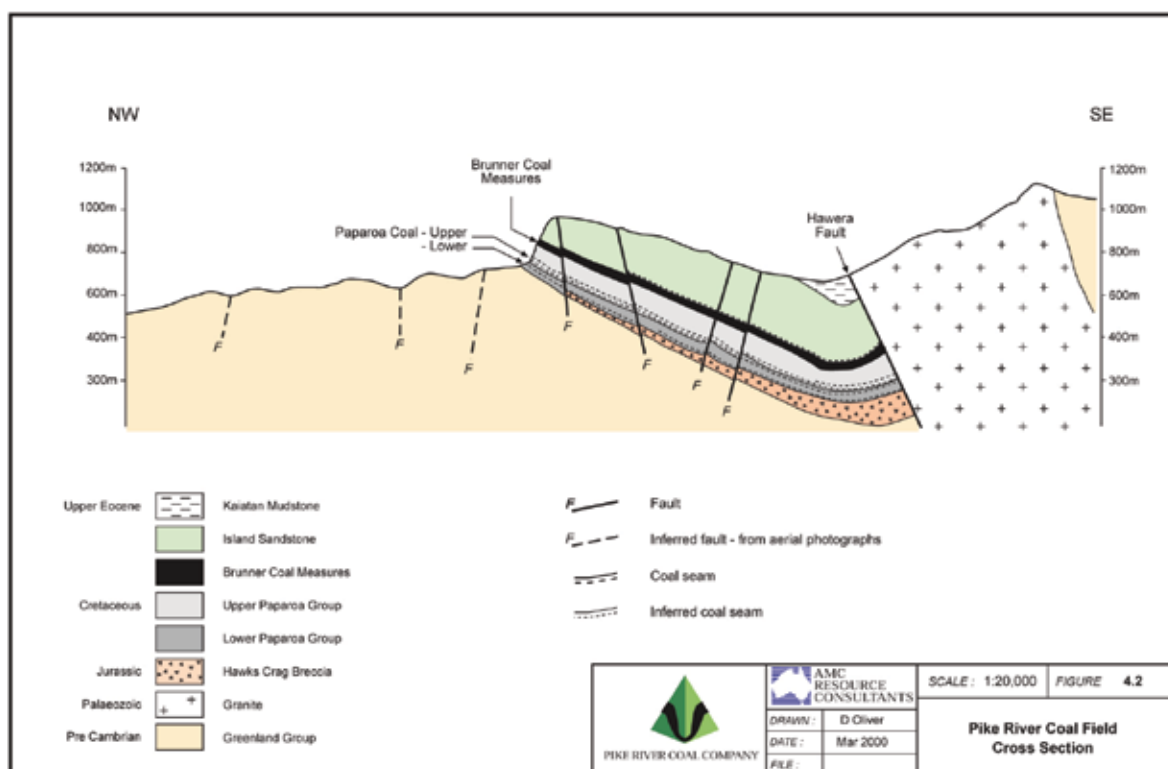


Figure 3.2: Pike River coal field cross-section¹

7. Other faults intersect the Brunner seam, which dips at a gradient of between 10° and 20°. Island sandstone of varying depths overlies the coal field depending upon the surface contours. As can be seen in the simplified diagram of the west to east cross-section below, the surface contour is highly variable, this being rugged country intersected by gullies and streams.

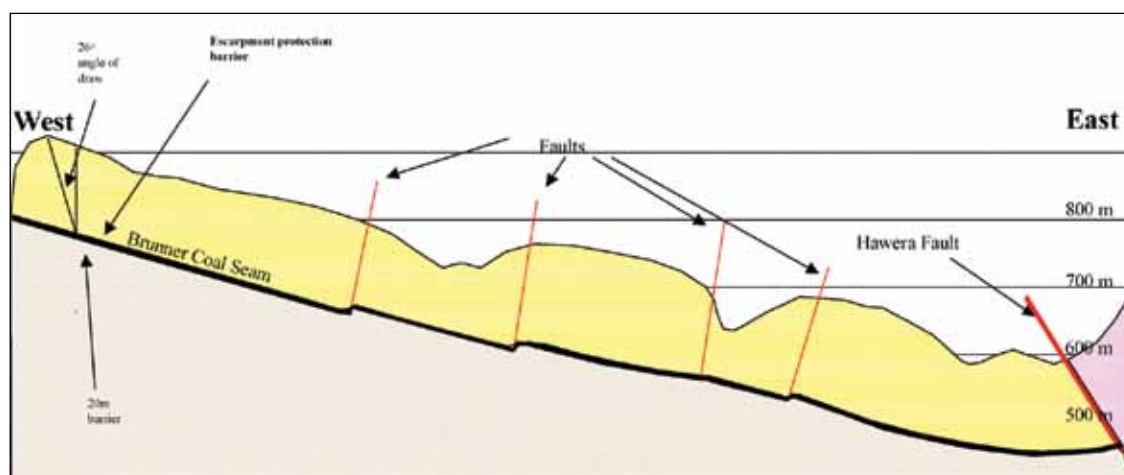


Figure 3.3: Pike River coal field west-east cross-section²

8. The Paparoa Range forms a barrier to the dominant westerly air flow from the Tasman Sea. As a result the coal field area has rainfall of up to 6m per annum. The altitude of the area makes it prone to snowfalls in winter; cloud and rain are the predominant climatic features for most of the year.

Exploration of the coal field

Outcrop sampling and drilling programmes

9. Although the existence of the two coal seams was well known, because of the outcrops on the western escarpment, exploration of the field did not begin until 1980. A mineral exploration company obtained prospecting licences and undertook geological mapping and the sampling of coal from the outcrops.
10. In 1982 the Pike River Coal Company Ltd (as it then was) was incorporated and took over the two prospecting licences by transfer from the previous holder. The following year the new company undertook a six-hole drilling programme (numbered PRDH1–6), using a drilling rig flown to each drill site by helicopter. Numerous core samples were obtained from the holes to a depth of between 130 and 270m.
11. In 1988 Pike became a wholly-owned subsidiary of New Zealand Oil & Gas Ltd (NZOG). Two years later, under a government-funded exploration scheme, one additional hole (PRDH7) was drilled to intersect both the Brunner and Paparoa seams. In 1993 the company obtained an exploration permit for a four-year term over an area of about 1782ha. In 1993 a further seven holes were drilled (M1–7) under a joint venture programme with Japanese firm, Mitsui Mining Engineering Co. Ltd.
12. On the strength of the testing of the cores obtained from these 14 drillholes, the company commissioned a pre-feasibility study in 1995, and the following year applied to the Ministry of Commerce for a coal mining permit. During mine construction, additional holes were drilled, but mainly in the area of the stone drift to the east of the coal measures, or in the area of the mine workings. Angled holes were sometimes drilled from a single site, to avoid moving the drilling rig. These holes provided geological information for the siting of underground infrastructure.
13. Dr Jane Newman gave evidence about the geology of the Pike River coal field. She first studied the area as a PhD student in 1980, was involved in some of the early drilling programmes and a geological modelling project in 2008. She subsequently offered the company informal advice during the construction of the mine. She said the coal field demonstrates both stratigraphic (strata) complexity and structural (faulting) complexity, and that one superimposed on the other does not simply double the complexity but increases it greatly. Given this complexity, it was not unusual for in-fill drilling to provide a grid at 100m spacings, given complex West Coast mining conditions.³
14. Dr Donald Elder, chief executive officer of Solid Energy, concurred, noting that detailed geological and coal information would have required boreholes at about 100m spacing.⁴

15. At Pike River boreholes were drilled on average from 400 to over 500m apart.⁵

Coal characteristics

16. Pike River contains one of New Zealand's largest deposits of hard coking coal. It has a low ash and phosphorus content, which gives it a competitive advantage over other coking coals. Early studies indicated a wide variation in the sulphur content of coal within the Brunner seam. Selective mining would be needed to ensure sulphur limits were not exceeded.
17. In 2007 Pike planned to extract and export high-quality, hard coking coal.⁶

From feasibility to final investment decision

Pre-feasibility study

18. A Christchurch mining consultant, CMS Ltd, undertook the 1995 pre-feasibility study. The key recommendations were that assessment of the coal field should continue to the feasibility stage, that seven more drillholes were required to confirm the coal reserve quality and to provide geotechnical assurance, and that access agreements should be obtained as early as possible. Development costs were estimated to be \$29 million, including \$13.65 million to develop the access road and establish the mine, \$4.55 million for plant and equipment and \$5.85 million as a 25% contingency allowance.⁷
19. NZOG commissioned a further pre-feasibility study in 1998 from Auckland-based Minserv International Ltd. The study included an assessment of the benefits of using hydro mining at Pike River. It described the 'significant dip' of the seam, allowing a water-assisted gravity flow of coal from the workings to pit bottom, from where it could be carried by a slurry pipeline to the CPP. Using this method, annual production of between 460,500 and 502,380 tonnes was estimated.⁸ Minserv also completed a revised financial model, including hydro-mining costings, and arrived at a capital outlay of \$43.26 million for the three initial development years.⁹

Mining permit

20. The company applied for a mining permit in March 1996. The application estimated the total recoverable coal reserves to be 26.7 million tonnes. Three years would be needed to develop the mine to the point of coal production, after which the life of the mine was estimated at 40 years.¹⁰
21. Mining permit number 41-453 for an underground coal mine was granted in September 1997. It was issued for a period of 40 years subject to mining beginning within five years and an average of 300,000 tonnes of coal being mined per annum. The total area covered by the permit was 1611ha, but this area was increased by 333ha in January 1998.¹¹

An access arrangement

22. In June 1998 the company applied to DOC for an access arrangement so it could mine for coal beneath the conservation estate. No application for an open cast mine was made, nor was such a proposal discussed. A detailed six-year process followed before the terms of an agreement were resolved. DOC was concerned to safeguard and preserve the land as required of it under the Conservation Act 1987 and the National Parks Act 1980. Its concerns included land subsidence, fire control, protection of flora and fauna, mine water discharge, protection of the western escarpment and protection of breeding habitats.
23. Numerous environmental reports and risk assessments were obtained to assess the risk from surface activities and underground mining. DOC engaged its own experts and there were exchanges between consultants in an endeavour to find acceptable solutions. In October 2000 the access application was amended after the area of the mining permit had been enlarged to include the area required for the mine access road.¹²

24. In March 2004 the minister of conservation approved the arrangement, but subject to the drafting of conditions.¹³ On 21 October 2004 a 25-year access arrangement was signed. The agreement conditions were extensive. Surface subsidence limits were prescribed, and the company agreed to develop 'trial mining panels' to demonstrate that any surface disturbance fell within the defined limits. A mining buffer zone prevented mining close to the western escarpment, and no 'untreated mine water' could be allowed into the tributaries of the Big River. Specific consent was required for any surface activity that could affect flora or fauna, such as establishment of drilling sites, roadworks or the construction of helicopter landing areas. The company also had to provide an annual work plan, fund a liaison person for the term of the agreement and arrange insurance and bonds for its obligations under the agreement.¹⁴
25. The rigour of the process and the detailed controls contained in the access agreement left no room for doubt concerning the high level of protection to be given to the surface environment of the mine. Pike understood and respected DOC's requirements. Regular liaison meetings occurred, mostly at the mine site. These worked well, so that for example every drillhole approval sought by Pike was approved by DOC.¹⁵
26. During the mine development seven variations to the access arrangement were negotiated to cover unanticipated environmental requirements and 144 work plan variations occurred.¹⁶

Resource consents

27. In mid-1998 the company applied for various resource consents from the Greymouth and Buller District Councils and the West Coast Regional Council. These were granted in June 1999. They covered a wide range of activities, including taking water from the Pike Stream; construction of the stone drive, ventilation shaft, access road, slurry pipeline, bridges, power and telecommunications lines, and the CPP; as well as consents required for a coal stockpile. However, in July 1999 interested parties lodged appeals to the Environment Court against the resource consent decisions.
28. In May 2002, to respond to concerns raised by the appellants, the company obtained a report on the environmental effects of the coal field development from consultant URS New Zealand Ltd. This outlined changes in the company's approach, including relocating the mine portal from beside the Pike Stream to its eventual location on the White Knight Stream. This increased the length of the stone drift by 400m, but avoided the need for road development beside the Pike Stream.¹⁷
29. In the end the Environment Court appeals were resolved by a consent order of the court, which approved numerous resource consents incorporating changes to those originally granted.¹⁸

The final investment decision

30. In June 2000 AMC Resource Consultants Pty Ltd provided the company with a final feasibility study. This assessed all aspects of the mine project from the extent of the resource to the proposed mine systems and required workforce. AMC was not paid a consultancy fee, but instead received a 25% shareholding in the company.
31. The study was not acted upon for some time. Instead the company focused on obtaining the access arrangement and resource consents, which were finally in place by late 2004. Minarco Asia Pacific Pty Ltd (previously AMC) then prepared an updated study, particularly of the capital costs to continue the project.
32. These were reflected in a mine plan and financial model ('the joint report') presented to the Pike board in July 2005 by Gordon Ward, the general manager, and Peter Whittall, the mine manager. Mr Ward was an NZOG appointee who, in 1998, assumed responsibility for the Pike River project. His background was in accountancy and auditing, not mining. Mr Whittall, who joined the company from Australia in February 2005, was a mining engineer and experienced in coal mine development and management.¹⁹
33. The joint report recommended that the board accept the proposed mine plan and development strategy, and authorise management to execute the plan including employing 'such staff as are required to complete the capital works within the approved budget'. On 20 July 2005 the board made a final investment decision in the terms recommended.

34. The capital development of the mine was costed at \$124.1 million to September 2007, including the following amounts and completion dates:

Access road	\$11.75 million	April 2006
Tunnel (drift) development	\$21.3 million	September 2006
Hydro set-up	\$28.4 million	October 2007
Full coal production	-	February 2008

Production capacity was estimated at 'up to 1.4Mtpa' (million tonnes per annum), comprising 20% from mine roadway development and 80% from hydro mining. A peak workforce of about 150 people was contemplated to enable a seven-day, three-shift operation; contractors would be used for 'specialist activities'.²⁰

Optimism prevailed

35. The company embarked upon development of the mine with optimism and confidence. Mr Ward, speaking at the November 2008 annual general meeting, referred to Pike River as a 'special mine', with 'the largest and most valuable hard coking coal deposit in the country' and 'the lowest ash content in the world and a high fluidity level'. These properties would make the coal attractive to the international steel and coke industries. These qualities were complemented by investment in 'new modern machinery and equipment, and [a] recruited skilled mining staff to make sure we achieve that target ... approximately one million tonnes of coal a year for each of the next 18 years'.²¹
36. At the 2009 annual general meeting Mr Ward told shareholders that 'Pike River's state-of-the-art hydro monitors will cut ... around 2,200 tonnes per day; that's about 800,000 tonnes a year' while roadway development would 'add another 200,000 tonnes a year on average'. The mine enjoyed advantages because of 'mining uphill nearly all the time and being able to use gravity to flume and pipe coal out of the mine'; and because it had 'much larger hydro-mining pumps' and was generally 'designed to be a bigger mine than all other New Zealand underground mines'.²²

Mine development

37. The mine infrastructure includes the coal stockpile and loadout facility at Ikamatua, 22km from the CPP and bathhouse, and the mine amenities area, about 7km up the access road from the CPP. The amenities area includes offices, the operations control room, and workshop. The portal is a further kilometre up the access road from the amenities area.

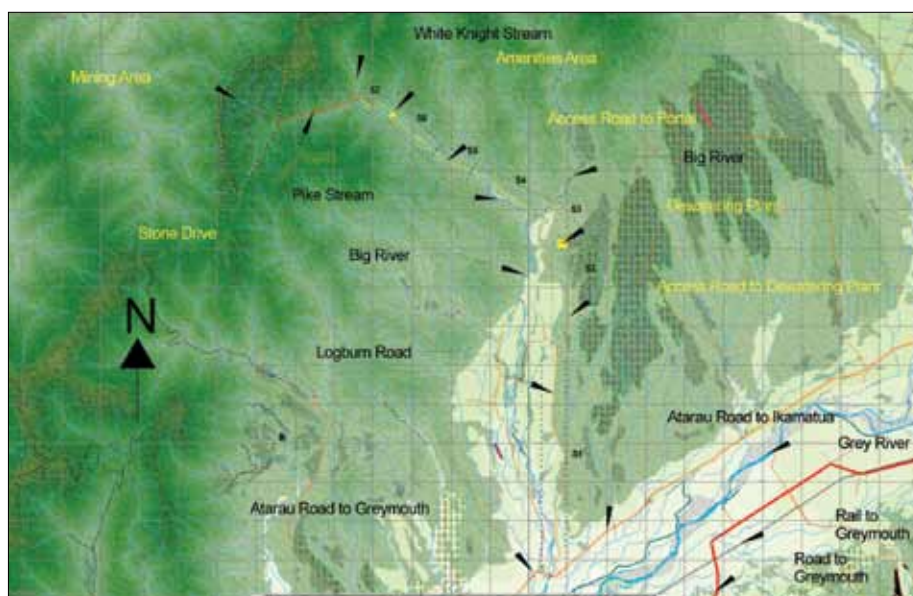


Figure 3.4: Pike River mine environs²³

38. Underground, the stone drive, or drift, stretches about 2.3km from the portal to the coal seam. It provided intake air, transport for men, materials and coal, and provision for power, water and communications services. A vertical ventilation shaft, over 100m deep, provided return ventilation and a second means of egress. A second drive was to be established as the mine developed towards the north-west of the licence area.

Access road

39. Work on construction of the access road from the CPP to the mine portal began in December 2005. As well as establishing a single-lane roadway, with passing bays, Ferguson Brothers, the Greymouth contractor, was required to construct several bridges.²⁴ The road was completed in September 2006, five months after the completion date envisaged in the joint report to the board. In November Ferguson Brothers won the Canterbury Contractors Federation Environment Award and Contractor of the Year for projects over \$1 million for its successful construction of the road through virgin native forest and conservation estate.

Pike River share offer

40. On 22 May 2007 Pike River Coal Ltd issued a prospectus offering 65 million \$1 shares for public subscription.²⁵ The company was still a subsidiary of NZOG, which held a 54% stake. The next two biggest shareholders were Indian companies, Saurashtra World Holdings and Gujarat NRE Ltd. Their combined shareholding was about 32%, with smaller investors holding the balance of the shares.²⁶

41. The prospectus included these financial details:

Total development costs: \$207 million (exclusive of pre-development costs of \$16 million) being:

\$64 million	spent to May 2007
\$99 million	to finish development
\$11 million	contingency sum
<u>\$33 million</u>	production working capital
<u>\$207 million</u>	

The capital required, therefore, was \$143 million, which was to be sourced from the share issue, some cash on hand and new borrowings. The prospectus anticipated coal production (in tonnes) of 243,000 in 2008, 1.039 million in 2009 and 968,000 in 2010.

A total production of 17.6 million tonnes over a 19-year mine lifespan was predicted, at an average annual extraction rate of 967,000 tonnes.²⁷

42. The share offer was oversubscribed and 85 million shares were allotted to new investors. NZOG's shareholding reduced to 31%, so that the company ceased to be an NZOG subsidiary.²⁸ In July 2007 the company was listed on the New Zealand and Australian stock exchanges.²⁹

Construction of the drift

43. McConnell Dowell Constructors Ltd developed the drift and the main ventilation shaft, as well as some surface facilities. Tunnelling work started in September 2006. The drift was to have a horseshoe profile, to form a roadway 5.5m wide and 4.5m high.³⁰ It was inclined upwards by about 5° over its length. This allowed the drift to intersect the Brunner seam near to its lowest point.
44. There were variations to the contract during the development of the mine. The most significant change was the inclusion of an area known as pit bottom in stone.³¹ This comprised 500m of roadways, either side of the drift, at about 1900m inbye, as depicted below. This area was to house a coal crushing station and water pumps used to provide water to the working faces in the mine, and water to the slurry pipeline leading to the CPP. During construction methane was encountered and some frictional ignitions occurred. Until then the work was deemed

tunnel development, but the ignitions caused the Department of Labour (DOL) to designate the tunnel a 'gassy mine'.³² This designation meant that project control also passed from McConnell Dowell to Pike.

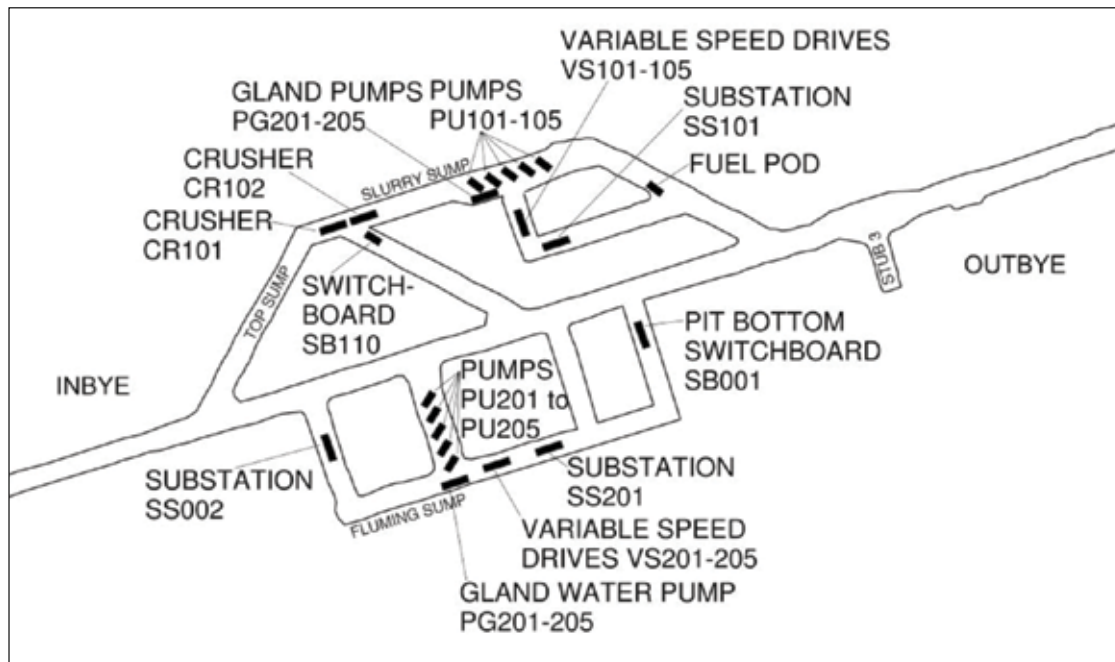


Figure 3.5: Plant location pit bottom in stone³³

Originally this area was to be developed to the west of the Hawera Fault, but a decision was taken to develop it in the hard gneiss stone.

45. In December 2008 the drift and pit bottom in stone were completed. This was two years and three months after the completion date in the joint report, and five months after the estimated date in the prospectus. Even allowing for the additional work, there was considerable delay, caused largely by unfavourable ground conditions. The contract with McConnell Dowell included a per metre payment rate based on rock quality. Because most of the drift attracted the highest metre rate, the total cost was about 100% over budget.³⁴ In August McConnell Dowell won a New Zealand Contractors Federation award for its work on a 'technically and geologically complex project' in the over \$20 million category.
46. On 27 November 2008 the mine was officially opened to mark 'the breakthrough to coal and achievement of operational status'.³⁵



Figure 3.6: Minister of Energy and Resources, the Hon. Gerry Brownlee, Pike Chief Executive Gordon Ward, Chair John Dow and General Manager Peter Whittall at the opening of the Pike River mine

Development of the ventilation shaft

47. By late 2007 a final decision was required about the site of the ventilation shaft, so that McConnell Dowell could develop the surface collar to the shaft over summer. The company did not want it outbye of the Hawera Fault, in stone, because of cost and significant problems with land stability. The site of an existing drillhole (PRDH13) was investigated, and a new drillhole (PRDH31) was bored. In September a site inbye of the Hawera Fault was finalised and in late summer McConnell Dowell constructed and grouted the surface collar.³⁶
48. But the shaft could not be completed until the drift was through the Hawera Fault and a roadway was driven to the ventilation shaft site. In December 2008 a bore began to ream out the shaft from the bottom up to the surface. This was completed in January 2009, but in early February 2009, before the 4.2m diameter shaft was fully lined, the bottom section collapsed, sealing any connection between it and the mine roadway.³⁷
49. Following investigation the company decided to abandon the bottom 35m, cap it with concrete and construct a bypass to reconnect to the upper 70m of the shaft, as shown in the diagram.

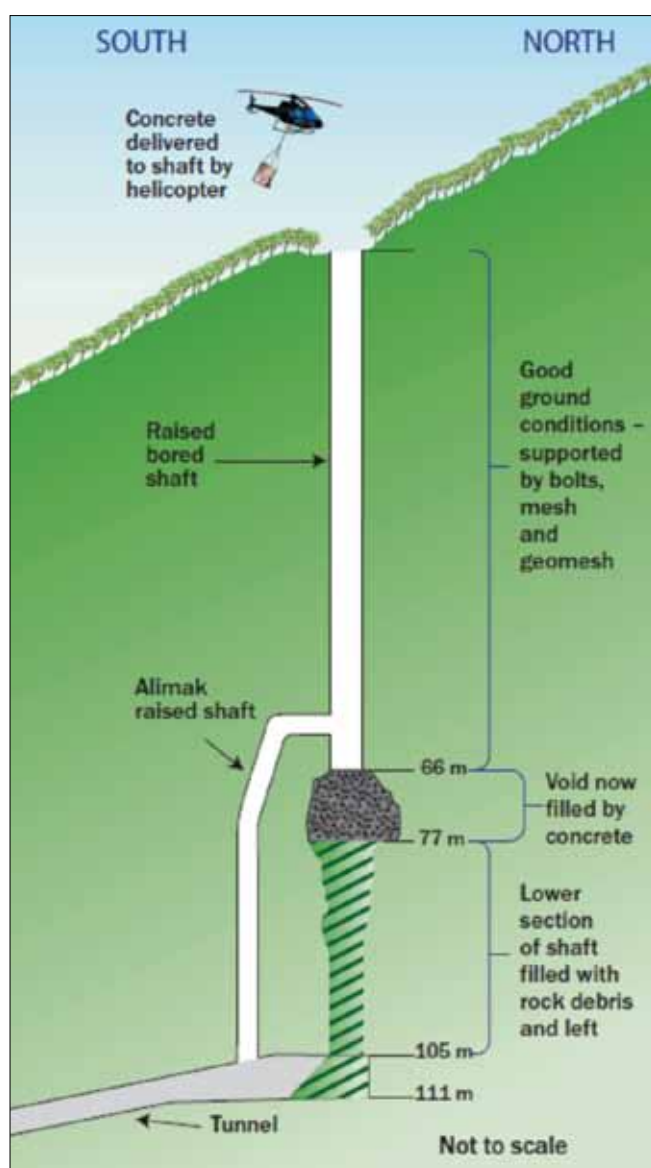


Figure 3.7: Ventilation shaft and Alimak raise³⁸

The bypass, called the Alimak raise, was constructed between April and June 2009. The raise was only 2.5 by 2.5m, and connected to the 4.2m diameter shaft. Obviously, the cost of the Alimak raise was unexpected, as was the five-month delay.

50. During this period, Pike also drilled a 600mm 'slimline' shaft to improve air capacity. It was completed in May 2009. A fresh air base, so called, was later established at the bottom of the slimline shaft to provide air in the event of an emergency.

Mine roadway development

51. From November 2008, when the drift reached its 2.3km design length and was through the Hawera Fault, mine roadway development began. The first roadway was driven 75m north, to the base of the proposed ventilation shaft.³⁹ Further roadway development was planned to the south, where there would be more mine facility infrastructure, and to the west, where coal extraction was to be centred.
52. These roadways, 5.2m wide by 3.6m high, provided access for men and machines, and carried such services as ventilation ducting; water, compressed air and methane pipes; and a coal flume to transport coal and water from the working faces. The roadway walls (ribs) and roof were bolted and secured with mesh for strata support.
53. In anticipation of roadway development, horizontal in-seam drilling of the Brunner coal seam began, using a drilling rig. Exploratory boreholes were drilled hundreds of metres into the seam to define the seam limits and to obtain geological data. The boreholes also released methane from the seam, although this was secondary to seam exploration.
54. Holes drilled to the west revealed the existence of a graben, a downthrust zone between two fault lines, which in this instance had depressed the coal seam and substituted a zone of island sandstone. Situated close to the Hawera Fault, the graben was about 200m wide. Driving roadways through the sandstone 'took several months longer than initially expected' and delayed mine development.⁴⁰
55. By April 2010 roadways through the graben were completed and the rate of development improved.

Mining machinery

56. The company purchased three mining machines for use in roadway development, two continuous miners and one roadheader at a total cost of \$14 million.⁴¹ The continuous miners were configured to cut the width of a roadway in two passes, bolting the roof and ribs at the same time. The roadheader was also suited for cutting stone.
57. The continuous miners proved unsatisfactory for the conditions. They were not fast enough and suffered heavy wear and tear while cutting through the graben. In the third quarter of 2010 one was withdrawn from service so it could be modified. This work was expected to take three months.
58. In August 2010 another brand of continuous miner, called the ABM20, was leased and began operating. It could cut a 5m roadway in a single pass and bolt at the same time. The ABM20 achieved improved daily advance rates. This led the company to buy another ABM20, to be delivered towards the end of the year.⁴²

Hydro mining

59. Initially the mine plan and access arrangement required trial panels in the north-western corner of the coal field to assess whether coal extraction caused surface subsidence. Roadways were to be driven to this area and hydro-mining panels established. Mining would then retreat back in a south-easterly direction, so that the last coal taken would be from the pit bottom area. However, delays and cost overruns forced a rethink. Mr Whittall raised with DOC the concept of a 'commissioning panel' to allow initial coal extraction close to pit bottom. This would provide \$15–\$20 million of revenue, and the company would then revert to the original plan.⁴³ This proposal was agreed to. In early 2010 approval was given to develop a smaller 'bridging panel' nearer to pit bottom.
60. Hydro mining started in September 2010. A hydro monitor cut the coal, using a high-pressure water jet. The coal was then collected and flumed under gravity to the slurry pipeline. The monitor gradually retreated, leaving a void, or goaf, from which coal had been extracted.
61. Teething problems affected hydro extraction. Coal production was not at the desired rate, owing to equipment problems, the hardness of the coal, mining crew inexperience and methane control difficulties.⁴⁴

Ventilation

62. Effective ventilation is essential in an underground coal mine. The ventilation system must deal with coal gases and dust, as well as supplying the miners with sufficient air at acceptable temperature and humidity levels. During the development of the drift a fan at the portal ventilated the mine. It was replaced in mid-2009 by a fan at the top of the ventilation shaft. In mid-2010 a new main ventilation fan was installed underground next to the main vent shaft. It was designed to draw air into the mine from the portal and expel polluted air up the shaft and out of the mine. The fan was commissioned in October 2010.
63. This is thought to be the first time a main fan had been located underground in a coal mine anywhere in the world. Some metalliferous mines have underground main fans, but they do not face a methane hazard. In locating the fan underground the company faced a number of challenges. The fan motor was not flameproof and had to be situated 'in fresh air' in an intake roadway, with the fan blades located in a return roadway to expel polluted air up the ventilation shaft. The fan was vulnerable in the event of an underground fire or explosion, dependent on a power supply cabled into the mine from the portal and inaccessible to electricians in the event of an underground emergency. It also experienced teething problems after it was installed.

Workforce

64. In October 2008 Pike River employed 82 full-time staff members.⁴⁵ Two years later the workforce numbered 174. Over the previous 12 months the company had been engaged in a 'significant offshore recruitment drive to build a top quality workforce'. The workforce included about 80 locals, other New Zealanders and a significant number from overseas.⁴⁶
65. The company also employed between 20 and 60 contractors including 'significant use of local contracting companies'.⁴⁷ This exponential increase in numbers created a demand for training courses, particularly as many people were new to New Zealand conditions, or new to the industry.
66. There was also a staff retention problem. One example of this was the turnover of mine managers at Pike River. From September 2008 until the date of the explosion six men held the position on a permanent or acting basis. A seventh person, Stephen Ellis, was to assume the role, as soon as he obtained a first class mine manager's certificate of competence.

An environmental award

67. In September 2008 DOC recognised Pike River for 'the environmental consideration it had demonstrated in the establishment of [its] mining facilities'.⁴⁸ The surface footprint on conservation land was restricted to only the 13ha needed to establish the 10km access road and locate administration buildings. Predator control programmes, constructing the road to wind through ancient native trees and blending buildings into the native bush setting also won praise. Two months later, on a visit to the mine, Minister of Conservation Chris Carter added that it was a 'showcase development which had set a new environmental standard for coal mining'.⁴⁹

Coal production and capital fundraising

68. In its 2007 prospectus Pike River anticipated that coal production would begin in the March 2008 quarter, with production of 243,000 tonnes for that calendar year, which would generate a cash flow of \$38 million at an average sale price of \$157 per tonne.⁵⁰ The first two coal shipments were not until February and September 2010, when 20,000 and 22,000 tonnes, respectively, were sold for around \$9 million.⁵¹ In October the company announced that its production forecast to June 2011 was downgraded from 620,000 to 320,000–360,000 tonnes.
69. The company therefore had to raise funds to meet operational and capital costs in each of its last three years of operation. In February 2010 Pike River announced a \$90 million fundraising initiative. It raised \$10 million from a share placement in April and \$40 million from a rights issue in May. By October 2010 capital raised over the previous three years had increased the number of ordinary shares on issue from 200 million on listing in 2007 to over 405 million.

70. In May 2010 NZOG advanced the company US\$28.9 million (NZ\$41 million) upon the security of a convertible bond. This sum was required to repay a debt owed to a Goldman Sachs entity (Liberty Harbor), after Pike River breached a production covenant contained in the loan agreement. In September NZOG also granted a short-term loan facility of \$25 million to meet a projected cash shortfall. In October Pike River drew down \$13 million.⁵²
71. On 18 November, the day before the explosion, the company was on the brink of raising a further \$70 million capital involving a share placement to ordinary shareholders of \$25 million and to institutional investors of \$45 million, fully underwritten by a major international investment bank. John Dow, chair of the board, considered that this \$70 million would have carried the company through to the third quarter of 2011 when 'we expected to be in fully steady state hydro-mining'.⁵³

NZOG's review of its investment

72. NZOG reviewed its investment in Pike during 2010.⁵⁴ It obtained management and technical reviews of Pike from Behre Dolbear Australasia Pty Ltd (BDA). The reviews contained recommendations, including the need to address equipment matters, tighten reporting and project management, ramp up production and accelerate training programmes. BDA noted that 'the impression (correct or otherwise) is that there does seem to be more of a focus on the market than the project, and there is a lot of effort being expended on presenting the project to the broking community'.⁵⁵
73. David Salisbury, the managing director of NZOG, says that, on 23 August 2010, he and Antony Radford, chairman of NZOG and a director of Pike, told Mr Dow that NZOG had lost confidence in both Pike's chief executive officer, Mr Ward and general manager, Mr Whittall,⁵⁶ but Mr Dow recalled that the criticism as confined to Mr Ward.⁵⁷ On 10 September Mr Ward's resignation was announced. On 13 September Pike's board announced the promotion of Mr Whittall to chief executive officer. Mr Dow commented in the board minutes that 'Pike River had in the past consistently overpromised and under delivered. This time it was important that we did a better job of forecasting the production schedule'.⁵⁸
74. On 23 November 2010, four days after the explosion, the company sought to draw down the remaining \$12 million under the short-term facility; NZOG agreed.⁵⁹ On 8 December Pike River was insolvent and was placed in voluntary receivership.

Challenges faced in 2010

75. The commission considers that Pike River faced several serious challenges during 2010:
 - It was operating in an area where, as Dr Elder said, 'the geology, geography and climate of the West Coast [made] all the processes around coal mining, not just the mining extraction process itself, as hard or harder than most other locations in New Zealand and in the world'.⁶⁰
 - Development of the mine had been affected by uncertainty owing to insufficient geological investigation before construction work began. Problems in driving the drift, the collapse of the vent shaft and the discovery of the graben demonstrated the extent of the deficit, which was likely to cause further difficulties.
 - Unsuitable machinery significantly hindered the mine's development, though good progress had been made towards addressing this issue.
 - The mine was in start-up mode, with a recently recruited and inexperienced workforce, and faced retention problems, particularly in relation to those in statutory and management positions.
 - A new main ventilation fan had been installed in an underground location, a first in the coal mining world, and was still being bedded down.
 - Hydro mining had begun, but production was held back by a combination of inexperience, equipment limitations and a methane control problem.

- Delayed production weakened the company's financial situation, resulting in a need to focus on fundraising.
- Its failure to meet targets, increased borrowings and shareholder discontent meant that the company faced significant risks to its reputation and credibility.

76. Together, these issues represented a major challenge to the company. In her evidence, Dr Kathleen Callaghan highlighted many of these same factors and expressed the opinion that 'the information I have seen shows me recurring patterns of causal factors that I know are well established in the literature to increase the likelihood of a process safety event'.⁶¹ The commission agrees with this assessment.

ENDNOTES

¹ AMC Resource Consultants Pty Ltd, Final Feasibility Study, Vol. 1, 23 June 2000, DOC0010030006/23. ('Hawera' corrected by the commission)

² Ibid., DOC0010030006/92. ('Hawera' corrected by the commission)

³ Jane Newman, transcript, pp. 192, 200.

⁴ Donald Elder, witness statement, 8 June 2011, SOL306956_1/26, para. 70.

⁵ Donald Elder, transcript, p. 20; Jane Newman, witness statement, 30 March 2012, NEW0069/5, para. 11.

⁶ Pike River Coal Ltd, New Zealand Prospectus: An Offer of Shares in a Major New Zealand Coal Company, 22 May 2007, DAO.012.02790/133, para. 4.1.

⁷ CMS Ltd, Pike River Coal Mine Pre-feasibility Study, 25 May 1995, DAO.012.03289/33, 42.

⁸ Minserv International Ltd, Pre-feasibility of the Pike River Coal Mining Project, March 1998, DAO.012.03362/3.

⁹ Minserv International Ltd, Pike River Coal Field Pre-feasibility Study, September 1998, DAO.012.03403/10.

¹⁰ Pike River Coal Company Ltd, Application to the Ministry of Commerce for a Coal Mining Permit Covering the Pike River Coal Field, February 1996, MED0010070015/4, 12, 15.

¹¹ Paul Carpinter, (Secretary of Commerce), Certificate of Extension of Permit Area, 21 January 1998, DAO.012.03587/2–5.

¹² Department of Conservation, Tier Two Paper, 3 June 2011, DOC0000010001/46–47.

¹³ Ibid., DOC0000010001/51.

¹⁴ Access Arrangement Under Crown Minerals Act 1991, Mining Permit 41–453 Pike River Coal Company Limited, 21 October 1994, DOC0010020044.

¹⁵ Mark Smith, transcript, p. 487.

¹⁶ Craig Jones, transcript, p. 461; Department of Conservation, Tier Two Paper, 3 June 2011, DOC0000010001/63–66.

¹⁷ URS New Zealand Ltd, Assessment of Environmental Effects for the Pike River Coalfield Development, 3 May 2002, DOC0010020043_24/22–23.

¹⁸ John Dow, witness statement, 9 June 2011, DAO.001.0003/25–26, para. 146.

¹⁹ New Zealand Oil & Gas Ltd, Paper Phase One – Context, 25 May 2011, NZOG0067/55, paras 6.88, 6.89.

²⁰ All preceding quotes and figures from Peter Whittall and Gordon Ward: Pike River Coal Company Ltd, Pike River Coal Company Final Mine Plan and Financial Model, 13 July 2005, DAO.012.03499.

²¹ Pike River Coal Ltd, AGM Managing Directors Address, 28 November 2008, DAO.009.10795.

²² Pike River Coal Ltd, 2009 AGM – Managing Directors Address, 23 November 2009, DAO.008.16781.

²³ Map, DAO.004.11082/1.

²⁴ New Zealand Oil & Gas Ltd, Paper Phase One, NZOG0067/57, paras 6.97, 6.99.

²⁵ The company name was changed from Pike River Coal Company Ltd on 13 March 2006.

²⁶ Pike River Coal Ltd, Prospectus, DAO.012.02790/156.

²⁷ Ibid., DAO.012.02790/12.

²⁸ New Zealand Oil & Gas Ltd, Paper Phase One, NZOG0067/8, para. 2.8.

²⁹ John Dow, witness statement, DAO.001.0003/5–20.

³⁰ Jonathan (Joe) Edwards, witness statement, 24 May 2011, MCD0001/12, paras 44–45.

³¹ Pike chose to put pit bottom in stone so that large excavations could occur in a stable environment: Peter Whittall, transcript, p. 713.

³² Health and Safety in Employment (Mining Underground) Regulations 1999, regs 2, 35–40, 55–59; Email, Kevin Poynter to Kobus Louw, 14 November 2008, DOL3000010087.

³³ Pike River Coal Ltd, Plant Location and Ventilation Plan: Rescue 101119_181, 22 March 2011, DAO.010.13140/1. (Extract of plan with typographical error corrected by the commission)

³⁴ Behre Dolbear Australasia Pty Ltd, Pike River Coal Project – Greymouth New Zealand Independent Technical Review, 20 May 2010, NZOG0065/8, 10.

³⁵ Pike River Coal Ltd, Activities Report: Quarter Ended 31 December 2008*, DAO.008.04847/1.

³⁶ Jonathan (Joe) Edwards, witness statement, 24 May 2011, MCD0001/22–23, paras 90, 93.

³⁷ Don McFarlane, witness statement, 30 May 2011 RM.0002/14–15, paras 8.13–8.20.

³⁸ Pike River Coal Ltd, Activities Report: Quarter Ended 30 June 2009*, DAO.007.10907/2.

³⁹ Pike River Coal Ltd, Submission for Pike River Coal Limited (In Receivership) in Relation to Certain Topics for Consideration in Phase One of the Royal Commission of Inquiry, 27 May 2011, DAO.001.0002/36, para. 245.

⁴⁰ Pike River Coal Ltd, Annual Review 2010, 22 September 2010, DAO.008.05092/5.

⁴¹ Pike River Coal Ltd, Activities Report: Quarter Ended 31 December 2008*, DAO.008.04847/2.

⁴² Pike River Coal Ltd, Annual Review 2010, 22 September 2010, DAO.008.05092/6.

⁴³ Department of Conservation, Meeting Notes, 21 December 2007, DOC3000010003/2.

⁴⁴ Masaoki Nishioka, transcript, pp. 3488–544.

⁴⁵ Pike River Coal Ltd, Submission, DAO.001.0002/36, para. 244.

⁴⁶ Pike River Coal Ltd, Annual Review 2010, 22 September 2010, DAO.008.05092/11.

⁴⁷ Ibid., DAO.008.05092/12.

⁴⁸ Department of Conservation, certificate, 11 September 2008, DOC0010020097/1; Pike River Coal Ltd, Annual Review 2008: Breakthrough to Coal, DAO.007.04664/11.

⁴⁹ Pike River Coal Ltd, Activities Report: Quarter ended 31 December 2008*, DAO.008.04847/1.

⁵⁰ Pike River Coal Ltd, Prospectus, DAO.012.02790/7.

⁵¹ Pike River Coal Ltd, Annual Review 2010, 22 September 2010, DAO.008.05092/12.

⁵² David Salisbury, witness statement, 25 May 2011, NZOG0068/24, paras 95, 147, 151.

⁵³ John Dow, transcript, pp. 3931–32.

⁵⁴ NZOG remained the cornerstone shareholder, holding 29.37% of the shares.

⁵⁵ Behre Dolbear Australia Pty Ltd, Independent Management Review, 19 May 2010, NZOG0064/7; Behre Dolbear Australia Pty Ltd, Pike River Coal Project – Greymouth, New Zealand: Independent Technical Review, 20 May 2010, INV.03.28442.

⁵⁶ David Salisbury, witness statement, 25 May 2011, NZOG0068/35, para. 137.

⁵⁷ John Dow, witness statement, 21 July 2011, DAO.001.0005/2, para. 5.

⁵⁸ Pike River Coal Ltd, Minutes of a Meeting of Directors, 13 September 2010, DAO.007.05996/9.

⁵⁹ David Salisbury, witness statement, 25 May 2011, NZOG0068/39, para. 158.

⁶⁰ Donald Elder, witness statement, 8 June 2011, SOL306956_1/11, para. 21.1.

⁶¹ Kathleen Callaghan, transcript, p. 3280.



Organisational factors

- + Organisational structure
- + Governance and management
- + The workforce
- + Health and safety management

CHAPTER 4

Organisational structure

1. This chapter briefly describes Pike's organisational structure at the time of the explosion, including some of the changes that occurred to the structure in 2010. Later chapters include more detailed discussion of the roles introduced here.

Board

2. Pike's board was responsible for 'overall corporate governance of the company including the strategic direction, determination of policy, and matters of finance, approval of significant contracts, capital and operating costs, and financial arrangements and investments.'¹ The board had overall responsibility for Pike's risk management and internal control system.

Directors

3. At the time of the explosion the board comprised John Dow (chairman), Raymond Meyer, Stuart Nattrass, Antony Radford, Dipak Agarwalla and Arun Jagatramka. Gordon Ward was an executive director from July 2006 until 1 October 2010. It appears that none of the directors had underground coal mining experience.² Mr Dow's career was in metalliferous mining, Professor Meyer was a mechanical engineer, Mr Radford was the chairman of New Zealand Oil & Gas (NZOG) and Messrs Agarwalla and Jagatramka were nominees of the Indian shareholder companies, both of which were coke producers.

Committees

4. There were three formally constituted board subcommittees: audit; health, safety and environment (HSE); and remuneration. There was also a less formal due diligence committee, meeting only when required, usually during large-scale projects such as capital raisings.
5. The audit committee reviewed and monitored Pike's financial affairs. Its members were Professor Meyer, Mr Nattrass and Mr Radford.
6. The HSE committee was responsible for ensuring Pike provided a safe workplace, monitoring compliance with environmental consents, permits and agreements, and reviewing projects. Its members were Mr Dow and Professor Meyer.³
7. The remuneration committee was to ensure Pike attracted and retained 'the right people' by offering competitive and fair remuneration packages.⁴ Its members were Mr Dow, Professor Meyer and Mr Radford.

Chief executive

8. As at 19 November 2010, Pike's management was led by the chief executive, Peter Whittall, who was based in Wellington. Before his appointment as chief executive at the start of October 2010, Mr Whittall was the general manager mines. Substantively, he had held this role since he was employed in February 2005. As general manager mines, Mr Whittall had reported directly to Mr Ward.⁵
9. Mr Ward was the chief executive from January 2007 to 1 October 2010. In his role as general manager of NZOG, Mr Ward was responsible from 1998 for 'all aspects of the Pike River coal project, taking it through to construction.'⁶

Site general manager

10. Reporting to the chief executive was the site general manager, Douglas White. Mr White originally started at Pike as operations manager in January 2010. As operations manager, he reported to Mr Whittall and had four managers reporting to him: engineering, safety and training, coal preparation plant (CPP) and the underground mine manager. The remaining managers reported directly to Mr Whittall.
11. Around the time Mr Whittall was promoted to chief executive, the management structure at the mine was reorganised and some roles were reviewed.⁷ Mr White became site general manager, which had previously been the general manager mines role, and the operations manager role was disestablished.
12. As site general manager, Mr White was based at the mine and had general responsibility for the mine's operations. Eight managers reported to him: human resources, environment, project and planning, technical services, underground mine operations, engineering, CPP and safety and training. McConnell Dowell Constructors Ltd also reported to Mr White. He understood his responsibilities as including guiding the mine safely through the project phase into development of hydro production.⁸
13. From 12 June 2010, Mr White was the statutory mine manager, which included supervising the health and safety of the underground operation. In the absence of a dedicated ventilation engineer, Mr White also took on overall responsibility for managing the ventilation system.

Underground mine operations

Underground mine manager/production manager

14. Responsibility for underground mine operations was effectively split between Mr White, as the statutory mine manager, and Stephen Ellis, as the production manager. The production manager role was created following the resignation in June 2010 of then underground mine manager, Michael Lerch. The role was initially filled by a temporary appointee and then by Mr Ellis in October 2010.
15. As production manager, Mr Ellis oversaw the operations underground and, in particular, development operations. He was expected to become the statutory mine manager once he obtained a first class coal mine manager's certificate of competence. That occurred in December 2010, with Mr Ellis appointed to an acting role on 24 December 2010 and then later as the permanent statutory mine manager in May 2011.

Underviewers and deputies

16. There were three underviewers (or shift co-ordinators), one for each shift, and a dedicated hydro co-ordinator, who did not hold a coal mine underviewer's certificate of competence. The underviewers and hydro co-ordinator reported directly to Mr White, in his capacity as the statutory mine manager, rather than Mr Ellis, who was at the same level as them.⁹
17. The underviewers were responsible for co-ordinating activities, planning activities, managing employee attendance and issues, ensuring safety systems were implemented and maintained, and carrying out inspections and examinations.¹⁰
18. Responsibility for the hydro monitor crews' activities lay with the hydro co-ordinator who was responsible for overseeing and managing hydro production, including planning activities, ensuring safety systems were implemented and maintained and ensuring hydro production met or exceeded production targets.¹¹
19. Beneath the underviewers were the deputies, with up to three working on each shift. The deputies carried out the inspections, examinations and reporting required by the company and by law and provided supervision and guidance to their crews.¹²

Mining crews

20. The mining crews comprised, in hierarchical order, senior miners, experienced miners, miners and trainee miners.¹³ They operated the mining equipment, including the hydro-mining equipment.

Contractors

21. Pike used a number of contractors to support mining operations underground. They were involved in a range of activities, including shot-firing, in-seam drilling, electrical and mechanical work, pipe-laying and construction. Many of the contractors in the mine had not previously worked in an underground coal mine and were not miners by trade.

Coal preparation plant

22. The CPP cleaned and separated coal from waste product, ready for transport to the coal handling facility near Ikamatua. The plant was managed by Johan Kloppe. His staff included a process engineer, crews working shifts similar to the mining crews, and an Ikamatua crew.

Engineering

23. The engineering department was responsible for maintaining commissioned fixed plant in the mine, mobile mining equipment and diesel vehicles. That included gas monitoring sensors, the electrical system, the surface fan and other auxiliary fans. It appears that handover of the equipment in the hydro panel to the engineering department had not occurred before 19 November 2010.
24. Robb Ridl was appointed engineering manager in August 2010. He had initiated a restructure of the engineering department, including the creation of new roles. Under the new structure, Mr Ridl would have had four staff reporting directly to him: an electrical engineer, a mechanical engineer, a maintenance engineer and a maintenance superintendent. Beneath them were a communications engineer, three co-ordinators and a maintenance planner and then shift engineers, with electrical and mechanical technicians below them.

Technical services

25. Technical services was responsible for mine design (including underground ventilation, but not gas monitoring), surface and underground exploration, strata control, scheduling, surveying and geotechnical functions. Gas drainage, which evolved from in-seam drilling for exploration, was also a function of the technical services department.
26. Pieter van Rooyen had been the technical services manager since February 2009, but resigned effective from 3 November 2010. A new technical services manager had been recruited, but was not due to start at Pike until December 2010. In the meantime, the technical services co-ordinator, Gregory Borichevsky, an experienced mining engineer, was the most senior member of the technical services department.
27. Nine staff reported to the technical services manager: a technical services co-ordinator, a mining engineer, two geologists (including a graduate), a geotechnical engineer, three surveyors and a surveyor's assistant. The contractor carrying out in-seam drilling, VLI Drilling Pty Ltd, reported to the geologist.

Project and planning

28. Underground infrastructure projects, such as building, installing and commissioning the hydro monitor and the main fan, were carried out by the project and planning department. The project/planning manager was Terence

Moynihan. The project and planning department also included a project engineer, a commissioning manager, a project supervisor, an electrical design and installation engineer, and a systems engineer. All but one were contractors.¹⁴ Many of the small contractors working at the mine reported to members of the project team.

Safety and training

29. The safety and training department was responsible for developing a health and safety system. Implementation of the system and associated plans were the responsibility of each of the operational departments.¹⁵ The safety and training department was not responsible for ensuring the health and safety of the workforce; each department was responsible for its own health and safety.¹⁶
30. Following a reorganisation in 2010, the training function was removed from the safety and training department and placed with the human resources department. Neville Rockhouse, who had been the safety and training manager, became the safety manager. He was supported by two administrative assistants, one of whom was a contractor.¹⁷
31. Before the reorganisation, Adrian Couchman had reported to Mr Rockhouse as the training and safety co-ordinator. By 19 November 2010, Mr Couchman had moved to the human resources department and his role had narrowed to training co-ordinator. Mr Rockhouse was required to pick up the safety-related duties that Mr Couchman no longer performed.¹⁸

Environment

32. The environmental department was responsible for all aspects of environmental compliance, including resource consents, access arrangements and subsidence. It was concerned primarily with surface operations. The environmental department had a total of seven staff, including the environmental manager, Ivan Liddell.

Human resources

33. Human resources was responsible for recruitment, remuneration, employment relations and, following the reorganisation in 2010, training. Additionally, the other departments were responsible for training their own staff. Richard Knapp was the human resources manager. Two staff reported to him, a training co-ordinator and a human resources adviser.

ENDNOTES

¹ Pike River Coal Ltd, Corporate Governance Manual, 1 June 2009, DAO.037.00002/5.

² John Dow, transcript, pp. 4120–22.

³ Ibid., p. 3901.

⁴ John Dow, witness statement, 23 November 2011, DAO.037.00001/22, para. 83(c).

⁵ Peter Whittall, transcript, pp. 727–28.

⁶ New Zealand Oil & Gas Ltd, Paper Phase One – Context, 25 May 2011, NZOG0067/55, para. 6.88.

⁷ Compare organisational structure at June 2010 (Pike River Coal Ltd, Organisational Chart June 2010, DAO.003.06725/1) and at 19 November 2010 (Pike River Coal Limited Organisation Chart as at 19 November 2010, PW23a/1).

⁸ Douglas White, transcript, p. 1118.

⁹ Pike River Coal Limited Organisation Chart, PW23a/1.

¹⁰ The description of the roles of the underwriters is taken from a 2008 draft company document and may not reflect their day-to-day practice: Pike River Coal Ltd, Roles and Responsibilities: Management Plan (Draft Document), 9 September 2008, DAO.002.00960/42.

¹¹ Pike River Coal Ltd, Pike River Coal Hydro Superintendent Job Role, INV.03.29025/1.

¹² Pike River Coal Ltd, Roles and Responsibilities, DAO.002.00960/50; Stephen Wylie, witness statement, 31 October 2011, WYL0001/4, para. 12.

¹³ Peter Whittall, transcript, p. 725.

¹⁴ Ibid., p. 734.

¹⁵ Neville Rockhouse, transcript, p. 4177.

¹⁶ Ibid., p. 4200.

¹⁷ Neville Rockhouse, transcript, p. 4161; Michelle Gillman, witness statement, 10 November 2011, GIL0001/3, para. 1.

¹⁸ Neville Rockhouse, transcript, pp. 4203–04.

Governance and management

Introduction

1. This chapter considers the governance of Pike by the board of directors and the consequential effects on health and safety at the mine. The chapter also deals briefly with the actions of executive managers. Their actions emerge in more detail in the subsequent chapters, which describe how the mine was managed.

Composition of the board

2. At 30 September 2010 the Pike board comprised John Dow, as chair, and five other non-executive directors, as listed in Chapter 4, 'Organisational structure'.
3. Mr Dow had retired following an international career in the metalliferous mining industry. He became a director of Pike in February 2007 and chairman in May 2007. Work had started on constructing the stone drive into the mine and a share market float was imminent. At the time of the explosion, the board had been looking to replace retiring directors with people who had underground coal mining experience.¹ Mr Dow provided the commission with written and oral evidence.² Antony Radford, a non-executive director, provided written evidence. Gordon Ward, an executive director and chief executive, refused to provide written or oral evidence to the commission but had provided evidence to the joint investigation.³ Mr Ward had been on the board since July 2006 and resigned in September 2010. He moved to Australia where he was effectively beyond the commission's reach.

Executive management

4. For the purpose of its report the commission has found it useful to distinguish between 'executive management' and 'functional management' responsible for specific areas such as engineering or technical services. Executive management comprised the chief executive, the general manager and the operations manager. Those positions were filled at various times by Mr Ward, Peter Whittall and Douglas White, as explained in Chapter 4. Mr Ward and Mr Whittall played major roles in the company. Mr Ward was chief executive from January 2007 to September 2010. In his previous capacity as general manager of New Zealand Oil & Gas Ltd he had been responsible for the Pike River project since 1998. Mr Whittall was general manager from February 2005 until he succeeded Mr Ward in October 2010. Mr White was the operations manager from January 2010 and became general manager in October 2010.

Legal obligations of directors

5. Under the Companies Act 1993, Pike's board of directors was responsible for managing the company's business or affairs, or directing and supervising that management.⁴ Under the health and safety legislation the company, as employer, was required to take all practicable steps to ensure the safety of its workers.⁵ The legislation places no specific duty on individual directors to ensure the safety of workers. Directors may be prosecuted if the company has committed an offence under the legislation but only when they have directed, authorised, assented to, acquiesced in, or participated in the company's failure.⁶

Governance by the board

6. The commission adopts the following definition of governance: ‘setting the strategic direction of the company and appointing and monitoring capable management to achieve this.’⁷ The key point is that directors must not only lead but also monitor management and hold it to account.
7. A range of external guidance on good governance practice was available to help the Pike board to govern effectively. Comprehensive guidance on good governance practices was available from the New Zealand Institute of Directors.⁸ This included the need for the board to systematically manage all business risks, to hold management strictly and continuously to account, and to ensure the company complied with regulatory requirements. Best governance practice on health and safety was also available from the UK Health and Safety Executive (the equivalent of the New Zealand Department of Labour).⁹
8. Three Australia/New Zealand Standards guidelines were also available for directors on governance principles, both generally and in respect of health and safety.¹⁰ Governance principles are discussed in more detail in Chapter 28, ‘Improving corporate governance’, when considering recommendations for the future.

Pike’s governance documents

9. The corporate governance manual included the board charter, the charter of the audit committee and the charter¹¹ of the health, safety and environment (HSE) committee.

The board charter

10. The charter described the responsibilities of the board. The ‘managing director’ was responsible for implementing strategy and managing operations. The board was responsible for ‘reviewing and ratifying systems of risk management and internal compliance and control, codes of conduct, and legal compliance’. According to the charter, the board had overall responsibility ‘for the company’s system of risk management and internal control, and has established procedures designed to provide effective control within the management and reporting structure.’¹²
11. The charter described three committees that oversaw aspects of governance on behalf of the board: the audit committee (essentially financial), the remuneration committee and the HSE committee. The use of such committees is commonplace. The allocation of health and safety oversight to the HSE committee is in line with international thinking on health and safety and follows good governance practice.¹³ The responsibility remains with the board and committees must report back so that other directors can raise questions.¹⁴

The corporate risk management policy

12. The board was responsible for annually approving the risk management policy¹⁵ and monitoring the management of risks in the company.
13. In its corporate governance disclosure statement filed with the New Zealand Stock Exchange in September 2010, the company described its risk management in reassuring terms:

Pike River has developed a framework for risk management and internal compliance and control systems which cover organisational, financial and operational aspects of the company’s activities...

Management is responsible for designing, implementing and reporting on the adequacy of the company’s risk management and internal control system. The board requires that management reports to it on a monthly basis as to whether material business risks are being effectively managed, and to the Audit Committee and the Health, Safety and Environment Committee...

The board has a Health, Safety and Environment Committee comprising two non-executive directors with mining and engineering experience... there is a strong safety culture which is fostered by management... detailed compliance programmes operate to ensure the company meets its regulatory obligations.¹⁶

Risk assessment

14. Risk assessment takes a number of forms and typically operates at different levels of a company. The basic concept is to identify risks faced by the company and assess their likelihood of occurring and their consequences if they do occur. To do this, the adequacy of the controls, or defences, intended to reduce likelihood or consequence have to be assessed and additional controls implemented if necessary. Finally, a decision is taken as to whether the risk is acceptable or not, and the risk is then managed. Risk assessment, which starts with the board, is an integral part of modern governance and a continuous process.
15. In Pike's circumstances, one could reasonably expect to see three interacting levels of risk assessment: corporate, mine site and specific proposal. The risk assessments at the corporate level, viewed by the board, should detail the major risks faced across the company, for example in the areas of finance, people and operations. At the mine, the major risks, such as ventilation, would be similarly documented and assessed by executive and middle managers and, depending on importance, would be summarised and included in the corporate-level risk assessment. Risks posed by specific processes or proposals, such as changes to the ventilation system, would be separately assessed at a detailed level by the relevant managers and experts, then summarised and included in the mine site assessment and, if necessary, the corporate assessment.
16. For a high-hazard activity such as underground coal mining, rigorous and continuous risk assessment, and subsequent management, are crucial at all three levels. According to Mr Dow, the board was 'keenly aware' of the risks posed by methane.¹⁷ But the board had no effective framework for ensuring there was a systematic assessment of risk throughout the organisation. The board commissioned no third parties to carry out such an assessment.
17. The corporate risk management policy required an overall risk management committee but this was not established.¹⁸ Mr Dow said Pike instead had committees that individually managed risk in specific areas. One was the HSE committee, which he chaired.

The challenges facing the board and executive management

18. In 2010 the board and executive management faced serious challenges, some of which had been apparent for years. The company had a history of not delivering on its promises. Coal production was years behind schedule and previous estimates of production capacity had to be severely reduced. Lack of revenue was driving the company to seek further funding. There were major problems with the advent of hydro mining, the company's main production method.
19. It appears that no one on the board had experience in the local underground coal mining industry. The business was new, with the mine still under development, as were its systems, including health and safety.
20. There was a rapid turnover of statutory mine managers and middle managers. Many workers were inexperienced. Morale and absenteeism were of concern. The company relied heavily on contractors and consultants. It had purchased equipment unsuitable for the difficult strata conditions encountered. Some key equipment and systems were unproven when production began. There was no suitable second egress for use by workers in an emergency.

Board meetings

21. The board met monthly, sometimes at the mine. The chief executive normally attended. Included in the monthly board papers was an operations report from the mine site, part of which was devoted to health and safety. Mr

Dow considered that 'quite a significant amount of the report focuses on the safety aspects of it and the board was getting quite a lot of good information'.¹⁹

22. The statistical information provided to the board on health and safety comprised mainly personal injury rates and time lost through accidents. Mr Dow was comfortable with the information provided to the board.²⁰ The information gave the board some insight but was not much help in assessing the risks of a catastrophic event faced by high-hazard industries. Pike had not developed more comprehensive measures which would have enabled the board and executive managers to measure what was being done to prevent catastrophes, such as the analysis of high-potential incidents (near misses which could have caused serious harm) and the steps taken to prevent their recurrence. The board appears to have received no information proving the effectiveness of crucial systems such as gas monitoring and ventilation. The nearest the board came to questioning management on such issues appears to have been on 15 November 2010, when the general manager, Mr White, attended his first board meeting and was questioned about safety systems.²¹
23. In describing his approach to governance, Mr Dow compared the difference between governance and management to the difference between 'church and state'.²² The commission does not accept the analogy. Management operated under delegation from the board. Good governance required the board to hold management strictly and continuously to account.

Meetings of the board's health, safety and environment committee

Composition, mandate and meetings

24. The HSE committee, which was to report to the board, consisted of Mr Dow as chair and another director, Professor Raymond Meyer. According to its charter, the committee was to assess management's effectiveness in providing leadership in health, safety and environment matters; review with management the company's strategy and performance in these areas, 'including receiving reports on any significant incidents and measures arising from them to avoid future incidents'; consider and review the identification and management of health, safety and environmental risks as part of the company's overall risk management system; and 'monitor compliance with legal and statutory obligations'.²³
25. The HSE committee was to meet every six months but by the time of the explosion it had not met for 13 months, with the exception of the board meeting of 15 November when it questioned the general manager on health and safety. Mr Dow said that this was because the board as a whole was taking more interest in health and safety.²⁴ No meetings of the HSE committee had been scheduled for 2011, in contrast to meetings of the board.²⁵

Obtaining information

26. In Mr Dow's view, health and safety were the responsibility of the health and safety manager,²⁶ who had charge of the corporate safety management plan, and the mine manager. The health and safety manager presented information to the committee when it visited the mine. Mr Dow did not consider the committee needed to obtain information from other managers.²⁷ If they wished to raise concerns with him they had the opportunity to do so, for example at company dinners or barbecues.²⁸ Mr Dow considered that neither the board nor the committee felt it necessary to obtain further information or seek independent advice on health and safety. The HSE committee recommended that third-party audits of the safety management systems should be done but did not require this when senior management considered they should be deferred until the systems had been bedded down.²⁹

Warning signals

27. In 2010 there were obvious warning signals that things were amiss. These included two third-party reviews that an alert chair and board would have found very revealing. The first review was a comprehensive risk survey by Hawcroft

Consulting International, commissioned by Pike's insurers. The second was a review of legislative compliance conducted by Minserv International Ltd (Minserv).

The Hawcroft risk survey 2010

28. Hawcroft is a specialist risk assessor for the insurance industry, carrying out over 150 insurance risk surveys annually at over 150 mining/processing operations around the world. Their risk survey at Pike covered underground, coal processing and surface operations.
29. In its 2010 report on Pike, Hawcroft repeated its 2009 recommendations that a 'broad-brush' risk assessment of the operation was needed, in order to develop a risk register and determine core hazards.³⁰ The report also identified that a number of specific risk assessments were outstanding on such vital matters as windblast, gas ventilation and hydro mining. Hawcroft rated the risk of a methane gas explosion as 'possible'. The Hawcroft review also commented on the need for timely and effective action on incident reports.
30. Mr Dow said that although the board was aware of the review, he had not read the report and the board had neither considered it nor been briefed on it.³¹ Mr Dow considered the matters raised would be appropriately dealt with by management at the mine.³² The Hawcroft report was not, in his view, something that would normally come to the board or its HSE committee.³³
31. Mr Dow added that the site managers were responsible for bringing the issues they considered important to the board's attention. These people were very competent and the board had every confidence in them.³⁴ There were plenty of opportunities for site managers to bring safety concerns to his attention in both formal and informal situations;³⁵ and he was surprised that they had not done so.

The Minserv legislative compliance audit 2010

32. In the course of eight visits to the mine between February and April 2010, David Stewart, an experienced mining consultant and principal of Minserv, conducted a legislative compliance audit.³⁶
33. In August 2009 Mr Dow had been approached by a professional colleague who expressed concern about aspects of the Pike River mine, including training and culture. Mr Dow discussed this with Mr Stewart. Mr Stewart said that Mr Dow was concerned about the turnover of senior managers, difficulties in recruiting good managers, morale and the failures to meet production targets.
34. Mr Stewart told Mr Dow that the management team needed help from someone entirely familiar with New Zealand regulations and conditions, and the starting point should be a legislative compliance audit.³⁷ Mr Dow referred Mr Stewart to Mr Whittall.
35. Mr Stewart's review identified serious problems with safety critical systems.³⁸ Among these he noted that:
 - the instrumentation of the main fan was not compliant with regulations;
 - there was no remote gas monitoring systems in the mine connected to the control room;
 - the ventilation structures (stoppings and doors) were inadequate and training on construction was needed;
 - the stoppings needed protection from blast damage caused by shot-firing;
 - there was a lack of information about ventilation air flow;
 - there were obstructions and debris in the main returns leading to the Alimak ventilation shaft;
 - there were no stone dust barriers;
 - the ventilation shaft was impractical as a second egress;
 - intershift reports by mine deputies were inadequate; and

- the methane gas drainage line alongside the main access road in Spaghetti Junction was at risk of damage by mobile equipment.
36. Mr Dow did not ask for Mr Stewart's reports. He did not require the board or the HSE committee to be briefed on them. He told the commission: 'Mr Stewart was engaged to help the management team deal with the issues. He was engaged by them, the reports went to them. I didn't consider that it was necessary for them to come to me as well and Mr Stewart testified that he didn't expect them to come to me either. I had a subsequent oral conversation with him to ask how it had gone.'³⁹ There does not appear to have been a comprehensive management response to all the issues raised in Mr Stewart's reports. The health and safety manager, Neville Rockhouse, did not see them.⁴⁰

Serious incidents at the mine

37. Mr Dow was asked to comment on a range of high-potential incidents at the mine in the month or so before the disaster.⁴¹ A sample of these was summarised in schedules prepared by the commission.⁴² Although Mr Dow was referred to only a few incidents, these were enough to show that over a five-day period in October 2010 there were six occasions when methane was over 5% of the air. Mr Dow viewed these as 'a series of operational incidents that are very much the prerogative of the onsite management team ... In due course I would expect the board to have been advised at its next meeting.'⁴³
38. Mr Dow was then referred to a number of earlier incidents, including one on 23 June 2010 that concerned dangerous recirculation of air. A mine deputy had attributed this to inadequate ventilation, inadequate leadership and supervision, inadequate engineering, inadequate maintenance, safety rules not enforced and poor stoppings. When Mr Dow was asked, 'Would the committee not have wanted to verify for itself whether those matters had been remedied or not?', he answered, 'No, as I've said on a number of occasions these are operational issues on site ... it's a management issue to follow up.'⁴⁴
39. Mr Dow accepted that the schedules presented to him showed many high-potential incidents were not reported to the board. But he did not accept that the systems were not working and said he was comfortable with the reporting.⁴⁵

Challenges facing executive management in 2010

40. The challenges faced by the executive management, and how they handled those challenges, are described in some detail in Chapters 7 to 12, but some general comments are made now. Although they are described in mining industry terms, the issues also relate to the generic management problems faced in other enterprises – strategy, planning, risks, systems, information and people.
41. Executive managers had to translate the board's strategic direction into operational plans but had difficulty in preparing a comprehensive, long-term operational plan because of continual changes in the mine design and production schedules.⁴⁶
42. Executive managers, like the board, focused on production and earning revenue. As noted in paragraphs 14 to 17 of this chapter, risk management was undeveloped at Pike. The risk of catastrophe was not identified by executive management and was not reported to the board. The warnings in the Hawcroft reports that risk management needed improvement were not heeded. Similarly, there was no comprehensive response to the Minserv legislative compliance audit. A number of other reports from consultants on safety critical issues, such as methane management and ventilation,⁴⁷ were not properly addressed by the time of the tragedy.
43. The mine's health and safety management systems, including vital systems such as ventilation management, methane drainage, gas monitoring and hydro mining, were still under development at 19 November 2010, as discussed in Chapters 7 to 12.

44. The management information systems were also undeveloped and vital information was not brought together, summarised and analysed for executive managers. For example, as is clear in Chapter 7, 'Health and safety management', key information on health and safety incidents in the mine was available but was not handled systematically and so did not result in a comprehensive response.

Conclusions

45. The board's focus on meeting production targets set the tone for executive managers and their subordinates. The board needed to satisfy itself that executive managers were ensuring that its workers were being protected. After all, the company was operating in a high-hazard industry. The board needed to have a company-wide risk framework and keep its eye firmly on health and safety risks. It should have ensured that good risk assessment processes were operating throughout the company. An alert board would have ensured that these things had been done and done properly. It would have familiarised itself with good health and safety management systems. It would have regularly commissioned independent audit and advice. It would have held management strictly and continuously to account.
46. Mr Dow's general attitude was that things were under control, unless told otherwise. This was not in accordance with the good governance responsibilities. Coupled with the approach taken by executive managers, this attitude exposed the workers at Pike River to health and safety risks.
47. Focused on production targets, the executive management pressed ahead when health and safety systems and risk assessment processes were inadequate. Because it did not follow good management principles and industry best practice, Pike's workers were exposed to health and safety risks.

The future

48. In Chapter 28, 'Improving corporate governance', and Chapter 29, 'Improving management leadership', the commission discusses governance and executive management more generally, identifies the lessons that the Pike River tragedy holds for directors and executive managers in high-hazard industries, and makes recommendations for the future.

ENDNOTES

¹ John Dow, transcript, p. 3900.

² Ibid., pp. 3891–4156.

³ Gordon Ward, Police/DOL interview, 29 September 2011, INV.03.28891.

⁴ Companies Act 1993, s 128.

⁵ Health and Safety in Employment Act 1992, s 6.

⁶ Ibid., s 56.

⁷ David Walker, A Review of Corporate Governance in UK Banks and Other Financial Industry Entities, 26 November 2009, p. 23, http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/d/walker_consultation_261109.pdf

⁸ Institute of Directors in New Zealand, Principles of Best Practice for New Zealand Directors: The Four Pillars of Board Governance, 2010, <https://www.iod.org.nz/Publications/TheFourPillarsOfGovernanceBestPractice.aspx>

⁹ Institute of Directors and Health and Safety Executive, Leading Health and Safety at Work: Leadership Actions for Directors and Board Members, October 2007, <http://www.hse.gov.uk/pubns/indg417.pdf>

¹⁰ Standards Australia and Standards New Zealand, Risk Management – Principles and Guidelines (AS/NZS ISO 31000:2009), 20 November 2009; Standards Australia and Standards New Zealand, Occupational Health and Safety Management Systems – General Guidelines on Principles, Systems

and Supporting Techniques, (AS/NZS 4804:2001), 15 November 2001;

Standards Australia and Standards New Zealand, Occupational Health and Safety Management Systems – Specification with Guidance for Use (AS/NZS 4801:2001), 15 November 2001.

¹¹ Pike River Coal Ltd, Corporate Governance Manual, 1 June 2009, DAO.037.00002.

¹² Ibid., DAO.037.00002/5.

¹³ Health and Safety Executive (UK), Leading Health and Safety at Work, October 2007, <http://www.hse.gov.uk>

¹⁴ Securities Commission New Zealand, Corporate Governance in New Zealand Principles and Guidelines: A Handbook for Directors, Executives, and Advisors, March 2004, p. 13, <http://www.fma.govt.nz/media/178375/corporate-governance-handbook.pdf>

¹⁵ Pike River Coal Ltd, Corporate Risk Management Policy, DAO.001.09450.

¹⁶ Pike River Coal Ltd, Corporate Governance Disclosure Statement, September 2010, NZX2292/6.

¹⁷ John Dow, transcript, p. 4028.

¹⁸ Ibid., p. 4000.

¹⁹ Ibid., p. 3905.

²⁰ Ibid., p. 4031.

²¹ Pike River Coal Ltd, Excerpt from PRC Board Minutes, 15 November 2010, DAO.014.00448/1.

²² John Dow, transcript, p. 3991.

²³ Pike River Coal Ltd, Corporate Governance Manual, 1 June 2009, DAO.037.00002/30.

²⁴ John Dow, transcript, p. 4012.

²⁵ Ibid., p. 3956.

²⁶ Ibid., p. 3984.

²⁷ Ibid., p. 3993.

²⁸ Ibid., p. 4080.

²⁹ Ibid., pp. 3947, 3992.

³⁰ Hawcroft Consulting International, Pike River Coal Limited, Pike River Mine – Risk Survey – Underground, CPP & Surface Operations: Final Report, July 2010, DAO.003.08710.

³¹ John Dow, transcript, p. 4005.

³² Ibid., p. 3983.

³³ Ibid., p. 3989.

³⁴ Ibid., p. 3984.

³⁵ Ibid., p. 3922.

³⁶ David Stewart, Pike River Compliance Audit – Ventilation, 11 February 2010, STE0004.

³⁷ David Stewart, transcript, p. 3324; John Dow, transcript, p. 3927.

³⁸ David Stewart, transcript, pp. 3326–34.

³⁹ John Dow, transcript, p. 4007.

⁴⁰ Neville Rockhouse, transcript, p. 4251.

⁴¹ John Dow, transcript, p. 4034.

⁴² For example: Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of Pike River Coal Limited Deputy Statutory Reports for March and October 2010, November 2011, CAC0115/15–17; Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, November 2011, CAC0114/10–30.

⁴³ John Dow, transcript, pp. 4035–36.

⁴⁴ Ibid., pp. 4037–38.

⁴⁵ Ibid., pp. 4040–41.

⁴⁶ Petrus (Pieter) van Rooyen, transcript, pp. 5181–83; Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/54–55, paras 320–24.

⁴⁷ For example: Drive Mining Pty Ltd, Pike River Coal Limited – Gas Drainage Assessment, 15 May 2010, DAO.001.04811; Comlek Electrical Engineering Contracting Ltd, Report on Ventilation System – History & Current Status, 31 March 2010, DAO.003.05885.

Introduction

1. The labour market for mine workers is global, and demand for skilled and experienced workers is high. Many mines face shortages of experienced staff and therefore need to recruit new entrants to the industry. Their training and supervision are critical.
2. Training is a significant defence against major mining hazards: an inexperienced workforce is less likely to appreciate inherent risks and know how to mitigate them safely. Training requires a strong focus on health and safety and the teaching of safe practical mining skills. Quality ongoing supervision and mentoring are essential, as is supervisor training.
3. At the time of the explosion Pike employed 174 staff.¹ Several contractors also had their own staff and subcontractors onsite. Many members of this combined workforce were inexperienced in the hazards of underground coal mining.

Workforce problems

4. In 2009 and 2010 Pike faced a number of problems with its workforce, at a time of significant change for the company and when pressure for coal production was increasing daily.

High turnover of staff

5. Pike had a high turnover of miners underground,² and was unable to retain personnel in many key operational management roles.
6. As shown in Figure 6.1, from the time the mine was classified as a gassy coal mine in November 2008, Pike had six mine managers, two technical services managers and three engineering managers. In 2010 the mine had two production managers.
7. The high management turnover 'compromised [Pike's] functioning and continuity',³ owing to inefficiencies, loss of institutional knowledge and the need for employees to adjust to differing management styles. There was no systematic handover process when staff changed; the exception was Pieter van Rooyen's handover when he left Pike in November 2010.⁴

Problems in attracting and retaining experienced staff

8. Lack of experience was a significant problem at Pike. As at November 2010 three key operational specialists in the technical services department, and the data and communication systems specialist, had no prior experience working in gassy underground coal mines.⁵
9. On occasion, Pike hired, for specialised roles, individuals who required intensive on-the-job learning amid the pressure for coal production. An example is the hydro co-ordinator who had no previous hydro-mining experience and had made that clear when interviewed for the position. He was promised training and support and was confident he could up-skill. But he received no formal training and was 'a little out of my depth because of my lack of knowledge of the hydro-machinery and equipment'.⁶ Other applicants with operational hydro-mining experience at West Coast mines applied for the role but were unsuccessful.⁷
10. It was also a 'struggle to obtain tradesmen with mining experience',⁸ and Pike sometimes had to rely on contract tradesmen from Australia.

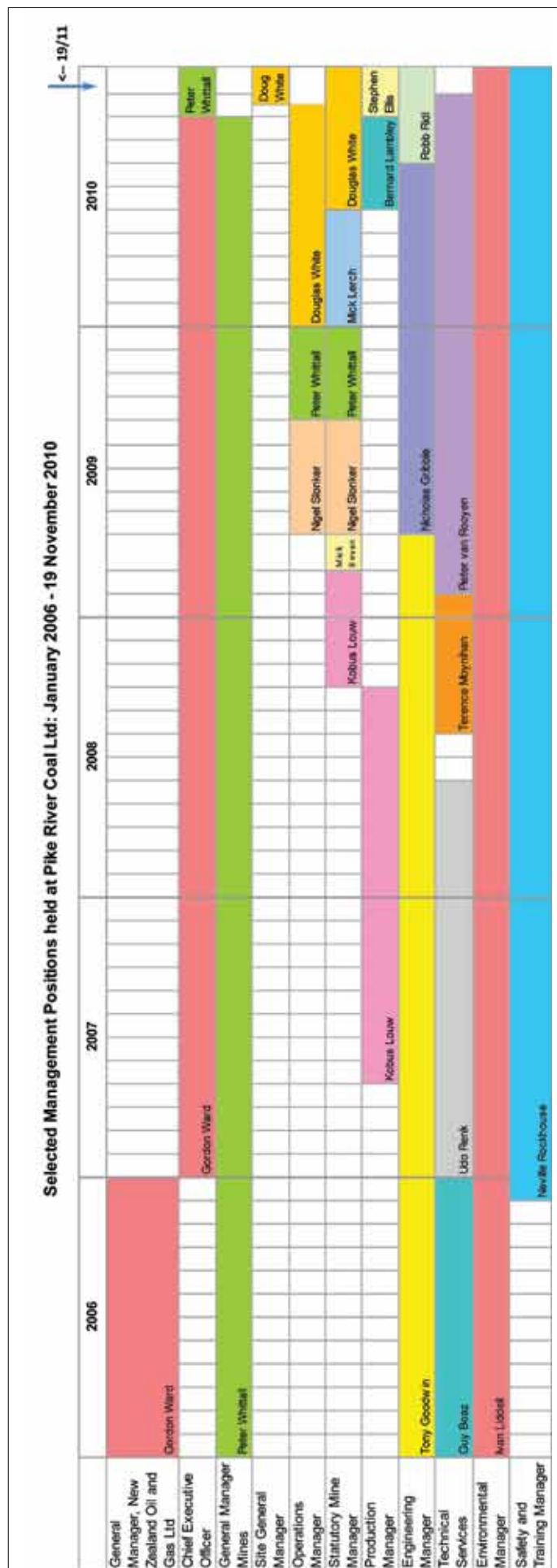


Figure 6.1: Selected management positions held at Pike River Coal Ltd, January 2006–19 November 2010⁹

Underviewers and deputies

11. Pike had an ongoing shortage of underviewers and deputies, which occasionally led to those on shift covering multiple roles.¹⁰ Among other problems, the shortage caused a delay in the training of the person identified as suitable to fill the role of ventilation officer, as the resignation of another underviewer left the mine short staffed at that level. Moving to a 24-hour production cycle in the hydro panel in October 2010, incorporating two 12-hour shifts, also meant that Pike could not have a deputy dedicated full time to the hydro production panel,¹¹ and there was no underviewer responsible for hydro mining.¹²

Percentage of cleanskins

12. Cleanskins are workers with little or no underground mining experience. The prominence of cleanskins within Pike's workforce was described as 'the nature of the modern industry'.¹³
13. There is no set or absolute ratio of experienced to inexperienced miners, but Neville Rockhouse estimated that 40 to 50% of workers at Pike were working in their first underground mine.¹⁴ To David Reece, an expert engaged by the Department of Labour (DOL), that level is a concerning 'sad reality' faced by the industry.¹⁵ Experienced mining consultant David Stewart from Minserv International Ltd (Minserv) considered that the ratio at Pike was not favourable and there were too few experienced miners given the nature of the operation and the conditions,¹⁶ which made it 'very difficult for [Pike] to maintain consistency and development and performance as so much of the work and skills were left to the experienced few'.¹⁷
14. The result of a high ratio of inexperienced miners is either reduced productivity or a lack of time for the experienced miners to 'actually teach and ... mentor all those people in the crews with them',¹⁸ as 'you can't easily do both'.¹⁹ Trainer/assessor George Colligan considered that the ratio at Pike was 'way [too] low' and slowed down the machinery certification process as experienced miners were required to supervise trainees.²⁰
15. Some of the experienced miners working underground had real concerns:

*I have got to admit I've found it very hard here with the young men. They seem to have too much self-confidence, too quick. They've been underground maybe six months and they are a miner. But they can't have in those six months appreciated the dangers down there. ... Some of these young men have called me some serious names while I've been here ... I said, 'Look, I don't care. I've been in this game all my life and I'm not going to die here just because you don't understand where you are working.' And that's why I jacked it in.*²¹
16. Pike recognised the ratio of cleanskins 'was starting to get out of whack' after it employed all the new trainees who completed its second intake of the three-month trainee induction programme, discussed in paragraph 44. Pike decided not to run a third intake for some time.²²

Absenteeism

17. The experience ratio was not assisted by absenteeism. The difficult working conditions underground (the cold, wet environment and steep grades), frustrations with underperforming equipment and low morale were no doubt contributing factors.²³
18. Reginald Matthews, a trainer/assessor at Pike in 2009 and 2010, described the level of absenteeism as 'very high': 'It was almost as if staff took the view that if you could get away with it, and there were no "consequences", then why not do it'.²⁴
19. Adrian Couchman considered that while 'on paper' the ratios per shift were correct, on many occasions experienced staff would be absent but the shift would proceed with trainees under the supervision of the shift deputy.²⁵ The level of absenteeism sometimes had a direct effect on development²⁶ and Pike issued warnings and terminated some employees for absenteeism through 2009 and 2010.²⁷
20. In July 2010 the hydro-mining start-up bonus discussed in Chapter 12, 'Hydro mining', was instituted, although the cause of the absenteeism problem was not clear to the board.²⁸ The bonus was reduced by \$200 for each non-attendance, defined as every day or shift on which an employee was rostered but did not work for any reason,

including sickness or lateness.²⁹ By November 2010, Pike considered that the bonus scheme had led to a 'reduction in sick leave usage'.³⁰

Diverse nationalities

21. Pike employed a diverse workforce. Mr Stewart's impression was that this diversity created a separation:³¹
*The workforce was further complicated by the mix of New Zealanders, Australians and South Africans scattered through all levels. In many operations this can be an advantage, but at PRC mine it appeared to add to the apparent dysfunctional nature of the organisation and communication within the mine and between underground and surface.*³²
22. As well as difficulties with communication and managerial styles, the diversity also meant a lack of consistency in approach and style to decision-making and in operational planning and implementation. At management level there was a notable lack of local mining experience in the West Coast's unique conditions,³³ and many of the overseas staff were used to operating under and complying with much more prescriptive mining regulations than existed in New Zealand.
23. Neville Rockhouse considered that the integration of diverse backgrounds of Pike's staff and contractors was also 'not an ideal situation for generating effective health and safety in the mine' and led to differing levels of understanding of health and safety documents, including risk assessments, job safety and environmental analyses (JSEAs) and safe operating procedures (SOPs).³⁴
24. In 2007 Pike had recognised that 'cultural diversity will certainly become an issue' as the company expanded,³⁵ and proposed training for the management team and employees. This had not occurred before the explosion.

Training at Pike

Obligations to workers

25. Under the Health and Safety in Employment Act 1992 (HSE Act) Pike was required to take all practicable steps to ensure that every employee had adequate supervision and training to work underground.³⁶

Industry qualifications

26. The mining industry in New Zealand has largely determined its workforce skill standards through the work of the Extractive Industry Training Organisation (EXITO). EXITO has set the curriculum and assessment requirements for regulated roles in mines, and worked with employers to develop national qualifications for the mining industry. DOL, as the regulator, has not been involved.
27. There are 24 extractives industry qualifications (national diplomas and certificates) available in New Zealand,³⁷ including several specific to the coal industry, all with a strong focus on health and safety in the workplace. All EXITO's national qualifications are made up of unit standards that set out short statements of what people need to know or be able to do to show that they are competent in a particular skill area.³⁸
28. People carrying out specific roles, including first class coal mine manager, coal mine interviewer and coal mine deputy, must have certificates of competence (COCs), also known as tickets, permits or licences. These are different from EXITO qualifications but are obtained by completing some of the same unit standards, together with relevant experience. DOL delegated authority to EXITO to issue COCs.

Recognition of overseas certificates of competence

29. The necessity to fill statutory positions with overseas workers led Pike to push for the development, through Tai Poutini Polytechnic and EXITO, of an industry programme known as professional conversation.
30. To qualify in New Zealand under this programme, workers holding COCs from other countries must obtain a

New Zealand gas ticket, complete New Zealand Qualifications Authority (NZQA) unit standard 7142 on legislative requirements,³⁹ and then appear before a panel comprising an educator, an EXITO moderator and an industry expert. The panel assesses each applicant to determine whether any further training is required before a New Zealand COC is issued.⁴⁰ Pike used this programme successfully for several of its overseas staff.

31. In 2009 an automatic process was established, under Part 3 of the Trans-Tasman Mutual Recognition Act 1997, allowing workers holding an Australian COC to obtain the New Zealand equivalent without further training, other than gaining their New Zealand gas ticket. Under this process applicants are not required to complete NZQA unit standard 7142, as long as the mine manager is satisfied that they understand New Zealand's mining legislation,⁴¹ a requirement met by Pike by its site induction or specific onsite training.⁴²
32. Peter Whittall was instrumental in establishing this process, suggesting to EXITO that those holding a COC from New South Wales or Queensland should not have to undergo the subjective professional conversation programme when the qualifications were mutually recognised.⁴³ EXITO and DOL eventually agreed. This means that no professional conversation is required,⁴⁴ and there is no objective assessment of an applicant's knowledge of New Zealand legislation.
33. Not everyone agrees with this approach. It is generally accepted in the industry that Australian mining qualifications are of a higher standard than their New Zealand equivalents and are more difficult to achieve,⁴⁵ yet the mutual recognition process also allows New Zealand COC holders to automatically qualify in Australia with limited further training required. This process leads to a perception that New Zealand can be a 'back door' way for Australian miners to more easily obtain their COCs.⁴⁶
34. Alignment of training and qualification standards with Australia and involvement of the regulator are discussed further in Chapter 31, 'Qualifications, training and competence'.

Resourcing of training

35. Organisation of formal training at Pike was the responsibility of the safety and training department. From 2007 Pike outsourced several aspects of its workforce training, including to Tai Poutini Polytechnic. But by late 2010 the increase in Pike's workforce meant those involved in health, safety and training had been overworked and under resourced for some time.⁴⁷
36. Mr Couchman was employed in September 2008 as the training co-ordinator, reporting to Mr Rockhouse. He developed and managed staff induction and training programmes, and had a secondary safety role that included issuing personal protection equipment to miners, underground audits of safety equipment, maintenance of the incident/accident reporting system and random drug and alcohol testing. He also chaired the workforce health and safety committee. Mr Couchman had no previous mining experience and arranged to outsource some of the technical training.
37. From June 2009 to May 2010 Reginald Matthews, a workplace trainer/assessor with over 30 years' mining industry experience, was contracted by Tai Poutini and based at Pike to conduct training and assessments on mobile machinery, and surface and underground safety audits.⁴⁸ He was joined in November 2009 by George Colligan, another experienced miner and trainer/assessor with more than three decades of industry experience.⁴⁹ Together, they were responsible for training and assessing everyone at Pike, including contractors, on their competencies on the mine's machinery and equipment. Messrs Matthews and Colligan established a database or skills matrix that recorded and updated every individual crew member's skill level and certified competencies.⁵⁰
38. After Mr Matthews left Pike, Mr Colligan became the sole trainer/assessor at the mine. Pike was employing more staff and commissioning more plant and equipment, leaving him 'run of [sic] my feet' trying to keep up with the workload.⁵¹ Mr Colligan had either trained or assessed 28 of the 29 men who died in the mine on 19 November 2010 in various roles and on different mining equipment and plant,⁵² and was confident that each had reached their respective certified skill levels and competencies in accordance with Pike's processes and procedures.⁵³
39. From July 2008 the safety and training department also had a part-time contractor, Michelle Gillman, who assisted Mr Rockhouse in controlling the safety management documents and planning safety materials.⁵⁴ Mr Rockhouse

campaigned for more staff and was given some administrative support,⁵⁵ but after restructuring in September 2010 Mr Couchman ceased his safety role and moved into the human resources department as the training officer.⁵⁶ Neither Mr Couchman nor Mr Rockhouse considered the restructuring a positive move, and other commitments left Mr Rockhouse little time to conduct safety audits underground after Mr Couchman was transferred.⁵⁷

Training of workers

Recognition of training needs

40. Pike's response to the difficulty in attracting and retaining experienced staff was to recruit 'suitable local people and to give them appropriate training'.⁵⁸ The company recognised that this meant a need for quality industry-based training, so it developed a number of training programmes from a basic induction through to specialised training for departmental staff.
41. For all its training programmes Pike used a consistent principle that 'three bodies of evidence of competency' were required: attendance at a training course, completion of a written assessment and an assessor's sign-off confirming competency.⁵⁹ Initially, each employee had performance appraisals when their individual training needs were identified by the head of department and signed off by the mine manager.⁶⁰ However, performance appraisals were 'overlooked' from mid- to late 2009, and Mr Rockhouse only had time to do 'a couple' of safety contacts (performance checks of staff underground) in 2010.⁶¹

Basic induction

42. Everyone working or visiting underground was first required to attend Pike's basic classroom-based induction training, which had up to four levels, depending on where an inductee would be working. Underground workers had to complete a 'level 2 – general surface induction' and 'level 3 – underground induction', which together took about two hours and introduced the mine site, covered rules for working on the surface and underground, and included instruction on emergency procedures.⁶² New employees had a more in-depth induction that initially took up to two and a half weeks, but was shortened to a week when employee numbers increased.⁶³ However, on occasion contractors were found working underground with no induction.⁶⁴
43. Every person working underground at Pike also had to pass a medical examination and complete the New Zealand NZQA unit standard 7146.⁶⁵ This two-day course, delivered offsite by the Mines Rescue Service (MRS), required participants to describe and demonstrate the basic skills necessary for working in an underground mine.⁶⁶

Trainee induction programme

44. In 2009, in partnership with Tai Poutini Polytechnic, Pike developed a 12-week trainee induction programme designed for people new to the mining industry. The programme, based on NZQA unit standards, involved an initial two-week induction course at Pike, which included an underground tour and a walk out of the mine, then four weeks offsite completing training from the MRS and experienced consultant trainers. There was a further six weeks onsite at Pike when they were assigned to a crew, rotating around shifts. During that period trainees would work two to three shifts per week under supervision, and spend two days offsite on further theoretical and practical study.⁶⁷
45. At the end of the programme, trainees completed a set of unit standards which gained them a Level 2 National Certificate in Extractive Industries (Introductory Skills). Then, if considered suitable, a trainee would be offered a job at Pike and, after one year underground as a trainee miner, could apply for miner status.
46. This trainee induction programme was described as 'ground breaking and extremely comprehensive', and the polytechnic received positive feedback from Pike management, experienced miners and the trainees themselves.⁶⁸
47. Two intakes were run before November 2010 and 11 trainees completed the programme in each intake, and were offered employment at Pike.⁶⁹

Continuing workforce training in 2010

48. Management appreciated that targeted ongoing training was necessary for its workforce, and made efforts to address training gaps when they were identified. Sources of information on training requirements included the statutory reports, incident/accident reports and the *I Am Safe* booklets completed by workers.
49. The trainer/assessors frequently found 'non-trained or non-competent' people operating machinery underground,⁷⁰ and provided specialised training to workers and licensed them for the operation of equipment and machinery.⁷¹ Shortly after his arrival at Pike, Douglas White brought in a consultant to audit Pike's training packages against the equivalent NZQA unit standards. Mr Couchman had begun to update some of the training packages for mine machinery by the time of the explosion, but it was a time-consuming process.⁷²
50. Pike's engineering department had developed a reputation for isolating itself and not being involved with the safety and training department's objectives and requirements. This changed when engineering manager Robb Ridl was appointed in mid-2010, and Mr Couchman was put in charge of engineering training. Specialist training programmes were designed, a specialist consultant was engaged to provide the training and sessions had begun before the explosion.⁷³
51. In April 2010 Mr White made changes to the shift roster system that meant day and afternoon shifts were shortened and overlapped to allow continuous production and daily one-hour training sessions at the beginning of the afternoon shift. These sessions covered SOPs, where available, supplemented by each department delivering training modules on chosen subjects. Friday was also a designated training day for crews not in production, which usually coincided with a maintenance day for one of the development machines. This session was designed for more advanced or detailed training on specific topics.⁷⁴
52. Mr White also initiated refresher training to be delivered within the Friday training session, targeting miners who had not had any follow-up training for some time. This session was designed to review policies and procedures, and to refresh staff knowledge in such areas as ventilation, use of self-rescuers and first aid training. Outside trainers were often brought in, and in September 2010 Mr Couchman arranged through the polytechnic for Harry Bell, a highly regarded and experienced West Coast miner, to conduct eight of these Friday refresher sessions on gas and ventilation management.⁷⁵
53. However non-attendance at the Friday training sessions had increased throughout the year. On one occasion underviewers told Mr Couchman that they could not afford to release staff for training because they did not have enough staff on shift to continue production. By October and November attendance had fallen so significantly that Mr Bell's training was postponed after only two sessions, and Friday training was cancelled for the rest of the year.⁷⁶ Human resources manager Richard Knapp reported the reasons to the management meeting on 10 November 2010:

The issue of Friday training being poorly attended has led to the decision to cancel the Friday training for the rest of this year (we also need the production). The reasons behind this are that it is costing the training budget over \$1000 per session to arrange this and when only 2 underground staff turn up to one session and on another occasion nobody turned up at all means that it is not good value for money to continue. This has been an ongoing issue and [sic] has been a struggle to get shift managers to release staff to participate in this process from the beginning.⁷⁷

Some training issues

54. Despite Pike's efforts, there were some gaps in the training programme and some worker behaviour underground revealed training failures.

Training gaps

55. The responsibilities of control room operators had become progressively more demanding as the mine developed but they had received only limited formal training. There had been no formal training on gas monitoring using the Safegas and SCADA programmes, with the exception of specific training from Mr White on a system he had put in

place for monitoring carbon monoxide levels.⁷⁸ After a meeting with the operators, management had agreed to provide more training but this had not occurred before the explosion.⁷⁹

56. Specific training was given to the first hydro-mining crew who worked five days a week commissioning the hydro monitor and equipment in September 2010. When Pike moved to a 24-hour four-crew operation there was limited time to train the new crews. Stephen Wylie, a deputy assigned to one of the hydro crews, had some hydro-mining experience from Spring Creek but asked for training on Pike's set-up. None was given, which 'made it difficult, like especially since I was a supervisor on the panel'.⁸⁰
57. There was also insufficient training in emergency preparedness at Pike. As discussed in Chapter 16, 'Search, rescue and recovery', training on the use of self-rescuers was inadequate. Many of the workers at the mine in November 2010 had not been involved in a mock underground evacuation, the last one having taken place in October 2009. There had been no training to test the practical implementation of the mine's emergency response management plan, which had not been reviewed since February 2009.⁸¹

Lack of leadership training for supervisors underground

58. There was no mentoring system for trainee miners once they were employed,⁸² other than being assigned to a deputy or to an experienced miner. But deputies or leading hands were not given any specialised training in how to supervise, mentor and train the trainees.⁸³ At Mr White's request, Mr Stewart had provided some informal mentoring of the undergrounders and deputies during his compliance audits, accompanying them underground for a shift and providing feedback and guidance,⁸⁴ but this had not continued after April 2010. Pike was working towards having a qualified workplace trainer/assessor on each shift to run the trainees, but this was not in place by November 2010.⁸⁵
59. Comments made to Mr Couchman in November 2010 by some of the second intake of trainees indicated that the safety approach taught in the classroom was not always evident underground.⁸⁶ This concerned Mr White, who considered there was a 'direct leadership issue, especially with our senior miners and deputies'.⁸⁷ He discussed engaging a consultant to help improve supervision underground, but a proposal from an Australian consultant was declined on 18 November 2010 to give Stephen Ellis, the production manager, an opportunity to 'right things himself'.⁸⁸

Contraband

60. Contraband incidents were reported and tool box talk safety advisory and newsflash notices were circulated throughout the Pike workforce.⁸⁹ Random searches for contraband began in late 2009,⁹⁰ and occurred frequently throughout 2010.⁹¹ A process for searches was included in the mine manager's rules.⁹² Contraband was also addressed in the NZQA unit standard training and in Pike's induction and in-house training, and Pike had signs around the site and at the portal entrance reminding of the prohibitions underground.⁹³ Although there are no completed incident/accident forms regarding contraband after April 2010, statements obtained from workers during the joint investigation suggested that the problem of workers taking contraband underground, intentionally or otherwise, continued.⁹⁴

Bypassing safety systems

61. Analysis of the incident/accident reports exposed incidents of deliberate bypassing of safety systems and tampering with safety locks or covers, rendering them inoperable.⁹⁵ As discussed in Chapter 12, 'Hydro mining', a worker admitted briefly taping a plastic bag over a methane monitor on the morning shift on 19 November 2010.⁹⁶

Unsafe ventilation practices

62. The commission received evidence of a number of incidents involving unsafe ventilation practices, including incidents where air was diverted away from a working face without workers being given prior notice,⁹⁷ where the ventilation had been shut down for over 40 minutes while maintenance work on machines underground continued and workers were overcome by fumes from machinery,⁹⁸ and where inexperienced workers showed a lack of regard for basic ventilation and gas practices and the need for set procedures.⁹⁹ These were the types of practices that Mr Bell had been hired to deal with before his training sessions were cancelled.

Contractor problems

Introduction

63. Under the HSE Act, Pike was required to take all practicable steps to ensure that no employee, contractor or subcontractor was harmed while working, and that no hazard in its workplace harmed people in the vicinity.¹⁰⁰ Pike had a contractor management system, but it was not fully implemented.

Induction of contractors

64. Before working underground at Pike, contractors had to complete only the basic two-hour induction training, a medical examination and the NZQA unit standard 7146. Short-term contractors (fewer than five days on site) working underground had only to complete the two-hour induction training.¹⁰¹ Other than delivering basic inductions and some on-the-job instruction, Pike was not involved in training contractors,¹⁰² and it was hit and miss whether all contractors received Pike's safety information by way of tool box advisory notices, newsflashes and the minutes of the health and safety committee.¹⁰³
65. Mr Couchman was concerned that Pike's standard of induction for contracted workers was deficient compared with that given to new employees.¹⁰⁴ To address the problem, in mid-2010 Mr Couchman designed a standardised five-day induction for employees and contractors, which he presented to Messrs White and Rockhouse. The programme was welcomed but he was told 'we would have to wait until we were in full coal production before it could be introduced'.¹⁰⁵ He understood that was because of the time needed to fully induct the large number of contractors on site, whereas by the time full coal production was reached (estimated for February 2011) there would have been a 'lot less reliance' on contractors.¹⁰⁶

Pike's policy on contractor management

66. Pike's policy and procedures for managing contractor health and safety were set out in its safety manual,¹⁰⁷ which included requirements for contractors to comply with the mine manager's rules, to report incidents or accidents using Pike's forms and to advise the company what risks they and/or their equipment would introduce into the mine.¹⁰⁸ Contractors were to operate under the supervision of Pike staff, usually the project manager who employed them,¹⁰⁹ and a contractor authority to work permit had to be issued by Pike before work started. This was to ensure contractors had the same level of understanding and experience of site operations and hazards as Pike employees.¹¹⁰

Contractor health and safety systems

67. Pike required all contractors without their own site specific health and safety system to complete the contract specific safety management plan in Pike's 'SubbyPack™'.¹¹¹ This was a suite of documentation designed to 'establish a minimum and auditable standard for the management of Occupational Health and Safety by contractors and sub-contractors',¹¹² and to ensure compliance by Pike and the contractor with their obligations under the HSE Act.
68. Both the large contractors, McConnell Dowell Constructors Ltd and VLI Drilling Pty Ltd (VLI), had their own extensive site-specific health and safety systems. McConnell Dowell had a health and safety officer at the mine who attended Pike's health and safety committee meetings and the daily production meetings.¹¹³ Only some of the smaller contractors had their own health and safety systems, but not all of those were specific to Pike or even to underground coal mining.¹¹⁴

Responsibility for contractor management

69. Some Pike staff directly managed contractors,¹¹⁵ and consultants assisting Pike in 2010 were managed by the department staff who engaged them. But from 2009 responsibility for the general management of many of the smaller labour hire contractors (those brought in when necessary to provide labour for projects in the mine) was

given to Terence Moynihan, himself an independent contractor working as manager of the project team,¹¹⁶ and two contractors he managed, Rem Markland and Matthew Coll. The project team managed the day-to-day work of their smaller contractors and were often underground checking on the workers and their tasks, but they did not see their role as including managing the contractors' health and safety, other than in a limited way during construction and installation activities.¹¹⁷

70. In early 2010 Mr Rockhouse learnt that Pike had begun to engage contractors on hourly hire contracts and in about July/August 2010 he asked Mr Moynihan for contractor documentation for the new faces he had noticed around the mine. But it did not exist because the project team was unaware of the health and safety documentation that Pike required from its contractors, or of their obligation to obtain that information before a contractor began work underground.¹¹⁸ This meant many contractors had staff working underground at Pike without their own health and safety system in place, and without the alternative protection of having their staff inducted into Pike's health and safety system, as required by the company's safety manual.¹¹⁹
71. Since management were confident that any safety matters would be addressed by the project team, it was agreed that Pike would improve its safety management system for contractors over the following three months rather than delay the project work (the commissioning of the hydro panel and underground fan) to review each contractor. Those improvements had not occurred by 19 November 2010.¹²⁰

No auditing of contractor safety

72. Although Pike's safety management system required regular audits of contractor safety performance,¹²¹ there is no evidence to establish that Pike audited either McConnell Dowell and VLI or any of the smaller contractors who lost men on 19 November 2010.¹²² As a result of this omission, Pike was missing vital information on its contractors and the hazards that their staff and/or equipment might introduce to the mine.¹²³

Supervision of contractors underground

73. There was no formal system requiring Pike's deputies to regularly check the safety of contractors while working underground.¹²⁴ In practice that was left up to their discretion when checking their areas of responsibility within the mine.
74. There was also no system to keep track of the locations of contractors underground, although the project team had a weekly plan that included information on where their contractors would likely be working each day. Contractors were not restricted from moving around the mine and 'pretty much looked after themselves'.¹²⁵ Visitors and contractors were required to sign in and out but that sometimes did not happen,¹²⁶ and neither that system nor the portal tag board helped the control room or the deputies to keep track of contractors' whereabouts underground.¹²⁷

Conclusions

75. Recognising the training needs of its relatively inexperienced and diverse workforce, Pike set out to create and implement good training programmes. But the company struggled to always train its workforce adequately. This was partly due to underresourcing and work pressures preventing the release of miners from their crews to attend training sessions. Some worker conduct underground reflected inadequate training, inexperience and a lack of underground leadership.
76. Pike's induction training for new employees was comprehensive, but the quality of contractor induction was inadequate. These workers faced the same hazards and should have received the same level of induction.
77. The management of contractors got away from Pike in 2010 and these workers were often left to their own devices. No person or department took overall responsibility for contractor management, and Pike did not ensure sufficient health and safety training and awareness for its contracted workforce. Safety performance audits of contractors were required but did not occur.

ENDNOTES

- ¹ Peter Whittall, witness statement, 22 June 2011, PW0/3, para. 5.
- ² Adrian Couchman, transcript, p. 3827.
- ³ David Stewart, transcript, p. 3344.
- ⁴ Pieter van Rooyen, Pieter van Rooyen Handover Notes, 2 November 2010, PVR002.
- ⁵ Department of Labour, Pike River Mine Tragedy 19 November, 2010: Investigation Report, [2011], DOL3000130010/243, para. 5.10.1.
- ⁶ George Mason, transcript, pp. 3638, 3663–64; George Mason, witness statement, 31 October 2011, MAS0001/5, para. 14.
- ⁷ Matthew Coll, witness statement, 20 November 2011, FAM00055/5, para. 19.
- ⁸ Pike River Coal Ltd, Minutes of a Meeting of Directors, 24 August 2010, DAO.007.28248/4.
- ⁹ Diagram adapted from: Peter Whittall, Selected Management Positions Held at Pike River Coal Limited, January 2005–19 November 2010, PW22/1.
- ¹⁰ Dene Murphy, witness statement, 2 December 2011, FAM00057/15, para. 84.
- ¹¹ George Mason, transcript, p. 3653.
- ¹² Stephen Wylie, transcript, p. 3708.
- ¹³ Peter Whittall, transcript, p. 2786.
- ¹⁴ Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/53, para. 189.
- ¹⁵ David Reece, transcript, p. 4699.
- ¹⁶ David Stewart, transcript, p. 3341.
- ¹⁷ Ibid., p. 3344.
- ¹⁸ David Stewart, Police/DOL interview, 4 April 2011, INV.03.17291/15.
- ¹⁹ Albert (Alan) Houlden, witness statement, 14 November 2011, FAM00053/12, para. 61.
- ²⁰ Alexander (George) Colligan, witness statement, 18 March 2012, COL0001/8, para. 42.
- ²¹ Albert (Alan) Houlden, witness statement, 14 November 2011, FAM00053/8, paras 38–41.
- ²² Adrian Couchman, transcript, p. 3828.
- ²³ Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/54, para. 192.
- ²⁴ Reginald Matthews, witness statement, 29 November 2011, MAT0001/15, p. 96.
- ²⁵ Adrian Couchman, transcript, p. 3828.
- ²⁶ An example occurred in August 2010 when three machines were in position ready to cut coal, but there was a lack of available operators to run them: Pike River Coal Ltd, Operations Meeting, 4 August 2010, DAO.002.14764/6.
- ²⁷ Pike River Coal Ltd, Operations Meeting, 8 October 2009, DAO.002.14097/6; Pike River Coal Ltd, Operations Meeting, 1 September 2010, DAO.002.14860/7.
- ²⁸ John Dow, transcript, p. 3934.
- ²⁹ Letter, John Dow to all staff, 5 July 2010, DAO.011.22212/3.
- ³⁰ Pike River Coal Ltd, Operations Meeting, 10 November 2010, DAO.002.14998/7.
- ³¹ David Stewart, transcript, p. 3369.
- ³² Ibid., pp. 3341–42.
- ³³ Matthew Coll, witness statement, 20 November 2011, FAM00055/6, para. 25.
- ³⁴ Neville Rockhouse, witness statement, 1 April 2012, ROCK0031/8, paras 37–38.
- ³⁵ Pike River Coal Ltd, Leadership Team Meeting – Minutes of the PRCL Leadership Management Team, 28 February 2007, DAO.025.43041/2.
- ³⁶ Health and Safety in Employment Act 1992, s 13.
- ³⁷ National qualifications are those approved and quality assured by the New Zealand Qualifications Authority. They feature in the National Qualifications Framework and levels of difficulty are assessed within this framework, with level 1 being the least difficult and levels 8 to 10 being university qualifications.
- ³⁸ Each unit standard has a level and a credit value, which gives an idea of how long it is likely to take. One credit is roughly equivalent to 10 learning and assessment hours, although this varies depending on the skills and knowledge a candidate already possesses: Extractive Industry Training Organisation, Adding Value to Industry with On-Job Training and National Qualifications, http://exito.org.nz/documents/cat_view/109-corporate-documents
- ³⁹ New Zealand Qualifications Authority, NZQA Registered Unit Standard 7142, Version 7: Demonstrate Knowledge of the Application of Regulatory Requirements to Manage an Extractive Site, 2010.
- ⁴⁰ Peter Fairhall, witness statement, 6 November 2011, FAI0001/1, paras 7–10.
- ⁴¹ Ibid., FAI0001/1, para. 12.
- ⁴² Email, Peter Whittall to Kevin Walker and others, 17 December 2009, DOL3000010036/1.
- ⁴³ Emails between Peter Whittall, Kevin Walker and others, 8 December 2009–4 February 2010, DOL3000010032, DOL3000010036.
- ⁴⁴ Peter Fairhall, witness statement, 6 November 2011, FAI0001/1, para. 12.
- ⁴⁵ Adrian Couchman, transcript, p. 3864; Robert (Gavin) Taylor, witness statement, 11 May 2012, DOL7770060001/2–3, paras 6–11.
- ⁴⁶ Stephen Ellis, transcript, p. 2314. An example at Pike is a mine manager who failed three times to obtain a first class mine manager's COC in Queensland in 2009 and 2010, because he did not pass oral examinations. After arriving at Pike in September 2010, he completed the unit standard requirements and a professional conversation in November 2010, and obtained a New Zealand first class mine manager's COC: Stephen Ellis, witness statement, 17 April 2012, DAO.042.00036; Robert (Gavin) Taylor, witness statement, 11 May 2012, DOL7770060001.
- ⁴⁷ Peter Fairhall, witness statement, 6 November 2011, FAI0001/2, para. 19; Michelle Gillman, witness statement, 10 November 2011, GIL0001/4, para. 17; Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/13, paras 30–31; Reginald Matthews, witness statement, 29 November 2011, MAT0001/8, paras 45–48; Adrian Couchman, witness statement, 28 November 2011, COU0001/7, paras 29–34; Alexander (George) Colligan, witness statement, 18 March 2012, COL0001/97, para. 40.
- ⁴⁸ Reginald Matthews, witness statement, 29 November 2011, MAT0001/4–6.
- ⁴⁹ Alexander (George) Colligan, witness statement, 18 March 2012, COL0001/4–5.
- ⁵⁰ Ibid., COL0001/6–7, para. 38.
- ⁵¹ Ibid., COL0001/7, para. 40.
- ⁵² Mr Colligan had not trained Joseph Dunbar, who was underground at the Pike River mine for the first time on 19 November 2010.
- ⁵³ Alexander (George) Colligan, witness statement, COL0001/8, paras 45–46.
- ⁵⁴ Michelle Gillman, witness statement, 10 November 2011, GIL0001/3, para. 1.
- ⁵⁵ Adrian Couchman, witness statement, 28 November 2011, COU0001/6, para. 26.
- ⁵⁶ Ibid., COU0001/5, para. 18.
- ⁵⁷ Adrian Couchman, transcript, pp. 3823–24; Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/16, 42, paras 39, 41, 141–42; Michelle Gillman, witness statement, 10 November 2011, GIL0001/4, para 14.
- ⁵⁸ John Dow, transcript, p. 3933.
- ⁵⁹ Adrian Couchman, witness statement, 28 November 2011, COU0001/10, para. 49; Adrian Couchman, transcript, p. 3780.
- ⁶⁰ Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/55, para. 195.
- ⁶¹ Neville Rockhouse, transcript, pp. 4273–74; Pike River Coal Ltd, Corporate Safety Manual: Section 1.7, June 2008, DAO.001.08593.
- ⁶² Adrian Couchman, transcript, pp. 3762–63.
- ⁶³ Ibid., p. 3764.
- ⁶⁴ Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, November 2011, CAC0114/64–65, sch I.
- ⁶⁵ Adrian Couchman, transcript, p. 3762; New Zealand Qualifications Authority, NZQA Registered Unit Standard 7146: Demonstrate Basic Knowledge and Ability Required to Work in an Underground Mine, Version 7, 2010, CAC0142.
- ⁶⁶ Including knowledge and use of self-rescuers, cap lamps and personal protective equipment; safe measures for isolation of energy systems to machinery and equipment underground; knowledge of emergency procedures; personnel security issues (contraband, restricted zones and restricted materials) and accounting systems (tag, paper, cap lamp number); and the ability to describe basic ventilation principles and practices in an underground mine, and demonstrate basic knowledge of mine gases. Knowledge of the requirements of the HSE Act and relevant regulations was

also required.

- ⁶⁷ Adrian Couchman, witness statement, 28 November 2011, COU0001/8, paras 36–39; Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/54, para. 190.
- ⁶⁸ Peter Fairhall, witness statement, 6 November 2011, FAI0001/1, para. 5.
- ⁶⁹ Adrian Couchman, transcript, p. 3772.
- ⁷⁰ Reginald Matthews, witness statement, 29 November 2011, MAT0001/6, para. 31.
- ⁷¹ Adrian Couchman, transcript, p. 3778.
- ⁷² Ibid., pp. 3780–81.
- ⁷³ Adrian Couchman, witness statement, 28 November 2011, COU0001/10, paras 50–51.
- ⁷⁴ Douglas White, transcript, pp. 1119–20; Adrian Couchman, transcript, p. 3782; Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/54, para. 191; Email, Michelle Gillman to Neville Rockhouse and Douglas White, 7 March 2010, ROCK0027/1.
- ⁷⁵ Adrian Couchman, witness statement, 28 November 2011, COU0001/9, para. 45; Adrian Couchman, transcript, pp. 3781–82, 3829–30.
- ⁷⁶ Adrian Couchman, witness statement, 28 November 2011, COU0001/9, para. 47; Adrian Couchman, transcript, pp. 3829–30; Peter Fairhall, witness statement, 6 November 2011, FAI0001/2, para. 17.
- ⁷⁷ Pike River Coal Ltd, Operations Meeting, 10 November 2010, DAO.002.14998/8.
- ⁷⁸ Douglas White, transcript, p. 4923.
- ⁷⁹ Daniel Duggan, transcript, p. 1609; Barry McIntosh, Police/DOL interview, 2 August 2011, INV.03.28697/33–34; Douglas White, transcript, pp. 4921–24.
- ⁸⁰ Stephen Wylie, transcript, p. 3705.
- ⁸¹ Douglas White, transcript, p. 1263; Neville Rockhouse, transcript, p. 1451.
- ⁸² Adrian Couchman, transcript, p. 3776.
- ⁸³ Ibid., pp. 3776–77.
- ⁸⁴ David Stewart, transcript, pp. 3343, 3360–61; Emails between Douglas White, David Stewart, Michael Lerch and Peter Whittall, 15–16 February 2010, CAC0138/4–5.
- ⁸⁵ Adrian Couchman, transcript, p. 3777.
- ⁸⁶ Adrian Couchman, witness statement, 28 November 2011, COU0001/8, para. 41; Adrian Couchman, transcript, pp. 3773–74; Pike River Coal Ltd, Trainee Miner Recommendations: August 2010 Intake, 9 November 2010, INV.04.00649/2–3.
- ⁸⁷ Email, Douglas White to Richard Knapp and Stephen Ellis, 9 November 2010, INV.04.00691/3–4.
- ⁸⁸ Emails between Douglas White and Ted Botham, 15–18 November 2010, INV.04.00661/4–7 and INV.04.00733/1.
- ⁸⁹ See, for example, Tool Box Talk Safety Advisory notices issued on 31 March 2009 (DAO.001.11364), 15 December 2009 (DAO.001.11428) and 16 April 2010 (DAO.001.11947); and General Newsflash notices on 5 January 2009 (DAO.001.08773), 30 April 2009 (DAO.001.08786), 17 September 2009 (DAO.001.08805) and 27 November 2009 (DAO.001.08820).
- ⁹⁰ In 2009 one of the first searches by an undermanager of 25–30 miners about to go on shift produced an estimated 18–20 restricted articles, including cigarettes, matches and lighters, cans and two cellphones. Pike also had instances of cigarette lighters left in the back of driftrunners, cigarette butts in the tunnel, a miner wearing a battery-operated watch underground, and other restricted items such as aluminium and glass vessels found underground: Reginald Matthews, witness statement, 29 November 2011, MAT0001/13, para. 77; Adrian Couchman, witness statement, 28 November 2011, COU0001/22, para. 119; Neville Rockhouse, transcript, p. 4247.
- ⁹¹ Pike River Coal Ltd, Contraband Searches Conducted, DAO.004.00002; Brett Murray, transcript, p. 4426.
- ⁹² Pike River Coal Ltd, Mine Manager's Rules, 13 September 2010, INV.03.25773/24–25.
- ⁹³ Pike River Coal Ltd, Training Module – Contraband Rules, May 2010, EXH0051/1; Brett Murray, transcript, p. 4423; Photograph, 'No Contraband Permitted Underground' sign, EXH0052/1.
- ⁹⁴ David Reece, transcript, pp. 4668–69.
- ⁹⁵ Royal Commission on the Pike River Coal Mine Tragedy, Summary of the Reports, CAC0114/20–24.

- ⁹⁶ Police/DOL interview, 8 April 2011, INV.03.17556/1–22. (The commission decided, by majority, to withhold the name of the worker concerned. Commissioner Bell dissented.)
- ⁹⁷ Albert (Alan) Houlden, witness statement, 14 November 2011, FAM00053/9, paras 45–47.
- ⁹⁸ Reginald Matthews, witness statement, 29 November 2011, MAT0001/11, para. 68.
- ⁹⁹ Albert (Alan) Houlden, witness statement, 14 November 2011, FAM00053/10, paras 50–51.
- ¹⁰⁰ Health and Safety in Employment Act 1992, ss 16, 18.
- ¹⁰¹ Email, Adrian Couchman to Andrew Sanders, 19 May 2010, attaching Pike River Coal Ltd, PRCL Contractor Management Overview, DAO.003.01788/1–2.
- ¹⁰² Adrian Couchman, witness statement, 28 November 2011, COU0001/13, para. 71.
- ¹⁰³ Department of Labour, Investigation Report, DOL3000130010/266, paras 6.14.1–8.
- ¹⁰⁴ Adrian Couchman, transcript, p. 3768.
- ¹⁰⁵ Adrian Couchman, witness statement, COU0001/14, para. 76; Adrian Couchman, transcript, p. 3768–69.
- ¹⁰⁶ Adrian Couchman, transcript, p. 3769.
- ¹⁰⁷ Pike River Coal Ltd, Corporate Safety Manual: Section 8.1, June 2008, DAO.001.08536/1–5.
- ¹⁰⁸ Ibid., section 8.1, DAO.001.08536/3.
- ¹⁰⁹ Ibid., section 8.4, DAO.001.08548/2.
- ¹¹⁰ Ibid., section 8.8, DAO.001.08287/1–3.
- ¹¹¹ Pike River Coal Ltd, SubbyPack – Contractor's Site Specific Safety Management Plan, 2008, ROCK0011.
- ¹¹² Ibid., ROCK0011/7.
- ¹¹³ Department of Labour, Investigation Report, DOL3000130010/260, para. 6.10.5; Jonathan (Joe) Edwards, witness statement, 24 May 2011, MCD0001/28, para. 124.
- ¹¹⁴ Department of Labour, Investigation Report, DOL3000130010/269–81.
- ¹¹⁵ For example, Douglas White (McConnell Dowell), Jimmy Cory (VLI) and Michael Scott (electrical contractors): Department of Labour, Investigation Report, DOL3000130010/260, para. 6.10.6.
- ¹¹⁶ Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/64, para. 246.
- ¹¹⁷ Terence Moynihan, Police/DOL interview, 21 April 2011, INV.03.19308/25–33; Rem Markland, Police/DOL interview, 5 April 2011, INV.03.17730/31–34.
- ¹¹⁸ Neville Rockhouse, witness statement, ROCK0002/65–67, paras 253–55; Terence Moynihan, Police/DOL interview, 21 April 2011, INV.03.19308/25–33; Matthew Coll, Police/DOL interview, 20 April 2011, INV.03.19129/14–16; Pike River Coal Ltd, Corporate Safety Manual: Section 8.1, June 2008, DAO.001.08536/3.
- ¹¹⁹ Ibid., DAO.001.08536/3.
- ¹²⁰ Neville Rockhouse, witness statement, ROCK0002/66–67, paras 256–58; Terence Moynihan, Police/DOL interview, 21 April 2011, INV.03.19308/26.
- ¹²¹ Pike River Coal Ltd, Pike River Coal Safety Audit Schedule V1, 12 August 2010, DAO.010.00316/2; Pike River Coal Ltd, Corporate Safety Manual: Section 8.5, June 2008, DAO.001.08557/1.
- ¹²² Department of Labour, Investigation Report, DOL3000130010/267–69, paras 6.15.1–15.
- ¹²³ Pike River Coal Ltd, Corporate Safety Manual: Section 8.1, June 2008, DAO.001.08536/3.
- ¹²⁴ Department of Labour, Investigation Report, DOL3000130010/264, para. 6.13.9; Simon Donaldson, Police/DOL interview, 11 July 2011, INV.03.24207/7–8; Shaun Whitau, Police/DOL interview, 4 February 2011, INV.03.12950/21–22.
- ¹²⁵ Rem Markland, Police/DOL interview, 5 April 2011, INV.03.17730/45; Craig Bisphan, Police/DOL interview, 12 July 2011, INV.03.24109/49.
- ¹²⁶ One contractor working at Pike River since 2009 said he was not instructed to and did not sign in at the control room; instead he believed that a microchip access button he was provided registered his whereabouts. He had lost his tag for the board about four months before the explosion and had not been given a new one: Phillip Smith, Police/DOL interview, 20 October 2011, INV.03.31617/33–34.
- ¹²⁷ Dene Murphy, Police/DOL interview, 28 January 2011, INV.03.18581/74.

Health and safety management

Introduction

1. Employers must take all practicable steps to ensure the safety of employees. In coal mining and other high-hazard industries best practice is to manage the significant risks involved through a health and safety management system that provides a mechanism for identifying hazards and the risks associated with them, and managing those risks.
2. This chapter introduces the systems concept and its basis in law and practice. It then discusses Pike's approach to planning, implementing, monitoring and reviewing its system.
3. The focus is on the people most involved in developing and managing the health and safety system and what was needed to put it into practice.
4. There is further analysis in other chapters on critical mine systems and organisational factors. Workplace safety is multi-faceted. In mining it is the product of good ventilation and gas control, effective hazard management, ongoing worker training and supervision, and a commitment by managers and directors to worker safety.

Health and safety management systems

5. A health and safety management system is 'that part of the overall management system which includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the OHS policy, and so managing the risks associated with the business of the organization'.¹ It integrates a range of safety management tools and functions including 'senior management commitment, hazard identification, risk management, safety reporting, occurrence investigation, remedial actions and education'.²
6. A health and safety management system provides a framework or structure for the development, implementation and review of the plans and processes necessary to manage safety in the workplace.³ The influences that shape the system and the main elements for an underground coal mine are illustrated in the following diagram.

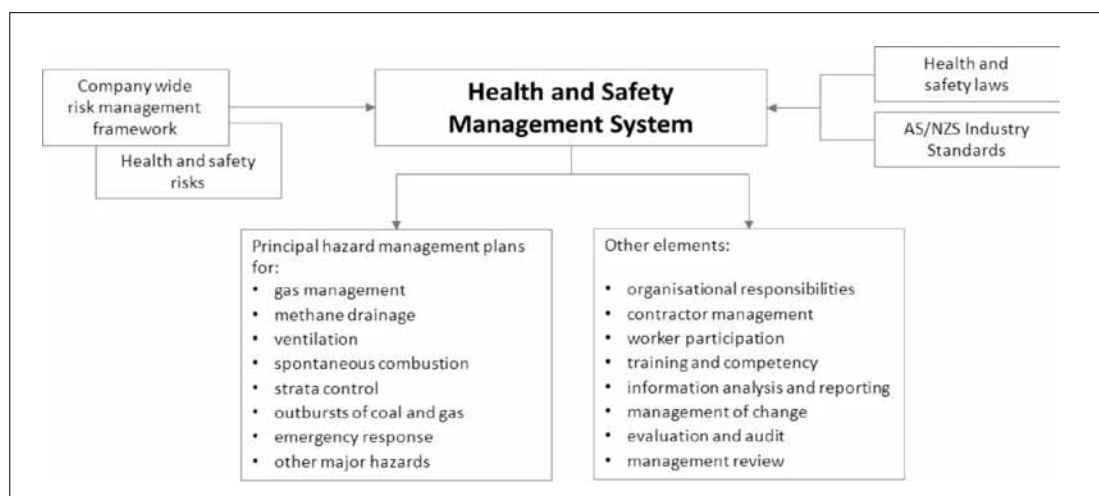


Figure 7.1: Elements of a health and safety system

Requirements of the Health and Safety in Employment Act 1992 (HSE Act)

7. The act's objective is to advance worker safety by 'promoting excellence in health and safety management, in particular through promoting the systematic management of health and safety'. Employers have a general duty to 'take all practicable steps to ensure the safety of employees while at work',⁴ through providing a safe environment, work facilities and plant and ensuring that workers are not exposed to hazards.⁵ Employers must identify and assess hazards,⁶ then implement a hierarchy of controls to eliminate, isolate or minimise those that might cause serious harm.
8. Other obligations on employers include informing employees about hazards to which they might be exposed and the steps to be taken to avoid being harmed by those hazards; ensuring worker health and safety representatives have access to information about health and safety systems; ensuring that employees are properly trained and supervised; and involving workers in health and safety matters.
9. Employees must take all practicable steps to keep themselves safe and not harm others.

The elements of a health and safety management system

10. Two Australasian industry standards provide guidance on health and safety management systems.⁷ These recommend that an organisation:
 - defines its health and safety policy and ensures commitment to the system through leadership and allocation of resources. This is a board and executive management function;
 - develops a management plan to control specific hazards;
 - implements the plan by involving people at all levels in the organisation. Implementation includes allocating resources, assessing training needs, making sure information is communicated, establishing incident/accident and hazard reporting systems, documenting the system and changes, and setting up procedures for continued assessment and control of hazards;
 - measures and evaluates health and safety performance, through inspections, monitoring, incident reporting, investigations and audits; and
 - reviews the system at the executive management level to ensure it is operating effectively and remains appropriate. 'Management review is the cornerstone of the system'.⁸
11. The design of a health and safety management system should be tailored to the circumstances of an organisation and its stage of development. Pike's system, for example, had to recognise that the company was in development and early production mode, mining in difficult conditions, reliant on a growing and diverse workforce, and planning to establish a high-production operation based on hydro mining. Hazard identification and control needed to take account of all these challenges.
12. The commitment of everyone in the organisation, from the chair of the board to trainee miners, is vital to a properly functioning health and safety management system. There must be attention to detail in all aspects of the operation, from design of the mine, procurement of plant and equipment to mining activities – all tasks that affect workplace safety, directly or indirectly.

The Pike approach

An integrated approach

13. Pike recognised the need for an organisation-wide, integrated approach to safety management. The corporate

health and safety policy stated that creating a safe work environment is 'both the individual and shared responsibility of all PRCL employees, management and board' and 'that people at all levels' must be committed to achieving high health and safety standards.⁹ Documentation shows that all aspects of the operation were seen as part of the health and safety management system and that responsibilities were dispersed across the organisation as depicted in this diagram.

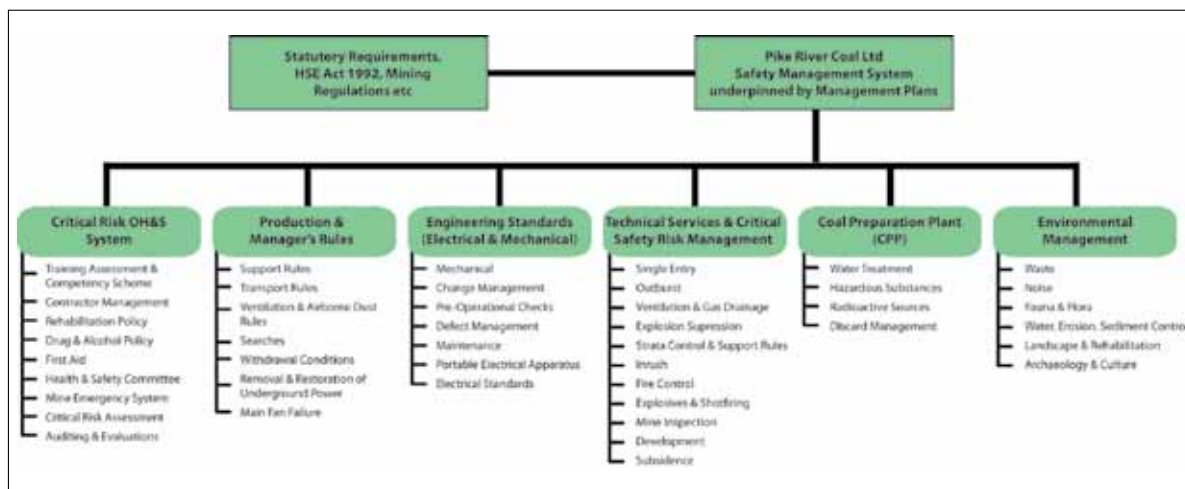


Figure 7.2: Pike safety management systems and management plan¹⁰

Role of the board

14. In its charter, the board's health, safety and environment (HSE) committee acknowledged that the board was ultimately responsible for health and safety and environmental policies and compliance with relevant laws. Responsibility for implementation rested with executive management. The actions of this committee and the board more generally are evaluated in Chapter 5, 'Governance and management'. The HSE committee and the board did not properly identify and manage the major health and safety risks facing the company.
15. Implementation of the health and safety management system was made more difficult because there were no clear objectives and targets during the development phase. Pike relied on having a fully externally auditable health and safety management system by the time 'steady-state production' was reached, which meant that 'virtually ... all of your infrastructure is in place, all of your plant and equipment has been ... fully commissioned and you are a coal mine producing coal.'¹¹
16. This goal was understandable if it meant the system would mature in pace with development of the mine. Workplace safety is a work in progress, and the identification and management of hazards ongoing. But it is critical that health and safety management begins at the planning, design and mine development stages and remains relevant to the stage the mine has reached. At Pike River the drive to produce coal in 2010 led to a view that management of some hazards could await the implementation of a long-term solution, when for example a suitable second egress and a usable fresh air base (FAB) should have been high-priority safety requirements.

The safety and training department

17. High-hazard and complex organisations generally employ specialist health and safety officers. Their existence does not remove the responsibility from directors or managers to manage health and safety in the same way as they manage other risks facing the organisation, such as those relating to production and finance.
18. The functions of Pike's safety and training department included developing the health and safety management system, developing and managing the incident and accident reporting system, conducting underground and medical equipment audits and inducting and training workers. Neville Rockhouse was the safety and training manager. He joined Pike in 2006. Mr Rockhouse had a post-graduate qualification and experience in health and

safety and, earlier in his career, some mining experience. However, at the job interview he impressed upon Peter Whittall that his mining work experience was distant, was not in a gassy mine and did not extend to hydro mining.¹²

19. Mr Rockhouse twice gave evidence to the commission. This posed special difficulties for him: he lost one son in the tragedy and another was one of the two survivors who escaped from the mine.
20. Mr Rockhouse had a heavy workload, sometimes working between 60 to 80 hours per week. He sought more staff for his department, but was largely unsuccessful.¹³ He found it difficult to get co-operation from other managers. Although Mr Rockhouse was the architect of most of the health and safety documents, he depended on technical input from the managers or staff of other departments. He had no authority over the managers and staff and there was no central oversight of the way departments managed health and safety other than Mr Rockhouse who was 'chasing them constantly to get stuff done'.¹⁴
21. The commission is satisfied that Mr Rockhouse needed significant support and guidance in developing Pike's health and safety management system, and direction on priorities. This was lacking. And when Mr Rockhouse was vocal in raising safety concerns, for example the absence of a second means of egress and the need for a refuge chamber,¹⁵ his concerns were not addressed. Generally, his department struggled for credibility alongside the more production-focused departments.
22. The resourcing of the safety and training department, including the staff members who assisted Mr Rockhouse, has been discussed in Chapter 6, 'The workforce'.

Implementing the system

23. Mr Rockhouse began in 2006 with 'pretty much a blank sheet of paper' and was told 'go for it'. He had previous experience in designing a system 'from scratch', but not for a coal mine. However, Mr Rockhouse saw it as 'an exciting project'.¹⁶ He drew on Australian and New Zealand industry standards and had access to management systems from other mines, mainly in Australia, which he adapted to Pike's circumstances. The system was to be computer-based, and was intended to be 'world class'.¹⁷

Documentation

24. The documented system was developed mainly by Mr Rockhouse.¹⁸ The main document was the *Corporate Safety Manual: Safety in the Pike River Coal Workplace*,¹⁹ which covered the employer commitment to safety management practices; planning, review and evaluation; hazard identification; information, training and supervision; incident/accident reporting and investigation; employee participation; emergency planning; and contractor management.
25. Beneath the manual was a hierarchy of documents, including departmental management plans, safe operating procedures (SOPs) to assist in managing known hazards, trigger action response plans (TARPs) to define the response to specific events, and job safety and environment analyses (JSEAs) for specific tasks.
26. A permit to work system operated to define the boundaries for specific work activities. Other documents included the mine manager's rules, an induction handbook, a SubbyPack™ (for contractors) and a hazard register.
27. By November 2010 there were over 398 documents in the electronic system.²⁰ Of these 227 were in draft as they were not signed off by two managers, although they were still used in the meantime. The number, and length, of the documents posed a challenge to the credibility of the system.
28. Although many of the documents were helpful, there were problems, not only with the sheer volume of material, but also with some of its content. For example, in 2010 two consultants and a Pike manager assessed the ventilation management plan and concluded it needed a complete review.²¹

Communication of health and safety issues

29. Informing workers, the board and the regulator about health and safety issues is an important component of any system.
30. Employees must be provided with a range of health and safety information, including about 'identified' hazards to which they may be exposed or that they may create. They may refuse to do work they believe is likely to cause them serious harm. That belief may be based on the advice of health and safety representatives, who must have access to sufficient health and safety information to enable them to perform their functions. Work cannot be refused because it carries an 'understood risk' of serious harm; the risk must have materially increased beyond the understood risk.²² These rights depend on access to accurate information.
31. Pike had a number of mechanisms for providing health and safety information to employees and contractors, including inductions, training, news flashes and tool box talk safety advisories. While these were no doubt of benefit, two problems are apparent.
32. First, it seems some known information, bearing on hazards and increased risk, was not widely published. For example in late October 2010 a high reading of methane occurred at the ventilation shaft. A ventilation expert, John Rowland, said 'I would assume that such an event would be of sufficient importance that subsequent investigations and remediation strategies would be widely publicised to at least all site personnel, as a matter of very urgent priority.'²³ Mr Rockhouse agreed but said 'I didn't even know about it so no, no it wasn't done.'²⁴
33. Prior to the tragedy Mr Rockhouse was not aware of methane readings of 5% reported by deputies during October 2010. When asked whether they received publicity or were notified to site personnel he stated 'No they didn't. You can't trust people can you.'²⁵ Methane readings were also not being properly reported in daily production or weekly operations meetings, nor through the health and safety system.²⁶
34. The hazard was not only that of a potentially explosive methane incident in the workplace, but also that the mine lacked the capacity to prevent that, and further potentially explosive methane levels.
35. Second, this and subsequent chapters identify hazards and risks, some at a systemic level, which it seems were not fully identified or assessed by Pike. Without Pike having accurately identified them and their nature, it is unlikely that workers were informed of them.
36. Board health and safety communication was mainly via executive management's monthly operations report. Direct contact between the safety department and the board was rare. There was a weak link between the board HSE committee and the safety and training department. The committee met Mr Rockhouse infrequently and he did not always receive its minutes.²⁷ There was what Mr Rockhouse termed 'a cursory look at what was going on' by the HSE committee.²⁸
37. Notification of health and safety information to the Department of Labour (DOL) was also inadequate. Employers must notify serious harm and other incidents prescribed by regulation 10 of the Health and Safety in Employment (Mining – Underground) Regulations 1999. These include an explosion or ignition of coal dust or gas, fire or spontaneous heating, unplanned outbursts of gas or water, loss of control of a vehicle, employees being trapped, structural failures, unplanned falls of ground, major collapses of part of the workings, uncontrolled accumulations of flammable or noxious gas, and failures of a main ventilation fan for more than 30 minutes.
38. Pike's incident and accident reporting procedure required serious harm notification, but did not capture and notify all matters required by regulation 10. Many notifiable incidents were not reported to DOL, including high methane readings of about 5% in October 2010.²⁹
39. To Mr Rockhouse's knowledge Pike did not review or take legal advice regarding whether it was notifying the matters it was required to notify.³⁰

The workers site health and safety committee

40. The site committee was of the kind envisaged in the HSE Act. It had the power to make recommendations about health and safety matters which an employer had to adopt, or give written reasons for not doing so.
41. The committee's function was defined as monitoring health and safety, but 'focused on injury prevention' and significant hazard identification and management because 'this process is the key to all of our injury prevention initiatives'. Its role was to gather information from workers, table that information and develop controls to 'manage risk and prevent harm'.³¹ The committee was to comprise an elected chair, a manager, a representative from each department and a union representative,³² although no union involvement eventuated.³³ The committee did not have a budget or authority over workers, although departmental managers had access to funds.³⁴ Later, membership of the committee was increased to include contractor representatives from McConnell Dowell Constructors Ltd and trucking company TNL Group Ltd.
42. The committee met monthly. Minutes were taken and widely circulated, including to the chief executive, general manager and Mr Rockhouse, who sometimes attended meetings. The minutes were also made available to workers by email and by placing copies on notice boards and on smoko tables. However, Adrian Couchman, the chair of the committee, said there was never any feedback from workers.³⁵
43. The committee maintained an 'action sheet' that recorded required actions, the person responsible for implementing them and an assignment and completion date. The sheets show that attention to completing actions varied. Ordinarily, simpler matters were attended to promptly, but actions assigned to some departments were routinely left unresolved. Mr Rockhouse stated, 'some department heads took little notice of action points arising from the meetings.'³⁶
44. Attendance at committee meetings was an ongoing problem. For example, only five of the 10 representatives attended the final meeting on 8 November 2010.³⁷ The engineering department was consistently unrepresented, and had still not appointed someone to the committee as at November 2010.³⁸ Sometimes, there were more managers than workers at meetings, which concerned Mr Couchman, given that the committee was intended to be a workforce forum for health and safety concerns.³⁹
45. Despite these problems the committee remained the voice of the workforce. Following the November 2010 meeting it raised numerous concerns, including the return to service of an unrepaired Jugernaut that had caused a back injury, poor underground management of fire hoses, the unavailability of a drifrunner underground at shift changeover periods and at other times when an evacuation could be declared, a shortage of fans and vent cans underground, the location of a toilet 1.2km away from the working faces, and the inability of miners to contact the control room by digital access carrier (DAC) or phone.⁴⁰ When Mr Couchman conveyed these concerns to Douglas White, Mr Rockhouse and Stephen Ellis, Mr White responded immediately, saying, 'my patience is wearing rather thin on some of these issues.'⁴¹ These were clearly recurrent problems.
46. The most significant obstacle the committee faced was its inability to make progress on the major issues it raised. On 3 March 2010 Mr Couchman, as chair, wrote to Mr Rockhouse asking 'if there has been any further progress made on reaching a resolution in regards to the 2nd means of egress.'⁴² On 17 March 2010 Mr Rockhouse replied, noting that, following a significant risk assessment, the Alimak section of the ventilation shaft would not be used as a second emergency egress if the drift was impassable. Instead a FAB was to be constructed in the slimline shaft stub. But a proper FAB was not completed by the end of June. There was only a pull-down brattice stopping to isolate the slimline shaft stub. This was an interim measure while the FAB was designed and ventilation surveys undertaken.⁴³
47. When the committee met on 13 September 2010, and noted that development of a second means of egress was planned 'sometime in the coming months', it resolved 'that this was not adequate and requested a firm plan be made available to identify when the 2nd means of egress would be actioned.'⁴⁴ Mr Couchman was designated to

action this. The matter was raised at the next meeting, on 11 October, when in the absence of any response from the company, it was reassigned to Mr Ellis to 'chase it up for us'.⁴⁵ At the November meeting it was noted that Mr Ellis would report 'next month'.⁴⁶

48. Hence, by the date of the explosion little progress had been made. There was a plan to establish a walkout second egress, but its construction was at least 12 months off. The interim safeguard of a proper FAB had not eventuated either. A fundamental concern of the workforce remained unaddressed – eight months after it was first raised.

Evaluation and monitoring

49. Ongoing evaluation of available information is an important component of a health and safety management system. It identifies emerging issues and risks and opportunities for improvements. This requires monitoring and reporting mechanisms, management analysis of the resulting information and a response to any warning signs, including effective feedback to the workforce.
50. As well as information from the site health and safety committee, numerous records and reports provided information about problems at the mine. Deputies and underviewers completed reports every shift. Control room operators prepared shift, daily and event reports. Engineers, electricians and machine operators regularly inspected and reported on diesel engines, fans, pumps, sensors and electrical equipment.⁴⁷
51. The safety and training department, assisted by the Mines Rescue Service, audited rescue and medical equipment; the New Zealand Fire Service undertook audits and prepared reports on surface facilities.
52. Later chapters consider the effectiveness of monitoring of specific systems such as those relating to methane, ventilation, strata and mining practices. This section looks at other reporting mechanisms and the company's general response to safety information from within the mine.

Incident/accident reporting and investigation

53. Pike had an incident/accident reporting and investigation system in place. Workers were required to report events on a report form.⁴⁸ These forms went to the safety and training department. Mr Rockhouse investigated some serious matters himself. Otherwise investigations were undertaken by a manager or staff member from the appropriate department. Some events were investigated by a team, which could include the mine manager.
54. The workers reported many incidents and accidents. The commission analysed 1083 reports and summarised a selection of 436 in a schedule.⁴⁹ The schedule groups events by type, including methane spikes, ventilation, strata, bypassing, equipment sparking and a number of others. The numbers suggest that the workforce, including contractors, were committed to reporting events, though the extent of non-reporting is unknown. The reports certainly contained a wealth of information which, if properly analysed, revealed much about the systems and conduct underground.
55. However, there were problems with the investigation process. Many reports were assigned to an investigator, but no investigation was completed. This was evident from the report forms filed with the commission. Mr Couchman described the extent of this problem. Some departments would have only a handful of investigations outstanding, while the engineering and production departments sometimes had up to 70 uncompleted investigations and some were over a year old. Measures to deal with the backlog were unsuccessful. When the backlog was discussed with Mr White in October 2010 he decided that they should be cleared and a fresh start made 'with a new management and a new mine manager'. This meant that the incidents were never properly investigated.⁵⁰
56. The site health and safety committee reviewed a selection of incident/accident reports at its monthly meetings. Approximately six of these were selected at random, and a committee member assessed whether stipulated remedial actions had been carried out.⁵¹ If not, the incidents were reopened and followed up.
57. There was some trend analysis of, and action was taken on, some issues, such as contraband. But because reports were not analysed systematically for recurring safety problems, or weaknesses in control measures, many matters

were not discovered. In this way potential information about safety and emerging risks was lost, and information that could have been obtained from completed investigations was not put to best use. The extent of this deficit was most apparent when Mr Rockhouse described his reaction to seeing the schedules prepared by the commission: 'Mr Wilding, when you spent that three days with me and you showed me that stuff you had me reduced to tears. I know there was no analysis like you've done with that [information] at Pike River.'⁵²

58. There was also a breakdown in providing feedback to the report writers. Mr Couchman considered there was no established system for providing feedback.⁵³ Mr Rockhouse understood that when an investigation was completed, there should have been feedback to the reporter but this 'didn't happen'.⁵⁴

Use of lead and lag data

59. An additional problem was the way overall safety performance was being measured at Pike. The health and safety management system and reporting to management and the board was based mainly on lag, rather than lead, data. Lead indicators 'are measures of pre-emptive actions or initiatives that assist in preventing workplace injury',⁵⁵ for example, the percentage of hazards rectified and near miss investigations. They enable trends and weaknesses in processes to be identified before serious incidents occur. Lag indicators measure events and impacts after the event.
60. In the early days of the mine there was discussion of using lead indicators as key performance measures for managers,⁵⁶ though lag indicators (lost time injuries and later medical treatment injuries) were used.⁵⁷ Lag rather than a mixture of lag and lead data was also reported to the operations meetings and to the board.⁵⁸ There is no sign that the board of directors appreciated the importance of using both types of data.

Management review

61. Periodic management review of the health and safety management system is essential to ensure it remains relevant and to plan improvements. Beyond an audit of statutory compliance in early 2010,⁵⁹ there was no systematic attempt to review the health and safety management system initiated by Pike management.
62. The closest to a review was an insurance risk survey conducted by Hawcroft Consulting International. This established risk ratings that influenced the premiums Pike paid for insurance cover. The company's health and safety management systems were rated as average or above, save in one respect – risk management. This received an average rating in 2009, but a below average/low standard rating in 2010.⁶⁰ The commentary to the survey explained that 'Over the next 12 months Pike River Coal will be in a transition phase from development to steady state coal production from the monitor panels. A number of risks exist associated with methane (gas drainage efficiency), wind blast potential (monitor panels only), goaf falls in monitor panels and actual behaviour of the immediate massive strata.' And, as at July 2010, 'management had not conducted a broad brush risk assessment or formal operational risk assessments into these principal hazards, therefore some risks may remain unknown'.⁶¹
63. Mr Rockhouse was alive to this problem. Aware of Hawcroft's recommendation for a broad-based assessment, he raised the matter at various managers' meetings. Mr Whittall responded that the issue should be 'taken offline', to be discussed 'at a later date outside of this forum'.⁶² There was no discussion and no broad assessment of risks before hydro mining began.
64. A review of the whole health and safety management system would have identified anomalies, many of which could have been readily rectified. For example, the mine manager's rules required people to go to 'a ventilated place' when gas concentrations exceeded 'safe levels',⁶³ whereas regulations prescribe a 'flammable gas' level of '2% by volume, or more' as the trigger point for withdrawal.⁶⁴ Management plans referred to compliance with codes of practice, when these did not exist in New Zealand. These errors probably resulted from using overseas materials when drafting the Pike documents.
65. There was also a gap between the documented system and actual practices underground. The ventilation management plan provided a glaring example of this. In accordance with best practice it required the appointment

of a ventilation engineer, whose critical role was to oversee the ventilation system. But no one was appointed to this position (see Chapter 8, 'Ventilation', paragraphs 89–101). The plan also contemplated the installation of a tube bundle monitoring system, but the mine did not have one.

66. More generally, when referred to numerous examples of conduct and practices that were contrary to the procedures described in the documented system, Mr Rockhouse lamented that 'the purpose of their creation was to actually be used and be followed to keep everyone safe. Clearly that has not occurred across a lot of departments.'⁶⁵

Hazard recording

67. Pike had a suite of documents that enabled the reporting and recording of hazards and associated information. This included accident and incident forms and 'I am safe' booklets which workers could use to report hazards and a 'baseline risk assessment significant hazard register' (register), which listed hazards rated for their risk and probability and their controls. However, that system was not effective. Four examples illustrate why.
68. First, new information gathered by Pike was not always incorporated into the register. When hazards were reported on the accident and incident forms or in 'I am safe' booklets there would be a check to ensure those hazards were listed in the register. If not, they would be included. But multiple occurrences of the same hazard, and reporting of an accident or incident, did not result in re-evaluation of the probability and consequence of the hazard.⁶⁶ The concerns raised in the Hawcroft report did not flow into the register.⁶⁷
69. Second, the register dealt with hazards discretely, for example hazards relating to vehicles, water management, working at heights and ventilation management. The register did not reflect the increased risks resulting from a combination of hazards. Those risks should have become apparent had there been a broad brush risk assessment of the type raised by Hawcroft.
70. Third, many of the controls listed in the hazard register were dependent on compliance with Pike's management plans and operating procedures, and the proper training and assessment of, and operation of equipment by, workers. Yet, as seen elsewhere, there were significant problems with those aspects, which suggest that many of the 'controls' did not exist or could not be relied on.
71. Finally, to Mr Rockhouse's knowledge the register was not used for management-level operational planning.⁶⁸

Conclusions

72. The company did not have a clear strategy from the board that set out its vision, objectives and targets for health and safety management. It did not treat health and safety as a key corporate risk and prioritise the development of an integrated health and safety management system.
73. The executive management team therefore did not always prioritise safety matters. Mr Rockhouse, without a strong mandate, found it difficult to influence and involve others. The safety and training department at Pike appears to have been marginalised.
74. The Pike health and safety management system was never audited internally or externally. If it had been, deficiencies would have been identified, including the gap between the standards and procedures laid down in the Pike documents, and the actual mine practices. Examples of this are highlighted throughout Chapters 8 to 12, on the critical mine systems.
75. Pike generated a lot of information about the safety of critical mine systems and practices underground. This included information about contraband, bypassing of safety devices, ventilation problems, methane spikes, sensor

failures and information on numerous other topics. But much of the information was not analysed and responded to. If it had been, some of the problems discussed in this report would have been highlighted, and a number of warning signs that pointed to the risk of an underground explosion would have been noticed.

76. The appointment of a specialist health and safety adviser does not alleviate the need for an organisation-wide acceptance of responsibility for health and safety management.

ENDNOTES

¹ Standards Australia and Standards New Zealand, Occupational Health and Safety Management Systems – General Guidelines on Principles, Systems and Supporting Techniques, (AS/NZS 4804:2001), 15 November 2001, p. 4.

² Civil Aviation Authority of New Zealand, Safety Management Systems Policy, http://www.caa.govt.nz/SMS/SMS_Policy.htm

³ David Cliff, The Management of Occupational Health and Safety in the Australian Mining Industry, 2012, International Mining for Development Centre, p. 5, http://im4dc.org/wp-content/uploads/2012/01/UWA_1698_Paper-03.pdf

⁴ Health and Safety in Employment Act 1992, ss 5(a), 6.

⁵ To ensure there is broad coverage, and reflect the variety of workplaces, similar duties are imposed on those who control workplaces, the self-employed, principals to contracts and suppliers of plant.

⁶ The definition of hazards is broad. It can include 'physical, chemical, biological, psychosocial and mechanical factors': Kathleen Callaghan, witness statement, 31 October 2011, FAM00042/8, para. 23.

⁷ Standards Australia and Standards New Zealand, Occupational Health and Safety Management Systems – Specification with Guidance for Use (AS/NZS 4801:2001), 15 November 2001; Standards Australia and Standards New Zealand, AS/NZS 4804:2001.

⁸ Standards Australia and Standards New Zealand, AS/NZS 4801:2001, p. 40.

⁹ Pike River Coal Ltd, Health & Safety Policy, DAO.001.09556/1.

¹⁰ Pike River Coal Ltd, Strata Control Management Plan: Management Plan (Final Document), 21 October 2010, DAO.025.38374/4.

¹¹ Neville Rockhouse, transcript, p. 4200.

¹² Ibid., pp. 4197–98.

¹³ Ibid., pp. 4340–41; Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/13, para. 30.

¹⁴ Neville Rockhouse, transcript, p. 4253.

¹⁵ Ibid., pp. 4290–91.

¹⁶ Ibid., pp. 4209, 4278, 4361.

¹⁷ Ibid., p. 4365.

¹⁸ Before Mr Rockhouse began work, Pike had a documented system that he considered would not meet AS/NZS 4801: Neville Rockhouse, transcript, p. 4209.

¹⁹ See table of contents: Pike River Coal Ltd, Corporate Safety Manual: Safety in the Pike Coal Workplace, 2008, DOL7770030013/1–7.

²⁰ Department of Labour, Pike River Mine Tragedy 19 November, 2010: Investigation Report, [2011], DOL3000130010/235, para. 5.5.2.

²¹ Andrew Sanders, Pieter van Rooyen and John Rowland, see Chapter 8, 'Ventilation', paras 39–42.

²² Health and Safety in Employment Act 1992, ss 12, 28A.

²³ John Rowland, witness statement, 25 November 2011, ROW007/1, para. 4.

²⁴ Neville Rockhouse, transcript, p. 4244.

²⁵ Ibid.

²⁶ Ibid., pp. 4224–25, 4244–45.

²⁷ Ibid., p. 4235.

²⁸ Ibid., p. 4366.

²⁹ Ibid., pp. 4266–67.

³⁰ Ibid.

³¹ Pike River Coal Ltd, Corporate Safety Manual: Section 1.8, 26 November 2008, DAO.001.08360/1–2.

³² Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/37–38, paras 125–26.

³³ Adrian Couchman, transcript, p. 3811.

³⁴ Neville Rockhouse, transcript, pp. 4231–32.

³⁵ Adrian Couchman, transcript, pp. 3818–19.

³⁶ Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/38, para. 126.

³⁷ Pike River Coal Ltd, Health and Safety Committee, Meeting Minutes, 8 November 2010, DAO.002.08159/1.

³⁸ Email, Adrian Couchman to Douglas White, Neville Rockhouse and Stephen Ellis, 9 November 2010, DAO.002.08157/1.

³⁹ Adrian Couchman, witness statement, 28 November 2011, COU0001/20, para. 109.

⁴⁰ Email, Adrian Couchman to Douglas White, Neville Rockhouse and Stephen Ellis, 8 November 2010, DAO.002.08157/1–2.

⁴¹ Email, Douglas White to Adrian Couchman, Neville Rockhouse and Stephen Ellis, 9 November 2010, DAO.002.08157/1.

⁴² Email, Adrian Couchman to Neville Rockhouse, 3 March 2010, DAO.002.08049/1.

⁴³ Letter, Neville Rockhouse to Adrian Couchman, 17 March 2010, DAO.002.08049/2–3.

⁴⁴ Pike River Coal Ltd, Pike Health and Safety Committee, Meeting Minutes, 13 September 2010, DAO.002.08125/2.

⁴⁵ Adrian Couchman, transcript, p. 3817.

⁴⁶ Pike River Coal Ltd, Health and Safety Committee, Meeting Minutes, 11 October 2010, DAO.002.08138/2.

⁴⁷ Karyn Basher, witness statement, 10 November 2011, CAC0117.

⁴⁸ Pike River Coal Ltd, Incident/Accident Form for All Accidents, Near Accidents, Incidents and/or Property Damage Incidents, DAO.001.08685.

⁴⁹ Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, 7 November 2011, CAC0114.

⁵⁰ Adrian Couchman, transcript, pp. 3803–04.

⁵¹ Ibid., pp. 3814–15.

⁵² Neville Rockhouse, transcript, p. 4227.

⁵³ Adrian Couchman, witness statement, 26 November 2011, COU0001/17, para. 97.

⁵⁴ Neville Rockhouse, transcript, p. 4257.

⁵⁵ Department of Employment, Economic Development and Innovation, Queensland Mines and Quarries: Safety Performance and Health Report, 1 July 2009–30 June 2010, p. 63.

⁵⁶ Neville Rockhouse, transcript, p. 4207.

⁵⁷ Neville Rockhouse, witness statement, 13 November 2011, ROCK0002/28, para. 87.

⁵⁸ Neville Rockhouse, transcript, p. 4206.

⁵⁹ David Stewart, Pike River Compliance Audits, February–April 2010, STE0004.

⁶⁰ Hawcroft Consulting International, Pike River Coal Limited, Pike River Mine – Risk Survey – Underground, CPP & Surface Operations: Final Report, July 2010, DAO.003.08710/17, 21.

⁶¹ Ibid., DAO.003.08710/11.

⁶² Neville Rockhouse, transcript, p. 4238.

⁶³ Pike River Coal Ltd, Safe Operating Procedure, 13 September 2010, DAO.002.06949/19, para. 8.3.

⁶⁴ Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 21.

⁶⁵ Neville Rockhouse, transcript, p. 4276.

⁶⁶ Ibid., pp. 4256, 4269.

⁶⁷ Ibid., p. 4270.

⁶⁸ Ibid.



Mine systems

- + Ventilation
- + Methane drainage
- + Gas monitoring
- + Electrical safety
- + Hydro mining

CHAPTER 8

Ventilation

Introduction

The purpose of mine ventilation

1. All underground coal mines require adequate ventilation. A mine's ventilation system must deal with the hazards of gas and dust, keep the temperature and humidity within acceptable limits, and ensure there is sufficient air for workers to breathe.¹ The ventilation system should form part of an overall gas management system, including gas monitoring, electrical safety procedures, measures to avoid sources of ignition and, in some cases, pre-drainage of methane.²
2. Poor ventilation is a serious hazard that creates a risk of a major explosion and loss of life. Multiple disasters over more than a century have shown the importance of robust ventilation, which has rightly been described as 'the life-blood of any operational mine'.³

Basic description of a ventilation circuit

3. The basic design of a ventilation system consists of an intake, which draws in fresh air, and a return, which expels contaminated air. This creates a ventilation circuit, with air flowing in, across a working face to collect gas and other contaminants, and out through the return. Mining consultant David Reece referred to the following diagram to explain the concept of a ventilation circuit:

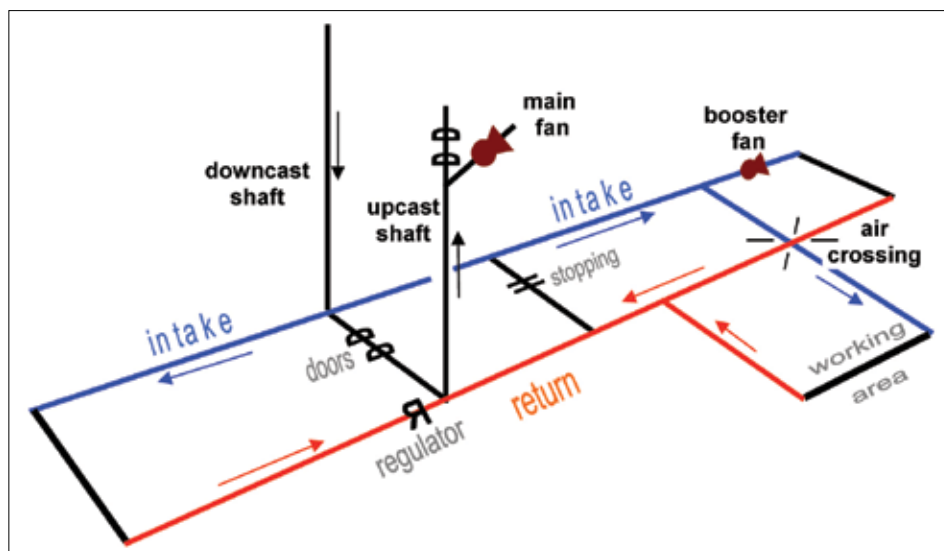


Figure 8.1: Typical elements of a main ventilation system⁴

4. Fresh air is drawn in through a downcast shaft, continues along the blue intake roadways, then across the mining faces shown in black. Contaminated air travels through the return airways, shown in red, and out the upcast shaft through the main fan. At Pike River, the intake was the 2.3km drift, and the main fan was at the base of the upcast shaft rather than on the surface, but the principle of a ventilation circuit was the same.
5. To create a ventilation circuit it is essential to direct air along the correct roadways and in the right direction. This is achieved with ventilation control devices. These consist of stoppings (solid barriers), overcasts or air crossings (which send air over a roadway) and other devices designed to direct or control the flow of air. Any leakage of air, through a poorly constructed stopping, for example, will make the ventilation circuit less effective.

6. The simplest ventilation circuit involves a U shape with the intake and return completely separated by solid walls. However, during development there will frequently be sections of one-way road, as well as dead-end stubs and other areas, that do not naturally fall within a circuit. One solution to ensure these areas are properly ventilated is to use an auxiliary fan, such as the one in the photograph.



Figure 8.2: Auxiliary fan

7. An exhausting auxiliary fan draws contaminated air away from the end of a stub or working face through a tube. A forcing fan may also help to send intake air in the correct direction towards the face. This is shown in the diagram, which shows an exhausting auxiliary fan drawing air away from the face through a ventilation tube, in red, with an additional forcing fan, in blue, on the right to help push fresh air up to the face.

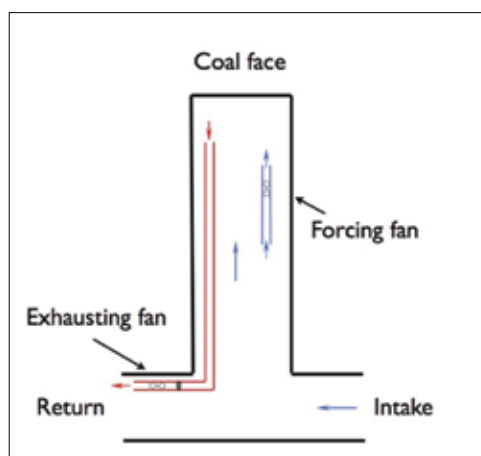


Figure 8.3: Right-hand diagram exhausting system with force overlap⁵

8. In order to function safely and effectively, an auxiliary fan must itself be located in sufficient air to keep it cool and to prevent recirculation of contaminated air. A standard requirement, which applied at Pike River, is that the main ventilation system must provide at least 30% more air to the auxiliary fan than the fan itself draws.

Who designed the Pike River ventilation system?

9. It was clear from an early stage that the Pike River ventilation system would need to deal with significant quantities of methane. As the next chapter describes in more detail, estimates of the methane content in the coal seam varied, and the Minarco Asia Pacific Pty Ltd ventilation report in June 2006 predicted a 'medium to high gas content throughout the resource area, particularly within close proximity to the Brunner fault'.⁶ As a result, Pike River was expected to need about twice the ventilation of a typical high-production longwall mine.⁷ Given the gassiness of

the coal seam, and the other challenges facing the design of the ventilation system, including the rugged surface terrain and complex geology, Pike should have had a dedicated ventilation officer⁸ to oversee the system's design.⁹

10. However, no one person assumed responsibility for designing the ventilation system. When Peter Whittall was asked who designed it, he referred to four different ventilation consultants providing specific advice at different times.¹⁰ It was appropriate for Pike to obtain advice from independent consultants, but the company did not establish clear responsibility and accountability for the overall design of the ventilation system.

Location of the main fan

Suggestions for an underground fan

11. On 31 October 2006 Pike invited four contractors to tender for the design, supply and installation of its main ventilation fans. The invitation stated that the fans were to be located on the surface. That is standard practice in the industry for a number of reasons, including the need for ready maintenance access, a secure power supply and access in an emergency. However, Pike faced significant challenges in installing fans on the surface. The proposed location was in mountainous conservation land, the only access was on foot by a bush track or by helicopter, there was no surface electricity supply and weather conditions on the surface were often harsh.
12. Two contractors ultimately proposed underground fans in addition to the conventional surface fans. It is unclear how the idea of underground main fans originated,¹¹ but Pike decided in favour of and developed the idea jointly with the preferred tenderer, Fläkt Woods Fan (Australia) Pty Ltd, in late 2006.¹²

Unique in the world

13. Pike ultimately decided to install its main fans underground, with a back-up fan on the surface. That situation is unique. Although underground booster fans are common in many countries, there is no evidence of any other coal mine in the world with a main fan underground.

The hazards of underground installation

14. Three main risks arise from locating a main fan underground.¹³ First, it is more difficult to re-establish ventilation after an explosion, which could compromise the survival chances for anyone underground. Second, an underground fan is more likely to be damaged by an explosion. Third, an underground fan is closer to explosive material such as methane and coal dust, and a malfunction of the fan or its motor can be a source of ignition.
15. No doubt for these reasons, legislation in other countries either expressly bans main underground fans in coal mines,¹⁴ or assumes they are installed on the surface and that only booster and auxiliary fans are installed underground.¹⁵ The International Labour Organisation (ILO) code of practice issued in 2006 also assumes main ventilation fans are installed on the surface.¹⁶ New Zealand law does not specifically prohibit the installation of main fans underground, and there is no mention of the location of main fans in the guidelines issued by the national health and safety council for the New Zealand minerals industry (MinEx), in October 2009.
16. Given the risks and the unique nature of the proposal, Pike should have insisted on a robust risk assessment and decision-making process to assess the proposal for an underground main fan. Three aspects of the process adopted by Pike are worthy of analysis: the risk assessment process, the level of oversight by Pike's board and the management's response to concerns raised.

Underground fan risk assessment

17. At the time of the tender process, Pike intended the ventilation shaft would be in stone measures, at a location east of the Hawera Fault. In February 2007 Pike held a professionally facilitated risk assessment into the placement of main fans underground. The risk assessment was led by two facilitators from Platinum Safety Ltd. Their role was specifically confined to facilitation of the assessment process as they had limited experience and knowledge of any

elements of mining.¹⁷ The expert group comprised Pike's engineering manager (Tony Goodwin), technical services manager (Udo Renk), mechanical co-ordinator (Robb Ridl), senior mine engineer (Guy Boaz) and health and safety manager (Neville Rockhouse). The group also included a representative from Fläkt Woods, and Jim Rennie, an Australian ventilation consultant engaged by Pike. Mr Whittall participated in scoping the risk assessment.¹⁸

18. The group noted that installing main fans underground required a rigorous risk assessment process because of the risks to employee safety and business continuity.¹⁹
19. The scope of the risk assessment was described as 'high level', and the facilitators described the process as 'very challenging' and difficult to maintain within the agreed scope and context because people continually left and returned to the meeting. A large number of 'unknown factors' required further analysis by Pike.²⁰

Problems with the underground fan risk assessment

20. In common with other risk assessments at Pike, the process rated the risks of various events and identified proposed controls. The risks were re-evaluated, and often reduced, in light of the controls.
21. For example, the hazard identified as '[b]oth main fans destroyed by explosion' involved the risks of 'destroyed fans', 'employee injury', 'business interruption' and 'suffocation from methane in the mine'. Two of these risks were initially rated as high in the 'red' or 'unacceptable' area, but revised into the 'green' or 'low' risk category in light of various controls, namely:
 - *design and layout of the installation with built in explosion proofing*
 - *protection of equipment by servicing and maintenance*
 - *design consideration of the doors*
 - *limit the sources of ignition*
 - *installation of blast panels to protect the surface fan*
 - *implement detailed Emergency Response Plans*
 - *require supervisors to monitor specific hazardous processes and the installation*
 - *install temperature and vibration sensing equipment*
 - *site in a solid rock housing.*²¹
22. Some of these proposed controls never eventuated. For example, Pike did not install explosion proofing for the main underground fan, did not site the fans in rock and the blast panels on the surface fan proved inadequate during the explosion.

Relocation of the ventilation shaft

23. In September 2007 Pike moved the location of the ventilation shaft from stone into coal, west of the Hawera Fault, as discussed in Chapter 3, 'The promise of Pike', paragraph 47. The fan site moved with it, and despite material changes in the risks, there was no further risk assessment. Commissioning engineer Andrew Sanders, who began work at Pike as a consultant, drew this to Pike's attention in March 2010,²² and listed three questions for the company:
 - Was the risk assessment report ever finalised?
 - Have resulting actions been followed up and signed off?
 - Would it be appropriate to conduct another risk assessment on the latest proposed design and installation?

Mr Sanders' questions were never answered.

24. The risk assessment report was not finalised. There were four versions of the draft report, but despite attempts by Platinum Safety between March and July 2007, Pike never finalised the report. In June 2007 Neville Rockhouse apologised to Platinum Safety for Pike's 'unprofessional conduct with regard to this project',²³ after a third version

circulated to management to provide content had not been completed. The fourth version was distributed to managers in early July 2007 for completion,²⁴ but Platinum Safety had no further communication with Pike.²⁵ Mr Renk described trying several times with Mr Rockhouse to finalise it, but said Mr Whittall disagreed 'with some of the risk ratings and wording of the report and we were not able to finalise it'.²⁶ Mr Whittall does not recall any such approaches. He said he was not on the risk assessment team and it could finalise the assessment without reference to him.²⁷

25. The failure to finalise the risk assessment, whatever the reasons, meant Pike had no adequate basis for deciding whether to proceed with the underground fan in light of the risks. That decision was critical, and should have been informed by a proper and final risk assessment.

Board oversight

26. Other than approving the expenditure required to enter into a contract with Fläkt Woods to manufacture and install the fans in July 2008,²⁸ neither the Pike board nor its health, safety and environment (HSE) committee took steps to ensure management had properly assessed the health and safety consequences of placing the main ventilation fans underground.
27. The board was informed in general terms of the underground fan risk assessment, but neither saw, nor asked for any audit of, the risk assessment report. The operations report to 23 February 2007 simply told the board there was 'no legislative or technical barrier to locating these fans underground with engineering solutions available to identified problems'.²⁹ From the board minutes, that advice appears to have been accepted without question.
28. Board chair John Dow was unaware of any other coal mine in the world with a similar arrangement,³⁰ but he said it was not a matter of particular concern for the board's HSE committee (which he chaired) to review the risks associated with having a main fan underground. He said he remembered having conversations about the location of the fan, but he saw it as a management issue.³¹

Management response to concerns

29. From early 2007, when the operational decision was made, numerous people at Pike raised concerns about locating the main fan underground.
30. In June 2007 Mr Rennie emailed Mr Whittall and proposed a forcing fan at the portal instead of an underground fan. He identified many advantages, including:
 - ease of installation;
 - immediate access to the fan for maintenance;
 - power to the fan would not have to be routed underground and no secondary fan/generator system was required;
 - minimal facilities would need to be maintained at the remote ventilation shaft surface with less environmental impact; and
 - the long-term escapeway via the ventilation shaft would not be needed.

Mr Rennie stated that while his proposal for a forcing fan was 'somewhat unusual', it was 'by no means rare'.³²

31. Mr Boaz was a participant in the February 2007 risk assessment. He left Pike later that year. He did not agree with the idea of putting fans underground and thought that the decision to do so was taken without full consideration of the risks involved.³³ Describing the concept as 'ground breaking', because he had not 'heard of it ever occurring in any other underground coal mine in the world', he raised his concerns with Mr Whittall.³⁴ However, Mr Whittall has 'absolutely no recollection' of this conversation.³⁵
32. Mr Renk, the technical services manager from January 2007 to May 2008, emailed Mr Whittall in October 2007 to say he 'strongly believe[d]' a forcing fan at the portal was preferable to an underground fan and quoted a number of economic arguments to support his case.³⁶ Mr Renk says he was told it was too late as the decision had already

been made.³⁷ Mr Whittall does not recall saying this and also said that in any event a forcing fan was ruled out as impracticable at Pike River.³⁸

33. Concerns continued to be expressed in 2009. Technical services manager Pieter van Rooyen recalled that in about February or March that year Mr Rennie expressed concerns about the placement of the main fans underground. Mr van Rooyen spoke to Mr Whittall, who said the decision had already been made, and one fan was already in New Zealand and the other partially constructed but on hold.³⁹

Oversight by the regulator

34. Michael Firmin, the Department of Labour (DOL)'s health and safety inspector responsible for liaison and inspections of Pike River mine from 2007 to mid-2008, recognised that an underground main fan was unusual and would give rise to more hazards than a surface installation.⁴⁰ Mr Whittall told him, at a meeting on 13 February 2007,⁴¹ that 'he looked at the regulations. And there was nothing that would stop Pike River doing this, and that's basically what he said.'⁴² Pike's risk assessment meeting on placement of the main fans underground occurred two days later.
35. Mr Firmin checked the New Zealand regulations and concluded they 'did not appear to prevent the main fan being installed underground.'⁴³ He was concerned enough to conduct internet research into the regulatory regimes in other countries but said he did not find any regulation preventing an underground installation.⁴⁴

The ventilation management plan

36. Pike had a ventilation management plan, which was signed off by mine manager Kobus Louw and Mr Rockhouse on 18 November 2008, soon after the main drift struck coal.⁴⁵ The ventilation management plan was a 78-page document, with 48 pages of appendices. It dealt with 11 major topics:
 - ventilation design, plans and reports;
 - ventilation fans;
 - ventilation structures;
 - underground environmental monitoring;
 - mine inspections;
 - prevention of ignitions;
 - respirable dust;
 - management of heat underground;
 - wind blast;
 - administration of the ventilation management plan; and
 - responsibilities under the plan.
37. The plan required a ventilation engineer, a tube bundle system, explosion barriers, a permit to work system involving detailed sign-off by the ventilation engineer, and a full risk assessment to determine the non-restricted zone – none of which existed as contemplated by the plan.
38. The plan contained detailed and prescriptive responsibilities attached to 14 different roles at the mine. The mine manager was required to appoint a ventilation engineer,⁴⁶ and to receive reports from the ventilation engineer dealing with any defects in the ventilation or personnel.

Criticisms of the ventilation management plan

39. A number of staff members and contractors at Pike voiced concerns about the ventilation management plan. Mr Sanders produced a report dated 31 March 2010, which noted that the ventilation management plan was out of

date and contained numerous references to standard operating procedures that did not exist or had not been approved. He listed 54 items that required follow-up before the main ventilation fan was commissioned and hydro-monitor operations began. These included:⁴⁷

- the appointment of a ventilation engineer;
- the lack of a tube bundle system;
- the risk of wind blast due to hydro mining;
- clarifying the various responsibilities under the plan;
- ensuring consistency between the ventilation management plan, the emergency response management plan and other plans and procedures at the mine;
- addressing inconsistencies in the definition of the restricted zone;
- confirming assumptions underlying the plan;
- completing an annual ventilation audit by an independent ventilation engineer;
- reviewing the actions to be taken when methane levels rose above set limits;
- creating a hydro monitor panel gas management plan;
- establishing special controls during initial operation of the hydro monitor;
- planning for safe access to the surface ventilation fan in the event of an emergency;
- reviewing of the ventilation management plan;
- carrying out a risk assessment before monitor start-up; and
- training and communication on the ventilation management plan.

40. Mr White accepted that he received a copy of Mr Sanders' report,⁴⁸ although he said he was not aware of the list of 54 things to be addressed before hydro-monitor extraction.⁴⁹ There was no process to check whether the items had been completed,⁵⁰ and many of them were not.
41. Mr van Rooyen, who arrived at Pike in February 2009, realised the ventilation management plan would need to be reviewed because it contained information he considered irrelevant and was sometimes 'too detailed and impracticable'.⁵¹ As a result, he asked ventilation consultant John Rowland to review the plan.
42. Mr Rowland did so and reported: 'to be honest I don't like it either!!' He described it as an all-encompassing plan covering ventilation management, explosion suppression, monitoring and other topics. It was 'gargantuan to be blunt and far too specific in my opinion in a lot of areas'. It would be difficult for him to adjust the plan in isolation: he would need to review the other management plans to see how they dovetailed together, and he would need to see a risk assessment. In his view the plan should be split up into various documents and this would take considerable thought. He said, 'It is ugly and will require far more discerning thought from you guys than you possibly realise'.⁵² Mr Rowland received no further instructions in relation to this matter.

Compliance auditing

43. Australian and New Zealand Standard 4801 provides for safety management systems to be regularly audited.⁵³ There was no process at Pike to audit compliance with the ventilation management plan, and no external auditing.
44. Mr Rowland was not asked to audit compliance with the ventilation management plan.⁵⁴ When David Stewart of MinServ International carried out a series of compliance audits at Pike in February to April 2010, he did not look at the ventilation management plan. Indeed, he 'deliberately stayed away from looking at the documentation as such',⁵⁵ because he believed the plan was to be reviewed and updated. Mr Stewart said it is not easy for any mine to ensure that management plans are complied with, and he expected Pike was typical in this respect.⁵⁶

45. Mr Dow said the HSE committee did not consider asking to see evidence of compliance with the ventilation management plan.⁵⁷ He said those were 'onsite activities',⁵⁸ and he did not accept that the HSE committee of the board should have ensured that the things required by the ventilation management plan were in fact happening at Pike River.⁵⁹

The Pike ventilation system as built

46. Pike's early planning contemplated multiple intakes beyond the first year of development.⁶⁰ In November 2010 the Pike River ventilation system was still a one intake and one return system, as shown in the following diagram:

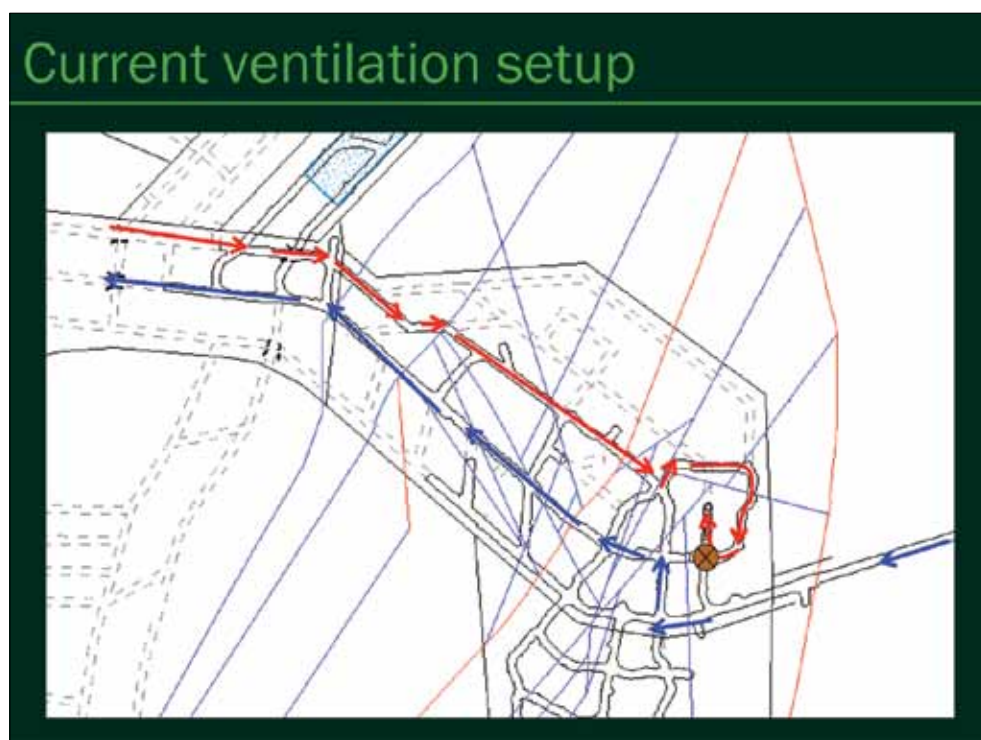


Figure 8.4 : Current ventilation setup⁶¹

47. The blue arrows depict fresh air entering through the intake (main drift), circulating through the workings and exiting through the return, shown in red. The main underground fan is depicted as a circled X towards the bottom right of the diagram, at the base of the ventilation shaft. Mr van Rooyen presented this simplified diagram of the Pike ventilation system to the Pike board in August 2010.
48. Mr Reece told the commission a single intake and return system is quite unusual for a mine with four or five working areas extending from it.⁶² The DOL experts' report states that a one intake and one return system is not uncommon in New Zealand coal mines but would not be considered acceptable for anything but initial development in Australia. The report notes that Pike did plan to establish a second intake but it appeared that the mine would always be restricted to a single return system. The report said this might be acceptable, given the difficult geographical environment, but from a ventilation perspective it left no room for error. Any compromise to the main return would become a very serious event.⁶³
49. The second intake was still planned. Mr van Rooyen presented the Pike board with a number of options in August 2010.⁶⁴ He estimated that it would have taken about a year for Pike to reach the recommended location of the second intake from the time he left in November 2010.⁶⁵

The surface fan

Design and installation

50. Pike installed the surface back-up fan at the top of the ventilation shaft in June 2009. The exhaust structure (evasé) for the surface fan is on the left in the photograph, and the larger evasé is for the main underground fan.



Figure 8.5: The surface back-up fan

51. Fläkt Woods designed, built and installed the surface fan. It was powered by a 132kW electric motor with a capacity of 90m³/s air flow at 0.4kPa (kilopascals) pressure.⁶⁶ The fan acted as the primary fan until the first main fan was commissioned underground.
52. The diagram below shows a bird's-eye view of the surface fan as installed. In the centre was the main underground fan evasé, designed to direct the air flow horizontally and prevent rain or snow entering the ventilation shaft.⁶⁷ The surface fan impeller (blades) and motor were to the right. To the left was an airlock entrance allowing access to the fan housing. Anyone climbing the ladder in the ventilation shaft would also exit through the airlock.

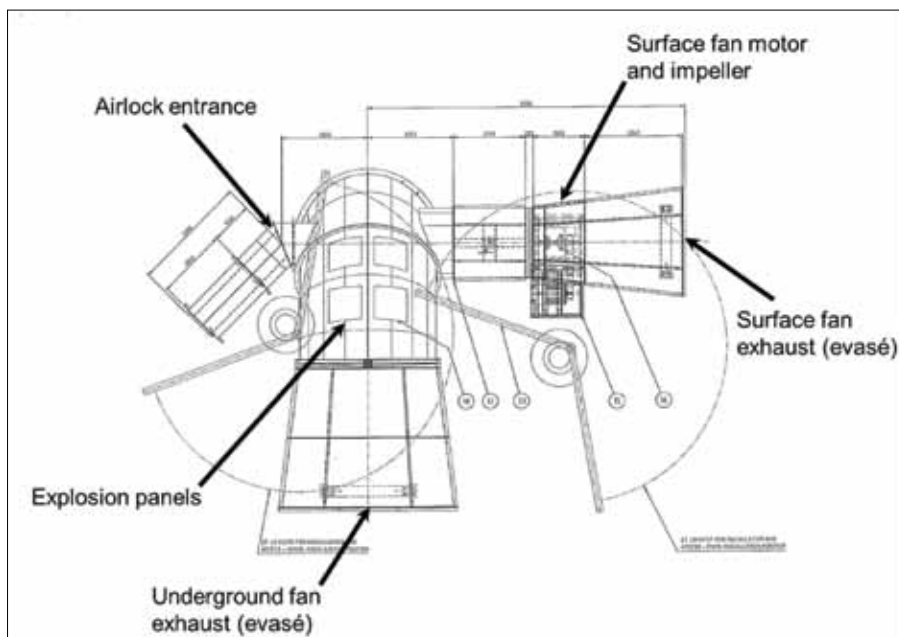


Figure 8.6: Surface fan as installed⁶⁸

53. On the top of the housing were four explosion panels, designed to allow a pressure wave of air and debris following an explosion to go straight through the top of the housing and minimise damage to the fan. The explosion panels are seen in black in Figure 8.5.
54. Because both the surface fan and main underground fan were connected to the same ventilation shaft, a system was needed to block off air flow through one or other *evasé*, depending which was in use. Initially Fläkt Woods designed a butterfly damper for that purpose, but this was damaged and not repaired for 12 months or more.⁶⁹ During commissioning of the underground fan a few weeks before the explosion, Pike installed a set of *louvres* at the end of the main fan *evasé* as shown below. These were designed to close if the main fan stopped and the surface fan started up to ventilate the mine.



Figure 8.7: Evasé showing louvres being installed

55. The surface fan was powered by electrical cabling that ran from the portal substation up the main drift and then to the surface via the shaft. This was unusual. It meant that if power was tripped to the main fan at the portal, for example because of methane in excess of 0.25% in the vicinity of the fan motor, power would also be unavailable to the surface fan. Accordingly, diesel generators were installed to start automatically if the main fan stopped, enabling the surface fan to operate.⁷⁰

Surface fan failures

56. On the evening of 5 October 2010, about three weeks before the commissioning of the underground fan, the surface fan failed after a blade sheared off.⁷¹ Methane levels rose, power tripped to the underground workings and all personnel underground were evacuated from the mine. The mine gassed out, and on 6 October drops in barometric pressure and temperature caused methane levels in pit bottom to rise to such a level that Pike was unable to send a Mines Rescue Service (MRS) team underground to degas.⁷² The daily volume of methane make peaked at 102,000m³ during degassing on 7 October.⁷³ Pike conducted a risk assessment together with MRS personnel,⁷⁴ and repaired and ran the surface fan using the damper door to 'gradually introduce ventilation underground diluting the gas levels until normal historical gas levels were reached'.⁷⁵
57. A similar event had occurred in July 2009 due to vibration.⁷⁶ Project manager Terence Moynihan believed that changes to underground ventilation and surface conditions meant the fan sometimes operated within the stall zone, leading to high levels of vibration and causing fan blade failure.⁷⁷ Given the changes from the original

ventilation shaft design, including the smaller Alimak raise installation, and based on an April 2010 ventilation survey conducted by Mr Rowland indicating high pressure losses between the shaft collar and the fan itself,⁷⁸ Mr Moynihan considered the surface fan was operating at significantly higher pressures than the instrumentation was recording. He felt that with the mine expanding, and increasing resistance, the surface fan would not have been able to meet its objective as a back-up ventilation fan.

58. Pike reviewed the surface fan failure in a meeting on 7 October.⁷⁹ The reason for the failure had yet to be determined by the engineering department,⁸⁰ and the review did not focus on preventing a repeat event. Rather, the meeting identified a number of improvements required to Pike's immediate response.⁸¹ It is unclear how many of the identified improvements had been achieved by 19 November 2010.⁸²
59. This failure occurred when the surface fan was about to take on a crucial back-up role to the underground main fan. Pike's ability to reventilate the mine in the event of a gassing out or an explosion underground was dependent on the surface fan, as the main ventilation fan could not be restarted in high methane levels. This incident was a near miss that should have led to more robust investigation and action.

The main underground fan

Installation of the fan

60. Pike's first main underground fan was installed in August and September 2010. Its size and configuration are shown in the photograph below. The fan motor (grey) is in the foreground, with the drive shaft (orange) connecting to the fan impeller (white).



Figure 8.8: Underground fan being assembled in factory

61. The bird's-eye diagram below shows the orientation and operation of the underground fan.

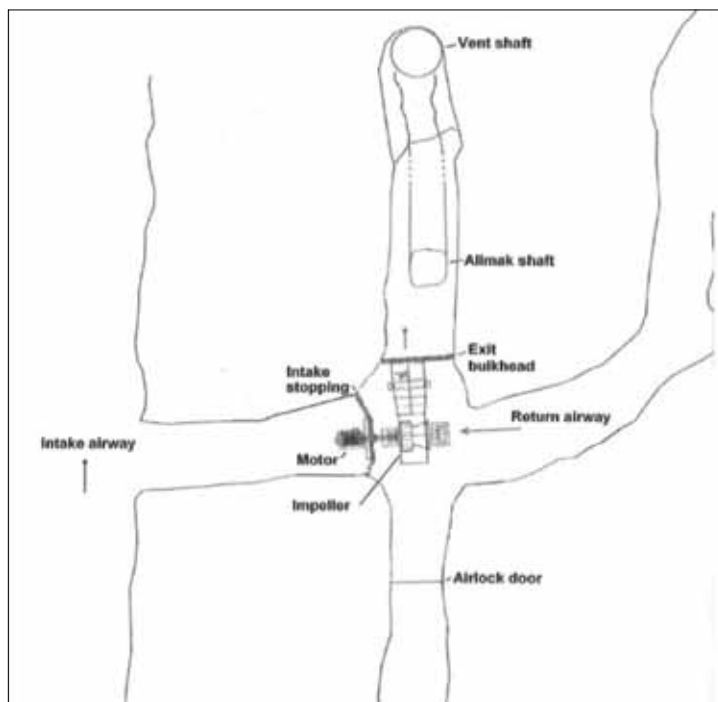


Figure 8.9: Orientation and operation of underground fan

62. Air entered from the return airway to the right of the diagram, then passed through the impeller and up the Alimak shaft. The non-flameproof motor was in fresh air on the intake side and sealed off from the fan impeller by a stopping, through which the drive shaft passed. The exit bulkhead was partly fitted with louvres, which were closed when the fan was working, but opened when it tripped. This enabled the surface fan to draw air more easily up the ventilation shaft to maintain mine ventilation. The airlock doors prevented return air from entering the mine intake system.
63. The main fan was designed to shut down in the event of a methane concentration in excess of 0.25% near the fan motor or when temperature or vibration cut-off points were reached, at which point the back-up surface fan was designed to start automatically.
64. The fan's maximum capacity was $128\text{m}^3/\text{s}$,⁸³ from the 375kW motor that was controlled by a variable speed drive (VSD) located about 94m away in pit bottom south.⁸⁴

Commissioning and operation of the fan

65. The main fan was first operated on 4 October 2010, but sparks came from the fan shaft at the junction with the intake stopping through which it passed.⁸⁵ To resolve the problem Pike removed a brass bush, which formed a seal between the drive shaft and the stopping.⁸⁶ This left a gap which Mr Sanders estimated was at least 20mm.⁸⁷ Mr White accepted there was potential for methane-contaminated air to leak through the gap if the fan was not operating.⁸⁸
66. Further testing continued and on 22 October 2010 the underground main fan came online and the surface fan switched to standby duty.⁸⁹ Almost immediately the main fan suffered problems associated with the VSD power supply and other issues. At first neither the supplier, Rockwell Automation (NZ) Ltd, nor the installer, iPower Ltd, could identify the problem. In late October Rockwell agreed to replace the liquid-cooled 700L VSD with an air-cooled and larger capacity 700H model.⁹⁰ Problems continued as the new model was installed in the same VSD cabinet but had a different thermal requirement, and to avoid rising temperatures tripping the power, the mine installed ducting to direct air over the VSD. An air conditioning unit was also ordered, but had not arrived at the time of the explosion.⁹¹

67. Testing of the fan was completed on 10 November 2010 and the fan was finally commissioned for operation.⁹² After installing the replacement 700H VSD, the main fan ran continuously until the explosion, apart from one problem caused by an auxiliary fan motor.⁹³

Explosion protection of the fans

The proposed explosion path and explosion proofing of the underground fan

68. In 2007 Mr Renk designed twin underground fans to be housed in a separate heading, offset at 90° from the main return.⁹⁴ This was an attempt to create an explosion path to mitigate the risk of damage to the underground installations in an explosion.⁹⁵
69. When the ventilation shaft was relocated into coal west of the Hawera Fault, Mr Renk redesigned the fans to remain offset from the shaft, with stoppings designed to fail in a pressure concussion event so a blast overpressure would bypass the fan and go directly into and up the shaft to the surface. He intended to install additional explosion-proof standard stoppings reinforced with steel to protect the fans.⁹⁶
70. After the collapse of the ventilation shaft and the installation of the Alimak raise, the technical services department had to review and redesign the underground fan installation, and Mr Renk's earlier explosion path design was no longer possible.⁹⁷ By that time he had left Pike and no one in the department, including the new manager Mr van Rooyen, had prior experience with the concept. In June 2009 Mr van Rooyen looked at trying to maintain an explosion path to protect the fan but, after some research,⁹⁸ that issue, and the decision over design of a second connection to join the ventilation shaft, were deferred until further geological information was available. It was noted the mine would be without an explosion path until the second connection to the shaft was completed, but the surface fan was considered to be a sufficient contingency, along with other methods, including installation of explosion barriers 'to reduce the potential damage of an explosion'.⁹⁹
71. Discussions in June 2009 (including with Jim Rennie and another consultant Steve Beikoff)¹⁰⁰ and again in September 2010 led to a consensus that explosion paths would not necessarily work as intended in an underground explosion,¹⁰¹ and were not proven to be effective.¹⁰²
72. The 2007 underground fan risk assessment had identified 'built-in explosion proofing' and protection as a control for placement of the main fan underground,¹⁰³ and Pike told insurance risk assessors in 2010 the underground fan would be located in 'explosion protected panels',¹⁰⁴ but no protection was in place.
73. This was described as 'somewhat deficient' by the joint investigation expert panel, who noted protection was a standard requirement in underground booster fan installations 'albeit in the form of a bypass mechanism'. Installation of explosion protection by means of a bypass in the underground workings near the fan 'may have contributed to reducing the extent or even the level of damage to the mine; as well as providing potential survivability of the ventilation system for later operation'.¹⁰⁵

Stone dusting

74. Stone dusting helps to mitigate the effect of an explosion by mixing an inert limestone dust, also known as stone dust, with the coal dust on the floor, roof and ribs of the mine.
75. New Zealand regulations require employers to take all practicable steps to ensure the roof, floor and sides of every accessible part of the mine were treated with stone dust so combustible matter did not exceed 30%.¹⁰⁶ Pike's ventilation management plan set out a stone dust monitoring plan, and required the production deputy and undermanager to ensure that stone dusting was maintained daily in all roadways to within 10m of any working heading.¹⁰⁷
76. Pike's stone dusting was inconsistent. When Mr White implemented a process in mid-2010 to test the standard of roadway dust, all samples failed the standard in Pike's draft standard operating procedure.¹⁰⁸ Although Pike was a

relatively wet mine, which would have mitigated the risk, the stone dusting was below standard and the problem had been raised during inspections and in writing twice by the DOL mines inspector in 2010.¹⁰⁹

Explosion barriers

77. Regulations also require employers to take all practicable steps to ensure water or stone dust barriers were erected at suitable sites to limit the effects of an explosion.¹¹⁰
78. The ventilation management plan stated that 'stone dust barriers of the bag type will be used',¹¹¹ and Pike advised the Hawcroft Consulting International insurance risk assessor, in 2009 and 2010,¹¹² that explosion barriers would be installed to 'provide added defences in the event of a gas ignition, preventing development of a coal dust explosion'. However, as at 19 November 2010, Pike had not installed any explosion barriers underground. The equipment had been purchased and was stored on site from mid-2009.¹¹³
79. Deputies were required to complete a report every shift, and answer the query 'Are explosion barriers in order?' Deputies regularly answered 'no' or 'N/A [not applicable]'. Some Pike employees were concerned about the lack of explosion barriers and said so.¹¹⁴
80. Mr Stewart noted the absence of stone dust or water barriers in any of the roadways, in contravention of the regulations. When he spoke to the engineering staff and interviewers he was told there were no plans for barriers to be erected and they were waiting for a stone dusting machine.¹¹⁵
81. The expert panel considered that stone dust explosion barriers would have been useful.¹¹⁶ Mr Reece accepted that stone dust barriers are not proven to extinguish a flame front from a methane ignition, but they can reduce the intensity of an explosion. Noting the common use of stone dust barriers within development panels of between 100 and 200m, and the relatively small size of the mine at the time of the explosion, Mr Reece said a stone dust barrier may have been appropriate in the main return to give some protection to the fan.¹¹⁷

The failure of explosion proofing of the surface installation

82. The surface fan failed in its vital back-up role. As shown in the photograph below, the explosion panels failed to divert the explosive air flow and debris from the first explosion, which damaged the fan, fan housing, shaft access doors, power generator and control infrastructure. Subsequent explosions propelled the fan and housing from their fixed positions.¹¹⁸



Figure 8.10: The surface fan after the first explosion

83. Gregory Borichevsky and an electrician examined the damage to the surface fan on 22 November 2010, before the second explosion on 24 November damaged it further. The airlock doors in the fan housing and the louvres installed on the evasé had been blown open and damaged. The fan was intact but three of the fan blades were damaged. The control panel had been blown over by the force of the blast coming out of the airlock doors and had fallen onto the emergency stop button of one of the generators.¹¹⁹ The DOL investigation report concluded that the surface fan did not start at all, but it appeared that at least one of the diesel generators had started, since some fuel had been used.¹²⁰
84. Mr Borichevsky believed the surface fan could and should have been restarted. Although damaged, his 22 November examination found the fan was intact, the second generator was running, the airlock doors could have been secured, the main cabling to the control panel appeared to be intact and could have been made safe to restart, the fan cowling, shutters and belts were slightly damaged but repairable, and the drive belts and motor on the fan appeared to be undamaged.¹²¹ He says he told the production manager, Stephen Ellis, of his inspection and his view that the fan could be repaired and restarted to ventilate the mine, but that did not occur. Mr Ellis does not recall this, but comments that effecting repairs would have been too dangerous and restarting the surface fan was a decision for the mine manager Mr White.¹²² Reventilating a mine following an explosion is an option that should always be available but can be dangerous and requires a risk assessment.
85. It is evident from the damage to the surface fan installation that the explosion panels could not cope with the explosion. The fan was too close to the ventilation shaft because of the limited space available at the site. The damage suffered meant the surface fan could not reventilate the mine.
86. Neither New Zealand or Australian mining legislation prescribes or provides guidance on the design of explosion panels. Pike provided no specifications to Fläkt Woods Fans. Fläkt Woods designed the explosion panels in accordance with a standard issued by the United States National Fire Protection Association (NFPA standard 68).¹²³ This standard requires complex calculations depending on analysis of several variables.¹²⁴ Fläkt Woods followed the design approach in this standard after it was specified for use by a Queensland mine for a surface fan installation Fläkt Woods completed in 2008, without comment from the Australian regulator.¹²⁵
87. The commission considers that best design practice is reflected in the United States Code of Federal Regulations for underground mining. These regulations require explosion panels to have a cross-sectional area at least equal to that of the area (in Pike's case the ventilation shaft) through which an explosion would pass.¹²⁶ Under that approach, Pike's explosion panels were less than half the size they should have been to operate effectively.
88. The US regulations also provide that a main fan must be 'offset by at least 15 feet [5m] from the nearest side of the mine opening unless an alternative method of protecting the fan and its associated components is approved in the ventilation plan.'¹²⁷ Although the Pike surface fan was a back-up fan, a similar level of protection was necessary. However, the surface installation site was congested and the fan blades were installed only approximately 2.3m from the edge of the ventilation shaft. This site layout made it much more likely they would be damaged by explosion overpressure and debris.

Responsibility for ventilation at Pike

A dedicated ventilation officer

89. Since 1999 it has been a requirement for underground coal mines in Queensland and New South Wales to have a dedicated ventilation officer. That requirement arose from a recommendation of the inquiry into the 1994 Moura No. 2 mine disaster. The officer's functions are defined by statute and by regulations. They include ensuring adequate ventilation in the mine, ensuring proper ventilation measurements are taken and ensuring all ventilation control devices at the mine are properly constructed and maintained.¹²⁸ In New Zealand, a committee headed by the chief inspector of coal mines reviewed the Moura No. 2 recommendations in 1996, but did not recommend the

creation of a statutory ventilation officer position in this country because at that time only the largest company, Coal Corporation of New Zealand Ltd, had the economy of scale, or need, for such a person.¹²⁹

90. In Australia, the ventilation officer's role is a full-time position. Queensland legislation does permit a ventilation officer to hold another role at the mine, but only if he or she can still carry out the functions of a ventilation officer. Mr Reece said a ventilation engineer would be 'constantly' looking into any methane issues in the mine and going underground every second or third day.¹³⁰
91. In New Zealand, there is no statutory requirement for an underground mine to have a ventilation officer. Non-binding industry guidelines established by MinEx recommend that the mine manager appoints someone to carry out certain functions concerning ventilation, but they are much less exacting than the Queensland requirements.¹³¹ Whereas in Queensland the ventilation officer must 'ensure' adequate ventilation and 'ensure' properly constructed ventilation control devices, the MinEx guidelines recommend that the relevant person carry out 'planning and design of ventilation systems and appliances' without reference to any particular standard.
92. From 2008 Pike's ventilation management plan required the mine to have a ventilation engineer, fulfilling the same role as a ventilation officer. However, no full-time ventilation engineer was ever appointed at Pike.
93. Mr Whittall said the role was subsumed within the mine manager's responsibilities. He thought Pike too small for a dedicated ventilation engineer and it might have been several years before the mine was large enough to merit a dedicated position.¹³² Mr Whittall also said that the mine manager's responsibility for ventilation was 'supplemented by having a full-time, on-call ventilation or a designated on-call ventilation consultant available to us and they acted in that capacity'.¹³³ In particular, he indicated that Mr Rowland filled that role.¹³⁴
94. However, Mr Rowland said he was never a 'full-time, on-call ventilation consultant' for the mine. He said he would not, under any circumstances, have accepted the ventilation engineer's responsibilities under the ventilation management plan as he was not permanently at the mine. Mr White accepted that Mr Rowland was not carrying out the role of ventilation engineer. He said it was never the intention to use Mr Rowland as a ventilation engineer but rather 'to seek his advice and have certain jobs done by him'.¹³⁵
95. Mr White said that when he started in February 2010 he did not think Pike required a ventilation engineer. However, he accepted in hindsight it would have been desirable to have had a full-time person in this role from an early stage, even from the design phase.¹³⁶

Concern at the lack of a ventilation engineer

96. A number of people at Pike raised the need for a ventilation engineer. Mr van Rooyen said that when he was appointed in February 2009 he assumed there would be a ventilation officer at the mine. He thought one was needed, particularly since he had very little ventilation experience. He suggested to Mr Whittall that Pike should send one of its engineers to New South Wales to complete a ventilation officer qualification. Mr Whittall said a ventilation officer was not required under New Zealand legislation, and not necessary owing to the size of the mine. Mr van Rooyen also raised this matter with Mr White.¹³⁷
97. Mr Sanders raised the lack of a ventilation engineer among the 54 matters in his March 2010 report.¹³⁸ The following month, he prepared another report documenting key aspects of the ventilation system and detailing how it was to be controlled and operated. The draft document contained dozens of queries and gaps on critical issues. No final document seems to have been created, and responsibility for the ventilation system and ventilation management plan was never clarified. Mr Moynihan wrote on his copy of the report, 'Who is the ventilation engineer?', 'Who "owns" the ventilation management plan?' and 'Who "maintains" the ventilation management plan and its requirements?'.¹³⁹
98. The subject was perhaps most stridently raised by Dene Murphy, one of the Pike deputies.¹⁴⁰ On 24 June 2010 he noted a problem with the ventilation system in an area containing two electrical substations. Mr Murphy filled out an incident form, noting, among other things, in capital letters, 'Who is the mine ventilation engineer?'. He went on to write, 'Ventilation engineer required', and 'Require immediate feedback within four days – or I will write a formal

letter to the mines inspector'.¹⁴¹ Mr White signed off the incident on 7 July 2010, with the comment, 'This has been discussed with Dene. Vent structures being organised to be made permanent.'

SECTION 4: Identify the Potential Root Causes			
Immediate Causes (tick and describe)		Basic Causes (tick and describe)	
Substandard practices ☐ Operating equipment without authority ☐ Unaware of hazard ☐ Failure to secure ☐ Operating at improper speed ☐ Not following procedure ☐ Removing safety devices ☐ Using defective equipment ☐ Failing to use PPE ☐ Improper loading ☐ Improper placement ☐ Improper lifting ☐ Improper position for task ☐ Servicing equipment in operation ☐ Horseplay ☐ Under influence of alcohol/drugs ☐ Making safety devices inoperable	Substandard conditions ☒ Inadequate guards or barriers ☐ Inadequate protective equipment ☐ Defective tools, equipment or materials ☐ Congestion/restricted action ☐ Inadequate warning system ☒ Fire & explosion hazards ☐ Poor housekeeping, disorder ☐ Noise exposure ☐ Radiation exposure ☐ High or low temperature exposure ☐ Inadequate or excess illumination ☒ Inadequate ventilation ☐ Weather	Personal factors ☐ Lack of knowledge/training ☐ Lack of skill/inexperience ☐ Lack of concentration ☐ Stress ☐ Misconduct ☐ Language difficulties ☐ Inadequate capability ☐ Improper motivation	Job factors ☒ Inadequate leadership/supervision ☒ Inadequate engineering ☐ Inadequate purchasing ☒ Inadequate maintenance ☐ Inadequate tools, equipment, materials ☐ Inadequate work standards ☐ Abuse ☐ Wear and tear ☒ Inadequate procedure ☒ Safety rules not enforced ☐ Insufficient staff numbers ☐ Sub standard/no training ☒ Substandard work practice
What was the ROOT CAUSE of this event? VERY INADEQUATE VENTILATION, POOR STOPPINGS, POOR VENTILATION MANAGEMENT, VENTILATION LEAKAGE HIGH PERCENTAGE			
SECTION 5: Remedial Actions Recommended, Including Any Injury Prevention & Training if Required			
Follow up of Event: What investigation/action has or will be taken to prevent a recurrence?			
VENTILATION ENGINEER REQUIRED CONSTRUCT PERMANENT STOPPING ETC TO CONTROL VENTILATION		By Whom	By When
Files			
			Date Completed
REQUIRE IMMEDIATE FEED BACK WITHIN 4 DAYS - OR I WILL WRITE A FORMAL LETTER TO			
New Hazard Identified - has this been added into the Hazard Register?		THE MINES INSPECTOR	
New Controls Implemented - Have these been recorded in the Hazard Register?		Yes ☐ No ☐	

Figure 8.11: Extract from Dene Murphy's 24 June 2010 Incident/Accident Form

99. In the absence of a ventilation engineer, Mr White said he adopted the role of 'de facto ventilation engineer', adding he had 'no choice' because nobody else was available.¹⁴² The ventilation management plan allocated more than 90 duties to the mine manager and ventilation engineer, and Mr White could not have fulfilled those while working as general manager.
100. Hydro-mining consultant Masaoki Nishioka said that when he arrived at Pike in July 2010 he found that 'nobody' was really taking care of ventilation at the mine.¹⁴³
101. After Mr van Rooyen raised the lack of a ventilation officer with Mr White, it was agreed that Dean Jamieson, an underviewer, would be an appropriate person to train as a ventilation officer.¹⁴⁴ However, Mr Jamieson's training was delayed because of the resignation of another underviewer,¹⁴⁵ and he had not started formal training before November 2010.

Ventilation control devices

102. In any mine ventilation circuit it is essential that fresh air is delivered to the correct locations and in the right quantities, and that contaminated air is kept isolated from intake air and from any potential sources of ignition.¹⁴⁶ For that reason, ventilation control devices, including stoppings, overcasts, regulators and other devices, are used to ensure ventilation air continues on the correct path.
103. A stopping is a solid barrier that prevents air travelling through a roadway. A permanent stopping may be constructed from masonry, concrete blocks, fireproofed timber blocks or steel.¹⁴⁷ As a short-term measure, stoppings may be constructed from timber and brattice (a fire-resistant, anti-static cloth). The photograph below shows a low-pressure stopping constructed from timber and brattice.



Figure 8.12: Board and brattice stopping¹⁴⁸

104. Stoppings must be constructed to a suitable standard to avoid leakage, which can compromise the performance of the ventilation system. Stoppings should also be built to withstand the pressures that may follow a roof fall or windblast within the mine.¹⁴⁹

Construction standards

105. In Queensland and New South Wales the law requires stoppings to be 'rated', that is, built to withstand identified pressures. This followed a recommendation of the Moura No. 2 inquiry dealing with the design and installation requirements for seals. A seal is used to isolate a worked-out area of a mine from the rest of the mine infrastructure. It may consist of two or more stoppings, 5–10m apart, with the space between occupied by sand, stone dust or other non-flammable material.¹⁵⁰ The Moura No. 2 inquiry recommended that the chief inspector of coal mines should determine and enforce minimum requirements for the design and installation of seals.¹⁵¹
106. That recommendation is reflected in the current Queensland coal mining safety and health regulation, which requires the ventilation officer to ensure ventilation control devices are installed in compliance with specified ratings. For example, a stopping installed as part of the main ventilation system must be capable of withstanding an overpressure of 35kPa.¹⁵²
107. Neither New Zealand law, nor the industry guidelines produced by MinEx, provide for stoppings to be built to any rated standard. The guidelines suggest temporary ventilation stoppings can be as many as four cross-cuts or 250m backbye of development headings.¹⁵³ Mr Reece told the commission this was 'significantly less of a standard' than Queensland regulators would accept.¹⁵⁴

The ventilation control devices at Pike River

108. In 2006 the Minarco ventilation report noted there were no specific construction requirements in New Zealand for ventilation structures, except that they be constructed from non-flammable material. The ventilation devices nominated for Pike River included roadway stoppings of a 'nominal 14kPa rating'.¹⁵⁵ The suggested 14kPa rating was only 40% of the equivalent standard in Queensland and New South Wales of 35kPa. The 2006 report did not offer any justification for the proposed lower standard at Pike River. Ultimately, Pike did not implement even the lower standard.

109. Appendix 5 of the Pike ventilation management plan set out a procedure for the construction of ventilation structures.¹⁵⁶ The ventilation engineer was to advise the undermanager on standards for ventilation stopping construction, and stoppings were to be built to standards set out in the 'Pike River Mine Manager's Ventilation Rules'. Whereas Minarco's ventilation report in 2006 had contemplated stoppings with a nominal rating of 14kPa, the ventilation management plan left the issue of standards for ventilation control devices to the 'Pike Mine Manager's Ventilation Rules'. No such documentation was created.
110. When Mr Stewart carried out a statutory compliance audit in early 2010 he referred to stoppings being 'badly constructed and leaking hugely', contaminated air recirculating back into the ... working place and overcasts with 'significant leakage'.¹⁵⁷ Improvements were made as a result of the audit, including the rebuilding of some stoppings. One report noted that an underviewer had been asked to develop designs for all the stopping types to form part of a construction template for Pike River. Mr Stewart also spoke to mechanical engineer Matthew Coll about stopping standards and gave him a copy of design and procedures for stopping construction for training purposes.¹⁵⁸
111. When he left Pike in April 2010 Mr Stewart was not satisfied with the stoppings. Some had been improved, and he had done 'very basic things', for example, pushing stoppings to see whether they rocked.¹⁵⁹
112. Responsibility for advising on standards for the construction of stoppings and other ventilation control devices rested with the ventilation engineer. When he arrived at Pike Mr White recognised that there were no permanent ventilation control structures, and he began organising a standard for building temporary stoppings and 'set about starting to talk to contractors in Australia with respect to the supply of equipment for building permanent stoppings'. Mr White added that it was 'difficult to nominate positions for permanent stoppings' because the mine plan changed so frequently.¹⁶⁰
113. In May 2010 Pike issued a standard operating procedure document entitled 'Underground Standards', which set out the standard for both temporary and permanent stoppings.¹⁶¹ The basic construction method was the same for both, namely board and brattice construction, as depicted in the diagram below and in Figure 8.12.

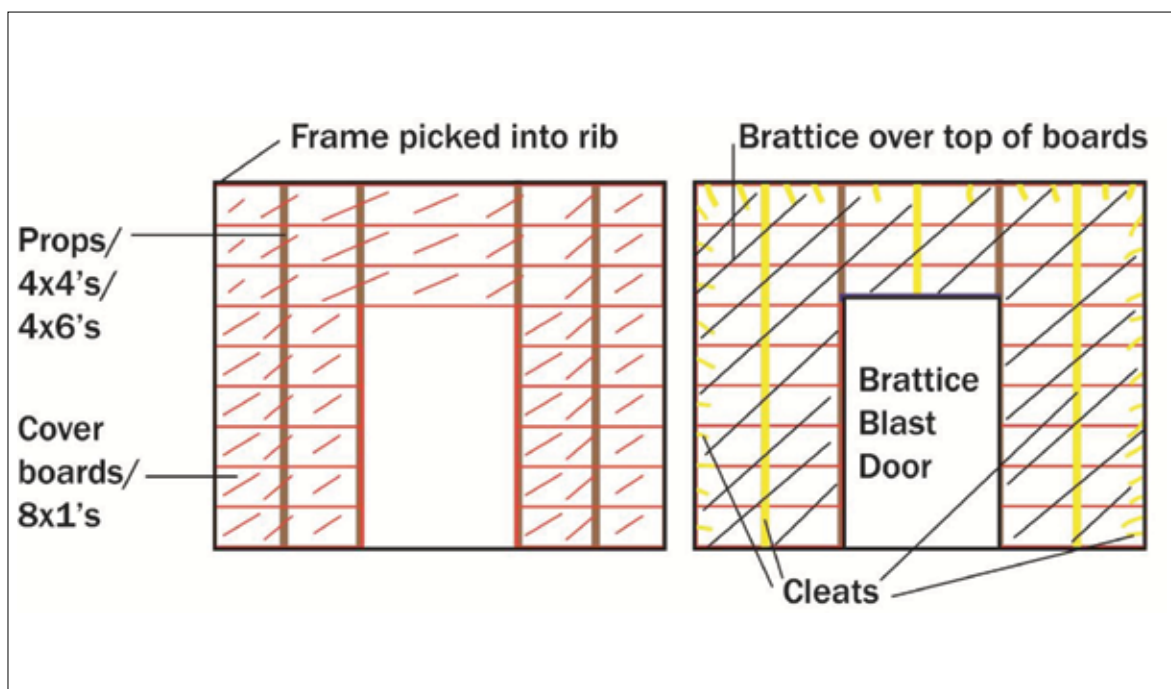


Figure 8.13: Board and brattice construction method¹⁶²

114. The construction method was essentially to use standard timber covered by brattice. The main difference with permanent stoppings was that these were covered in mesh and sprayed with shotcrete (this is concrete or mortar

projected through a hose at high velocity). The underground standards document made no reference to pressure ratings.

115. Despite the underground standards document, problems with stoppings continued. On 20 September 2010 Mr Nishioka noted repeated problems with methane levels in the hydro panel. The hydro operation was stopped, and on investigation it was discovered that the ventilation stopping in the hydro panel was leaking air so badly that recirculation of air was allowing methane to accumulate in the explosive range.¹⁶³ The board and brattice system used to construct the stopping was not robust enough to prevent leakage, and this was the type of issue that would have been raised with the ventilation officer if there had been one at Pike.¹⁶⁴

Roof fall on 30 October 2010

116. On 30 October 2010 there was a large roof fall in the goaf in the hydro panel. The roof fall generated a pressure wave that knocked over the stopping at cross-cut one in the hydro panel, marked in the diagram below.

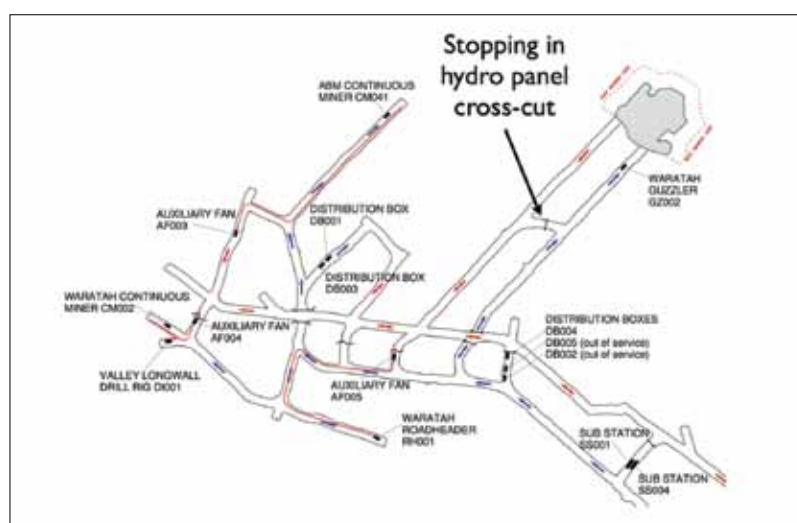


Figure 8.14: Stopping in hydro panel cross-cut¹⁶⁵

117. The incident occurred around 4:00am on 30 October 2010. Steve Wylie was the deputy on duty. Just before the roof fall the crew had been cutting to the left of a stump of coal in the goaf. Slabs of coal had been falling from the side of the stump, most likely as a result of downward pressure from the roof of the goaf. Mr Wylie heard the roof collapse and saw that it had fallen in, covering the front of the monitor.¹⁶⁶
118. He did not recall a significant windblast down the intake road, but the debris from the roof had blocked off the heading to the goaf and cut off ventilation. When he checked the stopping at cross-cut one he saw it had completely fallen over towards the intake roadway.¹⁶⁷ This indicated that a windblast had travelled down the return roadway and knocked the stopping over.¹⁶⁸ A gas reading showed greater than 5% methane in the return roadway at the intersection with cross-cut one.¹⁶⁹ Because his gas detector was not capable of reading greater than 5%, Mr Wylie could not tell the actual methane concentration, but there was clearly an explosive quantity of methane in the return.
119. Mr Wylie completed an incident report.¹⁷⁰ He attached a hand-drawn diagram showing the effects of the roof fall, including the blocked heading at the entry to the goaf and the damaged stopping in cross-cut one, with the words 'stopping blown over'.

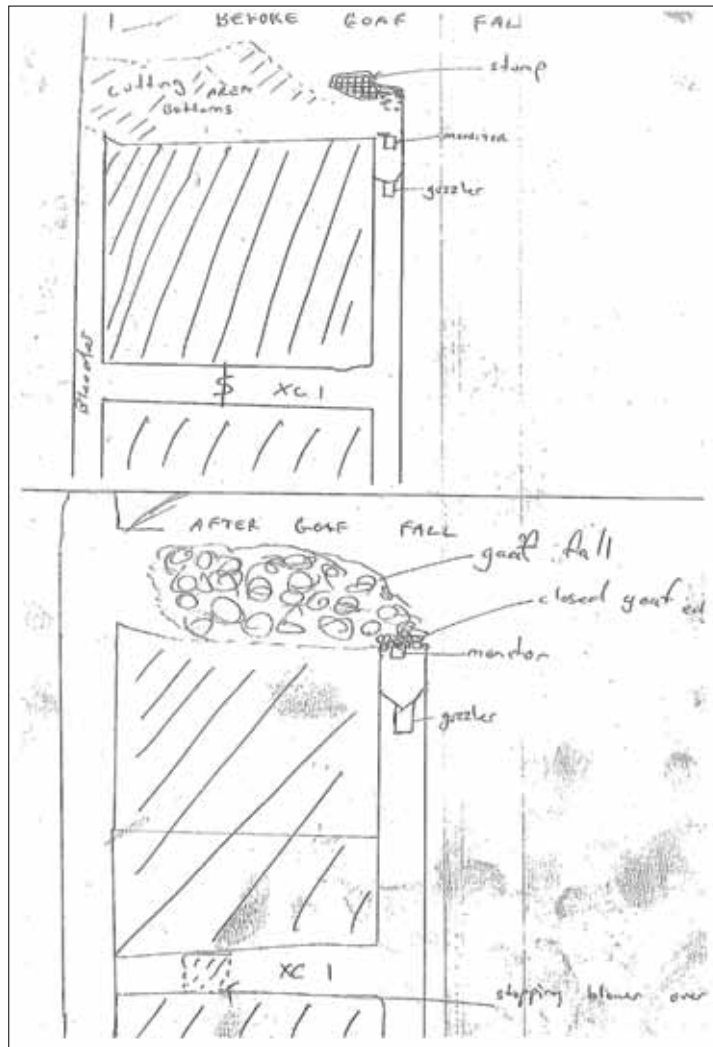


Figure 8.15: Effects of roof fall on 30 October 2010¹⁷¹

120. Mr Ellis signed off the incident form as 'closed' on 19 November 2010. The form stated the chance of this type of event happening again was 'occasional', and there had been 'extensive investigation and recovery'.¹⁷² The commission has not been able to locate any evidence of that investigation. Mr Ellis said he would have expected the investigation to have been carried out by Mr Wylie or George Mason, but neither can recall it.¹⁷³ In a supplementary statement to the commission, Mr Ellis said he searched the company's electronic and hard copy records but had not been able to locate any material relating to the investigation. He said he would not have signed off the incident as closed without reading a report.¹⁷⁴ There is no evidence of such a report, other than a short, five-sentence note prepared shortly after the event.¹⁷⁵
121. This incident provided a warning of a major hazard. It demonstrated the vulnerability of the mine's stoppings, as well as the potential for a roof fall in the hydro goaf to damage the ventilation system and lead to an explosive accumulation of methane.
122. Three aspects of the mine's response are significant. First, the incident was primarily categorised as property damage rather than as a safety issue. The original incident form noted that the incident had damaged a stab jack on the hydro monitor. The discussion at the weekly operations meeting focused on the cost of repair to the hydro monitor and the loss of production.¹⁷⁶ There is no indication that the broader significance of the event was discussed. When Mr Ellis signed off the incident on 19 November 2010 he did not answer the question whether any new hazard had been identified or new controls implemented, and he ticked the 'no' box in response to the question about a possible systematic failure.

123. Second, the incident highlighted the vulnerability at the mine caused by Pike's lack of a full-time ventilation engineer. The complete failure of a ventilation control device was a significant issue. Mr Rowland said he 'would expect the total failure of a ventilation appliance in a panel face area to be widely communicated to all persons on the site'.¹⁷⁷ Mr Reece agreed that, for a prudent mine operator, the roof fall would have signalled the urgent need to assess the integrity of all stoppings.¹⁷⁸ This task would have been the responsibility of the ventilation engineer, had there been one.
124. Third, the incident was not formally reported to DOL, despite the fact there was an uncontrolled accumulation of more than 5% methane. DOL inspector Kevin Poynter visited Pike three days after the roof fall, on 2 November 2010. Mr Ellis stated he discussed the roof fall with Mr Poynter, although he could not recall the specifics of the conversation.¹⁷⁹ Despite the seriousness of the incident, there was no formal notification and no investigation by the regulator.

The standard of ventilation control devices at Pike River in November 2010

125. The DOL investigation team carried out a detailed analysis of the ventilation control devices at Pike River, and concluded their quality was 'extremely variable'.¹⁸⁰ The stoppings near the main ventilation fan were made of steel and concrete, and rated to 35kPa. A number of stoppings were constructed using 'pogo sticks', expandable poles with an internal spring often used to hold up cables within the mine. Mr Reece described pogo sticks as 'very temporary arrangements',¹⁸¹ not intended for any type of permanent construction. The mine was attempting to achieve a number of permanent stoppings in the months leading up to November 2010, although these would not necessarily be rated.¹⁸² The stoppings in November 2010 would not have complied with Queensland standards.¹⁸³
126. The DOL investigation stressed the significance of the stopping at cross-cut 3, marked with an arrow below.

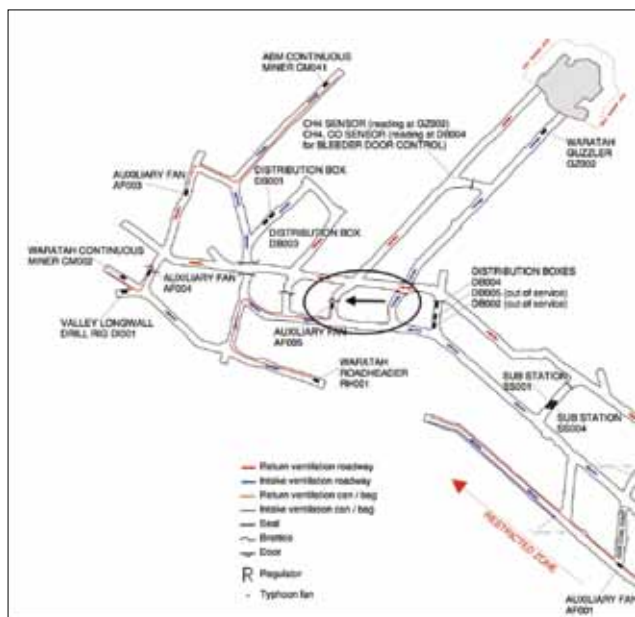


Figure 8.16: Hydro panel and cross-cut 3¹⁸⁴

127. That stopping was directly in line with the return from the hydro-monitor panel. Any significant roof fall in the hydro goaf would create an overpressure down the return, and the stopping would need to withstand that pressure.
128. Despite that risk, the stoppings at cross-cuts 3 and 4 remained in a temporary state on 19 November 2010. The collapse of the stopping at cross-cut 1 in the hydro panel on 30 October 2010 had served as a warning of this vulnerability, but Mr White said it was 'not likely' any consideration was given to the matter, even following the 30 October incident.¹⁸⁵
129. Mr van Rooyen agreed with the criticism of the stopping at cross-cut 3, and said it 'should have been made permanent preferably before or certainly early on in the excavation of the hydro panel'.¹⁸⁶ He agreed that the

increasing size of the goaf created a greater risk of a roof fall, resulting in damage to the temporary stopping in cross-cut 3, which could allow the short circuiting of air away from the inbye faces, and might also allow methane to enter the intake roadway.¹⁸⁷

130. Mr White said the intention was to make that stopping permanent after a panel move, which took place from Friday 12 November to Monday 15 November 2010, but this was not done.¹⁸⁸
131. There were three main problems with the ventilation control devices at Pike River in November 2010. First, there were too many temporary stoppings in light of the mining activity taking place. Second, with a few exceptions, the permanent stoppings that did exist were not rated to any particular standard. Third, there was insufficient oversight of the construction and maintenance of stoppings. The variable quality of stoppings at Pike River compromised the effectiveness of the ventilation system, and increased the risk of a catastrophic event. Rated stoppings may have assisted in an emergency, especially if combined with a functional surface fan, because they may have helped to re-establish a ventilation circuit to remove hazardous gases from the mine.

Sufficiency of ventilation at Pike River

132. Evidence before the commission indicated that Pike River had a 'serious lack of ventilation quantity for the number of faces being worked'.¹⁸⁹ At best the system was stretched to capacity, with no room for error.¹⁹⁰
133. Mr Ridl, by then the engineering manager, said the ventilation was 'pretty shit' before the main underground fan began operating in October 2010.¹⁹¹ Then 'there was a significant increase in ventilation and people were a lot happier'.¹⁹² However, Mr Rowland advised the mine in early November 2010 it needed more ventilation capacity 'relatively urgently' because the total amount of air available (120m³/s) was sufficient to run only four auxiliary fans on full speed while allowing standard margins for safety.¹⁹³ As at November 2010, the mine was running four auxiliary fans, with a fifth out of service. Mr Rowland's intention was to emphasise the importance of increasing the quantity of air available as soon as practicable and not 'resting on the apparent laurels of the new circuit capacity' provided by the underground fan.¹⁹⁴
134. The DOL investigation included detailed ventilation modelling of the mine based on the available data. That modelling indicated there was less than 25m³/s available for each place requiring ventilation, not allowing for leakage. That information, together with reports from mine officials, showed the ventilation system was struggling to cope with the gas quantity and the extent of mining operations.¹⁹⁵ DOL concluded that Pike had a ventilation shortfall, and should have been working one fewer place in the mine.¹⁹⁶ Pike considered the work was being managed within the limits of the ventilation system. As noted in paragraphs 139–144 methane problems persisted.
135. Ventilation inbye of the monitor panel was particularly fragile and struggling to cope with the extent of mining operations and gas load in the mine.¹⁹⁷ Those areas had a small amount of pressure (14Pa) and quantity (49m³/s) available to ventilate the three working places and two standing places inbye of panel 1. That area is shaded yellow in the following diagram.



Figure 8.17: Ventilation inbye of the monitor panel¹⁹⁸

136. DOL concluded that, given the gas make in the mine and the number of faces being worked, it should have been apparent that the ventilation system was stretched to its limit. Pike's approach allowed no factor of safety to deal with predictable hazards.¹⁹⁹
137. Mr Reece also noted other deficiencies with the ventilation system, for example, the placement of an auxiliary fan (AF003) immediately next to a stopping,²⁰⁰ which meant the fan did not have the necessary 30% of fresh air passing over it to ensure it did not overheat. The fan can be seen towards the left-hand side of the following diagram.

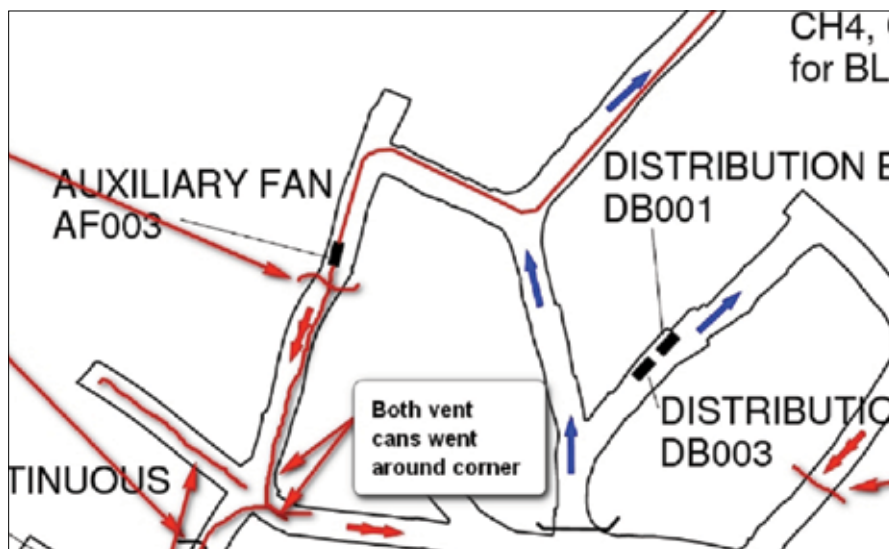


Figure 8.18: Location of the auxiliary fan²⁰¹

138. Mr White accepted that the evidence used by DOL in its modelling was correct, but considered that there was sufficient air to run the number of faces being mined.²⁰² He said Pike managed the amount of work done within the ventilation available and did not work all faces at the same time.²⁰³ However, Pike's own records, including incident reports and deputies statutory and production reports, show there were serious ventilation problems.

SPECIFIC PRODUCTION ISSUES, IMPROVEMENTS OR SUGGESTIONS									
IMPROVEMENT: GET THE DAM VENTILATION SORTED OUT SO WE CAN CUT COAL. THIS VENTILATION ISSUE HAS DRAGGED ON FOR 2 1/2 BLOODY YEARS!!!									
SHIFT ANALYSIS									
Shift start time: []									
Hours into shift	Target meters	Actual meters	Out	Boat	Delay	Comments			
1	4:00					X PRE-SHIFT MEETING - TRAVEL - LOAD POGO STICKS BRATICE X TRAVEL X TRAVEL X INSPECTION - UNLOAD GEAR FOUND DAMAGED AIR MANIFOLD X DEVELOPMENT HALLS SPOON NOT REPEATED X TO PROVIDE VENTILATION TO MOUNTAIN FACE, WHEN ARE YOU'S GOING X TO GET THIS SHIT SORTED!!! X IF YOU RUN A PRIVATE MINE LIKE THIS YOU WOULD BE SHUT SO IN A WEEK!!!			
2	8:00								
3	12:00								

Figure 8.19: Extracts from Dene Murphy's 21 October 2010 Deputies Production Report²⁰⁴

Recorded methane spikes

139. Evidence before the commission indicated a large number of methane spikes in the weeks and months before the explosion, many in the explosive range of greater than 5% methane. Mr White agreed that any instance of 5%

methane or more within a mine, even in the return, would be classified as a high-potential incident.²⁰⁵ The evidence indicates that methane greater than 2% were almost a daily event, both before and after the commissioning of the main underground fan.

Deputy statutory reports

140. Deputies' shift reports noted if they found greater than 1.25% methane in the general body of air. The reports between 3 October 2010 and 19 November 2010 contained recorded gas levels of 2% or higher on 48 occasions over 48 days. Concentrations of 5% were recorded within the mine 21 times during that period.²⁰⁶ The gas detectors used by Pike were not capable of reading higher than 5%, so it is not possible to know the actual level of gas on these occasions. Pike should have notified DOL of these events, but did not. This was supported by accident/incident reports.

Masaoki Nishioka's work record

141. Hydro consultant Masaoki Nishioka kept a daily work record. He noted methane levels on 14 days between 20 September and 15 October 2010, and on nine occasions methane levels exceeded 5% in the return airway.²⁰⁷ It was a safety hazard to continue monitor extraction with gas concentrations at that level.²⁰⁸ On 1 October Pike agreed to stop the hydro-monitor operation until the main fan became operational.²⁰⁹ During commissioning of the main fan, gas spikes in the hydro-monitor panel continued and Mr Nishioka's work record contained numerous references to methane levels above 5% and the 'poisoning' of the methane detectors.
142. When asked about these instances, Mr White said he believed the plugs of methane from the monitor panel would have been diluted below the explosive range in the main return.²¹⁰ Similarly, Mr Ridl's understanding was that the spikes of greater than 5% were present only in the hydro panel.²¹¹ However, the sensor at the top of the ventilation shaft was not capable of generating a reading higher than 2.96% methane, and it is not possible to be sure about levels in the main return. For that reason Mr White accepted that levels of methane may have remained in an explosive state all the way to the top of the ventilation shaft.²¹²

The gas monitoring system

143. DOL examined the records from the gas monitoring system for the period 25 October to 19 November 2010. Spikes over 1.25% were recorded 12 times. One of those spikes could be attributed to the calibration of the ventilation shaft gas detector, and a second to the restart of the main fan on 27 October 2010. Of the remaining 10, four events were of methane over 2.5% and a further two events were of methane over 1.8%. These were significant plugs of methane, and each one may have represented an explosive mixture if exposed to a source of ignition before dilution in the main return.²¹³ When asked about those conclusions Mr White said that number of spikes was a concern and, in hindsight, each should have been formally investigated.²¹⁴
144. In a report written shortly after the explosion, Gregory Borichevsky noted that potentially explosive levels of methane would have been present in the mine workings on a number of occasions, because methane levels in the ventilation shaft routinely exceeded 1%, regularly exceeded 1.5%, occasionally exceeded 2% and had exceeded 3% more than once in the weeks before the disaster.²¹⁵ Mr White was asked whether, in light of the number of methane spikes coming through the ventilation shaft, there was a risk that this situation had become normalised. He said he would hesitate to say 'normalised', but it was 'certainly something that was happening frequently, more frequently than would be desired'.²¹⁶

Accident/incident reports

145. Pike's accident and incident reports show other ventilation issues were reported often by workers. For example in October 2010 a typhoon fan ventilating a drill stub was not operating – the air hose had been disconnected and connected to other machinery. In June 2010 there was a higher pressure on the return side of a stopping near an electrical sub-station, leading to recirculation when the stopping door was open and the possibility of potentially flammable air in the presence of the substation. In January 2010 a blower fan was found on the floor 40 metres

from its original location, with the air hose disconnected. It was thought to have been hit by a passing vehicle. In April 2009 ventilation ducting was found damaged, resulting in an accumulation of flammable gas.

146. The reasons given for such incidents included lack of knowledge and training; lack of skill and experience; being unaware of hazards; inadequate work standards; safety rules not enforced; inadequate leadership/supervision, poor housekeeping and poor ventilation management.²¹⁷

Ventilation monitoring

147. The effectiveness of a mine's ventilation system should be measured in a number of ways, including manual pressure and quantity surveys. Pike used hand-held anemometers (Kestrels) to measure ventilation quantity. These instruments are necessary to verify ventilation speeds underground, and essential in the degassing process.²¹⁸
148. On at least 10 occasions during October 2010, deputies noted a lack of Kestrels underground. For example, on 20 October 2010 one deputy wrote: 'no Kestrel available for vent readings (5 wks now Hurry up and get em). Can't do job without the tools Bro.'²¹⁹
149. When asked about this, Mr White said that 'as far as I was aware we had an adequate supply of Kestrels',²²⁰ and that he would certainly have liked to have known this was an issue. He said it is not possible to start an auxiliary fan underground without measuring the air with a Kestrel, and he was disappointed to learn that someone had to wait five weeks to be given one.²²¹
150. The commission received further evidence that Pike lacked appropriate equipment for ventilation measurements. On 12 October 2010 the Pike project manager Mr Moynihan emailed the Spring Creek mine's ventilation officer Robin Hughes and invited him to come to Pike. Mr Moynihan wanted someone to check air flow and pressure measurements for the underground fan. He said, 'Pike still does not have a [hand-held] electronic manometer and a good quality anemometer.'²²² A manometer is a pressure measuring instrument that should be available at an underground coal mine.²²³

Three key decisions

151. The initial plan for the development of the Pike River mine envisaged a two-intake/single return ventilation system powered by two main forcing fans located on the surface. Three separate decisions put paid to this plan:
- In late 2006 a proposal was made to locate the main fans underground, but in stone measures to the east of the Hawera Fault, and this was decided on after a risk assessment in February 2007.
 - In late 2007, however, the location of the main ventilation shaft was moved from east of the Hawera Fault to its eventual position in pit bottom in coal. This meant also changing the location of the main fans so they would be adjacent to the shaft.
 - In early 2010 Pike obtained approval to locate a bridging panel near pit bottom, which meant that hydro mining began before the development of a second intake.

Hence, as at 19 November 2010, Pike had a single intake/single return ventilation system, powered by an underground main fan at a time when hydro coal extraction had begun.

Conclusions

152. The ventilation system at Pike River was inadequate:
- The ventilation management plan was incomplete, largely ignored in practice and required the appointment of a ventilation engineer to be responsible for the ventilation system. No one was

appointed to the role and the mine manager became the de facto ventilation engineer, without the time or resources to carry out the role adequately.

- The opportunity to improve ventilation capacity was lost when development of a second intake was deferred to accommodate the commencement of hydro mining in the bridging panel.
- The placement of the main fan underground was a major error, aggravated by the failure to adequately protect the fan motor against methane ingress.
- Aside from permanent stoppings erected at the location of the main fan, the mine stoppings were of variable quality and were not built to any rated standard. They compromised the effectiveness of the ventilation system, and created a safety hazard.
- The mine had a ventilation shortfall, with no factor of safety to meet foreseeable hazards, and one less mining or development area in the mine should have been worked.
- On 19 November 2010 the main and back-up fans were both damaged during the explosion, and the ventilation system failed. The mine was unventilated.

ENDNOTES

¹ MinEx Health and Safety Council, Guidelines for the Ventilation of Underground Mines and Tunnels, October 2009, MINEX0007/7.

² United Nations, Economic Commission for Europe, Best Practice Guidance for Effective Methane Drainage and Use in Coal Mines (ECE Energy Series No. 31), 2010, p. 17, http://www.unece.org/fileadmin/DAM/energy/se/pdfs/cmm/pub/BestPractGuide_MethDrain_es31.pdf

³ Douglas White, Submissions on Behalf of Doug White, 24 March 2012, WHI003//6, para. 4.4.

⁴ Malcolm J. McPherson, Subsurface Ventilation Engineering, CAC0158/88, ch. 4.2.1.

⁵ Ibid., CAC0158/110. (Labels added by the commission)

⁶ Minarco Asia Pacific Pty Ltd, Pike River Coal Company Ventilation Report, June 2006, DAO.012.02277/10.

⁷ Ibid., DAO.012.02277/27.

⁸ In this section, the terms 'ventilation engineer', as used in the Pike River ventilation management plan, and 'ventilation officer' are used interchangeably.

⁹ David Reece, transcript, p. 4563.

¹⁰ Peter Whittall, transcript, pp. 872–73.

¹¹ Ibid., p. 890; Letter, Michael Zeitoun to Royal Commission on the Pike River Coal Mine Tragedy, 1 June 2012, FWF0001/1.

¹² Email, Ian Miller to Tony Goodwin, 16 November 2006, DAO.012.02253/3–4; Fläkt Woods Fans (Australia) Pty Ltd, Mine Ventilation Tender, 15 December 2006, DAO.025.27141.

¹³ Department of Labour, Pike River Mine Tragedy 19 November, 2010: Investigation Report, [2011], DOL3000130010/101, para 3.8.6.

¹⁴ In the United States: Code of Federal Regulations, Mandatory Safety Standards for Underground Coal Mines, 30 CFR § 75.310; in Canada: Coal Mining Occupational Health and Safety Regulations SOR/90–97, regs 2, 114(b).

¹⁵ In Queensland: Coal Mining Safety and Health Regulation 2001, Part 11 Ventilation, Division 5, cls 353–58; in New South Wales: Coal Mine Health and Safety Regulation 2006, Part 4, Division 3, Subdivision 4, cls 118–22.

¹⁶ Clause 1.3.3. of the code of practice provides that in the absence of national laws and regulations on a particular occupational safety and health issue, guidance should be drawn from the code of practice, as well as from other relevant nationally and internationally recognised instruments. The ILO is a specialised agency of the United Nations of which New Zealand is a member state.

¹⁷ Platinum Safety Ltd, Institutional Report, 22 May 2012, PSL0001/4, para. 14.

¹⁸ Ibid., PSL0001/5, para. 16.

¹⁹ Platinum Safety Ltd, Risk Assessment Report: Underground Ventilation Fan Installation – Prepared for Pike River Coal Ltd, 27 February 2007, DAO.012.02318/4.

²⁰ Platinum Safety Ltd, Institutional Report, 22 May 2012, PSL0001/5, para. 17.

²¹ Platinum Safety Ltd, Risk Assessment Report, DAO.012.02318/21.

²² Comlek Electrical Engineering Contracting Ltd, Report on Ventilation System – History and Current Status, 31 March 2010, DAO.003.05885/8.

²³ Email, Neville Rockhouse to Paul Coleman, 15 June 2007, PSL0002/1.

²⁴ Platinum Safety Ltd, Risk Assessment Report, DAO.012.02318; Email, Neville Rockhouse to Paul Coleman, 12 July 2007, PSL0004/1.

²⁵ Platinum Safety Ltd, Institutional Report, 2007, PSL0001/6, para. 28.

²⁶ Udo Renk, witness statement, 18 May 2012, RENK7770010001/9, para. 41.

²⁷ Peter Whittall, witness statement, 31 August 2012, p. 2, paras 5–7.

²⁸ Pike River Coal Ltd, Minutes of a Meeting of Directors, 30 July 2008, DAO.013.11707/4.

²⁹ Pike River Coal Ltd, Operations Report, 23 February 2007, DAO.007.00608/8.

³⁰ John Dow, transcript, p. 4028.

³¹ Ibid., p. 4029.

³² Email, Jim Rennie to Peter Whittall, 21 June 2007, INV.04.01153/1.

³³ Guy Boaz, Police/DOL interview, 12 July 2011, INV.03.24596/14.

³⁴ Ibid., INV.03.24596/16.

³⁵ Peter Whittall, witness statement, 31 August 2012, p. 2, paras 9–10.

³⁶ Email, Udo Renk to Peter Whittall, Kobus Louw and Les McCracken, 2 October 2007, DAO.025.46674.

³⁷ Udo Renk, Summary of Telephone Conversation with Udo Renk, 4 October 2011, DOL3000150034/1.

³⁸ Peter Whittall, witness statement, 31 August 2012, p. 3–4, paras 11–20.

³⁹ Petrus (Pieter) van Rooyen, transcript, p. 5199; Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/33, paras 187–88.

⁴⁰ Michael Firmin, transcript, p. 2863.

⁴¹ Discussed further in Chapter 15, 'Regulator oversight at Pike River', paras 22–25.

⁴² Michael Firmin, transcript, p. 2898.

⁴³ Michael Firmin, witness statement, 19 October 2011, DOL7770040002/7, para. 26.

⁴⁴ Ibid., DOL7770040002/7, para. 29; Michael Firmin, transcript, p. 2899.

⁴⁵ Pike River Coal Ltd, Ventilation Management Plan, 2008, DAO.003.07114.

⁴⁶ Ibid., DAO.003.07114/54.

⁴⁷ Comlek Electrical Engineering Contracting Ltd, Report on Ventilation System, DAO.003.05885/13.

⁴⁸ Douglas White, transcript, pp. 4900, 4879.

- ⁴⁹ Ibid., p. 4879.
- ⁵⁰ Ibid., p. 4883.
- ⁵¹ Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/32, para. 179.
- ⁵² Email, John Rowland to Pieter van Rooyen, Terence Moynihan and Douglas White, 23 September 2010, INV.04.00238.
- ⁵³ Standards Australia and Standards New Zealand, Occupational Health and Safety Management Systems – Specification with Guidance for Use (AS/NZS 4801:2001), 15 November 2001, p. 12, para 4.5.4.
- ⁵⁴ John Rowland, witness statement, 22 October 2011, ROW001/11, para. 40.
- ⁵⁵ David Stewart, transcript, p. 3362.
- ⁵⁶ David Stewart, witness statement, 3 November 2011, STE0001/22, para. 42.2.
- ⁵⁷ John Dow, transcript, p. 4024.
- ⁵⁸ Ibid.
- ⁵⁹ Ibid., p. 4026.
- ⁶⁰ Minarco Asia Pacific Pty Ltd, Ventilation Report, DAO.012.02277/22–26.
- ⁶¹ Pike River Coal Ltd, Mine Design Considerations & Production Scheduling, 25 August 2010, DOL3000150005/3.
- ⁶² David Reece, transcript, p. 4486.
- ⁶³ David Cliff, David Bell, Tim Harvey, Anthony Reczek and David Reece, Pike River Coal Mine Explosion: Investigation for Nature and Cause (DOL Investigation Report, Appendix 6), October 2011, DOL3000130007/44.
- ⁶⁴ Petrus (Pieter) van Rooyen, transcript, p. 5207.
- ⁶⁵ Ibid., p. 5213.
- ⁶⁶ Department of Labour, Investigation Report, DOL3000130010/104, para. 3.8.19.
- ⁶⁷ Fläkt Woods Fans (Australia) Pty Ltd, Drawing of General Arrangement VP-2000 Auxiliary Fan Surface Ventilation, 26 February 2008, DAO.025.55292/1.
- ⁶⁸ Ibid. (Extract with labels added by the commission)
- ⁶⁹ Masaoki Nishioka, work record, NISH0002/28.
- ⁷⁰ Department of Labour, Investigation Report, DOL3000130010/104, para. 3.8.20.
- ⁷¹ Pike River Coal Ltd, Incident/Accident Form #1086, 5 October 2010, DAO.001.00359/15–16.
- ⁷² Pike River Coal Ltd, Review of Surface Aux Fan Failure 05/10/10, 7 October 2010, DAO.001.00359/17; Letter, Douglas White to Kevin Poynter, 8 October 2010, DOL3000070182.
- ⁷³ Pike River Coal Ltd, Operations Report Updated to 20 October 2010, DAO.019.00766/8.
- ⁷⁴ Pike River Coal Ltd, Risk Assessment – Reinstate Surface Ventilation and Underground Power and Ventilation after Fan Failure on 5 October 2010, DAO.002.05202.
- ⁷⁵ Pike River Coal Ltd, Review of Surface Aux Fan Failure, DAO.001.00359/17–26.
- ⁷⁶ R & D Consultancy (2007) Ltd, Failure Analysis of Damaged Fan Hub and Dislocated Fan Blade, 4 August 2009, DAO.025.56119.
- ⁷⁷ Terence Moynihan, witness statement, 25 May 2012, MOY7770010001/14, section 5.2.
- ⁷⁸ John Rowland, Ventilation Model Rebuild and Brief Assessment of Mine Ventilation Issues at Pike River Mine, April 2010, DAO.001.04771/14.
- ⁷⁹ Attended by Douglas White, Stephen Ellis, Nicholas Gribble, Robb Ridl and other members of the engineering department.
- ⁸⁰ Pike River Coal Ltd, Review of Surface Aux Fan Failure, DAO.001.00359/17–26.
- ⁸¹ Ibid., DAO.001.00359/21. Including the need to establish an incident management team early on in an event. Mr White was allocated this issue and tasked to 'introduce this process to PRCL' by December 2010.
- ⁸² Emails between Nicholas Gribble, Douglas White, Neville Rockhouse, Stephen Ellis, Danie du Preez, Peter Sinclair, Robb Ridl, Michael Scott and Adrian Couchman, 18–19 October 2010, SOE.024.00305/1–2 and 26 October 2010, SOE.024.00333/1.
- ⁸³ David Reece, witness statement, 2 February 2012, DOL3000150001/16, para. 70.
- ⁸⁴ Michael Scott, witness statement, 30 May 2012, SCO7770010001/22, para. 84.
- ⁸⁵ Masaoki Nishioka, work record, NISH0002/27; Douglas White, witness statement, 18 July 2012, WHI005/12, para. 51.
- ⁸⁶ Anthony Reczek, transcript, pp. 4778–79.
- ⁸⁷ Andrew Sanders, Police/DOL interview, 14 June 2011, INV.03.24725/93; Department of Labour, Investigation Report, DOL3000130010/96–97.
- ⁸⁸ Douglas White, transcript, p. 4974.
- ⁸⁹ Pike River Coal Ltd, Control Room Officer's Event Book, 22 October 2010, DAO.001.02063/1–2; Department of Labour, Investigation Report, DOL3000130010/101, para. 3.8.4; Andrew Sanders, Statement of Andrew John Sanders, 22 May 2011, INV.03.24720/4.
- ⁹⁰ Michael Scott, witness statement, 30 May 2012, SCO7770010001/26–27, paras 101–05.
- ⁹¹ Ibid., SCO7770010001/27–28, paras 107–09; Robb Ridl, witness statement, 14 May 2012, DAO.043.00050/8–9, paras 43–47.
- ⁹² Letter, Michael Zeitoun to Royal Commission, 1 June 2012, FWF0001/3; Andrew Sanders, Statement of Andrew John Sanders, May 2011, INV.03.24720/4; Terence Moynihan, witness statement, 25 May 2012, MOY7770010001/18.
- ⁹³ Michael Scott, witness statement, 30 May 2012, SCO7770010001/28, para. 110.
- ⁹⁴ Udo Renk and Jonathan McNee, 'Technical Challenges for the Pike River Coal Project in a Remote Mining Environment', IMM Conference, August 2007, DAO.001.04727/16.
- ⁹⁵ Udo Renk, second witness statement, 18 May 2012, RENK7770010001/10–11, paras 48–49.
- ⁹⁶ Email, Udo Renk to Jane Birdsall, 17 October 2011, DOL3000150035/2.
- ⁹⁷ Petrus (Pieter) van Rooyen, transcript, pp. 5199–201.
- ⁹⁸ Pike River Coal Ltd, Return Ventilation Design Planning Assistance Notes, undated, DAO.025.53827.
- ⁹⁹ Memorandum, Pieter van Rooyen to Peter Whittall, Nigel Slonker, Gregor Hamm and Terence Moynihan, 18 June 2009, DOL3000150004.
- ¹⁰⁰ Email, Pieter van Rooyen to Jim Rennie and Gregor Hamm, 30 June 2009, INV.03.30237/1.
- ¹⁰¹ Petrus (Pieter) van Rooyen, transcript, pp. 5202–03.
- ¹⁰² Memorandum, Douglas White to Peter Whittall, 16 September 2010, INV.03.30273/2; Petrus (Pieter) van Rooyen, transcript, pp. 5202–03.
- ¹⁰³ Platinum Safety Ltd, Risk Assessment Report, DAO.012.02318/21.
- ¹⁰⁴ Zurich Financial Services Australia Ltd, Pike River Coal Ltd – Risk Assessment and Improvement Report: Draft, 18 August 2010, INV.04.00868/16.
- ¹⁰⁵ David Cliff et al., Investigation for Nature and Cause, DOL3000130007/47, 19.
- ¹⁰⁶ Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 36(a).
- ¹⁰⁷ Pike River Coal Ltd, Ventilation Management Plan, 18 November 2008, DAO.003.07114/48, paras 8.8.2–8.8.3.
- ¹⁰⁸ Pike River Coal Ltd, Standard Operating Procedure – Collecting Stone Dust Samples, undated but created in February 2010, DAO.001.10700; David Reece, transcript, p. 4585; Department of Labour, Investigation Report, DOL3000130010/220, para. 4.40.
- ¹⁰⁹ Kevin Poynter, transcript, pp. 3096–98.
- ¹¹⁰ Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 36(c).
- ¹¹¹ Pike River Coal Ltd, Ventilation Management Plan, 18 November 2008, DAO.003.07114/48, para 8.8.1.
- ¹¹² Hawcroft Consulting International, Pike River Coal Ltd – Insurance Risk Survey – Underground, CPP and Surface Operations: Draft Report, July 2009, DAO.025.45387/48, para. 8.10; Hawcroft Consulting International, Pike River Coal Limited, Pike River Mine – Risk Survey – Underground, CPP & Surface Operations: Final Report, July 2010, DAO.003.08710/58, para 8.11.
- ¹¹³ Email, Gregor Hamm to Pieter van Rooyen, 12 June 2009, SOE.024.00211/1.
- ¹¹⁴ Dene Murphy, witness statement, 2 December 2011, FAM00057/14, para. 76.
- ¹¹⁵ David Stewart, transcript, p. 3328.
- ¹¹⁶ Department of Labour, Investigation Report, DOL3000130010/229, para. 4.43.6.
- ¹¹⁷ David Reece, transcript, p. 4588.
- ¹¹⁸ Department of Labour, Investigation Report, DOL3000130010/104, para. 3.8.21; Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/18, para. 119.
- ¹¹⁹ Gregory Borichevsky, Police/DOL interview, 26 April 2011,

INV.03.18954/125; Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/18, 56, paras 119, 394, 398; Department of Labour, Investigation Report, DOL3000130010/227–28, para. 4.42.18.

¹²⁰ Ibid., INV.03.18954/125; Ibid., DOL3000130010/225, para. 4.42.11.

¹²¹ Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/56, paras. 396–98; Gregory Borichevsky, notes, 22 November 2010, INV.03.29147/20–25.

¹²² Stephen Ellis, witness statement, 31 August 2012, pp. 1–2, paras 4–8.

¹²³ Emails, Ian Miller to Andrew Sanders, 30 March–9 June 2010, DAO.003.05299/4–5.

¹²⁴ National Fire Protection Association, NFPA 68: Standard on Explosion Protection by Deflagration Venting, 2007.

¹²⁵ Letter, Michael Zeitoun to Brett Murray, 22 December 2011, FWF0002.

¹²⁶ US Code of Federal Regulations, Mandatory Safety Standards for Underground Coal Mines, 30 CFR § 75.310, enforced by the Mine Safety and Health Administration.

¹²⁷ Ibid., 30 CFR § 75.310.

¹²⁸ Coal Mining Safety and Health Act 1999 (Qld), s 61; Coal Mining Safety and Health Regulation 2001 (Qld), s 341.

¹²⁹ Ministry of Commerce, Mining Inspection Group, Review of the Recommendations from the Wardens Inquiry into the Accident at Moura No 2 Mine, Queensland on Sunday August 7 1994, 1996, EXH0003/13.

¹³⁰ David Reece, transcript, pp. 4563–64.

¹³¹ MinEx Health and Safety Council, Guidelines, MINEX0007/8.

¹³² Peter Whittall, transcript, p. 872.

¹³³ Ibid., pp. 881–82.

¹³⁴ Ibid., p. 901.

¹³⁵ Douglas White, transcript, pp. 4887–88.

¹³⁶ Ibid., pp. 4884, 4886.

¹³⁷ Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/36, paras 207–11.

¹³⁸ Comlek Electrical Engineering Contracting Ltd, Report on Ventilation System, DAO.003.05885/13.

¹³⁹ Comlek Electrical Engineering Contracting Ltd, Control Functional Descriptions for Mine Ventilation System, DAO.025.49542/1.

¹⁴⁰ Shortly before the explosion Mr Murphy obtained certificate of competence as an undervuewer: see Dene Murphy, witness statement, 2 December 2011, FAM00057/3, para. 6.

¹⁴¹ Pike River Coal Ltd, Incident/Accident Form, 24 June 2010, DAO.001.00749/2.

¹⁴² Douglas White, Submissions, 24 March 2012, WHI003/7, para. 4.13.

¹⁴³ Masaoki Nishioka, transcript, p. 3489.

¹⁴⁴ Petrus (Pieter) van Rooyen, witness statement, PVR001/36, para. 211.

¹⁴⁵ Douglas White, transcript, p. 4891.

¹⁴⁶ Department of Labour, Investigation Report, DOL3000130010/11.

¹⁴⁷ Malcolm J. McPherson, Subsurface Ventilation Engineering, CAC0158/89, ch. 4.2.

¹⁴⁸ Department of Labour, Investigation Report, DOL3000130010/53.

¹⁴⁹ New South Wales Department of Primary Industries, Mine Safety Operations Division, Windblast Guideline: MDG 1003, November 2007, CAC0149.

¹⁵⁰ Malcolm J. McPherson, Subsurface Ventilation Engineering, CAC0158/89, ch. 4.2.

¹⁵¹ Queensland Warden's Court, Wardens Inquiry: Report on an Accident at Moura No 2 Underground Mine on Sunday, 7 August 1994, 1996, CAC0152/69.

¹⁵² Coal Mining Safety and Health Regulation 2001 (Qld), reg 350, sch 4, Ventilation Control Devices and Design Criteria, CAC0156/228, 261.

¹⁵³ MinEx Health and Safety Council, Guidelines, MINEX0007/2.

¹⁵⁴ David Reece, transcript, p. 4577.

¹⁵⁵ Minarco Asia Pacific Pty Ltd, Ventilation Report, 2006, DAO.012.02277/21, para. 5.1.

¹⁵⁶ Pike River Coal Ltd, 'Appendix 5: Specifications for Ventilation Structures', in Ventilation Management Plan, 2008, DAO.003.07046/27–28, paras 4.1–4.3.

¹⁵⁷ David Stewart, Pike River Compliance Audit – Ventilation, 11 February 2010,

STE0004/1–5.

¹⁵⁸ Ibid., STE0004/24.

¹⁵⁹ David Stewart, transcript, p. 3400.

¹⁶⁰ Douglas White, transcript, p. 4851.

¹⁶¹ Pike River Coal Ltd, Underground Standards: Standard Operating Procedure (Final Document), 6 May 2010, DAO.002.07473/11–12.

¹⁶² Ibid., DAO.002.07473/12.

¹⁶³ Masaoki Nishioka, work record, NISH0002/21; Masaoki Nishioka, transcript, p. 3513.

¹⁶⁴ Masaoki Nishioka, transcript, p. 3514.

¹⁶⁵ Pike River Coal Ltd, Plant Location and Ventilation Plan: Rescue

101119_181, 22 March 2011, DAO.010.13140/1. (Extract of the plan modified by the commission)

¹⁶⁶ Stephen Wylie, transcript, p. 3709.

¹⁶⁷ Ibid.

¹⁶⁸ Stephen Wylie, witness statement, 31 October 2011, WYL0001/10, para. 45.

¹⁶⁹ Ibid., WYL0001/11, para. 48.

¹⁷⁰ Pike River Coal Ltd, Incident/Accident Form, 29 [sic] October 2010, DAO.001.00436/21–25.

¹⁷¹ Ibid., DAO.001.00436/25.

¹⁷² Ibid., DAO.001.00436/22.

¹⁷³ Stephen Wylie, transcript, p. 3709; George Mason, transcript, p. 3659.

¹⁷⁴ Stephen Ellis, witness statement, 3 May 2012, DAO.042.00042/4, para. 14.

¹⁷⁵ Pike River Coal Ltd, Incident/Accident Form, 29 [sic] October 2010, Attachment — Panel 1 Goaf Fall 29/10/10, DAO.001.00436/23.

¹⁷⁶ Pike River Coal Ltd, Minutes of Operations Meeting, 3 November 2010, DAO.002.14976/2.

¹⁷⁷ John Rowland, witness statement, 25 November 2011, ROW007/2, para. 7.

¹⁷⁸ David Reece, transcript, p. 4581–82.

¹⁷⁹ Stephen Ellis, witness statement, 3 May 2012, DAO.042.00042/3, para. 8.

¹⁸⁰ David Cliff et al., Investigation for Nature and Cause, DOL3000130007/48.

¹⁸¹ David Reece, transcript, p. 4497.

¹⁸² Douglas White, transcript, p. 4947.

¹⁸³ Ibid.

¹⁸⁴ Pike River Coal Ltd, Plant Location and Ventilation Fan: Rescue 101119_181 (DOL Investigation Report, Appendix 4), 22 March 2011, DOL3000130005/2. (Extract of the plan modified by the commission)

¹⁸⁵ Douglas White, transcript, p. 4949.

¹⁸⁶ Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/35, para. 203.

¹⁸⁷ Ibid., PVR001/35, para. 204.

¹⁸⁸ Douglas White, transcript, p. 4852.

¹⁸⁹ David Reece, witness statement, 2 February 2012, DOL3000150001/16, para. 68.

¹⁹⁰ Department of Labour, Investigation Report, DOL3000130010/111, para. 3.11.12.

¹⁹¹ Robb Ridl, Police/DOL interview, 8 February 2011, INV.03.12713/14.

¹⁹² Ibid., INV.03.12713/15.

¹⁹³ John Rowland, Brief Report Pertaining to Current Model Update and Point-in-Time Circuit Capacities at Pike River Mine, 2 November 2010, ROW006/4.

¹⁹⁴ John Rowland, witness statement, 22 October 2011, ROW001/9, para. 35.

¹⁹⁵ David Cliff et al., Investigation for Nature and Cause, DOL3000130007/52.

¹⁹⁶ Department of Labour, Investigation Report, DOL3000130010/110, para. 3.11.5.

¹⁹⁷ Ibid., DOL3000130010/111, para. 3.11.11.

¹⁹⁸ Plan highlighted by David Reece, MBIE3000010014/1.

¹⁹⁹ Department of Labour, Investigation Report, DOL3000130010/111, para. 3.11.12.

²⁰⁰ The stopping is not shown in Figure 8.17 because it was not included in pre-explosion mine plans at Pike.

²⁰¹ Department of Labour, Plant Location and Ventilation Fan: Rescue 101119_181 (DOL Investigation Report, Appendix 8), 22 March 2011, DOL3000130008/1. (Extract of plan)

²⁰² Douglas White, transcript, p. 5144.

²⁰³ Ibid., p. 4861.

²⁰⁴ Pike River Coal Ltd, Pike River Coal Mine: Deputies Production Report, 21 October 2010, DAO.001.02459/1.

²⁰⁵ Douglas White, transcript, p. 4930.

²⁰⁶ Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of Pike River Coal Mine Deputies Production Reports for March and October 2010, November 2011, CAC0115/13–22; Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of Pike River Coal Mine Production Reports for November 2010, January 2012, CAC0115A/6–12.

²⁰⁷ Masaoki Nishioka, work record, NISH0002/21–32.

²⁰⁸ Ibid., NISH0002/22.

²⁰⁹ Ibid., NISH0002/27.

²¹⁰ Douglas White, transcript, p. 4937.

²¹¹ Robb Ridl, witness statement, 14 March 2012, DAO.041.00009/21, para. 84.

²¹² Ibid., DAO.041.00009/21, para. 85.

²¹³ Department of Labour, Investigation Report, DOL3000130010/124, para. 3.16.4.

²¹⁴ Douglas White, transcript, p. 4937.

²¹⁵ Gregory Borichevsky, Pike River Coal Mine Disaster 19 November 2010, 2 December 2010, INV.04.00001/7.

²¹⁶ Douglas White, transcript, p. 4945.

²¹⁷ Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, November 2011, CAC0114/10–13.

²¹⁸ Douglas White, transcript, p. 5137.

²¹⁹ Pike River Coal Ltd, Pike River Coal – Deputy Statutory Report, 20 October 2010, DAO.001.02793/1.

²²⁰ Douglas White, transcript, p. 4998.

²²¹ Ibid., p. 4999.

²²² Email, Terence Moynihan to Robin Hughes, 12 October 2010, EXH0036/1.

²²³ Craig Smith, transcript, p. 3474.

Methane drainage

Introduction

1. Knowledge and understanding of the basic principles of methane gas control is fundamental to a mine's ability to design effective controls and safe systems.
2. This chapter describes the hazard of methane in underground coal mines and summarises and assesses Pike's knowledge of its gas reservoir and its approach to managing methane.

Overview of best practice approach to methane drainage

Introduction

3. Methane gas occurs naturally in coal mines and is a natural by-product of mining. In the history of coal mining methane explosions have caused more loss of life than any other factor.¹
4. Increasing coal extraction rates often result in higher rates of methane emissions. However in modern mining, sustainable coal production should not be limited by a mine's inability to prevent gas concentrations from exceeding statutory safe limits, nor compromised by uncontrolled gas-related incidents that endanger life. Investment in effective gas drainage can ensure that mines meet production targets legally and safely.
5. Neither New Zealand's mining legislation nor MinEx Health and Safety Council (MinEx) guidelines specifically address the practice of methane drainage.
6. In February 2010 the United Nations Economic Commission for Europe published a best practice guidance on methane drainage,² and the following overview is sourced primarily from this.

Methane gas

7. Coal seam gases typically consist of 80 to 95% methane, with lower proportions of other gases, including carbon dioxide and nitrogen. Bag samples of gas tested by Pike in 2009 and 2010 showed the seam gas composition at levels between 95% and 99% methane.
8. Methane forms in coal seams as the result of chemical reactions taking place when the coal was buried at depth. Methane occurs in much higher concentrations in coal than other rock types because of the 'adsorption' process, which enables methane molecules to be packed into the coal interstices (gaps or spaces) to a density almost resembling that of a liquid. In a vertical sequence of coal seams like those at Pike River, the methane content of coal often increases systematically with depth and rank (maturity).
9. Methane and other gases stored in the coal seam and the surrounding strata can be released if they are disturbed by mining activity. The amount of gas and the rate of release or emission depend upon several factors, including the initial gas content of the coal, the distribution and thickness of the coal seams, the strength of the surrounding strata, the geometry of the mine workings, the rate of coal production and the permeability of the seam. The total gas flow varies proportionally to how much mining activity disturbs the strata and coal seam.
10. Coal seam gases become flammable and potentially explosive only when mixed with air. Methane is flammable when mixed with oxygen in a wide range of concentrations, but generally between 5 to 15% methane in air by volume. Gas released from mining activity inevitably mixes with the mine's ventilation air, is diluted and passes

through the flammable range. It is therefore critical that methane concentrations in the flammable range are limited in time and location as much as possible, to reduce the potential for exposure to ignition sources and the risk of explosion.

11. Methane is buoyant and rises in air, and layering of methane can occur in poorly ventilated areas underground. Concentrated methane tends:

to collect in roof cavities and to layer along the roofs of airways or working faces. In level and ascensionally ventilated airways with inadequate airflow, the layer will stream along the roof in the direction of airflow, increasing in thickness and decreasing in concentration as it proceeds. Multiple feeders of gas will, of course, tend to maintain the concentration at a high level close to the roof.³

12. Layering extends the area within which an ignition of methane can occur, and 'acts very effectively as a fuse along which the flame can propagate',⁴ with a risk of ignition of much larger accumulations of gas in roof cavities or goaf areas.
13. It is critical to reduce explosion risk by preventing occurrences of explosive mixtures wherever possible, and ensuring separation from potential ignition sources. It is essential to dilute high-purity methane by ventilation air to safe general body concentrations at the points of gas emission. This requires a well-designed ventilation system and knowledge of the seam's gas emission characteristics. Capturing high-purity gas in drainage boreholes at its source, before it can enter mine airways, and removing it from the mine, is another way of minimising the risks.

Gas emission characteristics

14. Peak flows of gas occur in a mine's return airways during the coal face cutting cycle and following roof caving. This is particularly the case with hydro mining, which is designed to quickly extract large quantities of coal from thick seams.
15. The volume of gas released from any coal disturbed by mining decreases over time, while continued mining activity adds new gas sources. When mining activity stops, gas continues to desorb from the coal seam and flow from rider seams and surrounding strata, but at a declining rate. Coal seams above and below the working seam may release methane that will migrate through the relaxed strata into the goaf.⁵ Unless methane drainage is carried out, this methane will also be emitted into the mine ventilation system.
16. When assessing gas flows and ventilation requirements, mine operators assume steady state coal production and uniform predictable gas emission characteristics. Although this approach suits most planning needs, other factors such as outburst and sudden emissions of gas from the floor create safety hazards and are not easily predicted, although the geological and mining factors indicating the risk of such events can often be identified.
17. Outburst is the sudden ejection of gas, coal and sometimes rock from a solid coal face into mine workings. Outburst hazards include asphyxiation, burial and impact injuries, and damage to mine equipment and systems. Outburst is a risk in certain mining situations where coal seams have a high gas content and low permeability. Structures in the coal seam, such as faulting, may increase the potential for outburst where they change gas migration or the gas drainage characteristics of the coal. Assessing the outburst risk for a coal seam requires collection, testing and analysis of gas data from core samples, and relating the results to other coal seams where outbursts have occurred. The use of such data for safety planning cannot be overstated. Management of the hazard typically involves pre-draining the coal, before mining begins, to reduce its methane content to below an identified critical gas content amount (m^3/tonne).⁶

Pre-drainage

18. Pre-drainage of gas ahead of mining is done by drilling boreholes into the coal seam. Drilling can occur from the surface or within the seam from underground drill rigs.
19. Horizontal in-seam drilling for pre-drainage involves the drilling of boreholes from underground roadways into future mining areas. Moderate to high natural coal seam permeability is required to ensure significant decay of gas content over a reasonable period of time. A standpipe is installed at the collar of the borehole and connected to a

pipeline that removes the captured gas from the area. Problems with this method can include high water emissions pressurising the pipeline, borehole instability and directional control of drilling. Additional hazards are created if actively draining boreholes are later intersected by mining operations.

20. Coal permeability directly affects the time needed to drain gas to the required average gas content value. The lower the coal's permeability, the more time is necessary. The ultimate feasibility of pre-drainage depends on the available time for degassing the coal before mining and the cost of the drilling operation.
21. Modern directional in-seam drilling techniques and patterns can maximise the amount of gas removed from the seam. Patterns designed for pre-drainage purposes typically involve multiple boreholes about 20–30m apart drilled from one location in a fan, or parallel, orientation, and in a formation to ensure minimal intersection by future mine workings. Boreholes are designed to target the gas and drain the coal, with a sufficient lead time, typically more than six months, before there is intersection by mining.⁷
22. The flow rate of gas from a gas drainage borehole will vary with time. High initial flow occurs from the expansion and desorption of gas in the immediate vicinity of the hole. This may diminish fairly rapidly but then increase again as the surrounding strata are dewatered, which increases the relative permeability of the coal and also the flow of gas. This in turn is followed by further decay as the area of influence is depleted of gas.⁸ Structures in the surrounding strata, including faulting, can also affect gas emission and flow rates.
23. From a strictly regulatory perspective, only enough gas needs to be captured to ensure that a mine's ventilation system can adequately dilute the methane to a level below the permitted maximum. However, methane drainage also affects productivity, since the capacity of the ventilation system and the efficiency of a mine's methane drainage system will determine the maximum rate of coal extraction that can be safely achieved from a gassy coal face.
24. Introducing a gas drainage system, or increasing its effectiveness, is often cheaper than increasing ventilation air volumes. Investment in 'good practice' gas drainage systems therefore results in less downtime from gas emission problems, safer mining environments and the opportunity to reduce emissions and use more gas, which may have financial benefits under emissions trading schemes.

The need for gas data

25. Pre-planning of methane drainage is critical, and the design of gas drainage and ventilation systems to ensure safe mining requires knowledge of the amount of gas adsorbed in the coal (the gas content). Coal seam methane contents typically range from trace levels up to around 30m³/t.
26. To assess gas content (which should not be confused with specific emissions),⁹ core samples are taken from the coal seam, sealed in canisters in as fresh a state as possible, and maintained at near reservoir temperature while gas is allowed to desorb. The measured release rate allows estimation of the quantity of gas lost before sampling, and the gas remaining in the coal is also measured, by crushing the coal and measuring the amount released. An overall gas content assessment can then be made. The composition of the gas can also be established by chemical analysis.

Design of a gas drainage system

27. The design of a methane drainage system should reflect the maximum expected gas flows from all sources in the mine. The system must ensure that gas in the drainage pipeline is not diluted to less than 30% methane in air, safely above the explosive range. That requires quality borehole sealing, including proper installation of standpipes, the systematic regulation of individual boreholes and suction pressure from the surface to assist with the flow of gas from the holes and through the pipeline, if assistance is required. Water also needs to be controlled in the system to prevent pressure build-ups.
28. Underground drainage pipe systems are vulnerable to damage from mining equipment, blasting activities, strata movement and roof collapse. The drainage system should be designed to minimise these risks.

Monitoring of drainage systems

29. Gas drainage systems require continuous monitoring and management to determine effectiveness and performance. Mixture, gas flow and concentration, gauge pressure and temperature should all be monitored, with measurements made of individual boreholes, the gas drainage pipework and at the surface. Changes in barometric pressure affect gas flows and should also be recorded to assist in standardisation of flow data. The data obtained from monitoring these parameters is essential for safety planning.
30. Modelling of gas emissions can provide predictive information on the effects of increased coal production rates on gas flows. Modelling can also forecast the maximum controllable gas flow and the associated maximum coal production rate, depending upon methane limits and ventilation quantities.¹⁰

The need for pre-drainage at Pike River

Methane content of the seam

31. When Japanese company Mitsui Mining Engineering Co. Ltd carried out drilling at Pike River in 1993, methane was 'bubbling out' of drillholes close to the fault,¹¹ and reports from a series of consultants between 2000 and 2010 described Pike River's gas content levels as moderate to high.¹² Pike technical services co-ordinator Gregory Borichevsky described the mine as 'very gassy' because areas being mined were bounded by faults that had isolated blocks of coal. In these areas the coal had not been exposed to atmospheric pressure and gas remained adsorbed within the seam until intersected by mining activity.¹³ In Masaoki Nishioka's experience, high methane emission was generally to be expected near faulting in coal seams.¹⁴
32. The company's knowledge of the gas content levels within the coal seams was limited because of the relatively small number and wide spacing of vertical drillholes from the surface. Core sampling of vertical drillholes for gas content analysis began in 1999, and gas content results were available from 18 of the 33 surface holes drilled before the explosion (PRDH8 to PRDH40). These showed methane gas content levels varying from 1 m³/t to 10 m³/t, with the higher levels recorded close to the Hawera Fault.¹⁵
33. The company's knowledge did not improve to any significant degree once in-seam drilling began, as discussed further below. Few of the horizontal in-seam boreholes had core samples taken for gas content testing.¹⁶ The day before the explosion Pike received gas content results from sampling of its most recent borehole, GBH019,¹⁷ ranging between 2.80m³/t to 5.32m³/t.¹⁸ After the explosion Pike advised Queensland's Safety in Mines Testing and Research Station (SIMTARS) that the mine's coal seam gas content before drainage was approximately 8m³/t.¹⁹

Advice on the need for pre-drainage

34. In 2006 Pike was informed that the high (but variable) permeability and porosity of the Brunner seam meant gas control 'will not be able to be accomplished by ventilation means alone.'²⁰ Minarco Asia Pacific Pty Ltd recommended pre-drainage in areas of the mine, particularly to the north and for the initial development inbye from the stone drive.²¹ Minarco also recommended flanking boreholes in advance of development, and suggested the extent of pre-drainage required should be confirmed by further modelling of the gas reservoir. Investigation into likely emission rates was 'essential', and regular gas surveys were necessary particularly during the first period of development.²²

Pike's intended approach

35. Pike intended to use pre-drainage to reduce methane gas content in the Brunner seam before mining. General manager Peter Whittall described Pike's intended approach in a paper presented to a coal operators' conference in 2006:

Recent sampling has determined a seam gas content of 7.0-7.5 m³/t at the proposed seam entry location. This is at a depth of 85 m. This gas content is considered to be difficult to control by ventilation means alone and in seam gas capture (pre-drainage) will be used as part of the roadway development process. PRCL

will aim to reduce seam gas to $<3\text{m}^3/\text{t}$ prior to mining, however where insufficient lead-time is possible, a maximum content of $6.5\text{m}^3/\text{t}$ will be sought so as not to pollute the intake airways with rib emissions. In thick seam mining a more significant impact is content per square metre as the whole seam is removed during hydraulic extraction and the gas is liberated to the return airways.²³

In-seam drilling at Pike River

Purpose

36. Pike intended to supplement its limited geological knowledge from surface drillholes by the use of in-seam directional drilling for geological exploration.²⁴
37. The delays that plagued the initial development of the mine infrastructure, and the resulting pressures to produce coal, meant that all the in-seam boreholes drilled up to the time of the explosion were designed for exploration of the seam, rather than for the systematic reduction of methane gas content.²⁵
38. Some long boreholes, over 2000m with multiple branches, were drilled to delineate the seam. Although these holes would have provided some reduction in seam gas content in the areas drilled,²⁶ coverage was neither wide nor systematic and methane drainage was incidental. The boreholes did not serve to reduce methane gas content in the hydro panel down to Pike's planned $< 3\text{m}^3/\text{t}$ levels.

Valley Longwall International

39. In 2008 Pike contracted VLI Drilling Pty Ltd (VLI) to provide in-seam drilling services. The contract required VLI to drill directional in-seam boreholes with branches to the roof and floor of the coal seam to Pike's specifications, take core samples from the boreholes when requested, provide and maintain the specialist equipment and provide trained drillers and fitters/offsiders.²⁷ The contract was managed by geologist Jimmy Cory from Pike's technical services department.
40. VLI's crews generally comprised an experienced driller and at least one offsider. VLI had its own health and safety management documentation system relating to the contracted tasks, which it provided to Pike.²⁸ Site-specific documents were also created and VLI staff participated with Pike staff in a risk assessment on 14 November 2008 into the hazards arising from the drilling operations.²⁹

The drilling method used at Pike River

41. The directional drilling equipment used by VLI comprised an electro-hydraulic drill rig and a drill string, consisting of a down-hole motor and rotating drill bit, drill rods and an electronic drill guidance system.³⁰ The drill rig, shown below, was fitted with a gas monitor that alarmed at 1% methane and cut power to the rig when the sensor detected 1.25% methane.



Figure 9.1: Track-mounted Boart Longyear LMC75 drill rig³¹

42. The drilling method involved orientation of the down-hole motor (a 3m rod) to aim the slight bend in the tool towards the desired drilling direction. The down-hole motor (driven by a supply of water intensified by a pump on the rig) was fed in and out of the hole and rotated (to change orientation) using the rig's hydraulics. The electronic guidance survey tool (also approximately 3m long) relayed information back to a receiver unit with the driller, and was separated from steel rods by a copper rod to ensure no magnetic interference. The driller operated the drill rig, spinning rods onto the drill string and using a rotation unit to push the rods, the survey tool, the down-hole motor and the resulting hole to the required distance.³²
43. The photographs below show the drill bit, down-hole motor and assembly, and a close up of the rotating drill bit with high-pressure water forced through the assembly to provide rotation and torque to the bit.



Figure 9.2: Bit, down-hole motor and assembly³³



Figure 9.3: Rotating drill bit with high-pressure water³⁴

44. At Pike River, roof touches or coal seam roof intersections (branches) were drilled as a hole proceeded forward, normally at 40m intervals depending upon structural complexity in the area. When the borehole reached the planned limit, the drill string was progressively withdrawn and branches drilled down to the floor of the coal seam.³⁵
45. The directional guidance system controlled the borehole trajectory, which was pre-planned using 3D modelling software, guided by the geological model of the seam. Real-time survey information was obtained at 6m intervals and combined with logs kept by the drillers, enabling accurate mapping of the coal seam.³⁶

Installation of gas riser and pipeline

46. A risk assessment into in-seam drilling involving VLI and Pike staff and held in November 2008, before drilling began, identified the need for a 'gas discharge solution'. Three options were assessed,³⁷ and Pike adopted the second, installing a gas drainage system during December 2008 and January 2009.³⁸
47. Pike installed a 6" gas riser into an existing cased vertical drillhole, PRDH36, which was located close to the first VLI drill stub. A 4" fire-resistant anti-static (FRAS) pipeline (range) was connected to the three standpipes in place in the drill stub. Pike installed a flame arrestor on the surface for safety reasons,³⁹ but no pump or suction arrangement to assist with gas flow through the range.
48. Mr Cory prepared a memorandum to staff on the procedures required for underground connection of the gas drainage line and the necessity for water traps to be drained regularly. He also suggested that the engineering department start a maintenance schedule for the surface flame arrestor.⁴⁰ Many of these procedures were not followed consistently.⁴¹

Management of gas at the drill face

49. VLI established a gas management system at its drill sites in accordance with its own standard procedures, which included:
 - drilling through a standpipe – a gland driven into the wall face and grouted into position as a permanent access point to the borehole;
 - using valves connected to the standpipe to divert the flow of water and/or gas while drilling, and contain or divert the water and/or gas after drilling;
 - using a stuffing box, which prevents gas or water from the borehole from entering the mine's atmosphere, enabling it to be diverted to a gas/water separator; and
 - using a gas/water separator to assist with managing the flow of gas from the borehole and directing it through a T-piece into the mine's gas drainage line, or free venting the gas into the return ventilation system, in accordance with Pike's instructions.⁴²

Initial in-seam boreholes

50. Boreholes were assigned individual identifiers, from GBH (geological borehole) 001 up to GBH019 by the time of the explosion.
51. In-seam drilling began at Pike River in December 2008 from a drill stub in pit bottom, aimed at development around that area. The second in-seam borehole intersected the large stone graben (a down-thrust block of strata bordered by parallel faults), estimated at up to 220m wide in places, the significance of which Pike was unaware from its earlier geological exploration. By the time Pike got through the graben the focus was on roadway development and the ability to pre-drain the coal seam was limited.⁴³
52. No core samples for coal seam gas desorption testing could be taken from the first few in-seam boreholes, as the drilling method and the size of the graben meant samples would have a 'coal to canister' time exceeding one hour, giving unreliable results.⁴⁴

The slimline shaft

53. The collapse of the ventilation shaft on 2 February 2009 severely limited mine ventilation. To recover air capacity, Pike drilled the slimline shaft from the same surface drill pad location it had recently used to install the gas drainage system. Figure 9.4 below shows the gas riser (yellow) with flame arrestors, and the brown pipe is connected to the top of the slimline fresh air shaft.



Figure 9.4: Gas riser and slimline shaft⁴⁵

54. The bottom of the 6" riser is shown below connected to the 4" gas drainage line labelled in yellow, at the entrance to what became the fresh air base (FAB) in mid-2010.⁴⁶



Figure 9.5: Bottom of gas riser at entrance to the FAB

55. To drill the slimline shaft the flame arrestors at the surface had to be disassembled and removed and the gas drainage line temporarily decommissioned, which resulted in suspension of the drilling programme. VLI's crews left Pike and returned to Australia.
56. The three active boreholes were temporarily closed at the collar, and boreholes GBH001 and GBH002 were soon intersected by development and became inactive for gas flow monitoring.⁴⁷

Commencement of drilling and extension of the drainage pipeline

57. VLI returned to Pike River in May 2009 and continued the drilling programme, completing GBH003 and drilling six more holes by the end of 2009.⁴⁸
58. Very limited gas flow data was obtained from these boreholes. Three were quickly intersected by roadway development and only initial flow measurements were taken,⁴⁹ and no gas flow measurements could be taken from the other three.⁵⁰ Nor were core samples obtained during the drilling of any of these holes to permit gas content analysis.
59. In October 2009 the gas drainage range was modified and extended by the installation of a 4" Victaulic pipeline dedicated to the in-seam drilling programme, and installation of a water trap at the riser.⁵¹ The pipeline continued to extend as new borehole drilling locations were established.⁵²

60. Four more boreholes were drilled between December 2009 and March 2010 and connected to the gas drainage line.⁵³ All had initial high gas and water makes, but subsequent gas flow measurement was hampered by those factors and by poor management of the drainage line.

Problems with Pike River's gas drainage system

System at full capacity

61. By April 2010 the gas drainage line was at full capacity. High water capture in recent boreholes, and ineffective dewatering of the drainage line and at the drill rig,⁵⁴ resulted in resistance and regular flooding of the line, impeding the drainage of gas from the holes and making the system ineffective and highly pressurised. Accurate measurement of gas flows was impossible.

Warnings from workers

62. On eight occasions in March 2010 Pike deputies completed statutory reports noting their concerns with the overpressurised gas drainage system.⁵⁵ VLI's drilling co-ordinator Gary Campbell also voiced his concern that the gas drainage system was inadequate for the gas make, which was affecting their ability to continue drilling some holes.⁵⁶
63. On 11 April 2010 Brian Wishart, an experienced underviewer, sent this email to Mr Cory:

Attention Jimmy Cory

General Concerns Methane drainage system PRCL 11/4/2010

I would like to bring to your attention again the inadequacy of our Methane Drainage system.

1 – The running of a gas drainage system in intake airways is of concern to me as any trouble that we have with water traps, which is very regularly causes methane to vent into our intake roadways this scenario would not happen in NSW or QLD as this kind of arrangement would not get past a risk assessment process and would not be allowed, we should also not allow this practice.

2 – The positioning of this system in 3ct also leaves it venerable to damage from jugos ect.

3 - We now also have a fresh air base with a methane riser in the middle of it.

4 – Over the weekend we had to reposition a water trap at the FAB as it was installed in such a way that the FAB door could not be dropped down in an emergency?

5 – On numerous occasions I have found methane free venting in the old drill stub, while we are drilling there is so much pressure in the line that this stub does not actually discharge any methane into the system.

6 – Water traps are continuously filling with water at a rate faster that they can be drained.

7 –The first trap in the line is that inundated with water while drilling that the trap tube is by bull hose draining straight into the flumes which also surges gas into the return.

8 – "There is a definite problem when we are pushing water up the riser".

9 – This is all due to the line being too small for the sheer volume of methane we are trying to force downhill then up the riser.

10 – My list goes on... but by now I'm sure you get the picture.

It is my opinion that the VLV drill program should be suspended until the line is renewed with larger pipes installed out of the intake. I am well aware of the pressures we are under as a company but this should not be the pressure that possibly one day causes us a serious incident.

Last night the surges in the system were so violent that I was concerned it could blow of the rubber pipe which connects to the trap in the 3/B intake position. This would be very dangerous, if this happened with nobody in the vicinity to close the valve at maddock crib which is not easily accessible we would have full flow methane directly into the intake and in turn across maddock headings I'm sure with that flow the methane would be in the 5 – 15% range with plenty of Oxy not a nice scenario.

Just to bring to your attention the suspected findings of the American pit that recently exploded was centered around an inadequate methane drainage system.

History has shown us in the mining industry that methane when given the right environment will show us no mercy. It is my opinion that it is time we took our methane drainage here at PRCL more seriously and redesigned our entire system.

Regards

Brian Wishart

Figure 9.6: Email from Brian Wishart to Jimmy Cory⁵⁷

64. Some issues with the system were already known,⁵⁸ but this email provoked an immediate response.⁵⁹ Mr Cory showed it to Pieter van Rooyen, who took it to the next production meeting where 'various actions' were discussed.⁶⁰ Short-term remedies were implemented, and Pike engaged an Australian gas drainage consultant, Miles Brown of Drive Mining Pty Ltd.⁶¹

Insufficient planning and design

65. At the time it was installed Mr Whittall 'fully expected' that the 4" pipeline would eventually become inadequate, but the small diameter pipeline was chosen because 'it was easiest to start with'.⁶²
66. In these circumstances, close management of the pipeline and monitoring of gas concentrations, pressure and flow was essential. Yet no manual measurement or monitoring processes were established when the system was installed, and commonly used sensors (measuring real-time flow and pressure and reporting to the control room) were not installed on the system.⁶³
67. Pike's gas drainage system was designed with insufficient information on gas flows or the mine's future drainage requirements. David Reece considered that the gas drainage system was clearly inadequate for the methane levels predicted and experienced.⁶⁴

Location of pipework and gas riser

68. Gas drainage pipelines carrying high-purity methane under pressure should be located in a mine's return airway to minimise the risk of damage from blasting and mining equipment.
69. At the time of the explosion, the whole pipeline ran downhill to the riser, working against the natural inclination of methane to rise.⁶⁵ Significant pressure was required to force the gas along the 4" pipeline and to the top of the riser, and the pressure peaked at the highest point on the pipeline, at the drill stub. This led to difficulties for the drilling crews in managing water and gas from boreholes.⁶⁶
70. The pipeline was installed primarily in the return airways leading from connected boreholes outbye to the riser (as shown below in green), but it also ran for about 100m in the intake airway (shown in pink) from the overcast near the underground fan through Spaghetti Junction before turning left and then right to the gas riser located at the entrance to the slimline shaft/FAB. This created a significant hazard.

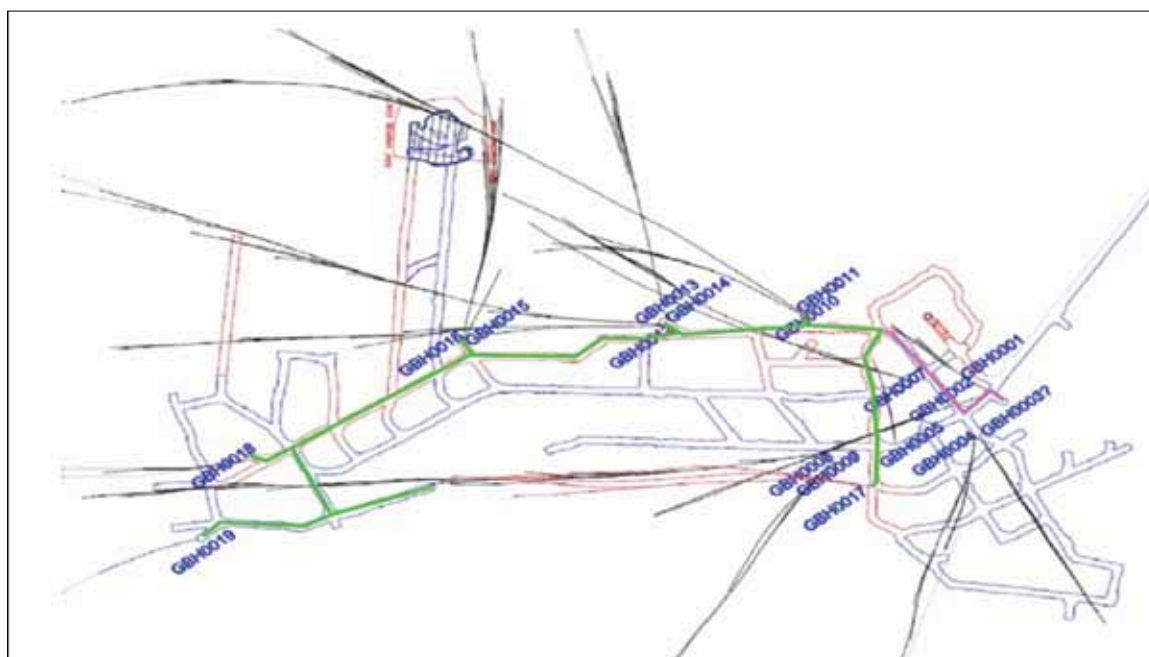


Figure 9.7: Gas drainage line and in-seam boreholes⁶⁷

71. During a risk assessment into the operation of the ventilation fans held on 14 October 2010, an action plan recorded the need to move the methane drainage lines into a better area, away from the methane sensor at the main fan motor.⁶⁸ This had not occurred by 19 November 2010.
72. Staff from the technical services department disagreed with the decision to establish an FAB near the gas drainage line and riser, but the design decision was not theirs.⁶⁹ Mr Reece also criticised the decision:

*you wouldn't have something of a hazardous nature like that in that sort of a location, you'd want to keep them significantly separated. ... A different roadway, you wouldn't have them anywhere near each other.*⁷⁰

The intersection of boreholes

73. Also not ideal was the frequent intersection of boreholes by the mining process. Intersections create a risk of frictional ignitions and the potential for release of large volumes of gas at the face. Intersections also reduce the effectiveness of gas drainage since boreholes must have a pipe connection to the drainage line to remain useful for that purpose.⁷¹
74. A safe operating procedure for borehole intersection was in place,⁷² but it appears the procedures were not necessarily followed.⁷³ Pike commissioned a review and received expert advice in July 2010 on changes required to its safe operating procedure.⁷⁴
75. A more structured approach to advising operational crews about upcoming intersections, via borehole warning zones marked on permits to mine,⁷⁵ was implemented but crews sometimes remained unaware of imminent intersections with gas boreholes. An example occurred in August 2010 when the ABM crew mined 3m past the indicated 'stop' point in the permit to mine for the intake in panel 1, intersecting in-seam boreholes and with the roof strata unsupported.⁷⁶
76. Intersections with boreholes sometimes occurred shortly after the holes were drilled.⁷⁷ This meant little time for reduction of methane levels in the area drilled, and did not allow the technical services department to obtain gas flow and content data from the holes for planning purposes.
77. Pike's accident and incident reports show gas drainage issues were reported by workers. For example in August 2010 a butterfly valve was found partially open, which allowed flammable gas to enter the fresh air intake. In July 2010 a worker found a borehole hose that was incorrectly connected. In February 2010 there was back pressure in the gas drainage range. In August 2009 there was a report that:

*The gas drainage holes in C/2-1 stub are all in floor & branching into multiple holes. This is making it very dangerous & hard to try & plug these holes which are producing large amounts of methane. To try & plug these holes requires people to be working in an explosive/very high CH₄ atmosph [sic]. Tech Services need to plan these holes & intersecting points better to avoid repeats of this situation.*⁷⁸

78. Vehicle collisions were sometimes reported. For example in July 2009 a buried gas pipe was hit by mistake, puncturing it and releasing methane into the workings. Also in July 2009 a worker was:
- using the roadheader to trim corner for vale fan the head caught some rib mesh pulling it down along with the gas drainage hose cutting it, releasing gas and water from the drainage line, 3-4% CH₄.*⁷⁹
79. Causes identified in the reports include not following procedure, lack of knowledge and training, lack of skill or experience, congestion and substandard work practices.⁸⁰

Expert advice on gas drainage

Drive Mining Pty Ltd

80. New South Wales mining engineer Miles Brown,⁸¹ engaged to advise Pike on its gas drainage system,⁸² conducted three site visits in 2010, each involving underground inspections and consultation with staff from the technical

services department. He gave Mr Cory training, including on gas flow measurement, and provided lengthy technical reports supplemented by email advice when required.

81. Mr Brown requested information on Pike's gas reservoir before he arrived. No gas content data was available as up until then Pike had not taken any core samples during its in-seam drilling programme.⁸³

Miles Brown's first site visit

82. When Mr Brown visited Pike River on 28–29 April 2010 he found Pike's drainage system under significant pressure and inadequate for the gas flows experienced from the thick Brunner seam. There was inadequate maintenance of the pipeline and no method for measuring gas flows. Mr Brown recommended the VLI drillers not to force any further gas into the pressurised pipeline, to reduce the risk of gas emissions around their drill site.
83. Mr Brown suggested the design of flanking drainage holes as a minimum for all development headings, including the proposed hydro bridging panels, and gas content core sampling at 200m spacing. A lack of data meant he was unable to properly design a gas drainage system and had to make assumptions about the gas reservoir. He provided a gas drainage schedule for Pike, noting:

This schedule highlights the fact that draining such a thick seam without a large lead time or enough data to quantify an accurate decay curve leads to the conclusion that if there is 8 m³/t of gas then development rates will be affected. The solution will be to gain more knowledge quickly and if high levels of gas are found introduce a smaller spacing of drainage holes. This will increase costs, however will assist with increasing development rates.⁸⁴

84. Mr Brown advised Pike to improve its gas drainage system by:
- installing a new gas riser inbye of current development within three months, with a minimum 10" internal diameter to service the current and future drainage needs; and
 - upgrading all current and future underground drainage pipes to 10" pipes to lower frictional resistance and pipeline pressure, increase drainage capacity and water control, and improve the ability to maintain the system.
85. Mr Brown also urged an assessment of the outburst risk of the Brunner seam, and cautioned that if the gas content was 'confirmed above 8m³/t or a GeoGas DRI of 900, then development should be stopped until a risk assessment for continuation has occurred'.⁸⁵ The DRI900 method has been universally accepted by the mining industry for determining outburst threshold limit values.⁸⁶

86. Mr Brown described the need for data collection over the next three months as a 'key' recommendation:

Gas Content Cores must be taken to not only allow the assessment of an area but to determine the drainage parameters. These core results also determine if the coal seam is liable to Outbursts. ... Hole flow data assists in the determination of pipeline and riser design. This flow data along with virgin core results help create the decay curve for drainage which is the backbone of a drainage model. This allows for the development of hole spacing requirements.⁸⁷

87. Pike accepted that recommendation, noting 'no historical gas-flow data has ever been collected from in-seam drill-holes and the gas reservoir content is therefore unknown'.⁸⁸ Collection of gas flow data and information on the gas reservoir began in mid-June 2010 when Mr Cory began recording some weekly gas data measurements.⁸⁹ Pike took one core sample on completion of in-seam borehole GBH014,⁹⁰ but the sample was compromised and no gas desorption testing or analysis was possible.⁹¹ From August 2010 Mr Cory began to measure and monitor essential flow data from all individual holes, after measuring sets were installed at the borehole standpipes and at the bottom of the 6" riser.⁹²

Outburst management plan

88. Pike created a draft outburst management plan in July 2009, although no signed or final version was available to the commission.⁹³ It aimed to reduce and minimise the risks associated with outbursts in development panels by

draining in-seam gas content to below agreed threshold limits, and by implementing a system of measurement and risk assessment before authorisation of mining, via the permit to work process.⁹⁴

89. Parts of the plan reflected Australian documents,⁹⁵ and had no relevance to Pike River.⁹⁶ Other parts were simply not followed or ignored in practice, for example:

*Prediction, in the form of comprehensive data acquisition and extensive in-seam drilling, and prevention by way of effective gas drainage coupled with gas flow monitoring, and regular core sampling so that the Mine Manager is always aware of the seam gas and structure environment into which the Mine is about to develop or extract, are the two prime components of The Plan. These form the input into the Authority to Mine process which, upon completion, will determine the mining methodology to be used to develop each roadway or sequence of roadways and extraction panels.*⁹⁷

90. The plan also stated, as a basic operating principle, 'that no mining will take place when the gas content of the coal is above the established Outburst Threshold Level'.⁹⁸ A risk assessment into ventilation and gas monitoring on 7 September 2010 also recorded 'propensity testing' as an existing control of the outburst risk.⁹⁹
91. The outburst threshold level for the Brunner seam was still unknown at the time of the explosion.

Miles Brown's second site visit and Pike's decision to free vent methane

92. Mr Brown returned to Pike River from 28 June to 1 July 2010. During his underground inspection he became concerned about the imminent uncontrolled intersection of GBH012, a highly pressurised borehole, by a development mining machine. After discussion, Douglas White made an operational decision to 'free vent' the borehole into the main return, by releasing gas directly into the mine atmosphere via a valve on the borehole standpipe. Free venting occurred over several days in a controlled manner and methane levels were kept within a target maximum of 1% in the main return. GBH012 was then intersected on 7 July 2010 with reduced gas make and limited impact on mining.¹⁰⁰
93. Free venting released large quantities of methane and allowed Pike to 'make full use of the existing dilution capacity in the main returns to relieve this pressure on the gas drainage line and to actively manage gas from the Panel 1 area in advance of mining'.¹⁰¹ This was a more attractive alternative than relying on an inadequate drainage system. In early July 2010 Pike decided to free vent all three boreholes in the hydro panel to the return before they were intersected by development of the panel headings, to avoid 'possibly days of lost development' while the holes were depressurised at the face.¹⁰² Large quantities of methane were free vented from these holes,¹⁰³ and methane levels were closely monitored.¹⁰⁴
94. Free venting became part of a new gas management strategy, although no formal procedure existed. In July 2010 the technical services department prepared a draft gas drainage management plan,¹⁰⁵ and issued operational advisory notices setting out the strategy.¹⁰⁶ Deputies, underwriters and surface controllers were to manage the process so the level of methane at the main fan remained below a maximum of 1.25%, with a target level of 1% in the return. Intersected boreholes required installation of standpipes and hosing into the return.
95. Mr Brown's second report, finalised on 22 July 2010 after discussions with Pike, recorded the continuing struggle to maintain the gas drainage system. Gas make was greater than the system's capacity, and the pressure at the bottom of the riser was considerably greater than the flow of gas up the riser.¹⁰⁷ Overall the system was highly restrictive.¹⁰⁸ Mr Brown made a number of short-term suggestions and advised Pike to plan for a suction unit on the upgraded system.
96. Mr Brown stated that beginning hydro extraction before the underground fan was commissioned would increase methane levels in the return and have a negative effect on the available ventilation. He doubted the desired extraction rates were achievable without an upgraded gas drainage line.¹⁰⁹
97. Mr Brown calculated production scenarios, but noted a number of assumptions,¹¹⁰ including the unknown effects of the surrounding strata on gas emission calculations for panel 1, and increased methane levels from the ABM20 development miner. Although his calculations indicated a more manageable situation once the main underground

fan was commissioned, he had 'major' concerns about predicted methane levels in the hydro panel return and advised that additional air would be required for panel 1.¹¹¹

98. Mr Brown suggested replacing the 4" pipeline with a 12" diameter line, and that Pike use the slimline fresh air shaft as the gas riser until a new 12" riser could be drilled and installed inbye.¹¹² He urged Pike to start 'vital' weekly gas flow and emission measurements, and create a database to inform future gas flow estimations and for emissions trading legislative requirements.¹¹³
99. By this time three core samples had been taken from GBH16,¹¹⁴ a borehole flanking the hydro panel. One worrying gas content result of 8.29m³/t fell just below the outburst threshold limit of 9m³/t identified for the Bulli coal seam in Australia. Mr Brown repeated his advice that additional gas cores must be taken from new boreholes drilled ahead of development, and cautioned:

*If ever the DRI900 limit is exceeded then development must not mine this area until drainage has occurred and a new core sample has been taken and found to be below this value. As Pike River is approaching outburst threshold limits additional drilling should be conducted to both drain the coal of gas but to [sic] understand the gas reservoir.*¹¹⁵

100. There was no additional in-seam drilling to reduce the gas content levels in panel 1, although one of Mr Brown's assumptions was pre-drainage down to 3m³/t in that area.

Mechanical Technology Ltd

101. Pike also engaged mechanical engineer Chris Mann, of Mechanical Technology Ltd in Auckland, to report on gas utilisation options and to address Mr Brown's recommendations for upgrading the drainage line.¹¹⁶ In his multi-purpose report to Pike in August 2010,¹¹⁷ Mr Mann agreed that Pike's gas drainage system was inadequate for the gas levels experienced and required upgrading. He described Pike's gas flow measurements as 'rudimentary' and dismissed the mine's historic predictions of gas drainage flows of 300l/s, estimating peak flows of up to 1400l/s for the next 10 years as multiple panels were drained.¹¹⁸
102. The system's borehole pressure was high and Mr Mann suggested that, before the pipeline upgrade, Pike should install a temporary blower at the top of the gas riser to provide suction on the system. He estimated this would approximately double the flow of gas from the boreholes and through the pipes.¹¹⁹ Mr Mann agreed that Pike should upgrade the current pipeline to a 12" diameter range, pre-drain the seam to a methane content of 2–3m³/t and install a temporary flare to flare gas out of the drainage system if that could be achieved safely.¹²⁰ He, too, suggested Pike consider using the slimline fresh air shaft as a temporary gas riser.

Miles Brown's third site visit

103. Mr Brown made a third visit to Pike River from 13 to 17 September 2010. Panel 1 roadways were completed, equipment was being installed for the monitor panel and Pike was about to begin hydro extraction. There had been no upgrade of the gas drainage infrastructure, the underground fan had not been commissioned and free venting was still occurring. Lack of certainty in mine planning and the fact that inadequate gas data had not been obtained for a sufficient period of time meant Mr Brown could not provide a drilling design for pre-drainage. His third report dealt primarily with short-term tasks.¹²¹
104. Mr Brown found improved control of the gas drainage holes and no water in the pipeline as a result of Pike's better management of the system, although only three non-critical holes were connected and only approximately 40l/s of gas was flowing up the riser.¹²²
105. Mr Cory was continuing with weekly gas drainage measurements and spreadsheets had been set up for recording data from each borehole.¹²³ Pike also planned, but had not yet begun, weekly gas emission measurements to identify where gas was being emitted and its effects on production.¹²⁴
106. Mr Brown also suggested the VLI drilling crews required greater direction to manage the gas at their stubs in a more regimented way, as their next drill site was at the highest elevation yet and at the end of the pipeline range, so

would be the most pressurised. He suggested continued free venting to the ventilation system with connection to the pipe range once a hole was completed.

107. An outburst threshold value had still not been estimated. Mr Brown described core sampling as 'the single most important task' that needed to be regimented, as results were vital for estimating an outburst threshold rating, estimating gas hole flows and for the creation of a decay curve for the Brunner seam. This in turn would assist Pike in estimating pipeline and riser requirements for the future. He suggested 'all efforts' should be made to obtain a DRI900 level for safe mining.¹²⁵
108. The evidence of further borehole core sampling provided to the commission is of samples taken from boreholes GBH018 in September 2010 and GBH019 in November 2010,¹²⁶ both located in the south-west corner of the workings as shown in Figure 9.7. Pike received results of gas desorption testing from those samples just before the explosion on 19 November, but no outburst threshold limit had been established.

Pike's approach to methane management

Insufficient pre-drainage of panel 1

109. The following diagrams show the proposed production area of the hydro panel, and the expected gas emission area for gas flows from the surrounding strata.¹²⁷ Long in-seam boreholes intersect the panel,¹²⁸ and faulting to the east of the panel is shown.

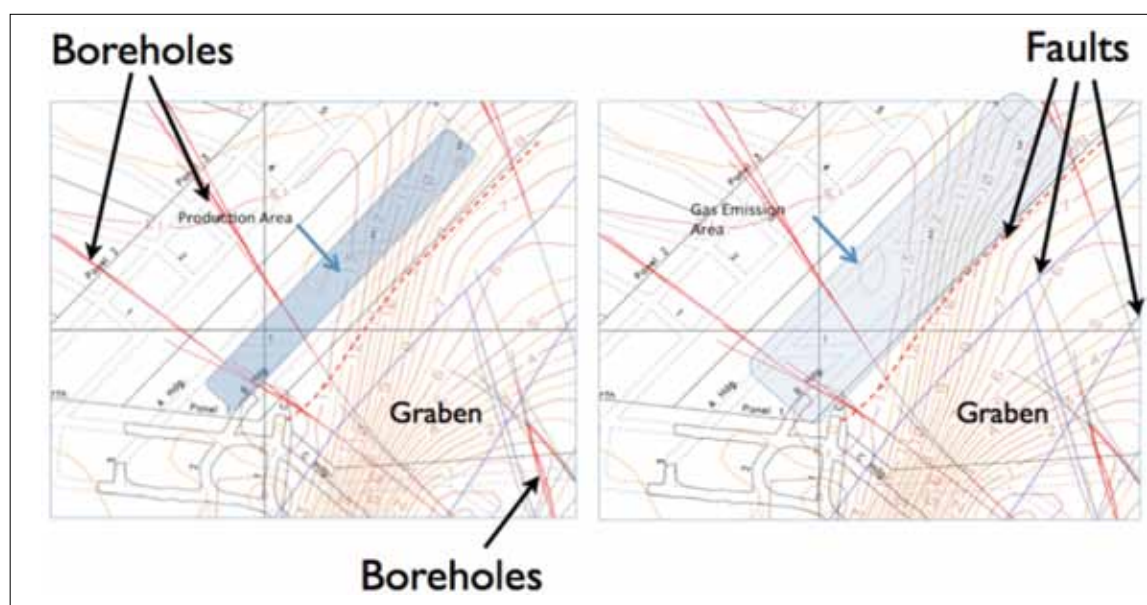


Figure 9.8: Panel 1 production area and panel 1 area of interest for gas emissions¹²⁹

110. Borehole GBH016 was subsequently drilled 'flanking' the eastern boundary of panel 1, but no drainage holes were drilled within or to the west of the panel. GBH016 and the intersected boreholes were designed primarily for exploration of the seam, not for systematic pre-drainage of methane from the panel before mining.¹³⁰
111. The gas content core sample result of 8.29m³/t from GBH016 underlined the need for further drainage of the area, particularly given the use of an untried hydro-extraction method in a thick seam with the likelihood of high methane release. However, coal extraction from panel 1 began without pre-draining the seam down to safer gas levels.

The hazard of free venting

112. Free venting created an additional hazard by increasing the level of methane within the mine's return, removing (up to) a 1% buffer and putting pressure on the ventilation system. It required close monitoring and effective management.

113. In practice, free venting involved staff opening a borehole until gas levels in the return got to around 1%, which allowed sufficient capacity for 'little peaks' to go up to a maximum of 1.25%, 'with the idea being that they could go, always go and turn it back down again if they needed to'.¹³¹
114. Mr Borichevsky monitored gas levels and trends and reported these to the daily production meetings until the new production manager, Stephen Ellis, took over running the meetings about mid-September 2010. Messrs Borichevsky and Ellis gave conflicting evidence about the change of focus in the production meetings, but the daily review and reconciliation of gas levels and trends did not occur regularly from that point on.¹³²
115. Although more air was available to the mine from October 2010, when the main underground fan came online, the ventilation system was almost immediately at capacity and at times struggled to cope with the high methane levels experienced from hydro and development mining.
116. Expert evidence before the commission was that the practice of free venting is only a 'stop-gap' measure and no longer a common or preferred practice for dealing with problem amounts of methane. Mr Reece described reliance on free venting as 'not done these days'.¹³³
117. Pike had initially described free venting as an interim measure when dilution capacity in the return permitted,¹³⁴ until the (then imminent) drainage system upgrade. Given anticipated high methane levels, it was not expected to continue once hydro panel extraction began.¹³⁵ But the practice did continue up to the time of the explosion.

Deferral of the system upgrade

118. Mr Mann had investigated the scope and cost of upgrading the drainage system, and budgetary approval had been given to install a bigger pipeline and riser.
119. The technical services department considered it was impractical to upgrade the current 4" pipeline or the 6" riser in the existing locations. It also rejected the suggestion that the larger slimline fresh air shaft be used as a temporary gas riser, given the stub was, by then, designated as the FAB. Instead a location inbye to the north-west was identified as suitable for installation of a new larger gas riser, which would then be connected to a new 12" pipeline installed from that location to the active drill stubs. Roadway development to this location was estimated to be three months away.¹³⁶
120. Mr van Rooyen explained that his department was concentrating on finding a longer term solution to Pike's problems, and installing a new larger capacity gas drainage system was part of that plan. Otherwise, 'trying just to solve a short term problem creates other problems that's not always foreseen when you try and solve the problem'.¹³⁷ Mr van Rooyen estimated installation of the new gas drainage infrastructure would have taken a further six months from the time he left Pike in early November 2010.¹³⁸ A temporary blower/pump arrangement on the surface to increase the flow of gas from the boreholes and through the pipes was not installed. Pike continued to extend the 4" pipeline to newly drilled in-seam boreholes.¹³⁹

Failure to assess the risks

121. The free venting programme successfully reduced the hazard created by the overpressurised drainage line. Yet the effect was the release of large quantities of methane into the mine's returns, extending the duration and location of potentially explosive mixtures underground. High methane levels continued, particularly after panel 1 extraction began, but there is no evidence of a risk assessment of the free venting practice.
122. In August 2010 both Hawcroft Consulting International and Zurich Financial Services Australia Ltd,¹⁴⁰ during annual insurance assessments, noted the need for Pike to conduct a risk assessment of the methane hazard in the mine. Hawcroft recommended Pike should 'expedite' a risk assessment into gas and ventilation, and 'implement suitable measures to ensure the methane in the underground workings remains at management, risk free levels'.¹⁴¹
123. The 7 September 2010 risk assessment report into ventilation and gas monitoring assessed the hazard of 'gas drainage',¹⁴² but made no mention of free venting. Some controls did not exist, or were ineffective in addressing the actual hazard. For example, the existence of a safe operating procedure for gas drainage was listed as an existing

control, although it was not finalised until 5 November 2010.¹⁴³ The risk of high methane levels from exploration holes in development headings referred to the 'specification of new drainage system' as an existing control,¹⁴⁴ but it did not exist. The assessment did not recognise the use of pre-drainage as a control measure to reduce in situ gas content to safer levels. Nor did it identify Pike's limited knowledge of the characteristics of its gas reservoir as a hazard in itself.

Lack of oversight by the Department of Labour

124. Kevin Poynter, the DOL mines inspector dealing with the company in 2010, was unaware that Pike's gas drainage system was inadequate for the gas levels encountered. He did not know of the reliance on free venting or the lack of gas data, and he did not audit the systems Pike used to measure and monitor gas flow and emission rates. He acknowledged that the department did not know whether Pike's methane drainage system met health and safety standards.¹⁴⁵ The location of the gas riser at the FAB should also have been an issue of concern to the regulator.¹⁴⁶

The gas drainage system at November 2010

125. A few weeks before the explosion, VLI had begun drilling GBH019, and several in-seam boreholes were free venting to the mine's atmosphere. Problems with management of the gas drainage system continued with gas flow from borehole GBH018 backing up and restricted by the 4" pipe.¹⁴⁷ Les Tredinnick, McConnell Dowell's underground superintendent, advised Pike staff in October of a 'whistling' standpipe and methane being emitted through the stone floor in A heading in pit bottom north. This had not been addressed by 19 November 2010.¹⁴⁸
126. The following graph prepared by the joint investigation expert panel¹⁴⁹ summarises the total daily methane volumes (m^3/day) for the drainage system gas from July 2010 until the explosion. The red line depicts the volume of methane measured at the bottom of the gas riser, which decreases from the beginning of July when the practice of free venting began with GBH012 disconnected from the range. The blue line shows the volume of methane free vented to the mine's atmosphere for dilution by ventilation; and the grey line shows the total methane flow from all boreholes. These measurements began on 20 August 2010, the start of gas flow measurement from individual boreholes. The green line shows the total methane volume flowing into the range from September 2010 when weekly gas drainage measurements commenced.

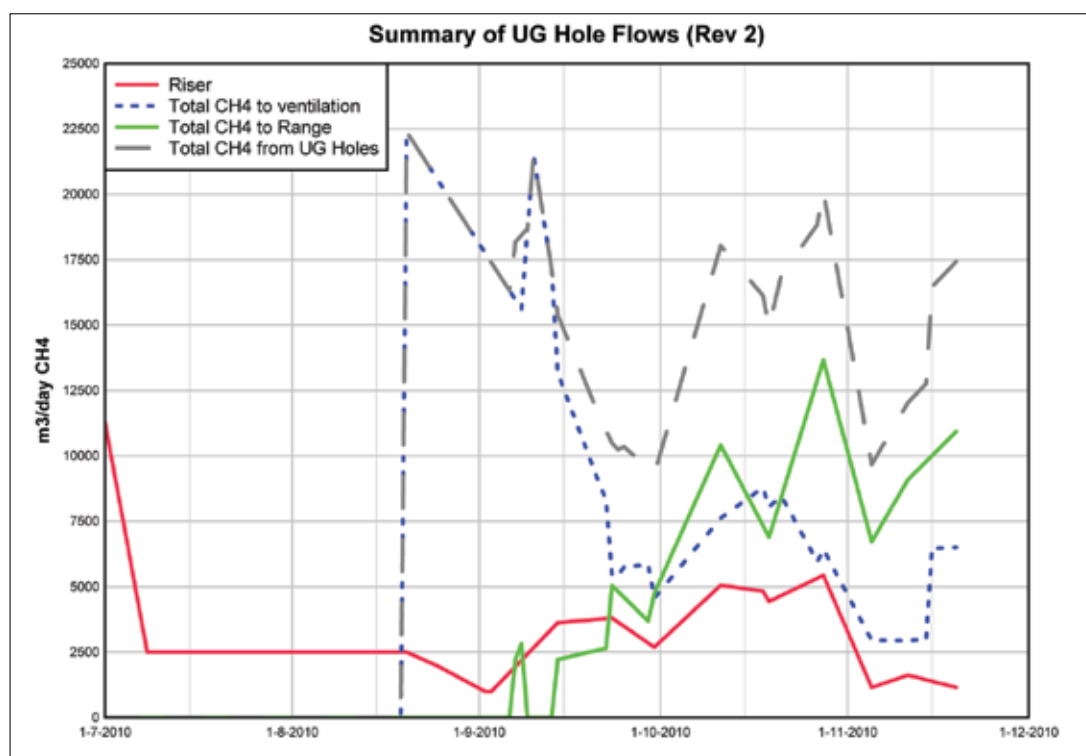


Figure 9.9: Graph summarising total daily drainage system gas flow measurements¹⁵⁰

127. The noteworthy features are the high volume of methane free vented when compared to the volume of gas entering the range, and the difference between the volumes entering the range and reaching the bottom of the riser. For example, on the day of the explosion the measured gas flow into the range was 126.4 l/s but only 13.3 l/s was measured at the gas riser. Such discrepancies dated back to the beginning of October. Various explanations for the difference have been suggested including leakage, methane back-feeding into other areas, a blockage in the range or incorrect measurements at the gas riser.¹⁵¹
128. As late as 27 October 2010, there was no accurate recording of methane emissions and no comprehensive system in place to capture, record and store all data permanently.¹⁵²
129. The expert panel criticised Pike's gas management approach:
- Significantly, there was a lack of specific gas drilling design and implementation for adequate in situ gas reduction; a particularly inadequate gas drainage system with substandard pipeline dimensions and lack of evacuation (pumping); and little determination of in situ gas content (cores) linked with an authority to mine.*¹⁵³

Conclusions

130. The following key features marked the management of methane drainage at Pike River:
- In-seam drilling undertaken from December 2008 was designed to explore and delineate the coal seam. Pre-drainage of the coal seam was a secondary purpose of the drilling and was often prevented by intersection of boreholes before gas levels could decay.
 - A limited gas drainage system was installed in 2009 which, by early 2010, was inadequate to service the gas flows experienced from in-seam boreholes and was poorly managed. Management of the system improved, but the system capacity was not upgraded.
 - Free venting of methane into the mine return began in July 2010 to relieve pressure on the range in the interim, and continued to the time of the explosion.
 - Adequate gas data was not gathered until August 2010. Knowledge of the gas reservoir remained limited.
 - Gas management continued to be a problem into November 2010 even after the main fan improved the ventilation capacity.

ENDNOTES

¹ Malcolm J. McPherson, Subsurface Ventilation Engineering, CAC0158/389, ch. 12.1.

² United Nations, Economic Commission for Europe, Best Practice Guidance for Effective Methane Drainage and Use in Coal Mines (ECE Energy Series No. 31), 2010, http://www.unece.org/fileadmin/DAM/energy/se/pdfs/cmm/pub/BestPractGuide_MethDrain_es31.pdf

³ Malcolm J. McPherson, Subsurface Ventilation Engineering, CAC0158/412, ch. 12.4.2.

⁴ Ibid.

⁵ Ibid., CAC0158/410, ch.12.4.1. The author suggests a range of methane migration from some 200m above to 100m below the working horizon.

⁶ Volume of gas contained per mass of coal substance in situ.

⁷ David Reece, transcript, pp. 4502–03.

⁸ Malcolm J. McPherson, Subsurface Ventilation Engineering, CAC0158/421, ch. 12.5.1.

⁹ Specific emissions represent the total volume of gas emitted per tonne of coal mined over any given period. Gas from all sources is measured, i.e. not just from the coal that is being extracted, but all the strata that is disturbed

and becomes relaxed as the void left by the mining process collapses.

¹⁰ Modelling requires adequate data collection that includes seam gas contents, mechanical properties of the rock and coal strata, mining geometry and coal production rates.

¹¹ Masaoki Nishioka, transcript, p. 3481.

¹² AMC Resource Consultants Pty Ltd, Pike River Coal Company Final Feasibility Study – Project Summary, 23 June 2000, NZOG0007/10, 18; Minarco Asia Pacific Pty Ltd, Pike River Coal Company – Ventilation Report, June 2006, DAO.001.04505/5; Hawcroft Consulting International, Pike River Coal Limited, Pike River Mine – Risk Survey – Underground, CPP & Surface Operations: Final Report, July 2010, DAO.003.08710/60; Zurich Financial Services Australia Ltd, Pike River Coal Ltd – Risk Assessment and Improvement Report, 18 August 2010, INV.04.00868/15.

¹³ Gregory Borichevsky, Police/DOL interview, 26 April 2011, INV.03.18954/7–8; Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/9, para. 57.

¹⁴ Masaoki Nishioka, transcript, p. 3481.

¹⁵ Pike River Coal Ltd, Summary Tables of Drillhole Gas Measurements, June

2008, DAO.025.42433; CRL Energy Ltd, CSG Canister Desorption Results (PRDH037), 2009, DAO.025.36396.

¹⁶ Pike River Coal Ltd, Monitor and Report on In-seam Gas Levels and Flow Rates from the In-seam Holes, 14 October 2010, DAO.025.44571/3.

¹⁷ Shown in Figure 9.7.

¹⁸ For example: CRL Energy Ltd, CSG Canister Desorption Results, 18 November 2010, DAO.025.34092, DAO.025.34090 and DAO.025.34094.

¹⁹ Safety in Mines Testing and Research Station, Review of Gas Data Following Pike River Explosion on 19 November 2010 for New Zealand Police, 7 April 2011, SOE.001.00004/8.

²⁰ Minarco Asia Pacific Pty Ltd, Ventilation Report, June 2006, DAO.001.04505/27.

²¹ Ibid., DAO.001.04505/27, 6.18. However as discussed below no pre-drainage of the area between the stone drive and the connection to the shaft occurred – Peter Whittall, transcript, pp. 878–79.

²² Minarco Asia Pacific Pty Ltd, Ventilation Report, June 2006, DAO.001.04505/6, 15.

²³ P. Whittall, 'Pike River Coal – Hydraulic Mine Design on New Zealand's West Coast', in N. Aziz (Ed.), *Coal 2006: Coal Operators' Conference*, University of Wollongong & the Australasian Institute of Mining and Metallurgy, 2006, pp. 161.

²⁴ Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/39, para. 230.

²⁵ Ibid., PVR001/43, para. 253; P. Whittall and J.J. Cory, 'In-seam Directional Drilling at Pike River Coal Mine – An Essential Planning Tool', in AusIMM New Zealand Branch Annual Conference 2009, CAV0001/705.

²⁶ David Reece, witness statement, 2 February 2012, DOL3000150001/21, para. 92.

²⁷ David Carter, witness statement, 9 August 2011, VLI0001/4, paras 8–10.

²⁸ The documentation included risk assessments, critical work procedures, JSEAs and work method statements on its directional drilling procedures and for coring and gas testing from underground exploratory drillholes: Valley Longwall International Pty Ltd, Standard Work Method Statement, 15 August 2008, DAO.032.03294.

²⁹ Pike River Coal Ltd, Risk Assessment Report – In-seam Directional Drilling Provided by Valley Longwall Drilling, 14 November 2008, DAO.032.00244.

³⁰ P. Whittall and J.J. Cory, 'In-seam Directional Drilling at Pike River Coal Mine', CAV0001/710.

³¹ Peter Whittall and Jimmy Cory, In-seam Directional Drilling at Pike River Coal Mine: An Essential Planning Tool – AusIMM conference – Queenstown, August 2009, DAO.007.25198/6.

³² David Carter, witness statement, 9 August 2011, VLI0001/5, paras 16–22.

³³ Peter Whittall and Jimmy Cory, In-seam Directional Drilling at Pike River Coal Mine, DAO.007.25198/4.

³⁴ P. Whittall and J.J. Cory, 'In-seam Directional Drilling at Pike River Coal Mine', CAV0001/709.

³⁵ Ibid., CAV0001/710.

³⁶ Ibid.

³⁷ Pike River Coal Ltd, Risk Assessment Report, DAO.032.00244/11–12.

The first option was to 'utilise existing gas drainage pipeline', which was (described as a 4" polypipe non-FRAS pipe) installed as a control measure when Pike mined through the Hawera Fault. Further details of this pipeline are unknown from documentation filed with the commission.

³⁸ Memorandum, Jimmy Cory to Peter Whittall, 29 January 2009, DAO.003.16304; Memorandum, Jimmy Cory to Kobus Louw, 12 February 2009, DAO.003.16311.

³⁹ Petrus (Pieter) van Rooyen, transcript, p. 5229.

⁴⁰ Memorandum, Jimmy Cory to Kobus Louw, 12 February 2009, DAO.025.53172.

⁴¹ John (Jimmy) Cory, witness statement, 18 June 2012, COR0001/12–13, paras 53–60.

⁴² David Carter, witness statement, 9 August 2011, VLI0001/7, para. 33.

⁴³ Peter Whittall, transcript, p. 879.

⁴⁴ Pike River Coal Ltd, Monitor and Report on In-seam Gas Levels and Flow Rates from the Inseam Holes, 14 October 2010, DAO.025.44571/3.

⁴⁵ Photograph sourced from Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report, 22 July 2010, DAO.001.04909/5.

⁴⁶ Mechanical Technology Ltd, Pike River Coal – Methane Gas Drainage and Utilisation Concept Design Report, August 2010, MED0010070099/22.

⁴⁷ Pike River Coal Ltd, Monitor and Report, 14 October 2010, DAO.025.44571/5.

⁴⁸ Ibid., DAO.025.44571/6. Boreholes GBH04-05 and 07-10. There was no borehole labelled GBH006.

⁴⁹ Ibid. GBH003 (greater than 50l/s), GBH004 (greater than 50l/s), and GBH008 (135l/s)

⁵⁰ Ibid. No measurements could be taken from GBH005 (as the borehole was abandoned as the area was required for development), GBH007 (due to a recovery operation for drilling rods lost down the borehole), or GBH009 (which was grouted on completion to allow a drill and blast crew to develop a heading through stone).

⁵¹ Memorandum, Jimmy Cory to Pieter van Rooyen, 21 October 2009, DAO.003.16400/2; Pike River Coal Ltd, Operations Report, 16 November 2009, DAO.019.00568/6; Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/43, para. 257.

⁵² Ibid., PVR001/40, para. 236.

⁵³ GBH010 to GBH013: Pike River Coal Ltd, Monitor and Report, 14 October 2010, DAO.025.44571/6–7.

⁵⁴ Ibid., DAO.025.44571/4.

⁵⁵ Simon Donaldson on 5 March (DAO.003.15146) and 6 March (DAO.003.15150), Stephen Wylie on 13 March (DAO.003.15197), Simon Donaldson on 14 March (DAO.003.15199), Boyd Molloy on 18 March (DAO.003.15215), Simon Donaldson on 22 March (DAO.003.15252), Russell Smith on 24 March (DAO.003.15261) and Simon Donaldson on 30 March (DAO.003.15304).

⁵⁶ Gary Campbell, Police/DOL interview, 13 January 2011, INV.03.08182/12–18.

⁵⁷ Email, Brian Wishart to Jimmy Cory, 11 April 2010, DAO.025.32975/1.

⁵⁸ Emails between Jimmy Cory and Lunagas Pty Ltd, 26 March 2010, INV.03.29639/3; John (Jimmy) Cory, witness statement, 18 June 2012, COR0001/20, para. 102.

⁵⁹ Ibid., COR0001/20, paras 97–100.

⁶⁰ Petrus (Pieter) van Rooyen, transcript, p. 5230.

⁶¹ Pike River Coal Ltd, Operations Report, 19 April 2010, DAO.019.00616/7; Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/44, paras 260–62.

⁶² Peter Whittall, transcript, pp. 913, 910.

⁶³ David Reece, transcript, p. 4537.

⁶⁴ Ibid., p. 4536.

⁶⁵ Department of Labour, Pike River Mine Tragedy 19 November, 2010: Investigation Report, [2011], DOL3000130010/93, para. 3.5.1.

⁶⁶ Drive Mining Pty Ltd, Pike River Coal Ltd – Gas Drainage Assessment, 15 May 2010, DAO.001.04811/9.

⁶⁷ Department of Labour, diagrams, DOL3000150025/1. (Diagram modified by the commission)

⁶⁸ Pike River Coal Ltd, Main and Standby Fans Operation and Control: Risk Assessment V2 (Draft Document), 14 October 2010, SOE.024.00333/11.

⁶⁹ Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/40–41, paras 239–42.

⁷⁰ David Reece, transcript, pp. 4542–43.

⁷¹ David Reece, witness statement, 2 February 2012, DOL3000150001/21, para. 93.

⁷² Pike River Coal Ltd, Mining Towards Boreholes not Fully Cemented: Safe Operating Procedure (Final Document), 6 January 2010, DAO.001.04188.

⁷³ Department of Labour, Investigation Report, DOL3000130010/90, para. 3.4.17.

⁷⁴ Memorandum, Jimmy Cory and Gregory Borichevsky to Peter Whittall, Pieter van Rooyen, Douglas White and Michael Lerch, 2 June 2010, DAO.003.16495/5; Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report, 22 July 2010, DAO.001.04909/21–22.

⁷⁵ Memorandum, James Wimbridge to Bernard Lambley, Brian Wishart, Lance McKenzie, Martin Palmer, Dean Jamieson, Jan Joubert and Peter O'Neil, 19 July 2010, DAO.003.16345; Pike River Coal Ltd, Risk Assessment – Intersection of In-seam Borehole GBH0008 along 1West CT AB6, 29 October 2010, DAO.025.34614.

- ⁷⁶ Memorandum, James Wimbridge to Douglas White, Bernard Lambley and Grant MacLean, 17 August 2010, DAO.025.41497.
- ⁷⁷ Gary Campbell, Police/DOL interview, 13 January 2011, INV.03.08182/18–19.
- ⁷⁸ Simon Donaldson, Incident/Accident Form, 30 August 2009, DAO.002.09069/2.
- ⁷⁹ D. Murphy, Incident/Accident Form, 31 July 2009, DAO.002.08933/2.
- ⁸⁰ Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, November 2011, CAC 0115/10–20.
- ⁸¹ Mr Brown was interviewed during the joint investigation by DOL and the police, and also by counsel assisting the commission in 2011, but subsequently declined to sign a witness statement for the commission.
- ⁸² Email, Jimmy Cory to Miles Brown, 13 April 2010, DAO.001.05060/1.
- ⁸³ Drive Mining Pty Ltd, Pike River Coal Limited – Gas Drainage Assessment, 15 May 2010, DAO.001.04811/16.
- ⁸⁴ Ibid., DAO.001.04811/8.
- ⁸⁵ Drive Mining Pty Ltd, Pike River Coal Limited – Gas Drainage Assessment, 15 May 2010, DAO.001.04811/17. GeoGAS DRI 900 is a method developed by GeoGAS Pty Ltd to define outburst threshold limits for coal seams other than the New South Wales Bulli seam. The method requires measuring the volume of gas emitted from a coal core sample after crushing for 30 seconds. The result is related to the total gas content of the full core sample in order to calculate a figure which, if above 900, indicates there is a risk of an outburst of coal and gas if a geological structure (such as faulting) is present.
- ⁸⁶ D. Black, N. Aziz, M. Jurak and R. Florentin, 'Outburst Threshold Limits – Are They Appropriate?', in N. Aziz (ed.), Coal 2009: Coal Operators' Conference, University of Wollongong & the Australasian Institute of Mining and Metallurgy, 2009, pp. 185–92.
- ⁸⁷ Drive Mining Pty Ltd, Pike River Coal Limited – Gas Drainage Assessment, 15 May 2010, DAO.001.04811/17.
- ⁸⁸ Memorandum, Jimmy Cory to Gregory Borichevsky, 24 May 2010, DAO.003.16501/2.
- ⁸⁹ Email, Jimmy Cory to Miles Brown, 20 June 2010, DAO.001.05096/1.
- ⁹⁰ Pike River Coal Ltd, Operations Meeting Minutes, 16 June 2010, DAO.002.14622/4.
- ⁹¹ Pike River Coal Ltd, Operations Meeting Minutes, 30 June 2010, DAO.002.14672/3.
- ⁹² Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report #2, 20 September 2010, DAO.012.02524/13; Pike River Coal Ltd, Monitor and Report on In-seam Gas Levels and Flow Rates from the In-seam Holes, 14 October 2010, DAO.025.44571.
- ⁹³ Pike River Coal Ltd, Outburst Management Plan: Management Plan (Draft Document), 7 July 2009, DAO.003.06920.
- ⁹⁴ Ibid., DAO.003.06920/4, 8.
- ⁹⁵ For example see University of Wollongong's website on outburst hazards: <http://www.uow.edu.au/pdfs/OMP.pdf>
- ⁹⁶ For example, the plan states that 'PRLC has a long history of mining the Bulli Seam' – a coal seam in New South Wales: DAO.003.06920/9, 11, 37.
- ⁹⁷ Ibid., DAO.003.06920/13.
- ⁹⁸ Ibid., DAO.003.06920/12.
- ⁹⁹ Pike River Coal Ltd, Formal Risk Assessment – Ventilation and Gas Monitoring, 7 September 2010, DAO.011.00025/4.
- ¹⁰⁰ Memorandum, Gregory Borichevsky and Jimmy Cory to Pieter van Rooyen, 5 July 2010, DAO.001.04572/1–2.
- ¹⁰¹ Ibid., DAO.001.04572/1.
- ¹⁰² Ibid.
- ¹⁰³ When the target level of 1% methane was achieved in the main return, daily methane volumes peaked at 67,514m³ with typical daily volumes of 62,000 to 63,000m³ from GBH012 and GBH013: Pike River Coal Ltd, Operational Advisory – Gas Drainage Management Plan – Panel 1 Degassing and Borehole Intersections, 27 July 2010, DAO.001.04566.
- ¹⁰⁴ Gregory Borichevsky, notes, July 2010, INV.03.29202/9–18.
- ¹⁰⁵ Pike River Coal Ltd, Gas Drainage Management Plan (Draft Document), undated, DAO.002.03631.
- ¹⁰⁶ Memorandum – Operational Advisory, Gregory Borichevsky to Pike River operational staff, 8 July 2010, DAO.001.04569; Memorandum – Operational Advisory, Gregory Borichevsky to Pike River operational staff, 27 July 2010, DAO.001.04566.
- ¹⁰⁷ Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report, 22 July 2010, DAO.001.04909/4.
- ¹⁰⁸ Ibid., DAO.001.04909/8: The drainage system showed a flow of approximately 135l/s of methane, and the flame arrestors at the surface of the gas riser were highly resistant due to coal fines and water emitted through the drainage pipelines.
- ¹⁰⁹ Ibid., DAO.001.04909/10–11.
- ¹¹⁰ Ibid., DAO.001.04909/10. Including a 20m-wide extraction panel and pre-drainage of the area down to a level of 3m³/t of methane, shown in a table.
- ¹¹¹ Ibid., DAO.001.04909/10–11.
- ¹¹² Ibid., DAO.001.04909/12.
- ¹¹³ Ibid., DAO.001.04909/23.
- ¹¹⁴ Pike River Coal Ltd, Q1 Sheet – GBH0016, 19 July 2010, DAO.025.34058; VLI Drilling Pty Ltd, Inseam Drillhole Report – GBH0016, 30 July 2010, DAO.025.45024/23.
- ¹¹⁵ Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report, 22 July 2010, DAO.001.04909/28.
- ¹¹⁶ Emails between Chris Mann, Gregory Borichevsky, Miles Brown and James Cory, 1–15 July 2010, DAO.001.05008.
- ¹¹⁷ Pike was interested in reducing its liability under New Zealand's Emissions Trading Scheme by capturing methane and converting it to carbon dioxide using a flare, and in future options for the generation of electricity. Mr Mann's report also addressed these options.
- ¹¹⁸ Based upon known flows from boreholes and an assumed decay curve prepared by Miles Brown: Mechanical Technology Ltd, Pike River Coal – Methane Gas Drainage and Utilisation: Concept Design Report, August 2010, MED0010070099/17–18.
- ¹¹⁹ Ibid., MED0010070099/23: He suggested the blower could be installed on the concrete pad at the current gas riser site subject to addressing safety issues with the flame arrestor.
- ¹²⁰ Ibid., MED0010070099/16–25.
- ¹²¹ Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report #2, 20 September 2010, DAO.012.02524/3.
- ¹²² Ibid., DAO.012.02524/4: Mr Brown was concerned that connected borehole GBH008 appeared to be blocked at the intersection point, meaning the gas flow make may only have been from a newly drilled hole.
- ¹²³ Ibid., DAO.012.02524/6.
- ¹²⁴ Mr Brown suggested these should be taken from the same locations at which a ventilation survey had been recently conducted with Pike's ventilation consultant John Rowland.
- ¹²⁵ Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report #2, 20 September 2010, DAO.012.02524/7, 11.
- ¹²⁶ Pike River Coal Ltd, Q1 Sheet – GBH0018, 27 September 2010, DAO.025.34088; Q1 Lost Gas Desorption Sheets – GBH0019, 8–10 November 2010, DAO.025.34782/2–4.
- ¹²⁷ The Riser and Paparoa seams above and below the hydro panel may also contribute to the gas emissions.
- ¹²⁸ Some of the in-seam boreholes are marked in red and black, used to represent drilling through coal and stone respectively.
- ¹²⁹ Drive Mining Pty Ltd, Pike River Coal Limited – Gas Management Primary Report, 22 July 2010, DAO.001.04909/10. (Labels added by the commission)
- ¹³⁰ Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/42, para. 253.
- ¹³¹ Gregory Borichevsky, Police/DOL interview, 7 June 2011, INV.03.20410/73.
- ¹³² Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/37, para. 257; Douglas White, transcript, pp. 4917–21; Petrus (Pieter) van Rooyen, transcript, p. 5215; Stephen Ellis, witness statement, 14 March 2012, DAO.041.00042/3–4.
- ¹³³ David Reece, transcript, p. 4541.
- ¹³⁴ Memorandum, Gregory Borichevsky and Jimmy Cory to Pieter van Rooyen, 5 July 2010, DAO.001.04572/1.
- ¹³⁵ Pike River Coal Ltd, Gas Drainage Management Plan (draft document), DAO.002.03631/4. Although undated or signed off, it must have been created in early July 2010. See also: Hawcroft Consulting International, Pike River Mine

– Risk Survey, DAO.003.08710/57.

¹³⁶ Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/46, 50, paras 271, 294. Subsequently a design review based upon further geological information resulted in a change of direction and development to the west (towards the proposed location of the second intake, return and egress), and another location for the new riser was identified.

¹³⁷ Petrus (Pieter) van Rooyen, transcript, p. 5235.

¹³⁸ *Ibid.*, pp. 5233–35.

¹³⁹ Gregory Borichevsky, notes, 3 August 2010, INV.03.29202/19; Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/35, para. 240.

¹⁴⁰ Zurich Financial Services Australia Ltd, Pike River Coal Ltd – Risk Assessment and Improvement Report, 18 August 2010, INV.04.00868/9.

¹⁴¹ Hawcroft Consulting International, Pike River Mine – Risk Survey, DAO.003.08710/58.

¹⁴² Pike River Coal Ltd, Formal Risk Assessment – Ventilation and Gas Monitoring, 7 September 2010, DAO.011.00025/11.

¹⁴³ Pike River Coal Ltd, Management of the Gas Drainage Line: Safe Operating Procedure (Draft), 5 November 2010, DAO.025.34471/3.

¹⁴⁴ Pike River Coal Ltd, Formal Risk Assessment – Ventilation and Gas Monitoring, 7 September 2010, DAO.011.00025/5.

¹⁴⁵ Kevin Poynter, transcript, pp. 3095–96.

¹⁴⁶ David Reece, transcript, p. 4543.

¹⁴⁷ Emails, Jimmy Cory to Miles Brown, 9 November 2010, DAO.001.05057/1.

¹⁴⁸ Leslie Tredinnick, Police/DOL interview, 15 December 2010, INV.03.03263/19–29, and map INV.03.03382.

¹⁴⁹ Keith Stewart, witness statement, 16 August 2012, MBIE3000010012; Email, Tim Harvey to Jane Birdsall, David Reece and Keith Stewart, 16 August 2012, MBIE3000010016.

¹⁵⁰ Graph, 16 August 2012, MBIE3000010017/1.

¹⁵¹ David Cliff, David Bell, Tim Harvey, Anthony Reczek and David Reece, Pike River Coal Mine Explosion: Investigation for Nature and Cause (DOL Investigation Report, Appendix 6), October 2011, DOL3000130007/43, para. 9.3.

¹⁵² Email, Gregory Borichevsky to Danie du Preez, Pieter van Rooyen and Jimmy Cory, 27 October 2010, INV.04.01375/1.

¹⁵³ David Cliff et al., Investigation for Nature and Cause, DOL3000130007/12, para. 6.1.

Introduction

1. All underground coal mines require gas monitoring to detect and help prevent explosive accumulations of gas. There are three main forms of gas monitoring: remote gas monitoring systems, machine-mounted sensors and hand-held sensors.¹ The first two systems may be used to isolate or 'trip' electric power if the concentration of flammable gas exceeds safe levels.²

Remote gas monitoring

2. Remote gas monitoring usually consists of tube bundle and/or real-time systems.³ Industry practice in Australia is to have both in place, and in Queensland it is also standard to have a gas chromatograph at each mine.⁴ A gas chromatograph provides the most comprehensive analysis of mine gases, and is particularly suited to manage spontaneous combustion events.⁵
3. Real-time or telemetric monitoring systems rely on underground electronic sensors that send a signal to the surface in real time. They provide rapid feedback to the control room about the underground conditions and are the best method for identifying a sudden event such as a methane plug or a fire. However, they require underground power, and the sensors must be located in underground conditions, which may be damp or dusty. The sensors tend to have limited measuring ranges; for example, methane can usually be detected only up to 5%. They are also prone to being 'poisoned', or shutting down when exposed to gas beyond their maximum level. They are not as useful as tube bundle systems for long-term trending or in oxygen depleted locations, and they require frequent recalibration. In addition, despite providing 'real-time' feedback, the signals are not instant. Energy New Zealand calculated the two systems at Pike River had lag times of up to 29 and 44 seconds each before results were reported to the control room.⁶ There was also a lag time of eight to 13 seconds before power was tripped underground following a high gas reading.⁷
4. A tube bundle system uses plastic tubes that run from within the mine to the surface. A vacuum pump draws gas samples to the surface, where they are analysed for a range of gases – usually carbon monoxide, carbon dioxide, methane and oxygen. The advantages of a tube bundle system include the ability to measure several different gases from a single sample, the fact the system does not rely on underground power, and the ability to use more sensitive analysis equipment on the surface. A tube bundle system is also more likely to remain functional after an underground explosion. The surface analysis and pumping equipment should always survive, and if underground tubing is damaged, new tubes may be lowered into the mine and connected to the system. Because of its greater accuracy and flexibility, the system is ideally suited to long-term trending, as well as monitoring oxygen depleted goafs and sealed-off areas that are not suitable for real-time equipment. The main downside of a tube bundle system is the time taken to retrieve a sample from underground, which may be 20 minutes or more, depending on the distance the gas sample must travel. This delay is not relevant when monitoring trends.

The Pike monitoring system as planned

5. Consistent with Australian practice, both the Minarco Asia Pacific Pty Ltd ventilation report in 2006 and the ventilation management plan in 2008 proposed real-time and tube bundle systems for Pike River.⁸ Under the ventilation management plan, the real-time and tube bundle systems were to run continuously.⁹ The ventilation engineer was to identify the location of all sampling points, and ensure these were marked on a plan,¹⁰ establish

alarm levels for each sample point, and review them monthly after a ventilation survey.¹¹ Alarm levels were to be posted on a ventilation plan in the surface controller's room,¹² and surface controllers were to acknowledge and record all alarms and the actions taken to investigate them.¹³ There was to be a trigger action response plan (TARP) setting out the mandatory responses to various alarm levels.¹⁴ Finally, any interruption in the electronic monitoring system was to be remedied as soon as practicable, and any delay was to be drawn to the attention of the mine manager and ventilation engineer.¹⁵ These procedures were appropriate, but they were not followed at Pike River.

The Pike River remote gas monitoring system as built

6. Pike River had a real-time gas monitoring system, but not a tube bundle system. In the absence of a ventilation engineer, general manager Douglas White determined the location of the underground sensors for the real-time system.¹⁶
7. In June 2010 consultant electrical engineer Michael Donaldson recommended the locations for the sensors. It was a matter for the ventilation officer to determine the final locations.¹⁷ Mr Donaldson's June 2010 plan had eight methane detectors, including two at the furthest inbye points in the mine as it existed at that time.¹⁸
8. Mr White said he sat down with Mr Donaldson approximately four or five weeks before the explosion to determine where the sensors would go.¹⁹ However, as at 19 November 2010 there were no sensors beyond the ventilation shaft reporting to the surface from the return.
9. The ventilation management plan required the mine manager and ventilation engineer to sign and date accurate ventilation plans at least every three months. These were required to show all key features of the ventilation system, including the gas monitoring sample points, the restricted zone, the location of emergency escapeways, refuge bays and rescue facilities, boreholes and many other features. No accurate plan was ever produced at Pike showing all these features.
10. On 10 March 2010 the then mine manager, Michael Lerch, signed a ventilation plan and asked, 'Is this the ventilation plan as defined in vent management plan 5 3.1 (attached)?', 'Restricted zones?', 'Other information listed in 3.1 attached?'.²⁰ Over the following months no ventilation plan at Pike contained accurate records of the required matters. All pre-explosion plans were incomplete or inaccurate to varying degrees, and none provided an accurate record of the gas monitoring system.
11. As at 19 November 2010 there were eight fixed methane sensors connected to the surface control room,²¹ shown in Figure 10.1.

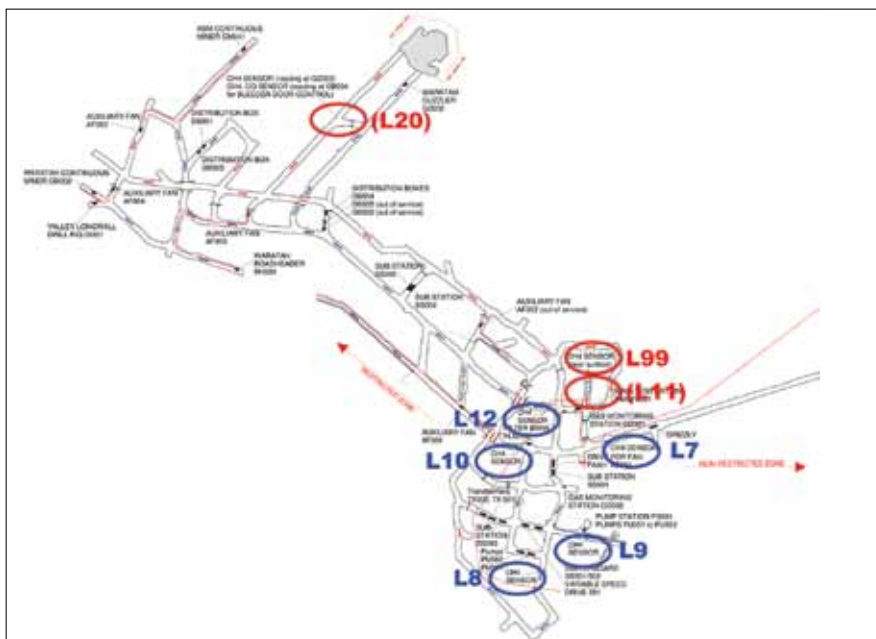


Figure 10.1: Location of fixed methane sensors²²

12. The five sensors circled in blue were all located within the intake roadways, in areas expected to be ventilated by fresh air. These sensors were located at or near electrical equipment in an area Pike designated as the 'non-restricted zone'. Regulations require the non-restricted zone to contain no more than 0.25% flammable gas. The sensors in this area at Pike River were set to trip power at 0.25% methane.

Sensors in the return

13. The three sensors circled in red were in the return of the ventilation system, and were intended to measure the concentration of methane in the contaminated air removed from the mine workings.²³
14. The sensor at L11 stopped working on 4 September 2010,²⁴ and the sensor at L20 stopped working on 13 October 2010,²⁵ leaving Pike with no gas sensors reporting to the surface from further into the return than the ventilation shaft. This did not give the mine adequate information about the location, source and quantities of flammable gas within the mine. Surface controller Barry McIntosh said the controllers had raised the issue of the location of gas sensors, and in his view the gas sensors 'weren't up far enough' in the mine.²⁶
15. By way of comparison, consultant David Reece provided on request a plan showing where Pike would have typically required gas sensors under Queensland legislation. His plan was not absolute and was subject to a number of technical qualifications including the proximity of other detectors, but on the basis of the plan, Pike would probably have required seven fixed sensors (marked in red) reporting to the surface from inbye of the ventilation shaft. As at 19 November Pike did not have any fixed gas sensors reporting to the surface in these areas. The only functioning sensor reporting to the surface from the return was at the position marked in green on the plan.

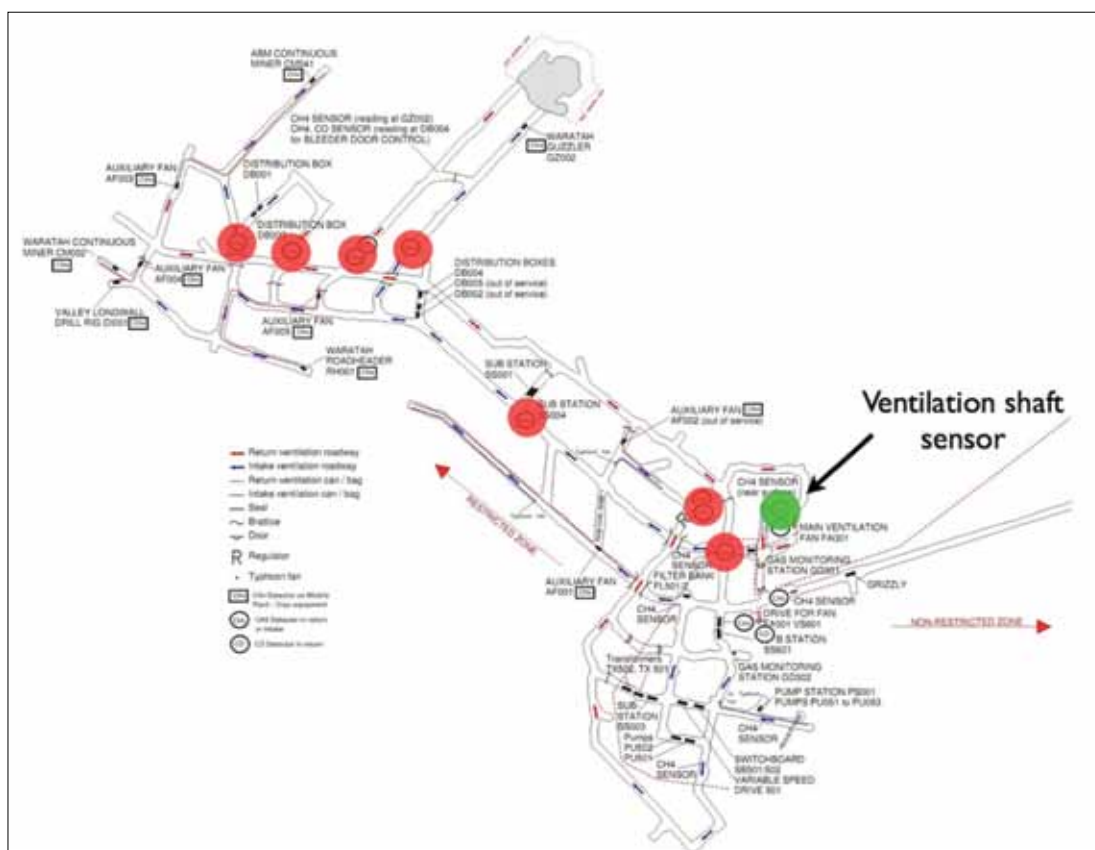


Figure 10.2: Plan of required gas sensors at Pike River under Queensland legislation²⁷

16. The joint investigation expert panel said that the mine 'should not have operated' without at least two sensors in the return, connected to an alarm and set to trip the power supply for the underground fan.²⁸

Hydro-panel sensors

17. There were two methane sensors located in the return from the hydro panel, circled in black on the diagram below.



Figure 10.3: Location of hydro-panel sensors²⁹

18. One provided a reading at the guzzler near the hydro monitor, but did not report to the surface or result in any permanent record of gas levels. The other sensor had been exposed to methane concentrations above 5%, and did not work after 13 October 2010.³⁰

Problems with the sensors in the ventilation shaft

19. There were several problems with the gas sensors in the ventilation shaft. First, the sensor at the bottom of the ventilation shaft stopped working on 4 September 2010, nearly 11 weeks before the explosion, and was never repaired or replaced.³¹ Indeed, the control room operator's screen on the Safegas system was permanently annotated to say the sensor was 'faulty' and 'waiting for spare'.

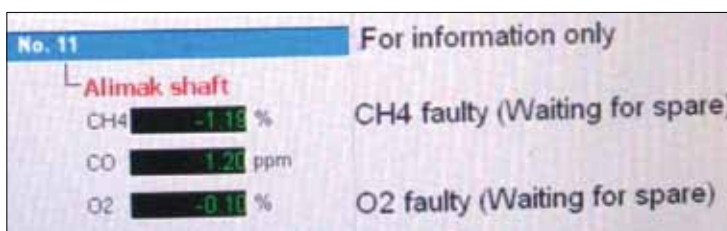


Figure 10.4: Control room operator's screen on the Safegas system³²

20. Mr White was not aware the sensor was not working and could not explain why the sensor was broken for two and a half months without his knowledge.³³ The problem appears to have been discussed at the review of the surface fan failure on 7 October 2010, at which Mr White was present.³⁴ It was resolved to 'Set up Gas Monitoring [at] shaft bottom',³⁵ but was still to be done at the time of the explosion.
21. With the bottom sensor broken, there was just one sensor in the return reporting to the surface. The expert panel described this situation as 'hard to comprehend' in a gassy mine.³⁶
22. Second, the sensor at the top of the ventilation shaft was incorrectly installed and unreliable. The sensor was hanging on a 2m piece of rope at the top of the shaft, and was wet and muddy when inspected on 4 November 2010.³⁷ A gas sensor is a sensitive instrument that should not be blocked or obstructed, much less covered in mud.

23. Further, Energy New Zealand concluded the sensor was installed in such a way that 5% methane (the upper limit of the sensor) would have reported as 2.96%.³⁸ This problem was not detected at the mine. Mr White said he was not aware of it,³⁹ and he agreed it raised serious issues about the reliability and accuracy of the sensor.⁴⁰ The sensor did go through a calibration exercise on 4 November 2010,⁴¹ but this was carried out with a concentration of 2.5% methane, 'which was within the functional operating range of the system'.⁴² Accordingly, the issue was not uncovered during the calibration process.
24. The ventilation shaft sensor also 'latched' or was poisoned on a number of occasions, causing a flat line to show on the surface controller's system. The flat line phenomenon indicated the sensor had been exposed to greater than 5% methane. This occurred during the 'gassing out' of the mine on Wednesday 6 October 2010, after the failure of the surface fan.

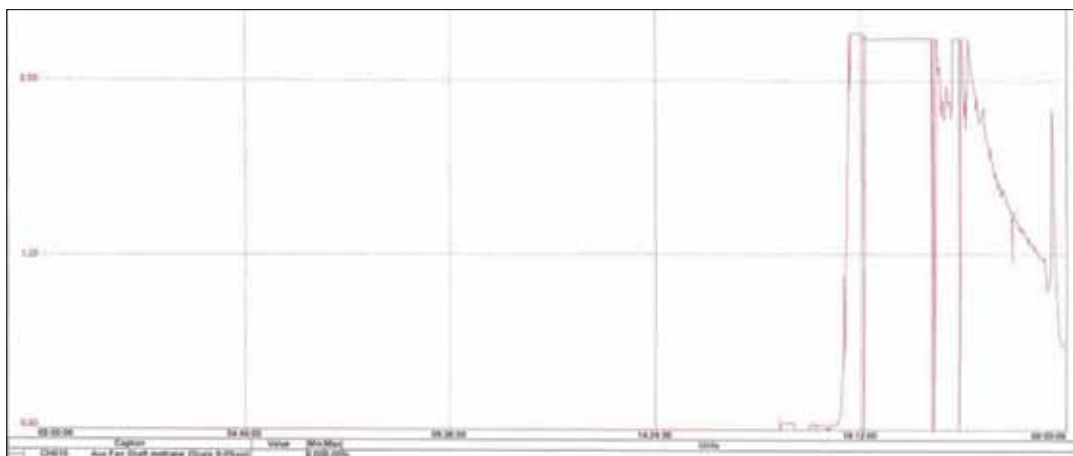


Figure 10.5: Auxiliary fan shaft methane – 6 October 2010⁴³

25. There was no data from the sensor from the time of the fan failure on 5 October. The control room system then showed a flat line around 2.5% during the evening of 6 October. Despite a review and a notification to the Department of Labour (DOL) about the incident, nothing was done about the flat line issue.
26. There was then a second flat line that started late on Thursday 7 October and continued through to Friday 8 October 2010 during the degassing procedures.

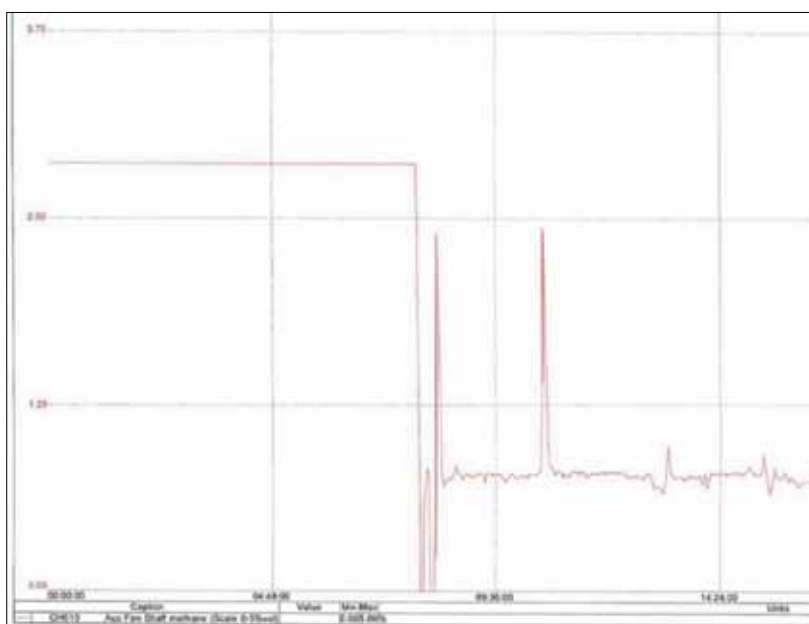


Figure 10.6: Auxiliary fan shaft methane – 8 October 2010⁴⁴

27. Mr White told the commission he was not aware of any flat lines, and if he had been, it would have been a cause for investigation.⁴⁵ However, he accepted that he signed a ventilation survey dated 7 October 2010 that said in red capital letters 'Had a spike of 2.8% at vent shaft – monitor stuck on this reading.'⁴⁶
28. Third, while the sensor at the bottom of the shaft was operational, there was an obvious discrepancy between the readings at the top and bottom of the shaft. The discrepancy is shown in the following graph prepared by DOL, which shows the reading from the top of the shaft in red, and the reading from the bottom of the shaft in blue.

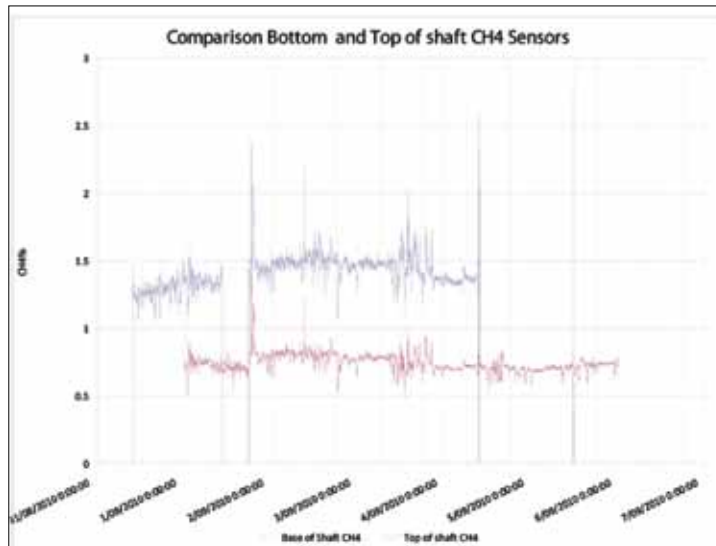


Figure 10.7: Comparison bottom and top of shaft CH₄ sensors⁴⁷

29. There was an obvious question to be answered given that two sensors in the same air stream were reading so differently.⁴⁸ The discrepancy was not investigated.⁴⁹
30. Fourth, the sensor at the top of the ventilation shaft was not connected to the Safegas monitoring system.⁵⁰ Safegas includes a control room operator's screen, multi-level alarms and an audit trail of all actions taken. It requires the operator to acknowledge all alarms, and helps to ensure that the appropriate actions are taken.
31. Pike installed Safegas in 2008 and the mine's remote gas sensors were connected to it. On 8 October 2010 the engineering manager, Nicholas Gribble, emailed Mr White and said that the mine should use Safegas for all gas monitoring, because 'when we get alarms Safegas requires the alarm to be accepted and [instructs] what action has to be taken'.⁵¹ Mr White agreed. By 19 November 2010 the gas sensor at the top of the ventilation shaft was still not connected to Safegas.

Maintenance and calibration of gas sensors

32. In November 2010 underground electrical co-ordinator Michael Scott took over responsibility for the fixed gas sensors following a reorganisation of engineering roles at the mine. He found the fixed sensors were not being calibrated on a regular basis as they should have been, and responsibility for the sensors in the ventilation shaft was 'falling through the cracks'.⁵² He said it was 'kind of a haphazard... maintenance programme',⁵³ and although six-monthly calibrations were done, the more frequent weekly or monthly calibrations were not being completed.⁵⁴ The detector at the top of the ventilation shaft was calibrated in early November, but the other sensors were due to be looked at the weekend after the explosion.⁵⁵ Mr Scott did not know whether the management level above him was aware of the problem.
33. On 22 September 2010 Robb Ridl wrote to Mr White stating that the Pike engineering department was 'currently unable to meet the needs of the business',⁵⁶ and fixed plant was 'not being proactively maintained due to lack of supervisory resources'.⁵⁷ He noted that three members of the engineering team had been seconded to the hydro project, and 'the maintenance of fixed and mobile plant is currently insufficiently covered due to the absence of these individuals'.⁵⁸

34. Mr White was asked whether he looked at maintenance or calibration records as a lead indicator of safety. He said he did not check the preventative maintenance programme; it was a matter he delegated to the maintenance department. He did take steps to encourage better maintenance of equipment.⁵⁹

Control room monitoring

35. The role of the surface controller is critical to the operation of a mine's gas monitoring system. Following recommendations from the Moura No. 2 inquiry,⁶⁰ Queensland regulations require standard procedures for acknowledging gas alarms.⁶¹ The control room operator is the first to respond to a gas alarm, and it is essential that person is well trained and able to perform the role.
36. Under Pike's ventilation management plan, surface controllers were required to acknowledge and record all gas alarms and notify the production deputy of any active alarms.⁶² However, Pike did not train the controllers adequately, ensure they were aware of their responsibilities, or keep them informed of developments in the monitoring system. There had been a meeting shortly before the explosion, when the control room officers requested training in gas monitoring and Safegas.⁶³ Mr McIntosh told investigators it was 'pretty bloody difficult' in the control room, because 'we were never given any training.'⁶⁴ He described the meeting with management and said the controllers 'spelt out a lot of things that we weren't happy about', including the way the controllers were treated, the lack of training and paucity of information.⁶⁵ Mr White said that after the meeting Mr Ellis was asked to organise training for surface controllers in the gas monitoring system.⁶⁶ No training had occurred before the explosion.
37. Pike had a TARP dealing with gas alarms,⁶⁷ which was signed off by the mine manager on 5 December 2008. The TARP was not in use or known to key people and the document itself was confusing and internally inconsistent. The first part dealt with three trigger levels, but the section relating to methane identified four, making it unclear which responses applied to methane. The plan referred to gas accumulations at 'lower levels' and 'higher levels', but these terms were not defined. A level three trigger was a gas accumulation at high levels over a 'prolonged period',⁶⁸ but that was not defined. These ambiguities undermined the purpose of a TARP, which is to give clear and precise rules.
38. In October 2010 Pike was in the process of drafting a standard operating procedure (SOP) to deal with methane alarms in the return.⁶⁹ The draft relied on several things that did not exist, including a ventilation officer, an underground text messaging service and a gas alarm log book. Although a log book was being drafted in October 2010,⁷⁰ neither this, nor the methane alarm SOP, had been introduced by 19 November 2010.
39. There was no effective process to make sure that gas alarms were monitored and then acted upon within the control room.⁷¹

Management oversight of gas monitoring

40. Although the mine manager and ventilation engineer were responsible for gas monitoring under the ventilation management plan, there was no reliable process to ensure that the results from the gas monitoring system, or problems with the system, were communicated to them.
41. Mr White said he 'made [himself] available every day at the start of the shift for the process of passing on information.'⁷² However, relying on informal feedback of that sort is a flawed approach, as demonstrated by the fact that Mr White remained unaware that a critical gas sensor was broken for 11 weeks before the explosion. Mr Ridl was also unaware of the broken sensor and the problems with the sensor at the top of the ventilation shaft.⁷³ Effective oversight requires an active system to make sure information is identified and passed on, rather than a passive system relying on senior managers being 'available'.
42. The company did make a concerted effort to record and communicate gas results to ensure compliance with the Emissions Trading Scheme (ETS). An email from technical services co-ordinator Gregory Borichevsky in October 2010 noted the ETS requirements were 'mandatory' and had 'significant commercial implications.'⁷⁴ He said 'because of our statutory compliance requirements for an accurate measure of methane emissions, it is critical that you put in place an accurate measure of ... the volume of methane produced.'⁷⁵

43. Because of the ETS, and the need to monitor methane levels during the free venting of gas drainage lines,⁷⁶ Mr Borichevsky paid attention to the gas monitoring results in the control room.⁷⁷ After the explosion he produced a document that said methane levels at the ventilation shaft 'routinely exceeded 1 per cent', 'regularly exceeded 1.5 per cent', 'occasionally exceeded 2.0 per cent' and 'had exceeded 3 per cent on more than one occasion in the weeks prior to the disaster'.⁷⁸ He said 'methane levels at the face would be expected to be at least 2 to 3 times those measured in the main return ventilation shaft due to the dilution factors involved', and that, on that basis, 'potentially explosive levels of methane would have been present in the active mine workings on a number of occasions'.⁷⁹ Mr White could not argue with Mr Borichevsky's observations.⁸⁰
44. Mr Borichevsky said at one stage he reported on methane spikes to morning production meetings.⁸¹ To do so, he obtained printouts of methane records, made a note of any spikes, reviewed the deputies' reports and other documents to try to establish the cause, and discussed the spikes in the meetings. However, Mr Borichevsky maintains that when Mr Ellis took over the morning meetings the agenda changed to focus on production, and Mr Ellis was not interested in methane spikes.⁸²
45. Mr Ellis rejected Mr Borichevsky's comments and said that although he did not recall Mr Borichevsky discussing gas levels at the production meetings, there was nothing to prevent him doing so.⁸³ What is clear is that methane spikes were no longer discussed at production meetings from late 2010. Coal extraction from the hydro panel had started, and there was an increased need to discuss and resolve high methane levels.
46. The failure of the surface fan on 6 October 2010 should have alerted senior managers to problems with the gas monitoring system. The review on 7 October 2010 noted, among other things, a need to '[s]et up/review Gas Monitoring procedures as per QLD', '[d]efine ownership of ... gas monitoring', address 'gas monitoring spares and procedures', and '[s]et up Gas Monitoring [at] shaft bottom'.⁸⁴ Both Mr White and Mr Ellis were present at the review, and received the report. This should have alerted management to the need for urgent action.⁸⁵

Inappropriate equipment

47. Five of the six functioning fixed gas sensors were located within the non-restricted zone. These sensors were required to establish there was no more than 0.25% methane, in order to comply with the Health and Safety in Employment (Mining – Underground) Regulations 1999. However, the sensors had a margin of error of plus or minus 0.25%. Accordingly, they were not fit for purpose.⁸⁶
48. The sensor in the hydro return was not capable of reading greater than 5%⁸⁷ methane, although concentrations above that occurred frequently in the return. This should have been capable of reading greater than 5%. Such a need was recognised in October 2010.

No tube bundle system

49. Another deficiency was the lack of a tube bundle system. Mr White made it clear he wanted such a system installed, plus a gas chromatograph.⁸⁸ He exchanged correspondence with the Safety in Mines Testing and Research Station (SIMTARS) in Queensland to investigate leasing a tube bundle system in 2010.⁸⁹ But in October 2010 Mr Whittall told the bank, who were to provide lease finance, that a decision about the tube bundle system was 'some way off',⁹⁰ January 2011 being a possible purchase date for the system.⁹¹
50. Pike River should have had a tube bundle system before coal mining began. Such a system would have provided important gas information and highlighted the serious problems with methane control.

Machine-mounted and hand-held gas monitoring

Machine-mounted sensors

51. A number of mining machines at Pike River were fitted with gas sensors. These were set to cut power to the machines if they detected methane concentrations above 1.25%. None of the sensors reported to the surface. The

sensors underground on 19 November 2010 had been maintained and calibrated appropriately.⁹² The sensor on the VLI Drilling Pty Ltd (VLI) drill rig was faulty and was scheduled for replacement.

52. The records of deputies underground noted numerous examples of gas trips activated by machine-mounted sensors. For example, the ABM production report for the day shift on 19 November 2010 referred to three individual gas trips, then 'continuous CH₄ trips', apparently caused by mining over a gas drainage hole. The references to gas trips are highlighted in the following image.

SHIFT ANALYSIS									
Shift start time:		7:00 am		0359					
Hours into shift	Target meters	Actual meters	Cut	Relt	Delay	Comments	Downtime Codes		
							Resp.	Group	Type
1						Comm Meeting Travel U/G Arrive face 7:30 Tidy up place - gear off floor			
2						Cutting / Meqs Gas trips - High CH ₄ - Gas bag in tunnel B drainage hole.			
3						Cutting Gas trips Catching			
4						Gas trips - High CH ₄ - hard to move. Fleet to rectal - waiting for gas to arrive Recal ABM - Power up Machine & Complete meqs bolts.			
5						Cutting - Continuous CH ₄ trips Catching move from floor Catching seems to be coming from floor. Meqs bolting			
6						Flume worked down for rest of shift Store dust by hand - No dusts available			
7						Walt down to McDowell / Shot fire place. Change over with Back shift.			
8						Timed out.			

Figure 10.8: References to gas trips⁹³

53. Machine-mounted sensors have an important role in an underground mine. However, workers may continue working in the face of gas trips, or be tempted to bypass the detectors, particularly under significant production pressure. Such behaviour defeats the purpose of the sensors.
54. The joint investigation revealed many reports of underground workers at Pike bypassing machine-mounted sensors by various means. One worker admitted he covered a gas sensor with a plastic bag.⁹⁴ He did that 'just to save it tripping and havin' to wait around for an electrician ... and save the boys' legs'.⁹⁵ He heard of gas detectors being covered on other machines including loaders, and he thought every miner knew how to do it.⁹⁶ Another miner saw compressed air being blown onto gas sensors to keep the machine cutting, and miners using metal clips to override machine-mounted sensors.⁹⁷ He saw machines overridden following gas trips 'quite a few times illegally'.⁹⁸ Indeed, 'it happened so often' that he would come on shift and find the previous shift had left the metal clip in place, because 'everyone - not everyone, but a lot of people did it'.⁹⁹ He said in his view workers bypassed gas detectors 'out of frustration' because of the poor standard of equipment at Pike River and the need to get the job done.¹⁰⁰
55. Unless there is a concerted effort by management to collect, monitor and respond to information about gas trips and safety bypassing, that information is likely to be lost or overlooked. Senior managers did not have an adequate system to identify and respond to the bypassing of sensors. One worker told investigators that written reports of sensors being bypassed would just 'disappear' without any response from management.¹⁰¹
56. Pike's incident/accident reporting system did contain at least 14 reports of gas sensors being bypassed.¹⁰² One such report in March 2010, shown here, was a plea to the mine manager to 'stop people from overriding safety circuits'.

What was the ROOT CAUSE of this event? <i>Someone has deliberately bypassed the CH₄ system</i>			
SECTION 5: Remedial Actions Recommended, Including Any Injury Prevention & Training if Required			
Describe event: <i>Attempt to find out how and why and stop people from over-riding safety circuits (PLEASE)</i>		By Whom: <i>Mine Manager</i>	By When: <i>ASAP</i>
Date Completed:			
New Hazard Identified – has this been added into the Hazard Register?		Yes ☐	No ☐
New Controls Implemented – Have these been recorded in the Hazard Register?		Yes ☐	No ☐

Figure 10.9: Plea to stop overrides of safety circuits¹⁰³

57. In many cases there was no management sign-off, and in other cases the solution was to speak to deputies and undermanagers, or issue a tool box talk. For example, Mr White signed off three incidents involving bypassing on 23 and 24 June 2010.¹⁰⁴ In each case the response was that Mr White had 'spoken to' statutory officials.
58. Given the heightened production pressure in 2010, and problems with safety culture, it was not enough to assume that talking to staff and officials would result in proper compliance. That lesson has emerged clearly from other disasters, which have shown that instructions to comply are no substitute for auditing and enforcement.¹⁰⁵
59. Previous disasters have also shown the importance of setting up systems to ensure managers are regularly informed of non-compliance.¹⁰⁶ The incident/accident system did not achieve that, and managers were not adequately informed of the scale and frequency of the problems at Pike River. For these reasons the effectiveness of machine-mounted gas sensors as a control against the risk of an explosion was compromised.

Hand-held sensors

60. Deputies and underviewers at Pike were given hand-held personal gas monitors. These were used to take gas readings for the deputy statutory reports, and to inform the miners underground. However, there were frequently shortages of hand-held gas detectors at Pike. Hydro-mining consultant Masaoki Nishioka said 'almost all [the] time' there was no methane detector for him to take underground.¹⁰⁷ The lack of gas detectors featured several times in incident reports.

SECTION 3: Description and Investigation of Accident/Incident and Immediate Actions			
Describe event: Give all details			
☐ Ask what happened, where, how and who (if not enough room, attach additional sheets of paper) ☐ Include a diagram to better explain what you are saying, if that is required. ☐ Ask why? Five times to really get to potential Root Cause. Remedial actions need to occur at this level to prevent recurrence.			
<i>LACK OF GAS DETECTORS AVAILABLE IN CONTROL ROOM - AT 14:00 Shift change over there is only 2 left AND 11 IS NOT fully charged - THERE IS 13 IN THE STORE TO BE SENT AWAY AND 4 TO COME BACK FROM CHARGE</i>			
Was plant/equipment involved? If so, describe including the ID/reg number of it e.g. CM1, MT004, Light vehicle rego number:			
FORM COMPLETED BY: <i>Dan Dugga</i>		SIGNATURE: <i>[Signature]</i>	POSITION: <i>Control</i> DATE: <i>2/06/2010</i>
(Sections below to be completed by Supervisor/Department Manager/or Safety & Training Manager):			

Figure 10.10: Report of lack of gas detectors¹⁰⁸

61. Mr White said he was not aware of any shortage and said, 'We'd actually just increased the number of gas detectors quite significantly.'¹⁰⁹ Given the frequency with which the issue featured in written reports at the mine, Mr White should have been aware of the problem.¹¹⁰ The fact he was not emphasises a weakness in the information management system.
62. Because methane is lighter than air and accumulates in the roof areas within a mine, it is important that deputies and underviewers are able to use methane detectors anywhere likely to contain gas. Pike did not have extension probes available, which would have given deputies a better understanding of the extent of methane layering in the higher areas of the mine.¹¹¹
63. Detection of methane with gas detectors was not necessarily comprehensive. DOL noted that high levels of gas were recorded in the ventilation shaft in the period 11 to 13 November 2010.¹¹² However, the deputies' statutory

reports did not record correspondingly high readings anywhere in the mine in that period. The expert panel noted there would have been levels greater than 5% somewhere in the mine to get the concentrations seen at the main ventilation shaft.

64. Miners are required by law to withdraw from the mine if flammable gas reaches 2% or more in the general body of air.¹¹³ One miner encountered methane over 2% 'quite a lot', and more than 5% on two occasions.¹¹⁴ One occasion involving over 5% was approximately two weeks before 19 November, after the commissioning of the main fan. He informed his deputy, who said, 'We'll be right, just quickly get [the job] done.'¹¹⁵ They remained working in the explosive atmosphere for at least 10 minutes,¹¹⁶ and 'there was no investigation because I never reported it.'¹¹⁷ He said there were times when they continued working in 2% methane contrary to the regulations.¹¹⁸ On another occasion, three contractors were found working in the ventilation return without gas detectors.¹¹⁹ These examples demonstrate the vulnerability of any system that simply assumes workers will comply with procedures, even those of such importance.
65. Mr White was asked whether he had any system to make sure that significant information from the deputies' statutory reports was being identified by undermanagers and filtered up to him as mine manager. He said he would 'on occasion' read the deputies' reports, and he had regular contact with the deputies and undermanagers which gave opportunity for feedback from them.¹²⁰ He said he did not see all the written reports, but 'relied on the face-to-face transfer of information.'¹²¹ For someone in Mr White's position, burdened with numerous responsibilities beyond the ventilation system, reliance on 'being available' meant he was not properly informed of the gas results recorded by the deputies. Mr White acknowledged that a more systematic approach to analysis of the deputies' statutory reports 'may well have helped',¹²² but reiterated that he made himself available to be informed of issues at the mine. Mr White acknowledged it was 'absolutely certain' that a ventilation officer, if the mine had one, would have looked at the information contained in the deputies' reports.¹²³

Deputies reports

66. The commission prepared a number of summaries of events, drawn from the deputy statutory reports and the deputies production reports, for each shift. A list is contained in Chapter 15, 'Regulator Oversight at Pike River' (see the footnote for paragraph 73). In relation to gas monitoring, one schedule compares readings of methane at the ventilation shaft with methane levels contained in the reports of the deputies. See Appendix 8 for an extract from that schedule, limited to November 2010.¹²⁴ It gives an insight into some of the issues that the deputies were managing in the 19 days before the tragedy.

Conclusions

67. Pike's gas monitoring system was deficient in several respects at the time of the explosion:
 - There was only one working fixed methane sensor reporting to the control room that measured contaminated air in the ventilation return. This was not capable of showing a methane level above 2.96%, and did not report to the main Safegas system.
 - The mine should not have operated without multiple methane sensors located throughout the main return.
 - The maintenance and calibration of the fixed methane sensors was inadequate, at least in November 2010.
 - Machine-mounted sensors, which were well maintained and calibrated, were sometimes bypassed, resulting in men working in unsafe conditions.
 - Reporting by underground workers disclosed significant methane management problems, and there was no effective system to respond to this.

- The mine lacked a tube bundle system and was short of hand-held gas monitors.
- The poor standard of gas monitoring at the mine was a very serious problem throughout the period leading up to the explosion.

ENDNOTES

¹ The purpose of gas monitoring systems is discussed in: David Cliff, David Bell, Tim Harvey, Anthony Reczek and David Reece, Pike River Coal Mine Explosion: Investigation for Nature and Cause (DOL Investigation Report, Appendix 6), October 2011, DOL3000130007/18, para. 7.2 and John Rowland, witness statement, 22 October 2011, ROW001/3, para. 10. Douglas White agreed with Mr Rowland's comments: Douglas White, transcript, p. 4892.

² Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 58, requires electricity to be disconnected if the concentration of flammable gas exceeds 1.25% in the general body of air.

³ Darren Brady, 'The Role of Gas Monitoring in the Prevention and Treatment of Mine Fires', in N. Aziz (Ed.), Coal 2008: Coal Operators' Conference, University of Wollongong & the Australasian Institute of Mining and Metallurgy, 2008, pp. 202–08.

⁴ Ibid., p. 202.

⁵ Ibid., p. 204.

⁶ Department of Labour, Pike River Mine Tragedy 19 November, 2010: Investigation Report, [2011], DOL3000130010/64, para. 2.39.1; Energy NZ Ltd, Department of Labour – Pike River Coal Audit Report for November 19, 2010, 25 January 2012, DOL3000140001/52.

⁷ Department of Labour, Investigation Report, DOL3000130010/140, para. 3.26.17.

⁸ Minarco Asia Pacific Pty Ltd, Pike River Coal Company: Ventilation Report, June 2006, DAO.012.02277/21, para. 5.2; Pike River Coal Ltd, Ventilation Management Plan, 2008, DAO.003.07114/33, para. 6.1.

⁹ Ibid., DAO.003.07114/34–35, paras 6.2.1.1–6.3.2.

¹⁰ Ibid., DAO.003.07114/78–79, para. 282.

¹¹ Ibid., DAO.003.07114/38, para. 48.

¹² Ibid., DAO.003.07114/59, para. 136.

¹³ Ibid., DAO.003.07114/38, para. 54.

¹⁴ Ibid., DAO.003.07114/38 para. 55.

¹⁵ Ibid., DAO.003.07114/59, para. 135.

¹⁶ Douglas White, transcript, p. 4894.

¹⁷ Michael Donaldson, Police/DOL interview, 14 April 2011, INV.03.17838/17, 32.

¹⁸ Pike River Coal Ltd, P&ID Gas Monitoring, 5 June 2010, DOL7770050005/4.

¹⁹ Douglas White, witness statement, 24 May 2012, WHI004/3, para. 15.

²⁰ Pike River Coal Ltd, Mine Ventilation & Gas Drainage: PB-Vent-024, 10 March 2010, DAO.032.00163. (Plan annotated by Michael Lerch)

²¹ Energy NZ Ltd, Coal Audit Report, DOL3000140001/55.

²² Pike River Coal Ltd, Plant Location and Ventilation Plan: Rescue 101119_181, 22 March 2011, DAO.010.13140/1. (Extract of the plan modified by the commission based on source information from Energy NZ Ltd, Coal Audit Report, DOL3000140001, Robb Ridl, witness statement, 14 March 2012, DAO.041.00009 and Keith Stewart, witness statement, 9 August 2012, MBIE3000010011.)

²³ This was accepted by Douglas White: Douglas White, transcript, p. 4899.

²⁴ Department of Labour, Investigation Report, DOL3000130010/124 para 3.16.2; Pike River Coal, Trend Friday, 3 September 2010–Saturday 4 September 2010, DAO.001.03907/1.

²⁵ Keith Stewart, witness statement, 9 August 2012, MBIE3000010011/2, para. 6.

²⁶ Barry McIntosh, Police/DOL interview, 2 August 2011, INV.03.28697/6.

²⁷ David Reece, plan annotated with gas sensor locations, MBIE3000010009/1.

²⁸ David Cliff et al., Investigation for Nature and Cause, DOL3000130007/48.

²⁹ Pike River Coal Ltd, Plant Location and Ventilation Plan: Rescue 101119_181, 22 March 2011, DAO.010.13140/1. (Extract of the plan modified by the commission)

³⁰ Department of Labour, Investigation Report, DOL3000130010/139, para. 3.26.7; Keith Stewart, witness statement, 9 August 2012, MBIE000010011/2, para. 6.

³¹ Department of Labour, Investigation Report, DOL3000130010/124, para. 3.16.2; Pike River Coal Ltd, Trend Friday, 3 September 2010–Saturday 4 September 2010, DAO.001.03907/1.

³² David Cliff, An Evaluation of Elements Relating to the Cause of the First Explosion at Pike River Coal Mine: Draft, 16 September 2011, DOL3000140009/12.

³³ Douglas White, transcript, p. 4902.

³⁴ Pike River Coal Ltd, Review of Surface Aux Fan Failure 05/10/10, 7 October 2010, DAO.001.00359/17–25.

³⁵ Ibid., DAO.001.00359/21. (The entry reads 'Set up Gas Monitoring and shaft bottom', but presumably 'and shaft bottom' should read 'at shaft bottom'.)

³⁶ David Cliff et al., Investigation for Nature and Cause, DOL3000130007/48.

³⁷ Department of Labour, Investigation Report, DOL3000130010/145, para. 3.32.12.

³⁸ Energy NZ Ltd, Addendum 1: Surface Methane System Report, Version 1.1, January 2012, DOL3000140002/6.

³⁹ Douglas White, transcript, p. 4899.

⁴⁰ Ibid., p. 4901.

⁴¹ Department of Labour, Investigation Report, DOL3000130010/145, para. 3.32.12.

⁴² Energy New Zealand, Surface Methane System Report, DOL3000140002/7.

⁴³ Pike River Coal Ltd, Auxiliary Fan Shaft Methane, CAC0112/7. (Gas reports compiled by the commission)

⁴⁴ Ibid., CAC0112/9.

⁴⁵ Douglas White, transcript, p. 4898.

⁴⁶ Pike River Coal Ltd, Mine Ventilation & Gas Drainage: PB-Vent-028, 7 October 2010, DAO.001.05378.

⁴⁷ Department of Labour, Investigation Report, DOL3000130010/146.

⁴⁸ David Reece, transcript, p. 4573; Douglas White, transcript, p. 4897.

⁴⁹ Douglas White, transcript, p. 4897.

⁵⁰ Safegas is a system designed by Queensland's Safety in Mines Testing and Research Station (SIMTARS) for underground coal mines.

⁵¹ Email, Nicholas Gribble to Douglas White, 8 October 2010, INV.04.00676/1.

⁵² Michael Scott, Police/DOL interview, 3 October 2011, INV.03.28829/4–5.

⁵³ Ibid., INV.03.28829/5.

⁵⁴ Ibid., INV.03.28829/4, 30.

⁵⁵ Ibid., INV.03.28829/6–7.

⁵⁶ Memorandum, Robb Ridl to Douglas White, 22 September 2010, DAO.043.00004/1.

⁵⁷ Ibid.

⁵⁸ Ibid.

⁵⁹ Douglas White, transcript, pp. 4988–4989.

⁶⁰ Queensland Warden's Court, Wardens Inquiry: Report on an Accident at Moura No 2 Underground Mine on Sunday, 7 August 1994, 1996, CAC0152/1.

⁶¹ Coal Mining Safety and Health Regulation 2001, ss 224–26.

⁶² Pike River Coal Ltd, Ventilation Management Plan, DAO.003.07114/74, paras 250–51.

⁶³ Ibid.

⁶⁴ Barry McIntosh, Police/DOL interview, 2 August 2011, INV.03.28697/33.

⁶⁵ Ibid., INV.03.28697/34.

⁶⁶ Douglas White, transcript, p. 4924.

⁶⁷ Pike River Coal Ltd, Acknowledgement of Gas Alarms: TARP (Trigger Action

Response Plan), 5 December 2008, DOL7770030078.

⁶⁸ Pike River Coal Ltd, Acknowledgement of Gas Alarms, DOL7770030078/1.

⁶⁹ Email, Nicholas Gribble to Douglas White and Stephen Ellis, 19 October 2010, SOE.024.00323.

⁷⁰ Grey Star–James Print, Proof Sign-off: Control Room Gas Log Book, 21 October 2010, DOL5000010018.

⁷¹ Douglas White, transcript, p. 4915.

⁷² Ibid., p. 4925.

⁷³ Robb Ridl, witness statement, 14 March 2012, DAO.041.00009/18–19, paras 70–76.

⁷⁴ Email, Gregory Borichevsky to Danie du Preez, 27 October 2010, INV.04.01375/1.

⁷⁵ Ibid.

⁷⁶ Petrus (Pieter) van Rooyen, transcript, p. 5151; Email, Gregory Borichevsky to Danie du Preez, 18 June 2010, INV.04.00354; Memorandum, Gregory Borichevsky to Pike River operational staff, 27 July 2010, DAO.001.04566.

⁷⁷ Petrus (Pieter) van Rooyen, transcript, p. 5151; Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/33–34, paras 225–29; Email, Gregory Borichevsky to Danie du Preez, 18 June 2010, INV.04.00354/1–2; Memorandum, Gregory Borichevsky to Pike River operational staff, 27 July 2010, DAO.001.04566.

⁷⁸ Gregory Borichevsky, Pike River Coal Mine Disaster, 19 November 2010, INV.04.00001/7.

⁷⁹ Ibid.

⁸⁰ Douglas White, transcript, p. 4946.

⁸¹ Gregory Borichevsky, Police/DOL interview, 26 April 2011, INV.03.18954/87.

⁸² Ibid., INV.03.18954/89–91.

⁸³ Stephen Ellis, witness statement, 14 March 2012, DAO.041.00042/3–4, paras 8–13.

⁸⁴ Pike River Coal Ltd, Review of Surface Aux Fan Failure, DAO.001.00359/19–21.

⁸⁵ Email, Nicholas Gribble to Douglas White, Stephen Ellis, Neville Rockhouse, Peter Sinclair, Chris Coetzer, Danie du Preez and Robb Ridl, 7 October 2010, SOE.024.00287.

⁸⁶ Department of Labour, Investigation Report, DOL3000130010/137, para. 3.24.8.

⁸⁷ Ibid., DOL3000130010/142, para. 3.28.7.

⁸⁸ Douglas White, Operation PIKE Investigation: Summary of Interview, 5 May 2011, INV.03.17891/10.

⁸⁹ Email, Paul Harrison to Douglas White, 28 October 2010, EXH0042/1.

⁹⁰ Ibid.

⁹¹ Douglas White, transcript, p. 1294.

⁹² Department of Labour, Investigation Report, DOL3000130010/141, figure 45.

⁹³ Pike River Coal Ltd, Pike River Coal Mine: Deputies Production Report, 19 November 2010, DAO.001.02568/1.

⁹⁴ Police/DOL interview, 8 April 2011, INV.03.17556/15–16. (The commission decided, by majority, to withhold the name of the worker concerned. Commissioner Bell dissented.)

⁹⁵ Ibid., INV.03.17556/16.

⁹⁶ Ibid., INV.03.17556/16–17.

⁹⁷ Police/DOL interview, 29 April 2011, INV.03.20794/3. (The commission decided, by majority, to withhold the name of the worker concerned. Commissioner Bell dissented.)

⁹⁸ Ibid., INV.03.20794/7.

⁹⁹ Ibid., INV.03.20794/8.

¹⁰⁰ Ibid., INV.03.20794/10.

¹⁰¹ Ibid., INV.03.20794/4.

¹⁰² Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, November 2011, CAC0114/20–24.

¹⁰³ Pike River Coal Ltd, Incident/Accident Form, 2 March 2010, DAO.002.09871/2.

¹⁰⁴ Pike River Coal Ltd, Incident/Accident Forms: DAO.001.00754/2 (10 June 2010); DAO.001.00746/2 (9 June 2010); DAO.001.00777/2 (6 June 2010).

¹⁰⁵ Andrew Hopkins, Failure to Learn: The BP Texas City Refinery Disaster, 2008, CCH Ltd, p. 15.

¹⁰⁶ Ibid., pp. 107–20.

¹⁰⁷ Masaoki Nishioka, transcript, p. 3546.

¹⁰⁸ Pike River Coal Ltd, Incident/Accident Form, 2 June 2010, DAO.001.00826/2.

¹⁰⁹ Douglas White, transcript, p. 5000.

¹¹⁰ See the following Pike River Coal Ltd incident/accident forms: DAO.001.00359/28 (11 October 2010); DAO.001.00682 (13 July 2010); DAO.001.00826 (2 June 2010).

¹¹¹ Department of Labour, Investigation Report, DOL3000130010/142, para. 3.29.5.

¹¹² David Cliff et al., Investigation for Nature and Cause, DOL3000130007/39.

¹¹³ Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 21.

¹¹⁴ Police/DOL interview, 8 December 2010, INV.03.01747/13–15. (The commission decided, by majority, to withhold the name of the worker concerned. Commissioner Bell dissented.)

¹¹⁵ Ibid., INV.03.01747/43.

¹¹⁶ Ibid., INV.03.01747/47.

¹¹⁷ Ibid., INV.03.01747/43.

¹¹⁸ Ibid., INV.03.01747/47–48.

¹¹⁹ Pike River Coal Ltd, Incident/Accident Form, 7 May 2010, DAO.001.00885/2.

¹²⁰ Douglas White, transcript, p. 4994.

¹²¹ Ibid., p. 4995.

¹²² Ibid., p. 4999.

¹²³ Ibid., p. 5002.

¹²⁴ Royal Commission on the Pike River Coal Mine Tragedy (Karyn Basher), Instances of Methane Recorded in ‘CH610 Aux Fan Shaft Methane’ Graphs, Deputy Statutory Reports and Deputies Production Reports (30 September – 19 November 2010), February 2012, CAC0145/7–11.

Introduction

1. This chapter considers the underground electrical system at Pike River. The integrity of parts of that system, and its potential to be a source of ignition for the first explosion, have been the subjects of conflicting evidence.
2. Relevant evidence and submissions have been received from many sources, including the Department of Labour (DOL); Anthony Reczek, an electrical expert engaged by DOL and the New Zealand Police; Rockwell Automation (NZ) Ltd, the supplier of key electrical components called variable speed drives (VSDs); and certain Pike directors, employees and contractors.
3. Because it has not been possible to access the underground parts of the mine in which significant electrical equipment is located, its installation and functioning, and its potential contribution to the explosion, cannot be determined. That is still being investigated by the health and safety regulator. Accordingly, the commission is compelled to limit its analysis.

Electrical systems at Pike River

4. Underground electrical systems are critical to mine safety and production. They must be designed, sited, installed and maintained so that they do not create hazards, including the risks of electric shock and sparking, which may provide an ignition source for flammable gas or material. These systems are complex, and use specialised equipment requiring expertise beyond that of a generalist electrician.
5. Their functions include powering the ventilation system of a mine, the monitoring and communications systems (including those for use in an emergency) and mining equipment. At Pike River that included the ABM, continuous miners and roadheader, the VLI Drilling Pty Ltd drill rig and the water pumps for the hydro monitor and coal transport systems. Although some parts of the electrical system, for example the surface fan, had back-up power supplies, those were often of limited duration.
6. Pike River's underground power supply came from two substations. One, at Logburn, stepped the voltage down 110kV to 33kV. It fed power to another substation near the portal entrance, which stepped that 33kV down to 11kV. From that substation, three 11kV lines delivered power into the mine through the main drift, two to the main electrical distribution board located in pit bottom in stone, identified as SB001 in Figure 11.1. Through that board power was supplied to much of the underground equipment. The third line delivered power to the main ventilation fan distribution board pit bottom south, at location SS601 in Figure 11.1. Pit bottom south extended to the coal reserves of the mine.
7. Those two areas, pit bottom in stone and pit bottom south, contained more substations to further step down the voltage, from 11kV to either 1kV, 690V or 400V, to power underground electrical equipment. Those areas also had the greatest concentration of fixed electrical equipment.
8. Generally, fixed electrical equipment could be controlled and monitored from the surface control room. Some of the equipment had methane sensors and safety cutouts, including in the event of overheating.¹
9. The red line in Figure 11.1 marks the boundary between two underground zones, the restricted zone, which is to the left of the line and includes the coal workings, and the non-restricted zone to the right. That non-restricted zone includes Spaghetti Junction and much of pit bottom south. The zones are explained below.

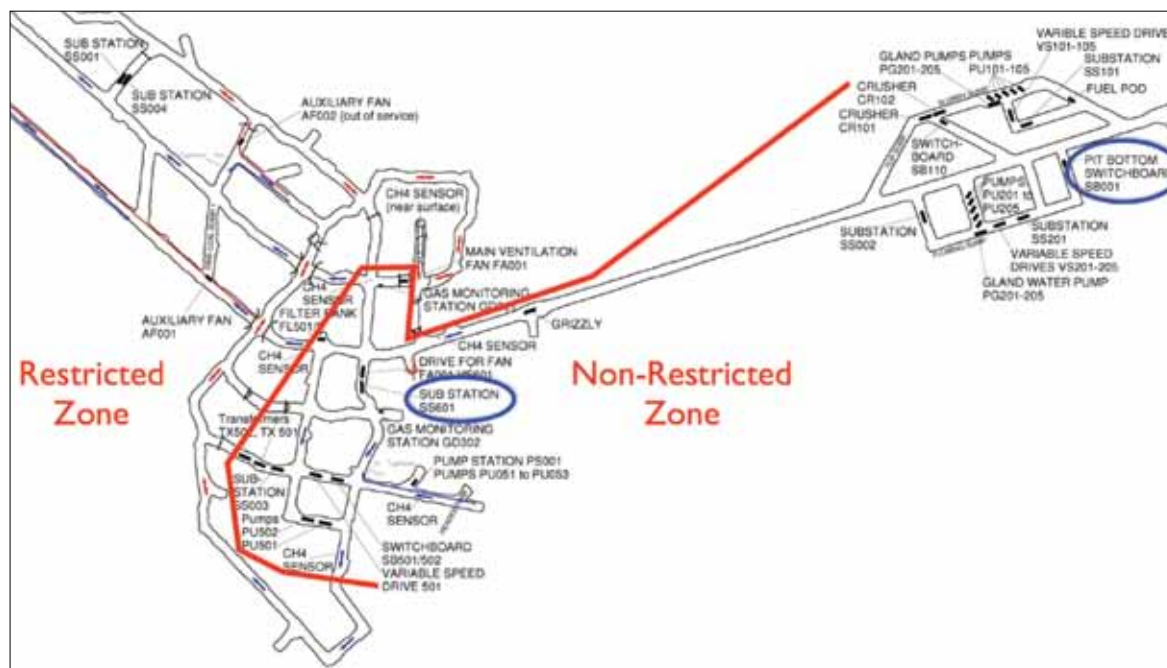


Figure 11.1: Main electrical area and zones underground²

The restricted and non-restricted zones

10. Because of the risk of an electrical system being a source of ignition, the Health and Safety in Employment (Mining – Underground) Regulations 1999 provide for restricted and non-restricted zones in gassy coal mines.
11. In gassy mines the restricted zone includes the working faces, the return, any area where flammable gas is likely to be 2% or more in the general body of air and any area containing electrical equipment that has not been shown to be free from flammable gas. Free from flammable gas means there is no more than 0.25% flammable gas in the general body of air.³
12. All practicable steps must be taken to ensure electrical equipment used in a restricted zone meets certain safety standards, so that it is not a source of ignition. Essentially, it must be intrinsically safe or flameproof.⁴ Intrinsically safe equipment operates at such a low energy level that it is incapable of igniting methane. Flameproof equipment is enclosed in a special housing to ensure any ignition of methane is safely contained inside the enclosure.⁵
13. These requirements were reflected in Pike's detailed ventilation management plan. It contemplated that an 'electrical supervisor' would define any non-restricted zones, following a risk assessment. The zones were to be shown on a plan kept in the surface controller's office.⁶ Electrical equipment had to meet legislative standards. Inspections were to occur with a frequency that differed according to the equipment.
14. The restricted and non-restricted zones were defined in August 2010, but the process outlined in the management plan was not followed. There was no risk assessment to define the location of the restricted zone.⁷
15. By then Pike had already installed a large amount of electrical equipment, some of which was neither intrinsically safe nor flameproof, in the pit bottom south and Spaghetti Junction areas of the mine. The motor for the main fan, numerous pumps and VSDs fell within that non-restricted zone as defined.⁸
16. Some electrical equipment was tested on the surface before being installed underground. In addition, before underground electrical equipment in pit bottom south was powered up, gas samples were taken in the vicinity over three days to ensure there was less than 0.25% methane. Methane sensors were placed at various parts of the non-restricted zone.⁹

17. Despite those precautions, the non-restricted zone in pit bottom south extended to the coal measures in the gassy mine and was close to the return. Michael Scott, an underground electrical co-ordinator at Pike, noticed that some of the methane sensors in the non-restricted zone in 'pit bottom south near switchboard SB501 would trip. This was because the tunnel where the header tank is located is a non-free ventilated stub, or dead end, and we did have methane coming out there in small amounts ... very low concentrations, maybe 0.3%.¹⁰ The sensor was moved and ventilation of the area improved. Methane greater than 0.25% in the non-restricted zone was reported though the accident and incident reporting system on at least one occasion.¹¹
18. The location of the non-restricted zone did not go without comment at the mine. One deputy said:

*I asked one of the electrical engineers what [the main fan] motor was doing up there, right next to the main return and fan. He just said it was a non-restricted zone. I can't understand how it could be a non-restricted zone when it was within 10m of a temporary stopping into the main return where all the gas was leaving the mine.*¹²
19. A stopping failure or ventilation fan failure (which may be followed by the reversal of ventilation) could result in methane being introduced into the pit bottom south non-restricted zone.¹³ Because some equipment in that zone was not intrinsically safe or flameproof, methane sensors and the associated safety cutouts had to be relied on if methane entered the area.
20. The location of the non-restricted zone concerned Mr Reczek, the electrical expert engaged by DOL and the police. In his view it did not make logical sense and the whole area inbye of the main drift should have been a restricted zone.¹⁴ He stated that 'despite the fact that the presence of methane was possible, there was no explosion protection technology used on the major items of electrical equipment located in the designated "unrestricted" area of the mine's inbye workings at the end of the stone drift entry'.¹⁵
21. A risk assessment would likely have led to the view that the non-restricted zone, and thus non-flameproof or non-intrinsically safe equipment, ought not to be located within or so near to the coal measures of a gassy mine or, if it was, very good protection would be needed to prevent methane coming into contact with electrical equipment.
22. Such a risk assessment is not expressly required by the underground mining regulations. This contrasts with the Queensland legislation in which a risk assessment is required to define three types of zones, those with a negligible explosion risk (methane likely to be less than 0.5%), explosion risk 1 (methane likely to be 0.5 to 2%) and explosion risk 0 (methane likely to be greater than 2%).¹⁶

Proximity of non-restricted zone and electrical equipment to utility services

23. The inclusion of pit bottom south and Spaghetti Junction in the non-restricted zone led to another hazard. These areas contained roadways and significant utility services – water pipes, compressed air pipes and gas drainage pipes. To those were added 11kV lines. The sheer quantity, and lack of separation, of utility services at Spaghetti Junction is shown in Figure 11.2. The high-voltage cables are red.
24. Of that configuration mining consultant David Reece said:

*This is quite unusual to have pipes like this, this sort of configuration in a mining situation. The other thing is the high-tension cables that are also interspersed with all these services in that particular area. So this is potentially an area where these could be hit by a diesel vehicle or something of that nature ... it's certainly hazardous and the combination of services that you've got there with high-tension cables, and we're talking about 11,000 volts in those cables, if you damaged that at the same time as the pipeline, it is highly likely that you would get an ignition at that point.*¹⁷



Figure 11.2: Spaghetti Junction¹⁸

25. Consultant Comlek Electrical Engineering Contracting Ltd had raised the proximity of electrical cabling and equipment to other utility services and the roadways in a 30 October 2009 electrical audit report commissioned by Pike. Its purpose was to assess the compliance of electrical equipment located in a potentially explosive atmosphere with relevant Australian and New Zealand standards and to make corrective recommendations.
26. Comlek was concerned that high-voltage lines 'crossing the mine access road is considered dangerous due to it not specifying clearance heights by signage and not having indication of aerial location' and that standards of electrical equipment and location of storage needed 'major improvement'. An example was an item of electrical equipment (a starter) being located under water pipes, on the floor and without barrier identification.¹⁹
27. High-voltage cabling and electrical equipment should not be located close to gas, water and compressed air utility services. Where this is unavoidable, protective housing should be used, including protection against vehicle impact.

The variable speed drives

28. Pike used VSDs to allow the fixed speed motors for the main fan and underground pumps to operate at variable speeds. The VSDs do this by varying the frequency of the power supply to the motors.²⁰ This enables a softer start-up process and also allows the operating speeds of a motor to match its output demand, resulting in cost savings and improved performance.
29. Pike had 12 VSDs underground, at the locations circled in red in Figure 11.3. There were five VSDs in each of the locations to the top right of the plan and one at each of the locations to the bottom left of the plan.
30. There were concerns about the use of VSDs. Mr Reczek was aware of the use of VSDs underground elsewhere, but they were 'explosion protected. They're in flameproof enclosures and they're confined to the body of machinery'.²¹

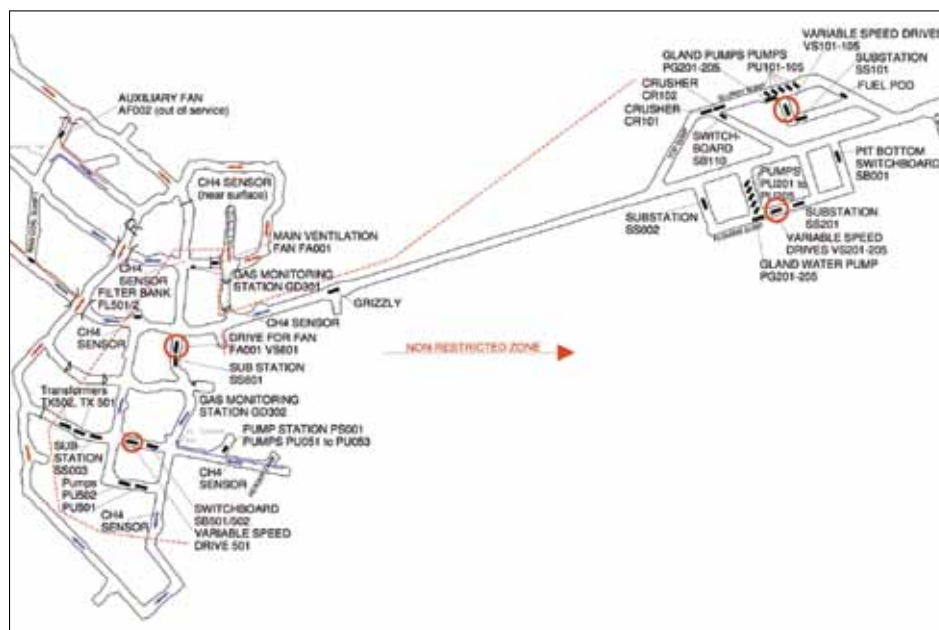


Figure 11.3: Plan showing VSDs underground at Pike River²²

He had never seen a configuration such as that at Pike River, which was essentially a significant number of fixed VSDs underground.

31. Mr Reczek and Mr Nishioka gave evidence that VSDs need to be placed in a very clean, dust-free environment with a consistent temperature. Mr Reczek thought that 'unless you have a totally enclosed room which is dust free and filtered and separately ventilated, I don't think you could provide a satisfactory environment' underground in a coal mine.²³ Evidence indicates that Pike created, or sought to create, such an environment.²⁴
32. VSDs have the potential to cause enough harmonic distortion to generate sparking within the earth system of the power supply. The extent to which harmonics occur depends on many matters, including the type of VSD, the manner in which it is installed and the cabling type, length and connection. The installation and cabling details at Pike River remain unclear.²⁵ There is conflicting evidence from Mr Reczek and Rockwell, the supplier of VSDs, about the extent and effect of harmonics. This is referred to in more detail in Chapter 14, 'The likely cause of the explosions'.
33. There were other problems associated with the use of VSDs. There was an overvoltage in the power supply to at least one VSD, affecting its performance; this was rectified on about 9 November 2010. Five VSDs failed and were removed. In one case a power structure exploded. On several occasions pre-charge resistors failed. This problem was to be solved by changing the ratings of protective fuses. New fuses had been ordered but not replaced by the time of the explosion.
34. During commissioning of the main underground fan there were intermittent and difficult problems with the associated VSD. On 27 October 2010 the VSD was replaced with an air-cooled model, which was placed within an enclosure to provide protection. It seems this led to overheating. Pike took steps to correct that, including leaving open the doors to the enclosure and installing ducting to direct air into it. On about 9 November 2010 Pike ordered an air conditioner to improve the cooling. It had not arrived by the time of the explosion.²⁶
35. In summary, despite Pike's efforts and those of external experts, there was a range of problems associated with the use of VSDs, not all of which had been addressed by the time of the explosion.

Regular electrical inspections

36. Documents filed with the commission show that, as with much other plant, there were frequent inspections of and written reports on electrical plant and equipment. The frequency varied, but some were daily.²⁷ Despite containing information relevant to health and safety, those reports did not make it as far as the safety and training department.²⁸

37. The timing of tests and inspections does not always seem to have been consistent. The October 2009 Comlek audit report shows, at that stage at least, no weekly and monthly tests on certain electrical equipment. A selection of work orders from October 2010 shows that daily electrical checks on some equipment were not always done. The reasons are unclear or not explained.²⁹
38. Comlek also pointed out that there was no single line diagram of the underground and above-ground electrical reticulation and that reporting of events and transfer of information at shift handovers needed improvement.³⁰

Electrical staffing at Pike River

39. Pike contracted in expert electrical advice,³¹ and had its own electrical staff, usually including electrical engineers,³² within the engineering department. Mr Scott, the underground electrical co-ordinator at the time of the explosion, noted '[w]e had trouble getting good electricians as they needed to be industrial electricians, but the majority of the electricians were up to standard in my view. A couple were beyond the standard.'³³ In October 2009 Comlek identified the lack of procedures for sign-off of electricians at Pike River as having certain certificates of competence.³⁴
40. Mr Reczek envisaged an electrical engineer with an overview of the management and operation of electrical equipment and responsibility for the implementation of risk controls as part of an electrical management plan. The relationship with the mine manager would be close.³⁵
41. Two early documents of Pike, a draft management plan of September 2008 and a draft electrical engineering management plan of November 2008,³⁶ contemplated an electrical engineer of some seniority. The final electrical engineering management plan dated 30 April 2010 provided for an electrical co-ordinator.³⁷ This appears to be a lesser, more maintenance orientated, position than that described by Mr Reczek. It is reflected in the structure of the engineering department before 24 August 2010 (Figure 11.4).

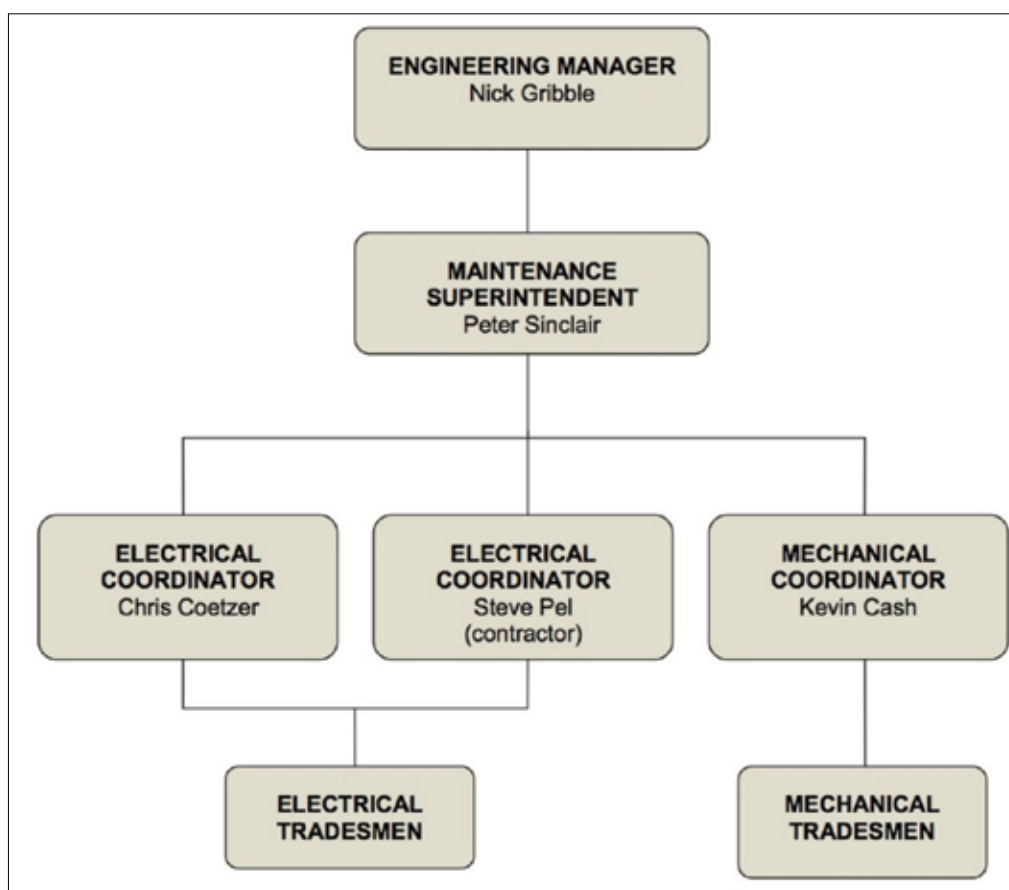


Figure 11.4: Structure of Pike engineering department before 24 August 2010³⁸

42. In September 2010 that structure was reviewed by Robb Ridl, the engineering manager for Pike from 24 August 2010 to 30 September 2011.³⁹ A memorandum from Mr Ridl dated 22 September 2010 records the reasons for the review and resulting recommendations:

The current Pike River Engineering Department is currently unable to meet the needs of the business and a new engineering organisational structure has been developed to provide for the maintenance requirements of the business in an operational phase.

... The current structure does not have clearly defined areas of responsibility and fixed plant is not being proactively maintained due to lack of supervisory resources.⁴⁰

43. A new structure with increased staffing was proposed and was approved by Douglas White and Peter Whittall (see Figure 11.5).⁴¹ It included the position of electrical engineer.
44. This was not as senior as the position suggested by Mr Reczek but did include responsibility for many aspects of the electrical system, including risk management, ensuring maintenance in accordance with statutory requirements, electrical inspections and continuous improvement.⁴²

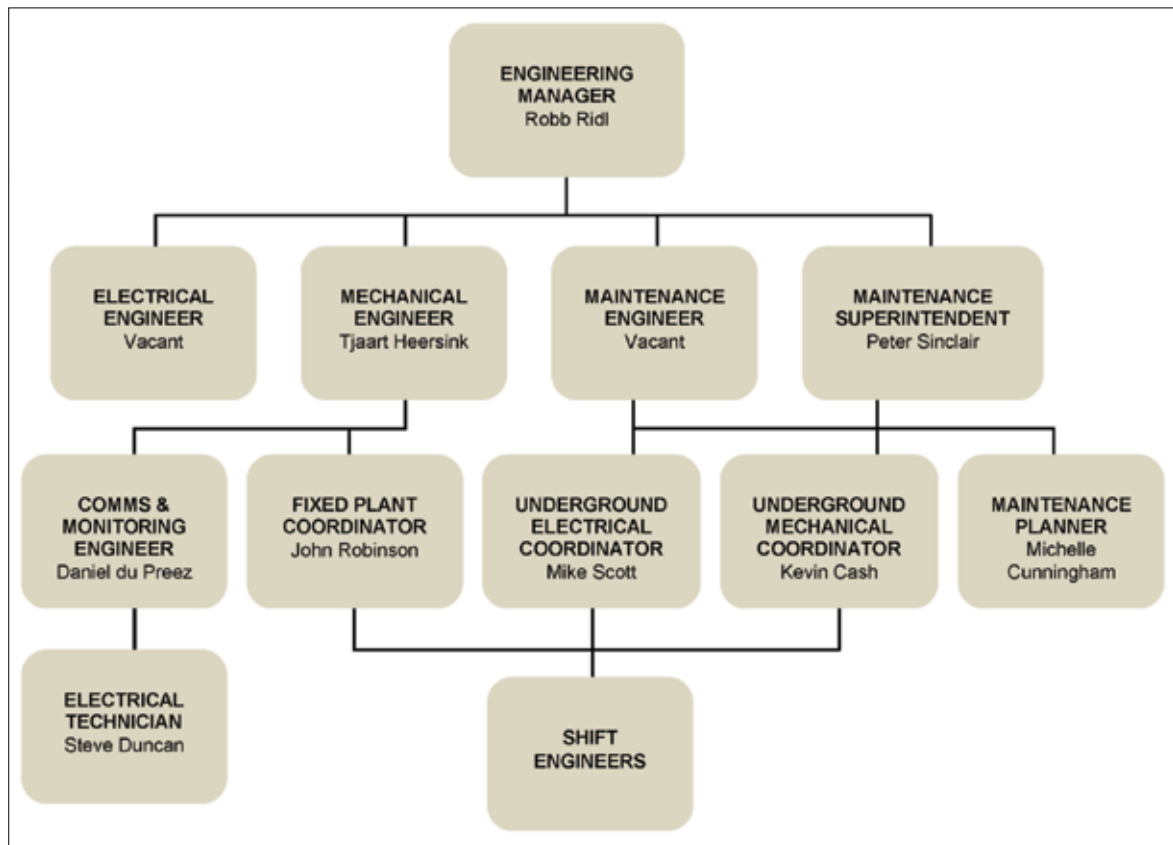


Figure 11.5: New structure for Pike engineering department⁴³

45. By 19 November 2010 an electrical engineer, a contractor who had been an electrical co-ordinator, had been appointed but he had not started in the new position.⁴⁴

Overall management of electrical safety at Pike River

46. All of the above issues call into question the extent to which Pike was properly managing electrical issues. The DOL investigation report states:

Taken together, it appears that [Pike] was experiencing an excessive number of issues with its electrical system and especially with its VSD operation. Each issue seems to have been explained and dealt with on an

*ad hoc basis, as and when it occurred. However, given the high risk environment [Pike] was operating in, and the number of unknown reasons for the electrical failures [Pike] management should arguably have approached the issues first and foremost as a safety matter. From this perspective, it may have been reasonable for [Pike] to have ceased operations and sought further third party expert advice to determine the causes of the electrical issues and the appropriate controls necessary. [Emphasis in original]*⁴⁵

47. The DOL investigation report also states that Pike had:

*four departures from conventional electrical arrangements for an underground coal mine. These were the placement of the main fan underground, the use of VSDs to drive key infrastructure systems, the long single entry (the Drift) and use of non-hazardous zones and equipment. These four unconventional arrangements individually and together created an increased level of risk because they were largely untested and unusual.*⁴⁶

Given the importance of a safe and efficient electrical system, Pike should have introduced 'compensatory processes to mitigate the higher risk.'⁴⁷ Those would include carrying out sufficient research to understand the risks those unconventional arrangements created in a hazardous environment, obtaining independent expert advice on the use and installation of VSDs underground, and a risk assessment.

48. Pike obtained significant advice about the VSDs. Experts were involved in designing and maintaining its electrical system. Assessments were undertaken for certain electrical equipment and there was some above-ground testing before installation. However, problems still occurred.
49. There does not appear to have been a comprehensive assessment of the potential risk of the electrical system. Mr Ridl thought such an assessment necessary but in the short time between his starting employment and the explosion he did not become aware of one.⁴⁸ Mr Scott thought the risk assessment process at Pike was more extensive than at other places he had worked, but did not recall an overall risk assessment concerning the use of electrical equipment underground.⁴⁹ Mr White was not sure of the extent of electrical risk assessments, and it was outside of his expertise.⁵⁰ The Pike board's health, safety and environment committee did not seek confirmation that the underground electrical systems were correctly installed and safe.⁵¹
50. A comprehensive risk assessment, in mid- to late 2010, would have taken into account the individual and cumulative risks raised by DOL and the problems with important components of the electrical system. The risks should have been considered in the context of Pike's move to hydro mining. This would have indicated the desirability of halting, or at least restricting, hydro-mining operations (because of its introduction of significant accumulated methane in the goaf), until all the electrical problems had been fixed.

Electrical inspections

51. Mr Reczek considered that the underground Pike electrical system warranted 'a significant amount of attention' from a regulator, because of its location in a hazardous area and its unconventional nature. The focus would be on the measures undertaken to assure safety.⁵²
52. However, regulator oversight was limited. On 13 February 2007 Richard Davenport, from the Electrical Safety Service of the Ministry of Economic Development (MED), and Michael Firmin of DOL, inspected the electrical system. They approved the then installation, but at that stage the drift was still being developed and the underground electrical cabling and system had not been installed.⁵³
53. On 26 November 2008 Mr Davenport, with Kevin Poynter of DOL, conducted another electrical inspection.⁵⁴ This concluded that all electrical installations were compliant.⁵⁵ At that stage the underground electrical equipment had not been installed.
54. From January 2009 MED no longer conducted electrical inspections in underground coal mines and DOL did not have the expertise to carry them out.⁵⁶ As a result, key underground electrical systems installed in 2010 were not scrutinised by an electrical expert from or on behalf of DOL.

Conclusions

55. The underground electrical system at Pike was unconventional in a number of ways:
 - the main fan was underground;
 - the non-restricted zone, which contained some non-flameproof and non-intrinsically safe electrical equipment, extended to the coal measures in this gassy mine;
 - there was significant use of VSDs underground to drive key infrastructure and a range of problems was associated with their use; and
 - high-voltage cables and utility services were intermeshed at Spaghetti Junction.
56. Individually, and in combination, these unconventional arrangements introduced significant risks to the underground environment. The location of the non-restricted zone, and the overall electrical system, ought to have been subject to comprehensive risk assessment, followed by any necessary actions. Within the overall context of the mine's development and operation in mid- to late 2010, that may have led to a halting or restriction of hydro-mining operations while electrical problems were being corrected.
57. A risk assessment conducted before creating the non-restricted zone at pit bottom south would likely have led to the view it ought not to be located in or near the coal measures in this gassy mine.
58. Pike had both external and internal electrical expertise, but did not have a sufficiently senior electrical engineer with responsibility for the whole electrical system.
59. There was inadequate regulatory oversight of the electrical system from 2009 onwards, owing to a lack of expertise within the DOL mines inspectorate.
60. The commission has significant concern about the electrical system and whether it played a role in the explosion.

ENDNOTES

¹ For example the VSD for the main ventilation fan: Robb Ridl, witness statement, 14 March 2012, DAO.041.00009/28, para. 116. See also: Pike River Coal Ltd, Incident/Accident Form, 12 October 2010, DAO.001.00359/3–5.

² Pike River Coal Ltd, Plant Location and Ventilation Plan: Rescue 101119_181, 22 March 2011, DAO.010.13140/1. (Extract of the plan modified by the commission)

³ Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 2.

⁴ Ibid., reg 55.

⁵ Anthony Reczek, witness statement, 7 February 2012, DOL3000160001/5, para. 16.

⁶ Pike River Coal Ltd, Ventilation Management Plan, 2008, DAO.003.07114/72, para. 242.

⁷ Douglas White, transcript, p. 4971.

⁸ Michael Scott states the electrical equipment for the hydro monitor was installed between June and August 2010: Michael Scott, witness statement, 30 May 2012, SCO7770010001/17, paras 64–66.

⁹ Michael Scott, witness statement, 30 May 2012, SCO7770010001/18, paras 68–69; Douglas White, transcript, pp. 4968–70.

¹⁰ Michael Scott, witness statement, 30 May 2012, SCO7770010001/36–37, para. 150.

¹¹ Pike River Coal Ltd, Incident/Accident Form, 12 October 2010, DAO.001.00359/3–5; Douglas White, transcript, p. 4972.

¹² Dene Murphy, witness statement, 2 December 2011, FAM00057/12, para. 60.

¹³ Michael Scott, witness statement, 30 May 2012, SCO7770010001/37, para. 151 (stopping failure); Dene Murphy, witness statement, 2 December 2011, FAM00057/11, para. 58 (ventilation fan failure).

¹⁴ Anthony Reczek, transcript, pp. 4774–75.

¹⁵ Anthony Reczek, witness statement, 7 February 2012, DOL3000160001/28, para. 108.

¹⁶ Coal Mining Safety and Health Regulation 2001, cls 286–91.

¹⁷ David Reece, transcript, p. 4485.

¹⁸ DR12 – Photo of Spaghetti Junction, DOL3000150019/1.

¹⁹ Comlek Electrical Engineering Contracting Ltd, Audit Report of Electrical Management Systems at Pike River Coal NZ, 30 October 2009, DAO.025.26626/6–7, paras 1.14–1.15.

²⁰ Anthony Reczek, witness statement, 7 February 2012, DOL3000160001/16, para. 55.

²¹ Pike River Coal Ltd, Plant Location and Ventilation Plan, DAO.010.13140/1 (extract of the plan modified by the commission).

²² Anthony Reczek, transcript p. 4760. In a memorandum, Mr White referred to a VSD unit that he said was 'the only one of its kind on site, and, we are lead to believe, the only one of its kind in the Southern Hemisphere [sic]': Memorandum, Douglas White to Peter Whittall, 22 March 2010, DOL3000160011/1.

²³ Anthony Reczek, transcript pp. 4760–61; Masaoki Nishioka, transcript, p. 3494.

²⁴ Gregory Borichevsky, Police/DOL interview, 7 June 2011, INV.03.20410/30.

²⁵ Department of Labour, Report on Electrical System Evidence, 8 June 2012, DOL7770050017.

²⁶ Michael Scott, witness statement, 30 May 2012, SCO7770010001/26–28.

²⁷ Karyn Basher, witness statement, 10 November 2011, CAC0117/3.

²⁸ Neville Rockhouse, transcript, p. 4234.

²⁹ Pike River Coal Ltd, Work Order No 17075, 26 October 2010,

DAO.004.05509/1; Pike River Coal Ltd, Work Order No 16856, 19 October 2010, DAO.001.07114/1; Pike River Coal Ltd, Work Order No 15936, 27 September 2010, DAO.001.07211/1; Kevin Poynter, transcript, pp. 3018–28.

³⁰ Comlek Electrical Engineering Contracting Ltd, Audit Report, DAO.025.26626/5, paras 1.7–1.9.

³¹ Anthony Reczek, transcript pp. 4823–29.

³² Douglas White, transcript, p. 4965.

³³ Michael Scott, witness statement, 30 May 2012, SCO7770010001/7, para. 20.

³⁴ Comlek Electrical Engineering Contracting Ltd, Audit Report, DAO.025.26626/4, para. 1.1.

³⁵ Anthony Reczek, transcript, pp. 4771–73.

³⁶ Pike River Coal Ltd, Roles and Responsibilities: Management Plan (Draft Document), 9 September 2008, DAO.002.00960/67; Pike River Coal Ltd, Electrical Engineering Management Plan: Management Plan (Draft Document), 2 November 2008, DAO.002.00662.

³⁷ Pike River Coal Ltd, Electrical Engineering Management Plan, 30 April 2010, DAO.003.07228/9.

³⁸ RJR1: Engineering Structure Before 24 August 2010, DAO.041.00006/1.

³⁹ Robb Ridl, witness statement, 14 March 2012, DAO.041.00009/3, para. 2.

Mr Ridl had also been a mechanical co-ordinator at Pike from August 2006 to May 2007.

⁴⁰ Memorandum, Robb Ridl to Douglas White, 22 September 2010, DAO.043.00004/1.

⁴¹ Robb Ridl, witness statement, 14 May 2012, DAO.043.00050/12.

⁴² Pike River Coal Ltd, Engineering Department Areas of Responsibility, DAO.043.00001.

⁴³ Pike River Coal Limited Organisation Chart as at 19 November 2010, PW23a/1. (Extract with 'Note 2' removed from beside Robb Ridl's name by the commission)

⁴⁴ Pike River Coal Ltd, Manager's Promotion Recommendation, 4 November 2010, DAO.043.00049/1; Douglas White, transcript, pp. 4965–68.

⁴⁵ Department of Labour, Pike River Mine Tragedy 19 November, 2010: Investigation Report, [2011], DOL3000130010/161, para. 3.37.10.9.

⁴⁶ Department of Labour, Investigation Report, DOL3000130010/151, para. 3.37.4.6.

⁴⁷ Ibid., DOL3000130010/151, para. 3.37.4.7.

⁴⁸ Robb Ridl, witness statement, 14 May 2012, DAO.043.00050/9–10, paras 50–51.

⁴⁹ Michael Scott, witness statement, 30 May 2012, SCO7770010001/41, paras 169–170.

⁵⁰ Douglas White, transcript, p. 4967.

⁵¹ John Dow, transcript, p. 4033.

⁵² Anthony Reczek, transcript, p. 4770.

⁵³ Richard Davenport, Inspection Audit Report, 13 February 2007, DAO.025.42883/2–3.

⁵⁴ Kevin Poynter, witness statement, 19 October 2011, DOL7770040003/17, paras 84–86.

⁵⁵ Ministry of Economic Development, Energy Safety, ES Audit Report, 4 December 2008, MED3000010002/2–4.

⁵⁶ Michael Firmin, transcript, pp. 602–04, 684.

Introduction

1. This chapter summarises the hydro-mining systems used at Pike River, and assesses the management, safety and effectiveness of the company's hydro-mining operation.

The hydro-mining technique

2. Hydro mining is particularly suited to the West Coast, where coal seams are thick and geologically disturbed. Seams have steep variable gradients and are often severely faulted, which means the coal seam can be completely displaced, as shown in the simplified diagram of Pike River's Brunner seam below.¹ Minor faults are often present within areas separated by major faults, creating further variation. Such steeply dipping coal seams are unsuitable for conventional mining methods such as longwall mining, which may be unable to extract the full seam thickness.²

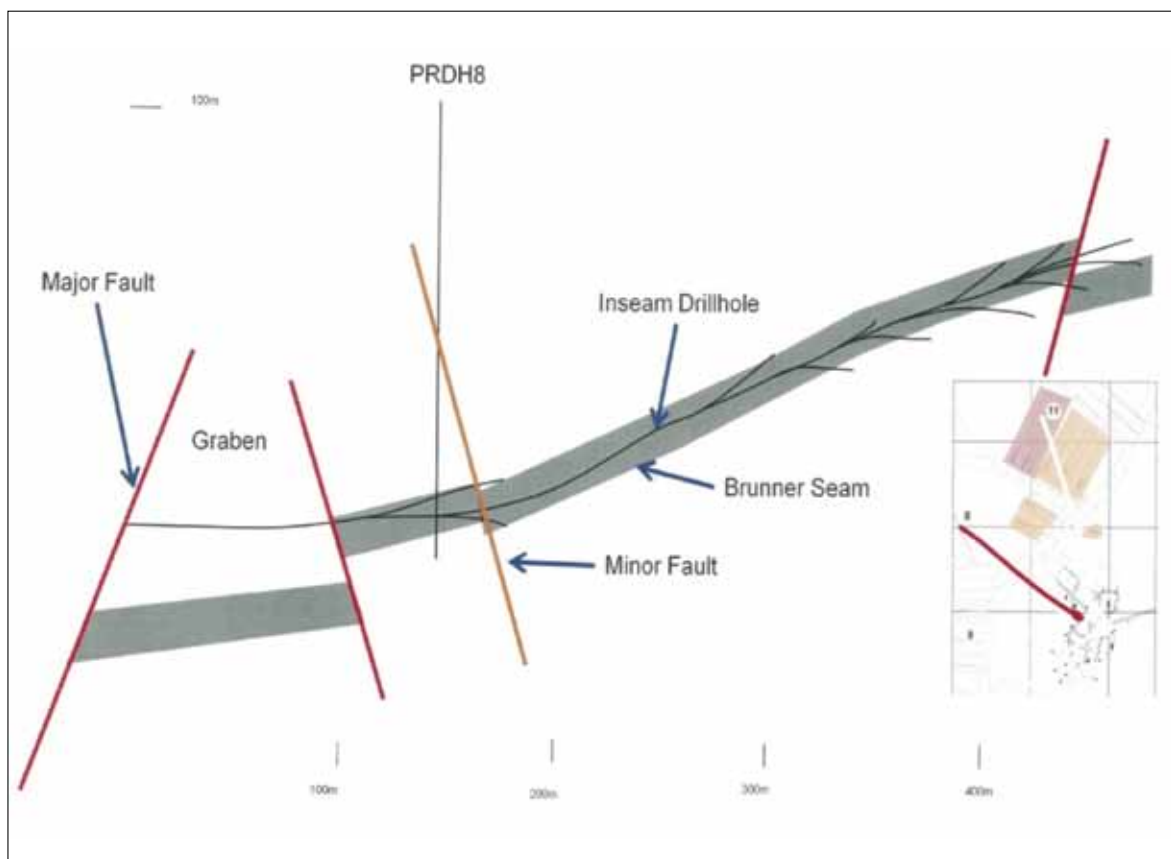


Figure 12.1: Pike River's Brunner seam

3. Hydro mining uses a high-pressure water jet from a hydro monitor to cut coal:



Figure 12.2: Hydro monitor at work³

4. The first hydro panel at Pike River followed a simple design: it had one intake roadway and one return roadway, with the hydro-monitor unit located at the top of the intake roadway under a supported roof. The hydro panel sloped uphill, with the return roadway higher than the intake roadway, as shown in the three-dimensional sketch below. Water from the hydro monitor flowed naturally downhill, carrying the extracted coal.

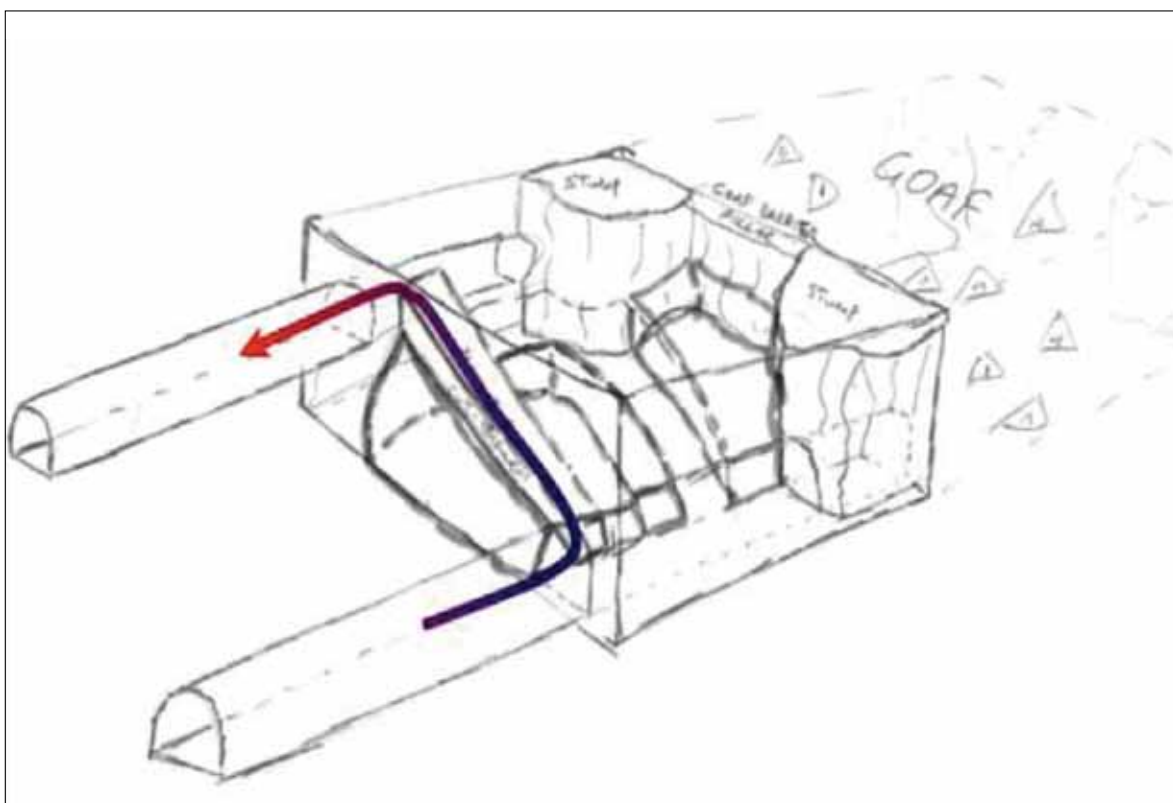


Figure 12.3: Three-dimensional sketch of hydro panel showing height difference between intake and return and ventilation path when panel idle⁴

5. At Pike River a machine called a guzzler was located 18m behind the hydro monitor, and directed the mixture of coal and water into the roadway flume system. The guzzler also crushed any large lumps of coal.⁵ It is shown in the photograph with its 'wings' open ready to gather and direct the coal/water mixture.



Figure 12.4: Guzzler ready to gather and direct water/coal mixture⁶

6. Having passed through the guzzler, the coal and water slurry was flumed under gravity to the crushing station at pit bottom, where it was pumped down the 2.3km drift and on to the coal preparation plant approximately 10km away.⁷
7. Miners operated the hydro monitor from a series of controls at the guzzler. It was a cold, tedious job,⁸ given the long periods spent operating levers to direct the water jet. Operators extracted coal in blocks of coal called lifts, following a set cutting sequence. After lifts were extracted across the full panel width, the monitor and guzzler retreated to a new position further in the intake roadway, and the process was repeated.⁹
8. The following diagram shows a bird's-eye view of the coal cutting sequence in place at November 2010 for each lift. The monitor position is marked M and operators cut coal in the areas defined as A to F, in that order, using the water jet within parameters bounded by the 'clock' numbering, i.e. for lift A the operator directed the water jet between 9 and 10 o'clock. Extracting coal first from A and B created the ventilation cut through between the intake and the return roadways. Areas X, Y and Z were designed to be temporary support pillars, called stumps, to keep the roof up until they, too, could be safely extracted and the roof allowed to fall.

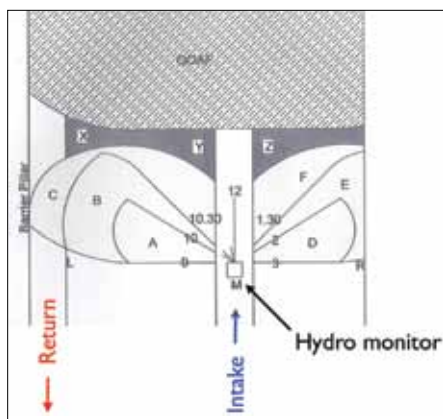


Figure 12.5: Bird's-eye view of the coal cutting sequence at Pike River¹⁰

9. The diagram below shows a cross-section of the seam in panel 1. The squares depict the return (left) and intake (right) roadways, with the return driven higher in the coal seam. Operators used the water jet to cut coal from the tops and bottoms of the seam as the hydro monitor was retreated, but were to avoid cutting into the rock in the roof and floor.

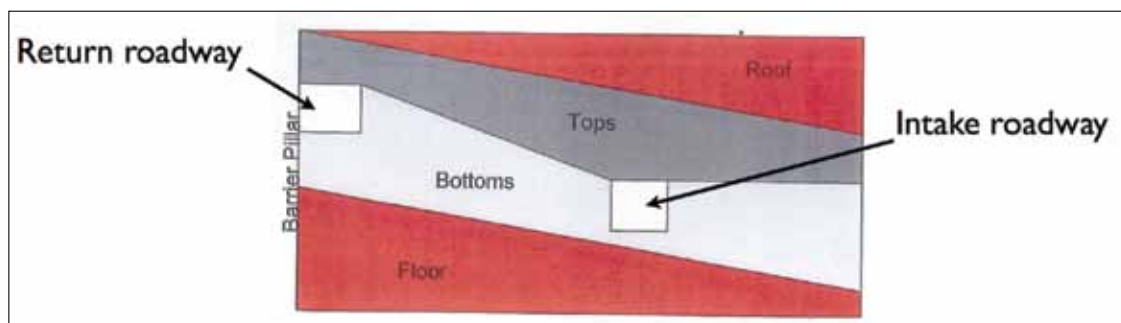


Figure 12.6: Cross-section of the seam in panel 1¹¹

Hazards associated with hydro mining

10. Hydro mines must deal with specific risks and challenges, particularly in gassy West Coast conditions. Gas management can be particularly challenging. Hydro mining releases high volumes of methane as a result of extracting the full height of thick coal seams. That methane tends to build up in the goaf (the empty space left behind after coal extraction). The force of the water jet can disturb gas in the goaf and a roof fall can displace large amounts of gas. Rapid falls in barometric pressure can also draw methane out of the goaf.
11. Hydro-monitor operators face the risk of a windblast or high-velocity wind either injuring them directly, or surrounding them with irrespirable gas. Large volumes of coal slurry may also overwhelm the guzzler where the operator stands.¹²
12. A massive roof fall in the goaf is a major hazard. Such a fall may generate a blast of air that can injure people, damage stoppings and equipment, and send out a large plug of flammable gas. Panels should therefore be designed so the goaf collapses progressively after the coal has been cut.¹³ If necessary, the roof can be made to fall by deliberately aiming the water jet at it in a controlled way. It is important to manage the risk by obtaining as much information as possible about the characteristics of the roof in the goaf, in order to avoid the creation of a large goaf and the potential for a massive roof fall.
13. For all these reasons, hydro mining calls for particular skill, experience and judgement on the part of the operator and management team. It is important that the operator can see the monitor nozzle to gauge the angle of the water jet when cutting, and to control the jet, so large amounts of methane are not displaced from the goaf. To cut coal productively and safely, an experienced operator relies on a constant assessment of factors, including the noise of the monitor jet, the size of the coal lumps in the slurry, changes to the water flow coming from the face, the noise of falling coal and stone, and gas readings in the return. There is little room for error unless all the back-up safety systems are well established.¹⁴

Development and production stages

14. Hydro mining is a two-stage process. The first stage involves development of the roadways and panels and the installation of infrastructure. The second stage is production – the extraction of coal using the hydro monitor. Development work generates some coal from the driving of roadways, but it is the production phase that produces large volumes of coal.¹⁵

The development of hydro mining at Pike River

15. Pike River was planned as a hydro mine from the early 1990s.¹⁶ Later feasibility studies confirmed the proposal to use hydro mining,¹⁷ and no other mining method was ever seriously considered.

The bridging panel

16. In 2004 Pike agreed with the Department of Conservation (DOC) that it would mine trial panels before beginning full hydro production. This was to enable monitoring of surface subsidence and roof caving characteristics underground.¹⁸
17. By late 2007 delays with the main drift had cost tens of millions of dollars, and Pike proposed the development of a 'commissioning panel' in advance of the trial panels. It was hoped that this would realise an additional \$15 to \$20 million for the company.¹⁹
18. In response to continuing delays,²⁰ the technical services department was told in May 2009 to locate coal for earlier production.²¹ Pike identified six bridging panels that could be mined before the commissioning panel. These were designed with a narrow extraction width (30m) in order to test mining techniques in a controlled panel with 'low risk to the surface'.²² In November 2009 DOC approved the concept and altered the access arrangement accordingly.²³
19. In May 2010 DOC approved another variation for Pike to reduce the number of bridging panels and move the first panel closer to pit bottom.²⁴ This became known as panel 1 and is shown in Figure 12.7, as 'Bridging Panel'.



Figure 12.7: Pike's Four-year Plan for 2010–2014²⁵

Ongoing delays

20. At the initial public offering in 2007, investors were told that hydro mining was scheduled to start in the first quarter of 2009.²⁶ By early 2010 the overall project was well behind schedule, and the planned start of the hydro monitor had been pushed out to at least July 2010.²⁷

21. Problems with the design, manufacture, delivery and commissioning of equipment accounted for a major part of the delay in 2010. In 2004 and 2005 Pike had engaged Japanese company Seiko Mining and Construction Ltd (Seiko) to advise on the necessary equipment for hydro mining.²⁸ That advice was largely provided by Masaoki Nishioka, a world expert in hydro mining with more than 40 years of hydro-mining knowledge, including considerable experience on New Zealand's West Coast, and who had intermittent involvement with Pike.²⁹ Mr Nishioka said that although he had not been given proper design criteria, he provided Pike with a comprehensive quotation for all necessary hydro-mining equipment.³⁰ Seiko supplied some of the hydro-mining equipment, including the slurry pipeline.
22. Pike obtained other core hydro-mining equipment, including the track mounted monitor unit, from Australian companies who lacked expertise in hydro mining. Some of the equipment was essentially at the prototype stage.
23. Pike engaged a range of external consultants to assist with the development of the hydro-mining system.³¹ In February 2010 a review of some of the equipment by external consultants found that the commissioning time frame for the equipment had been underestimated, software issues had plagued the commissioning stage, there was a significant problem with track clearances, re-engineering was required in part because of a contractual misinterpretation and there were insufficient trained service people available.
24. Against that background, Peter Whittall asked Mr Nishioka to come to Pike River in June 2010 to assist with the commissioning of the hydro-monitor system. Mr Nishioka arrived at Pike on 25 July and he soon had concerns about many aspects of the mine.
25. Mr Nishioka considered Pike's ventilation system insufficient for the hydro-monitor operation to begin before the commissioning of the main fan. He believed it was poor planning to have a large hydro goaf located so close to pit bottom and the Hawera Fault.³² He was critical of Pike's equipment, including the monitor unit, which he thought was unwieldy and did not provide easy visibility for the operator.³³ The guzzler unit was also too big, heavy and complicated, and the pump units and high pressure pipe joints were unsuitable.³⁴
26. Mr Nishioka also had other concerns. The hydro panel was too wide for the monitor jet; the proposed approach to roof caving was not good practice; there was a substandard work and safety culture underground; the workforce was inexperienced; and the mine was under obvious financial pressure. He said the system was generally not well engineered and not fit for a hydro-mining operation.³⁵

The hydro bonus

27. In response to the increasing delays, in July 2010 the Pike board authorised the payment of a hydro-production bonus to staff when hydro extraction began. The bonus started at \$13,000 if hydro production (defined as 1000 tonnes of coal) was achieved, together with 630m of roadway development, by 3 September 2010. After that date the amount of the bonus reduced each week, as shown in the following table that was presented to staff.

Hydro Mining Bonus Table

- In the event that hydro is achieved earlier than 24 September this rate will increase and in the event that we do not achieve it until after 24 September, the amount will decrease as set out in the table below:

Date Achieved										
Date	3 Sep	10 Sep	17 Sep	24 Sep	1 Oct	8 Oct	15 Oct	22 Oct	29 Oct	6 Nov
\$	13,000	12,000	11,000	10,000	7,500	5,000	2,500	1,000	1,000	0
Metres	630	680	735	790	790	790	790	790	790	790

- The scheduled date for hydro start-up is 3 September 2010.

Figure 12.8: Hydro-mining bonus table³⁶

28. The bonus, budgeted to cost Pike \$2.3 million,³⁷ came when the board acknowledged internally it was facing credibility problems because of overpromising and underdelivering.³⁸ In April and May 2010 Pike had raised a further \$50 million from the market,³⁹ but by 24 June 2010 it was forecasting a \$5.8 million cash shortfall. In an email to directors on 5 July 2010, board chair John Dow said it was 'worth paying [the hydro bonus] to retain short-term market credibility'.⁴⁰
29. At the commission's hearings, Mr Dow suggested the bonus was a response to poor work practices and in particular a lack of productivity and efficiency by workers. He said workers were not showing up for shifts, not looking after equipment and forgetting to fuel vehicles, and the bonus was 'about making sure people were thoughtful before they came to work'.⁴¹ The board did not consider the potential impact of the hydro bonus on health and safety, but 'would have considered ... There would be no reason why there'd be any relaxation in health and safety attention'.⁴² Mr Dow believed the targets were 'modest enough and readily achievable'.⁴³
30. Three points arise from the board's decision to implement the hydro bonus. First, the board did not give sufficient consideration to the ventilation requirements of the hydro monitor. Hydro mining began on 19 September 2010, two weeks before commissioning of the main fan started on 4 October 2010.⁴⁴ Because of the large amount of methane generated by the hydro monitor, Pike should have established robust ventilation from the main fan before starting hydro mining. Several people at Pike expressed that view.⁴⁵ Problems with methane recurred and on Friday 1 October, following the achievement of the hydro bonus, Pike agreed to stop monitor operations until the main fan became operational in booster mode the following week.⁴⁶
31. Second, the board failed to address the risk that the bonus would place undue focus on production at the expense of safety.⁴⁷ Following the bonus, the mine pulled out 'all stops' to start hydro mining as quickly as possible.⁴⁸ Mr Nishioka reported that workers made 'strenuous effort' to produce 1000 tonnes of coal by midnight on 24 September, the due date for the \$10,000 bonus,⁴⁹ although methane levels rose to explosive levels in the return twice in the days leading up to this deadline. It was hazardous to continue extraction in those conditions, and Mr Nishioka recommended that the operation stop until the main fan became operational.⁵⁰ This did not happen until the bonus had been achieved.
32. Although production bonuses are common in the coal mining industry, the hydro bonus at Pike created particular risks. Pike offered the bonus when there were known problems with equipment, ventilation, staff inexperience, and a lack of effective monitoring systems.
33. Third, the bonus was introduced when the board and senior management had not been assured that Pike's systems were ready for hydro mining. In early July 2010 the company had not undertaken the appropriate risk assessments, and it did not properly complete them before beginning hydro extraction.

Haste to begin hydro extraction

34. By mid-2010 Pike was committed to starting hydro production as soon as possible. The mine went through a number of exercises that identified major weaknesses in the mine's systems. These exercises identified that some critical systems were not yet in place, and others were not yet working properly.

Operational preparedness gap analysis

35. This exercise occurred during the third week of August 2010 (a month before the start of hydro mining), facilitated by Bob Dixon of Palaris Mining from New South Wales.⁵¹ He prepared a report of the exercise in the following format:

Operational Preparedness Gap Analysis					
Specific Area	Plan, Policy, Procedure	Priority	Status / Action	Who	When
Ventilation					
Spon Com		2	yes – exists and needs reviewing to encompass hydro mining	Doug	
Degassing procedure review			In place		
Gas plug		1	no procedure exists	Doug	
Sealing off panel			plan needs to be developed	Doug	
Ventilation network			plan needs to be developed	Doug	
Panel ventilation plan		1	plan needs to be developed	Doug	
Broad brush risk assessment		1	windblast, ventilation and gas, hydro mining, and fire fighting risk assessments to be reviewed or completed	DW	
Gas monitoring manual and automatic		1	plan needs to be developed	Doug/ Nick	
Ventilation TARP – operator requirements		2	needs to be reviewed	Doug	
Safety critical systems include dilution doors, CH ₄ protection, emergency stops, guarding,	Risk Assessment	1	need to be identified, checked, and implemented	Doug / NG / MC	
Mining plan		2	needs to be completed	PVR/Doug	
Hydro extraction plan - ATM		2	needs to be completed and updated with geotechnical, geological, strata control, and operating requirements	Doug / PVR	
Start-up strategy e.g. Day shift only		2	needs to be finalised	Doug/ Bernie	

Figure 12.9: Operational preparedness gap analysis⁵²

36. The full document identified 15 'priority 1' actions, including creating or finishing plans for critical hazards such as gas plugs, panel ventilation and gas monitoring. The mine needed to complete risk assessments for windblast, ventilation and gas, hydro mining and fire fighting. Safety critical systems, including dilution doors (a mechanism to dilute large volumes of methane), gas protection and emergency stops needed to be identified, checked and installed.
37. The gap analysis provided a vital 'to do' list for the mine and a stocktake of the project's readiness, but was of little use without a mechanism to make sure these things were actually done before hydro start-up.
38. Pike supplied this document to external insurance risk assessor Jerry Wallace of Hawcroft Consulting International. On 23 August 2010 Mr Wallace emailed Mr Whittall to express concern about 'the lack of formal risk assessments [one] month out from the start-up of the first monitor panel'.⁵³ He was particularly concerned that so many priority 1 actions were unresolved in relation to ventilation and gas management, and that a risk assessment into windblast was yet to be conducted.⁵⁴ He considered it 'unfortunate' that Pike was beginning hydro mining 'with many controls currently being developed but not yet implemented'.⁵⁵
39. In the 10 days following Mr Wallace's email, Pike did complete two risk assessments regarding hydro extraction, and ventilation/gas monitoring. Many other actions on the gap analysis list remained unaddressed, and were not completed even by the time of the explosion on 19 November 2010.

Panel 1 risk assessment

40. This risk assessment took place on approximately 3 September 2010, although the document filed with the commission is undated and in draft. The treatment of windblast and ventilation, and the risk of explosive mixtures in the return, are all significant.
41. Windblast is caused by a sudden plate-like roof fall in a goaf. This can push air and gas out of the goaf at high speed, and a windblast is technically defined as generating an air velocity greater than 20m/s. Such velocities can injure people by knocking them over or hitting them with airborne objects. They can also damage the mine and mining equipment, seriously disrupt ventilation and create potentially explosive mixtures. Wind velocities of less than 20m/s are not technically considered windblasts, but can still cause significant damage and displace large plugs of methane from a goaf into mine roadways.⁵⁶
42. Pike's risk assessment report recorded a number of hazards arising from windblast, including a change in ventilation pressure, which was considered to have only relatively minor consequences because of four 'existing controls'.⁵⁷

Hazard	Existing Controls	Assessment			
		Consequence	Likelihood	Risk Score	Risk Rankin
Change in ventilation pressure due to windblast	Ventilation	2	A	16	
	Rated vent structures				
	Dilution doors				
	Windblast investigation (PRCL 2010)				

Figure 12.10: Hazards arising from windblast

43. However, it was not correct to refer to these four matters as ‘existing’ controls. The generic label ‘ventilation’ was not a meaningful control since ventilation in the hydro panel was not robust enough to deal with the effects of a windblast, particularly as hydro extraction started before the main fan was working. As noted in Chapter 8, ‘Ventilation’, Pike did not have rated ventilation structures, and the structures around the hydro panel were some of the weakest in the mine – as shown by the failure of the stopping in panel 1 after the roof fall on 30 October 2010. Similarly, dilution doors were never operational at Pike River, and the windblast investigation was, at best, a work in progress. The four ‘existing controls’ amounted to little or no protection, and the risk should have been rated ‘high’ or ‘unacceptable’.
44. The risk assessment also considered the hazard of an explosive mixture of gas in the return/through the fan.

Explosive mixture through return / through fan	Fan design (electric installation on intake side)	5	C	22	Restricted access into return	5	D	19
	Dilution doors				Ventilation management plan review (TARP)			
	Monitoring				Ventilation procedures			
	Fan design (anti-spark)							
	Ventilation quantities							

Figure 12.11: Hazard of an explosive mixture of gas in the return/through the fan⁵⁸

45. That hazard initially received a high (red) rating, but that was downgraded to medium because of three proposed additional controls. Neither the existing nor the additional controls were accurately described.
46. The planned dilution doors were not operational, and the monitoring system was not an effective control for the reasons set out in Chapter 10, ‘Gas Monitoring’. The ‘anti-spark’ fan design did not stop sparks coming from the fan on 4 October 2010,⁵⁹ and ‘restricted access into the return’ did not stop contractors and employees working in the return, even in explosive range methane, on several occasions.⁶⁰ Moreover, the review of the ventilation management plan never took place, and the generic description ‘ventilation procedures’ did not translate into anything meaningful. This hazard should also have been rated ‘high’ or ‘unacceptable’.
47. The remainder of the document contained similar problems. Although tasks were assigned to individuals, no dates were set for completion and none were signed off as completed. The exercise was an inaccurate and incomplete assessment of the existing risks and the effectiveness of Pike’s proposed controls. It may have identified problems at the mine, but they were not properly addressed.

Ventilation and gas monitoring risk assessment

48. The third exercise was a ventilation and gas monitoring risk assessment dated 7 September 2010.⁶¹ This also suffered from reliance on non-existent controls and relied on the ventilation management plan as a control for many risks. Yet, as discussed in Chapter 8, the company largely ignored this plan and it was not an effective risk control.

49. The risk assessment generated a list of actions, including some fundamental requirements, such as:
- *Specify construction requirements for [ventilation control devices];*
 - *Ensure [gas] monitors are installed to a standard;*
 - *Determine the capabilities of real time monitoring ;*
 - *Control room operators to be trained in SafeGas; and*
 - *Ensure regular auditing of ventilation system.*⁶²
50. These actions were not allocated to individuals until 16 September 2010, three days before hydro extraction began. In emailing the list to key personnel, Mr White stated 'None of these issues are show stoppers and some will take time to implement.'⁶³ It is a revealing insight into the thinking at the mine that such fundamental requirements were not seen as 'show stoppers'. Many of these requirements had still not been attended to before the explosion on 19 November 2010.

The start of hydro extraction

51. On 19 September 2010 Pike operated the hydro monitor for the first time, and extracted approximately 140 tonnes of coal.⁶⁴ Over the next two months the hydro team encountered a catalogue of problems, including equipment issues, gas and ventilation problems, a lack of hydro experience, the departure of Mr Nishioka and continuing difficulty cutting coal. The hydro team did not achieve the targets it had been set.
52. Neither the hydro project manager (Terence Moynihan) nor the hydro co-ordinator (George Mason) had any hydro-mining experience.⁶⁵ Most of the crew lacked operational hydro-mining experience, and one study by Gregory Borichevsky indicated that operators were not following the cutting sequence up to a third of the time.⁶⁶ In particular, workers were spending too long mining the roof and the floor, diluting the coal with ash and stone.⁶⁷
53. To help address its inexperience in hydro mining, Pike hired Mr Nishioka to help with the commissioning process. During a commissioning stage some teething issues can be expected, but in addition there were equipment and design issues.
54. Mr Nishioka's work record during the monitor's first week of operation noted that:
- the guzzler was too large and complicated;
 - it was hard for the operator to see the direction of the monitor nozzle, because vision was blocked by the housing;
 - methane in the return exceeded 5% as soon as the monitor began cutting;
 - loose stoppings caused methane levels to rise above 5% on several occasions;
 - every hour to hour and a half the monitor clogged up and stopped working;
 - the slurry pipeline became blocked;
 - the 30m panel was too wide for the water jet; and
 - the flume leaked in many places.⁶⁸
55. In mid-October Mr Nishioka left Pike. This was the scheduled time for him to depart, but he told the commission he did not feel comfortable staying.⁶⁹

24-hour production

56. The original aim for the bridging panel was to have a single-shift operation conducting technical investigations and ensuring the equipment was fully operational and effective. However some weeks after hydro mining started, Pike moved to a 24-hour production cycle in the hydro panel, incorporating two 12-hour shifts. The change also required more hydro crews, which exacerbated the problems with operator inexperience.

Strata control in the hydro panel

57. Strata control is critical to ensure the roof and walls of a mine do not collapse. Within a goaf, roof collapse is often desired, in which case it must be managed in a controlled way. Good strata control requires a management plan, adequate geotechnical knowledge and a variety of techniques to manage and monitor underground stability. The three main hazards to be avoided are unplanned roof collapse, unwanted surface subsidence and windblast.

Pike's strata control management plan

58. MinEx produced guidelines in 2009 for the management of strata control in underground mines. The guidelines state that an employer is responsible for the development of a strata management plan. This outlines procedures for safe excavation of strata, for monitoring the effects and for managing strata control issues; it also defines the roles and responsibilities of personnel. Section 3.3 provides that a 'formal documented technical risk assessment ... shall be performed for strata and geological hazards for all excavations prior to development' of its strata management plan.⁷⁰ Such risk assessments 'shall' consider a number of geological and geotechnical factors including the adequacy of the mine's exploration data and its interpretation of the data. The guidelines note that design of adequate strata control requires a geotechnical assessment of many factors, including assessment of the method of extraction, void or caving characteristics, in-situ stress and gas drainage and exploration data.⁷¹
59. There is no evidence of a risk assessment into strata and geological hazards before panel 1 excavation. In October 2010 Pike had a draft strata control management plan based on three stated principles: prediction, prevention and protection. Prediction required the mine to collect, analyse and maintain detailed geotechnical information, and set out the design process for planning strata control, support and pillar design. Prevention required regular evaluation and monitoring, with responsibilities assigned to a 'hydro-mining undermanager' and 'Strata Management Team'. Protection required permits to mine, a trigger action response plan (TARP) and staff training in strata control.⁷²
60. Pike did not fully comply with these principles. It had insufficient geotechnical information on the strata in panel 1 and undertrained hydro crews. There was some monitoring and evaluation,⁷³ but no strata management team and no qualified hydro-mining undermanager. None of the qualified undermanagers at Pike had responsibility for the panel.⁷⁴

Subsidence

61. Minimising surface subsidence was particularly important at Pike River because of DOC requirements under the access arrangement.
62. Consultant geotechnical engineer Dr John St George was Pike's principal adviser on subsidence. He prepared reports supporting the proposed designs of Pike River's bridging and commissioning panels, to ensure minimal surface subsidence and compliance with its access arrangement with DOC.⁷⁵ These reports focused largely on surface effects, rather than the underground safety of Pike's proposals.

Windblast

63. In July 2010, as part of its annual insurance risk assessment, Hawcroft Consulting 'strongly recommended' Pike undertake a thorough risk assessment into the potential for windblast before coal extraction began in panel 1.⁷⁶
64. On approximately 3 September 2010 Pike carried out the 'panel 1' risk assessment, which dealt with many aspects of windblast. However, Pike had inadequate information to assess the likelihood of windblast occurring and, as noted above, many of the 'existing controls' relied on in the risk assessment did not exist or were ineffective.
65. There was no vertical borehole in the area of the hydro panel, so the only geotechnical data available was from vertical drillholes PRDH8 and PRDH37. These were some distance apart to the south and north of panel 1, as shown below circled in red. PRDH47 (shown below circled in blue) was not drilled until after the explosion.

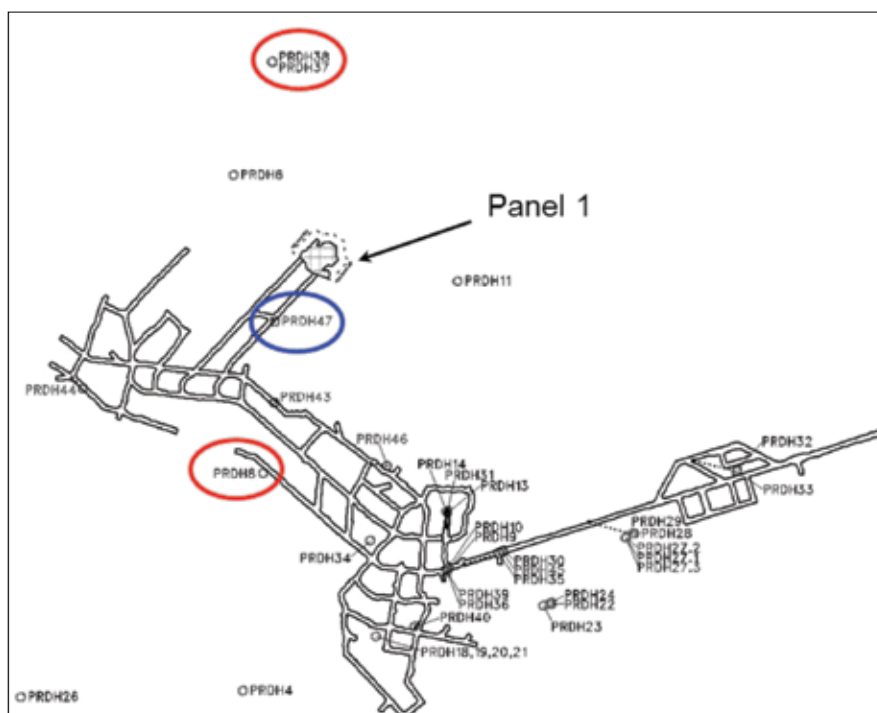


Figure 12.12: Drillholes in the vicinity of Panel 1⁷⁷

66. Consultants Strata Engineering used information from drillholes PRDH8 and PRDH37 to provide Pike with windblast advice on 29 August 2010, and Pike relied on this advice repeatedly in the risk assessment. The advice noted that Pike River's bridging panels were planned to be 31m wide in the first instance, but might increase to 50m in the future, with an extraction height in the 10–13m range.⁷⁸ Pike generally took Strata Engineering's advice, based on modelling, as encouraging about the windblast hazard. The island sandstone was considered likely to bridge over panel widths of up to 30m, and although it might fail over larger distances, this was likely to be progressively in smaller blocks rather than a large plate-like fall associated with windblast.⁷⁹
67. However, Strata Engineering tempered its advice, noting the areas of uncertainty, and emphasised the desirability of 'ongoing collection of structural data ... to assess the structural environment on ... a panel by panel basis'.⁸⁰ Moreover, Strata Engineering later stated that although it knew the Hawera Fault was to the east of panel 1, its advice to Pike would have been different if it had been asked about extending extraction 15m closer to the edge of the fault.⁸¹ However, this was disputed by Mr van Rooyen. He noted Strata Engineering personnel were on site in September and October providing further advice on strata control issues for panels 1 and 2, had seen plans of the extension of panel 1 to the east, and had not altered their advice to Pike.⁸²

Core logging

68. Pike had two main options to obtain more geological information. First, it could have drilled another vertical borehole from the surface above the hydro panel. This would have been expensive and further delayed the start of hydro extraction. Pike did not pursue this option.
69. As an alternative, Pike planned to use core logging. This involved drilling holes in the roof and floor and taking a core sample for geotechnical logging. The technical services department wanted to complete core logging to assess the risks identified by Strata Engineering, and to assess such things as the spontaneous combustion potential of the rider seam, the depth of the interburden layer and its characteristics and capabilities, whether there were weak zones in the strata, and the layering of the sandstone structure. Pike also wanted to develop a correlation between what was cored and the strata behaviour recorded before, during and after panel 1 was mined.⁸³
70. Dr St George also supported core logging of all extraction zones. He emphasised it was essential that caving of the roof strata was 'monitored and managed since it presents a safety hazard as well as an influence on subsidence'.⁸⁴

71. Pike did not achieve core logging before hydro mining began. On 10 September 2010 Pieter van Rooyen expressed his frustration in an email to Mr White and others, writing in capital letters 'CAN THIS ISSUE PLEASE BE ADDRESSED ASAP', noting the information was required to 'ensure the assumptions in strata control designs, windblast and caving characteristics is correct (or at least acceptable)'.⁸⁵
72. The main obstacle was Pike's inability to supply enough air pressure to run the required drill rig. Despite the engineering department suggesting another option, that did not occur and extraction began in panel 1 without core logging being done.⁸⁶
73. There was bore scoping done in panel 1 roadways, where holes were drilled and a bore scope inserted allowing the operator to view and log the strata and its geology.⁸⁷ But the results were of poor quality and Strata Engineering advised that they should be treated with some caution.⁸⁸
74. Starting coal extraction in panel 1 before geotechnical core logging could be done meant the opportunity to obtain vital geotechnical data was lost. The importance of data from this area of the coalfield should not have been underestimated.

Further advice, and the widening of the panel

75. In early September 2010 Pike engaged an Australian geotechnical engineering consultant, Dr William Lawrence of Geowork Engineering Pty Ltd, to assist with strata issues. Among other tasks,⁸⁹ he was asked to consider and review work already done on the effects on the overlying strata of varying the proposed widths of bridging panels.⁹⁰
76. On 27 September, a week after hydro extraction began, Pike asked Dr Lawrence to assess the ability of the island sandstone to form a bridging beam across both panels 1 and 2.⁹¹ Dr Lawrence faced the same difficulties as Strata Engineering with the lack of data from Pike, and requested information that was not available.⁹²
77. On 6 October 2010 the technical services department recommended widening panel 1 by up to 15m to the east to extract more coal. Pike estimated this would increase the recoverable coal by 50%.⁹³ This was authorised on 15 October 2010,⁹⁴ although Mr White did not formally sign off on widening panel 1 until 18 October 2010.⁹⁵
78. On 25 October 2010 Dr Lawrence gave Pike his report summarising the characteristics, behaviour and spanning capability of the island sandstone. As with the earlier report by Strata Engineering, Pike drew comfort from Dr Lawrence's views. However, the report emphasised that the lack of data to date meant 'critical parameters have been assumed, which does result in some uncertainty'.⁹⁶

A warning – roof fall on 30 October 2010

79. Five days later, on 30 October 2010, part of the roof in the panel 1 goaf collapsed. The resulting rush of air was strong enough to knock over the stopping in the hydro panel cross-cut, and result in an explosive accumulation of methane.⁹⁷
80. There was no formal investigation into the roof fall, but visual examinations of the rubble found larger blocks of white stone had fallen but no coal, and there were different views on whether the roof collapse had extended up to the rider seam.⁹⁸
81. Pike did not want a recurrence of stumps of coal left in the goaf that were unreachable by the monitor water jet. A 'best practice' monitor cutting technique was designed, directing the hydro crews to create only temporary stumps in the goaf, to be extracted last. This was intended to ensure a more controlled roof fall in future.⁹⁹

Further assessment of risks

82. After receiving advice from Strata Engineering and Geowork Engineering that windblast and large goaf falls could not be excluded, given the lack of geotechnical data, Pike did not reconsider the potential for these hazards and the effectiveness of its possible controls and did not suspend hydro extraction to enable further data collection from panel 1. The unexpected large roof fall on 30 October also failed to trigger any further review, despite the methane plug released and the destruction of the panel ventilation stopping.

Ongoing problems

83. Pike's problems with the hydro-monitor production continued, and on 19 October 2010 Pike downgraded its production forecast for the period to 30 June 2011 from 620,000 tonnes to between 320,000 and 360,000 tonnes.¹⁰⁰
84. By late October Pike internally described the lack of hydro output as 'untenable'.¹⁰¹ Mr Mason instigated a productivity review group and Mr White sought advice by email from Mr Nishioka.¹⁰²
85. Pike considered that the difficulties arose from the hardness of the coal, technical issues with the hydro monitor cutting performance and inconsistent operating standards. The first retreat of the monitor was authorised on 22 October 2010, meaning a month was spent attempting to extract its first lifts of coal.¹⁰³
86. In its search for answers, the review group considered panel design issues, including extraction pillar dimensions, viable monitor cutting distances and repositioning of monitor and water jet orientation; the need for systematic collection of operational data; changes to management responsibilities; greater insistence on cutting sequences and standards from monitor operators; use of drill and blast methods within the panel to loosen up the coal; and the need for more testing, given the lack of 'raw data gathered to characterise the coal that we are cutting'.¹⁰⁴ The group identified changes to the process, but the explosion intervened.¹⁰⁵
87. On 15 November 2010 Mr Whittall told Pike's annual general meeting:

*I am very pleased with the way the process has gone. There have been no significant issues and the hydro system cuts and flows through the Coal Preparation Plant as it is supposed to.*¹⁰⁶

Conclusions

88. Delays in achieving coal production resulted in a change of location for the hydro panel. This change was hurried and poorly managed in a number of respects:
 - Geotechnical knowledge of the bridging panel strata conditions was limited and the risks arising from hydro extraction were inadequately assessed.
 - The board initiated a staff bonus scheme based on reaching a coal production target promptly, with the bonus then reducing from week to week.
 - Hydro production was affected by equipment, crew inexperience, ventilation and methane problems. Coal production levels remained very low.
 - On 30 October a roof fall in the hydro panel goaf expelled a large volume of methane and damaged a nearby stopping, but there was no adequate management review and response to this event.
 - Generally, the hazards of hydro mining were not sufficiently understood and coal extraction at Pike River should have been suspended until a second egress and strata, ventilation and gas management problems were resolved.

ENDNOTES

¹ Diagram provided by Peter Whittall, PW54/1.

² Craig Smith, witness statement, 9 November 2011, SOL446723/9, para. 28.

³ Department of Labour, *Pike River Mine Tragedy 19 November, 2010: Investigation Report*, [2011], DOL3000130010/54.

⁴ David Reece, DR3 and DR4 Hydro Panel – Goaf Diagram, DOL3000150011/1. (Extract of diagrams modified by commission to remove caption from image)

⁵ George Mason, witness statement, 31 October 2011, MAS0001/9–11, paras 36–43.

⁶ Ibid., MAS0001/11.

⁷ Peter Whittall, witness statement, 22 June 2011, PW0/12, para. 45.

⁸ Stephen Wylie, transcript, pp. 3715–16.

⁹ Pike River Coal Ltd, Monitor Extraction Guidelines, 10 November 2010, DAO.010.00399/1–8; Craig Smith, transcript, p. 3405.

¹⁰ Ibid., DAO.010.00399/8. (Diagram modified by commission)

¹¹ Ibid.

¹² Craig Smith, transcript, p. 3410; Craig Smith, witness statement, 9 November 2011, SOL446723/11, para. 34.3.

- ¹³ Craig Smith, transcript, p. 3405; Masaoki Nishioka, transcript, p. 3491.
- ¹⁴ David Stewart, transcript, p. 3339.
- ¹⁵ Craig Smith, witness statement, 9 November 2011, SOL446723/7, paras 18–19.
- ¹⁶ Masaoki Nishioka, transcript, p. 3478.
- ¹⁷ CMS Ltd, Pike River Coal Mine Pre-feasibility Study, 25 May 1995, NZOG0002/6; Minserv International Ltd, Pre-feasibility of the Pike River Coal Mining Project, March 1998, NZOG0005; Graeme Duncan, witness statement, 31 January 2012, GD00/11, para. 26.
- ¹⁸ Access Arrangement under Crown Minerals Act 1991, Mining Permit 41-453, Pike River Coal Company Ltd, 21 October 2004, NZOG0018/20–21.
- ¹⁹ Department of Conservation, Meeting Notes, 21 December 2007, DOC3000010003/2.
- ²⁰ Pike River Coal Ltd, Concept Options to Increase Production Outputs Jan–Jun 09, 8 December 2008, DAO.004.10880/1–9.
- ²¹ Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/19, para. 99.
- ²² John St George, Technical Memorandum on Subsidence Related to the Commissioning of Bridging Panels at Pike River Coal Mine, 28 September 2009, DAO.003.10936/3.
- ²³ Department of Conservation, Departmental Decision Request Regarding Mining Operations at Pike River Coal Mine, 17 November 2009, DOC3000010011/1–2.
- ²⁴ Department of Conservation, Departmental Decision Request Regarding Mining Operations at Pike River Coal Mine, 24 May 2010, DOC3000010013/1–2. The approval was based upon an amended technical memorandum prepared by John St George, Subsidence Implications of Amended Design to the Commissioning and Bridging Panels at Pike River Coal Mine, 7 May 2010, DAO.004.10148/1–2.
- ²⁵ Pike River Coal Ltd, 4-Year Plan, 10 November 2010, EXH0008.
- ²⁶ Pike River Coal Ltd, New Zealand Prospectus: An Offer of Shares in a Major New Zealand Coal Company, 22 May 2007, DAO.012.02790/45.
- ²⁷ Hydro-Project Update, 24 February 2010, DAO.002.14285/1.
- ²⁸ Masaoki Nishioka, transcript, pp. 3485–86.
- ²⁹ Ibid., pp. 3476–77. Mr Nishioka was involved with Mitsui Mining Engineering Co. Ltd in the Spring Creek proposal in the 1980s, as well as the successful trial of hydro mining at the old Strongman mine in the 1990s, and the early exploration phase for Pike River mine: Report of the Ministry of Energy for the Year Ended 31 March 1983, MED0010040007/31.
- ³⁰ Masaoki Nishioka, transcript, p. 3486; Seiko Mining & Construction Ltd, Equipment & Material Specifications for Pike River Coal Ltd, March 2008, DAO.025.20325/1.
- ³¹ Masaoki Nishioka, transcript, pp. 3606–07.
- ³² Ibid., p. 3490; Masaoki Nishioka, witness statement, 25 October 2011, NISH0001/11, para. 42.
- ³³ Masaoki Nishioka, transcript, p. 3487; Masaoki Nishioka, work record, NISH0002/21.
- ³⁴ Masaoki Nishioka, transcript, pp. 3492–94; Masaoki Nishioka, witness statement, 25 October 2011, NISH0001/6–8, paras 22–24. For example, the high-pressure joints were a prototype that had never been field tested, and when they were used they leaked and created a safety hazard.
- ³⁵ Masaoki Nishioka, transcript, pp. 3491, 3496, 3503, 3555.
- ³⁶ Pike River Coal Ltd, Performance Bonus 2009/10, 2010, DAO.001.13841/5.
- ³⁷ Email, Peter Whittall to John Dow, 5 October 2010, DAO.007.28453/1.
- ³⁸ John Dow, transcript, p. 4043.
- ³⁹ John Dow, witness statement, 9 June 2011, DAO.001.0003/6, paras 27–28.
- ⁴⁰ Email, John Dow to Gordon Ward, 5 July 2010, DAO.008.21575/1.
- ⁴¹ John Dow, transcript, pp. 3934, 4056.
- ⁴² Ibid., p. 3936.
- ⁴³ Ibid., p. 4055.
- ⁴⁴ At the time the Pike board of directors approved the bonus, internal documents said the commissioning of the main underground fan would not start until 6 September 2010, or more likely 11 September 2010: Hydro Project Update, 15 June 2010, DAO.002.14606/3; Masaoki Nishioka, work record, NISH0002/27; John Dow, witness statement, 9 June 2011, DAO.001.0003/47, para. 315.
- ⁴⁵ Masaoki Nishioka, transcript, p. 3490; Michael Scott, witness statement, 30 May 2012, SCO7770010001/15, para. 58; Petrus (Pieter) van Rooyen, transcript, pp. 5225–26; Drive Mining Pty Ltd, Pike River Coal Ltd – Gas Management Primary Report, 22 July 2010, DAO.001.04909/10–11.
- ⁴⁶ Masaoki Nishioka, work record, NISH0002/27.
- ⁴⁷ Masaoki Nishioka, transcript, p. 3620.
- ⁴⁸ Pike River Coal Ltd, Operations Meeting Minutes, 15 September 2010, DAO.002.14871/6.
- ⁴⁹ Masaoki Nishioka, work record, NISH0002/23.
- ⁵⁰ Ibid., NISH0002/22.
- ⁵¹ Douglas White, transcript, p. 4883; Hydro Project Update, 17 August 2010, DAO.002.14796/11.
- ⁵² Pike River Coal Ltd, Operational Preparedness Gap Analysis, August 2010, DAO.003.08875/1–5.
- ⁵³ Email, Jerry Wallace to Peter Whittall and Gregory Borichevsky, 23 August 2010, INV.04.00275/9.
- ⁵⁴ Email, Jerry Wallace to Gregory Borichevsky and Peter Whittall, 27 August 2010, INV.04.00849/1.
- ⁵⁵ Ibid., INV.04.00849/2.
- ⁵⁶ New South Wales Department of Primary Industries, Mine Safety Operations Division, Windblast Guideline: MDG 1003, November 2007, CAC40149.
- ⁵⁷ No additional controls were listed: Pike River Coal Ltd, Formal Risk Assessment, undated, DAO.011.00007/5–6.
- ⁵⁸ Ibid., DAO.011.00007/6–7.
- ⁵⁹ Masaoki Nishioka, work record, NISH0002/27.
- ⁶⁰ Pike River Coal Ltd, Incident/Accident Form, 6 May 2010, DAO.001.00885/1–2; Daniel Rockhouse, Police/DOL interview, 8 December 2010, INV.03.01747/12–13.
- ⁶¹ Pike River Coal Ltd, Formal Risk Assessment, Ventilation and Gas Monitoring, 7 September 2010, DAO.011.00025/1.
- ⁶² Email, Douglas White to George Mason, Pieter van Rooyen, Robb Ridl and Bernard Lambley, 16 September 2010, INV.04.00712/14.
- ⁶³ Ibid., INV.04.00712/1.
- ⁶⁴ Masaoki Nishioka, work record, NISH0002/21.
- ⁶⁵ Terence Moynihan, witness statement, 25 May 2012, MOY7770010001/22; George Mason, witness statement, 31 October 2010, MAS0001/5, para. 14.
- ⁶⁶ Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/47, paras 321–22.
- ⁶⁷ Ibid., BOR0001/47, para. 325.
- ⁶⁸ Masaoki Nishioka, work record, NISH0002/21–23.
- ⁶⁹ Masaoki Nishioka, transcript, p. 3545.
- ⁷⁰ MinEx Health & Safety Council, Guidelines for the Management of Strata in Underground Mines and Tunnels, October 2009, CLO0010014980/3.
- ⁷¹ Ibid., CLO0010014980/9, 11.
- ⁷² Pike River Coal Ltd, Strata Control Management Plan: Management Plan (Final Document), 21 October 2010, DAO.025.38374/9–11, 13, 15.
- ⁷³ Strata Management/Control Monitoring, DAO.003.16430/1 (undated but believed to be November 2010); Petrus (Pieter) van Rooyen, transcript, pp. 5244–46.
- ⁷⁴ Stephen Wylie, transcript, pp. 3707–08. The hydro co-ordinator acted as the undermanager but did not hold the necessary certificate of competence for that role: George Mason, transcript, p. 3662.
- ⁷⁵ John St George, Subsidence Implications of Amended Design to the Bridging Panels at Pike River Coal Mine: Amendment 2, 23 August 2010, DAO.025.42050/1.
- ⁷⁶ Hawcroft Consulting International, Pike River Coal Limited, Pike River Mine – Risk Survey – Underground, CPP & Surface Operations: Draft Report: PRCL Comments, July 2010, DAO.003.08590/58. The draft report was first given to Pike by Jerry Wallace of Hawcroft on 4 August 2010: Email, Jerry Wallace to Peter Whittall, Colin Whyte, Gregory Borichevsky, 4 August 2010, INV.04.00392/4.
- ⁷⁷ Pike River Coal Ltd, Surface Boreholes, 30 August 2011, DAO.031.00004/1. (Extract of the plan modified by the commission)

⁷⁸ Strata Engineering (Australia) Pty Ltd, Windblast Potential for Panel 1 at Pike River Coal, 29 August 2010, DAO.001.11042/1. It seems that Strata Engineering was not aware, at least at that stage, that Pike already intended to widen panel 1 up to 50m to extract more coal.

⁷⁹ Ibid., DAO.001.11042/4–5.

⁸⁰ Ibid., DAO.001.11042/5.

⁸¹ Email, David Hill to Jane Birdsall, 7 October 2011, DOL3000150007/1.

⁸² Petrus (Pieter) van Rooyen, transcript, pp. 5165–67.

⁸³ Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/40, paras 279–80.

⁸⁴ John St George, Workshop on Subsidence, 15 October 2010, DAO.025.38605/5.

⁸⁵ Email, Pieter van Rooyen to Douglas White, Robb Ridl, Peter Sinclair, Bernard Lambley and others, 10 September 2010, DOL3000150006.

⁸⁶ Petrus (Pieter) van Rooyen, transcript, pp. 5243–44.

⁸⁷ Ibid., pp. 5244–45.

⁸⁸ Strata Engineering (Australia) Pty Ltd, Secondary Roof Support Recommended for the Extraction of Panel 1, 5 October 2010, DAO.001.11049.

⁸⁹ On 18 September 2010 Dr Lawrence provided Pike with a report on interpanel barrier pillar widths: Geowork Engineering Pty Ltd, Production Panel Pillar Width – Initial Specification, 18 September 2010, DAO.001.10765/1–9.

⁹⁰ From 30m to 60m and 90m in width: Email, Huw Parker to William Lawrence, 21 September 2010, DAO.025.38932/1.

⁹¹ Email, Huw Parker to William Lawrence, 27 September 2010, DAO.025.39088/1.

⁹² Email, William Lawrence to Huw Parker, 21 September 2010, DAO.025.39010/1. He also asked whether Pike was aware of other areas where island sandstone bridging had occurred: Email, William Lawrence to Huw Parker, 12 October 2010, DAO.025.37384/1.

⁹³ Memorandum, Gregory Borichevsky to Douglas White, Pieter van Rooyen and Stephen Ellis, 6 October 2010, DAO.025.33968/2–4.

⁹⁴ Pike River Coal Ltd, Permit to Mine – 1 West 1 Right – Panel 1 Extraction CH189m, 15 October 2010, DAO.001.03568/1. This permit to mine was for chainage (position) 189m only, as Mr van Rooyen said he was not prepared to permit a full panel width extension until Pike had received the further report on caving and subsidence from Dr Lawrence – Petrus (Pieter) van Rooyen, witness statement, 27 January 2012, PVR001/22, para. 118.

⁹⁵ Memorandum, Gregory Borichevsky to Douglas White, Pieter van Rooyen and Stephen Ellis, 6 October 2010, DAO.025.33968/3.

⁹⁶ Geowork Engineering Pty Ltd, Production Panels 1 and 2 Layout Considerations – Summary of Numerical Modelling Outcomes, 25 October 2010, DAO.001.10780/10.

⁹⁷ Stephen Wylie, Pike River Coal – Deputy Statutory Report, 29 October 2010, DAO.001.02837.

⁹⁸ Stephen Wylie, written statement, 31 October 2011, WYL0001/10, para. 49; George Mason, written statement, 31 October 2011, MAS0001/16, para. 72.

⁹⁹ Pike River Coal Ltd, Monitor Extraction Guidelines, 10 November 2010, DAO.010.00399/1–8; Gregory Borichevsky, witness statement, 26 June 2012, BOR0001/49, paras 340–41; Terence Moynihan, witness statement, 25 May 2012, MOY7770010001/24, para. 9.1.18.

¹⁰⁰ David Salisbury, witness statement, 25 May 2011, NZOG0068/37, para. 148.

¹⁰¹ Email, George Mason to Matt Coll, Terence Moynihan, Gregory Borichevsky, Robb Ridl, Huw Parker, Stephen Ellis and Douglas White, 31 October 2010, MOY7770010008/1.

¹⁰² Emails between Douglas White and Masaoki Nishioka, 9–10 November 2010, MOY7770010008/3–4.

¹⁰³ Pike River Coal Ltd, Permit to Mine – 1 West 1 Right – Panel 1 Extraction CH 183m, 22 October 2010, DAO.001.13932/1.

¹⁰⁴ Email, Terence Moynihan to Douglas White, 17 November 2010, MOY7770010008/2, Email, Terence Moynihan to George Mason, Gregory Borichevsky, Tjaart Heersink and Huw Parker, 17 November 2010, MOY7770010008/6–8.

¹⁰⁵ Pike River Coal Ltd, Panel 1 Lift 3 Modified Mining Plan – Risk Assessment (Draft Document), 17 November 2010, DAO.025.38089/1.

¹⁰⁶ Pike River Coal Ltd, News Release, 2010 AGM – Chief Executive Address, 15 November 2010, NZX2422/3.



How did it happen?

- + Pike's safety culture
- + The likely cause of the explosions
- + Regulator oversight at Pike River

Workplace culture

What is safety culture: is it tangible?

1. In considering safety culture, Neil Gunningham and David Neal, in their 2011 review of the Department of Labour (DOL)'s interactions with Pike River, stated that it was 'exceptionally difficult for the inspectors to address issues of safety culture', since their occasional visits provided only a snapshot and 'they were not equipped to investigate complex issues of safety culture (or the lack of such a culture), which are largely intangible and do not lend themselves to ready investigation'.¹ Dr Kathleen Callaghan strongly disagreed with the latter part of this statement. In her view the published literature shows that safety culture is not intangible, and that it may be evaluated. Moreover, she believed that for the commission 'to dismiss safety culture as too complex and intangible [would be] to ignore a core element of the disaster at Pike River'.²
2. This difference of opinion suggests the need to define what is meant by culture. The commission has found a discussion by Andrew Hopkins helpful.³ He suggests that two common understandings about culture centre on 'mindset', and on 'the way we do things around here'. 'Mindset' involves a focus on individual values, while 'the way we do things' concerns collective behaviour. There is no conflict between the two ideas; rather they reflect a difference of emphasis. Both, in fact, go to make up culture – the way in which people both think and act.
3. Hopkins, however, stresses the importance of organisational practices because individual attitudes are more difficult to determine and unlikely to be capable of modification in a workplace unless the environment is conducive to change. James Reason suggests that the key may be conscious attention to safety systems and practices, in particular 'a safety information system that collects, analyses and disseminates the knowledge gained from incidents, near misses and other "free lessons"'.⁴

What organisational practices measure culture?

4. Operators in a high-hazard industries must establish structures that enable a response to the unexpected. These structures include safety, reporting, auditing, training and maintenance systems.⁵ They require resources, which should be allocated at governance level. This essential leadership from the top begins to set the cultural tone.
5. A safety conscious organisation needs to involve people at all levels: management, supervisors and workers at the coal face. Take methane control, a critical safety concern in an underground coal mine. Methane levels must be monitored throughout a mine on every shift. This requires the input of many people, from miners using portable gas detectors to control room operators who receive periodic methane readings from fixed sensors. Management must establish systems to assess this data to determine whether there is a hazardous trend and, if so, decide on the appropriate response.
6. The methane readings, however, are backward-looking indicators. Equally important are forward-looking indicators, which test the worth of the monitoring regime itself. There must be verification that portable detectors are readily available and accurate, and that there are enough fixed sensors in appropriate positions and that their calibration and accuracy are assured. This requires the involvement of operational planners, managers, electricians and technicians, who test and report on the monitoring system. Ongoing review and verification of the system's adequacy are also necessary as the mine grows and develops.

7. An assessment of the methane monitoring systems and practices, including the resourcing provided, the level of reporting, the response to data, the testing of devices, and the ongoing review and oversight of the system as a whole, will provide a valuable insight into the organisational culture.

A number of cultural influences

8. Organisational culture is not one-dimensional. A mixture of behaviours and attitudes is to be expected in a workplace, and particularly in a large and diverse organisation like Pike. Nor will the cultural influences be consistent, or all point in a single direction. Other chapters identify a number of cultural strands that existed at the mine.

An environmental culture

9. Pike had a strong environmental culture. When the company received an award from the Department of Conservation (DOC) in September 2008, the minister of conservation shortly afterwards described the mine as a 'showcase development'.⁶ Pike not only met the environmental requirements of its access agreement with DOC, but also initiated predator control programmes over and above its contractual obligations.

Production before safety

10. Coal production is, of course, the core objective of a mining company. But this imperative remains subject to an employer's statutory obligation 'to take all practicable steps to ensure the safety of employees'.⁷ The commission considers that the way in which hydro mining began at Pike indicates a culture that put production before safety.
11. Chapter 12, 'Hydro mining', discusses the reasons for this conclusion. They include locating the panel next to pit bottom, beginning coal production before a second outlet from the mine was developed, introducing hydro mining without completing a comprehensive risk assessment process, not adequately understanding the roof strata, proceeding before the ventilation fan was commissioned, widening the panel despite a geotechnical deficit, and failing to reassess the operation in light of methane issues and the collapse of the goaf on 30 October 2010.
12. In addition, Pike had no previous experience in hydro mining, and used a largely inexperienced workforce and a co-ordinator who was neither qualified nor confident in the role. The Pike board approved a hydro-mining bonus payable to workers if a production target was met by a defined date, after which the bonus reduced progressively each week. These factors, in combination, compel the commission to conclude that, in September 2010 as hydro mining began, the pressure for production overrode safety concerns.

Recklessness underground

13. Chapter 6, 'The workforce', considers workforce matters, including the inexperience of many of the miners and the low ratio of experienced to inexperienced men in the crews. A witness with almost 40 years' mining experience, who was trained in an English colliery, recounted safety incidents at Pike that he attributed to a gung-ho attitude underground. Inexperienced workers could be overconfident, failed to understand how their actions endangered others and did not treat mining with respect.⁸ He attributed these problems mainly to the experience ratio, saying that there were too few experienced miners to set and maintain the required standards.⁹
14. The commission accepts this opinion. It is supported by the evidence of contraband and bypassing incidents, conduct that seems inexplicable if viewed in isolation. There was clearly an attitude of recklessness in at least some quarters of the workforce.

The response to safety information

15. Many catastrophic accidents are preceded by situations in which warning signs are normalised, dismissed as intermittent or simply ignored.¹⁰ At Pike, however, a lot of safety information was not assessed at all. It simply remained unnoticed in the safety management system.

16. These aspects are discussed in Chapter 7, 'Health and safety management'. Throughout the commission's hearings, witnesses disavowed knowledge of methane spikes, ventilation problems and a host of other signs that suggested all was not well underground. A repeated refrain from witnesses was that no one drew this or that report or data to their attention. Pike's safety management system lacked an essential component – procedures that made specific people responsible for collecting, assessing and responding to safety information. Nor was there a functioning process for communicating information to everyone on a need-to-know basis.

Was health and safety management taken seriously?

17. As Pike's health and safety manager told the commission, his brief from the company was to develop a world-class health and safety management system. Much time and effort was devoted to putting in place what was seen as a best practice system. Documents were drawn up, systems were prescribed and training programmes established.
18. But, as discussed in the chapters on health and safety management and the critical mine systems, commitment from others was lacking. The board and executive management did not lead the process. Most documents remained in draft, and many were not followed anyway. Systems were set up, but were not used as intended. Safety information was not well monitored, and internal and external review of the system was very limited.
19. Ultimately, the worth of a system depends on whether health and safety is taken seriously by everyone throughout an organisation; that it is accorded the attention that the Health and Safety in Employment Act 1992 demands. Problems in relation to risk assessment, incident investigation, information evaluation and reporting, among others, indicate to the commission that health and safety management was not taken seriously enough at Pike.

The risk of an explosion

20. Did culture affect the ability of decision makers at Pike to appreciate the risk of an explosion? A culture that put short-term production before safety as hydro mining began could well affect the ability to appreciate an explosion risk as well. The following aspects are also relevant to this question.

The emergency response management plan

21. This plan was prepared in 2009, and signed off by Peter Whittall as general manager. Section 6.5 of the plan described emergency response actions with reference to six emergency situations: earthquake, flood, pipeline rupture, major slope failure, underground fire, and explosion and outburst.
22. The risk posed by explosion and outburst was described at 6.5.6 in these terms:

The risk of outburst is considered as being low at PRCL [Pike River Coal Ltd] and gas build up is minimised via ensuring that ventilation is maintained at a level considered to be of sufficient quantity to dilute the methane content to more acceptable levels. Gas drainage is also conducted via in-seam drilling to pre-drain ahead of workings to further reduce the potential of outburst occurring and to reduce the gas make in active workings. Stone dusting practice is also maintained to reduce the risk of coal dust explosion potential. The use of hydro-extraction will minimise the risk of frictional ignition in the main coal extraction panels.¹¹
23. This is an optimistic assessment of the risk posed by an underground explosion. It assumes that good ventilation and in-seam drilling to reduce the gas make will prevent a methane accumulation. It anticipates only one potential ignition source, frictional ignition, an unlikely source during hydro mining. Given that Pike River was a gassy mine located in a region with a history of methane tragedies, the commission regards the description of the risk profile as understated.

An indifference to methane spikes

24. Chapter 10, 'Gas monitoring', contains a review of methane monitoring at the mine, including reference to the prevalence of methane spikes in the period from 1 October to 19 November.¹² Employees must be withdrawn from

a mine when the volume of flammable gas in the general body of air is 2% by volume,¹³ and methane becomes explosive at a level of 5% in air.

25. Despite a paucity of well-positioned fixed methane sensors at Pike River, there were still numerous methane readings that provided ample warning of regular high methane accumulations in the period before the explosion. Deputies using hand-held detectors reported readings of 2% or higher on 48 occasions in 48 days, and 5% concentrations on 21 occasions. Readings of 5% were also routinely recorded in the hydro panel return, and the mine's remote monitoring system logged four methane readings of 2.5% or more in the final 26 days.¹⁴ Together, these readings provided a graphic illustration of the extent of this problem.
26. The mine manager, Douglas White, was asked whether this evidence indicated that the occurrence of methane spikes had become 'normalised' at Pike River, to which he responded not normalised but 'certainly something that was happening frequently, more frequently than was desired'.¹⁵

Disbelief on 19 November 2010

27. The explosion occurred at 3:45pm. All reporting and communications from the mine ceased immediately. At 4:26pm, 41 minutes after the explosion, Mr White finally authorised a call to emergency services. By then, Mattheus Strydom had been into the mine and had confirmed that an explosion had occurred.
28. In Chapter 16, 'Search, rescue and recovery', the commission finds that the loss of power and of telemetric reporting from underground, and the absence of response to calls from the control room, were unprecedented and indicated a serious situation that should have been recognised straightaway.

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.

Conclusions

33. The commission considers that as at November 2010, the emphasis placed on short-term coal production so seriously weakened Pike's safety culture that signs of the risk of an explosion either went unnoticed or were not heeded.

ENDNOTES

¹ Neil Gunningham and David Neal, Review of the Department of Labour's Interactions with Pike River Coal Limited, 4 July 2011, DOL0100010001/131, para. 471.

² Kathleen Callaghan, witness statement, 31 October 2011, FAM00042/55, para. 205.

³ Andrew Hopkins, Failure to Learn: The BP Texas City Refinery Disaster, 2008, CCH Australia Ltd, p. 141.

⁴ James Reason, 'Achieving a Safe Culture: Theory and Practice', *Work and Stress*, 1998, Vol. 12, No. 3, p. 302.

⁵ Andrew Hopkins, Failure to Learn, p. 145.

⁶ Pike River Coal Ltd, Activities Report: Quarter ended 31 December 2008*, DAO.008.04847/1.

⁷ Health and Safety in Employment Act 1992, s 6.

⁸ Albert (Alan) Houlden, witness statement, 14 November 2011, FAM00053/8, para. 39.

⁹ Ibid., FAM00053/11–12, paras 58–61.

¹⁰ Andrew Hopkins, 'A Culture of Denial: Sociological Similarities between the Moura and Gretley Mine Disasters', *Journal of Occupational Health and Safety – Australia and New Zealand*, 2000, Vol. 16, No. 1, pp. 29–36.

¹¹ Pike River Coal Ltd, Emergency Response Management Plan, 20 February 2009, DAO.001.08110/39.

¹² Chapter 10, 'Gas monitoring', para. 43.

¹³ Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 21.

¹⁴ Chapter 8, 'Ventilation', paras 140–141, 143.

¹⁵ Douglas White, transcript, p. 4945.

¹⁶ Ibid., p. 1259.

¹⁷ Stephen Ellis, transcript, p. 2228.

¹⁸ Peter Whittall, transcript, p. 2791.

CHAPTER 14

The likely cause of the explosions

Introduction

1. The commission is required to report on the cause of the explosions at Pike River on and after 19 November 2010. Because the mine has not been re-entered, the cause of the first, and subsequent, explosions can be based only on the evidence available without a scene examination.
2. The commission accessed work undertaken by a team of investigators and a panel of experts established by the Department of Labour (DOL).¹ The panel was co-ordinated by David Reece, a Brisbane-based mining consultant with a wealth of experience in mine management, mine inspection and advising the mine industry. The other panel members are Professor David Cliff, an expert in gas analysis and mine explosions, Dr David Bell, a mining geologist, Tim Harvey, a ventilation engineer, and Anthony Reczek, an electrical engineer. In October 2011 the panel provided the department with a report on the nature and cause of the first explosion. In February 2012 the investigation team leader, Brett Murray, and Messrs Reece and Reczek gave evidence at a commission hearing. The commission acknowledges DOL's co-operation in making the main investigation and the expert reports available and also in providing oral evidence.
3. Determination of the cause is complex. As will be seen, the commission is confident that the explosions were caused by the ignition of methane. But to determine why and where they occurred required expert analysis and assumptions. One of the most important estimates the experts had to make was the volume of methane that ignited; this then allowed the circumstances surrounding the explosion to be inferred. Estimates of the amount of methane varied depending on the assumptions adopted.²
4. The following discussion about the causes of the explosions is not intended to be definitive. If, and when, the mine is re-entered, any conclusions about the causes of the explosions will need to be re-evaluated.

The cause of the first explosion

Activities in the mine on the day

5. The DOL investigation report contains a close description of the mine workplaces and an intricate analysis of all known events that occurred during the morning shift and into the afternoon shift on 19 November.³ The following discussion does not replicate this level of detail, but reviews the essential facts.
6. On the afternoon of 19 November there were eight places in the mine where workers were engaged in different activities. These areas are best explained by reference to a mine map drawn to indicate the last-known position of all the men underground at 3:45pm.

The ABM20

7. The ABM20 continuous miner was driving a roadway at the north-west extremity of the mine. An eight-man morning crew cut 3m of new roadway during the shift. Progress was slow because branches of an in-seam borehole were intersected, resulting in methane emissions that caused the continuous miner to trip out. Readings of up to 3.5% methane were recorded in the general body of air, until the gas was dispersed using a typhoon fan and the transected branches of the borehole were plugged.

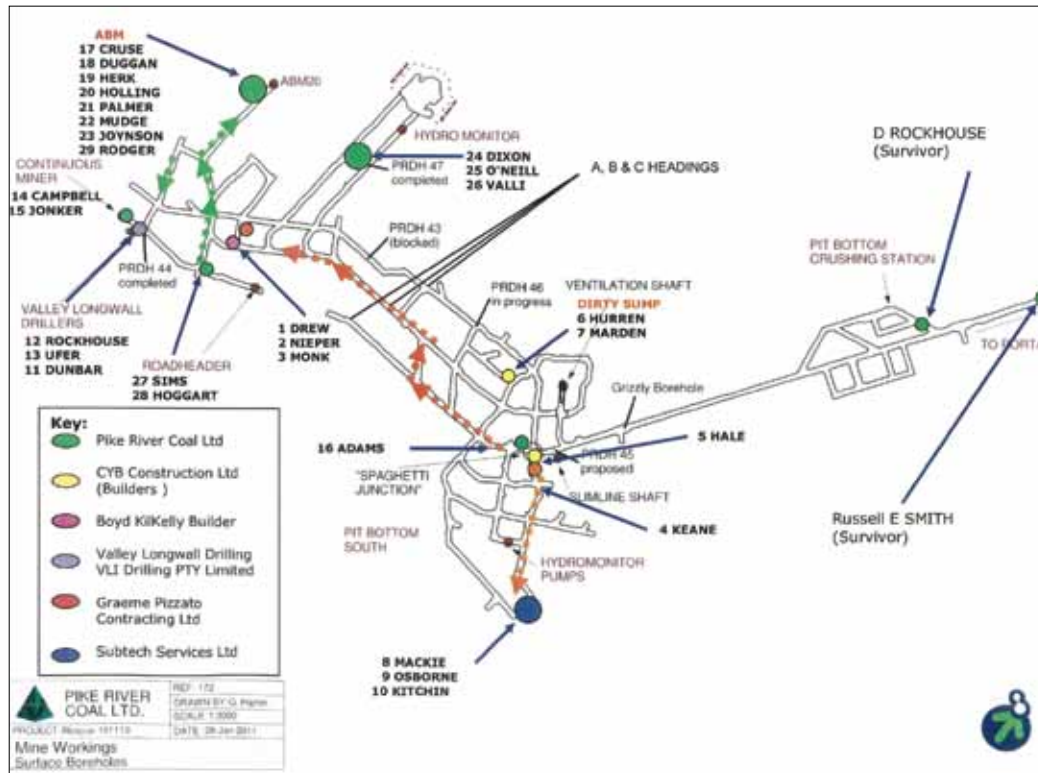


Figure 14.1: Last known position of the 29 deceased and two survivors⁴

The three main roadways running in parallel from pit bottom in a north-westerly direction are known as headings A, B and C from the bottom of the plan, with A heading still incomplete.

8. At 12:20pm mining ceased because fluming water to carry coal from the face was lost owing to a planned shutdown. The afternoon crew reached the face about 2:00pm, and were stocking up the ABM20 and carrying out roadway maintenance while waiting for mining to recommence. Some men may have begun stone dusting or been on a crib break at 3:45pm. Mining could not have resumed because the fluming pumps were still in start-up mode at the time of the explosion.

The roadheader

9. The roadheader was located in A heading, mining in an easterly direction to link up the two branches of this heading. The morning shift experienced some methane layering, although the air readings were steady at 0.8% up to 1:00pm. A fan was operated to control the methane level.
10. The afternoon crew was undermanned, so the roadheader was not scheduled to work until Monday 22 November. Two men moved the roadheader back from the face to ready it for operation after the weekend. It is unclear whether they were still at the roadheader at the moment of the explosion.

Continuous miner CM002

11. This machine was located in a stub at the western end of A heading, but had not been operational for some time and was being serviced on 19 November. Two men, an engineer and a fitter, were working on the machine during the afternoon. Daniel Duggan, the control room operator, was speaking to Malcolm Campbell, the engineer, at the time of the explosion. Gas readings taken at this location during the day were unremarkable.

VLI Drilling Pty Ltd drilling rig

12. This in-seam drilling rig was at drill stub 3 near the western end of A heading. The two-man crew began a day shift at 7:00am. The night shift experienced a malfunction with the drilling rig, as a result of which the connection to 16 drilling rods in the borehole was lost. The day shift endeavoured to reconnect to the rods and retrieve them. Whether they succeeded is not known. An observer, who was to start work the next week, was also with the crew that afternoon.

13. Gas readings, and a measure of the methane flow rate from the borehole taken during the morning, were normal for a drilling rig stub.

Cross-cut 4, B–C headings

14. Three contractors were working a day shift in an inbye cross-cut between B and C headings. They were constructing a board and brattice stopping required for ventilation control. Comparatively little was observed of their progress during the day. By 3:45pm they may have finished work in preparation for catching the 4:00pm taxi out of the mine from Spaghetti Junction.

The hydro-monitor panel

15. The three-man hydro-mining crew began a 12-hour shift at 7:00am. The night shift had experienced a water leak while operating the monitor. However, the day shift used it to cut coal until 12:20pm, when the supply of fluming water to the mine was halted. Little was seen of the crew throughout the day, but they likely used the downtime to undertake maintenance work, including fixing the monitor leak. The three men were probably in the hydro panel at the time of the explosion. Video footage obtained via a drill hole into the hydro panel cross-cut (PRDH47) confirmed the presence of one body in that location.

The dirty water sump heading

16. Two contractors were working in this heading using a bucket excavator, known as a brumby, to excavate an area in readiness for the construction of a concrete sump. This machine did not have a fixed methane detector or an automatic shutdown system, and nor did the men remember to take a portable gas detector with them into the mine. At 3:45pm the men may still have been at work in the heading, or preparing to leave on the 4:00pm taxi.

Pit bottom south

17. Four contractors were working a day shift installing a water pipeline at this location in the southern extremity of the mine. The contractors used a dump loader to cart and dump excavated material at the grizzly. The machine broke down several times during the day and was last seen at Spaghetti Junction where the operator, Riki Keane, was working on it. It is not known whether the other three contractors remained at their workplace at 3:45pm or were en route to catch the taxi.

Four workers in transit

18. An interviewer, Conrad Adams, drove a drifrunner into the mine at 3:15pm and was last seen near Mr Keane's broken-down dump loader. The taxi driver, John Hale, was also in the Spaghetti Junction area ready to take miners and contractors out of the mine at 4:00pm.
19. Daniel Rockhouse was a member of the ABM20 afternoon crew, but at the time of the explosion he was parked at pit bottom in stone, refuelling a vehicle. Russell Smith was late for work and driving inbye up the drift at the time of the explosion.

The fuel consumed in the first explosion

What was the fuel type?

20. An explosion is a violent release of energy resulting from a rapid chemical reaction, which produces a pressure wave, substantial noise, heat and light. An explosion requires an explosive fuel source, oxygen and contact with an ignition source.
21. Methane occurs naturally in coal seams and is released by mining activity. It is explosive in the range of 5–15% methane in air. The coal measures at Pike River had a gas content of approximately 8m³/tonne of coal. The gas composition of the seam was at least 95% methane, with small quantities of carbon dioxide and ethane.⁵ Methane

was the suspected fuel source as soon as the explosion occurred.

22. The other possible fuel type was airborne coal dust, although wet mining conditions at Pike River suggested it was not likely to be the primary fuel source. It could, however, have been a minor contributor to a methane-fuelled explosion.
23. Professor Cliff analysed the results of gas samples obtained from about 9:00pm on 20 November, principally from the top of the fan shaft. The ratio of gases found in these post-explosion samples is 'consistent with methane being the primary cause of the first explosion'.⁶
24. The only potential evidence that implicated coal dust as a contributor to the explosion was some coking located at the exhaust infrastructure at the top of the vent shaft. Samples were sent to the University of New South Wales for analysis, specifically to establish if coking had occurred. If it had, this would indicate the conversion of coal dust into coke as a result of explosion temperatures. Only a very small percentage of coked particles were found, consistent with a minor involvement of coal dust, if any. Coal dust explosions are extremely violent and the first explosion at Pike River was sluggish. The joint investigation expert panel concluded that it was a methane explosion.⁷

What quantity of methane?

25. To determine the source of the methane consumed in the explosion, the panel first assessed the likely volume of methane required to produce an explosion of the kind recorded on the portal closed circuit television (CCTV) footage. This footage was the starting point from which to work back and endeavour to extrapolate the initial methane volume.
26. The blast exited the portal for approximately 52 seconds,⁸ with most energy expended in the first 30 seconds. The cross-sectional area of the stone drift at the portal was approximately 22m². To estimate the velocity of the blast, the speed at which debris passed through the 7.5m field of vision of the camera was calculated. The camera recorded four frames per second and debris cleared the field of vision in less than one frame. This indicated a blast velocity greater than 30m/s (metres per second) and within a range up to 70m/s.⁹
27. The expert panel's analysis of the blast enabled the volume of gas ejected at the portal to be estimated. Then followed the extrapolation process:

Explosion products ejected at the portal	30–70,000m ³
Double this for a similar volume of products ejected at the vent shaft	60–140,000m ³
Divide by 5 (the assumed expansion factor of the explosion) to establish the volume of mine atmosphere which exploded	12–28,000m ³
Reduce explosive mine atmosphere volume to 5% (the lower limit of the explosive range of methane) to establish the minimum volume of methane consumed in the explosion	600–1400m ³ .

28. However, the expert panel concluded that the methane consumed in the explosion was more likely to be at least 1000m³, and possibly a much higher amount. This reflected the high concentration of carbon monoxide in the post-explosion gases, as confirmed by the two survivors' prolonged loss of consciousness and the analysis of early samples from the vent shaft. High post-explosion concentrations of carbon monoxide indicate a fuel rich explosion.¹⁰

Some revised thinking

29. In light of points raised in the cross-examination of Mr Reece, and following subsequent discussions between experts, Professor Cliff revised some aspects of his explosion calculations. He discussed these aspects in a transcribed telephone conference on 13 March 2012, to which an expert adviser to the commission, Darren Brady of Queensland's Safety in Mines Testing and Research Station (SIMTARS), contributed.

30. The first change related to the methane content of the first explosion. After discussion and consulting experts from the United States, Professor Cliff (supported by Mr Brady) concluded that it was likely the explosion consumed even more than 1000m³ of methane. Although the pressure wave at the portal was significantly long, the explosion was not particularly powerful; rather it was slow and weak. It was also described as a 'deflagration' (explosive burn), rather than a 'violent detonation'. This supported a methane rich mixture greater than 10%, and perhaps approaching the upper limit of the explosive range, 15%.¹¹
31. The previously adopted expansion factor of five was also revised. Discussion with other experts led Professor Cliff and Mr Brady to conclude that the expansion factor could have been as low as two and was not likely to be as high as five. A lower expansion factor indicated that the volume of the explosive atmosphere in the mine was likely to be larger than previously thought, in order to still produce the gas volume.
32. The combination of the two factors, a higher methane concentration and an increased volume of explosive atmosphere, pointed to an even larger methane volume than the previously favoured 1000m³. In the course of the discussion, Professor Cliff favoured 2000m³ of methane as the upper end of the likely range.¹²

Possible sources of the methane

The goaf

33. The expert panel concluded that there were few potential locations within the mine capable of producing the required volume of methane. One possible location was the hydro panel goaf.
34. Hydro mining at Pike River had created an irregular goaf approximately 30m wide, 40m deep and up to 9m high. The void volume was approximately 6000m³. The goaf was not ventilated. Methane would have continued to bleed from the coal seam into the goaf.¹³ It also contained an in-seam borehole drilled to explore the limits of the seam and also pre-drain methane. The borehole had been intersected during hydro mining, and therefore provided an additional potential source of methane.¹⁴ The diagram below illustrates the area of the goaf (top right corner) and the intersecting borehole. The gas drainage lines are marked in red.

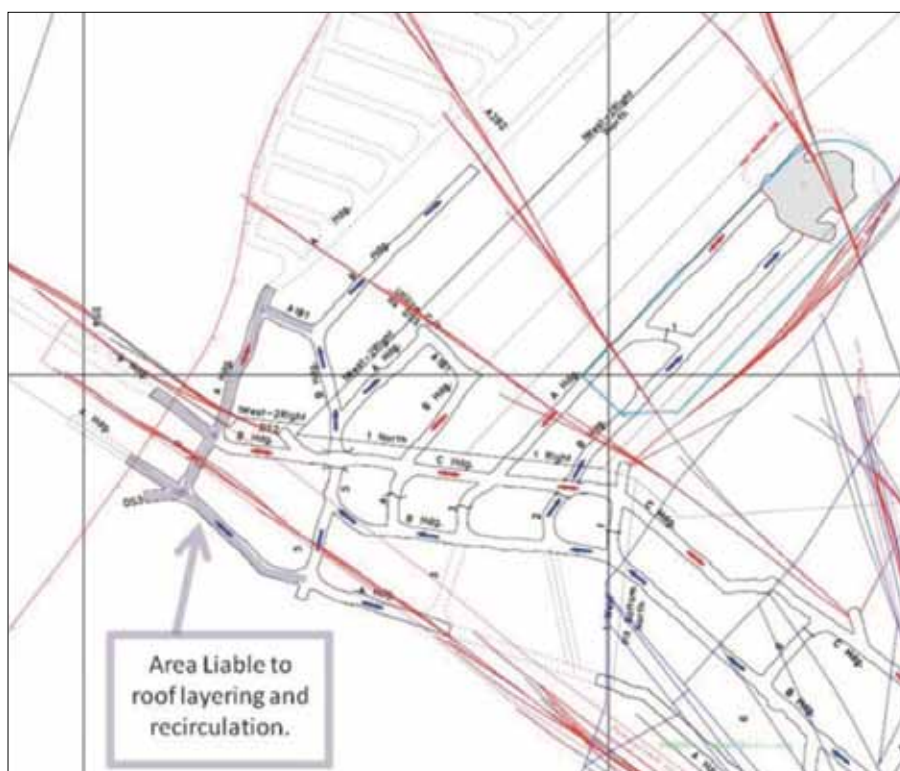


Figure 14.2: The area of the goaf and the intersecting borehole¹⁵

There was also a rider seam above the goaf which, after disturbance of the roof strata during mining activity, could leach further methane into the goaf.

35. The panel considered that up to 5000m³ of methane could have built up in the goaf.¹⁶ Methane is buoyant and would not move unless disturbed and flushed out during mining or expelled by a significant roof fall. The goaf was unsupported, so strata failure and roof falls were to be expected. Indeed, the mine had experienced a large goaf fall in October, and a flushing out of methane by the monitor during mining on 17 November. Both events expelled significant volumes of methane into the adjacent roadways.¹⁷
36. In cross-examination, Mr Reece was asked whether a drillhole into the goaf would confirm the occurrence of a roof collapse large enough to have expelled the required volume of methane, but his answer demonstrated that this is a highly problematic issue.¹⁸
37. The expert panel favoured the goaf as the most likely source of the methane and a roof fall as the likely expulsion mechanism.¹⁹

Three explosion scenarios

38. The expert panel suggested three potential ways in which an explosive atmosphere of between 5 and 15% methane in air may have formed to become the fuel source consumed in the explosion. Scenarios one and two implicated the goaf, with methane emitted by a goaf fall as the initiating event, but with different transmission paths outside the hydro panel as the methane was diluted to within the explosive range. The difference between these scenarios was one of degree. The third scenario, however, envisaged a layered accumulation of methane in the western working areas of the mine.
39. Scenarios one and two are best explained by reference to the following diagram.

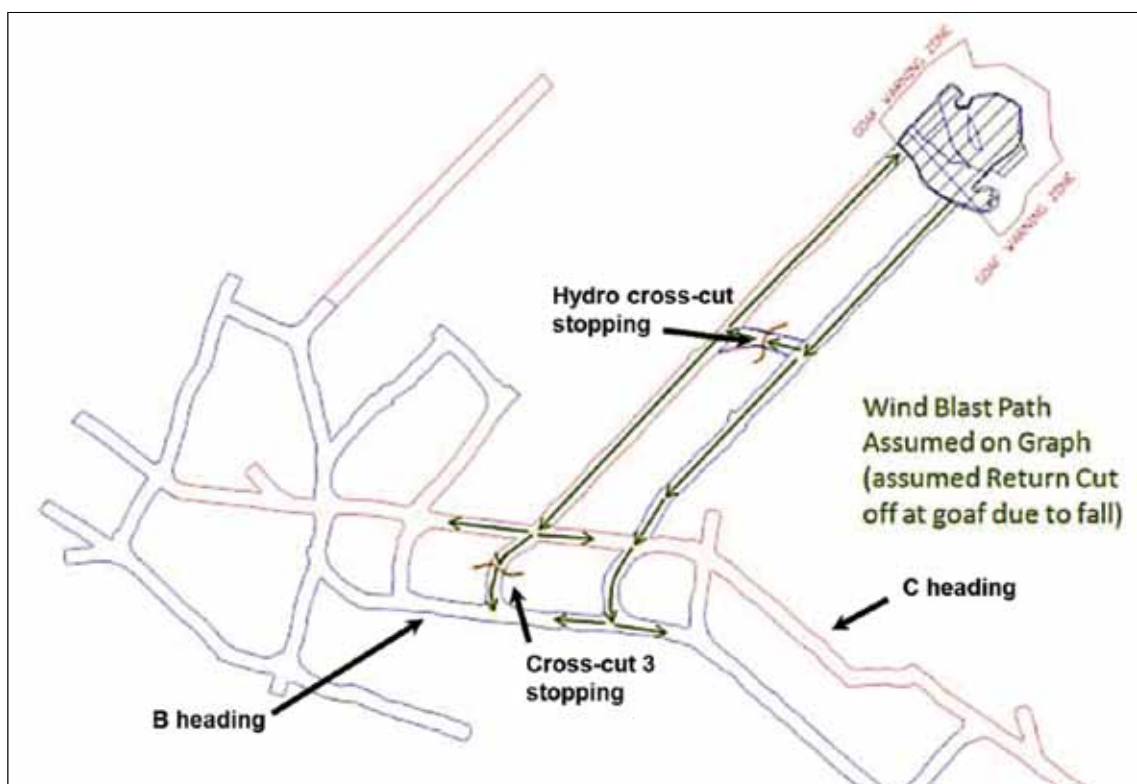


Figure 14.3: Gas flow path due to goaf fall²⁰

40. The expert panel assumed that the return roadway from the hydro panel (left side of the diagram) would have been 'cut off at the goaf due to (the roof) fall'. Hence, the diagram depicts only methane expelled along the intake roadway (right side of the diagram) as far as B heading, and then flowing both inbye and outbye. In addition, it was thought that methane would be forced into the hydro panel cross-cut, would breach the stopping in this cross-cut

and travel in both directions along the return (left-hand) roadway. The southern flow was assumed to have crossed heading C, then breached the stopping in cross-cut 3 to reach B heading.

41. The difference between the two scenarios appears to lie in the extent of the methane spread. In scenario one the methane was more localised, while scenario two contemplated a greater spread of methane, including inbye towards the working areas of the mine.²¹

An inbye gas accumulation

42. The third, and 'less likely', scenario was a gas accumulation centred in the most inbye and western area of the mine, where the two continuous miners, the roadheader and the in-seam drilling rig were located. This area is depicted in Figure 14.2 and labelled 'area liable to roof layering and recirculation'. There had previously been ventilation and gas management problems in this area, which triggered the shutdown of machinery and the initiation of various methane control measures. In giving evidence, Mr Reece said scenario three was considered less likely because of the significant volume of methane required, which experienced workers, and statutory officials, should have detected and reacted to.²²

Difficulties concerning the possible sources of the methane

43. The commission considers that there are some contentious issues relating to the source of the methane.
44. First, the CCTV footage showed that the blast at the portal was variable, being at its strongest for only the first 30 seconds. This variation, however, was not taken into account in calculating the volume of gas emitted. Mr Reece explained that the fall off in the pressure wave could affect the calculation of methane consumed in the explosion.²³ Second, in arriving at the total volume of gas expelled by the explosion it was assumed that equal volumes were emitted from the portal and up the vent shaft. Again, Mr Reece explained that a lesser volume may have been ejected from the vent shaft, given its smaller dimensions and the absence of video evidence at this location.²⁴
45. In a working paper dated 16 September 2011 Professor Cliff included a schedule of times recorded on various of the mine's systems in relation to the explosion, including a time reference: '15.45.36–15.46.22, explosion visible at portal for this duration – 47 seconds'.²⁵ Although only a difference of five seconds, this shortening of the duration of the blast would still reduce the methane volume required to produce the explosion. It is apparent, when viewing the CCTV footage, that assessment of the exact duration of the blast is no easy matter; a value judgement is required.
46. Lastly, Mr Brady pointed out that the standard dimensions of the mine roadways were 5m by 3.5m,²⁶ although these exact measurements were not consistently achieved. An explosive atmosphere volume of 12,000m³, for example, would occupy between 686 and 1600m of standard roadway. This represents a significant distance in a small mine, which may suggest that the explosive atmosphere consumed in the explosion was not as voluminous as the panel calculated.

The source of ignition

The amount of energy required

47. Mr Reczek described methane as 'very easily ignited' by an ignition source that is 'intimately engaged', or comes into contact, with the fuel source.²⁷ The actual energy requirement to ignite methane at its most explosive point (9.8% of methane in air) is 0.29 millijoules. This means that a wristwatch battery has 'many times the amount of energy' required to ignite methane (hence the prohibition on using battery-powered watches underground).²⁸
48. The expert panel identified a range of potential ignition sources. The most favoured was an electrical ignition at any one of numerous points in the mine's electrical infrastructure.

A timing coincidence

49. The supply of fluming water to the mine was cut about 12:20pm on 19 November owing to a planned service shutdown at the surface coal preparation plant. Very shortly before 3:45pm the plant advised Daniel Duggan, the control room operator, that the water supply was back on. He switched on the number one fluming pump and made a call to the working faces, using the digital access carrier (DAC) system. Malcolm Campbell, the shift engineer who was repairing a continuous miner at the most western inbye point of the mine, answered the call, but communication to the mine was lost as the two men were speaking. Simultaneously, all telemetric reporting from the mine to the control room also stopped.²⁹
50. Data subsequently obtained from the mine electrical system confirmed that the start-up signal from the control room initiated the number one fluming pump start-up sequence at between 3:45:14pm and 3:45:18pm (GPS time). Seconds later, at 3:45:26pm, all power to the mine was lost when circuit breakers at the portal substation tripped.³⁰ The coincidence of the switching on of the pump followed so soon by an explosion persuaded the expert panel that an electrical cause was the most likely ignition source.

Potential electrical sources

51. The timing coincidence, coupled with some operational problems in the lead-up to 19 November, resulted in a focus on variable speed drives (VSDs) installed in the mine. VSDs enable fixed speed motors to operate at continuously variable speeds. By varying the frequency of the power supply to a motor, VSDs can achieve a softer start-up process with a consequent power saving. And by varying the operating speed of the motor to match its output demand, further savings and improved performance are achievable. VSDs were installed underground at Pike River in conjunction with the main ventilation fan, and pump, motors.
52. However, in varying the frequency of the power supply, VSDs can cause an electrical waveform distortion, termed harmonic distortion. Harmonics are a normal characteristic of a VSD's operation. The distorted waveform can flow back into the power supply grid and into the motor, and from there into the mine earthing system.³¹ Harmonics may also flow into metal works, such as a pipeline, that are connected to electrical equipment powered by a VSD.³²
53. Mr Reczek considered that 'harmonic currents flowing in the earth circuits of the underground power supply would be capable of generating incendive sparking across any mechanical surface connection in the earth circuit.'³³ This incendive sparking, also termed arcing, could 'basically light the entire electrical system up like a Christmas tree' and produce sufficient energy to ignite an explosive methane mixture, should there be one at the point of an arcing.³⁴ Mr Reczek stated the phenomenon of arcing occurred in many underground coal mines when machines made contact, causing shocks to men who were in contact with mobile machinery and the ground.³⁵ This risk extended to metal infrastructure connected to a VSD-powered motor, and could, in Mr Reczek's view, have caused arcing anywhere on a pipeline, for example, particularly at a joint.
54. Mr Reczek was supplied with correspondence and other documents relating to the underground electrical installations at Pike River. He considered that technical issues raised in the documents indicated a heightened risk from harmonics.
55. Loadflow studies suggested to Mr Reczek that the main power supply to the mine was insufficient to meet the demands of the underground fans, pumps and other electrical installations. A soft power supply may cause motors to achieve less than their specified output, leading to overheating, 'hot joints' at connections to conductors and drive instability.³⁶ In these circumstances, VSDs also produce higher currents in an attempt to compensate for the inadequate power supply, and higher currents are a cause of increased harmonics.³⁷
56. Documentary evidence confirmed that overheating and instability had affected the main fan and the monitor pump at Pike River.³⁸ Mr Reczek also highlighted harmonic analysis reports,³⁹ which showed high levels of waveform distribution and in areas of the mine where this should not have been found.⁴⁰
57. He also relied on photographs that he concluded showed physical evidence of arcing.⁴¹ These depicted pitting caused by arcing to the metal surface of a component of the methane sensor located near to the surface in the vent shaft, but connected to the underground power supply.

58. Before the explosion, the VSD driving the motor of the main fan was replaced because of a circuit breaker problem that caused intermittent tripping of the fan.⁴² Other VSDs were also to be replaced by the supplier at a cost of \$140,000 because of various failures, including the failure of pre-charge resistors.⁴³
59. Although his evidence contained a considerable emphasis on harmonics, Mr Reczek considered that arcing was only a 'potential' ignition source at Pike River. He acknowledged that the lack of access to the VSD units in the mine, limited information about the way electrical equipment was installed and the non-availability of information following the forensic analysis of the failed resistors in the United States all limited the weight that should be placed upon his opinions.⁴⁴ Indeed, in another answer, Mr Reczek described his report as 'incomplete' because it involved 'drawing conclusions or inferences, if you like, based on information which is available [but] which isn't conclusive.'⁴⁵

Rockwell Automation (NZ) Ltd

60. This company supplied the Powerflex 700L model VSDs installed at Pike River, and the replacement 700H model for the main fan. The company filed an institutional statement with the commission in which it strongly disputed Mr Reczek's views concerning harmonics. Although Rockwell sought and was given interested party status at an early stage, it did not actively participate in the inquiry until the commission drew its attention to Mr Reczek's witness statement.
61. Rockwell described Mr Reczek's conclusions as 'implausible'.⁴⁶ It maintained that he had not taken account of modern VSD technology, which ensures:
- VSD Input voltage and current waveforms contain very little low frequency harmonics due to active wave shaping of the line current with embedded AC line filters. Modern VSD input voltage and current waveforms meet IEEE [Institute of Electrical and Electronics Engineers] standards which therefore cannot create hot joints and possible resulting methane ignition.*⁴⁷
62. Further, Rockwell conducted a simulation study based on the actual specifications for the number one fluming pump, a 700L model VSD and any associated componentry, including the cabling between the pump motor and the VSD. The essential conclusions reached were that a 700L model VSD generates only low-level harmonic currents, that these are contained in the cabling system and that the energy level of any stray currents going into the earthing system would be insufficient to ignite methane. Rockwell also contended that the overheating of motors at Pike River was caused by defective resistors, and that it was incorrect to attribute the overheating problem to a soft power supply, which could lead to hot joints as a potential ignition source.⁴⁸
63. Since March 2012, when Rockwell filed its institutional report with the commission, there has been ongoing communication between it and the DOL investigation team resulting in a number of outcomes:
- DOL accepts that 'the simulation work in the Rockwell report is detailed and thorough for the cases it considers'.⁴⁹
 - However, DOL draws attention to the substitution of a 700H model VSD at Pike to power the main fan,⁵⁰ while its investigations have not revealed a sample of the actual cable used at Pike River,⁵¹ but have confirmed the cable termination arrangements used in connecting VSDs to electric motors at the mine.⁵² DOL asked Rockwell to undertake further simulation work based on a 700H model VSD, the actual Pike cable termination arrangements and, if possible, cabling of the kind described by Pike's underground electrical co-ordinator.⁵³ The cable and termination arrangements can affect harmonics.
 - Rockwell responded that the scenarios it was requested to simulate were 'speculative'; would not be of assistance and it declined to undertake them.⁵⁴
64. There have also been four developments of relevance to the evidence Mr Reczek gave to the commission. He had understood that the number one fluming pump motor was very large, 10 times the size of the main fan motor.⁵⁵ This was not the case, meaning that the VSD starting this pump would not have generated a very high level of harmonics. In addition, it is now 'less certain' whether the VSD had actually started, or whether it remained in

start-up mode, at the time of the explosion.⁵⁶ If the latter, the scope for harmonic generation is removed, or at least minimised. Thirdly, investigators are now unsure whether there is a 'direct pipework' connection between number one fluming pump and the inbye area of the mine. The number one pump replenished the fluming water supply before another pump in the sequence pumped water inbye. This may eliminate pipework as a connection route, leaving the mine earthing system as the only path for harmonics to travel from pit bottom in stone to an inbye ignition location.⁵⁷ Finally, Mr Reczek's view that the power supply to the mine was soft has been contested by Pike's electrical co-ordinator.⁵⁸

65. In June 2012 DOL observed that it had 'not been able to confirm or to rule out' harmonics generated by a VSD as the ignition source of the explosion. Its investigation was described as 'continuing'. When he gave evidence, Mr Reczek acknowledged the constraints he was under. The wisdom of his warning has been borne out by subsequent developments.

Other potential ignition sources

66. In addition to an electrical cause, the expert panel considered a range of different, 'less likely' potential ignition sources. These alternatives included spontaneous combustion, frictional ignitions (from metal on rock, or metal on metal, sparking), a conveyor belt heating or fire, diesel vehicle 'hot surface' ignition and ignition from the introduction of contraband into the mine.
67. Some of these potential sources were discounted for lack of evidence. For example, testing indicated that the Pike River coal seam was not prone to spontaneous combustion and there was no history of its occurrence, and that the conveyor belt was not in service at 3:45pm.

A diesel engine 'hot surface' ignition

68. The expert panel concluded that a fault in the protection system of a diesel engine could not be ruled out as the ignition source. The diesel-powered vehicles and machines used underground at Pike River were fitted with flameproof enclosures designed to prevent an overheated engine from becoming an ignition source. But component failure, incorrect settings and poor maintenance can compromise these safety systems.⁵⁹
69. In addition, throughout Pike River's short history there were instances of the deliberate bypassing of various safety devices designed to counter the risk of methane explosions. Some incidents of this kind were recorded in statutory reports, which were subsequently summarised in a schedule compiled by the commission.⁶⁰ The schedule included several instances of interference with vehicle shutdown systems, so that an engine would not cut out in the event of an overheating.
70. This history also influenced the panel in concluding that an engine hot surface ignition remained a potential ignition source.

Contraband

71. Regulations prohibit taking any device or material likely to cause a spark or flame into an underground coal mine.⁶¹ Devices powered by a battery (including wristwatches or cameras) must not be used underground, unless the device is fitted with an intrinsically safe battery system. Matches and cigarette lighters are also banned and smoking is of course prohibited. Aluminium cans are another contraband item, because contact between aluminium and other metals can produce sparking.
72. Again, there had been instances at Pike River of contraband both taken and used underground.⁶² In particular, aluminium cans, cigarette butts and unsafe battery-powered devices featured in incident/accident reports that covered the period from August 2008 to October 2010. Although management had taken significant steps to deal with contraband, the expert panel concluded it remained a potential ignition source.

Frictional ignition

73. Although there was no mining activity at the time of the explosion, maintenance and building work was taking place. Machines, including scrapers and diggers, were being used, as were vehicles to transport workers. Frictional ignition from these activities, such as a spark caused by a metal to metal contact, cannot be ruled out. Machinery related sparks had previously been reported.⁶³

The main fan

74. The main fan was located underground with its non-flameproofed motor in fresh air in the intake airway and the fan impeller in the return airway. As explained in Chapter 8, 'Ventilation', there had been sparking problems with the fan, and changes had been made, but there was an increased potential for contaminated air to reach the motor.

The site of the ignition

Introduction

75. Pike River was still in a development phase at the time of the explosion. The area of the workings was small, by comparison with a mature mine. Developed mines typically have a number of sections where coal extraction has finished, plus current working sections. Despite the small size of the mine, the information available to the expert panel was limited, meaning it could offer only an indicative conclusion about the likely ignition site.

Some indicative factors

76. The panel concluded that three factors indicated the most likely site: the absence of a reflective explosion wave, the temperature levels experienced by the survivors in the drift and the duration of the explosion wave at the portal.⁶⁴
77. Only one pressure wave was discernible from the CCTV portal footage. Had the explosion occurred close to the inbye western side of the mine, a reflective wave at the portal would have been expected. An initial explosion wave would be transmitted through the workings and down the drift, followed soon after by a reflected wave that had hit and rebounded from the western parts of the mine.⁶⁵
78. An explosion that emanated in the middle of the mine workings, or even outbye of this point, would not be expected to produce a discernible reflective wave. Any such effect would be absorbed or weakened by the web of roadways, intersections and cross-cuts that make up the mine workings.⁶⁶
79. Neither of the survivors, Daniel Rockhouse or Russell Smith, experienced significant ill effects from excessive heat when the pressure wave struck them in the drift. Had the explosions occurred near to the inbye end of the drift, the expert panel expected the hot post-explosion atmosphere would have expanded well along the drift, to the point 800m outbye where Mr Smith was hit by the pressure wave. By contrast, in the panel's view, gases and heat generated by an explosion significantly inbye of the drift would be dissipated and cooled before reaching the survivors, particularly in a wet mine.⁶⁷
80. The third factor was the duration of the explosion pressure wave at the portal. The duration of about 52 seconds was more than twice the duration of the pressure waves generated by the three subsequent explosions, all of which were more likely to have occurred at pit bottom than further inbye. The panel therefore concluded that the longer duration of the first explosion was consistent with a more inbye location, although there were other possible explanations.⁶⁸

Explosion modelling

81. In order to verify that the explosion probably occurred inbye of pit bottom, computational fluid dynamic modelling undertaken by engineering consultant BMT WBM was used to test the panel's assumption. The model replicated the layout of the entire mine, and testing was then conducted using different figures for the volume, and the methane concentration, of the explosive atmosphere consumed in the explosion.⁶⁹

82. Two ignition site locations were chosen: an auxiliary fan next to the intake roadway to the hydro panel and the main fan.⁷⁰
83. The modelling suggested that an explosion located at the main fan was 'less likely', while a location further into the mine appeared 'plausible'. The modelling also indicated that a 10% methane concentration and an explosive atmosphere volume of about 25,000m³ best matched the explosion footage. These parameters were also considered consistent with the heat exposure experienced by, and the survival of, Messrs Rockhouse and Smith, but less consistent with a blast duration of 52 seconds.

Conclusions concerning the first explosion

84. Based on the evidence available to date, and without a scene examination, the commission finds that:
 - methane fuelled the explosion, with no or very little contribution from coal dust;
 - the volume of methane consumed in the explosion was substantial;
 - the actual volume can only be estimated, but could have been as high as 2000m³;
 - the hydro goaf probably contained approximately 5000m³ of methane;
 - a roof fall in the goaf could have expelled sufficient methane to have fuelled the explosion;
 - a layered accumulation of methane in the roof of the western workings of the mine was another possible methane source, either alone or in combination with methane from the goaf;
 - the ignition source remains contentious, but a number of possible sources exist, including:
 - an electrical cause, given the timing coincidence between the switching on of the fluming pump and the explosion
 - a diesel engine hot surface ignition
 - contraband taken into the mine
 - frictional ignition from activities that were continuing in the mine
 - sparks from the non-flameproofed underground fan; and
 - the possible site of the ignition, and resulting explosion, was in the centre area of the mine workings.
85. Despite the level of uncertainty surrounding several aspects of this exercise, there is no doubt that a large explosive methane atmosphere existed in the mine at the moment of the explosion. This shows that methane control at Pike was not adequate. Ultimately, all explosions are a manifestation of the failure of an organisation's health and safety management system.⁷¹

The subsequent explosions

Introduction

86. The commission received less detailed evidence concerning the three subsequent explosions, but there was also less conjecture about their nature. Their occurrence was predicted by many of the experts gathered at the mine, who stressed the need to seal the mine to avoid further damaging explosions.
87. There were three subsequent explosions. The second occurred on Wednesday 24 November at 2:37pm, five days after the first explosion. The next explosion was on Friday 26 November at 3:39pm, after a gap of only two days. The fourth explosion was on Sunday 28 November at 1:50pm, also after a two-day gap.

88. The later explosions differed from the first. The second and third explosions had a duration of 30 and 23 seconds at the portal, respectively. Both caused a much more forceful pressure wave than that from the first explosion. Following the pressure wave, air was initially drawn into the drift and then there was a reversal or expulsion of air.⁷²
89. The fourth explosion was different again. It caused a billow of black smoke, followed by a fire ball out of the vent shaft and, subsequently, flames that diminished over time, but continued to be visible until 8 December.⁷³



Figure 14.4: Fire coming from the ventilation shaft following the fourth explosion⁷⁴

The fuel type and source

90. It is clear that all three explosions were fuelled by methane. A build-up of methane in the workings was expected as soon as the ventilation system was disabled on 19 November.
91. Mr Brady provided a comprehensive overview of gas data gathered at the mine between 20 November 2010 and March 2011.⁷⁵ Samples obtained at 4:00pm on 22 and 23 November contained an explosive gas mixture, and there was a methane concentration of over 6% before the explosion on 24 November. The methane concentration rose and fell depending on the time of day, changes Mr Brady considered were related to the natural ventilation flow between the portal and the vent shaft. Predominantly the flow was up the vent shaft, but there were reversals driven by a variable pressure differential that changed according to the temperature and barometric pressure.⁷⁶
92. In the two-day gap before the third explosion there were similar fluctuations in the methane concentration, which climbed to a high of almost 12% at one point. Following the third explosion, few samples were collected owing to damage to the sampling lines and the danger involved in re-establishing them.⁷⁷
93. However, it can be inferred that there was a similar build-up of methane, which ebbed and flowed with ventilation changes, until an ignition source and an explosive fringe coalesced to cause the fourth explosion on 28 November.

The ignition source and the ignition site

94. The most likely ignition source for each of the subsequent explosions was 'hot coal'.⁷⁸ Following the heat generated in the first explosion, conditions in the mine were ripe for coal fires or for spontaneous combustion to occur and

provide an ignition source, leading to an explosion once an explosive atmosphere gathered and came into contact with that source.

95. The expert panel concluded that the ignition site of each of the subsequent explosions was probably close to, or a little inbye of, the vent shaft. Logically, there would be an accumulation of methane within the workings and the development of a fringe where oxygen from the natural ventilation circuit mixed with the methane rich atmosphere to reduce it to within the explosive range. When a hot coal ignition source and an explosive atmosphere combined, each of the further explosions occurred.

ENDNOTES

¹ This work was part of the joint investigation, but DOL led the explosion analysis aspect.

² Including (1) the estimated velocities and quantities of gas ejected at the portal; (2) the volume of gas ejected through the ventilation shaft; (3) the percentage of methane (somewhere between 5 and 15%) in the air when ignition occurred; (4) the expansion factor of 5, being how many times the volume of flame was greater than the original explosive mix; (5) the assumed location of the ignition; (6) the dimensions, area and resistance of the mine's roadways; and (7) the path taken through the mine by the explosion.

³ Department of Labour, Pike River Mine Tragedy 19 November, 2010: Investigation Report, [2011], DOL3000130010, pt. 2, sections 3–4.

⁴ Department of Labour, Last Known Position of Deceased and Two Survivors. Final Version, 28 January 2011 (DOL Investigation Report, Appendix 3), DOL3000130004/2. ('A, B, & C headings' locations added to the map by the commission).

⁵ Darren Brady, Review of Gas Data Following Pike River Explosion 19th November 2010: For New Zealand Police – Operation Pike, 5 May 2011, SOE.008.00001/14.

⁶ David Reece, witness statement, 2 February 2012, DOL3000150001/8, paras 29–30.

⁷ David Reece, transcript, pp. 4454–56.

⁸ See para. 45 for discussion concerning the accuracy of this time duration.

⁹ The upper limit of the range was viewed as consistent with the evidence of Russell Smith, who survived the blast 1500m inbye of the portal and suffered significant deafness, but not ear drum damage: David Reece, witness statement, DOL3000150001/10, para. 36.3.

¹⁰ David Reece, transcript, pp. 4458–60.

¹¹ Notes from Pike River Discussion, 13 March 2012, MEM0001/8, 11, 17–19.

¹² Ibid., MEM0001/9.

¹³ David Reece, transcript, p. 4467.

¹⁴ Ibid., pp. 4467–68.

¹⁵ Department of Labour, Investigation Report, DOL3000130010/74.

¹⁶ David Reece, witness statement, 2 February 2012, DOL3000150001/11, para. 41.

¹⁷ David Reece, transcript, pp. 4465–66.

¹⁸ Ibid., pp. 4616–18.

¹⁹ David Cliff, David Bell, Tim Harvey, Anthony Reczek and David Reece, Pike River Coal Mine Explosion: Investigation for Nature and Cause (DOL Investigation Report, Appendix 6), October 2011, DOL3000130007/7.

²⁰ David Reece, DR5 – Gas flow Path Due to Goaf Fall, DOL3000150012/1. (Plan modified by the commission)

²¹ David Reece, witness statement, February 2012, DOL3000150001, paras 20–22.

²² David Reece, transcript, p. 4478.

²³ Ibid., p. 4604.

²⁴ Ibid., pp. 4604–05.

²⁵ David Cliff, An Evaluation of Elements Relating to the Cause of the First Explosion at Pike River Coal Mine: Draft, 16 September 2011, DOL3000140009/33.

²⁶ Darren Brady, witness statement, 2 April 2012, SIM0003, para. 2.5.

²⁷ Anthony Reczek, transcript, pp. 4706, 4835.

²⁸ Ibid., pp. 4732–33.

²⁹ Daniel Duggan, transcript, p. 1581.

³⁰ Anthony Reczek, transcript, p. 4733.

³¹ David Cliff et al., Investigation for Nature and Cause, DOL3000130007/76.

³² Anthony Reczek, transcript, p. 4792.

³³ Anthony Reczek, witness statement, 7 February 2012, DOL3000160001/17, para. 60.

³⁴ Anthony Reczek, transcript, p. 4737.

³⁵ Anthony Reczek, witness statement, 7 February 2012, DOL3000160001/14, para. 45.

³⁶ Anthony Reczek, transcript, pp. 4742–45.

³⁷ Ibid., p. 4746.

³⁸ Anthony Reczek, transcript, p. 4731; Rockwell Automation service records, iPower Ltd, Australia Rockwell Automation to Pike River June 2009–October 2010, DOL3000160006.

³⁹ Email, Cosmin Cosma to Mike [no surname], 13 October 2010, DOL3000160012.

⁴⁰ Anthony Reczek, transcript, p. 4727.

⁴¹ AAR10 (photographs), DOL3000160013.

⁴² Michael Scott, witness statement, 30 May 2012, SCO7770010001/26–27, paras 101–06.

⁴³ Energy NZ Ltd, Department of Labour – Pike River Coal Audit Report for November 19, 2010, 25 January 2012, DOL3000140001/27.

⁴⁴ Anthony Reczek, transcript, pp. 4765–67.

⁴⁵ Ibid., p. 4785.

⁴⁶ Rockwell Automation (NZ) Ltd, Institutional Report of Rockwell Automation (NZ) Ltd in Response to the Statement of Anthony Arthur Reczek for Phase Three (Dated February 7, 2012), 15 March 2012, ROC.001/2, para. 8.

⁴⁷ Ibid., ROC.001/22, para. 67.

⁴⁸ Ibid., ROC.001/4, 6–8.

⁴⁹ Department of Labour, Department of Labour Report on Electrical System Evidence, 8 June 2012, DOL7770050017/4, para. 6.

⁵⁰ Ibid., DOL7770050017/4, para. 6.1.

⁵¹ Ibid., DOL7770050017/8–9, paras 17–23.

⁵² Ibid., DOL7770050017/9–10, paras 24–30.

⁵³ Rockwell Automation (NZ) Ltd, Memorandum (Second) Regarding the Institutional Report of Rockwell Automation (NZ) Limited and Further Enquiries Received from the Department of Labour, 23 July 2012, ROC. M40001. (Department of Labour letters annexed to memorandum)

⁵⁴ Ibid., with Rockwell Automation letter annexed.

⁵⁵ Anthony Reczek, transcript, p. 4737.

⁵⁶ Department of Labour, Report on Electrical System Evidence, DOL7770050017/7, para. 14.2.

⁵⁷ Ibid., DOL7770050017/10, para. 33.

⁵⁸ Michael Scott, witness statement, 30 May 2012, SCO7770010001/39, para. 161.

⁵⁹ Mine Safety, New South Wales, recently issued a safety warning on the

failure rate of explosion-protected diesel engine systems. A lengthy study indicated that, although reliability had improved, the annual failure rate probability for each system was 23%, meaning it was 90% certain that about six failures per annum coincided with a reportable methane accumulation in a mine: NSW Trade and Investment, Mine Safety Operations Branch, Safety Bulletin: In-Service Failures of Explosion Protected Diesel Engine Systems During 2010 and 2011 (Mine Safety Report No. SB12-01), 19 March 2012, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/428614/SB12-01-ExDes-report1.pdf

⁶⁰ Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, November 2011, CAC0114/20–24.

⁶¹ Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 35.

⁶² Royal Commission on the Pike River Coal Mine Tragedy, Summary of the Reports, CAC0114/29–30.

⁶³ Ibid., CAC114/27–28.

⁶⁴ David Reece, witness statement, DOL3000150001/27–28, para. 118.

⁶⁵ Department of Labour, Investigation Report, DOL3000130010/76, para. 2.49.1.

⁶⁶ David Reece, transcript, pp. 4453–54.

⁶⁷ Ibid.

⁶⁸ David Reece, witness statement, 2 February 2012, DOL3000150001/28, para. 118.5.

⁶⁹ Ibid., DOL3000150001/27, para. 117.

⁷⁰ Department of Labour, Investigation Report, DOL3000130010/76–77, para. 2.49.3, figure 24.

⁷¹ United Nations, Economic Commission for Europe, Best Practice Guidance for Effective Methane Drainage and Use in Coal Mines (ECE Energy Series No. 31), 2010, p. 3, http://www.unece.org/fileadmin/DAM/energy/se/pdfs/cmm/pub/BestPractGuide_MethDrain_es31.pdf

⁷² New Zealand Police, Sequence of Events: Search, Rescue and Recovery, SOE.014.00001/76, 88, 104.

⁷³ Darren Brady, Review of Gas Data, SOE.008.00001/81.

⁷⁴ New Zealand Police, Pike River Coal Mine – Sequence of Events: Search, Rescue and Recovery, SOE.014.00118/64.

⁷⁵ Darren Brady, Review of Gas Data, SOE.008.00001.

⁷⁶ Ibid., SOE.008.00001/77.

⁷⁷ Ibid., SOE.008.00001/81.

⁷⁸ David Reece, witness statement, 2 February 2012, DOL3000150001/25, para. 105.

CHAPTER 15

Regulator oversight at Pike River

Introduction

1. This chapter considers the oversight of the mine by the Department of Labour (DOL) inspectorate. The commission has received good co-operation from DOL in providing both historical information concerning the mining inspectorate and direct evidence and records relevant to the inspections conducted at Pike River.
2. Both inspectors gave candid evidence, Michael Firmin at two separate hearings and Kevin Poynter at one for which he returned from Australia. DOL also commissioned an internal operational review of its inspectors' interactions with Pike River Coal Ltd.¹ Conclusions from the Gunningham and Neal review are sometimes referred to in the chapter. In assessing these, and any different views expressed by the commission, it should be borne in mind that the review was based on departmental files (excluding health and safety investigations) and written without access to Pike managers or any post-tragedy documents.²

The statutory background

The functions of inspectors

3. The Health and Safety in Employment Act 1992 defines the functions and powers of the inspectorate with reference to all health and safety inspectors, not just mines inspectors. The inspectors have three functions:
 - to provide information and education to promote workplace health and safety;
 - to ascertain whether the act has been, and is likely to be complied with; and
 - to take all reasonable steps to ensure that compliance is being achieved.³

Other functions may be conferred on inspectors in the act, or by other enactments.

The powers of inspectors

4. Inspectors enjoy extensive powers of entry and inspection at any workplace, and may require an employer to provide assistance, preserve a scene for examination, produce and allow examination of records and provide witness statements. An inspector may take photographs or other forms of enduring records and may also seize anything of evidential value.
5. There is a hierarchy of compliance and enforcement options: an improvement notice, a prohibition notice, an infringement notice and, lastly, an inspector may charge an employer with an offence.⁴
6. An improvement notice identifies a non-compliance, which must then be addressed. The notice may also specify the steps to be taken. A prohibition notice, reserved for failures likely to cause serious personal harm, prohibits an activity until measures to eliminate or minimise the hazard are put in place.
7. Enforcement using an infringement notice is restricted to lesser offences, while an information may be laid in relation to serious harm offences, which carry a maximum penalty of two years' imprisonment, a fine of up to \$500,000, or both.⁵

Duties owed to inspectors

8. The HSE act imposes duties on everyone in a workplace to assist the inspectorate and not to obstruct an inspector in the course of their duties. Anyone in charge of a workplace must maintain a register of accidents that caused

personal harm or might have done so, and an incident register of events that caused serious harm. Serious harm includes significant injuries and illnesses, and conditions that result in hospitalisation for 48 hours or more.⁶

Duties specific to mining

9. The Health and Safety in Employment (Mining – Underground) Regulations 1999 impose specific duties in relation to coal mines. An inspector must be notified of the commencement and cessation of a mining operation and of the installation of a shaft.⁷ Details of the time, place and management of the operation, and contact details, must be notified. Different notification time limits apply, according to the nature of the operation.⁸
10. Regulation 10 defines accidents that must be notified to DOL. They are accidents involving an explosion or ignition, a fire or spontaneous heating, an outburst of gas or water, contact with harmful chemicals, a winding plant event, loss of control of a vehicle, the trapping of an employee, a structural failure, an unplanned fall of ground, a major collapse, an uncontrolled gas accumulation, a main fan failure for more than 30 minutes or an electric shock requiring medical treatment.
11. Regulation 11 requires that mine plans are kept for every operation, are updated at least once every six months and are 'copied to an inspector' at regular intervals. Mine owners must also keep certain other records onsite, which an inspector may inspect as necessary.

The mining inspectorate personnel

12. From May 2005 to November 2010 two inspectors, Michael Firmin and Kevin Poynter, separately had responsibility for the Pike River mine.
13. Mr Firmin obtained a bachelor of science degree in mineral technology from the Otago School of Mines in 1977. After graduating, he joined the Mines Department and over the next 15 years held various office, surface and underground positions. In 1984 Mr Firmin obtained a first class coal mine manager's certificate and subsequently held statutory positions, including about three months as an underground mine manager at Moody Creek near Greymouth. In 1995 Mr Firmin joined the Ministry of Commerce as a health and safety inspector with responsibility for inspecting mines and quarries. In 1998 he transferred to DOL, where he has since worked as a mines inspector.⁹
14. Mr Poynter worked in the coal mining industry from 1977 for about 30 years, from time at the coal face through to management positions in Australia. In 1985 he obtained a first class mine manager's certificate and subsequently held the position of mine manager in three New Zealand mines. He became a trainee health and safety inspector in April 2008 and obtained a certificate of appointment (warrant) in June 2009.
15. The commission considers that both inspectors were adequately qualified and sufficiently experienced. Mr Firmin had limited experience as a mine manager, but this would not have been a difficulty if the inspectorate worked in a supportive environment, was properly resourced and had been able to access specialist advice from other experts. Unfortunately, Messrs Firmin and Poynter faced fundamental difficulties in performing their role, as discussed in Chapter 22, 'The decline of the mining inspectorate'.

The operational methods of the mines inspectors

16. The inspectors' workload was formidable. They were required to inspect all coal mines, metalliferous mines, quarries and tunnels in New Zealand.¹⁰ In early 2010, for example, there were eight underground coal mines, 21 open cast coal mines, 11 metalliferous mines, 925 quarries and four tunnels under construction.¹¹
17. The South Island was divided by the Rakaia River, with Mr Firmin living in Dunedin and responsible for the south, and Mr Poynter based in Westport with responsibility for the north. They shared responsibility for the North Island,

and conducted inspections as time permitted. Quarries were viewed as the last priority, and many North Island quarries were not inspected at all.¹²

18. An 'inherent risk' assessment form was used to set the frequency of inspections to the various workplaces.¹³ However, underground coal mines were automatically classified as high risk, to be inspected every three months.¹⁴ Inspections were either proactive, initiated by DOL, or reactive, in response to an event notified from a particular workplace. Proactive visits (hereafter called inspections) were arranged with the mine operator, not unannounced.¹⁵ Responding to requests for technical information and advice was a further significant aspect of the inspector's role. The Pike managers often raised concerns and sought input from the inspectorate. These contacts were conducted electronically, through meetings or a combination of the two.
19. From June 2009 until the time of the explosion Mr Poynter conducted five proactive inspections at Pike River. He made a similar number of reactive visits to the mine in relation to accidents or other mining incidents. In addition there were numerous attendances concerning technical mining issues raised by the company.¹⁶ A record of interactions was maintained in an information database named INSITE.

Three representative interactions

Introduction

20. An assessment follows of three interactions between the inspectorate and Pike River mine personnel between February 2007 and November 2010. These cover important aspects of the mine's development and provide an insight into the inspectorate's relationship with the company. The commission accepts the assessment that the nature of these interactions was consistent with DOL policy.¹⁷

Location of the main fan underground

21. The first contact with Pike was in May 2005. Peter Whittall phoned Mr Firmin, introduced himself and explained that he wished to develop the access tunnel into the mine without using flameproof machinery, given that the development would be in rock, not coal. After conferring with an Auckland-based colleague, Mr Firmin advised Mr Whittall that designation of the drift as a hard rock tunnel was acceptable, at least until the approach to the Hawera Fault, at which point a coal mine designation might be required.¹⁸
22. The first mine inspection took place on 13 February 2007. Mr Firmin, accompanied by Richard Davenport, a senior technical officer with the energy safety service of the Ministry of Economic Development, visited the mine. Mr Whittall first provided a PowerPoint presentation at the company's Greymouth office. He outlined progress to that time: construction of the access road, establishment of an electrical supply to the mine and development of the drift to 320m. Mr Whittall also explained that the main ventilation fan was to be located underground, with a back-up diesel fan situated at the top of the ventilation shaft. At this point the shaft was to be located in stone to the east of the Hawera Fault. He said this would provide ease of maintenance, whereas there was no space and it was too steep for the fan to be located on the hillside above the shaft.¹⁹
23. Following the presentation, Messrs Firmin and Davenport went to the mine. Mr Firmin inspected the tunnel, focusing on the gradient, roof stability and the adequacy of strata control. Mr Davenport audited the safety of the electricity supply to the mine, which at that stage was an 11kV supply, to be upgraded to a 33kV supply later. He approved the existing installation in a written report that included a request for the ministry to be kept informed about the installation of the upgraded supply.²⁰
24. Mr Firmin prepared handwritten notes of his inspection. These included a simple diagram depicting the intended configuration of the main fan, with the motor located in the intake in fresh air, and the fan separated in the ventilation return and expelling exhaust up the vent shaft.²¹ This proposal concerned Mr Firmin. He had experience of main fans located underground in hard rock tunnels, but never in an underground coal mine. He noted that

the regulations required employers to take all practicable steps to ensure the provision of fresh air in every place in a mine where employees could go.²² The location of the main fan underground was not expressly prohibited. Still not convinced, Mr Firmin said he checked regulations in other countries, but found none that prohibited an underground location. He concluded that 'fans were put outside for ease of maintenance'.²³

25. On 28 February 2007 Mr Firmin wrote to the company about the inspection. He recorded matters relevant to roof support in the drift and also enclosed a copy of Mr Davenport's audit report. The letter made no reference to placement of the main fan underground.²⁴ Mr Firmin neither spoke to anyone about his unease nor considered seeking expert advice.²⁵ On 6 November 2007 Mr Firmin inspected the mine, was told that the fan would now be located to the west of the Hawera Fault and asked for further operational details.²⁶ These were not available.²⁷
26. Mr Poynter became responsible for the Pike River mine in 2008. He, and occasionally Johan Booyse, the high hazards adviser, visited the Pike mine but DOL took no action in relation to the location of the main fan underground. Mr Poynter said that he did not inspect the fan after its installation, or obtain information about its performance.²⁸

Assessment

27. In the commission's view, DOL's actions in relation to this issue were inadequate. Although not expressly prohibited in New Zealand, location of a main ventilation fan underground was at odds with established practice throughout the mining world. Mr Firmin needed to confront the issue in 2007, particularly in November, when he was told that the fan was to be located west of the fault. Failure to question the proposal at that point made it more difficult for Mr Poynter to do so later. Even so, given the delay until mid-2010 when the fan was installed, there was ample time to have dealt with the matter.
28. Nor does the commission accept that the regulatory position in other countries is obscure. An International Labour Organisation (ILO) code treats the location of ventilation fans on the surface as a given: stating the 'surface ventilating fan' is to be 'offset from the nearest side of the mine opening at least 5 metres' in order to avoid explosion forces.²⁹ In addition, regulations in the United States, Canada, Queensland and New South Wales expressly provide,³⁰ or take it for granted, that main fans (as opposed to auxiliary and booster fans) must be installed above ground.
29. This failure not only allowed a highly questionable ventilation system at Pike River, but also set the tone for subsequent interactions between the company and the inspectorate.

Frictional ignitions

30. By October 2008 the drift was developed to a point close to the Hawera Fault. Pit bottom in stone was completed and it was expected that methane levels would increase as the drive towards the fault continued. Because control of the mine had passed from McConnell Dowell to the company, Pike deputies managed the McConnell Dowell crews.³¹
31. On 11 November several methane ignitions occurred in a stub under development off the main drift. A roadheader was cutting when methane was released, which was ignited when the cutter head struck the hard rock floor. Pike's production manager, Kobus Louw, investigated the ignitions and prepared a memorandum containing preventative actions that were to be communicated to crews at tool box talks. The actions included the use of an air mover at the face to assist ventilation, the application of extra water on the cutter head to prevent ignitions and increased methane monitoring at the face before cutting started.³²
32. On 13 November Mr Louw notified Mr Poynter of the ignitions by telephone.³³ The next day Mr Louw emailed a copy of the investigation memorandum to Mr Poynter and they discussed the ignitions and agreed that use of the roadheader would cease, with development to continue using a drill and blast method. Workers would withdraw from underground when blasting occurred. Mr Poynter sent an email to Mr Louw seeking further information and recording that 'the mine should [now] be deemed to be a Gassy Mine'.³⁴ Mr Louw also confirmed by email that an explosive which could not ignite methane would be used for blasting.

33. Mr Poynter discussed the ignitions with Mr Firmin. They agreed the hazard was 'a significant one', but agreed that the steps implemented by the company were adequate.³⁵ Sometime over the next few days Mr Poynter was rung by Harry Bell, a former chief inspector of coal mines, who had assisted McConnell Dowell as a tunnel supervisor in the early development of the drift. Mr Bell had been told of the ignitions by a senior McConnell Dowell employee, who referred to '10 ignitions in the past fortnight'.³⁶ Mr Bell considered the essential problem was the inadequate ventilation from a forcing fan near the portal.³⁷ He told Mr Poynter that work in the drift should be prohibited until the ventilation was improved. He added that he did not mind if the company was told that he was 'the whistle blower', since to his mind the matter was extremely serious.³⁸
34. Mr Poynter considered the matter, but concluded that he could not intervene because 'there is no legislative requirement that determines the method of ventilating coal mines' and 'forcing ventilation when using explosives or developing in stone is an acceptable method'.³⁹ Mr Poynter consulted Mr Booyse, and on 19 November emailed Mr Louw requesting the supervisors' reports for each ignition, weekly ventilation recordings and a ventilation plan to show recording positions. The email continued: 'Have you considered the adequacy of the ventilation. Given that the mine is now in coal and that the amount of gas emissions will only increase as you advance it is my opinion that the ignitions are probably caused by insufficient ventilation at the face.' The situation was termed a matter of extreme concern to be dealt with 'urgently'.⁴⁰
35. On 20 November Mr Poynter again phoned Mr Firmin and discussed whether work should be stopped while an assessment was obtained from a ventilation engineer but they decided to wait for a new risk assessment.⁴¹ Nothing happened for several days until 28 November, when Mr Poynter received an email from Mr Louw to which was attached a McConnell Dowell procedure for the use of explosives in a gassy mine, together with deputies' reports for 24 and 25 November and a ventilation plan.⁴² Mr Poynter responded immediately by email: 'I am still waiting on the shift reports of each of the ignitions and any investigations undertaken'.⁴³
36. On 3 December Mr Louw replied by email, attaching incident/accident and accident investigation reports, both of which related to another methane ignition on 15 November.⁴⁴ Nothing more occurred for three weeks when, on 24 December 2008, Mr Poynter sent a further email to Mr Louw: 'I have been working on this file and noted that I have only received advice of two ignitions. I have been told by a number of people now that there were at least 10.' He requested information on the other incidents.⁴⁵
37. Mr Louw replied the same day: 'Don't know who feed [sic] you information but there was a few ignitions on 4 shifts that I know of and that you should have the information, (including the one at hawera fault [sic]). If there is more then supervisors chose not to report them hence I don't know of them and is not been investigated'.⁴⁶
38. Finally, on 13 February 2009 Mr Poynter recorded in an INSITE entry that the matter was closed.⁴⁷ By then the focus of attention was west of the Hawera Fault, where mine development was under way.

Assessment

39. The commission notes that the Gunningham and Neal review includes an analysis of the inspectors' actions in relation to this aspect.⁴⁸ The authors said that Pike voluntarily provided a detailed flow of safety information, which Mr Poynter cross-checked for completeness. This, they concluded, 'was a sound approach and provides a good basis for concluding that the inspectors discharged their duty to satisfy themselves about the level of compliance by the mine'.⁴⁹
40. In the commission's view, the inspectorate's performance in relation to this aspect was positive in some respects, but not in others. Mr Poynter was decisive when the methane ignitions were first drawn to his attention: he required Pike River to be deemed a gassy mine and secured an agreement not to use the roadheader. He took a consultative approach by discussing matters with Mr Firmin on two occasions and with the high hazards adviser on at least one. This was probably to be expected, given that Mr Poynter had still not obtained a certificate of appointment. He also persisted in contacting Mr Louw when requested information had not been provided.
41. On the other hand, his approach to the interpretation of the regulations was odd. Mr Bell said the underlying

problem was the use of forcing ventilation and said work must stop. Mr Poynter decided he could not act because the regulations did not require the use of exhausting, as opposed to forcing, ventilation. Regulation 28 requires an employer to take all practicable steps to ensure a supply of fresh air in every workplace.⁵⁰ No one ventilation method is prescribed over another. Instead a standard is imposed, leaving it to the mine operator to select an appropriate work method. It should have been obvious to an inspector that he had to decide whether the company had taken all practicable steps to supply fresh air to the face and, if not, what response was appropriate. To decide there was no breach because the regulation did not prevent the use of forcing ventilation was to misunderstand the regulation.

42. The commission does not regard the actions of the company as those of a motivated and compliant employer. The initial report to Mr Poynter came two days after the event. Thereafter, information was sometimes provided only after a follow-up request. The production manager's final response to Mr Poynter bordered on being truculent. There were clear indications that Pike was not properly investigating and reporting notifiable incidents. A reappraisal of the company's compliance status was needed, but did not occur. Instead DOL persevered with a low-level compliance strategy based on negotiated agreements.

Second means of egress

43. The background to this aspect is discussed in Chapter 16, 'Search, rescue and recovery', paragraphs 134–45.
44. In brief, in the mid-1990s Pike planned to have two stone drives into the mine. By 2000 a vertical ventilation shaft was planned, serviced by an electric hoist. In 2005, when the final mine plan was approved, a ventilation shaft remained the proposed second means of egress, but with a ladder system rather than an electric hoist. This was to be a short-term solution until a walkout egress could be developed to exit in the valley of the Pike River stream.
45. The inspectorate first considered a second egress during an inspection on 27 May 2008. This was Mr Poynter's first visit to the mine; he accompanied Mr Firmin. Mr Louw took them underground. The drift was about 20m from the Hawera Fault. Work had begun at the surface to sink the vent shaft. This prompted discussion in which Mr Louw said that a ladderway was to be installed in the shaft to be used for about seven months.⁵¹ His reference to this period was consistent with the longstanding plan to establish a second egress during the early development of the mine.
46. Development of the mine proved slower than predicted. By January 2009 boring of the ventilation shaft was completed, and installation of a construction hoist required to finish development of the shaft was under way. But on 2 February the bottom 30m of the ventilation shaft collapsed and blocked the connection between the shaft and the mine, also causing a loss of ventilation.⁵²
47. On 12 February 2009 Mr Poynter visited the mine, was flown to the surface and lowered down the shaft in the construction hoist. He wanted to understand the issues relevant to recovering the shaft.⁵³ Mr Poynter conducted a further inspection on 8 April, by which time the company had decided to bypass the collapsed portion of the shaft and install the Alimak raise, which took several months to construct.
48. Mr Poynter did not consider the second egress during inspections he made on 9 October 2009 and 22 January 2010. During his next inspection, on 8 April 2010, Douglas White accompanied Mr Poynter underground and the latter raised the matter of a second means of egress. He was told that the workforce had also asked about it. Mr Poynter viewed the shaft, saw a climbing wire and was told that wires extended to the top of the shaft. There was also reference to safety harnesses for use in an escape up the ladder system. Mr Poynter said that although somebody could technically climb up the shaft, and it therefore constituted an egress, in his view it was not a suitable emergency escapeway.⁵⁴ He asked the company to provide a plan and timeline for developing the additional walkout egress and associated elements.⁵⁵
49. Mr Poynter subsequently considered whether enforcement action was required. He decided that 'a prohibition or improvement notice had the possibility of failing if Pike challenged it in the court because technically a person could climb up the shaft and exit the mine', so he favoured a voluntary compliance approach.⁵⁶
50. On 12 April 2010 Neville Rockhouse emailed an action plan to Mr Poynter. The document recorded a risk assessment

meeting conducted by the company on 5 March 2010, at which various actions were agreed about use of the ventilation shaft as an escapeway. One was that the shaft should not be deemed a second egress 'unless another full risk assessment is completed.'⁵⁷ The document did not refer to development of a second walkout egress.

51. Mr Poynter made a further inspection on 12 August 2010. While underground with Mr White he again raised the second egress and recorded the discussion on INSITE: 'The existing second egress is through the shaft. This allows the evacuation of employees one at a time up the ladderway and while this meets the minimum requirement it is agreed that a new egress should be established as soon as possible.'⁵⁸ On 31 August Mr Poynter wrote to Mr White and stated that, given the plan to start coal extraction and the increased underground population, another egress was required 'as soon as possible. Please provide a plan and time line for this work.'⁵⁹
52. Again, nothing occurred until Mr Poynter's next inspection on 2 November 2010. By then, hydro mining had begun and Mr Poynter inspected the hydro panel with Stephen Ellis. At the mine Mr Poynter was given a memorandum prepared by the technical services co-ordinator, Gregory Borichevsky, which outlined a second egress development plan. There was no time to read and consider the memorandum onsite.⁶⁰ The memorandum, addressed to Mr White, proposed a walkout second egress, which would double as a second air intake for the mine, 250m north-west of the existing workings. However, access to the site required building 1400m of roadway, which was estimated to take over 50 weeks, subject to obtaining conservation approvals and resolving any geological problems. Yet it was thought the egress could be completed 'by June to September 2011.'⁶¹
53. Mr Poynter read the memorandum and understood that there would be no development of the second egress/ intake until after full hydro coal extraction (as opposed to trial extraction) had begun. He regarded this as unsatisfactory, wanted further details and resolved to discuss the matter with the company, but the explosion occurred before he could do so.⁶²

Assessment

54. The attention given to this issue was clearly inadequate. Providing a second egress from an underground mine is a matter of fundamental importance. The workers recognised this and communicated their concern to senior management. Yet the company took no decisive action to ensure that it met its legal obligation.
55. Decisive action was also required from DOL. Construction of the ventilation shaft and the installation of a ladder system was completed in mid-2009. Pike should have been required to provide its plan for a proper second egress then. When, in 2010, the focus turned to starting hydro extraction the issue of a prohibition notice was the only appropriate response.
56. This was put to Mr Poynter in cross-examination. He referred to the difficulty in interpreting Regulation 23, the need for a decision from someone more senior in DOL if a prohibition notice was issued, and his perception that Pike's management viewed this matter as 'a priority', meaning that a negotiated agreement remained a preferable approach.⁶³ The commission cannot accept this.

Use of the inspectorate's powers at Pike River

The Department of Labour policy

57. As in many countries DOL used a risk-based regulatory approach. Inspectors were to assess the compliance risk posed by individual employers, and tailor a suitable compliance response. If an employer was co-operative and compliant, then informal methods or lesser powers would ordinarily be used rather than intervention.
58. DOL used three broad approaches regarding intervention. The first involved 'negotiated agreements', where inspectors discussed a required improvement with the employer and sought an agreement by negotiation. Next was 'directed compliance', where an improvement notice or a prohibition notice was used to secure compliance. These were appropriate where an employer had a history of non-compliance or where prompt intervention was

needed to prevent immediate serious harm.

59. The third approach involved enforcement action via an infringement notice or a prosecution. These options were appropriate where a workplace failure warranted a deterrent approach.⁶⁴ Enforcement action often had to be preceded by a written warning.
60. Procedure required that negotiated agreements had to be recorded in writing and include a completion date for the agreed actions. If the agreement was not honoured, ordinarily the inspector would need to move on to directed compliance.⁶⁵
61. Improvement notices identified a regulatory breach and, if obvious, the required remedial steps, together with a compliance date.⁶⁶ Prohibition notices had to both identify a breach and why it was likely to cause serious harm. Inspectors were advised to consult if in doubt.⁶⁷ Written warnings were to be given where a non-compliance was found during an inspection, but was immediately remedied. The warning meant an infringement notice for a similar non-compliance could be issued without further warning.⁶⁸

Gunningham and Neal review

62. The authors of the external review considered whether the inspectorate's enforcement approach at Pike River was appropriate. They thought it 'striking' that the inspectors only ever used negotiated agreements in their dealings with the company. This, they noted, could raise the concern that the 'inspectors had been captured' and had acted with undue sympathy towards the company's interests.⁶⁹ But the authors concluded that 'over the period of the Pike River mine's operation, there was no single occasion where the inspectors had needed to take a ... robust stance because they never met resistance in any form.'⁷⁰

The compliance approach adopted at Pike River

63. Because Mr Firmin and Mr Poynter regarded the company as a responsible and compliant operator, their preferred approach was to conclude negotiated agreements with Pike, but they did not include a deadline for the performance of agreed actions. Indeed Mr Firmin said that 'just about all my letters don't have a timeframe and they should have really but as soon as you stick down a time often, you know, they might be a week later or something and it presents its own problems.'⁷¹
64. The frictional ignitions in November–December 2008 raised a number of concerns, particularly in relation to Mr Poynter's interpretation of the regulations and to the company's attitude towards compliance. The interactions regarding a second egress demonstrate even more clearly the potential pitfalls of negotiated arrangements. Initially there was no written agreement, then an agreement with no date for completion. There was no sense of authority or urgency.
65. In the view of the commission, and contrary to the conclusion reached in the external review, DOL did meet with resistance from the company and should have taken a much stronger stance. Pike may have expressed good intentions, but its actions were another matter. There was no option but to issue a prohibition notice in relation to the second egress and, generally, firmer compliance methods should have been used at Pike, as shown in the next example.

The roadheader investigation

66. At 4:30am on Sunday 14 February 2010 a miner sustained a serious injury to his foot, which was crushed, causing a bone fracture, some 'degloving' and lacerations. He was flown by helicopter to Greymouth hospital. Mr Poynter arrived at the mine at 9:30am, went underground and inspected the roadheader involved in the accident. Subsequently, he prepared an investigation report.⁷²
67. A roadheader bores mine roadways and is equipped to install roof bolts as it moves forward. Holes are drilled into the roof, bolts are inserted and glued in position and tightened to provide strata support. A bolting rig is part of the roadheader and is hydraulically operated. The miner climbed onto the rig to provide manual assistance when the

automatic bolter encountered difficulties owing to excessive roof height. The bolter auto-retracted, crushing the miner's foot between it and the surface of the rig on which he was standing.

68. Mr Poynter's investigation report was detailed and reached a number of key conclusions. These included the victim's actions being contrary to the mine rules, a mine deputy observing a similar action earlier in the shift and doing nothing to prevent a recurrence, the faulty bolter rig not being withdrawn from service and an apprentice fitter operating the machine without authorisation at the time of the accident. The mine deputy was subsequently dismissed. Mr Poynter concluded that the company, the victim and the mine deputy had committed 'a number of possible breaches', but he recommended against prosecutions. He reasoned that the dismissal of the deputy, the serious injuries suffered by the victim and the company's corrective actions justified 'that no further action will be taken'.⁷³
69. This recommendation was approved by Mr Poynter's manager and on 22 September 2010 the matter was closed by an INSITE entry that included this comment: 'further inspection found that the Deadman lever on the opposite bolter had been tied down with an electrical cable tie. Although this had no impact on the incident'.⁷⁴ In cross-examination Mr Poynter accepted that tying down the deadman lever disabled the bolting rig safety device and that this was of itself a serious matter. There was no investigation into this aspect, although Mr Poynter said he had a number of contacts with Mr White concerning workforce briefings about the risk of overriding safety devices.⁷⁵

Assessment

70. The Gunningham and Neal review included discussion of this investigation.⁷⁶ The authors concluded that Mr Poynter's approach was 'entirely consistent with the precepts of responsive regulation, which was the formal approach of DOL to compliance and enforcement'.⁷⁷
71. It is difficult to fathom why there was no prosecution or, at the very least, a written warning issued to Pike. The investigation exposed a serious safety incident involving the miner, a maintenance fitter and a mine deputy. Serious harm resulted and the incident had no mitigating features. Mr Poynter also discovered a disabled safety device on the same machine, which should have increased concern about the safety culture at Pike and called into question the need for a much firmer compliance approach from the inspectors.

The inspection of mine records

Introduction

72. The mine kept comprehensive records compiled by employees throughout the company. Most concerned production and operational issues, but both these and incident and accident reports contained information directly relevant to workplace safety. The records included incident reports, deputy statutory reports, machine and equipment inspection reports, gas data and charts, control room reports, the incident/accident register, the hazard register and the near-hit register.⁷⁸
73. The commission analysed a large part of the available information and data, and compiled schedules that grouped safety-related information according to subject matter.⁷⁹ The topics included mine ventilation, methane spikes, the bypassing of safety devices, tag board issues, emergency equipment, and actual and potential ignition sources.
74. Mr Poynter was questioned by counsel assisting the commission with reference to numerous excerpts from the schedules. Mr Poynter was unaware of most of this relevant safety-related information. Some examples of his answers and reactions follow.

Methane spikes

75. Gas charts recorded methane readings obtained from a sensor at the top of the main vent shaft. Numerous spikes, where the methane reading was 1.25% or more, were recorded in the weeks before the explosion. Mr Poynter agreed that these readings indicated an even higher methane content somewhere in the mine, given that methane

would be considerably diluted by the time it reached the top of the vent shaft. Mr Poynter observed that these spikes were occurring because of uncontrolled gas incidents and ‘each one of those, in my view, should’ve been notified.’ He added that the extent of the spikes suggested ‘an issue with the ability of the mine to control the gas, and that’s a ventilation issue.’⁸⁰

76. Another indicator of methane control problems was the tripping of the main fan or machines when a safety device shut off an engine in response to a high methane level. Mr Poynter was asked whether at any time before the explosion he was aware of the extent of tripping, including tripping of the main fan. He responded: ‘not the frequency that I’m being shown here. I was aware of one scenario where I was rung by a deputy to get a clarification of when it was appropriate to, what the regulation said about exiting the mine but not to this extent.’⁸¹

Bypassing and contraband

77. Mr Poynter was also questioned about the practice of bypassing methane sensors or safety devices and confirmed that he was unaware of this practice and that had he known of it an investigation and compliance action would have followed.⁸² Similarly, Mr Poynter did not know about problems with contraband, including the discovery of cigarette butts, cigarette lighters and aluminium drink cans underground. Had he been aware of this conduct occurring in 2009 and 2010 he would have required the mine to ‘carry out a retraining programme, like a re-induction around this particular issue and that there would be random daily, random checks every day, every shift, so people were searched before they went underground.’ He would also have considered enforcement action against the company.⁸³

A provision of safety data

78. On 22 January 2010, while conducting an inspection at the mine, Mr Poynter saw information from the accident register displayed onscreen. He requested the details for the last three months and received 41 pages by email the same day.⁸⁴ He had not, however, reviewed the information because of time and other work pressures.⁸⁵
79. The commission observed that, in giving evidence, Mr Poynter was obviously disturbed when the extent of the safety issues at the mine was revealed to him. He said that ‘there just wasn’t enough time’ to peruse mine records, that there was no system provided by DOL to facilitate obtaining and analysing documents, that the inspectors were not ‘trained in auditing’ and agreed that the mine inspectors were essentially there to conduct physical inspections.⁸⁶

Conclusions

80. The commission has reached a number of conclusions:
- The inspectors acted in accordance with DOL policy and largely met the operational requirement to conduct mine inspections at three-monthly intervals.
 - They also collaborated and responded well to requests from the company for technical advice and approvals.
 - The inspectors obtained only a limited snapshot of the mine’s physical systems during inspections, and possessed insufficient information to make an informed judgement concerning the level of compliance at Pike River.⁸⁷
 - It was also essential to conduct targeted audits of the documented mine systems and operational information, but the inspectors had no system, training or time to undertake this work.⁸⁸
 - Nonetheless, the inspectors assumed that the mine was compliant and indeed that Pike was a ‘best practice’ company.
 - The inspectors used only negotiated agreements and then did not always record agreed actions in

accordance with DOL's operating procedures; nor did agreements stipulate a date for the performance of such actions.

- If the inspectors had properly understood the level of compliance at the mine, they would not have used only negotiated agreements but a range of compliance/enforcement options.
- The inspectors found the requirement that employers use 'all practicable steps' to comply with their obligations under Regulations 23 and 28 of the Health and Safety in Employment (Mining – Underground) Regulations 1999 difficult to interpret, and feared that any compliance action could result in a successful court challenge.⁸⁹
- The provision of a second egress from the mine was so serious as to require the issue of a prohibition notice.

81. These conclusions should be viewed in the context of the environment within which the inspectors were forced to operate. In an answer under cross-examination Mr Poynter said, 'We were dysfunctional in that we reported to separate managers. We had one advisor who had no coal background, although he was technically very good ... and there was no co-ordinated approach even ... we weren't resourced and we weren't particularly well set up to be able to provide the service that we were expected to provide.'⁹⁰ The commission agrees with these comments, and emphasises the need to consider this section alongside Chapter 22, 'The decline of the mining inspectorate'.

82. The above conclusions represent an assessment of the DOL's actual oversight of the mine. Another question is whether a well led and operationally competent regulator would have acted more decisively at Pike River. The commission considers it is probable that an effective regulator would have issued a prohibition notice when Pike commenced hydro mining in September 2010 without a usable second outlet (egress) from the mine. The notice would have stopped hydro mining until the planned second intake (to double as a walkout egress) was developed and importantly would have provided the opportunity for the development of improved ventilation and methane control within the mine.

ENDNOTES

¹ Neil Gunningham and David Neal, Review of the Department of Labour's Interactions with Pike River Coal Limited, 4 July 2011, DOL0100010001.

² Ibid., DOL0100010001/11.

³ Health and Safety in Employment Act 1992, ss 29(a), 30(b), 30(c).

⁴ Ibid., ss 31, 39, 41, 56(B), 54(A).

⁵ Ibid., s 49(3).

⁶ Ibid., ss 47, 48, 25, sch 1.

⁷ Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 8.

⁸ Ibid., reg 8(1).

⁹ Michael Firmin, transcript, pp. 605–07.

¹⁰ Ibid., p. 590.

¹¹ Memorandum, Department of Labour Mining Steering Group to Workplace Services Management Team, 12 February 2010, DOL0020020022/3.

¹² Michael Firmin, transcript, p. 598.

¹³ Department of Labour, Mines Quarries and Tunnels – Indication of Inherent Risk, DOL0020020003/1.

¹⁴ Michael Firmin, transcript, pp. 590, 667.

¹⁵ Ibid., p. 628.

¹⁶ Kevin Poynter, witness statement, 19 October 2011, DOL7770040003/2–3.

¹⁷ Alan Cooper, witness statement, 21 October 2011, DOL7770040001/2.

¹⁸ Michael Firmin, witness statement, 19 October 2011, DOL7770040002/4–5, paras 11–18.

¹⁹ Michael Firmin, transcript, p. 2898.

²⁰ Richard Davenport, Inspection Audit Report, 13 February 2007, DOL3000070190/2–3.

²¹ Michael Firmin, notes, DOL3000070008/1.

²² Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 28.

²³ Michael Firmin, witness statement, 19 October 2011, DOL7770040002/7, para. 29.

²⁴ Letter, Michael Firmin to Neville Rockhouse, 28 February 2007, DOL3000070190/1.

²⁵ Michael Firmin, transcript, pp. 2863, 2896–97.

²⁶ Michael Firmin, witness statement, 19 October 2011, DOL7770040002/16, para. 82.

²⁷ Michael Firmin, transcript, p. 2895.

²⁸ Kevin Poynter, transcript, p. 3092.

²⁹ International Labour Organisation, Code of Practice on Safety and Health in Underground Coalmines, May 2006, p. 129, para. 21.5.2., http://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/normativeinstrument/wcms_110254.pdf

³⁰ United States: Code of Federal Regulations, Safety and Health Standards – Underground Metal and Nonmetal Mines, 30 CFR § 57.22202(a)(1); Canada: Coalmining Occupational Health and Safety Regulations, 1990, reg 114(1)(b); Queensland: Coal Mining Safety and Health Regulation, 2001, reg 353(1), (3); New South Wales: Coal Mine Health and Safety Regulation 2006, reg 118.

³¹ Jonathan (Joe) Edwards, witness statement, 24 May 2011, MCD0001/18–19, paras 70–73.

³² Memorandum, from Kobus Louw, to all staff, 13 November 2008, DAO.025.34372.

³³ Kevin Poynter, witness statement, 19 October 2011, DOL7770040003/14, para. 66.

- ³⁴ Email, Kevin Poynter to Kobus Louw, 14 November 2008, DOL3000010087/1.
- ³⁵ Michael Firmin, notes, 14 November 2008, DOL3000070204/1.
- ³⁶ Henry (Harry) Bell, witness statement, 23 June 2011, FAM0001/10–11, para. 34.
- ³⁷ Kevin Poynter, witness statement, 19 October 2011, DOL7770040003/15, para. 76.
- ³⁸ Henry (Harry) Bell, witness statement, 23 June 2011, FAM0001/10–11, paras 35–36.
- ³⁹ Kevin Poynter, witness statement, 19 October 2011, DOL7770040003/15, para. 76.
- ⁴⁰ Email, Kevin Poynter to Kobus Louw, 19 November 2008, DOL3000010086/1.
- ⁴¹ Michael Firmin, notes, 20 November 2008, DOL3000070205/1.
- ⁴² Email, Kobus Louw to Kevin Poynter, 28 November 2008, DOL3000020037.
- ⁴³ Email, Kevin Poynter to Kobus Louw, 28 November 2008, DOL3000010085/1.
- ⁴⁴ Email, Kobus Louw to Kevin Poynter, 3 December 2008, DOL3000020036.
- ⁴⁵ Email, Kevin Poynter to Kobus Louw, 24 December 2008, DOL3000010084/1.
- ⁴⁶ Email, Kobus Louw to Kevin Poynter, 24 December 2008, DOL3000020035/1.
- ⁴⁷ Kevin Poynter, INSITE file detail report, 13 February 2009, DOL3000070077/1.
- ⁴⁸ Neil Gunningham and David Neal, Review, DOL0100010001/65, paras 211–35.
- ⁴⁹ Ibid., DOL0100010001/103, para. 369.
- ⁵⁰ Health and Safety in Employment (Mining – Underground) Regulations 1999.
- ⁵¹ Michael Firmin, witness statement, 19 October 2011, DOL7770040002/26–27, paras 150–56.
- ⁵² Kevin Poynter, witness statement, 19 October 2011, DOL7770040003/18–20, paras 91–102.
- ⁵³ Ibid., DOL7770040003/20–21, paras 104–07.
- ⁵⁴ Kevin Poynter, transcript, p. 3076.
- ⁵⁵ Kevin Poynter, INSITE file detail report, 8 April 2010, DOL3000070155/3.
- ⁵⁶ Kevin Poynter, witness statement, 19 October 2011, DOL7770040003/38, para. 220.
- ⁵⁷ Email, Neville Rockhouse to Kevin Poynter, 12 April 2010, DOL3000010009/7.
- ⁵⁸ Kevin Poynter, INSITE file detail report, 12 August 2010, DOL3000070169/3.
- ⁵⁹ Letter, Kevin Poynter to Douglas White, 31 August 2010, DOL3000070170/1.
- ⁶⁰ Kevin Poynter, witness statement, 19 October 2011, DOL7770040003/47, paras 280, 282.
- ⁶¹ Memorandum, Gregory Borichevsky to Douglas White, 29 October 2010, DOL3000070172/1–2.
- ⁶² Kevin Poynter, witness statement, 19 October 2011, DOL7770040003/47, para. 282.
- ⁶³ Kevin Poynter, transcript, pp. 3080–82.
- ⁶⁴ Department of Labour, Operating Procedure: Improvements and Improvement Notices, 17 October 2005, DOL3000100031/1.
- ⁶⁵ Ibid., DOL3000100031/2.
- ⁶⁶ Ibid., DOL3000100031/4–7.
- ⁶⁷ Department of Labour, Operating Procedure – Prohibition Notices, 5 May 2003, DOL3000100034.
- ⁶⁸ Department of Labour, Operating Procedure – Written Warnings, 5 May 2003, DOL3000100039.
- ⁶⁹ Neil Gunningham and David Neal, Review, DOL0100010001/122, para. 447.
- ⁷⁰ Ibid., DOL0100010001/127, para. 463.
- ⁷¹ Michael Firmin, transcript, p. 2854.
- ⁷² Department of Labour, Crush Incident: Pike River Coal, 14 February 2010, DOL3000070137.
- ⁷³ Ibid., DOL3000070137/13, paras 8.1–8.4.
- ⁷⁴ Kevin Poynter, INSITE file detail report, 22 September 2010, DOL3000070134/3.
- ⁷⁵ Kevin Poynter, transcript, p. 3014.
- ⁷⁶ Neil Gunningham and David Neal, Review, DOL0100010001/125–26, paras 459–60.
- ⁷⁷ Ibid., DOL0100010001/127, para. 464.
- ⁷⁸ Karyn Basher, witness statement, 10 November 2011, CAC0117.
- ⁷⁹ Royal Commission on the Pike River Coal Mine Tragedy (Karyn Basher), Instances of Methane Recorded in ‘CH610 Aux Fan Shaft Methane’ Graphs, Deputy Statutory Reports and Deputies Production Reports (30 September – 19 November 2010), February 2012, CAC0145; Royal Commission on the Pike River Coal Mine Tragedy (Karyn Basher), Summary of Pike River Coal Mine Deputies Production Reports for March and October 2010, November 2011, CAC0116; Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of Pike River Coal Limited Deputy Statutory Reports for March and October 2010, November 2011, CAC0115; Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of Pike River Coal Mine Deputies Production Reports for November 2010, January 2012, CAC0116A; Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of Pike River Coal Mine Deputy Statutory Reports for November 2010, January 2012, CAC0115A; Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, November 2011, CAC0114.
- ⁸⁰ Kevin Poynter, transcript, pp. 3030–31.
- ⁸¹ Ibid., p. 3033.
- ⁸² Ibid., pp. 3033–36, 3043–44.
- ⁸³ Ibid., pp. 3040–43.
- ⁸⁴ Ibid., p. 3011.
- ⁸⁵ Pike River Coal Ltd, Incident Registers – Site Summary – Pike River Mine: Report Period 1/09/2009 to 31/12/2009, 22 January 2010, DOL3000020014/2–42; Kevin Poynter, transcript, p. 3037.
- ⁸⁶ Kevin Poynter, transcript, p. 3038.
- ⁸⁷ Ibid., p. 3018.
- ⁸⁸ Kathleen Callaghan, witness statement, 31 October 2011, FAM00042/46, 57.
- ⁸⁹ As provided for in s 46 of the Health and Safety in Employment Act 1992, and as a result made ineffectual decisions about the location of the underground fan and the adequacy of egress from the mine.
- ⁹⁰ Kevin Poynter, transcript, p. 3040.



After the explosion

- + Search, rescue and recovery
- + The families of the men

Deployment of Pike's emergency response management plan (ERMP)

1. This section examines the effectiveness of Pike's emergency response management plan (ERMP), with particular emphasis on the immediate reaction to the emergency, and what lessons can be learnt. Because the police took control of the emergency response almost immediately the analysis of what happened subsequently is covered from paragraph 19 onwards, 'Police control of the emergency'.

Pike's ERMP

2. Pike had prepared a plan to manage emergencies at the mine, which was part of a wider corporate safety management plan being developed by the safety and training manager, Neville Rockhouse, and is described in Chapter 7, 'Health and safety management'.
3. The core of the ERMP is in a document dated 18 February 2009, written by Mr Rockhouse, and approved by Peter Whittall, as general manager mines.¹ The document appears to be a work in progress. It contains material applicable to Australia but not to New Zealand. The ERMP had not been reviewed as at 19 November 2010.²

Detail of the ERMP

4. The ERMP describes three levels of emergency response according to the seriousness of the event that has occurred. On 19 November 2010 Pike faced a Level 1 incident – an emergency beyond the resources of the mine to manage and requiring external help.
5. The ERMP is centred on the concept of one incident controller, usually the mine manager, who takes control of the emergency and establishes an incident management team (the Pike IMT) that prepares a series of incident management plans. The aim is to have clear responsibilities and good decision-making in an environment of great stress and confusion. The ERMP defines the organisational structures and summarises the duties of the participants on 12 duty cards, which are held in the control room at the mine. These cards are issued as the key positions are filled.

The process of activating the ERMP

6. The process for activating the ERMP is as follows:
 - The control room operator receives information suggesting an emergency and assesses the situation. He or she follows the instructions on Duty Card 1. He or she contacts the most senior manager available and issues Duty Card 2 to that person, who then becomes the incident controller, at least until a more senior manager arrives.
 - The incident controller, using Duty Card 2:
 - evaluates the nature of the emergency and the appropriate level of response (including whether to call for external assistance);
 - forms and leads the Pike IMT to operate from a designated location on site;
 - oversees the incident management plans, including the goals, objectives, priorities and decision-making processes;
 - notifies the Department of Labour (DOL); and
 - issues or ensures the issue of the remaining 10 duty cards to other managers.

- Those remaining 10 duty card holders assume a variety of responsibilities including site access control, operations management (advises the board, notifies families and liaises with the media), equipment control and distribution, provision of mine information, and portal control.

How the ERMP was activated on 19 November 2010

7. Douglas White, the site general manager, says he began to implement the ERMP about 4:30pm, almost 45 minutes after the explosion. His first steps were to allocate the duty cards and recall the senior staff who had left.³ Mr White says that he does not know exactly which cards were issued or to whom or when, 'but the system was fulfilled with respect to ensuring we had enough people to manage the emergency at the time.'⁴
8. Neville Rockhouse had left the mine about 4:30pm, not realising that there was anything wrong. He was called back. On his return he arranged for the incident management room to be established and arrived in the control room shortly before 5:00pm. He says Mr White was holding the red emergency clipboard, which signified to Neville Rockhouse that the emergency procedures had been activated. Mr White said there had been an explosion. He decided to go up the mountain by helicopter to check on the auxiliary fan. Mr White says that before leaving he delegated some actions to Robb Ridl and Terence Moynihan, but he cannot remember what these were. He says he gave instructions that no one was to leave the site. In his absence, Neville Rockhouse became the incident controller and issued duty cards to various people as they arrived.
9. At 5:26pm the two survivors, Daniel Rockhouse and Russell Smith, emerged from the mine. No one was waiting there to provide immediate assistance. Daniel Rockhouse called the control room for help. Neville Rockhouse answered the call, but did not recognise his son's voice.
10. Production manager Stephen Ellis soon arrived in the control room and Neville Rockhouse handed over to him as incident controller, briefing him on events to that stage.⁵ Neville Rockhouse then took a team and equipment to the portal to assist the two survivors.
11. Mr White says: 'Regrettably due to the fact that so much else was going on, I accept that I overlooked sending someone to the portal specifically to meet Daniel and Russell when they came out.'⁶ He added that this caused no actual harm. It is correct that help was made available within minutes but only because Daniel Rockhouse had sufficient strength left after his ordeal to make his second call.
12. Under the ERMP Neville Rockhouse as safety manager should have been given Duty Card 7, which includes responsibilities for co-ordinating emergency services. Because one of his sons, Ben Rockhouse, was one of the 29 workers still in the mine, Neville Rockhouse was unable to assume the role. Mr White does not remember allocating it to anyone else.⁷ He had given no thought to how the police or other emergency services would relate to the Pike IMT.⁸

Douglas White's view

13. Mr White believes he led the emergency response effectively until the police imposed their own incident management structure. When asked to comment on how the emergency structure set out in the ERMP worked, he said, 'None other than the fact that relatively speaking that's exactly how it worked on the day.'⁹
14. Throughout his evidence Mr White maintained that only hindsight revealed a major event had occurred. It was put to him that there was cause for concern from about 4:00pm based on five factors:¹⁰
 - communications (all telemetric information was down);
 - power was out throughout the mine;
 - no communication with the men underground;
 - the unusual smell; and
 - Daniel Duggan's view of events (discussed in Chapter 1, 'Friday afternoon, 19 November 2010').

He answered, 'I would accept that there was cause for concern, in hindsight, but that concern also has to be verified.'¹¹

Conclusions

15. Mr White was faced with a very difficult situation but it would have been more manageable had he started by following the company's ERMP. He was unfamiliar with its principles and detail. He did not take control of the incident. He handed over the incident controller's role to a more junior manager and went off to carry out an investigation of the ventilation shaft that he could have delegated.
16. Although time was of the essence Mr White was reluctant to call out the Mines Rescue Service (MRS) and the emergency services. He could have ordered this soon after the explosion, when he entered the control room and saw that all telemetric information had been lost, the power was off and there was no response to Mr Duggan's attempts to contact people underground. This was unprecedented and had serious implications
17. Only when Mattheus Strydom, the electrician who went underground after the explosion, left the mine at 4:25pm and reported in were the MRS and emergency services called. These delays appear to have made no difference to the survival of the 29 men, but Mr White was not to know that. Further, the delays could potentially have adversely affected the survival of Daniel Rockhouse and Russell Smith.
18. However, Mr White took the stance that an emergency had to be proved before external help was sought. The commission considers that it would have been better to activate the ERMP, including calling emergency services and the MRS as soon as it was clear that the situation was unprecedented, in that all information from the mine was lost and no contact could be made with the men underground. If the situation somehow proved to be not serious, then the MRS and emergency services could have been stood down.

Police control of the emergency

19. The police consider they took the lead agency role at the mine in line with the co-ordinated incident management system (CIMS) model, that they applied that model, albeit with some necessary amendments, and that it worked well.¹² This section summarises the CIMS model and tests the police viewpoint, then assesses the effectiveness of the police-led response and identifies lessons for the future.

CIMS

20. CIMS was designed in 1998 on the initiative of the New Zealand Fire Service (NZFS). Its overall purpose is 'Safer Communities through integrated emergency management'.¹³ It is aimed at the various agencies that provide emergency services, especially the police, ambulance, fire and Civil Defence. It provides a common management structure, principles and terminology which enable the production of consolidated incident action plans (IAPs). These, in turn, allow effective use of the total resources across the agencies.
21. CIMS is built around the concept of one incident controller and three managers acting under his or her authority, as the diagram below shows. These are the manager planning/intelligence, the manager operations and the manager logistics. These four people make up the incident management team (IMT). Under the CIMS model there is only one incident controller and only one IMT, which operates from one incident control point (ICP).

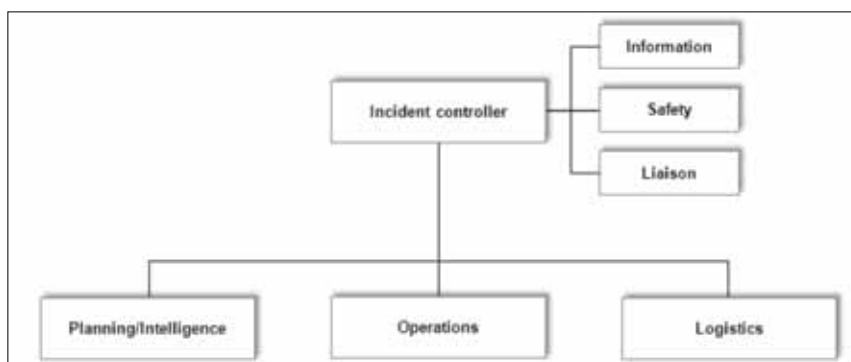


Figure 16.1: Co-ordinated incident management system

22. The incident controller provides the overall direction and co-ordination of the emergency response. There are two concepts used – control and command.
23. ‘Control’ is exercised horizontally across agencies through a consolidated IAP approved by the incident controller. ‘Command’ operates vertically within a single agency, at a level below the IMT. The incident controller does not command those agencies.
24. The manager planning/intelligence gathers and evaluates information and creates the consolidated IAP, which defines response activities and the use of resources. The IAP is for a specific time period (usually of hours) and is regularly renewed. The manager operations contributes to the IAP and implements it. The manager logistics also contributes to the IAP and provides facilities, material, equipment, services and resources, including people, as required to implement the plan.
25. Incidents that occur at multiple sites require an incident controller and IMT at each. This may in turn require overall co-ordination, in which case a response co-ordinator is appointed to provide higher level support. He or she works from a separate emergency operations centre, usually an existing facility. The response co-ordinator does not have an operational function but may provide support in planning/intelligence, logistics, liaison with others involved, and communications. In that event he or she is responsible for approving an incident co-ordination plan that aligns the individual IAPs.
26. The CIMS manual appears to suggest that a response co-ordinator may be necessary for a major incident at a single site, but this is not explicit. Regardless, the manual stresses that incident controllers remain in control of their incidents.
27. The CIMS model assumes one agency will lead the response and other agencies will provide support. The lead agency is determined either by legislation or by agreement among the agencies. The CIMS manual and the NZFS manual assume that the incident controller will come from the lead agency. The manual does not contemplate the involvement of private enterprise and individuals.

So much for the principles. How were they applied in practice?

The police decide to take control

28. The first policeman at the scene was Sergeant David Cross, the duty sergeant at the Greymouth police station. He arrived at 5:13pm. He was accompanied by Constable Shane Thomson. Soon after arrival Sergeant Cross says he met Mr White and Mr Ridl and received brief information. Sergeant Cross says that after the meeting he:
 - advised Police Southern Communications that he ‘had command and control’; that the MRS would be the lead agency for any re-entry or rescue attempt and that ambulance services would be the lead agency for any injured miners;
 - established an incident control point in the conference room in the administration building; and
 - assumed the role of incident controller.¹⁴

Sergeant Cross ‘did not ask Mr White what plans they had in the event of an explosion in the mine, or for a rescue, as I knew we had to wait for the MRS to arrive and start that process.’¹⁵

29. From that point on Sergeant Cross directed police staff at the mine and had various dealings with Mr White and Pike River Coal staff, the MRS, the NZFS and DOL. He stated:

*At no time were police involved in making any decision about promoting or preventing a rescue. We were relying on the advice being supplied by Mines Rescue staff and Pike River Coal senior management, in particular Mr White regarding this issue.*¹⁶

It is clear that the police had not set up a CIMS structure.

30. At 5:40pm, Deputy Commissioner Rob Pope at Police National Headquarters (PNHQ) advised Superintendent Gary Knowles that the police would be the lead agency for the emergency. There is no evidence that other emergency agencies or Pike were consulted.
31. Superintendent Knowles was commander of the Tasman Police District. He was instructed to go to the mine and take control of the operation. Superintendent Knowles had already instructed Inspector John Canning in Greymouth to go to the mine and 'take command'¹⁷.
32. Inspector Canning arrived at the mine at 7:40pm on 19 November and left at 2:30am on 20 November. He attended a number of meetings and issued some instructions to Sergeant Cross. His role under the CIMS structure is unclear: he did not take over as incident controller and does not appear to have assumed the command function.
33. Sergeant Sean Judd arrived at the mine at 11:30pm. He took over from Sergeant Cross as police incident commander at 12:30am on 20 November.¹⁸ He requested the participants meet hourly in the incident control room.

*It was apparent to me that that it was time to put in place a more formal Incident Management Team system under the Coordinated Incident Management System model which Sergeant Cross had started.*¹⁹

34. Meetings were then held approximately hourly, attended by representatives of the police, the NZFS, St John Ambulance, the MRS and Pike management. There was some confusion about the roles of the participants because the IMT structure was not applied. At the 3:00am meeting Sergeant Judd tried to clarify the situation. According to the MRS:

*The Police Incident Controller Shaun [sic] Judd then said that the Police were the lead agency in charge of the search and rescue operation ... [He] emphasised the importance of having a strong IMT structure on-site. He stated that the Police were not experts in mining and would be taking advice on mining related matters (including from MRS) but their role was to ensure that there was an effective IMT and that decisions were documented.*²⁰

35. The first IAP was developed early on 20 November and covered the period from midnight to 8:00am. Although incomplete regarding objectives, it did bring together situation reports prepared by the police, ambulance, the NZFS and Pike. The IAP noted that '[t]he Police and supporting Emergency Services are working with Mine Management team to provide a comprehensive Incident Action Plan.'²¹ An IMT based on CIMS principles was not established; rather, the control and command functions were fused.
36. Later that morning Inspector Canning arrived with Senior Sergeant Allyson Ealam and Sergeant Judd formally handed over to Inspector Canning as 'forward commander', the police officer in charge at the mine, with Senior Sergeant Ealam as second in charge.²² An IMT based on CIMS principles was not established.

Clarity of decision-making structure in the first 24 hours

37. It is unclear at this stage who belonged to the IMT in terms of the CIMS model. Sergeants Cross and Judd and Inspector Canning appear to have been forward commanders in line with the police command structure, but not incident controllers.
38. Certainly the decision-making structure set up by the police was unclear to some key participants, at least initially. Mr White stated that he realised the police were in charge when he returned to the mine at 6:00pm on 20 November.²³ He was not familiar with CIMS, although he had heard of it.²⁴
39. Mr Ellis says he was chairing the IMT at night and Mr White during the day. He says this continued through the emergency period, though by 20 November he was aware the police had taken charge. For reasons unknown to Mr Ellis, on Tuesday 23 November the police decided to chair the 11:00am and 1:00pm IMT meetings, but then the police asked him to resume chairing later meetings.²⁵
40. Neither Mr White nor Mr Ellis understood at first that key decisions were to be made elsewhere. This became apparent as the emergency continued. Mr White says he knew by 6:00pm on 20 November that all decisions were being channelled back to Wellington and he concentrated on participating in the police process.²⁶

41. The lack of a clear CIMS structure complicated the emergency response at the mine. This was exacerbated by the roles taken by senior police officers and DOL at Greymouth and at PNHQ. This resulted in a hierarchy with at least three levels, slowing down decision-making.

Greymouth

42. Superintendent Knowles had no formal training on the CIMS model but did have experience in it.²⁷ He described the response arrangements as follows:²⁸
- Inspector Canning was the forward commander, based at the mine. His function was 'tactical';
 - Superintendent Knowles was incident controller, based in Greymouth. His function was 'operational'; and
 - Assistant Commissioner Grant Nicholls was the response co-ordinator, based at PNHQ in Wellington. His function was 'strategic'.
43. On his initial four- to five-hour visit to the mine on the night of 19–20 November Superintendent Knowles did not personally clarify to people at the mine who was the incident controller under the CIMS model. He explained:
- I didn't because prior to my arrival I told Inspector Canning to take command and do that, and also when I arrived it was obvious to me that Sergeant Judd was wearing a fluoro [sic] jacket which said 'Incident Commander' and everyone can see it.*²⁹
44. In any event, after that initial visit Superintendent Knowles operated from Greymouth. He says he visited the mine 'three or four times' over the first two days but stepped back so he could make decisions outside the emotional environment prevailing there.³⁰
45. It follows that Superintendent Knowles did not lead the IMT. He spent his time mainly on communications, including regular briefings of families, media, liaison with other agencies and liaison with PNHQ. These activities were onerous and took six to eight hours a day, including preparation.³¹ Superintendent Knowles had 17 people to assist him at Greymouth but lacked the benefit of expert mining advice, unlike the forward commander at the mine.³² He did not appoint an officer to run the separate information function envisaged by CIMS, which is a dedicated resource for communications with the media.
46. Superintendent Knowles could also have appointed an officer to brief the families, but did not do so initially because he had not realised how complex and lengthy the operation would be. Once committed to the regular family meetings, he did not delegate the responsibility to someone else as he felt that would be seen as having 'backed away' from the families.³³
47. Superintendent Knowles was the public face of the police operation but did not perform the incident controller role as described in CIMS.

Wellington

48. Assistant Commissioner Nicholls, based at PNHQ, described his role as follows:

*It is the job of the Response Coordinator, operating at a strategic level, to also ensure that the staff on the ground have what they need to act and to ensure that the decision making process includes a robust risk assessment. The problem solving (working out what is to be done) comes from those at the scene (Forward Command and the Incident Controller) while Police National Headquarters provides the means to ensure that what is required is available ... The strategy is the domain of the Response Coordinator while the Incident Controller manages the incident at a direct level working closely with Forward Command.*³⁴

The Risk Assessments were completed at Forward Command with the input of the various experts and agencies on the ground at the mine site. The plans were then forwarded to the Incident Controller who reviewed them with the group of experts he had available. The Assessments [sic] were then sent to the

Response Coordinator for checking and final approval ... I liaised with other agencies involved in the operation ... As the operation progressed I drew on a core panel of experts who provided a review of the risk assessments.³⁵

Power to decide

49. Although Superintendent Knowles had been told at the outset that he had overall command of the operation, that role was in reality assumed by Assistant Commissioner Nicholls at PNHQ. This became clear as difficult issues relating to re-entering and sealing the mine came to the fore. On Monday 22 November Superintendent Knowles received detailed instructions from Assistant Commissioner Nicholls about what he could and could not decide. Superintendent Knowles said, 'I personally didn't need it ... I felt someone in higher command probably thought it was an aid to me.'³⁶
50. Assistant Commissioner Nicholls agreed that, with the benefit of hindsight, many of the decisions he took should have been left with the incident controller. However he maintained that two key decisions – entry to the mine by rescuers and sealing the mine – were correctly made in Wellington.³⁷
51. It is clear that the police regarded those decisions as too weighty for one person and as having national and international significance, and therefore requiring approval at the very top of the police structure.

Functioning of the IMT

52. The police filled all the IMT positions with their own people. The police started what were described as IMT meetings, although neither the police incident controller nor the police forward commander chaired them. Several participants have commented on the large numbers of attendees.³⁸
53. Darren Brady is a senior manager from Queensland's Safety in Mines Testing and Research Station (SIMTARS) and heads the SIMTARS emergency response team. In that capacity, he has experience in responding to mine emergencies and attending state-wide emergency exercises using the mine emergency management system (MEMS), Queensland's mining equivalent of CIMS. Mr Brady was at the mine to provide expert advice on gas monitoring and interpretation. He commented:

In my opinion far too many people were attending these meetings with several organisations over-represented. ... If structured planning, logistics and operation groups had been formed there would be no need for many of those attending the IMTs to be there.³⁹

Activities in these areas appeared to be done by individuals assigned the task, often directly from the incident management team meetings. ... The process would operate differently in Queensland under the Mine Emergency Management System ... with each of the three groups having their own meetings and generally only the co-ordinator of each group attending the IMT meetings. ... This lack of structured groups under each of the co-ordinators may be attributed to the fact that the police were filling these roles.⁴⁰

Access to expert advice

54. The numerous technical matters (for example, on the mine's atmosphere) arising from the emergency were complex and required expert advice. Contrary to Assistant Commissioner Nicholls' understanding, Superintendent Knowles did not have a separate group of experts to assist him at Greymouth. Superintendent Knowles described himself, rightly, as 'the meat in the sandwich' between the mine and PNHQ.⁴¹
55. The group of experts at the mine available to assist the forward commander included a range of highly qualified and experienced people drawn from New Zealand and overseas. For example, at least seven of the 13 mine managers in New Zealand with first class coal mine manager's qualifications were at Pike River.⁴² Those qualifications require knowledge of emergency response in underground coal mines.⁴³ The rescue/recovery plans being prepared at the mine had varying degrees of input from the experts there, including those mine managers, representatives of the mines rescue services of New Zealand, Queensland and New South Wales, and SIMTARS.

56. Risk assessments prepared at the mine were reviewed by Superintendent Knowles and DOL staff elsewhere in Greymouth. Superintendent Knowles then sent the assessments to Wellington to be signed off by Assistant Commissioner Nicholls. Neither Superintendent Knowles nor Assistant Commissioner Nicholls has mining expertise.
57. Assistant Commissioner Nicholls did not appreciate the level of the expertise available at the mine,⁴⁴ and was seeking other expert advice before he signed off the risk assessments. From the morning of 20 November he was in regular contact with James Stuart-Black, national manager, special operations, NZFS. But it was not until 24 November, nearly five days after the first explosion, that Assistant Commissioner Nicholls convened a panel to assist him. The panel was drawn from the national offices of DOL and the NZFS, together with Dr John St George, a mining geologist. Although these people were obviously of assistance, they lacked the relevant mining expertise already available at the mine. By the time of the second explosion on 24 November PNHQ were still trying to find other experts to assist Assistant Commissioner Nicholls.⁴⁵ Dr St George had already told him that the experts at the mine were the best available.⁴⁶

Conclusions

58. The police were faced with a major emergency that did not appear to be under control. They clearly created some initial order by, for example, setting up meetings and starting to prepare IAPs.
59. The police were unaware of Pike's ERMP and there was no discussion about melding the ERMP structure and the police command structure.
60. The PNHQ decision to take control was almost immediate. It was made with no reference to Pike or other agencies. Although this speed was entirely understandable, it was essential that the police confirmed to others their assumption of control and incorporated mining expertise into their decision-making.
61. Filling one or more of the three subordinate positions in the IMT from organisations other than the police would have made up for their lack of mining expertise and experience in responding to emergencies in underground coal mines. Instead the police imposed their normal command structure (operational command and forward command) plus a remote decision-making function based in Wellington.
62. The commission does not accept that the police correctly implemented the principles of the CIMS model at Pike River. It is fundamental that there be one incident controller, located at the incident control point, who controls the direction and co-ordination of the emergency response. He or she decides whether to approve response actions contained in IAPs formulated by the IMT. A response co-ordinator, if one is appointed, does not have an operational function, but may approve a co-ordination response plan. Instead of following the CIMS model, the police set up a complicated three-tiered structure that removed control from the incident controller to a Wellington-based response co-ordinator, who made decisions with assistance from a non-expert panel. The CIMS model is not inflexible, but in this case it was stretched beyond breaking point.
63. The consequences of the police's structure included:
 - an inability for the IMT and the incident controller to act quickly and decisively;
 - decision-making divorced from the reality of the situation at the mine;
 - key decisions, including those about re-entering and sealing the mine, being seen as matters for the police hierarchy, rather than decisions for experts at the mine;
 - a lack of early parallel planning on such vital issues as the survivability of the 29 men and the steps required had they not survived, such as procuring equipment to seal the mine;
 - a bureaucratic approach to the risk assessment process; and
 - non-experts trying to review expert findings on such matters as gas analysis or a drilling proposal.

Role of the Department of Labour (DOL)

64. DOL administers the Health and Safety in Employment Act 1992 (HSE Act). During emergencies, DOL retains its ability to prohibit activities if they may result in serious harm to any person. It also has a role in investigating accidents to determine if there has been a breach of the HSE legislation.
65. DOL provided assistance to the emergency response at the mine, at Greymouth and in Wellington. From a statutory viewpoint DOL had no role in making decisions on the emergency response but was drawn into doing so at Pike River.

DOL assistance

66. DOL Deputy Chief Executive (Labour Group), Lesley Haines, was told about the explosion about 5:00pm on 19 November 2010. She sent to the mine DOL employees who might be able to assist. The first to arrive was mines inspector, Kevin Poynter, about 7:30pm. Ms Haines said:
*The department's role in the search, rescue and recovery operation was in the provision of technical information and advice about mining and safety issues. My own role was leadership of the department's activities relating to the incident. In the search and rescue phase ... the department made available two mines inspectors, both of whom had technical expertise in mining, held a first class mine manager's certificate and were familiar with the mine.*⁴⁷
67. Other staff were also made available at the mine and a temporary office was set up in Greymouth, headed by the DOL regional manager. Ms Haines also assisted with decision-making at PNHQ in Wellington. Thus DOL was represented at the three levels of the structure established by the police. Ms Haines says DOL participated in the risk assessment process at the request of the police.⁴⁸
68. DOL staff, sent to the mine with the vague mandate to provide 'technical information and advice', got drawn into decision-making. Their role caused confusion for other participants. For example, the police thought that 'the Mine's Inspector had ultimate responsibility for authorising any plan.'⁴⁹ This misunderstanding may have been caused by DOL's power to issue a prohibition notice. DOL inspectors had referred to this during discussions about sealing the mine.⁵⁰
69. Ms Haines accepted that 'our role wasn't that clear at the frontline' and that the confusion extended beyond the police.⁵¹ In fact there was confusion beyond the frontline. Ms Haines considered that DOL people were not involved in decision-making,⁵² but documentary evidence of DOL 'approving' risk assessments showed otherwise.⁵³ Ms Haines is correct, though, when she says that the ultimate decisions lay with the police.

Regional manager

70. On 23 November DOL regional manager, Sheila McBreen-Kerr, tried to define the decision-making process for risk assessments flowing through the three levels.⁵⁴ This appears to have been driven by suggestions of delays on DOL's part. The elements of the process she described were:
 - MRS staff and others at the mine formulate plans and risk assessments. DOL people at the mine provide input.
 - The police command centre at Greymouth receives a risk assessment and asks for a DOL review. DOL staff at Greymouth review it, advise police and copy to DOL in Wellington.
 - PNHQ receives the risk assessment for approval. DOL's national office provides consent or seeks a review.
 - PNHQ approves the assessment (or not) and advises the mine.

Conclusions

71. DOL had no people with relevant mining expertise, other than those at the mine. Other DOL staff at Greymouth and Wellington became part of the cumbersome three-tiered response structure. The DOL staff in Wellington were too far from the action and did not have the expertise to understand the issues and make quick decisions.
72. DOL is to be commended for seeking to help with the emergency response but, along with the police, became part of a bureaucratic process that slowed down decision-making.

The risk assessment process

73. An integral aspect of the search and rescue operation was the assessment of the risks associated with intended actions. The police, as the lead agency, required a risk assessment for all hazardous activities. It was prudent to adopt such a strategy.
74. The commission received extensive evidence concerning the effectiveness of the risk assessment process. This included evidence of people from all the agencies involved in the search and rescue operation at the mine, and from the police, DOL and the NZFS.

Conclusions

75. The commission concludes that:
 - The risk assessment structure was cumbersome, involved too many levels and had the potential to cause delay. The actions being assessed for risk required prompt decision-making.
 - The police did not effectively harness the abundance of Australasian mining expertise at the mine. This included members of the New Zealand, Queensland and New South Wales mines rescue services, SIMTARS representatives and Solid Energy New Zealand Ltd and Pike employees. Several held New Zealand first class mine manager's qualifications and similar Australian qualifications.
 - Under CIMS, decision-making should happen at the incident control point where the incident controller is stationed. Risk should be assessed onsite using the services of experts who have both the necessary technical knowledge and a first-hand understanding of the incident. Some experts became disillusioned as operational decisions were made at a distance without their input. One expert left the mine on the evening of 21 November after concluding he could not make a positive contribution, given the structural arrangements and the focus of the rescue effort.⁵⁵ Others contemplated withdrawing from the operation.⁵⁶

Assessment of survivability

76. Discussion of the cause and timing of the men's deaths begins at paragraph 160. The following discussion concerns the process of assessing survivability.
77. When and how should survivability have been assessed during the search and rescue operation? The commission received much evidence that showed the assessment of survivability must begin very early in an operation.
78. A decision about survivability is of fundamental importance. It determines whether an operation focuses on rescue or recovery. But it also affects other operational decisions, including whether the mine should be sealed.
79. At Pike River survivability was not properly confronted until after the second explosion, on the afternoon of 24 November. The assessment should have begun at the first reasonable opportunity, i.e. during the morning of

Saturday 20 November. Suitably qualified experts onsite should have evaluated the available mine information and suitably qualified medical practitioners should have been placed on standby to provide medical opinions as soon as sufficient information was available.

80. Although a decision about survivability would not necessarily have been possible early on, it was essential for the process to begin, so that the matter could be progressively assessed as further information came to hand. The police as lead agency did not fully comprehend the importance of that decision. Had there been advance interagency planning for a catastrophic mine disaster, the question of survivability would have been identified as crucially important and there would have been a process for its evaluation. This is an essential requirement for the future.

Sealing the mine

81. After an underground coal mine explosion there is an ever-present risk of secondary explosions. Their occurrence is likely to damage the mine infrastructure, increase the risk of roof collapse and decrease the chances of body recovery. One possible defence is to seal the mine and starve the underground atmosphere of oxygen. Sealing and inertisation may stop the dilution of methane to explosive levels and prevent further explosions. However, depending on the underground conditions, sealing may also promote an explosion. Sealing will change those conditions, which may bring an explosive fringe and an ignition source into contact.⁵⁷ The other dilemma is that sealing is not an option while life underground remains even a possibility. As one witness said, it is a 'damned if you do and damned if you don't situation'.⁵⁸
82. The commission received consistent evidence from mining experts, including the MRS and Solid Energy, that like survivability, the associated question of sealing the mine should have been considered earlier at Pike River. Everyone agreed that a decision to seal the mine was extremely difficult, given the possibility of survivors underground. But they all expressed concern that a plan and the means to seal the mine should have been in place, ready to be implemented as soon as it was decided there were no survivors.
83. The origin of this problem appears to have been in events that occurred over the first weekend. On the evening of 20 November MRS personnel met and discussed survivability and whether the portal and main vent shaft should be sealed. The group concluded there was only a remote possibility anyone had survived the blast and investigation of the sealing option should begin immediately.⁵⁹
84. At an incident management meeting after midnight, Seamus Devlin, the state manager of the New South Wales Mines Rescue Service, raised the need to consider sealing the mine. This was rejected until there was zero chance of survival.⁶⁰
85. The next day the MRS recommended a sealing plan at the 6:00pm meeting of the IMT. However, DOL officers David Bellett and Johan Booyse indicated they had been advised that any decision to seal the mine would not be approved unless it was clear no one was alive in the mine.⁶¹
86. It seems that the police and DOL reactions to a sealing recommendation inhibited further discussion. Douglas White, however, approached the executive director of SIMTARS, Paul Harrison, concerning deployment of the Queensland Górniczy Agregat Gaśniczy (GAG) inertisation unit at Pike River. He also met the police at the Greymouth police station on 23 November, accompanied by Mr Brady of SIMTARS. They explained the capability and deployment of the GAG at the meeting. The response was to begin preparations to bring it to New Zealand, but 'we don't want it in the car park'. This was because the presence of the GAG would send a message that the operation was moving from rescue to recovery.⁶² This was not in line with effective parallel planning, which requires concurrent planning for alternative courses of action.
87. Structured planning to seal, and inertise, the mine was delayed until after the second explosion on 24 November.⁶³ A decision to bring the GAG to New Zealand was made, and the unit and an operating crew left Mackay on the

evening of 25 November and arrived at the mine site the next day. Had there been parallel planning this timeframe would have been shorter. There were two more explosions on 26 and 28 November 2010, before the GAG was commissioned on 1 December, following the construction of a seal and docking station at the portal.

88. The police accepted the need for the GAG, but were reluctant to bring it to New Zealand while the recovery phase continued. However, as Superintendent Knowles acknowledged, better parallel planning is desirable in the future.⁶⁴ There is also a need for advance planning at mine sites, so that an inertisation unit can be readily deployed.

The availability of information on 19 November 2010

The number of men in the mine

89. There is a regulatory requirement to maintain a record of all employees underground, which is to be 'kept at the entry point'.⁶⁵ At Pike River two systems were used to record employees' entry into, and exit from, the mine: a tag board system, and an electronic system known as Northern Lights.
90. The tag board was the main means of tracking who was underground. All Pike employees and contractors were given an individual tag that incorporated a personal photograph and identifying information. Each worker had to hang their tag on the tag board immediately before going underground and retrieve it as soon as they returned to the surface. Initially the tag board was placed at the portal of the mine, but it was later moved to a position outside the lamp room at the administration area, about 1 km from the portal entrance.
91. Workers did not always hang or retrieve their tags. Between July 2007 and October 2010 there were 15 incident reports listing instances of non-placement and non-removal of tags, and other irregularities that compromised the reliability of the tag board system.⁶⁶ On 19 November 2010 there were 34 tags on the tag board. The correct number of men underground could not be verified for several hours. This complicated the rescue operation and caused distress to anxious friends and family.
92. The Northern Lights system was acquired in 2008 before the mine reached the coal measures. A microchip was located within intrinsically safe battery packs attached to the men's belts. A scanner was installed at the portal to track the entry and exit of men from the mine. The plan was to install further scanners at additional locations inside the mine as it developed.
93. Neville Rockhouse said the scanner could not detect the microchip if men were 'sitting inside a steel cage' as they travelled on a vehicle into the mine. He said engineering staff were made aware of the problem and were working with the manufacturers to obtain a solution. Despite the problems, he believed the system was still in use at the time of the explosion.⁶⁷
94. The Northern Lights scanner reported to the Pike River control room. Those who had access to the control room computer could check and establish who was underground. An incident report dated 8 November 2010 recorded that the Northern Lights system 'needs new parts and hasn't been running for a long time'.⁶⁸
95. The commission is satisfied the Northern Lights system was not in use on 19 November and that the tag board was not always accurate.

The atmosphere in the mine

96. In an underground emergency, being able to obtain reliable and representative samples of the mine atmosphere is essential. Mines rescue crews depend on this information to determine whether it is safe to enter the mine, and other crucial decisions, including human survival, depend on its availability. The emergency response was impeded by the inability to obtain representative gas samples from the mine and the inadequacy of the available pre-explosion gas data.
97. Fixed sensors were located underground at Pike River. The problems with their location and functioning are described in Chapter 10, 'Gas monitoring'. After the first explosion reporting from all sensors was lost. Although the

sensors were fitted with uninterrupted power supply units, it is likely the sensors or their wiring were damaged in the explosion.⁶⁹ Pike did not have alternative equipment designed to obtain gas samples from within the mine, should the sensors fail and access be restricted. Makeshift methods had to be developed.

98. During the early evening of 19 November Mr White authorised employees to fly to the main vent shaft with hand-held 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. Another, more fruitful initiative was to position flexible tubes down the vent shaft and connect those to a stomach pump, lent by ambulance personnel, which could suction samples from lower down in the shaft.⁷⁰
99. Bag samples obtained by hand or by use of the stomach pump were flown to the mines rescue station at Rapahoe. A gas chromatograph analysed the samples. By about 9:30am on 20 November a SIMTARS team from Queensland arrived at the mine, armed with two gas chromatographs. This allowed concurrent analysis of samples at two sites, followed by a comparative evaluation of the results across a significant spectrum of gases.⁷¹
100. Samples were mainly taken from the vent shaft and were unlikely to be representative of the atmosphere in the mine. There was a natural ventilation flow from the portal up the vent shaft and vice versa following a ventilation reversal. This meant that the gas readings from vent shaft samples were probably diluted by the ventilation flow. The readings obtained could represent half or even less of the actual gas concentrations in the mine workings.
101. In addition to real-time telemetric gas monitoring systems, many mines install a tube bundle system. It does not require sensors, which are susceptible to damage in an explosion. The disadvantage is a time delay between taking and analysing each sample. At Pike River this delay would have been at least 20 minutes – the time required to draw a sample from the mine to the surface.
102. The company had budgeted to install a tube bundle system by mid-2011. Had this happened before 19 November 2010, it is likely that atmospheric monitoring from at least some locations in the mine would have continued after the explosion. SIMTARS sourced a 10-point tube bundle system, which was commissioned on 13 December and used extensively from then on.

Additional bore holes

103. During the rescue the only surface-to-mine access points were the vent shaft, the slimline shaft and the grizzly borehole. The latter was of limited value because of its location in the drift, where there was a natural ventilation flow. The limited number of, and problems with, the available sampling locations resulted in a decision to drill additional boreholes into the heart of the mine. The preferred location for the first drillhole, PRDH43, was a short distance outbye of the hydro panel to intersect the main return roadway back to the area of the underground fan and vent shaft.
104. Once this location was chosen, a helicopter transported a drilling rig to the hillside site. Drilling began on 21 November and strenuous efforts were made to work as quickly as possible. About 5:00am on 24 November the drillhole reached the required depth, but it had struck the rib wall rather than the roof of the roadway. Within a few hours, however, there was confirmation that gas from the mine was entering the borehole and sampling could begin.
105. After analysis of the first samples, Mr Brady of SIMTARS concluded that 'this data was enough to indicate that an ignition source existed, possibly where an explosive mixture could form so the decision was made that it was not safe to send mines rescue teams into the mine.'⁷² That ended any notion that the underground atmosphere had improved sufficiently to consider re-entering the mine that day. A short time later, at 2:37pm on 24 November, the second explosion occurred.

Use of robots

106. The New Zealand Army provided robots and support crew for use at Pike River. Atmospheric testing equipment was installed and a robot was sent into the drift on 23 November. It travelled 550m before failing, probably

through contact with water. A second robot was obtained and deployed on 24 November. It provided audio-visual information to 800m and then failed. However, power was restored to the first robot and it travelled to 1050m before power was again lost. Both robots remain in the mine.

107. The use of the army's robots in an underground coal mine had not been contemplated before the explosion at Pike River and considerable ingenuity was required to modify the robots for use in a mine.
108. A robot belonging to the Australian Water Corporation was also flown to New Zealand and sent into the mine on the night of 25–26 November. It was equipped to monitor gas levels and transmit audio and visual data. The robot penetrated to 1570m, encountered Mr Smith's abandoned loader and then retreated, having confirmed that the atmosphere in the drift was normal.

Was there a 'window of opportunity'?

109. Immediately after the first explosion there was high public expectation that MRS teams would enter the mine and endeavour to rescue the men, or at least recover their bodies. When a rescue operation did not eventuate, there was disappointment, even frustration.
110. This was probably understandable. Following the Strongman mine disaster near Greymouth in 1967, which claimed the lives of 19 men, a rescue team entered the mine and within 14 hours recovered all but four of the bodies. Similarly, in the 1926 Dobson mine disaster, rescuers entered the mine soon after the explosion and recovered the bodies of four of the nine victims. These, and other, mine tragedies gave rise to a belief that, after an explosion, there was a window of opportunity within which it was possible to enter the mine safely. The assumption was that the explosion would have consumed the methane in the mine atmosphere, and that there was time to re-enter before the methane built up again.
111. There are, however, just as many examples of second explosions that claimed the lives of would-be rescuers. In August 2010 a rescue team entered the Rospudskaya coal mine in Western Siberia before a second explosion, which occurred about four hours after the first one and killed 19 rescuers. In other mines secondary explosions have occurred within even shorter periods, sometimes within only minutes of the first explosion.⁷³
112. The commission had the benefit of expert evidence concerning the so-called window of opportunity, and it all pointed one way. Mines rescue experts from both Australia and New Zealand agreed that, even with the benefit of hindsight, there was no window within which the Pike River mine could have been entered.⁷⁴ The witnesses also explained the basis for their view.
113. First, all mines are different and even sections within a mine may differ. Without accurate and representative information, the atmosphere in an underground coal mine cannot be predicted. That difficulty is particularly acute when the mine ventilation system is not functional as the coal seam continues to produce methane. Damage to the methane drainage system may also add to the accumulation of methane. After an explosion there is also a significant risk of a continuing ignition source, or fire, within the mine. These factors create an unpredictable situation, during which secondary explosions are commonplace.
114. Before re-entry is a safe option there must be reliable and representative information about the conditions underground, especially the make-up of the mine atmosphere and the risk of fire or an ignition source. No information of this kind was available at Pike River. Throughout, the experts onsite were unanimous that, without better information, a safe re-entry was not possible.
115. Second, the concept of a window of opportunity presupposes a time of known duration within which rescuers may safely remain within the mine. Trevor Watts, the general manager of the MRS, gave evidence concerning the time required to enter Pike River and inspect the areas where the men were believed to be working. He explained that ideally a rescue team would have been able to drive the first 1600m into the drift in a driftrunner. At this point the team would have encountered the abandoned loader and if possible, moved it.⁷⁵ Even so, from the end of the

drift a reconnaissance on foot would have been required. The rescuers would have worn long duration breathing apparatus. This was rated to provide four hours of oxygen, but rescuers operate to a one-third rule. That is, the duration of the breathing unit is divided into three: a third for search activity, a third to leave the mine and a third in reserve. This would provide a period of 80 minutes to search the mine workings. Mr Watts considered it would take much longer than this for a team to conduct a search, particularly if there was explosion damage. He thought that more than one entry into the mine would be required.⁷⁶

116. The commission finds that there was no window of opportunity to enter the Pike River mine in the days following the first explosion. There was little or no reliable and representative evidence of atmospheric conditions within the mine to determine whether there was a fire or an ignition source underground. There could be no assurance of safe re-entry, and the decision not to enter the mine was correct.

Self-rescue

117. The term self-rescue refers to the ability of someone to escape from an underground mine after an emergency, without direct assistance from others. History has shown that after an underground fire or explosion very few miners worldwide are saved by mines rescue teams. If miners cannot self-rescue, it is likely that rescuers will not be able to go underground in time to save them. In order to escape miners need immediate access to breathing units and other equipment and aids, as well as emergency training.

Self-rescuers

118. Miners and contractors at Pike River were provided with Dräger Oxyboks K self-rescuers, contained in a canister that can be attached to the user's belt. The self-rescuers contain a chemical substance, which reacts with exhaled carbon dioxide and water vapour to liberate respirable oxygen. It supplies oxygen for about 30 minutes, depending upon the wearer's level of activity and breathing rate.
119. It was standard practice at Pike River for employees to carry a self-rescuer when going underground. The company also provided an underground store of spare self-rescuers. There were 108 self-rescuers stored in two large heavy-duty plastic boxes located in the slimline shaft stub, also known as the upper fresh air base (FAB). Some of the stored self-rescuers were one-hour units.
120. The Dräger self-rescuers were fit for purpose and should have enabled a trained person who survived the explosion to walk to the slimline shaft, obtain a spare unit and escape from the mine via the drift.
121. Concerns about the adequacy of the self-rescuer training arose out of the evidence of two of the three men who were in the mine after the explosion. Despite his concern that there had possibly been an explosion underground, Mattheus Strydom did not carry a self-rescuer with him when he drove into the mine at 4:11 pm. He was forced to retreat when he encountered the fringe of an irrespirable atmosphere.
122. Daniel Rockhouse did have a self-rescuer, but found on 19 November that using one in a real emergency was a 'different story' to training with a dummy self-rescuer.⁷⁷ He donned the device but could not make it work. He then removed and discarded the self-rescuer, succumbing to the irrespirable atmosphere a short time later. Daniel Rockhouse had not participated in an emergency drill in his two and half years at the mine.
123. Training in self-rescuers should include participation in regular exercises using self-rescuers. Those exercises must simulate, as much as possible, the conditions and stress of an actual emergency. Workers must also receive regular refresher training in use of self-rescuers. That did not happen at Pike River.

Compressed air breathing apparatus (CABA)

124. CABA is similar to underwater scuba diving gear. Strapped to the user's back is a compressed air oxygen cylinder that is connected to a positive pressure full face mask. CABA has several advantages over self-rescuers. It is easier to

use, allows its wearer to speak to others and rehydrate, and enables the wearer to undertake other activities such as fire fighting and helping others to escape.

125. There were no CABA units at Pike River. Self-rescuers were the only breathing units available to the workers, although the introduction of CABA was being contemplated.

Changeover stations/fresh air bases/refuge chambers

126. To use self-rescuers and CABA units workers must have a safe place to which they can go in the course of an evacuation. Workers will ordinarily need to exchange their self-rescuers for fresh ones, or exchange them for CABA. A safe place may be a changeover station, an FAB or a refuge chamber.
127. A changeover station is the least sophisticated option and could be as simple as a small space created in a stub using brattice. Fresh air is introduced permanently or temporarily. It is at higher risk of contamination than FABs or refuge chambers. A FAB is generally a constructed and maintained room-like facility properly sealed to maintain a respirable atmosphere inside, even during emergency conditions. Communication and escape equipment are also available. Refuge chambers are the most sophisticated option. They are purpose-built steel rooms, which are usually moveable and provide a continuous source of fresh air from the surface. They contain replacement breathing units (self-rescuers or air cylinders), a communication link to the surface, first aid equipment, food and water.
128. In a coal mine the first objective is always for workers to rescue themselves given the risks of explosions and a toxic atmosphere. If for some reason they cannot do so a refuge chamber provides a place where they may wait in relative safety for rescuers to arrive. Refuge chambers are more commonly used in metal mines, where there is normally no gas and the major risk is of a roof collapse.
129. Pike did not have a refuge chamber. Although Neville Rockhouse raised the purchase of one in late 2009, nothing came of his suggestion.
130. Two locations in the Pike River mine were described as FABs. The first, referred to as the lower FAB, was in the stone drift 1500m inbye of the portal. The second, known as the upper FAB, was in the stub containing the slimline shaft near Spaghetti Junction.
131. The lower FAB was installed by McConnell Dowell during the development of the drift. Located in a stone stub, it was a converted container with sealable double doors. At the time of the explosion it had been decommissioned and was no longer supplied with compressed air. The telephone connection to the surface was not working and replacement self-rescuers, first aid equipment and fire-fighting equipment had been removed.
132. The upper FAB was developed in March 2010 following a risk assessment which found that the main vent shaft was not suitable as a second means of exit from the mine. The slimline stub was 15m deep, 5m wide and 5m high. The methane drainage line passed through the stub and vented through a gas riser to the surface. A roll-down brattice door was installed so the stub could be isolated in an emergency. Fresh air was available from the surface through the 600mm diameter slimline shaft. The stub contained a cache of 108 self-rescuers (60 of 30 minutes' duration and 48 of 60 minutes' duration), first aid equipment, fire-fighting equipment, a digital access carrier (DAC) and three telephones, one of which was connected to the surface. Pike had planned improvements to the slimline stub, such as increasing its size, installing concrete walls and double doors incorporating an air lock system. The improvements were meant to have been completed by June 2010 but had not been done by the time of the explosion.
133. The roll-down brattice screen would not have prevented the FAB being polluted with the toxic atmosphere. Following the explosion, the failure of the underground fan resulted in a reversal of the air circuit, meaning the slimline shaft became a chimney through which noxious explosion products were drawn into the stub and up to the surface. The upper FAB was not a place of safety and was not functional as an FAB at 19 November 2010. It was not even fit as a changeover station.



Figure 16.2: View of the upper FAB from outside⁷⁸



Figure 16.3: View of the upper FAB looking inside⁷⁹



Figure 16.4: Inside the upper FAB looking towards the entrance⁸⁰

Second means of egress

134. Underground mining has a long history of multiple fatalities caused by fire, explosion and roof collapse. Legislation was enacted throughout the mining world making two means of egress from underground mines mandatory.
135. A statutory requirement for a second means of egress existed in New Zealand until 1993 when the Coal Mines Act 1979 was repealed. A replacement provision was included in the Health and Safety in Employment (Mining – Underground) Regulations 1999. Regulation 23 requires employers to take all practicable steps to ensure their mines have suitable and sufficient outlets for entry and exit. Suitability and sufficiency are determined according to the size of the mine, the maximum number of employees, ‘the need to have at least two outlets that are separate from each other but that interconnect’,⁸¹ and the requirement to have at least one outlet that can be traversed on foot and another that has a mechanical means of entry and exit.
136. When the Pike board approved the final mine plan in 2005 the ventilation shaft was the proposed second means of egress with a ladder system to be installed. This was an interim solution. As the mine was developed into the coal measures nearer to the western escarpment, the mine plan contemplated the development of another near-horizontal walkout egress termed an adit, which would also double as a second ventilation intake into the mine.
137. Development of the ventilation shaft in 2009 in its eventual location is described in Chapter 3, ‘The promise of Pike’, paragraphs 47–49. In summary, the shaft located at pit bottom comprised a 2.5m square bypass to a height of 45m, known as the Alimak raise, and a 4.5m diameter shaft to the surface, a total height of 110m.
138. Neville Rockhouse was adamantly opposed to the use of the vent shaft as an escapeway, even as an interim measure. In October 2009 he initiated a risk assessment and invited members of the risk assessment team

to participate in a test climb up the main shaft. Mr Whittall was invited to participate, but on the day another commitment took priority.⁸² The first two men to attempt the climb, Adrian Couchman and Nicholas Gribble, reached the top of the Alimak raise and then abandoned the exercise, doubting their ability to get to the surface. The group concluded that the vent shaft was entirely unsuitable as a second egress.

139. A lengthy risk assessment process followed and in March 2010, a representative group, including Messrs Watts, White and Neville Rockhouse, concluded that the vent shaft was unsuitable as a second means of egress in an irrespirable atmosphere. By the time of the explosion planning for a second egress was under way.
140. Neville Rockhouse also researched the purchase of a coal-safe refuge chamber from Western Australia, at a cost of approximately \$300,000,⁸³ as an interim and partial solution to the second egress problem. The proposal was not taken up, so he proposed the development of the slimline stub as an FAB. Approval was given and some work was undertaken to establish the upper FAB.⁸⁴
141. Mr Poynter raised the adequacy of the vent shaft as a second egress in the course of an inspection visit on 8 April 2010. His actions are reviewed in Chapter 15, 'Regulator oversight at Pike River'. Although he contemplated issuing an improvement or prohibition notice, in the end he took no formal action. On a further visit to the mine on 12 August 2010, when he found no progress had been made, Mr Poynter said that the second egress should be established as soon as possible, and before full coal extraction began.
142. In 29 October 2010 Gregory Borichevsky addressed the development of the second egress in a technical services memorandum to Mr White.⁸⁵ The proposed location of the egress was identified 250m north-west of the then most western margin of the workings. 'High level investigations' were required into numerous aspects, including flooding risk, slope stability, strata control and portal construction, as well as Department of Conservation (DOC) approval. Mr Borichevsky predicted that the egress could be established by June to September 2011.
143. As at 19 November 2010 the ventilation shaft remained the designated second egress. Using it as an escapeway was a fundamentally flawed concept. It was very physically demanding to climb the 105m ladder system in normal conditions. Wearing a self-rescuer it would have been even more difficult, probably impossible. Injured men would have had no chance. After the explosion the vent shaft became a chimney for flame and noxious gases.
144. Development of the hydro panel, and coal extraction, took priority over construction of a proper second egress. That was in spite of the workers' extreme concern that the interim egress was not adequate. Establishment of the second egress should have been prioritised over extraction. Neville Rockhouse agitated for this but with little result.
145. Given the nature of the explosion, and the timing of the men's deaths soon after the event, it is likely the absence of a second egress was not of any practical consequence. But emergencies can take many forms and had the drift been blocked there would not have been an alternative escapeway out of the mine. Extraction should not have been allowed to continue while there was no effective second egress.

Other self-rescue aids

146. Workers may face visibility problems when, in an emergency, a mine becomes filled with smoke. This can cause disorientation and loss of direction. Smoke lines are a simple but useful tool for guiding workers out of the mine or to escape facilities.
147. The lines are attached to the roadway walls or roof, or to mine equipment such as pipelines within reach, and directional cones guide miners in the right direction. Walking canes can be hooked onto the smoke lines, or used to feel for obstructions. Reflective signs may also be used to identify locations or provide directions.
148. Smoke lines and reflective signs were used at Pike River, but there were installation and maintenance problems. The installation of smoke lines did not match development of the mine,⁸⁶ and some lines were inaccessible,⁸⁷ or damaged and not promptly repaired.⁸⁸ There were also concerns about the adequacy of signage installed in the mine.⁸⁹

Use of vehicles in self-rescue

149. Mine personnel transport vehicles designed for use in an emergency provide a faster means of escape and enable injured workers to be rescued.
150. There was a shortage of personnel carriers at Pike in 2010. Men sometimes walked out of the mine because of delays in the taxi service caused by breakdown and maintenance problems. On at least one occasion a group of miners walked off the job because of their concern that the lack of vehicles meant they would be unable to escape quickly enough in an emergency. Pike River's personnel carriers did not incorporate self-escape features.

Self-rescue training and readiness

151. Training is integral to successful self-rescue in an actual emergency. There are three aspects to a best practice training programme:
 - self-rescue training for new miners, usually as part of an induction process;
 - periodic refresher training; and
 - onsite evacuation exercises during which the workforce evacuates the mine in simulated emergency conditions.
152. Pike gave trainee miners induction training spread over a 12-week period. The men worked for three days and spent two days, generally offsite, undergoing training. The spread of the course was considerable, including a self-rescue component provided by the MRS over two separate days. There was instruction in the use of self-rescue units, which included donning a self-rescuer in the dark. There was also tuition about the use of changeover stations and a blind walkout exercise in the MRS training tunnel and a further evacuation exercise at Pike River. The induction training included competency assessments and culminated in the award of an underground extraction certificate.
153. There was little refresher training. Mr White introduced refresher training at the mine in August 2010. It was to be conducted by experienced West Coast miner Harry Bell, and was intended to include self-rescue, but the initiative was not successful. There was one three-hour training session in early October, but the following week only three men were available to attend the session owing to production pressures. The training was put on hold.
154. Contractors made up a significant proportion of the Pike workforce and comprised almost half of the men underground at the time of the explosion. Initially there was no induction training for contractors. During development of the drift McConnell Dowell used its own health and safety programme, and from late 2008 Pike River Coal provided training for the employees of smaller contractors. This induction training included the two-day self-rescue component provided by the MRS. It is doubtful that the entire contractor workforce received training.
155. The commission accepts that the company took steps to provide self-rescue training for its employees and for contractors working at the mine. However, it doubts that training covered the whole workforce.
156. Following development of the workings in coal, there was one drill in October 2009 and a further emergency drill was planned for December 2010. This meant that not all shifts had participated in an evacuation drill. Regular drills covering every shift were planned when the mine attained steady state coal production, but this did not occur.
157. The evidence from the two survivors, and from the electrician who was sent underground, does not encourage confidence in the adequacy of the training these men had been given. The commission also notes that there is no regulatory requirement governing self-rescue training in New Zealand.

Accident/incident reports

158. Pike's accident and incident reports show that there was a range of issues reported on Pike's emergency preparedness through to November 2010. These included: tags not being removed from the tag board, a worker not tagging in when he went underground and too many tags being placed on the board; phones not placed in the right locations, the DAC not being answered by surface control or being faulty; inadequate smoke lines; missing

self-rescuers; damaged or missing fire fighting equipment and fire hoses being used for non-emergency reasons; and medical equipment missing.

159. The reasons given for these incidents included lack of knowledge and training; being unaware of hazards; inadequate work standards; forgetfulness; laziness; misconduct; safety rules not being enforced; inadequate leadership and supervision; and inadequate purchasing and stock.⁹⁰

The deaths of the men

Introduction

160. The timing and cause of the men's deaths is an important issue relevant to several aspects of the search and rescue operation. At an inquest in Greymouth on 27 January 2011 Chief Coroner Judge A.N. MacLean found that:

*the death of all 29 men occurred on the 19th of November either at the immediate time of the large explosion which occurred in the mine or a very short time thereafter. It is also clear that the cause of death, although it may well vary in degree between individuals depending on their location, was the result of a substantial explosion and the combination of concussive and thermal injuries due to the explosive pressure wave, together with acute hypoxic hypoxia through exposure to toxic gases and lack of oxygen.*⁹¹

This section will evaluate whether the chief coroner's finding needs to be revisited in light of the extensive additional evidence available to the commission.

Expert evidence as to survivability – evidence presented at the inquest

161. The chief coroner's finding was based upon reports from mining experts and medical opinions from three highly qualified doctors. As well as these, the commission heard extensive evidence relating to the mine systems, the search and rescue operation and the views of mining experts on survivability in light of all the information now available.
162. None of the expert evidence was given in person. Instead, Superintendent Knowles produced a number of expert reports.
163. Kenneth Singer, the deputy chief inspector of coal mines in Queensland, Australia, prepared two of the reports. The first, entitled *Explanation of Gas Analysis and Interpretation*,⁹² dated 24 November 2010, explained the analysis of samples obtained at the main shaft after the first explosion, the rate of production of methane from the coal seam in the mine ('methane make') and the impacts of an explosion overpressure. The second report, entitled *Prospects of Survival Pike River Mine*,⁹³ dated 26 November 2010 at 6:00pm, reflected the views of a group of experts who considered survivability at the mine following the second explosion on 24 November. This report assessed survivability by reference to four likely causes of death – blast-wave injuries, burns, oxygen depletion asphyxiation and carbon monoxide poisoning – and in relation to four districts into which the mine was divided for the purposes of the analysis. The group concluded there was no prospect of survival in any part of the mine. However, by the time this report was written, the third explosion had occurred at 3:49pm on 26 November 2010.
164. Another report was prepared by Professor David Cliff, the operations manager of the Minerals Industry Safety and Health Centre, University of Queensland, Australia,⁹⁴ entitled *A Preliminary Evaluation of the Situation at Pike River Coal Mine, as at Sunday 12 December, 2010*.⁹⁵ This concentrated on the physiological impact of a post-explosion gas atmosphere. In particular, Professor Cliff analysed carbon monoxide readings obtained at the main shaft following the explosion. These peaked at a concentration of over 3000ppm (parts per million) and he concluded that it was not unreasonable to assume concentrations more than twice this amount within the mine immediately after the first explosion.
165. Three doctors provided medical opinions, which were produced at the inquest. Dr Andrew Veale, an Auckland respiratory physician, Dr Robin Griffiths, director of occupational and aviation medicine at the University of Otago, and Dr Alan Donoghue, director of health and chief medical officer of a mining company in Perth, all specialise in

the question of survival in oxygen-deprived environments. All three doctors independently concluded that none of the men would have been alive on 26 November, following the third explosion.

166. This was hardly surprising. By then a week had passed with no sign of life from within the mine. However, the reports from the three doctors also included a focus on survivability at the time of, and immediately after, the first explosion. It is clear that this evidence influenced the chief coroner in reaching his conclusion about the immediacy of the deaths.
167. Dr Veale's report was representative of the views of his colleagues. He identified four likely causes of death:
 - He considered the men close to the explosion would have been subject to an immediate concussion impact and thermal injuries, with secondary shrapnel effects, which would have been fatal.
 - He thought the compression and expansion wave caused by the explosion would, in the confines of a small mine, have caused internal tear injuries, including to the lungs and sinuses. Associated bleeding, particularly into the lung, would have caused immediate, or delayed, death to men within the main roadways of the mine.
 - He concluded that exposure to carbon monoxide (CO) produced in the explosion would have produced a progressive CO build-up in the bloodstream, which prevents the absorption of oxygen. In a confined environment and without an air source this, too, would have been fatal.
 - Then there was lack of oxygen (hypoxia) caused by the burning of oxygen in the course of the explosion and any subsequent fire. Fresh air contains 20.9% oxygen. An oxygen level less than 10% leads to unconsciousness, and a level less than 6% results in death within minutes. And in combination, CO absorption and hypoxia are a more lethal mix.

An open box at the slimline shaft

168. To recap, the stub containing the slimline shaft, called the FAB, contained various items of equipment to facilitate self-rescue or for use in providing first aid.
169. The equipment included three sizeable boxes sitting on the floor next to the right-hand rib as viewed from the drift. Two of the boxes were of solid blue plastic construction, measured 1100 x 550mm, and 450mm in height, and contained self-rescuers. The third box, made of plywood, was slightly smaller and contained canisters of fire-fighting foam.
170. The blue plastic boxes had an overlapping lid, which could be secured using three metal locking mechanisms on the front. An Environmental Science and Research (ESR) scientist, who examined an identical box at the request of the police, concluded that the locking mechanisms would have been effective against an explosive force, provided they were in the clamped position. If they were unclamped, she was unsure whether the lids might open in an explosion.
171. The three boxes were last examined on 18 November by Mr Couchman, a Pike River safety training co-ordinator. He opened the blue cache boxes, calculated that they contained 108 self-rescuers, then closed and secured the lids.
172. About 2:00pm on 19 November Gary Campbell and Joe Verberne, VLI Drilling Pty Ltd employees, checked the mine methane drainage line, including its entry into the slimline stub. They used a self-rescue box as a step to inspect the gas riser that vents to the surface. They replaced the box with its lid in the closed position.

The C-ALS images

173. On Wednesday 24 November the area at the bottom of the slimline shaft was scanned using a C-ALS (Cavity Auto Scanning Laser System) laser device. The scans were taken before the second explosion. A Solid Energy mining engineer, John Taylor, was in charge of the scanning crew, which is probably the world's most experienced in this work.

174. The probe has a cable back to the surface through which data is recorded from underground. The motorised scanning head can rotate in all directions. It fires a laser beam that travels through the underground void until it hits a solid object. The beam rebounds off the object back to the receiving port and after multiple rotations of the scanner a three-dimensional (3D) image of the void is obtained.
175. Analysis of the data obtained indicated that the scanned images were affected by the presence of airborne water droplets, which interfered with the laser beams and the quality of the images. However, equipment in the stub was still clearly visible, and in Mr Taylor's opinion the lid of one of the large blue boxes was open.
176. On 17 February the crew rescanned the slimline shaft. This revealed that there had been a major roof collapse in the drift, which caused spoil to spill into the stub over the area where the three boxes were positioned, so no further evidence was obtained.

Enhancement of the images

177. At Mr Taylor's suggestion the original scans were sent to Adelaide-based James Moncrieff, an expert in the interpretation of 3D laser images. He enhanced the images and agreed that the lid to one of the blue boxes was open.
178. He found one factor that differed from the conclusions of the ESR scientist in New Zealand. The blue plastic box that she examined could open to only 105° from its closed position. Mr Moncrieff calculated that the C-ALS image showed the lid open to 156° from the closed position.
179. Mr Moncrieff considered that there was only a limited view into the open box, which revealed an object of 'high intensity' in the back corner. This was probably 'a reflective object (shiny or bright)'.⁹⁶ Self-rescuers are kept in shiny metal canisters.
180. Mr Moncrieff also enhanced an indistinct image of something lying at floor level in front of the boxes. The data quality of this image was inferior to other images. He concluded that '[t]he size, shape and intensity changes appear ... to be consistent with that of an upper torso shape. However the shape is not consistent with it being a complete body'.⁹⁷ However, he considered that the shape could equally be fallen coal or rock, brattice lying crumpled on the floor or a bucket containing rescue items that had been lowered down the slimline shaft on the evening of 19 November.
181. The last possibility can be discounted. The bucket was retrieved by the scanning crew before C-ALS images were obtained on 24 November and the contents were found to be undistributed.

Conclusions concerning the open lid

182. The commission accepts that one of the blue plastic boxes containing self-rescuers was probably open when scanned on 24 November. However, how it was opened remains unclear. There are at least three possible explanations all of which are conjecture:
 - If the box was not securely latched before the explosion, the lid could have been blown open. The overlapping construction of the lid would make it difficult for an explosive force to blow it open. On the other hand, the extent to which the lid was open, 156°, might support this possibility.
 - Someone opened the box and left the lid open before the explosion. However, it is difficult to envisage why anyone would consciously do this, and there was a window of only about an hour and three-quarters from when Messrs Campbell and Verberne saw the boxes with lids closed to the moment of the explosion.
 - Someone survived the first explosion, made his way to the slimline shaft and opened the lid in search of a self-rescuer, but was unable to escape the mine. However, that no one called the control room from the FAB may tell against this possibility.

183. In brief, how the lid was opened remains unexplained and there are at least three possible explanations, one of which could be consistent with a period of survival. Unfortunately, further C-ALS images taken on 17 February 2011 indicate that spoil from a major roof collapse has eliminated any possibility of obtaining further evidence about the open lid.

Expert evidence as to survivability – evidence before the commission

184. Much of the additional evidence before the commission was direct evidence, as opposed to written reports. The commission also heard a personal account of the effects of the first explosion from one of the survivors, Daniel Rockhouse, plus evidence from mining experts, who expressed opinions about survivability after the first explosion.
185. Mr Watts, the general manager of the MRS, concluded that most of the men would have been killed, or rendered unconscious, by the first explosion. Those rendered unconscious would have died from noxious gases, or lack of oxygen, within minutes. If anyone had been able to don a self-rescuer he may have survived for the duration of the device.⁹⁸ He highlighted some relevant factors:⁹⁹
- Pike River was a very small mine, the video evidence showed the intensity and duration of the explosion, suggesting that the initial shock wave was probably immediately fatal or that it rendered the men unconscious.
 - The workforce was trained to self-rescue by walking out of the mine, not to take refuge in the mine, but no one walked out from within the workings.
 - Anyone who survived the immediate effects of the blast and had time to don a self-rescuer would have had 30 minutes of oxygen and time to walk no more than 700m to the FAB, where there were spare self-rescuers.
 - A natural ventilation circuit existed into the mine soon after the first explosion, which probably saved Messrs Rockhouse and Smith and would have enabled a survivor who got to the same location to walk out of the mine.
 - There was no communication from anyone within the mine (apart from Daniel Rockhouse), including from the FAB into which air was downcasting when a telephone was lowered down the shaft at 8:00pm on 19 November.
 - Air pockets would not have existed because Pike River was a gassy mine and methane would have risen to fill the higher inbye areas of the mine as air was displaced. Following an earlier failure of the main fan the mine gassed out in about nine hours.¹⁰⁰
186. Mr Devlin, the New South Wales Mines Rescue Services manager, supported Mr Watts' assessment. He said it was 'almost certain' that the men died, if not immediately, then within the first hour after the explosion.¹⁰¹ His experience, based on other mine disasters, was that if the explosion did not result in instantaneous death, then the subsequent contaminated atmosphere and lack of oxygen would have been fatal. Mr Devlin formed this assessment when he reached Pike River, and by the time he gave evidence nothing had occurred to change his view.

Conclusions

187. The chief coroner found on the basis of medical evidence that the men died at the time of the explosion, or a short time after it. The evidence of the mining experts was generally supportive of this finding. The open box lid in the slimline stub could indicate that someone survived for a period, but this is conjecture and only one of at least three possible explanations.
188. The commission finds that the 29 men probably died instantly, or from the effects of noxious gases and oxygen depletion soon after the explosion on 19 November. It heard no evidence sufficient to displace the chief coroner's findings concerning the timing, or cause, of the deaths.

The recovery operation

Introduction

189. Recovery of human remains from the mine became the principal objective following the second explosion on 24 November. There has been limited progress towards achieving this objective. Understandably this is a source of great concern and frustration to many of the men's families. In this section the commission reviews the key developments to the present time.

The period to 31 December

190. Between 2:37pm on 24 November and 1:50pm on 28 November three further explosions occurred. The risk of still more explosions, and the need to bring fires burning in the mine under control, made sealing the mine the first priority. This was the key objective for the balance of the year.
191. In early December a temporary seal was constructed, after two shipping containers were inserted into the portal and a seal effected around them. This enabled the GAG brought from Queensland to be commissioned and it began pumping gas and steam into the mine to extinguish any fires. The vent shaft was also sealed using a fabricated metal cap. Subsequently, the Floxal, a nitrogen generating unit from Australia, was substituted for the GAG. However, atmospheric readings from the mine deteriorated and the GAG was recommissioned.
192. On 13 December Pike River Coal Ltd went into receivership, with John Fisk, Malcolm Hollis and David Bridgman appointed joint receivers. Before Christmas, the company in receivership presented a draft re-entry plan to the police, which envisaged stabilisation of the mine over 45 days at a cost of \$3.87 million, and recovery of the remains over 70 days at a cost of \$6.99 million.¹⁰² Earlier, the MRS had also provided a draft re-entry plan to the police and the company.¹⁰³ Neither plan was adopted.

Key events in 2011

193. Early in the new year fires and heatings in the mine were brought under better control. Ongoing monitoring using a tube bundle system allowed for an improved understanding of the mine atmosphere. The focus became to stabilise the atmosphere, finalise a plan and effect a staged re-entry into the mine.
194. On 9 March the police relinquished control of the recovery operation to the receivers,¹⁰⁴ who assisted by an expert panel formed by them, the MRS, SIMTARS, DOC, DOL, Solid Energy and others, continued recovery-related work. This included nitrogen injection using the Floxal, drilling new boreholes, thermal imaging to identify gas leaks from the mine, further sealing and scanning inside the mine from boreholes.
195. The families were frustrated at the lack of progress, and in May their counsel convened a meeting of interested parties in Christchurch to discuss means of advancing the recovery operation. The main agreed outcome was that a working group should begin immediately to plan for re-entry into the mine beyond the rock fall at the inbye end of the drift.
196. A difference of view developed over the best approach to re-entry into the mine. In August the MRS proposed a 'reconnaissance walk' up the drift to the rock fall.¹⁰⁵ The drift atmosphere was irrespirable, with less than 3.5% oxygen detected, and the re-entry team would need to use breathing apparatus. The objective was to establish the conditions in the drift from pit bottom in stone to the rock fall, and whether there were any bodies in this area.
197. The mine manager, Mr Ellis, disagreed with this approach. He favoured establishing a remote seal near the rock fall, by drilling a borehole at that location and injecting an expandable foam (Rocsil). The Rocsil would create a seal and enable the drift to be reventilated using a forcing fan at the portal. MRS teams could then enter the drift in a respirable atmosphere.¹⁰⁶ Mr Ellis presented this option for approval by the expert panel, but not the MRS proposal.¹⁰⁷ Pressed in cross-examination at the September hearings, he said, 'We will reclaim that tunnel before Christmas, I'm quite confident of that.'¹⁰⁸ In the event, re-entry proved more complex than expected.

198. Some progress has been made towards re-entry. The MRS constructed temporary seals at 170m, and then at 108m and 70m into the drift. A nitrogen buffer zone was established between the 108m and 70m seals. This enabled the December 2010 seal at the portal to be removed. The company then installed permanent steel doors at 35m and 5m inbye, to provide an airlock entrance into the mine.¹⁰⁹ In December drilling of the Rocsil borehole began, but it was not completed until January 2012.

Key events to date in 2012

199. During January the outbye area of the drift was degassed and ventilated up to the MRS temporary seal at 170m.
200. In March, Solid Energy reached a conditional agreement with the receivers to purchase the mining assets of Pike, and in May the agreement became unconditional. On 17 July 2012, a subsidiary of Solid Energy, Pike River Mine (2012) Ltd, took ownership of the assets. That day the government, Solid Energy and the subsidiary signed a deed relating to body recovery. It requires Solid Energy to 'take all reasonable steps to recover the remains' provided this 'can be achieved safely, is technically feasible and is financially credible'. The Crown agreed to contribute to recovery costs over and above those 'required for commercial mining purposes'. No timeframe is prescribed, and recovery of the remains hinges on a resumption of 'commercial mining operations'.¹¹⁰
201. Before the deed was concluded, emeritus professor Jim Galvin, University of New South Wales, gave Solid Energy advice concerning the risks associated with, and the likelihood of, body recovery. He considers there are very substantial risks involved in re-entering the old workings, as opposed to the drift area of the mine. These include drowning if water has accumulated, explosion if air enters the workings and hot spots exist, fire from spontaneous combustion, roof fall owing to the absence of strata maintenance, and exposure to carcinogens (products from underground coal fires), fungi and bacteria which can flourish in an unventilated mine environment. In addition, there is likely to be a need to clear rock falls within the mine using mining machinery in an irrespirable atmosphere. Working in these conditions, wearing breathing apparatus, would be particularly hazardous. Accordingly, Professor Galvin concluded it was 'extremely unlikely' that the risks could be managed, 'irrespective of the level of expenditure',¹¹¹ so he views recovery of the remains as a remote possibility.

Keeping the mine safe

202. The commission is required to recommend what ought to be done to ensure the safety of the mine and the surrounding areas if the mine is not reopened. This proviso poses a difficulty because it is uncertain whether the mine will be reopened and any decision concerning reopening may be some years off. The safety of the mine in the meantime, and in the long term, requires separate consideration.
203. Pending a decision concerning a resumption of mining, Solid Energy obtained an independent review of security at the mine site. Arrangements in place to safeguard the mine and its surrounds include continuous monitoring of the underground atmosphere using a tube bundle system, controlling access to the mine site by a series of security gates, remote camera surveillance of the approach road and site and an immediate response arrangement in the event the area is entered by intruders. Trained personnel also oversee the onsite facilities on a regular basis.¹¹² The commission considers these arrangements are adequate. If control of the mine is transferred to a new owner similar arrangements should apply. This could be done by way of a condition attaching to the transfer of the permit, or imposed if a new permit is issued.
204. If the mine is not to be reopened it will need to be permanently sealed. At present the shafts into the mine are capped and multiple steel doors are installed at the mine entrance.¹¹³ These seals will have to be made permanent, probably using concrete. The commission considers that arrangements to make the mine safe on a permanent basis should be agreed in consultation between the mine owner, the regional or local authorities and the land owner or administrator.

ENDNOTES

- ¹ Pike River Coal Ltd, Emergency Response Management Plan (ERMP), 18 February 2009, DAO.001.00096.
- ² Douglas White, transcript, p. 1263.
- ³ Ibid., p. 1129.
- ⁴ Ibid., p. 1317.
- ⁵ Neville Rockhouse, transcript, p. 1374.
- ⁶ Douglas White, transcript, p. 1138.
- ⁷ Ibid., p. 1326.
- ⁸ Ibid., p. 1299.
- ⁹ Ibid.
- ¹⁰ Ibid., pp. 4865–66.
- ¹¹ Ibid., p. 4866.
- ¹² Simon Moore, transcript, p. 1632.
- ¹³ New Zealand Fire Service Commission, The New Zealand Coordinated Incident Management System (CIMS): Teamwork in Emergency Management, 1998, SOE.001.00027/2.
- ¹⁴ David Cross, witness statement, 1 July 2011, POLICE.BRF.11/3–6, paras 9–28.
- ¹⁵ Ibid., POLICE.BRF.11/5, para. 23.
- ¹⁶ David Cross, witness statement, 1 July 2011, POLICE.BRF.11/15, para. 106.
- ¹⁷ Gary Knowles, witness statement, 1 July 2011, POLICE.BRF.18/14, para. 63.
- ¹⁸ David Cross, witness statement, 1 July 2011, POLICE.BRF.11/15, para. 104.
- ¹⁹ Sean Judd, witness statement, 1 July 2011, POLICE.BRF.14/6, para. 27.
- ²⁰ New Zealand Mines Rescue Service, Brief of evidence of New Zealand Mines Rescue Service, 1 August 2011, MRS0030/12, para. 62.
- ²¹ Sean Judd, Incident Action Plan, 20 November 2010, PIKE.00505/3.
- ²² Allyson Ealam, witness statement, 1 July 2011, POLICE.BRF.16/7, para. 37.
- ²³ Douglas White, transcript, p. 1178.
- ²⁴ Ibid., p. 1264.
- ²⁵ Stephen Ellis, transcript, p. 2250.
- ²⁶ Douglas White, transcript, p. 1156.
- ²⁷ Gary Knowles, transcript, p. 2151.
- ²⁸ Gary Knowles, witness statement, 1 July 2011, POLICE.BRF.18/8, para. 28.
- ²⁹ Gary Knowles, transcript, p. 2115.
- ³⁰ Ibid., pp. 2101–02.
- ³¹ Ibid., p. 1896.
- ³² Gary Knowles, witness statement, 1 July 2011, POLICE.BRF.18/62, para. 320.
- ³³ Gary Knowles, transcript, p. 1893.
- ³⁴ Grant Nicholls, witness statement, 1 July 2011, POLICE.BRF.29/11–12, paras 32–33.
- ³⁵ Ibid., POLICE.BRF.29/13, para. 36.
- ³⁶ Gary Knowles, transcript, p. 2104.
- ³⁷ Grant Nicholls, transcript, p. 1681.
- ³⁸ Seamus Devlin, transcript, p. 2037; Darren Brady, transcript, p. 1970.
- ³⁹ Darren Brady, transcript, p. 1970.
- ⁴⁰ Ibid., p. 1969.
- ⁴¹ Gary Knowles, transcript, p. 1886.
- ⁴² Grant Nicholls, transcript, p. 1738.
- ⁴³ Ibid., p. 1856.
- ⁴⁴ Ibid., p. 1660.
- ⁴⁵ Ibid., pp. 1727–28, 1826.
- ⁴⁶ Ibid., p. 1799.
- ⁴⁷ Susan (Lesley) Haines, transcript, p. 2341.
- ⁴⁸ Ibid., p. 2342.
- ⁴⁹ Stephen Christian, witness statement, POLICE.BRF.12/14, para. 56.
- ⁵⁰ David Bellett, witness statement, DOL7770020004/5, para. 24.
- ⁵¹ Susan (Lesley) Haines, transcript, pp. 2354, 2356.
- ⁵² Ibid., p. 2372.
- ⁵³ Sheila McBreen-Kerr and Brett Murray, Approval of Down-hole Video, 23 November 2010, DOL7770020002_10/1.
- ⁵⁴ Sheila McBreen-Kerr, Pike River Mine Disaster Risk Assessment Approval Process Chart, 23 November 2010, DOL2000010032/2.
- ⁵⁵ Craig Smith, transcript, p. 2651.
- ⁵⁶ Timothy Whyte, witness statement, 28 June 2011, CFMEU0001/18, para. 69 referring to Clive Hanrahan's advice to police that the Queensland Mines Rescue Service team would return to Australia if Pike's management did not start sharing information and providing assistance.
- ⁵⁷ Darren Brady, transcript, p. 1975.
- ⁵⁸ Trevor Watts, transcript, p. 2509.
- ⁵⁹ New Zealand Mines Rescue Service, Brief, MRS0030/17, para. 82.
- ⁶⁰ Seamus Devlin, transcript, p. 2053.
- ⁶¹ New Zealand Mines Rescue Service, Brief, MRS0030/22, para. 109.3.
- ⁶² Darren Brady, transcript, p. 1973.
- ⁶³ Ibid.
- ⁶⁴ Gary Knowles, transcript, p. 1917.
- ⁶⁵ Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 15.
- ⁶⁶ Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, 7 November 2011, CAC0114/31–32.
- ⁶⁷ Neville Rockhouse, transcript, pp. 1340–41.
- ⁶⁸ Royal Commission on the Pike River Coal Mine Tragedy, Summary of the Reports, CAC0114/31 (Incident number 1126).
- ⁶⁹ Trevor Watts, transcript, p. 2519.
- ⁷⁰ Douglas White, witness statement, 19 August 2011, WHI001.1/12, para. 107.
- ⁷¹ Darren Brady, witness statement, 24 August 2011, SIM0001/6, paras 4.4–4.5.
- ⁷² Ibid., SIM0001/8, para. 5.16.
- ⁷³ New Zealand Mines Rescue Service, Brief, MRS0030/93, para. 491.
- ⁷⁴ These experts included Trevor Watts, General Manager New Zealand Mines Rescue Service; Douglas White, Site General Manager, Pike; Seamus Devlin, State Manager, New South Wales Mines Rescue Services of Coal Services Pty Ltd; Darren Brady, Manager SIMTARS Occupational Hygiene, Environment and Chemistry Centre; and Kenneth Singer, Deputy Chief Inspector of Coal Mines. Messrs Brady and Singer work for the Queensland government.
- ⁷⁵ Trevor Watts, transcript, p. 2483.
- ⁷⁶ Ibid., pp. 2483–91, 2550–53.
- ⁷⁷ Daniel Rockhouse, transcript, pp. 1067–68.
- ⁷⁸ Fresh Air Base (FAB) photographs (Phase Three Hearing exhibit 44, produced by Neville Rockhouse), EXH0044/3.
- ⁷⁹ Ibid., EXH0044/4.
- ⁸⁰ Ibid., EXH0044/7.
- ⁸¹ Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 23.
- ⁸² Peter Whittall, transcript, p. 2686.
- ⁸³ Neville Rockhouse, transcript, p. 1363.
- ⁸⁴ Email, Neville Rockhouse to Adrian Couchman, 17 March 2010, DAO.011.21810/2–3.
- ⁸⁵ Memorandum, Gregory Borichevsky to Douglas White, 29 October 2010, EXH0024/1–2.
- ⁸⁶ Email, Adrian Couchman to Neville Rockhouse, 3 March 2010, DAO.011.21810/1.
- ⁸⁷ New Zealand Mines Rescue, Pike River Emergency Response August Audit, 12 September 2010, DOL7770030096/2.
- ⁸⁸ Michael Smit, Police/DOL interview, 19 December 2010, INV.03.07753/42; Russell Smith, Police/DOL interview, 9 February 2011, INV.03.13092/64–65.
- ⁸⁹ Lyndsay Main, Police/DOL interview, 17 December 2010, INV.03.06096/50, 52.
- ⁹⁰ Royal Commission on the Pike River Coal Mine Tragedy (Katherine Ivory), Summary of the Reports of Certain Incidents and Accidents at the Pike River Coal Mine, November 2011, CAC0114/31–38.
- ⁹¹ Counsel's Submissions and Coroner's Findings, 27 January 2011, INV.01.27510/8.
- ⁹² Kenneth Singer, Explanation of Gas Analysis and Interpretation, 24 November 2010, PIKE.17762.
- ⁹³ Kenneth Singer, Prospects of Survival Pike River Mine, 26 November 2010, PNHQ.16398.

⁹⁴ Professor Cliff later joined the expert panel engaged by DOL and the police during their investigations.

⁹⁵ David Cliff, A Preliminary Evaluation of the Situation at Pike River Coal Mine, as at Sunday 12 December, 2010, PIKE.15383.

⁹⁶ James Moncrieff, witness statement, 29 August 2011, POLICE.BRF.51/15, para. 42.

⁹⁷ Ibid., POLICE.BRF.51/26–27, para. 72.

⁹⁸ Trevor Watts, transcript, p. 2450.

⁹⁹ Ibid., pp. 2450–51.

¹⁰⁰ Ibid., p. 2452; New Zealand Mines Rescue Service, Brief, MRS0030/13, para. 64.

¹⁰¹ Seamus Devlin, transcript, p. 2044.

¹⁰² Pike River Coal Ltd, Pike River Coal Mine Re-entry Plan to Facilitate Recovery of Deceased Miners (Draft), 22 December 2010, DAO.007.20116/2–3.

¹⁰³ New Zealand Mines Rescue Service, New Zealand Mines Rescue Service Mine Re-entry Action Plan for Pike River Mine, 5 December 2010, MRS0066.

¹⁰⁴ New Zealand Police, Pike River Coal to Implement Mine Stabilisation Plan, 9 March 2011, SOE.003.00104/1.

¹⁰⁵ New Zealand Mines Rescue Service, Reconnaissance of the Main Drift at the Pike River Mine: Risk Assessment, 16 August 2011, PRCL.1284.

¹⁰⁶ Stephen Ellis and Gregor Hamm, Tunnel Reclamation Proposal, 29 August 2011, PRCL.1908.

¹⁰⁷ Stephen Ellis, transcript, p. 2302.

¹⁰⁸ Ibid., p. 2305.

¹⁰⁹ Ibid., p. 2299.

¹¹⁰ Deed relating to body recovery at the Pike River Coal Mine, 17 July 2012, SOL0503445.001.

¹¹¹ Jim Galvin, Attachment 'B' – Potential Risks Associated with Body Recovery at Pike River Coal Mine, 10 June 2012, FAM0061, pp. 21–26.

¹¹² Letter, Catherine Schache to James Wilding, 18 September 2012, CAC0176.

¹¹³ Ibid.

The families of the men

Introduction

1. Many people were affected by the Pike River tragedy, and none more so than the families and friends of the 29 men. Some filed witness statements detailing concerns about the search and rescue operation and seven family members appeared before the commission. This chapter reviews the initial contact with family members following the explosion, the conduct of family briefings, and the manner and extent to which the families were kept informed of subsequent developments.

Initial contact with family members

2. After the explosion Pike needed to establish who remained underground. As discussed in Chapter 16, 'Search, rescue and recovery', there were problems with both the placement and removal of tags from the tag board.
3. At 4:40pm the police communications centre was told that 25 to 30 people remained in the mine. At 5:55pm Douglas White told police officers that 33 men were thought to be underground. At 6:00pm a count of the tags on the board indicated that 32 men were in the mine. At 7:30pm Peter Whittall told the media he understood 27 men were underground – 15 Pike employees and 12 contractors. By 4:30am on 20 November that number had been revised to 29 missing. This figure was further revised to 28 a few hours later, and then at an 8:00am media briefing Mr Whittall confirmed the correct numbers; 29 men were missing underground – 16 Pike employees and 13 contractors.
4. Pike had required its employees and contractors to supply details of next of kin who were to be contacted in the event of an emergency. The health and safety induction checklist, completed before employees and contractors began work at the mine, provided space for the contact details of one person nominated as next of kin. There was no space for alternative contacts.¹ Pike asked workers to inform it of any changes to their next of kin details.²
5. After the explosion, the company decided not to contact next of kin until accurate information was available. As noted, that took about 16 hours. Meanwhile, media reports of the explosion were broadcast in New Zealand and overseas as early as 5:00pm, New Zealand time. Families were immediately desperate for confirmation of the whereabouts of their men. The explosion had occurred 15 minutes before a number of workers were to finish at 4:00pm with, in some cases, a new shift ready to go underground. There was much uncertainty. Family members phoned the company and the police in search of information, but neither could give them information. By mid-evening the Red Cross had established a facility in Greymouth where families could register their contact details.
6. At 7:30am on Saturday 20 November the first family meeting was held at the welfare centre in Greymouth. This was followed by a media briefing, at which it was confirmed that 29 men were still in the mine, but names were not released.
7. By this time families living in the Greymouth area had sufficient information to know whether their man was missing. The failure of a worker to return home the previous night was stark confirmation of the worst. But the families had not received formal advice from the company concerning who was underground.
8. More distant family members were left in the dark. For example, Richard Valli, brother of Keith Valli, lived in Southland but was named as his brother's next of kin in Pike's records. On learning of the explosion, he spoke to his brother's partner, who thought that Keith had worked a day shift on 19 November. Phone calls were made to Pike, but these were either not answered or the person who answered could provide no information.

9. The Valli family arrived in Greymouth on Saturday towards the end of the 4:30pm family meeting. Richard Valli asked Mr Whittall to confirm whether his brother was missing. Mr Whittall could not do so. Richard Valli then asked the proprietor of the hotel where his brother stayed in Greymouth and '[h]e confirmed that Keith was on day shift and that he had left for work that [Friday] morning. This was the first confirmation he was down the mine.'³
10. The witness statements of other family members contained similar accounts. The families of the two Australians, two British citizens and one South African among the 29 men experienced particular difficulty in obtaining information.
11. Some of Pike's next of kin details were out of date, which contributed to the difficulties contacting the families.⁴ However, there were also family members correctly listed as next of kin who were never formally notified by Pike that their men were still underground.⁵

Communications with family during the rescue phase

Communication methods used

12. From Saturday 20 November family meetings were held each day to brief the families on developments in the search and rescue operation. Typically the meetings took place at 7:30am and 4:30pm.
13. There were two principal speakers at the meetings: Superintendent Gary Knowles spoke on behalf of the police and Mr Whittall on behalf of Pike. Before each meeting Mr Whittall was briefed on recent developments by company staff, particularly Messrs White and Stephen Ellis, who initially worked alternating 12-hour shifts at the mine. Commendably, a 'families first' policy applied throughout the search and rescue so that families received information before it was given to the media.
14. The police set up an 'e-text tree',⁶ which was used to send messages to the cellphones of family members. These messages informed families of meeting times and significant developments. An 0800 number provided 24-hour access to the on-duty inspector, who was either Inspector Wendy Robilliard or Inspector Mark Harrison.
15. Some family members experienced difficulties obtaining information directly from the police in the first few days of the rescue operation because they were not listed as next of kin in Pike's records.⁷

Family meetings: were false hopes raised?

16. A consistent theme in the witness statements filed by the families was that they were given false hope about the chances that the men had survived the initial explosion and about the prospects of their rescue.
17. The flavour of what the families were told emerges from a sample of the information they were given, including comments made to the media on the evening of Friday 19 November. About 7:30pm on Friday Mr Whittall told media representatives in Wellington there was 'no evidence of fatalities at this stage',⁸ but nor had there been any communication from the men still in the mine. Later that evening, while Mr Whittall travelled to the mine, Pike chairman John Dow told the media that all the men were equipped with portable self-rescuers and knew where additional air was stored in the mine.⁹
18. About 5:30am on Saturday 20 November Mr Dow told the media it was possible that those underground could have made their way to the mine's safety refuge, where fresh air could be available.¹⁰ At an 8:00am media briefing meeting in Greymouth Mr Whittall said he hoped the state of the ventilation in the mine would be known by 2:00pm, so a rescue could proceed.¹¹ He referred to a compressed air line and said:

*We have kept those compressors going and we are pumping fresh air into the mine somewhere so it is quite conceivable that there is a large number of men sitting around the end of that open pipe waiting and wondering why we are taking our time getting to them.*¹²

19. At the morning media briefing on Sunday 21 November Superintendent Knowles said that the focus was still on a rescue operation, but the risks were too great to allow rescuers underground.¹³ One of the risks was the possibility of a fire in the mine.

20. Experts at the mine had debated the existence of a fire as early as Saturday. They considered a fire a real possibility, if not a likelihood. At family meetings, Mr Whittall described a possible ignition source in the mine as a 'heating'.¹⁴ By way of explanation he referred to 'smouldering rags' or a 'gas hob burning in a kitchen'.¹⁵ Generally, the tone of the information supplied at family meetings throughout the weekend conveyed that all or at least some of the missing men could still be alive.
21. This contrasted with what some others were told. Over the weekend Mr Ellis visited Daniel Rockhouse, who was suffering from 'survivor guilt'. He assured Daniel Rockhouse that in his view the shock wave from the first explosion would have killed the men further into the mine.¹⁶ Mr Ellis did not, however, share this with Mr Whittall, and when questioned at the commission's hearings he said this was because he also believed there was still a slim chance that some men survived until the second explosion.¹⁷ This is more likely evidence of Mr Ellis trying to help Daniel Rockhouse rather than withholding information from Mr Whittall.
22. At the hearings Mr Whittall was questioned about survivability. Counsel for the families drew attention to the impact of explosive forces upon men in such a small mine, the lack of oxygen without a functioning ventilation system and questioned how the men could have escaped the effects of carbon monoxide poisoning. Mr Whittall responded that Pike continued to pipe compressed air into the mine and that men could have found refuge in stubs and used brattice to create a barrier to prevent their exposure to noxious gases.¹⁸ The commission found that answer to be unduly optimistic in the circumstances.
23. That said, the commission does not consider Mr Whittall was dishonest about the information he supplied at family or media briefings. His state of mind was captured in an answer he gave under cross-examination with reference to the witness statements of next of kin: 'while their heads believed that the men may have gone, their hearts still wanted to hope for that miracle and I was in exactly the same position'.¹⁹
24. By Monday 22 November, it was recognised that the information being provided at family meetings lacked balance. That day Mr Whittall told the media that while it remained a rescue operation, 'the reality is, it's been three days. The reality is we haven't heard anything from anyone since the two guys came out of the pit. The reality is for the families now it's becoming more and more grave with every hour that goes past'.²⁰
25. On Tuesday 23 November Police Commissioner Howard Broad visited Greymouth. One of several matters he raised with Superintendent Knowles was the tone of communications with the families. The need for a change of approach was accepted.
26. The commission generally accepts the criticism made in many of the families' witness statements that the information provided at family meetings, particularly over the weekend, stimulated false hopes. Some family members had accepted the loss of their men at an early stage. They were familiar with coal mining or knew others who understood the realities of methane explosions in coal mines. But many of the families did not come from a coal mining background and relied very much on the information received during family meetings. This emphasises the need to be careful about how information is conveyed to families. A person who is emotionally involved in the events may not be the right person to act as spokesperson.

Advice of the second explosion

27. On Wednesday 24 November the gas levels in the mine improved and a rescue attempt by Mines Rescue Service (MRS) members was being considered. Superintendent Knowles and Mr Whittall were at the mine at the time of the second explosion at 2:37pm. After discussion, and viewing video footage, it was clear that no one could have survived the second explosion. Both men returned to Greymouth for the family meeting to be held later in the afternoon. Next of kin were sent a text message about 3:00pm: 'OPERATION PIKE – there will be a significant update at the 4.30 family meeting. It is recommended that all families attend'.²¹
28. Superintendent Knowles and Mr Whittall met briefly in the recreation centre car park before the meeting. The Honourable Gerry Brownlee, the Minister of Energy and Resources, was also present. Mr Whittall saw it as his responsibility to tell the families about the second explosion. There were up to 500 people in the recreation centre,

including young children and a significant police contingent. Mr Whittall spoke first. He began by saying that earlier in the day the gas levels had shown improvement, and he had been called to the mine because the MRS was preparing to go in. People began to cheer and clap. Mr Whittall, Superintendent Knowles and Mr Brownlee raised their arms and motioned for silence. Then Mr Whittall told the audience of the second explosion. The reaction was one of extreme distress; people began to wail and sob. Superintendent Knowles explained that the second explosion was not survivable, so the operation had moved to a recovery phase.

29. Recollections differed about whether Mr Whittall or Superintendent Knowles revealed the fact of the second explosion. This is of no moment. The important point is the initial comments Mr Whittall made about a possible rescue attempt. These words were the subject of strident criticism in many of the families' witness statements. They complained that the meeting was mishandled and that the ill-chosen opening words raised the families' hopes, only to have them dashed.
30. The commission accepts the key announcement was mishandled, or, as one witness put it, that matters 'went horribly wrong'²² and that this caused added distress for family members. That said, the commission accepts Mr Whittall's evidence that this outcome was unforeseen and entirely unintended. He was under great pressure and, in the agony of the moment, he sought to begin on a positive note. This led to extra anguish for next of kin, but in all the circumstances, it would be unfair for the commission to criticise him.

Were there deficiencies in updating the families?

31. The witness statements filed by some family members raised concerns about the provision of information, including an apparently unreasonable delay in providing information, and claimed that in one instance the information was misleading.

CCTV recording

32. The first concern related to the closed-circuit television (CCTV) recording of the first explosion, taken at the portal. This was not viewed in the control room as the explosion occurred, but was retrieved later and a number of people saw the recording during the evening of 19 November. However, it was some days before this information was shared with the families.
33. Curiously, at the outset no one drew the existence of the recording to the attention of either Superintendent Knowles or Mr Whittall. Mr Whittall first learnt of the camera at the portal when he visited Russell Smith on 21 November. That evening he asked Mr White to obtain a copy of the recording. On 22 November, at an interagency briefing, Mr Whittall showed the recording to Superintendent Knowles. On the afternoon of 23 November Mr Whittall showed it at a family meeting.
34. Some family members considered they should have seen it much earlier. They felt they would then have had a better appreciation of the size of the first explosion and been more able to assess the reliability of the information they were given.
35. The commission understands the concern but does not find anything sinister about the delay in playing the recording. The delay was a result of the two spokespeople not becoming aware of its existence for some days. Once Mr Whittall became aware of the recording, prompt action was taken and it was soon shown to the families. Importantly, the families viewed the recording before it was shown to the media.
36. The second concern was whether the recording shown to the families depicted the full duration of the explosive blast recorded at the portal. The original recording showed an explosion that lasted 52 seconds. Bernard Monk told the commission his wife, Kathleen, timed the recording as it was shown by Mr Whittall at 32 seconds.
37. Mr Whittall said he had not sought to mislead anyone about the duration of the explosion. After his call to Mr White on 21 November, a memory stick was delivered to him in Greymouth the following day. He did not have the 'technical capability of editing a video like that',²³ and simply used the memory stick he was given. The commission accepts Mr Whittall's evidence. Nor is there evidence to suggest that anyone else edited the recording. Danie du Preez, the communications and monitoring engineer at Pike River, provided the recording. He did not edit it.²⁴

C-ALS images

38. Another concern of the families related to the images taken by the Cavity Auto Scanning Laser System (C-ALS) device on 24 November at the foot of the slimline shaft. Mr Monk said that neither the families nor their counsel were made aware of the images until the inquest on 27 January 2011, and even then their potential significance was not explained. The written evidence given to the chief coroner included a one-line reference to 'evidence of a self-rescuer box open' in the fresh air base.²⁵ After the inquest, Mr Ellis arranged for Solid Energy New Zealand Ltd's John Taylor to show the C-ALS images to some family members, but this demonstration did not draw attention to the open box. As a consequence, counsel for the families, oblivious to the potential significance of the images, had already invited the chief coroner to find that the men died at, or about, the time of the first explosion.
39. In late March 2011 counsel for the families received confidential advice about the open box. An approach to the police resulted in a meeting at the Hornby police station, at which Mr Monk and counsel were shown an image of the open box in a manner that enabled them to grasp its potential significance. This prompted an approach to counsel assisting the commission. As a result, Mr Taylor and others gave evidence at the Phase Two hearings. The C-ALS images were fully explored.
40. The commission considers that beyond recording this concern and setting out the background, it is not necessary to consider the matter further. Having seen and understood what is involved in producing an understandable C-ALS demonstration, the commission is not surprised that the potential significance of the images remained shrouded for some time. Although the delay was unfortunate, thanks to the vigilance of the families and their counsel, the matter has been addressed.

Communications during the recovery phase

41. Immediately after the second explosion, recovering their men became of the utmost importance to many of the effected families. Not everyone shared this viewpoint. The mother of one of the men stated that 'not all families want the recovery of the remains, preferring their loved one to be left to rest in peace. That millions would be spent to achieve recovery I find untenable.'²⁶ A majority of family members, however, remain committed to recovery of the remains.

Police communication

42. Following the change from a rescue to recovery operation, family meetings continued to be held but with decreasing frequency from December 2010. After the police withdrew from the operation and handed the mine to the receivers, the police family liaison officers continued to attend meetings with the families. Communication through the e-text tree and the 0800 number continued.
43. On 16 January 2011, the police set up a secure, private website accessible only by registered family members. It contains a range of information and is a forum for families to ask questions. The website remains online.

November to December 2010

44. In late November 2010, Prime Minister John Key visited Greymouth and met the families. Following the company going into receivership in December 2010 he said, 'I gave a commitment to the families at Pike River I'd do everything I could to get their men out. I stand by that.'²⁷
45. The MRS asserted in an institutional statement to the commission that 'once it had been decided that it was a recovery operation Mr Whittall made comments to the media that "the boys" would be brought home for Christmas.'²⁸ This, MRS suggested, was foolhardy because no one could provide a timeline for recovery.
46. The commission, however, received no evidence confirming that Mr Whittall had spoken of a recovery by Christmas. On 29 November 2010 he was quoted as saying that the families had asked if they would get their men home by Christmas, but that he responded 'it could be some weeks before the bodies were returned' and 'without being too

blunt, Christmas is another X on the page as far as what the rescue teams are working towards. They've got to look at the actual time it takes them to do their job.²⁹

47. These comments probably explain the source of the assertion contained in the MRS statement. Mr Whittall did not endorse a recovery by Christmas, but his reference to a period of 'some weeks' was unfortunate. Understandably, the families listened with an optimistic ear and believed that recovery of the men was not too far off.

Developments in 2011

48. Throughout 2011 the families pursued recovery of the remains, including convening the meeting of interested parties in May 2011 (discussed in Chapter 16, paragraph 195) and questioning witnesses during the commission's hearings, including Mr Ellis when he gave evidence in September 2011. Although there was only modest progress towards re-entry into the drift, there were no signals that the chances of recovery were remote.
49. With a commitment to plan for re-entry made at the meeting in May 2011 and Mr Ellis' comments in September that the tunnel would be reclaimed by Christmas 2011, the message was that progress was being made toward re-entry and ultimately, potential body recovery. But by late January 2012 an adequate plan to seal, reclaim and re-enter the tunnel had not been developed.

Sale of the mine in 2012

50. The mine was sold to Solid Energy in mid-2012 (discussed further in Chapter 16, paragraph 200). As part of the sale process, Solid Energy carried out due diligence and met with the families several times. Solid Energy has explained they 'can see no way to safely carry out a standalone re-entry of the abandoned workings as part of a body recovery'. Solid Energy's position, made clear to the families, is that recovery can be attempted only as part of a wider commercial mining operation.
51. A briefing received by the families from Solid Energy chief executive Dr Donald Elder in May 2012 was based on advice Solid Energy had received from Professor Jim Galvin. The families were provided with a copy of Professor Galvin's report, and obtained an independent review of it from their own expert. It was made clear that successful recovery of the remains was very unlikely, and that if recovery did occur it may be many years away (See Chapter 16, paragraph 201). This seems to have been the first time the families were given a realistic appraisal of the situation based on evidence and in a manner that could not support their hopes.

Impact on the families

52. As noted earlier, the commission received both written and oral evidence in 2011 from members of the families. Many spoke of their dismay that the bodies had not been recovered and that no end was in sight. A high level of frustration, even anger, was evident concerning the delay in finalising and effecting a recovery plan.
53. In April 2012 the commission received evidence from Kathryn Leafe, chief executive of the Focus Trust, which provides social services to the West Coast community. The trust gave support after the tragedy and has continued to do so. Ms Leafe stated:

In most post-disaster situations by the six month point, the primary stressor or event is usually over and it is the secondary stressors that are the cause of concerns. However, with Pike River, the primary event is still in many ways ongoing as there remains the possibility of the recovery of human remains. Therefore families have been in a prolonged stage of grief and are still dealing with the primary stressor.³⁰

Her statement also explained that this has not only increased the demand for support, but also made providing it more complex.

54. In July 2012, senior counsel for the families filed a submission contending that the families received 'information which proved hopelessly optimistic throughout 2011', and that they were left 'to find their own way' because there was a 'lack of authoritative leadership over this period'.³¹
55. He said that the families attended the briefing in May 2012 with excitement, anticipating that re-entry and recovery may

be likely given the sale of the mine to Solid Energy. Instead, they were 'shocked by the harsh realities' outlined, of which they had 'no forewarning', so the outcome was devastating.³² As a result, the families' present focus is upon re-entry into the drift where they believe there may be remains in the section between pit bottom in stone and the rock fall.

Conclusion

56. The commission accepts that communications with the families concerning body recovery have not been well managed. Statements made in the period following the explosions raised expectations that the remains would be recovered within a modest timeframe. When this did not happen the families were naturally frustrated, and eventually angry. The management of communications is a matter of concern because it affected the families' ability to cope with the loss of their men.
57. The modest progress made in 2011 was, in the commission's view, a reflection of the complexities that confronted the receivers, MRS and others. The mine represented a unique re-entry challenge, given the combination of a single entry into the mine, the four explosions in late 2010, a major fire in the workings, at least one significant rock fall and limited knowledge of the underground conditions.
58. It seems it was not until the mine sale in 2012, when the government required that the terms of sale include a commitment from the purchaser to recover the bodies, that the hazards were fully assessed. This perhaps explains some of the communication deficiencies in 2011. After that assessment, Solid Energy confronted the problem, promptly met with the families and told them of the realities of the situation, unwelcome as the news proved to be.

Responsibility for recovery

59. The families underlined to the commission the isolation they have felt since the explosion. They have had to push for recovery and have felt on their own. The families seek a recommendation relating to who will retain responsibility for pursuing the question of recovery as far as reasonably possible because their 'abandonment has been deep seated and plagued them every day since the 19th of November'.³³
60. In Queensland and New South Wales, the company, through mine management, has control of the recovery operation and would be responsible for the costs. The company works in co-operation with other organisations, such as mines rescue and the mines inspectorate. Once the mine is safe and re-entry possible, the police are responsible for recovery of the remains. In practice, the police take control of the remains on behalf of the coroner only after the remains are retrieved by other specialty organisations, such as mines rescue. In both Queensland and New South Wales most coal mines are run by large companies who have the resources to cope with a recovery operation. There does need to be clarity about who is responsible for recovering the remains in New Zealand, especially where the mining company has limited funds or is in receivership. The pursuit of recovery should not be left solely to the friends and families of those who have died.
61. Recovery of the remains from Pike River now lies within the control of Solid Energy and the other parties to the July 2012 body recovery deed (discussed in Chapter 16, paragraph 200). The deed defines the new owner's obligations in relation to body recovery and contains mechanisms that enable the government to exercise some oversight. The commission is not in a position to influence these matters.

Welfare support provided to the families

Unstinted praise for welfare support

62. Criticisms contained in the families' witness statements about communication with them were balanced by unstinted praise of the support services made available.
63. One mother, for example, said: 'I cannot fault, or speak highly enough of the way we were treated by the personnel

of Pike River Coal, NZ Police, Mine Rescue, the Government, Air NZ, the Mayor and people of Greymouth, and the many voluntary groups we were helped and supported by during this time.³⁴

64. The spokesperson for some of the families, Mr Monk, said this about the support services:

The support offered, taken up and provided by Air New Zealand was outstanding. Many family members say [sic] great value in the liaison they had with Air New Zealand staff. The Air New Zealand support person for us was a constant prop.

Our police support liaison officer, Constable Terri Middleton, was simply excellent. She had so much empathy towards the family and was a wonderful communicator.

We received fantastic support from the Red Cross. They provided food, cups of tea, their facilities and as much information as they were able to give. There was a huge support from the local churches, the Greymouth community and the businesses, the local polytech, Victim Support and as time went on, the wider New Zealand community.

I also found great support and leadership from Greymouth Mayor Tony Kokshoorn. In those early days before the family group was organised, he was the voice for the families.³⁵

65. Other witness statements mentioned the assistance provided by John Robinson as the family liaison officer for Pike. He was assisted by Adrian Couchman, and also Denise Weir, previously human resources manager at Pike. She flew to Greymouth from Australia and for over three weeks voluntarily helped to co-ordinate Pike's support efforts.
66. On the evening of 19 November Air New Zealand sent its special assistance team to Greymouth and within 48 hours as many as 30 airline staff were based in the town. A liaison person was assigned to each of the 29 families who, as necessary, were given support in relation to travel, accommodation, obtaining passports and other immediate needs. The team remained until 29 November, when a staged departure began.
67. The police also established a Greymouth-based family liaison team to provide information on the rescue and recovery operations, and gather information as necessary. Two inspectors managed the team, which comprised 22 police staff at its height. Each family was assigned a liaison officer.
68. An online survey subsequently conducted by the police indicated that family members were highly satisfied with the performance of the liaison officers, the facilitation of family meetings and the quality of their secure website. The police plan to train 40 police staff who will undertake victim liaison duties on an as required basis in response to major disasters. The police are also developing written liaison guidelines to promote national consistency in relation to major crisis management.
69. The commission acknowledges the outstanding level and value of the support offered to the families by numerous agencies and individuals including (in addition to those already mentioned) St John Ambulance, Tai Poutini Polytechnic, the Grey District Council, the Accident Compensation Corporation, Work and Income New Zealand, the Salvation Army and the ministries of Social Development and Health. It also commends the police initiative to further develop its crisis liaison capacity.

Some early difficulties

70. As noted in paragraph 11, the identification of 'next of kin' caused some difficulties in terms of communication with family members. It also had an impact on who received welfare support services in the first few months following the explosion. When the Focus Trust became aware, in December 2010 and January 2011, of family members who had received little or no contact from support services, it set about building a better picture of individual family profiles. The trust found there were 'significantly more than 29 separate family units and a number of families where "next of kin" is complicated'.³⁶ All were entitled to access support services.

Conclusions

71. The experiences undergone by the families of the deceased men suggest that the strategies and processes for communicating to them need improvement. Some recommendations are made in Chapter 32, 'Improving the emergency response'.

ENDNOTES

¹ Pike River Coal Ltd, PRCL H & S Induction Checklist, 27 November 2008, DAO.001.08679/4.

² See Pike River Coal Ltd, Employee Handbook: Induction Training, 2008, DAO.002.05609/15.

³ Richard Valli, transcript, p. 2595.

⁴ Gary Knowles, transcript, p. 2111.

⁵ See for example, Tammie O'Neill (wife of Peter O'Neill), witness statement, 18 July 2011, FAM00010/2, paras 3–4.

⁶ Wendy Robilliard, witness statement, 1 July 2011, POLICE.BRF.54/4, para. 12.

⁷ See for example, Carol Rose (mother of Stuart Mudge), transcript, p. 2582.

⁸ 'Pike River Coal Mine CEO', Close Up [Television broadcast], 19 November 2010, <http://tvnz.co.nz/close-up/mining-disaster-3904365/video?vid=3904435>

⁹ One News, New Zealand Press Association and Newstalk ZB, Pike River Mine Explosion Updates: First 48 Hours, 19 November 2010, <http://tvnz.co.nz/national-news/pike-river-mine-explosion-updates-first-48-hours-3904262>

¹⁰ Ibid.

¹¹ Ibid.

¹² One News, Newstalk ZB and New Zealand Press, Miners Spend Second Night Underground, 21 November 2010, <http://tvnz.co.nz/national-news/miners-spend-second-night-underground-3905380>

¹³ One News, New Zealand Press Association and Newstalk ZB, Pike River Mine Explosion Updates: First 48 hours.

¹⁴ Barbara Dunn, Operation Pike Barb's Notes: Fri 19 Nov – Wed 24 Nov, 19–24 November 2010, PIKE.01842/14.

¹⁵ Peter Whittall, transcript, p. 2778.

¹⁶ Stephen Ellis, transcript, pp. 2289–90.

¹⁷ Ibid., p. 2294.

¹⁸ Peter Whittall, transcript, p. 2755.

¹⁹ Ibid., p. 2774.

²⁰ Peter Whittall, as cited by Stacey Shortall, transcript, p. 2797.

²¹ Wendy Robilliard, witness statement, 1 July 2011, POLICE.BRF.54/4, para. 12.

²² Gary Knowles, transcript, p. 2145.

²³ Peter Whittall, transcript, p. 2720.

²⁴ Danie du Preez, witness statement, 2 April 2012, DUP0001, para. 6.

²⁵ Bernard Monk, transcript, p. 2613.

²⁶ Marion Curtin, letter to the editor, The Press, 21 January 2012.

²⁷ Radio New Zealand, Who Will Pay for Mine Recovery Operation Unclear, 14 December 2010, <http://www.radionz.co.nz/news/pike-river-2010/64183/who-will-pay-for-mine-recovery-operation-unclear>

²⁸ New Zealand Mines Rescue Service, witness statement, 1 August 2011, MRS0030/77, para. 424.

²⁹ Andrea Vance, Michael Fox and Amy Glass, 'New Blast Makes Mission More Difficult', The Press, 29 November 2010, <http://www.stuff.co.nz/the-press/news/pike-river-disaster/4399940/New-blast-makes-mission-more-difficult>

³⁰ Focus Trust West Coast, Royal Commission of Inquiry Pike River Mine Coal Mine Tragedy: Submission, FOC0001/13, para. 94.

³¹ Nicholas Davidson, Counsel for the Families of Men Who Died in Pike River Mine – Submissions for Families in Response to Minute No. 14, 19 July 2012, FAM0061/9, paras 37–38.

³² Ibid., FAM0061/8, paras 29, 31, 33.

³³ Nicholas Davidson, transcript, p. 5607.

³⁴ Marion Curtin, witness statement, 20 July 2011, FAM00030/2, para. 2.

³⁵ Bernard Monk, transcript, p. 2606.

³⁶ Focus Trust West Coast, Submission, FOC0001/11–12, paras 79–86.