CHAPTER 12

Hydro mining

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]

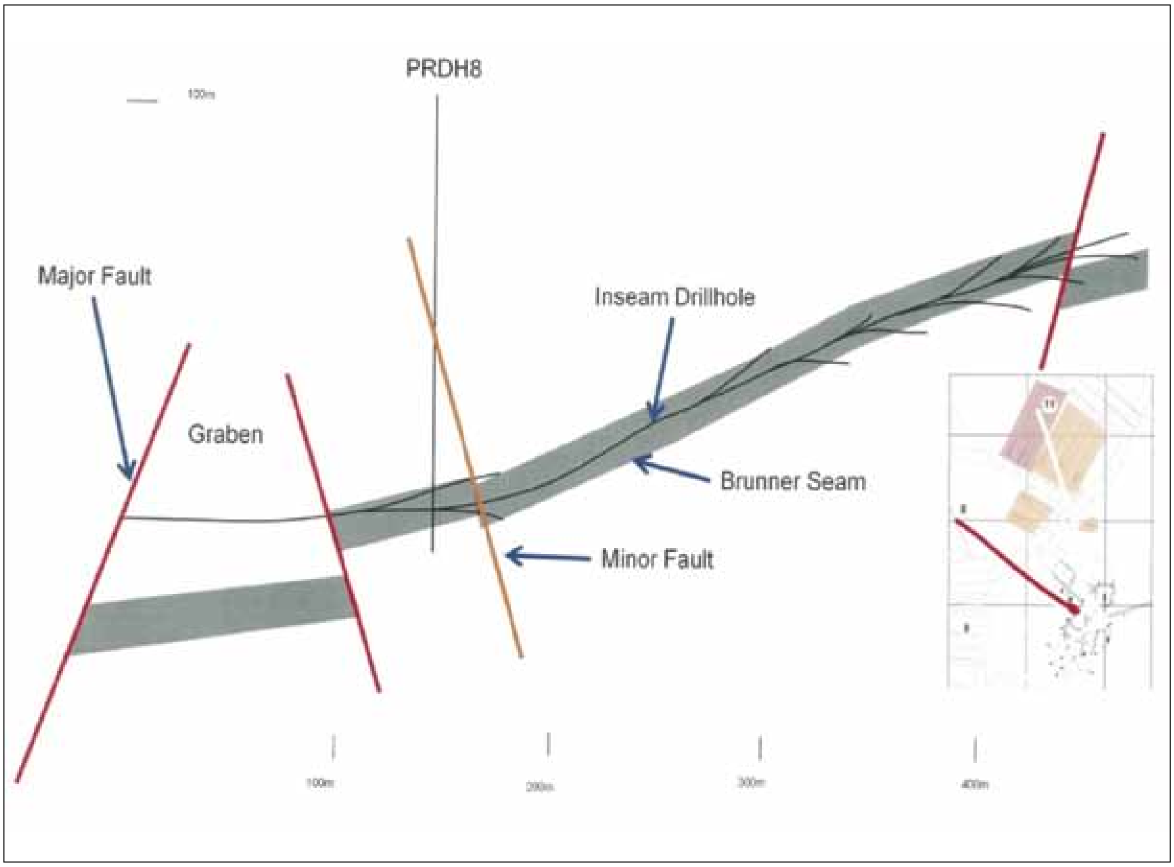

Figure 12.1: Pike River's Brunner seam

3. Hydro mining uses a high-pressure water jet from a hydro monitor to cut coal:

Figure 12.2: Hydro monitor at work[3]

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.

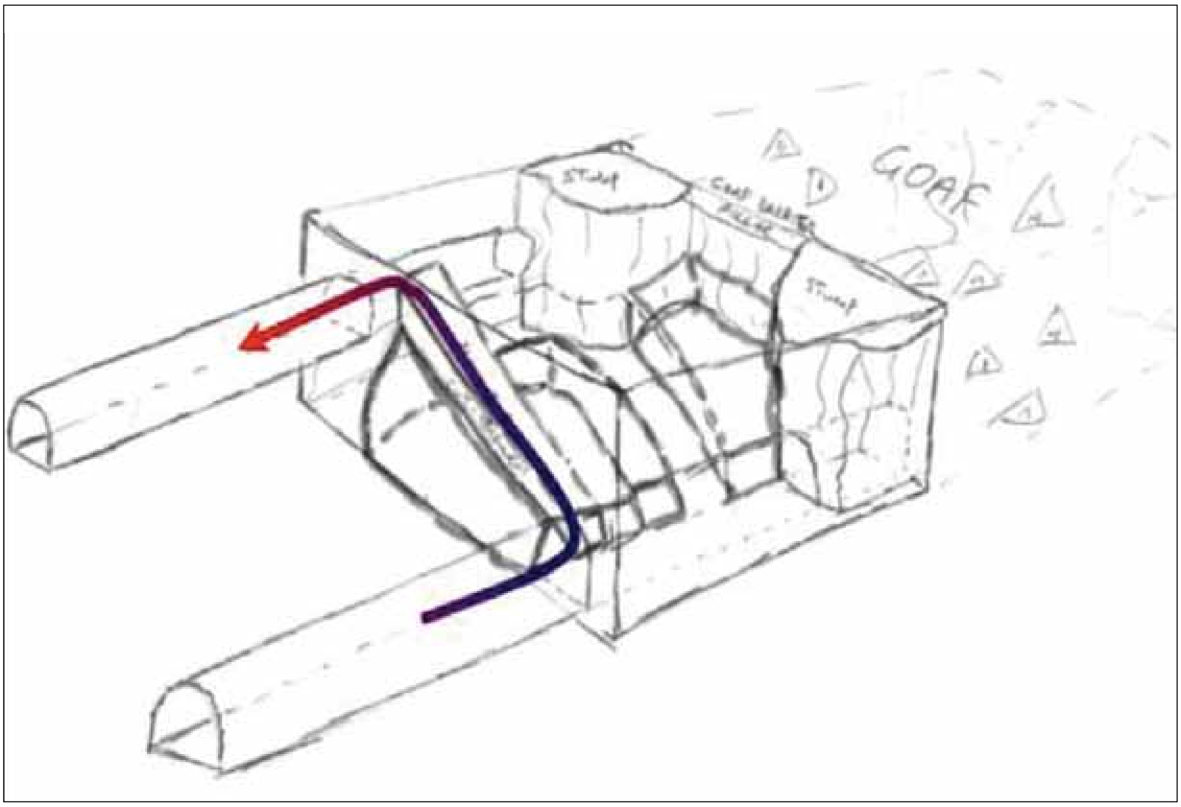

Figure 12.3: Three-dimensional sketch of hydro panel showing height difference between intake and return and ventilation path when panel idle[4]

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 mixture[6]

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.

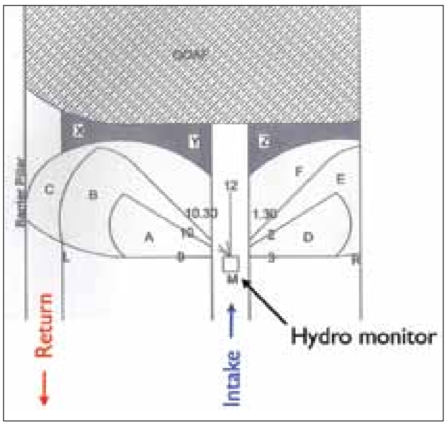

Figure 12.5: Bird's-eye view of the coal cutting sequence at Pike River[10]

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.

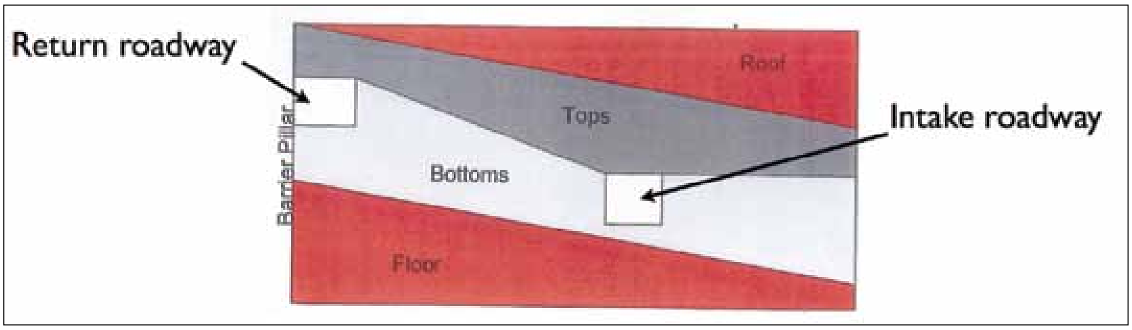

Figure 12.6: Cross-section of the seam in panel 1[11]

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'.

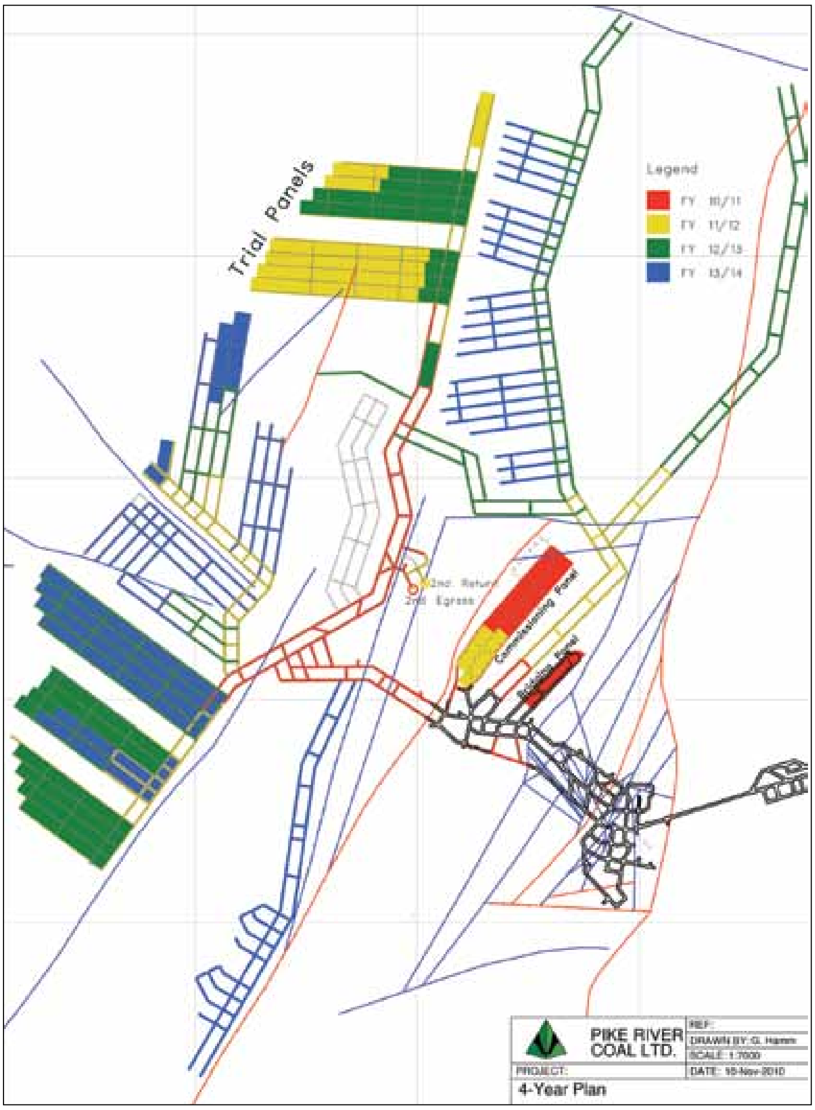

Figure 12.7: Pike's Four-year Plan for 2010–2014[25]

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 hyro-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.

PIKE RIVER COAL

Figure 12.8: Hydro-mining bonus table[36]

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, CH4 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 analysis[52]

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			
		Conse quenc	Likelih	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 fan[58]

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.

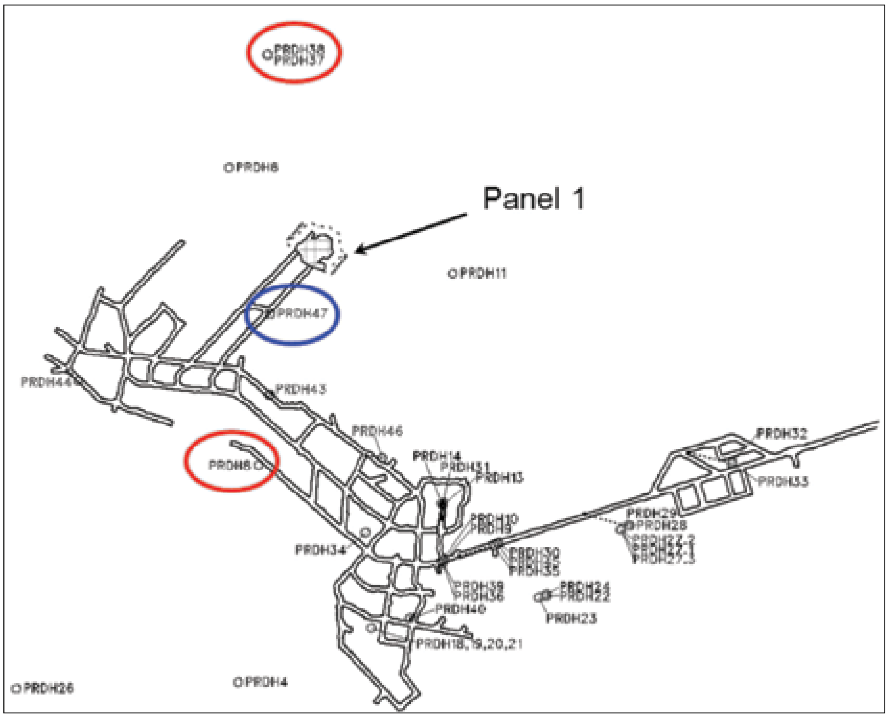

Figure 12.12: Drillholes in the vicinity of Panel 1[77]

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

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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)
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[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.

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[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.

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[31] Masaoki Nishioka, transcript, pp. 3606-07

[32] Ibid., p. 3490; Masaoki Nishioka, witness statement, 25 October 2011, NISH0001/11, para. 42.

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[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.

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