

# WAMBO COAL PTY LIMITED



## SOUTH BATES UNDERGROUND MINE

### EXTRACTION PLAN LONGWALLS 11 TO 16

#### REPORT 4 SUBSIDENCE RISK ASSESSMENT



**Operational Risk Mentoring**  
*Practical Solutions for Operational Risk Management*

For Wambo Coal Pty Ltd

## **South Bates Underground Mine – Longwalls 11 to 16 Subsidence Risk Assessment Report**

Report Title: South Bates Underground Mine – Longwalls 11 to 16 Subsidence Risk Assessment Report

Client: Wambo Coal Mine, Environment and Community Manager

By: Peter Standish, Director and Principal Consultant

Team Session: First team session – 31<sup>st</sup> October 2014  
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## DOCUMENT DISTRIBUTION AND CONTROL

<b>Ref No.</b>	ORMJ1408 / 1622
<b>Title</b>	South Bates Underground Mine Longwalls 11 to 16 Subsidence Risk Assessment Report
<b>General Description</b>	This report summarises the results and recommends follow up actions from the study conducted into the Longwalls 11 to 13 and Longwalls 14 to 16 subsidence risk assessments in relation to the South Bates Underground Mine. It reviews the various aspects and impacts of the potential effects of subsidence due to mining Longwalls 11 to 16 inclusive.
<b>Key Supporting Documentation</b>	AS/NZS ISO 31000: 2009 Risk Management – Principles and Guidelines. MDG1010 – Minerals Industry Safety and Health Risk Management Guideline. Wambo Coal Pty Limited – Wambo Development Project Environmental Impact Statement (2003). Wambo Coal Pty Limited – South Bates (Wambo Seam) Underground Mine Modification (2015). MSEC – Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Extraction Plan for WYLW11 to WYLW13 in the Whybrow Seam and WMLW14 to WMLW16 in the Wambo Seam (2016). Operational Risk Mentoring – South Bates (Whybrow Seam) Underground Mine – Longwalls 11 to 13 Subsidence Risk Assessment Report (2015).

### Versions

Rev	Date	Description	Created By	Checked
0	24/04/2015	Draft report issued for client and team review	P Standish	J Webster
1	27/08/2015	Revised draft for client and team review	P Standish	J Webster
2	02/10/2015	Final issue	P Standish	J Webster
3	04/11/2016	Revised report following the team session which considered the extraction of Longwalls 14 to 16 in the Wambo Seam immediately below Longwalls 11 to 13 in the Whybrow Seam.	P Standish	J Hinks
4	1/12/2016	Final issue following client and team review	P Standish	J Hinks

### Distribution List of Latest Version

No	User	Position
1	Wambo Coal Pty Ltd	Steve Peart/Tim Britten
2	Resource Strategies	Joanna Hinks
3	Operational Risk Mentoring	Records



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## 1 EXECUTIVE SUMMARY

Wambo Coal Mine is an open cut and underground coal mining operation located approximately 15 kilometres (km) west of Singleton, near the village of Warkworth, New South Wales (NSW). The Wambo Coal Mine is owned and operated by Wambo Coal Pty Limited (WCPL), a subsidiary of Peabody Energy Australia Pty Limited. The South Bates Underground Mine is a component of the approved Wambo Coal Mine and is approved for extraction in the Whybrow Seam (Longwalls 11 to 13) and the Wambo Seam (Longwalls 14 to 16). Longwall extraction in the Whybrow Seam commenced in 2016. Longwall extraction from the Wambo Seam is planned to commence in mid-2017.

An Extraction Plan for Longwalls 11 to 13 at the South Bates Underground Mine was approved by the Department of Planning and Environment on 9<sup>th</sup> February 2016.

This risk assessment report has been prepared to support an updated Extraction Plan for Longwalls 11 to 16 in both the Whybrow and Wambo Seams at the South Bates Underground Mine.

This work follows on from a team based risk assessment facilitated by Operational Risk Mentoring in October 2014. The earlier team based risk assessment undertaken in October 2014 highlighted:

- Groundwater issues – such as failure of the monitoring program to detect and respond to an impact on the groundwater system;
- Surface water – with issues related to the North Wambo Creek diversion and the open cut void;
- Flora and fauna – with potential undermining of Remnant Woodland Enhancement Program (RWEP) areas;
- Land impacts due to subsidence of major or minor cliff lines; and
- Public safety – with potential for step cracking due to subsidence impacts on access tracks.

The team based risk assessment undertaken in October 2016 highlighted:

- Subsidence effects appear to be occurring in line with predictions by Mine Subsidence Engineering Consultants (MSEC);
- Experience of subsidence impacts as a result of Longwall 11 indicates that the likelihood of some risks may not be as high as previously anticipated; and
- The shortening of the commencing ends of Longwalls 11, 12 and 13 since the previous risk assessment workshop results in reduced risks associated with some surface features.

All identified risks have a Risk Treatment Plan (Appendices). These risks have been assessed by the team to be as low as reasonably practicable (ALARP) or tolerable after the effective implementation of the identified controls and actions.

Recommendations made by the team in the risk assessment workshops are included in Table 1. The team understood that WCPL will track and review these actions – updating this Risk Assessment Report as required, and confirm the adequacy of the identified controls.

With the application of the identified controls the team consensus was that subsidence related impacts over Longwalls 11 to 16 could be managed at a tolerable level of risk.



### 1.1 Consolidated Action Plan

The following table presents consolidated follow up actions identified during the risk assessment workshops conducted in October 2014 and October 2016.

**Table 1: Consolidated Action Plan**

ID	Ref	Description	Responsible	Comment	Due
A1	SB028/ SB039	Lodge Variation to Consent 2222 to cover all of Application Area.	WCPL Environment and Community Manager	Complete – new AHIP issued	-
A2	SB064	Conduct relevant technical studies to support Ventilation and Gas Management Plan.	WCPL Technical Services Manager	Complete	-
A3	SB046	Prepare a subsidence monitoring program that takes into account access limitations for RWEPA Areas.	WCPL Environment and Community Manager	Complete – in Subsidence Monitoring Program	-
A4	SB008/ SB009	Review groundwater monitoring program in the vicinity of South Bates Underground Mine, and need for additional monitoring sites.	WCPL Environment and Community Manager	Complete – additional monitoring sites installed.	-
A5	SB050	Review potential influence of geological features on groundwater predictions.	WCPL Environment and Community Manager	Completed for Longwalls 11 to 13 Ongoing review of monitoring data	-
A6	SB010	Revise relevant assessments for Clause 33 notification process for Longwalls 14 to 16.	WCPL Technical Services Manager	Completed for Longwalls 11 to 13	30/06/2017
A7	SB023	Confirm the Extraction Plan includes a requirement to check for slack on pipelines and cables over the subsidence areas.	WCPL Technical Services Manager	Complete – in BFMP	-
A8	SB026/ SB038	Subsidence assessment to consider impacts on high and end walls in consideration of work by Golder Associates.	WCPL Environment and Community Manager	Complete – in Subsidence Assessment (Technical Report 1)	-
A9	SB053	Subsidence assessment to consider location of Montrose East Dam relative to predicted subsidence.	WCPL Environment and Community Manager	Complete – in Subsidence Assessment (Technical Report 1)	-

ID	Ref	Description	Responsible	Comment	Due
A10	SB037	Subsidence assessment to consider impacts to levee along North Wambo Creek Diversion.	WCPL Environment and Community Manager	Complete – in Subsidence Assessment (Technical Report 1)	-
A11	SB011	Subsidence to consider most accurate LiDAR and other as built data on the diversion.	WCPL Environment and Community Manager	Complete – in Subsidence Assessment (Technical Report 1)	-
A12	SB008/ SB009	Confirm whether N2 and GW21 piezometers are still operational following nearby longwall extraction.	WCPL Environment and Community Manager	New action identified in 26/10/2016 workshop.	31/12/2016 (Complete – in Technical Report 2)



## 2 DEFINITIONS

The following table provides guidance on terms used throughout this report.

Term	Explanation
ALARP	"As Low As Reasonably Practicable". The level of risk between tolerable and intolerable levels that can be achieved without disproportionate expenditure in relation to the benefit gained.
Aspect	A classification of risk normally applied to environmental matters. "Aspects" are best thought of as mechanisms of harm – or causes of loss. Typical aspects are: surface water contamination or loss; land changes; or fauna/flora changes. Each of these aspects produces a subsequent environmental "impact".
BFMP	Abbreviation – Built Features Management Plan – a document to identify proposed management objectives and performance measures to manage potential subsidence impacts to public infrastructure and all classes of other built features within the Project area and surrounds.
Causal Pathway	A term used to describe the "flow" of events beginning from a root cause and leading to an unwanted outcome. The flow is typically causes prevented from becoming incidents by preventative controls and incidents reduced in severity by mitigating controls which lead to different severity outcomes. A causal pathway is a cause to failed preventative controls to incident to successful mitigating controls to outcome.
GWMP	Abbreviation – Groundwater Monitoring Program – a document defining an approach to monitoring groundwater conditions and potential changes due to potential subsidence impacts.
Hazard	A thing or a situation with potential to cause loss.
HAZOP	Method of analysing mining operations, plant or processes to identify potential causes of incidents and prompt for required controls. Guidance on the method is available in AS/IEC 61882-2003 Hazard and operability studies (HAZOP).
Impact	A result of risk normally used when considering environmental matters. Impacts are the end result of the realisation of an "aspect". For example – surface water changes have an impact that includes loss of habitat for water dwelling fauna and flora.
Incident	A step in the causal pathway which describes the point at which control of pathway is lost. System required preventative controls have failed or been circumvented when an incident occurs. An incident is NOT a risk as it should not be described as a consequence.
Inherent/Initial Risk	The risk associated with an unwanted event <i>before</i> any consideration of the existing controls is taken into account.
Inspection	A regular check of workplace equipment, working environment and practices, to identify hazards and deficiencies.
Instrument	Term used to describe either statute, standards, policies or other legal or corporate document which imposes obligations on the site and the personnel filling roles in the organisation.
Issue	Is used in the document to describe any point raised by the team or in the risk review process generally. An issue can be any of cause, hazard, incident, control, outcome (risk), requirement, background information or general point related to the subject area.
LMP	Abbreviation – Land Management Plan – A document outlining the management of potential environmental consequences due to potential subsidence impacts within the Project area and surrounds.
LW	Abbreviation – Longwall – the key method of secondary extraction considered.
SBU	Abbreviation – South Bates Underground Mine.
Personnel	Includes all people working in and around the site (e.g. all contractors, sub-contractors, visitors, consultants, project managers, etc.).



Term	Explanation
Practicable	The extent to which actions are technically feasible, in view of cost, current knowledge and best practices in existence and under operating circumstances of the time.
Residual Risk	The risk associated with an unwanted event <i>after</i> consideration of the existing control measures is taken into account.
Review	An examination of the effectiveness, suitability and efficiency of a system and its components.
Risk	The combination of the potential consequences arising from a specified hazard together with the likelihood of the hazard actually resulting in an unwanted event.
Risk Management	The systematic application of management policies, procedures and practices to the tasks of identifying, analysing, assessing, treating and monitoring risk.
RWEP	Abbreviation -Remnant Woodland Enhancement Program. Areas being managed by WCPL to help to conserve regional biodiversity, whilst enhancing the habitat available to flora and fauna.
SGWRP	Abbreviation – Surface and Groundwater Response Plan.
SWMP	Abbreviation – Surface Water Monitoring Program.
WCPL	Abbreviation – Wambo Coal Pty Ltd.
WMP	Abbreviation – Water Management Plan.

### 3 INTRODUCTION

#### 3.1 Objectives and Deliverables

The primary objectives of this risk assessment were to:

- Use the risk assessment to identify items to be addressed in the Extraction Plan (and related plans);
- Use the risk assessment as input into the preparation of the Extraction Plan for the South Bates Underground Mine Longwalls 11 to 16;
- Develop parameters for inclusion in other management plans;
- Involve a cross section of WCPL, subject matter experts, decision makers and key stakeholders in the issue (hazard) identification process;
- Prioritise identified issues;
- Determine the criticality of controls;
- Identify recommended actions for follow up; and
- Document the process and the results.

#### 3.2 Client

The client for the risk assessment is the WCPL Environment and Community Manager.

#### 3.3 Scope

On the 26<sup>th</sup> October 2016, a team consisting of WCPL technical and environmental staff and specialist consultants participated in a facilitated risk assessment workshop on South Bates Underground Mine Longwalls 11 to 16 inclusive. The scope of the workshop was:

*“To review the risk assessment for South Bates Underground Mine with an emphasis on identifying those subsidence impacts with high-risk levels and/or potentially severe consequences.*

*To confirm that adequate risk treatment measures are applied such that the residual risk ranking is tolerable.”*

This 26<sup>th</sup> October 2016 risk assessment team studied and extended existing considerations to include implications of Longwalls 14 to 16 (which had not been fully considered by the earlier workshop) in addition to Longwalls 11 to 13 (which was also considered in a workshop on 31<sup>st</sup> October 2014).

The risk assessment workshops included:

- Establishing the context including review of supporting information and objectives;
- Identifying risks via a number of risk management techniques, including:
  - Brain storming;
  - Modified hazard and operability analysis; and
  - Gap analysis against the subsidence impact performance measures in the Development Consent (DA 305-7-2003) and the features that may be affected by underground coal mining listed in Appendix B of EDG17 – Guideline for Applications for Subsidence Management Approvals (Department of Mineral Resources, 2003)<sup>1</sup>;
- Analysis of identified risks and nomination of key potential environmental issues; and
- Ranking of the risks, including consideration of mitigation measures.

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<sup>1</sup> It is noted that although this Guideline no longer applies, it still provides a list of features that aid in hazard identification.

### 3.4 External Facilitation

The team sessions were facilitated by Dr Peter Standish of Operational Risk Mentoring – a company specialising in risk assessment and risk management processes.

### 3.5 The Team

The team met or joined by virtual meeting technology on 31<sup>st</sup> October 2014 and 26<sup>th</sup> of October 2016 at the WCPL site, near Singleton, NSW. A team-based approach was utilised in order to incorporate an appropriate mix of skills and experience to identify the potential loss scenarios/issues relating to Longwalls 11 to 16. Details of the team members and their relevant qualifications and experience are shown in Table 2.

**Table 2: Team Members**

Name	Role	Qualifications and Experience	31/10/14	26/10/16
<b>Peter Standish</b>	Operational Risk Mentoring – Facilitator	PhD, B Eng (Hon), Dip Bus Mgt, Risk Analysis Trained, Certificate of Competence as a Manager; 33 years experience in underground and open cut mining operations with operating, managerial and contract management experience. Involved in facilitating risk assessments for 15 years.	✓	✓
<b>Michael Millgate</b>	WCPL – Technical Services Superintendent <sup>1</sup>	B Survey, Registered Mine Surveyor; over 10 years industry experience.	✓	–
<b>Troy Favell</b>	WCPL – Environment and Community Manager <sup>1</sup>	B Sc (Ecology & Botany); over 5 years experience at the Wambo Coal Mine.	✓	–
<b>Tim Britten</b>	WCPL – Technical Services Manager	B Sc (Geol), M Eng (Geotech), Diploma in Coal Mine Strata Control and Ventilation, VO's ticket; over 20 years industry experience.	✓	✓
<b>Mal Walker</b>	WCPL – Chief Surveyor	B Survey, Statutory Surveyors Registration; over 30 years industry experience.	✓	✓
<b>Mark Mills</b>	WCPL – Technical Services Superintendent (Open Cut)	B Eng (Mine); 20 years industry experience.	✓	–
<b>Noel Merrick</b>	Heritage Computing – Director	PhD (Groundwater Management), Grad Dip Data Proc, MSc (Research Geophysics), BSc (Physics), Grad Course in Hydrology; 40 years industry experience.	✓	✓
<b>Darrell Rigby</b>	RPS Australia Asia Pacific – Archaeologist	B Arts (Archaeology & Palaeontology); over 10 years archaeological experience.	✓	–
<b>Joanna Hinks (nee Webster)</b>	Resource Strategies – Project Manager	B Eng (Env); 9 years environmental management and project approvals experience in resource industry.	✓	✓
<b>Peter Jaeger</b>	Senior Environmental Adviser	B EnvSci; 9 years environmental management experience in resource industry.	–	✓
<b>James Barbato</b>	MSEC – Associate Director	B Eng (Civil); over 10 years experience as a subsidence engineer.	–	✓

<sup>1</sup> Position at the time of the facilitated risk assessment workshop.

Team member “goals” were used to confirm that initial expectations of the team session were met – with the team members reflecting on these goals towards the end of the session.

## 4 ESTABLISH THE CONTEXT

### 4.1 Project Context

Wambo Coal Mine is an open cut and underground coal mining operation located approximately 15 km west of Singleton, near the village of Warkworth, NSW. The Wambo Coal Mine is owned and operated by WCPL, a subsidiary of Peabody Energy Australia Pty Limited.

A range of open cut and underground mine operations have been conducted at the Wambo Coal Mine since mining operations commenced in 1969. Mining under the Development Consent (DA 305-7-2003) commenced in 2004 and currently both open cut and underground operations are conducted.

The South Bates Underground Mine is a component of the approved Wambo Coal Mine, located north-west of the completed North Wambo Underground Mine (see **Figure 1**). The South Bates Underground Mine is approved for extraction in the Whybrow Seam (Longwalls 11 to 13) and the underlying Wambo Seam (Longwalls 14 to 16).

The extent of mining at South Bates Underground Mine (see **Figure 2**) is constrained by the open cut workings to the east, fault structures to the south and the Wollemi National Park and gas constraints to the south-west. Longwall extraction in the Whybrow Seam commenced in 2016, with extraction of Longwall 11 complete at the time of the October 2016 workshop. Longwall extraction from the Wambo Seam is planned to commence in mid-2017.

This risk assessment report has been prepared to support an updated Extraction Plan for Longwalls 11 to 16 in both the Whybrow and Wambo Seams at the South Bates Underground Mine.

More information on the mine and its operation can be found on the company's website: [www.peabodyenergy.com.au](http://www.peabodyenergy.com.au).

### 4.2 Risk Management and Organisational Context

The Development Consent (DA 305-7-2003) outlines a range of performance measures regarding the potential consequences of subsidence risks posed by mining. These subsidence impact performance measures are shown in Table 3.

**Table 3: Performance Measures**

Feature	Subsidence Impact Performance Measure
Wollombi Brook	Negligible impact. Controlled release of excess site water only in accordance with EPL requirements.
Wollemi National Park	Negligible subsidence impacts. Negligible environmental consequences.
Warkworth Sands Woodland Community	Minor cracking and ponding of the land surface or other impact. Negligible environmental consequences.
White Box, Yellow Box, Blakely's Red Gum, Woodland/Grassy White Box Woodland Community	Minor cracking and ponding of the land surface or other impact. Negligible environmental consequences.
Other threatened species, populations or communities	Minor cracking and ponding of the land surface or other impact. Negligible environmental consequences.
Wambo Homestead Complex	Negligible impact on heritage values, unless approval has been granted by the Heritage Branch and/or the Minister.
All built features	Always safe. Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.
Public Safety	No additional risk.



**Figure 1: Wambo Coal Mine Collective General Arrangement**

**Figure 2: Aerial Photograph of Longwalls 11 to 16**



The Extraction Plan review process involved the following key steps:

1. Risk assessment workshop for Longwalls 11 to 13 conducted on 31<sup>st</sup> October 2014;
2. Extraction Plan for Longwalls 11 to 13 approved on 9<sup>th</sup> February 2016;
3. Risk assessment workshop to consider Longwalls 14 to 16 in addition to Longwalls 11 to 13 conducted on 26<sup>th</sup> October 2016; and
4. Revise Extraction Plan for Longwalls 11 to 16 for lodgement in early 2017.

The assessment of risks has also referred to:

- Relevant criteria defined by statutory requirements;
- Community consultation findings;
- Requirements by local and state government agencies with responsibilities in the area;
- Structural tolerances of man-made surface structures;
- Operational licenses of public utilities which may be affected by subsidence in the proposed mining area;
- Relevant guidelines published by the NSW Government;
- Previous observations/information collected in the area; and
- Other relevant information made available to the team.

### **4.3 Key Assumptions**

The identification of key assumptions is a critical part of the risk assessment process – forming the basis for many engineering/project decisions. It is important that these assumptions are validated and reviewed as part of the risk management process. Key assumptions applied during the risk assessment process were:

- The risk assessment relates to the extraction of Longwalls 11 to 13 inclusive in the Whybrow Seam and Longwalls 14 to 16 inclusive in the Wambo Seam at the South Bates Underground Mine only;
- All commitments made in approval documentation (e.g. the *Wambo Development Project Environmental Impact Statement*) or controls currently allocated to a work stream were taken to be “planned controls”; and
- Risk ranking was undertaken on the basis of consequences being in excess of approved levels and in consideration of remediation.

## 5 METHOD

### 5.1 Key Steps

The key steps in the risk assessment process were:

1. Background analysis on the subsidence issues and experiences of underground mining at the Wambo Coal Mine;
2. Facilitation of a scoping session (developed by Resource Strategies and communicated to Operational Risk Mentoring) with decision making personnel to discuss scope material, and to confirm the risk analysis process and key outcomes sought;
3. Facilitation of a team-based analysis to evaluate and treat risks, comprising:
  - a. an open discussion with the team on “what do we want to achieve” in relation to the analysis;
  - b. presentation by Troy Favell (31/10/14) and Tim Britten (26/10/16) on the subsidence experiences at the nearby North Wambo Underground Mine and from the mining of Longwall 11;
  - c. brainstorming (writing) to capture general issues;
  - d. review of earlier relevant Risk Assessment studies (for Longwalls 11 to 13 and the North Wambo Underground Mine);
  - e. modified HAZOP - reviewing an aerial photo view of the mine to identify potential surface features which could contribute to/be affected by subsidence;
  - f. cross mapping to the applicable subsidence impact performance measures in the Development Consent (DA 305-7-2003) and surface and sub-surface features that may be affected by underground coal mining in Appendix B of EDG17 to confirm all items have been addressed;
  - g. prioritisation (of identified items) – through a voting system conducted by the team;
  - h. risk ranking of the outcomes shown in the confirmed risk and control chart;
  - i. identification of planned (existing) and additional controls to mitigate risk levels to a tolerable state; and
  - j. generation of an action plan to complete the identified additional controls;
4. Complete draft report to AS/NZS ISO 31000: 2009 standard for review by personnel; and
5. Finalise the report and issue as a controlled copy for ongoing use.

## 6 IDENTIFYING HAZARDS AND ISSUES

### 6.1 *Background Analysis of Documents*

The various documents listed in the References section were reviewed to determine the nature of specific threats and controls identified for the operation.

### 6.2 *Brain Writing*

Brain writing is a technique based on the work of de Bono (who built on the work of Alex Faickney Osborne) and is intended to promote creative thought amongst a group of people. As applied by Operational Risk Mentoring, the process involves:

1. Quiet reflection – where individuals write their thoughts on the subject onto paper or card(s);
2. Group discussion – with each person in the team taking a turn to read out one of their issues – and then refinement of each issue based on input from other team members who had similar items on their list; and
3. Key word association (where relevant) to identify additional Issues for the register based on connection with the subject.

### 6.3 *Modified HAZOP*

An aerial photograph of the mine was used to identify potential subsidence impacts – with key word prompts connected with the various aspects of potential harm. The output from this process was added to the over-arching risk register from the team session (shown in Table 6).

### 6.4 *Statute and Guideline Cross Map*

The main guidance information considered comprised:

- Subsidence impact performance measures in the Development Consent (DA 305-7-2003); and
- Surface and sub-surface features that may be affected by underground coal mining listed in Appendix B of EDG17 – Guideline for Applications for Subsidence Management Approvals<sup>2</sup>.

These documents provided a range of points which were considered by the team and used to generate additional issues (hazards or controls) for consideration.

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<sup>2</sup> It is noted that although this Guideline no longer applies, it still provides a list of features that aid in hazard identification.

## 7 ANALYSE RISK

Analysis of identified issues requires the stakeholders to determine the risk that the identified threat poses to the organisation or the importance of the potential control. Risk is the product of the consequence and the likelihood of the event occurring with and without controls in place.

Risk analysis involves determining the consequences or impact of a potential event occurring in combination with the likelihood of that event occurring. The result is a “level of risk” defined by the following.

$$\text{Level of Risk} = \text{Consequence} \times \text{Likelihood}$$

The elements of risk level determination are as follows:

1. Consider the causal pathway – the balance between the intensity and frequency of the cause(s) and the preventative controls in place to prevent them from becoming incidents;
2. Identify existing mitigating control strategies and tactics that act to minimise negative outcomes from an incident;
3. Determine the consequences of the outcome reached by the causal pathway – with a negative impact or an opportunity. Where appropriate, the causal pathway considered should identify the dimension upon which is impacted (e.g. outcome is related to harming people, natural environment, property, process continuity, etc.);
4. Determine the likelihood of the outcome being reached – giving balance to the cause, preventative and mitigating controls for a negative consequence or positive opportunity occurring. Likelihood is defined as the product of the probability of the event occurring and the overall exposure to the event;
5. Estimate the level of risk of an outcome by combining the consequence and likelihood rankings using the risk matrix; and
6. Identify and consider any uncertainties in the estimates, validate these where appropriate.

This technique was applied to reach the risk scores shown in Table 6. Note that in some instances the risk levels were not scored – which flows from guidance including:

- Uncertainty – if the causal pathway cannot be clearly described – any estimation of risk levels would be misleading, and the matter should be referred as an action to the Client to more clearly determine the level of risk;
- Being Control Related – where an issue such as failing to follow a procedure or a detection system not functioning are identified. In this case it is impossible to generate a meaningful risk score, as it requires the combination of the probability of the control failing AND the causal pathway being “traversed” at the same instant in time – which is rarely assessable in a team environment; and
- Being Undefined – where a causal pathway has no clear outcome and so no meaningful risk score can be assigned.

Priority issues identified by the team are shown in Table 4.

### 7.1 Prioritisation

The key potential hazards/issues were identified through a “voting” system whereby team members were assigned a number of “votes” to allocate to what they considered to be the key hazards/issues.

Based on Operational Risk Mentoring’s review of fatality and incident data, comparing the number of root causes implicated in losses against the number identified in predictive analyses, a division of 90:10 is indicated. That is 90% of the losses arise as a result of 10% of the issues (root causes etc.)<sup>3</sup>.

<sup>3</sup> This division is more pronounced than that determined by Vilfredo Pareto in 1906 - and the taxonomy of this difference has not been researched at this stage. The team generally acknowledged that the items given priority in the process plausibly represented the vast majority of the potential risk/reward in the subject area.

Some 10% of the total number of points raised were then issued to the team members as “votes” which they could allocate against the various individual points.

The results of this output are shown in Table 4, ordered by descending vote frequency with the nominated aspect area included. This provided a method for the team to identify and sort initial concerns at an early stage. The resulting level of risk is summarised in the Risk Treatment Plan in the Appendices.

**Table 4: Priority Issues<sup>4</sup>**

Ref	Process/Issue/Activity	Votes	Aspect Type
SB008	Failure of the monitoring program to detect and respond to an impact on the groundwater system.	6	Groundwater
SB037	Impact on stability/serviceability of levee bank between North Wambo Creek and the open cut void leading to water flows into the Bates South pit.	6	Surface Water
SB010	North Wambo Creek Diversion damaged by subsidence (surface cracking along diversion directly above Longwalls 11 to 16) resulting in inflow to workings and delay to operations.	5	Infrastructure
SB046	Creation of subsidence monitoring tracks affects the conservation values of the RWEPA areas.	4	Flora/Fauna
SB042	Subsidence impacts on access tracks restrict access for monitoring/remediation.	3	Infrastructure
SB013	Subsidence impacts resulting in instability or rock fall of major or minor cliff lines and associated environmental consequence (i.e. lower level cliff lines and spur).	3	Land
SB045	Induced leakage from North Wambo Creek Diversion due to subsidence.	3	Surface Water
SB028	Mine subsidence impacts on items of known Aboriginal heritage.	2	Archaeological
SB055	Mine subsidence impacts due to the extraction of Longwalls 11 to 16 on riparian vegetation of Stony Creek resulting in environmental consequences.	2	Flora/Fauna
SB032	Subsidence effects on Stony Creek, including cracking of stream bed and loss of flow.	2	Surface Water
SB064	Ingress of oxygen into mine workings as a result of subsidence cracking and subsequent spontaneous combustion events.	1	Business
SB016	Subsidence impacts on Remnant Woodland Enhancement Areas (RWEPA) areas reducing biodiversity values.	1	Flora/Fauna
SB019	Mine subsidence impacts resulting in impacts on vegetation along the North Wambo Creek Diversion.	1	Flora/Fauna
SB050	Boundary faults result in differences between modelled and observed groundwater drawdown (possibly conservative at a distance, but inaccurate locally).	1	Groundwater
SB009	Structural damage to wells and bores close to the mine footprint, in particular monitoring bores and Gas Riser 01.	1	Infrastructure
SB057	Subsidence impacts resulting in injury to livestock.	1	Infrastructure

<sup>4</sup> These votes were not updated in the team session of 26/10/16 although they were confirmed as being largely aligned with the team's perceptions on the day.

Ref	Process/Issue/Activity	Votes	Aspect Type
SB001	Environmental consequences associated with water flow and quality changes in Stony Creek (including changes to channel stability) resulting from subsidence impacts.	1	Surface Water
SB011	North Wambo Creek Diversion damaged by subsidence resulting in reduced flow affecting downstream water quality.	1	Surface Water
SB054	A change in flood regimes or extent of potential inundation due to subsidence resulting from the extraction of Longwalls 11 to 16.	1	Surface Water

## 7.2 Referred Issues

Issues raised during the risk assessment workshop brainstorming that were outside the scope of the risk assessment are considered to be 'referred issues'.

Referred issues identified during the risk assessment workshop are shown in Table 5.

**Table 5: Referred Issues**

Ref	Description of Issue	Justification
SB049	Variation to Consent 2222 required to extend expiry date and cover all of the Application Area.	Outside the scope of the risk assessment (regulatory issue).
SB063	Failure to gain approval of the Extraction Plan resulting in production delays.	Outside the scope of the risk assessment (regulatory issue).
SB030	Difficulty in access for subsidence surveys due to harshness of terrain.	Outside the scope of the risk assessment (control related).
SB043	Potential for variability in subsidence profiles due to faulting.	Outside the scope of the risk assessment (technical assessment issue).
SB062	Failure to implement the approved Extraction Plan.	Outside the scope of the risk assessment (regulatory issue).
SB031	Ability to implement adequate groundwater monitoring for South Bates.	Outside the scope of the risk assessment (control related).
SB018	Disruption to (or lack of access for) subsidence monitoring activities.	Outside the scope of the risk assessment (control related).
SB040	Remediation plan for the North Wambo Creek Diversion in place prior to commencement of subsidence.	Outside the scope of the risk assessment (control related).
SB036	Failure to adequately classify strata and fill around North Wambo Creek Diversion leading to insufficient assessment of subsidence above workings to the Diversion.	Outside the scope of the risk assessment (technical assessment issue).

## 8 ASSESS RISK

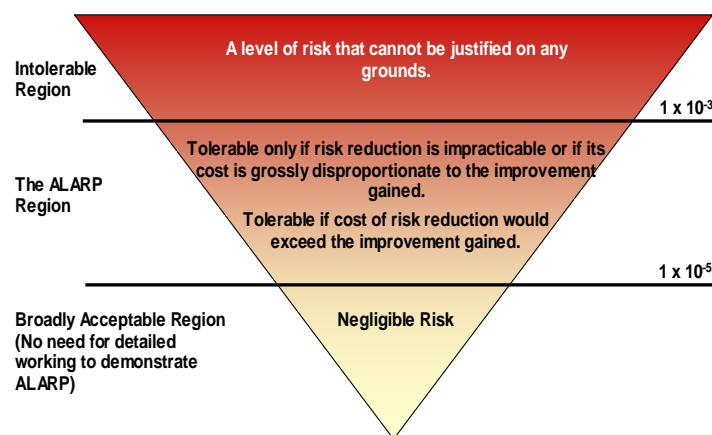
### 8.1 Risk Acceptability and Risk Criteria

The 'tolerability' of a risk is the willingness to live with a risk to secure benefits, on the understanding that the risk is being properly controlled (HB 203:2006 – *Environmental Risk Management – Principles and Process*). Legislation and good practice is targeted to reduce risk to "As Low as Reasonably Practicable" (ALARP). ALARP is often interchanged with "As Low as Reasonably Achievable" (ALARA).

The purpose of risk criteria is to allow the organisation to clearly define unacceptable levels of risk, or conversely the level of risk which is acceptable or tolerable. In essence the risk criterion enables the organisation to prioritise actions proposed to control the risk during the risk assessment – leading to the development of the Risk Treatment Plan (Appendices).

The ALARP principle, as represented in the diagram below, was developed to assist in the definition of the acceptability of risk and to demonstrate that an organisation has done all that is considered to be practical in reducing the level of exposure to a risk. More often this is done qualitatively rather than as a quantitative probability as shown on the right-hand side of the diagram presented in **Figure 3**. A risk may be tolerable in the ALARP zone if the cost of removing the risk is disproportionate to the benefits gained.

**Figure 3: Risk Criteria "ALARP"**



### 8.2 Risk Ranking

The risk ranking likelihood, consequences and risk matrix considered by the team during the ranking process are outlined in the Appendices. The Risk Treatment Plan given in the Appendices shows the risk ranking results. The teams took into account cumulative impacts throughout all loss scenarios.





## 9 TREAT RISKS

A systems approach to the treatment of risks involves consideration of three aspects:

1. Areas of Intervention (Prevention, Monitoring, Mitigation, Response/Recovery);
2. Wheel of Safe Production (Nertney Wheel); and
3. Sequence of Barriers (Hierarchy of Controls).

Additional information is provided in the Appendices.

A selection of controls to reduce the likelihood of the risks associated with the topic under review were made with due regard to their prospective reliability. That is, installing engineering modifications is a superior control to relying on operator training efforts. As part of the process, existing controls are assessed and recommendations for amendments or additions made where these existing controls are deemed unacceptable or inadequate.

Further, the prospective reliability of the controls identified as issues were also reviewed. These controls were qualitatively reviewed by considering their position on the hierarchy of controls, the ability to detect any deterioration in the control and the ability to mitigate this deterioration.

### 9.1 Risk Treatment Plan

The Risk Treatment Plan given in the Appendices shows the risk evaluation results.

## 10 MONITOR AND REVIEW

### 10.1 *Nominated Coordinator*

The nominated coordinator is the WCPL Environment and Community Manager. The coordinator should encourage all parties who attended the risk assessment team session to review this report and the identified hazards/issues – commenting as needed.

The nominated coordinator should also:

1. Review the report to confirm the accuracy of the material recorded from the team session;
2. Provide feedback to the parties who attended the risk assessment on any decisions which may be different from team expectations/recommendations raised on the day; and
3. Monitor the completion of the additional actions to confirm there is close out of each action.

### 10.2 *Implementation Review Plan*

It is important to confirm the controls and actions identified are appropriately managed. The expectation of the team was that:

1. Appropriate personnel would be allocated for implementation of recommended actions in a timely manner for completion;
2. Assumptions are validated; and
3. Action items would be appropriately resourced and implemented.

WCPL can make modifications to the recommended actions, but these should be done in light of the risk management framework. Where a change is required, the basis for the change and a desktop review to assess if the risk of the underlying hazard remains tolerable is required.

### 10.3 *Communication and Consultation*

Communication and consultation form an integral part of the risk management process. It is the Client's responsibility to confirm that this report is shared with all participants involved in the process and other stakeholders as appropriate throughout the life cycle of the study subject area.

### 10.4 *Concluding Remarks*

A significant goal of the risk assessment process was to identify and analyse the subsidence related hazards with rigour. The desired outcome was to prevent losses to people, equipment, the environment and consequential business by evaluating the causal pathways and developing recommended controls for inclusion into an action plan. This outcome was achieved by following the risk assessment process described within this document.

Ongoing review will be needed to manage the additional controls identified, and to ensure that subsequent risk management activities are conducted as required.

Dr Peter Standish would like to thank all personnel – particularly Joanna Hinks (nee Webster), Peter Jaeger and Troy Favell who arranged the sessions and resources provided – and other team members who contributed to the risk assessment.

## 11 REFERENCES

- Department of Mineral Resources (2003) *EDG17 – Guideline for Applications for Subsidence Management Approvals*. Rev 3.
- Department of Mineral Resources (2011) MDG1010 – Minerals Industry Safety and Health Risk Management Guideline.
- Mine Subsidence Engineering Consultants (2016) Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Extraction Plan for WYLW11 to WYLW13 in the Whybrow Seam and WMLW14 to WMLW16 in the Wambo Seam.
- Operational Risk Mentoring (2015) South Bates (Whybrow Seam) Underground Mine – Longwalls 11 to 13 Subsidence Risk Assessment Report.
- Wambo Coal Pty Limited (2003) Wambo Development Project Environmental Impact Statement.
- Wambo Coal Pty Limited (2015) South Bates (Wambo Seam) Underground Mine Modification.



## 12 APPENDICES

## 12.1 Risk Treatment Plan

The following Risk Treatment Plan was developed by the team during the sessions on 31<sup>st</sup> October 2014 and 26<sup>th</sup> October 2016. Changes made during the second workshop are *italicised* with comments where appropriate. Actions identified during the first workshop that are complete have a ~~strike through~~. Previously identified risks that are no longer relevant to the Extraction Plan are shaded grey.

The table is ordered by aspect type and priority.

**Table 6: Risk Treatment Plan**

Ref	Process/Issue/Activity	Aspect Type	Planned Controls	Cat	L	C	R	Actions [ <del>strike through</del> = complete]	By Whom/By When
SB028	Mine subsidence impacts on items of known Aboriginal heritage.	Archaeological	Implementation of Heritage Management Plan. Consent 2222 in place for the majority of the Application Area. Due diligence process for surface disturbance (Surface Disturbance Permit process).	Env	D	4	21	<del>Lodge Variation to Consent 2222 to cover all of Application Area.</del>	WCPL Environment and Community Manager (Complete)
SB029	Mine subsidence impacts on items of unknown Aboriginal heritage.	Archaeological	Implementation of Heritage Management Plan. Due diligence process for surface disturbance (Surface Disturbance Permit process).	Env	D	4	21	-	-
SB039	Potential subsidence impacts on grinding groove site outside the current Consent 2222 area.	Archaeological	<i>LW 14-16 Review: Further analysis of the groove site determined the site was not of Aboriginal origin. Therefore, this risk is no longer relevant to the Extraction Plan.</i>	-	-	-	-	<del>Lodge Variation to Consent 2222 to cover all of Application Area.</del>	WCPL Environment and Community Manager (Complete)
SB064	Ingress of oxygen into mine workings as a result of subsidence cracking and subsequent spontaneous combustion events.	Business	Implementation of Ventilation and Gas Management Plan, Mines Inspection System and Spontaneous Combustion Management Plan. Subsidence modelling and monitoring. <i>LW 14-16 Review: Risk ranking changed from C 4 18 to D 4 21(reduced likelihood) based on experience from LW 11.</i>	Bus	D	4	21	Conduct relevant technical studies to support Ventilation and Gas Management Plan.	WCPL Technical Services Manager (Complete)

Ref	Process/Issue/Activity	Aspect Type	Planned Controls	Cat	L	C	R	Actions [strike through = complete]	By Whom/By When
SB041	Unexpected operational impacts associated with mining deeper than previous operations at Wambo (limited borehole information).	Business	Clause 33 notification process (for second workings).	Env	D	4	21	-	-
SB048	Operational impact associated with mining through boreholes from Wollemi workings.	Business	Clause 33 notification process (for second workings). Implementation of Inrush Management Plan. <i>LW 14-16 Review: Noted that relevant to Whybrow Seam workings only. No change to risk ranking.</i>	Bus	D	5	24	-	-
SB060	Operational impact associated with mining in proximity to adjacent previous workings in the Wambo Seam.	Business	Previous workings (including angle of draw) outside expected subsidence zones. Clause 33 notification process (for second workings).	Bus	D	5	24	-	-
SB061	Operational impact associated with mining in proximity to adjacent previous workings in the Whybrow Seam.	Business	Previous workings (including angle of draw) outside expected subsidence zones. Clause 33 notification process (for second workings).	Bus	D	5	24	-	-
SB046	Creation of subsidence monitoring tracks affects the conservation values of the RWEPP (Remnant Woodland Enhancement Program) areas.	Flora/Fauna	Adherence to Surface Disturbance Permit as per Flora and Fauna Management Plan. <i>LW 14-16 Review: Risk ranking changed from C 5 22 to D 5 24 (reduced likelihood) based on the use of LiDAR for subsidence monitoring.</i>	Bus	D	5	24	<del>Prepare a subsidence monitoring program that takes into account access limitations for RWEPP Areas.</del>	<del>WCPL Environment and Community Manager (Complete)</del>
SB055	Mine subsidence impacts due to the extraction of LWs 11 to 16 on riparian vegetation of Stony Creek resulting in environmental consequences.	Flora/Fauna	Implementation of the Extraction Plan, Biodiversity Management Plan, bed and bank stability management, monitoring and response capacity, Biodiversity Management Plan and visual inspections through subsidence monitoring. <i>LW 14-16 Review: Noted that predicted subsidence impacts on Stony Creek have reduced. No change to risk ranking.</i>	Env	D	5	24	-	-
SB016	Subsidence impacts on the RWEPP (Remnant Woodland Enhancement Program) areas reducing biodiversity values.	Flora/Fauna	Implementation of the Extraction Plan, Biodiversity Management Plan, bed and bank stability monitoring, flora and fauna monitoring program, visual inspections and remediation.	Env	D	5	24	-	-

Ref	Process/Issue/Activity	Aspect Type	Planned Controls	Cat	L	C	R	Actions [ <del>strike through</del> = complete]	By Whom/By When
SB019	Mine subsidence impacts resulting in impacts on vegetation along the North Wambo Creek Diversion.	Flora/Fauna	Implementation of the Extraction Plan, Biodiversity Management Plan, bed and bank stability monitoring, flora and fauna monitoring program, visual inspections and remediation.	Env	C	5	22	-	-
SB020	Subsidence impacts and surface disturbance due to the extraction of Longwalls 11 to 16 resulting in loss of habitat for threatened species.	Flora/Fauna	Implementation of the Extraction Plan, Biodiversity Management Plan, bed and bank stability monitoring, flora and fauna monitoring program, visual inspections and remediation.	Env	E	5	25	-	-
SB021	Subsidence impacts and surface disturbance due to extraction of Longwalls 11 to 16 resulting in long-term loss of native vegetation.	Flora/Fauna	Implementation of the Extraction Plan, Biodiversity Management Plan, bed and bank stability monitoring, flora and fauna monitoring program, visual inspections and remediation.	Env	E	5	25	-	-
SB059	Mine subsidence impacts resulting in damage to rehabilitated areas ( <i>including North Wambo Creek Diversion</i> ).	Flora/Fauna	Implementation of the Extraction Plan, Biodiversity Management Plan, bed and bank stability monitoring, flora and fauna monitoring program, visual inspections and remediation.	Env	C	5	22	-	-
SB008	Failure of the monitoring program to detect and respond to an impact on the groundwater system.	Groundwater	Documentation and execution of the Water Management Plan (including the Surface Water Management Plan, Groundwater Management Plan, Surface and Groundwater Response Plan and North Wambo Creek Subsidence Response Strategy). Assessment of impacts during development of the Extraction Plan. Clear allocation of roles and responsibilities in the management plans. <i>LW 14-16 Review: Noted that monitoring program has improved with the installation of additional bores in accordance with previous action. No change to risk ranking.</i>	Env	D	4	21	<del>Review groundwater monitoring program in the vicinity of South Bates Underground Mine, and need for additional monitoring sites.</del>	WCPL Environment and Community Manager (Complete)
								Confirm whether N2 and GW21 piezometers are still operational following nearby longwall extraction.	WCPL Environment and Community Manager (31/12/2016 - Complete)



Ref	Process/Issue/Activity	Aspect Type	Planned Controls	Cat	L	C	R	Actions <small>[strike through = complete]</small>	By Whom/By When
SB050	Boundary faults result in differences between modelled and observed groundwater drawdown (possibly conservative at a distance, but inaccurate locally).	Groundwater	Documentation and execution of the Water Management Plan (including the Surface Water Management Plan, Groundwater Management Plan and Surface and Groundwater Response Plan). Assessment of impacts during development of the Extraction Plan.	Env	D	5	24	Review potential influence of geological features on groundwater predictions.	WCPL Environment and Community Manager (Ongoing)
SB010	North Wambo Creek Diversion damaged by subsidence (surface cracking along diversion directly above Longwalls 11 to 16) resulting in inflow to workings and delay to operations.	Infrastructure	Adequate design of North Wambo Creek Diversion. Implementation of the Extraction Plan. Implementation of a TARP for crack remediation. Installation of adequate mine dewatering capacity.	Bus	C	4	18	Revise relevant assessments for Clause 33 notification process for Longwalls 14 to 16.	WCPL Technical Services Manager (30/06/2016)
SB042	Subsidence impacts on access tracks restrict access for monitoring/remediation.	Infrastructure	Implementation of Extraction Plan and Built Features Management Plan, including monitoring and remediation. <i>LW 14-16 Review: Noted that experience indicates impacts rarely significantly affect access. No change to risk ranking.</i>	Bus	C	5	22	-	-
SB009	Structural damage to wells and bores close to the mine footprint, in particular monitoring bores <i>and Gas Riser 01</i> .	Infrastructure	Implementation of Extraction Plan and Built Features Management Plan.	Bus	D	5	24	<del>Review groundwater monitoring program in the vicinity of South Bates Underground Mine, and need for additional monitoring sites.</del>	<del>WCPL Environment and Community Manager (Complete)</del>
								Confirm whether N2 and GW21 piezometers are still operational following nearby longwall extraction.	WCPL Environment and Community Manager (31/12/2016 - Complete)

Ref	Process/Issue/Activity	Aspect Type	Planned Controls	Cat	L	C	R	Actions [ <del>strike through</del> = complete]	By Whom/By When
SB057	Subsidence impacts resulting in injury to livestock.	Infrastructure	Implementation of Public Safety Management Plan (particularly notification and fencing requirements).	Com	E	5	25	-	-
SB017	Subsidence impacts to unsealed gravel access roads or fire trails.	Infrastructure	Implementation of Extraction Plan and Built Features Management Plan, including monitoring and remediation.	Bus	C	5	22	-	-
SB022	Mine subsidence impacts to fences on WCPL owned land.	Infrastructure	Implementation of Extraction Plan and Built Features Management Plan, including monitoring and remediation.	Bus	C	5	22	-	-
SB023	Mine subsidence impacts to WCPL mine dewatering pipeline.	Infrastructure	Implementation of Extraction Plan and Built Features Management Plan, including monitoring and remediation.	Bus	D	5	24	Confirm the Extraction Plan includes a requirement to check for slack on pipelines and cables over the subsidence areas.	WCPL Technical Services Manager (Complete)
SB024	Mine subsidence impacts to other water management infrastructure (pipelines, roads and pumps and dewatering bores).	Infrastructure	Implementation of Extraction Plan and Built Features Management Plan, including monitoring and remediation. <i>LW 14-16 Review: Noted that no dewatering bores are planned. No change to risk ranking.</i>	Bus	D	5	24	-	-
SB025	Exploration activities affected by subsidence.	Infrastructure	Ground Disturbance Permit and Surface Disturbance Permit processes.	Bus	E	5	25	-	-
SB027	Subsidence impacts to active services lines over LWs 11 to 16 resulting in delays in production.	Infrastructure	Implementation of Extraction Plan and Built Features Management Plan.	Bus	D	5	24	-	-
SB034	Impact on statutory inspections and service provision to open cut (e.g. low voltage and high voltage maintenance activities, access for other operational activities etc.).	Infrastructure	Implementation of Extraction Plan, Built Features Management Plan, Slope Stability Management Plan and high wall inspection program.	Bus	E	5	25	-	-

Ref	Process/Issue/Activity	Aspect Type	Planned Controls	Cat	L	C	R	Actions [ <del>strike through</del> = complete]	By Whom/By When
SB026/ SB038	High wall or end wall instability or collapse of the Bates South pit due to insufficient protection from subsidence impacts.	Infrastructure	Implementation of Built Features Management Plan, Slope Stability Management Plan, high wall inspection program. Execution of geotechnical assessment processes.	Bus	E	5	25	Subsidence assessment to consider impacts on high and end walls in consideration of work by Golder Associates.	WCPL Environment and Community Manager (Complete)
SB053	Subsidence impact on proposed Montrose East Dam.	Infrastructure	Monitor distance from active mining area. <i>Note: Dam not yet constructed.</i>	Bus	E	5	25	Subsidence assessment to consider location of Montrose East Dam relative to predicted subsidence.	WCPL Environment and Community Manager (Complete)
SB056	Subsidence impacts to WCPL buried power lines and communication cables.	Infrastructure	Implementation of Extraction Plan and Built Features Management Plan. <i>LW 14-16 Review: Risk ranking changed from C 5 22 to D 5 24 (reduced likelihood) as there are no cable joins within the subsidence area.</i>	Bus	D	5	24	-	-
SB013	Subsidence impacts resulting in instability or rock fall of major or minor cliff lines resulting in environmental consequence (i.e. lower level cliff lines and spur).	Land	Implementation of Extraction Plan, Land Management Plan and Public Safety Management Plan. <i>LW 14-16 Review: Risk ranking changed from C 4 18 to D 4 21 (reduced likelihood) due to shortened commencing ends of longwalls.</i>	Env	D	4	21	-	-
SB012/ SB044	Unintended subsidence impacts resulting in rock instability of the Wollemi National Park escarpment and associated environmental consequences.	Land	Implementation of Extraction Plan, Land Management Plan and Public Safety Management Plan. Identification of cliff lines that are associated with the Wollemi National Park with appropriate mine design offsets applied. <i>LW 14-16 Review: Noted that same design offset applies to LW 14-16. No change to risk ranking.</i>	Env	E	3	20	-	-

Ref	Process/Issue/Activity	Aspect Type	Planned Controls	Cat	L	C	R	Actions [ <del>strike through</del> = complete]	By Whom/By When
SB014	Subsidence impacts resulting in instability of rock pagodas and associated environmental consequences.	Land	Implementation of Extraction Plan, Land Management Plan and Public Safety Management Plan. <i>LW 14-16 Review: Risk ranking changed from C 4 18 to D 4 21 (reduced likelihood) due to shortened commencing ends of longwalls.</i>	Env	D	4	21	-	-
SB015	Subsidence impacts resulting in instability of steep slopes and associated environmental consequences.	Land	Implementation of Extraction Plan, Land Management Plan and Public Safety Management Plan. <i>LW 14-16 Review: Risk ranking changed from C 4 18 to D 4 21 (reduced likelihood) due to shortened commencing ends of longwalls.</i>	Env	D	4	21	-	-
SB051	Impacts on access for fire fighting or fire management purposes over Longwalls 11 to 16.	Public Safety	Implementation of Public Safety Management Plan. Subsidence monitoring and remediation.	Per	E	2	16	-	-
SB052	Impacts on public access to areas subject to subsidence.	Public Safety	Implementation of Public Safety Management Plan. Subsidence monitoring and remediation.	Per	D	5	24	-	-
SB058	Injury to animals or riders engaged in horse riding activities over Longwalls 11 to 16.	Public Safety	Implementation of Public Safety Management Plan. Subsidence monitoring and remediation.	Per	D	5	24	-	-
SB037	Impact on stability/serviceability of levee bank between North Wambo Creek and the open cut void leading to water flows into the Bates South pit.	Surface Water	Subsidence modelling and assessment prior to extraction. Subsidence monitoring and remediation.	Env	D	3	17	Subsidence Assessment to consider impacts to levee along North Wambo Creek Diversion.	WCPL Environment and Community Manager (Complete)
SB045	Induced leakage from North Wambo Creek Diversion due to subsidence.	Surface Water	Implementation of Water Management Plan and subsidence remediation.	Env	D	3	17	-	-
SB032	Subsidence effects on Stony Creek, including cracking of stream bed and loss of flow.	Surface Water	Implementation of Extraction Plan and Water Management Plan, including bed and bank stability monitoring and remediation.	Env	D	3	17	-	-

Ref	Process/Issue/Activity	Aspect Type	Planned Controls	Cat	L	C	R	Actions [ <del>strike through</del> = complete]	By Whom/By When
SB001	Environmental consequences associated with water flow and quality changes in Stony Creek (including changes to channel stability) resulting from subsidence impacts	Surface Water	Implementation of Extraction Plan and Water Management Plan, including bed and bank stability monitoring and remediation.	Env	D	4	21	-	-
SB011	North Wambo Creek Diversion damaged by subsidence resulting in reduced flow affecting downstream water quality.	Surface Water	Implementation of Extraction Plan and Water Management Plan, including bed and bank stability monitoring and remediation.	Env	D	4	21	<del>Subsidence to consider most accurate LIDAR and other as built data on the diversion.</del>	WCPL Environment and Community Manager (Complete)
SB054	A change in flood regimes or extent of potential inundation due to subsidence resulting from the extraction of Longwalls 11 to 16.	Surface Water	Implementation of Extraction Plan and Water Management Plan, including monitoring and remediation. <i>LW 14-16 Review: Noted that this risk will not be exacerbated by extraction in the Wambo Seam. No change to risk ranking.</i>	Env	D	5	24	-	-
SB002	Induced leakage from Stony Creek resulting from a lowering of the water table associated with the extraction of Longwalls 11 to 16.	Surface Water	Implementation of Extraction Plan and Water Management Plan, including monitoring and remediation. <i>LW 14-16 Review: Risk ranking changed from D 5 24 to E 5 25 (reduced likelihood) due to shortened commencing ends of longwalls and modelling predictions.</i>	Env	E	5	25	-	-
SB003	Reduced base flow to North Wambo Creek ( <i>including diversion</i> ) resulting from a lowering of the water table associated with the extraction of Longwalls 11 to 16.	Surface Water	Implementation of Extraction Plan and Water Management Plan, including monitoring and remediation.	Env	D	5	24	-	-
SB004	Environmental consequences associated with water flow and quality changes in unnamed minor drainage lines resulting from subsidence impacts associated with the extraction of Longwalls 11 to 16.	Surface Water	Implementation of Extraction Plan and Water Management Plan, including monitoring and remediation.	Env	D	5	24	-	-



Ref	Process/Issue/Activity	Aspect Type	Planned Controls	Cat	L	C	R	Actions <small>[<del>strike</del>through = complete]</small>	By Whom/By When
SB007	A change in land surface slope and preferential pathways for rainfall infiltration resulting from fracturing to the land surface caused by the extraction of Longwalls 11 to 16.	Surface Water	Implementation of Extraction Plan and Water Management Plan, including bed and bank stability monitoring and remediation. <i>LW 14-16 Review: Noted that additional subsidence will occur with Wambo Seam extraction, however existing gradients mitigate against ponding outside of North Wambo Creek Diversion. No change to risk ranking.</i>	Env	D	5	24	-	-
SB033	Increased ponding along Stony Creek as a result of subsidence.	Surface Water	<i>LW 14-16 Review: This is no longer a credible risk relevant to the Extraction Plan due to the reduction in longwall panel length at the commencing ends (beneath Stony Creek).</i>	-	-	-	-	-	-
SB035	Increased ponding along North Wambo Creek Diversion as a result of subsidence.	Surface Water	Implementation of Extraction Plan and Water Management Plan, including bed and bank stability monitoring and remediation.	Env	B	5	19	-	-

## 12.2 Systems Approach to Risk Treatment

### Areas of intervention

Controls need to be considered through their area of intervention. Controls can act to:

- **Prevent:** Preventative controls act in the causal pathway to stop incidents from occurring. A preventative control is typically aimed at the root causes of an incident – e.g. by designing out the risk, using a different process or providing multiple hard barriers between causes (energy sources) that cause situations to operate as required by the organisation; or
- **Mitigate a Loss:** Where mitigating controls act to limit the outcome of any incident – and typically operate in layers of protection such as:
  - **First Response:** Which react quickly to minimise the consequence of a loss event. Typical examples are engineered crash devices, pumping systems or first aid capacity; and
  - **Restore/Recovery:** Where the controls restore the system to the best possible state after an incident – such as limiting a fatal accident to a serious injury or a major environmental incident to a significant incident. Mitigating controls include emergency response capability and contingency measures.

### Wheel of Safe Production (Nertney Wheel)

To achieve safe production (centre of the wheel), certain key groups shown in the figure below need to be considered:

Figure 4: Wheel of Safe Production



The following is a general description of the groups within the wheel:

#### Competent People and Safe Work Practices

- Appropriately selected and appointed personnel, who are;
- Trained/educated in the procedures and practices required in their role, and are;
- Adequately supervised and mentored; and
- Have discipline processes supported in a just culture.



Fit For Purpose Equipment

- Designed or selected to meet the known operating conditions;
- Introduced to site to confirm standards are met;
- Included in maintenance regimes to maintain the equipment to manufacturer specifications;
- Regularly proof tested (safety functions); and
- Withdrawn from service if standards are not met and addressed through a reporting and breakdown system.

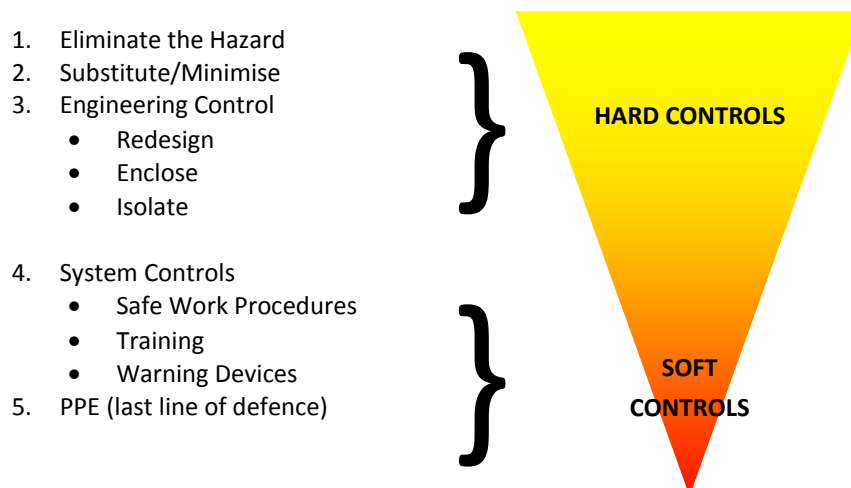
Controlled Work Environment

- Physical environment such as the weather, hot/cold, dust, noise;
- Management such as rosters, time of work, communication, shift changes, systems generally;
- Policies;
- Planned inspections; and
- Audits and reviews.

**Sequence of Barriers (Hierarchy of Controls)**

Additional controls were developed throughout the hazard identification section of the risk assessment with a focus on the hierarchy of controls as depicted in **Figure 5**.

**Figure 5: Hierarchy of Control**



### 12.3 Risk Ranking Tables

**Table 7: Qualitative Measures of Likelihood**

Rank (L)	Likelihood	Description
A	Almost Certain	Happens often.
B	Likely	Could easily happen.
C	Possible	Could happen and has occurred elsewhere.
D	Unlikely	Hasn't happened yet but could.
E	Rare	Conceivable, but only in extreme circumstances.

**Table 8: Qualitative Measures of Consequence**

Ref (C)	Consequence	Comment
1	Extreme environmental harm	e.g. widespread catastrophic impact on environmental values of an area.
2	Major environmental harm	e.g. widespread substantial impact on environmental values of an area.
3	Serious environmental harm	e.g. widespread and considerable impact on environmental values of an area.
4	Material environmental harm	e.g. localised and considerable impact on environmental values of an area.
5	Minimal environmental harm	e.g. minor impact on environmental values of an area.

**Table 9: Quantitative Measures of Maximum Reasonable Consequence to Assets/Business**

Ref (C)	Consequence
1	More than \$1 billion (B) loss or production delay.
2	\$100 million (M) to \$1B loss or production delay.
3	\$5M to \$100M loss or production delay.
4	\$250 thousand (k) to \$5M loss or production delay.
5	Less than \$250k loss or production delay.

Table 10: Risk Ranking Table

Consequence (C)	Likelihood (L)				
		A	B	C	D
	1	1 (H)	2 (H)	4 (H)	7 (M)
	2	3 (H)	5 (H)	8 (M)	12 (M)
	3	6 (H)	9 (M)	13 (M)	17 (L)
	4	10 (M)	14 (M)	18 (L)	21 (L)
	5	15 (M)	19 (L)	22 (L)	24 (L)

Notes:

L = Low; M = Moderate; H = High

Risk Numbering:

1 = highest risk, 25 = lowest risk

Legend:

	Broadly Acceptable
	ALARP – As low as reasonably practicable
	Intolerable

## **12.4 About Your Report**

Your report has been developed on the basis of your unique and specific requirements as understood by Operational Risk Mentoring and only applies to the subject matter investigated.

We have endeavoured to accurately gather information from observations, document reviews and from site personnel. Analysis has been conducted using the best methods of risk engineering science known to the author(s) and should represent a useful suite of information on which the site can base subsequent actions.

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