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<b>WHC_PLN_NAR_SUBSIDENCE RISK ASSESSMENT - PANELS 201 - 202</b>			

# NARRABRI MINE

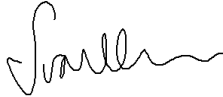

## EXTRACTION PLAN

### SUBSIDENCE RISK ASSESSMENT

#### PANELS 201 - 202

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<b>WHC_PLN_NAR_COAL RESOURCE RECOVERY PLAN - PANELS 201 - 202</b>			

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Date of Risk Assessment	29 September 2021
Operations	Narrabri Mine EP Panels 201-202
Department	Environment
Risk Assessment Title	Subsidence Risk Assessment Narrabri Mine EP Panels 201-202
Person responsible for review	Brent Baker, Environmental Superintendent
Signature	
Date	30 March 2022

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## Acronyms and abbreviations

Acronym	Description
°	degree
AHD	Australian Height Datum
BFMP	Built Features Management Plan (as Appendix D to the Extraction Plan)
CCC	Community Consultative Committee
CHPP	Coal Handling and Preparation Plant
DGS	Ditton Geotechnical Services
DoE	The former Commonwealth Department of the Environment
DPE	The NSW Department of Planning and Environment
DPE Water	The Water group within DPE
EA	Environmental Assessment
EES	Environment, Energy and Science
EP	Extraction Plan (this document)
EPA	The NSW Environment Protection Authority
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i> (NSW)
EP&A Regulation	Environmental Planning and Assessment Regulation 2000
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Cth)
EPL	environment protection licence under the POEO Act
ha	hectare
HSE	health, safety and environment
km	kilometre
LiDAR	light detection and ranging
LW	longwall panel
m	metre
ML	mining lease
mm	millimetre
mm/m	millimetre per metre
Mt	million tonnes
Mtpa	million tonnes per annum
NCOPL	Narrabri Coal Operations Pty Ltd
NSC	Narrabri Shire Council
NSW	New South Wales
PED	personal emergency device (communications system)
PSMP	Public Safety Management Plan (as Appendix E to the Extraction Plan)
SoC	Statement of Commitments
ROM	run of mine
TARP	trigger action response plan

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Acronym	Description
WHC	Whitehaven Coal Limited

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## 1. Introduction

### 1.1 Background

The Narrabri Mine is an existing underground coal mining operation situated in the Gunnedah Coalfield. It is located approximately 25 kilometres (**km**) south-east of Narrabri and approximately 60 km north-west of Gunnedah, within the Narrabri Shire Council (**NSC**) Local Government Area in New South Wales (**NSW**). The Narrabri Mine includes an underground coal mine, a coal handling and preparation plant (**CHPP**) and associated rail siding and surface infrastructure.

The Narrabri Mine is operated by Narrabri Coal Operations Pty Ltd (**NCOPL**), on behalf of the Narrabri Mine Joint Venture, which consists of two Whitehaven Coal Limited (**WHC**) wholly owned subsidiaries, and other joint-venture partners<sup>1</sup>. The underground mine is covered by Mining Lease (**ML**) 1609 which covers an area of 5,298 hectares (**ha**) for the predominate purpose of mining for coal from the Hoskissons Coal Seam.

Stage 1 of the Narrabri Mine was approved in November 2007 under Part 3A of the *Environmental Planning and Assessment Act 1979* (**EP&A Act**). Construction of the mine and supporting infrastructure commenced in 2008, with production using a continuous miner following in 2010. Following the approval of the Stage 2 Environmental Assessment (R.W Corkery & Co., 2009) (the **EA**) and the issue of Project Approval 08\_0144 for Stage 2 (**Project Approval**) in July 2010 and EPBC approval (2009/5003) in January 2011, the Narrabri Mine was converted to an 8 million tonnes (**Mt**) per annum (**Mtpa**) run of mine (**ROM**) longwall mining operation, which commenced in 2012.

The Project Approval has subsequently been modified on a number of occasions. The environmental assessment for Modification 5 (Resource Strategies, 2015) (**MOD 5**), approved in December 2015, changed the mine geometry by reducing the number of longwall (**LW**) panels from 26 to 20, increased some LW panel widths and increased the production to 11 Mtpa of ROM coal until July 2031.

Modification 7, the most recent modification of the Project Approval, was approved on 23 November 2021. The environmental assessment for Modification 7 (Resource Strategies, 2021) (**MOD 7**) describes the change in mining method within the extent of the previously approved LW 201 and LW 202 and instead allows for up to 0.7 Mtpa via bord and pillar extraction at pillar reduction panels CF 201 to CF 205<sup>2</sup>. The bord and pillar mining will occur concurrently with existing longwall operations, and is scheduled to commence in 2022 for a period of approximately five years. The maximum ROM coal production rate of the concurrent operation remains within the approved limit of 11 Mtpa.

The Extraction Plan provides further details of the Narrabri Mine operations to date; a consideration of the applicable statutory requirements and the modifications to the Project Approval; and information relevant to the extraction of coal from pillar reduction panels CF 201 to CF 205 (hereafter referred to as **Panels 201 to 202**). The surface area predicted to be affected by the proposed secondary extraction of Panels 201 to 202 has been defined as the **Extraction Plan Area**.

The underground mining layout for Panels 201 to 202 is presented in Figure 1.1.

<sup>1</sup> For full details on the joint venture ownership, please refer to the introduction of the Extraction Plan.

<sup>2</sup> The pillar reduction panel naming 'CF' is an acronym for 'cut and flit'.





Source: Geoscience Australia (2011); NSW Spatial Services (2019)

#### LEGEND


- — Underground Mine Footprint
- Electricity Transmission Line (Constructed)

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Figure 1.1 : Underground Mining Layout for Panels 201 and 202



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## 1.2 Purpose and scope

As required by Project Approval Schedule 6 Condition 2, this Subsidence Risk Assessment (**Risk Assessment**) for Panels 201 to 202 has been prepared in accordance with the former NSW Department of Planning and Environment (**DPE**) *Draft Guidelines for the Preparation of Extraction Plans* (unpublished) (**Extraction Plan Guidelines**). The Extraction Plan Guidelines require all main subplans of the Extraction Plan to give appropriate consideration to risk assessment and risk management, particularly the Public Safety Management Plan (**PSMP**) and the Built Features Management Plans (**BFMP**). Rather than risk assessments split over a number of documents, the potential risks of subsidence resulting from bord and pillar extraction mining process at the Narrabri Mine have been assessed together and reported in this document.

Previous risk assessments were completed for subsidence hazards above LW 101 to LW 110. The scope of this risk assessment, undertaken on 29 September 2021, was to identify hazards and assess the risks to people, structures and services, mining operations and the environment as a result of the extraction of Panels 201 to 202, and to identify controls to reduce these impacts and consequences to an acceptable level.

## 1.3 Objectives

The objective of the qualitative (level 2) risk assessment was to facilitate a structured process to enable critical and objective challenge of the subject, to assist NCOPL to fulfil their obligations to protect the health and safety of persons on the surface and underground and prevent damage to infrastructure and natural features in accordance with the requirements of the:

- *Workplace Health and Safety Act 2011* (NSW);
- *Workplace Health and Safety Regulation 2011* (NSW);
- *Workplace Health and Safety (Mines and Petroleum Sites) Act 2013* (NSW); and
- *Workplace Health and Safety (Mines and Petroleum Sites) Regulation 2014* (NSW).

The participant in the risk assessment process included the relevant Narrabri Mine management, technical personnel and external specialists. It was undertaken in accordance with the WHC Risk Management Standard, based on the requirements of Australian Standard AS/NZS ISO 31000:2018 *Risk Management - Guidelines* and MDG1010 - *Risk Management Handbook for the Mining Industry*.

## 1.4 Statutory requirements

This Risk Assessment has been prepared in accordance with the applicable conditions and requirements of the Project Approval, EPBC 2009/5003, ML 1609 and all relevant legislation and guidelines as set out in the following sections. A full consideration of the applicable compliance requirements is provided in section 2 of the Extraction Plan.

### 1.4.1 Project Approval

Although not directly relevant to this Risk Assessment, Project Approval Schedule 3 Condition 2 requires NCOPL to ensure that the Narrabri Mine does not cause any additional risk to public safety, which is further addressed in the PSMP, provided as Appendix E to the Extraction Plan. There are no specific Project Approval conditions related to the completion of a risk assessment. There are no specific commitments in the Statement of Commitments (Appendix 3 of the Project Approval) related to risk management or assessment for mine subsidence.



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#### 1.4.2 EPBC approval

The Narrabri Mine is subject to EPBC 2009/5003 issued under the EPBC Act. There are no specific EPBC conditions related to this Subsidence Risk Assessment.

#### 1.4.3 Mining lease

Condition 8 of ML 1609 states that NCOPL must ensure that the approved Extraction Plan provides for the effective management of risks associated with any subsidence resulting from mining operations carried out under the ML. This is addressed in this document, the BFMP and the PSMP.

#### 1.4.4 Extraction Plan Guidelines

As stated in the Extraction Plan Guidelines, all six key component plans<sup>3</sup> to the Extraction Plan should give appropriate consideration to risk assessment and risk management, particularly the BFMP and PSMP. This is further described in those two documents.

### 1.5 Consultation and approval

This Risk Assessment does not require any specific individual consultation or approval. The overall consultation and approval obligations for the Extraction Plan by the Project Approval are detailed in section 1.9 of the Extraction Plan.

### 1.6 Risk assessment participation


The participants of the Risk Assessment, their roles at the Narrabri Mine and their level of experience are listed in Table 1.1. Detailed responsibility descriptions are provided in section 5.1 of the Extraction Plan.

**Table 1.1 - Risk Assessment participation**

Participant	Organisation	Role	Experience (yrs)
Owen Salisbury	NCOPL	Technical Services Manager	40
Chris Strohfeldt	NCOPL	Surface Operations Manager	20
Brent Baker	NCOPL	Environmental Superintendent	13
Shane Rily	NCOPL	Environmental Officer	10
Servaes van der Meulen	Onward Consulting	Environmental Consultant	25
Mark Vile	Onward Consulting	Environmental Consultant	20
Carmen Osbourne	Onward Consulting	Environmental Consultant	8

Note that a separate risk assessment has been completed for rehabilitation and mine closure, which is provided in the Rehabilitation Management Plan.

<sup>3</sup> The six key component plans are the Water Management Plan; Land Management Plan; Biodiversity Management Plan; Heritage Management Plan; Built Features Management Plan and the Public Safety Management Plan.

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## 2. Limitations, exclusions, predictions and assumptions

### 2.1 Limitations and exclusions

The following limitations have been applied to the risk assessment:

- this risk assessment will concentrate on Panels 201 to 202 only, consisting of the extraction of coal from pillar reduction panels CF 201 to CF 205;
- this risk assessment is undertaken based on subsidence predictions and measured values above LW 101 to 109;
- water liberated by mining will not be considered once it has been pumped out of the mine and discharged into the surface storage ponds; and
- disposal of brine-rich waters into any previously mined longwall goaves will not be considered.

### 2.2 Predictions and assumptions

The report *Mine Subsidence Assessment for Pillar Reduction Panels CF201-CF205 (A-J) and Longwalls LW203 to LW205 at the Narrabri Underground Mine* by Ditton Geotechnical Services (DGS, 2021) has been used as a basis for this Risk Assessment. The DGS analysis and results are contained, in full, as Appendix B to the Extraction Plan and the predictions and assumptions that have been used in this Risk Assessment are listed in the following sections.


#### 2.2.1 Mining geometry

The proposed mining geometry will be as follows:

- the lower 4.6 m of the Hoskissons Seam (HS2) will be extracted with a nominal extraction height of approximately 4.3 m;
- five pillar reduction panels CF 201 to 205 will be orientated east-west and have two subpanels each (A/B to I/J) in the Lower Hoskissons Seam;
- the pillar reduction panels will have cover depths ranging from 177 to 212 m and widths ranging from 154 to 280 m. The completed panels will have 'critical' to 'supercritical' W/H ratios of 0.80 to 1.39. The panel lengths will range from 155 to 348 m;
- the subpanels (production panels) will be developed on a grid of 30.5 m square pillars (solid) in the upper 3.2 m of the lower Hoskissons Seam (HS2). Second workings will 'pocket' every second row of pillars and increase the extraction ratio from 31% to 66%;
- the floor would then be brushed to 1.1 m depth on retreat to give a total roadway height of 4.3 m.
- the 6.2 m wide by 3.2-3.5 m high roadway and 1.1 m deep floor brushing with a width of 5.5 m effectively decreases the pillar height from 4.3 to 4.13 m; and
- a five-heading mains panel is proposed between CF 201-205 and LW 203 (outside of the scope of this Extraction Plan). The distance between the pillar reduction and longwall panel will be 266 m;

#### 2.2.2 Surface features

The land within the Extraction Plan Area is exclusively owned by NCOPL and has historically been used for livestock grazing and occasional cereal cropping. Although largely cleared, vegetation includes several dense to scattered stands of Cypress Pine, Casuarina (She-Oak) and Eucalypt (Box, Red-gum, Ironbark). Other

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trees, shrubs & grasses of note include Kurrajong, Wilga and Acacia (wattle) species. The Pilliga East State Forest covers the areas to the west.

Topographic relief above the proposed mining area ranges from 279 m Australian Height Datum (**AHD**) to 311 m AHD. The surface terrain is generally flat with slopes ranging from 1 degree (°) to 5°. Slopes increase to 10° to 15° in several of the ephemeral creeks and tributaries (or gullies) of Kurrajong Creek Tributary 1, which drains the Extraction Plan Area towards the north-east. There are a few broad ridges of moderate rocky slopes between 10° and 15° directly above Panels 201 to 202.

The existing surface features within the zone of expected subsidence due to the proposed pillar reduction panels include the following:

- semi-cleared, gently to moderately undulating agricultural land (predominately used for grazing cattle) that is owned by NCOPL;
- one ephemeral watercourse with a sandy bed and exposed sandy clay banks with slopes up to 15° (Kurrajong Creek Tributary 1);
- riparian vegetation areas along the creeks;
- steep rocky slopes up to 15 m high;
- subsurface groundwater aquifers at depths ranging from 5 to 50 m (typically of poor quality);
- one Aboriginal cultural heritage sites ('Claremont' grinding grooves on exposed sandstone) above CF 201 (Panel B) with 'low' scientific significance according to the Extraction Plan - Heritage Management Plan (refer to Appendix J to the Extraction Plan);
- five farm dams for livestock watering (D49, D65, D66, D67 and D68);
- soil conservation (contour) banks and property fencing (post and wire); and
- no groundwater supply bores (stock and domestic) and no monitoring bores.

### 2.2.3 Subsidence effects

The subsidence predictions for the Extraction Plan Area have been based on several empirical and calibrated analytical models of overburden and chain pillar behaviour developed in New South Wales coalfields. The predicted values may be occasionally exceeded (up to 5% of the time) due to discontinuous strata behaviour associated with near surface cracking, joint displacement, geological features (e.g. faults) and/or rapid changes in topography (creek beds).

The key results of the assessment for the pillar reduction panels (CF 201-CF 205) are presented below:

- the maximum subsidence estimates due to remnant pillar crush within the panel limits after mining is completed ranges from 0.50 to 1.77 m;
- the timing of subsidence is difficult to predict and may not occur at all or years after mining is completed;
- maximum production panel subsidence ranges from 1.42 to 1.77 m (34%h to 43%h);
- maximum gateroad access pillar subsidence ranges from 0.50 to 0.73 m (12%h to 18%h);
- maximum panel tilt ranges from 14 to 36 mm/m;
- maximum panel concave curvatures range from 0.7 per kilometre (km<sup>-1</sup>) to 3.3 km<sup>-1</sup> (radii of curvature 1.4 to 0.3 km);
- maximum panel convex curvatures range from 0.7 to 3.1 km<sup>-1</sup> (radii of curvature 1.4 to 0.32 km);
- maximum panel compressive strains range from 7 to 31 mm/m; and
- maximum panel tensile strains range from 7 to 33 mm/m.

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#### 2.2.4 Predicted impacts - natural features


The results of this study indicate that the surface deformations due to mining are likely to cause the following impacts in the Extraction Plan Area:

- typical crack widths in relatively 'flat' terrain (slopes <18°) are estimated to range from 130 to 320 mm, with occasional (<5% probability) cracks up to approximately 260 mm in sand or loam and approximately 650 mm in clay or rock;
- surface gradients are likely to increase or decrease by up to 2.5% (+/- 1.5%) along creeks;
- connective cracking is estimated to range from 99 m to 240 m above the proposed panels (i.e. 52% to 87% of the cover depth; 0.42 to 0.62 times the effective panel width or 37 to 56 times the effective mining heights of 4.13 to 4.3 m);
- direct hydraulic connection to the mine workings due to subsurface fracturing is estimated to encroach within 27 to 70 m depth below the surface.;
- it is assessed that the A/H = 0.8 line represents the point at which there is a risk (25% probability) that the predicted connective fracture zone could interact with the surface cracking zone but also depends on the near-surface geology (see below);
- creek flows could be temporarily rerouted into open cracks to below-surface pathways and resurface downstream of the mining extraction limits in the mining area;
- discontinuous fracturing would normally be expected to occur above the proposed mining area, causing an increase in rock mass storage capacity and horizontal permeability, without direct hydraulic connection to the workings. Groundwater levels would be lowered in the medium to long terms as a consequence of these impacts;
- two potential (pre-existing) ponding locations have been identified for the Extraction Plan Area. The majority of potential ponding areas already exist and will probably develop laterally between 50 to 500 m away from the watercourses. The maximum changes in pond depths are estimated to range from 0.1 to 0.5 m.
- there are two farm dams (D67, 68) above CF 203(F) that may be inundated by post-mining ponding.

#### 2.2.5 Predicted impacts - built features

- there are five farm dams for livestock watering that have been assessed in the Extraction Plan Area. Four dams are located within the 20 mm subsidence contour from the proposed panels and estimated to be impacted by tensile and compressive strains ranging from 3 to 15 mm/m;
- several farm dams have already been subsided by LW 101 to 109 but have not required remedial works to be undertaken. Notwithstanding, non-engineered farm dams and water storages are susceptible to surface cracking and tilting (i.e. storage level changes) due to mine subsidence. The tolerable tilt and strain values for the Extraction Plan Area dams (before remediation is required) will depend upon the dam wall materials, construction techniques, and foundation type;
- the expected phases of tensile and compressive strain development may result in breaching of up to five dam walls or water storage areas. Loss or increase of storage areas may also occur due to the predicted tilting. Maximum tensile crack widths across dam wall or storage areas are estimated to range between 30 and 400 mm;
- post and wire fences around the dams and along property boundaries could also be damaged after mining;
- unsealed gravel access roads and tracks are likely to be damaged by cracking and shearing/heaving in the tensile and compressive strain zones, respectively, above the Extraction Plan Area. Maximum



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tensile crack widths across or along roads are estimated to range between 50 and 300 mm. Surface 'steps' or humps due to compressive shear failures are estimated to range between 30 and 320 mm;

- there is one State Survey mark (SS 39336) that is likely to be subsided 0.01 m by the Extraction Plan Area panels.

## 2.2.6 Predicted impacts - Aboriginal heritage

- the Claremont grinding groove site ('Claremont GG1') is situated above proposed CF 201(B) and located on exposed sandstone.';
- the results of the impact assessment indicate that grinding grooves on loose boulders are 'possible to unlikely' to be impacted. Partially buried boulders may crack due to confinement of the boulder and could result in significant strain transfer into the boulder/slab;
- the Claremont GG1 grinding groove site is 'very unlikely' to be affected by the predicted tensile strains <1 mm/m due to the proposed mining restriction zone above CF 201(B); and
- impacts on isolated and scattered surface artefacts are not anticipated;

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### 3. Hazard identification

To successfully identify the hazards involved with predicted subsidence the hazard identification techniques listed in Table 3.1 were adopted.

**Table 3.1 - Hazard identification techniques**

Hazard identification techniques	
<ul style="list-style-type: none"> <li>Incident reports</li> <li>Inspections, surveys and audits (including specialist audits)</li> <li>Workplace observations</li> <li>Specific reviews (e.g. noise, air quality, machine guarding etc.)</li> <li>Review and analysis of incident report data</li> </ul>	Yes
<ul style="list-style-type: none"> <li>Technical or scientific evaluations</li> <li>Information from equipment designers, manufacturers, suppliers and other parties</li> <li>Communication forums, including safety committee meetings</li> <li>Information from regulators (e.g. safety alerts, safety bulletins)</li> <li>Australian Standards</li> <li>Industry Codes of Practice (e.g. Codes of Practice approved under the WHS Act)</li> </ul>	Yes
<ul style="list-style-type: none"> <li>Brain storming</li> </ul>	No
<ul style="list-style-type: none"> <li>Use of previous risk assessment (refer to section 1.2)</li> </ul>	Yes
<ul style="list-style-type: none"> <li>Scientific or historical data that identifies and/or quantifies the level of the hazard present in the workplace is attached? (refer to the Subsidence Predictions Report, presented as Appendix B to the Extraction Plan)</li> </ul>	Yes

Using the above hazard identification techniques, the predicted subsidence impacts were considered against a series of aspects that could be impacted to determine if a risk existed.

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#### 4. Level 2 qualitative risk assessment worksheet

Item	Aspect	Hazard	Existing controls	Current risk			Additional controls	Residual risk		
				C	L	R		C	L	R
Subsidence impacts to natural features										
1	Natural water courses and streams	Water quality (TSS and EC) is impacted by subsidence in Namoi River tributaries	<ul style="list-style-type: none"><li>Monitoring and repairing of cracks carried out - included in Land Management Plan</li><li>Ongoing monitoring of water quality upstream and downstream of site, included in Water Management Plan</li><li>Use agriculture methods to reduce salinity of ponded areas</li><li>Water quality monitoring undertaken</li></ul>	2	D	L	<ul style="list-style-type: none"><li>Implement the management measures from the former Subsidence Pond Management Plan (incorporated into the Land Management Plan)</li><li>Implement the management measures from the former Gully Erosion Management Plan (incorporated into the Land Management Plan)</li></ul>			
2	Natural water courses and streams	Channel stability is compromised leading to increased erosion and channel realignment	<ul style="list-style-type: none"><li>Monitoring and repairing of cracks carried out - included in Land Management Plan which includes trigger action response plan (<b>TARP</b>)</li><li>Ongoing monitoring of water quality upstream and downstream of site included in Water Management Plan</li><li>Riparian subsidence monitoring line installed for Kurrajong Creek and tributaries</li><li>LIDAR survey used across all panels</li><li>Subsidence monitoring lines installed along creeks</li><li>Annual creek monitoring</li></ul>	2	D	L	<ul style="list-style-type: none"><li>Implement the management measures from the former Gully Erosion Management Plan (incorporated into the Land Management Plan)</li></ul>			
3	Natural water courses and streams	In channel / over bank ponding leading to loss of farming land and / or loss of riparian vegetation	<ul style="list-style-type: none"><li>Monitoring and assessment of ponding carried out - included in Land Management Plan and Biodiversity Management Plan</li><li>Riparian subsidence monitoring line installed for Kurrajong Creek and tributaries</li><li>LIDAR survey and remote sensing techniques used over extraction area</li></ul>	2	D	L	<ul style="list-style-type: none"><li>Implement the management measures from the former Subsidence Pond Management Plan (incorporated into the Land Management Plan)</li></ul>			
4	Natural water courses and streams	Reduction in stream flow during rain events	<ul style="list-style-type: none"><li>Modelling to confirm no interconnection between surface and seam due to depth of cover and height of fracturing according to subsidence modelling</li><li>Monitoring and repairing of subsidence cracking carried out - included in Land Management Plan</li><li>Monitoring of height of fracturing using surface extensometers and piezometers</li></ul>	3	D	M				

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Item	Aspect	Hazard	Existing controls	Current risk			Additional controls	Residual risk		
				C	L	R		C	L	R
5	Natural water courses and streams	Flooding of mine leading to stoppage of mining	<ul style="list-style-type: none"> <li>Modelling to confirm no interconnection between surface and seam due to depth of cover and height of fracturing according to subsidence modelling</li> <li>Mine dewatering system to remove water from the mine</li> <li>Monitoring of water quantities being pumped out of mine</li> <li>Monitoring of height of fracturing using surface extensometers and piezometers</li> <li>Monitoring and repairing of cracking planned to be carried out - included in Land Management Plan</li> </ul>	3	E	M	<ul style="list-style-type: none"> <li>Implementation of the procedures identified in the Inrush Principal Mining Hazard Management Plan</li> </ul>			
6	Creek or river catchments	Water quality (TSS and EC increased) in the Namoi River is impacted by subsidence	<ul style="list-style-type: none"> <li>Monitoring and repairing of cracks carried out - included in Land Management Plan</li> <li>Ongoing monitoring of water quality upstream and downstream of site included in Water MP</li> </ul>	1	D	L	<ul style="list-style-type: none"> <li></li> </ul>			
7	Swamps and water-related ecosystems	No swamps or water-related ecosystems will be impacted by subsidence in Extraction Plan Area No groundwater dependent ecosystems (GDEs) exist within the Extraction Plan Area	<ul style="list-style-type: none"> <li>Flood study was conducted revealing limited impacts of flooding</li> <li>Monitoring and assessment of ponding carried out - included in Land Management Plan and Biodiversity Management Plan</li> <li>Riparian subsidence monitoring line installed for Kurrajong Creek and tributaries</li> <li>LIDAR survey and remote sensing techniques used over extraction area</li> </ul>	1	E	L	<ul style="list-style-type: none"> <li></li> </ul>			
8	Foreshores and land prone to flooding or inundation	Change in flooding behaviour impacting farming land, mine infrastructure or surface improvements along Kurrajong Creek and tributaries	<ul style="list-style-type: none"> <li>Flood study was conducted revealing limited impacts of flooding</li> <li>Monitoring and assessment of ponding carried out - included in Land Management Plan and Biodiversity MP</li> <li>Riparian subsidence monitoring line installed for Kurrajong Creek and tributaries</li> <li>LIDAR survey and remote sensing techniques used over extraction area</li> </ul>	1	E	L				
9	Escarpments / cliff lines / steep slopes	No steep rocky slopes above within the Extraction Plan Area	N/A							



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Item	Aspect	Hazard	Existing controls	Current risk			Additional controls	Residual risk		
				C	L	R		C	L	R
10	Threatened & Protected Species including Endangered Ecological Communities (EEC)	Potential loss of individuals of species or degradation of EEC and habitat	<ul style="list-style-type: none"> <li>Ongoing monitoring and condition assessment under Biodiversity Management Plan and Landscape Management Plan</li> <li>Well established vegetation</li> <li>Modelling to confirm no interconnection between surface and seam due to depth of cover and height of fracturing</li> <li>Monitoring and repairing of cracks carried out - included in Land Management Plan</li> <li>Depth of cover is increasing reducing subsidence impacts to vegetation and habitat</li> </ul>	2	D	L				
11	State Forests	No state forests in Extraction Plan Area	N/A							
12	Native fauna	Injuries to native fauna	<ul style="list-style-type: none"> <li>Monitoring and repairing of cracks carried out - included in Biodiversity Management Plan</li> </ul>	1	D	L				
13	Native fauna	Loss of habitat	<ul style="list-style-type: none"> <li>Ongoing monitoring and condition assessment under Biodiversity Management Plan and Landscape Management Plan</li> <li>Well established vegetation</li> <li>Modelling to confirm no interconnection between surface and seam due to depth of cover and height of fracturing</li> <li>Monitoring and repairing of cracks carried out - included in Land Management Plan</li> <li>Increasing depth of cover reducing subsidence impacts to vegetation and habitat</li> </ul>	1	D	L				
<b>Subsidence impacts to built features</b>										
14	Tracks / roads / bridges	Damage to machinery	<ul style="list-style-type: none"> <li>Monitoring of cracks and remediation</li> <li>Warning signage erected in subsidence area</li> <li>Mine owned land, authorised access only</li> </ul>	2	D	L	<ul style="list-style-type: none"> <li>Demarcate active subsidence areas</li> </ul>			
15	Tracks / roads / bridges	Injury to personnel	<ul style="list-style-type: none"> <li>Monitoring of cracks and remediation</li> <li>Warning signage erected in subsidence area</li> <li>Mine owned land, authorised access only</li> </ul>	2	D	L				
16	Transmission lines	Currently no transmission lines in the predicted subsidence area	N/A							
17	Pipelines	No hazard identified to gas drainage pipelines from subsidence. No other pipelines in this area	N/A				<ul style="list-style-type: none"> <li>No subsidence of infrastructure corridor</li> <li>Any future mine infrastructure to be designed appropriately</li> </ul>			

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Item	Aspect	Hazard	Existing controls	Current risk			Additional controls	Residual risk		
				C	L	R		C	L	R
18	Mine infrastructure	Damage to goaf gas drainage boreholes and associated infrastructure	<ul style="list-style-type: none"> <li>Steel cased boreholes</li> <li>Flexible connection from borehole top to gas drainage surface pipeline</li> <li>Goaf drainage units / mobile extraction units can be located outside active subsidence area or have the ability to be re-levelled if within active subsidence area</li> </ul>	2	D	L				
19	Mine Infrastructure	Damage to PED cable buried on surface	<ul style="list-style-type: none"> <li>PED cable has been designed/installed with sufficient slack to accommodate subsidence</li> </ul>	2	D	L				
20	Mine infrastructure	Far field impacts on life of mine industrial area not considered a credible risk	<ul style="list-style-type: none"> <li>Built Features Management Plan</li> </ul>							
21	Survey control stations	Loss of function of State Survey Marks	<ul style="list-style-type: none"> <li>At the completion of subsidence, or otherwise as required by the Surveyor General, ensure that the functionalities of any survey marks affected by subsidence are fully restored to the satisfaction of the Surveyor General</li> </ul>	2	D	L				
22	Public facilities / amenity / users	No public facilities / amenity / users will be undermined by Panels 201-202	N/A							
23	Environmental monitoring stations	Damage to piezometers	<ul style="list-style-type: none"> <li>Life-of-mine groundwater monitoring network installed outside of LW and CF mining area</li> <li>Replace piezometers as required</li> </ul>	1	E	L				
24	Drainage structures	Flooding and erosion of road	<ul style="list-style-type: none"> <li>Monitoring and repairing drains as required</li> <li>Routine visual inspection of roads and carrying out repairs as required</li> <li>Signage</li> </ul>	2	D	L				
25	Drainage structures	Injury to personnel due to flooding and erosion of road	<ul style="list-style-type: none"> <li>Monitoring and repairing drains as required</li> <li>Routine visual inspection of roads and carrying out repairs as required</li> <li>Signage</li> </ul>	3	D	M	<ul style="list-style-type: none"> <li>Culvert and road design to be based on anticipated water flow / volume to minimise localised flooding</li> <li>Don't drive through flooded areas (If it's flooded – forget it)</li> <li>Demarcate / repair eroded areas / roads</li> </ul>	2	D	L
26	Farm houses and sheds	Damage to septic tanks from subsidence resulting in release of effluent	<ul style="list-style-type: none"> <li>If present, septic tanks will be drained prior to undermining</li> </ul>	2	D	L				
27	Industrial / commercial / business establishments	No industrial / commercial / business establishments impacted by predicted subsidence	N/A							
28	Declared dams and / or other Dams Safety Act 2015 structures	No declared dams and /or other Dams Safety Act structures within the Extraction Plan Area	N/A							


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Item	Aspect	Hazard	Existing controls	Current risk			Additional controls	Residual risk		
				C	L	R		C	L	R
29	Other surface improvements	Breaching of farm dam walls resulting in personal injury	<ul style="list-style-type: none"> <li>Monitor dams and drain / remediate as required</li> <li>Low-capacity dams</li> <li>Earthen dams</li> <li>Each dam is to be assessed as to need to lower water level in dam based on impacts to farm dams from previous LW subsidence</li> </ul>	2	D	L				
30	Other surface improvements	Breaching of water storage dam resulting in personal injury	<ul style="list-style-type: none"> <li>Monitor and drain dams if required</li> </ul>	2	E	L				
31	Other surface improvements	Drainage water storage dam into mine workings resulting in flooding of mine	<ul style="list-style-type: none"> <li>Modelling to confirm no interconnection between surface and seam due to cover depth and height of fracturing</li> </ul>	2	E	L				
32	Other surface improvements	Damage to drainage contour banks	<ul style="list-style-type: none"> <li>Pre- and post-mining survey and remediate as required</li> </ul>	2	D	L				
33	Other surface improvements	Damage to fences releasing livestock and impacting with vehicles	<ul style="list-style-type: none"> <li>Built Features Management Plan requires destocking of paddocks in active subsidence zone and repair of fences post subsidence</li> </ul>	2	E	L	<ul style="list-style-type: none"> <li>New fencing standard for cultural areas is stock proof</li> <li>New fencing being installed retrospectively</li> </ul>			
34	Telecommunications	No telecommunications infrastructure in the predicted subsidence area	N/A							
35	Railway	Far field impacts to railway not expected	N/A							
<b>Impacts to subsurface</b>										
36	Groundwater resources (quantity and quality)	Drawdown or base flow reduction in Namoi River alluvials	<ul style="list-style-type: none"> <li>Life-of-mine groundwater monitoring program installed</li> <li>Western edge of the Namoi alluvium to the eastern edge of the longwall panels is approximately 4.5 – 5km</li> <li>Conservative groundwater prediction model predicted minimal influence, confirmed in 2021</li> <li>Periodic recalibration of groundwater model using observed data whilst longwall is being extracted</li> <li>Significant barrier of low permeability strata between the Namoi River alluvium and the mine</li> <li>Neither the Hoskissons Seam nor the other rocks of the Black Jack Group are directly in contact with the Namoi Valley alluvium in the Extraction Plan Area.</li> <li>Water quality testing</li> </ul>	3	E	M				

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Item	Aspect	Hazard	Existing controls	Current risk			Additional controls	Residual risk		
				C	L	R		C	L	R
37	Groundwater resources (quantity and quality)	Decreased volume of groundwater available for other users	<ul style="list-style-type: none"> <li>Groundwater monitoring program</li> <li>Modelling to confirm no interconnection between surface and seam due to cover depth and height of fracturing</li> <li>Conservative groundwater prediction model predicted minimal influence</li> <li>Periodic recalibration of groundwater model using observed data whilst longwall/CF panel is being extracted</li> <li>Groundwater take for the mine is licenced and periodically reviewed</li> </ul>	2	C	M				
38	Increased mine water discharge	Increased water make into the mine workings due to fracturing the aquifer above the goaf resulting in flooding of mine workings	<ul style="list-style-type: none"> <li>Groundwater monitoring program</li> <li>Modelling to confirm no interconnection between surface and seam due to cover depth and height of fracturing</li> <li>Conservative groundwater prediction model predicted minimal influence</li> <li>Periodic recalibration of groundwater model using observed data whilst longwall/CF panel is being extracted</li> <li>Appropriate capacity of surface water dams</li> <li>Contingency for construction of additional storages</li> </ul>	4	D	M	<ul style="list-style-type: none"> <li>Implementation of the procedures identified in the Inrush Principal Mining Hazard Management Plan</li> </ul>			
<b>Impacts to Aboriginal cultural and archaeological heritage and European / historic heritage</b>										
39	European heritage	No heritage sites identified	<ul style="list-style-type: none"> <li>Unexpected finds procedure</li> <li>Heritage Management Plan</li> <li>Subsidence monitoring program</li> </ul>	1	E	L				
40	Cultural heritage sites	Damaging, defacing or destruction of archaeological sites	<ul style="list-style-type: none"> <li>Surveys completed and identified sites have been fenced</li> <li>Heritage Management Plan for site identifies management measures</li> <li>Subsidence monitoring program</li> </ul>	3	D	M				
<b>Impacts to agriculture</b>										
41	Agricultural suitability/ productivity	Reduction in agricultural capability of land	<ul style="list-style-type: none"> <li>Land Management Plan with TARP includes ongoing monitoring and remediation, through annual remote sensing</li> <li>Rehabilitation Management Plan includes weed management and control</li> </ul>	2	D	L				



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## 5. References

Department of Planning and Environment (unpublished). *Guidelines for the Preparation of Extraction Plans*.


Ditton Geotechnical Services (2017) *Mine Subsidence Assessment for the Proposed LW 107 to LW 110 Extraction Plan at the Narrabri Mine*. Prepared for Narrabri Coal Operations Pty Ltd.

Ditton Geotechnical Services (2021) *Mine Subsidence Assessment for Pillar Reduction Panels CF201-CF205 (A-J) and Longwalls LW203 to LW205 at the Narrabri Underground Mine*. Prepared for Narrabri Coal Operations Pty Ltd. DGS Report No. NAR-004/8. Prepared for Narrabri Coal Operations Pty Ltd.

Resource Strategies (2015) *Narrabri Mine Modification 5 - Environmental Assessment*. Prepared for Narrabri Coal Operations Pty Ltd.

Resource Strategies (2021) *Narrabri Mine Modification 7 - Environmental Assessment*. Prepared for Narrabri Coal Operations Pty Ltd.


RW Corkery & Co. Pty Ltd (November 2009) *Environmental Assessment for the Narrabri Coal Mine Stage 2 Longwall Project*, Project Application No:MP08\_0144. Prepared for Narrabri Coal Operations Pty Ltd.

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## 6. Glossary

Term	Definition <sup>4</sup>
Angle of draw	The angle between the vertical and the line joining the edge of the mining void with the limit of vertical subsidence, usually taken as 20 mm.
Anomalous subsidence	Normally refers to unexpected subsidence effects and is usually caused by latent geological conditions (joints, faults, dykes)
Chain pillar	The pillar(s) of coal left between adjacent longwall panels. This forms a barrier that allows the goaf to be sealed off and facilitates tailgate roof stability.
Compressive strain	A decrease in the distance between two points on the surface. This can cause shear cracking or steps at the surface if > 3 millimetres per metre (mm/m).
Council	Narrabri Shire Council
Cover depth	The depth of coal seam from the ground surface (metres).
Department	The NSW Department of Planning and Environment (DPE)
Environmental consequences	The environmental consequences of subsidence impacts including: damage to built features; loss of surface flows to the subsurface; loss of standing pools; adverse water quality impacts; development of iron bacterial mats; cliff falls; rock falls; damage to Aboriginal heritage sites; impacts to aquatic ecology; ponding.
Extraction Plan Area	The area predicted to be affected by the proposed secondary extraction of the approved pillar reduction panels CF 201-205
Far-field subsidence	Mining-induced movements of the ground surface in areas where vertical subsidence is less than 20mm.
First workings	Development headings created by a continuous mining machine - designed to remain stable during development and longwall extraction. Provide ventilation and services, access for staff and materials, and allow for transportation of raw coal out of the mine (i.e. also referred to as mains headings, gate roads, maingate, tailgate).
Goaf	The mined-out area into which the immediate roof strata breaks.
Groundwater	Water contained in the interconnected pore spaces and voids of the saturated zone of sediments and rocks.
Incident	An occurrence or set of circumstances that causes or threatens to cause material harm and which may or may not be or cause a non-compliance
Material harm	Material harm to the environment is defined in section 147 of the POEO Act
Minimise	Implement all reasonable and feasible mitigation measures to reduce the impacts of the Narrabri Mine
MOD 5	Reduced the number of longwall panels from 26 to 20; increased the longwall panel widths for LW 107 to LW 120 from approximately 295 m to approximately 400 m; extended the western footprint approximately 60 m; and increased the maximum ROM coal processing rate from 8 Mtpa to 11 Mtpa.
MOD 7	Describes the change in mining method within the extent of the previously approved LW 201 and LW 202 and allows for up to 0.7 Mtpa via bord and pillar extraction at pillar reduction panels CF 201 to CF 205

<sup>4</sup> The majority of the definitions are as provided in Project Approval 08\_0144.

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Term	Definition <sup>4</sup>
Panels 201 to 202	Pillar reduction panels CF 201 to CF 205
Pollution incident	Has the same meaning as in the POEO Act
Project Approval	Development consent (DA_08_0144) issued on 26th July 2010 under Section 75J of the <i>Environmental Planning and Assessment Act 1979</i> by the Department of Planning & Infrastructure (as modified).
Rehabilitation	The restoration of land disturbed by the development to ensure it is safe, stable and non-polluting over the short, medium and long term
Second workings	Extraction of coal from longwall panels, mini-wall panels, or pillar extraction.
Secretary	Planning Secretary under the EP&A Act, or nominee
Subsidence	The totality of subsidence effects, subsidence impacts and environmental consequences of subsidence impacts.
Subsidence effects	Deformation of the ground mass due to mining, including all mining-induced ground movements, including both vertical and horizontal displacement, tilt, strain and curvature.
Subsidence impacts	Physical changes to the ground and its surface caused by subsidence effects, including tensile and shear cracking of the rock mass, localised buckling of strata caused by valley closure and upsidence and surface depressions or troughs.
Tailgate	Refers to the tunnels or roadways down the side of a longwall block which provides a ventilation pathway for bad or dusty air away from the longwall face. It is usually located on the side of the longwall panel adjacent to extracted panels or goaf.
Tensile strain	An increase in the distance between two points on the surface. This is likely to cause cracking at the surface if it exceeds 2 mm/m. Tensile strains are usually associated with convex (hogging) curvatures near the sides (or ends) of the panels.
Tilt	The rate of change of subsidence between two points (A and B), measured at set distances apart (usually 10m). Tilt is plotted at the mid-point between the points and is a measure of the amount of differential subsidence
Unacceptable risk	The level of risk at which mitigation actions are deemed to be warranted.
Upsidence	Relative vertical upward movements of the ground surface associated with subsidence.
Vertical subsidence	Vertical downward movements of the ground surface caused by underground coal mining.
Watercourse	A river, creek or other stream, including a stream in the form of an anabranch or tributary, in which water flows permanently or intermittently, regardless of the frequency of flow events: In a natural channel, whether artificially modified or not, or in an artificial channel that has changed the course of the stream. It also includes weirs, lakes and dams

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## Attachment 1 WHC risk matrix



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		CONSEQUENCE					
		Insignificant	Minor	Medium	Major	Catastrophic	
		1	2	3	4	5	
LIKELIHOOD	Almost Certain	A	Moderate	High	High	Critical	Critical
	Likely	B	Moderate	Moderate	High	High	Critical
	Occasional	C	Low	Moderate	High	High	High
	Unlikely	D	Low	Low	Moderate	Moderate	High
	Rare	E	Low	Low	Moderate	Moderate	High

Critical	Risks that significantly exceed the risk acceptance threshold. Immediate attention needed, stop the job.
High	Risks that exceed the risk acceptance threshold. Additional risk control measures required. If further risk control measures are not practicable the responsible Manager must sign off.
Moderate	Risk acceptance threshold. Additional control measures could be implemented to control risks further. Active monitoring of risk control measures required.
Low	Risks that are below the risk acceptance threshold. No additional control measures required. Monitoring of risks may be needed.

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## CONSEQUENCE

Level	Descriptor	Safety	Health	Environment	Reputation	Community	Compliance	Economic
5	Catastrophic	Single or multiple fatalities	Exposure to health hazards (significantly exceeding the OEL) resulting in single or multiple fatalities	Unconfined detrimental impact requiring long term recovery leaving major residual damage (typically years)	On-going severe impact on WHC reputation  On-going public exposure in international media  Serious public outrage	Widespread mistrust / opposition among stakeholders setting the agenda for key decision makers	Cancellation of approval to operate imposed by regulators  Prosecutions with custodial sentencing	>\$50M
4	Major	Severe impairment or irreversible damage to one or more persons (typically a permanent disability injury)	Exposure to health hazards (significantly exceeding the OEL) resulting in irreversible impact on health with loss of quality of life (typically a permanent disability illness)	Unconfined detrimental impact requiring medium term recovery leaving residual damage (typically months)	Severe impact on WHC reputation  Major public exposure in national media  Significant public outrage	Tangible mistrust / opposition among stakeholders with significant influence on key decision makers  Irreparable damage to site or item of high cultural significance	Suspended or severely reduced operations imposed by regulators  Breach of legislation, regulation or approval, or repeated non-compliance, with high potential for prosecution  Systemic non-conformance with WHC standards with high impact	\$10M - \$50M
3	Medium	Reversible injury or moderate irreversible damage or impairment to one or more persons (typically a restricted work day or lost time injury)	Exposure to health hazards (exceeding the OEL) resulting in reversible impact on health, or permanent change with no disability or loss of quality of life (typically a restricted work day or lost time illness)	Near source confined detrimental impact requiring medium term recovery (typically months)  Unconfined detrimental impact requiring short term recovery (typically weeks)	Adverse impact on operation's reputation  Significant public exposure in regional media	Mistrust / opposition among some stakeholders with moderate influence on public opinion and decision makers  Reparable damage to site or item of high cultural significance	Non-compliance with external, or non conformance with internal, requirement with moderate impact and / or issue of a financial penalty	\$2M - \$10M

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Level	Descriptor	Safety	Health	Environment	Reputation	Community	Compliance	Economic
2	Minor	Reversible injury requiring treatment but does not restrict duties (typically a medical treatment injury)	Exposure to health hazard resulting in symptoms requiring medical intervention and full recovery with no restrictions or lost time (typically a medical treatment illness)	Near source confined reversible impact requiring short term recovery (typically weeks)	Operation's reputation is adversely affected with a small number of stakeholders  Local public or media attention and complaints	Tangible mistrust / opposition among a few stakeholders with some influence on public opinion and decision makers  Irreparable damage to site or item of low cultural significance	Non-compliance with external, or non conformance with internal, requirement with low impact and / or issue of a regulatory notice without financial penalty	\$100K - \$2M
1	Insignificant	Low level short term inconvenience or symptoms (typically a first aid or no treatment injury)	Exposure to health hazard resulting in temporary and reversible discomfort (typically a first aid or no treatment illness)	Near source confined negligible or temporary impact (typically a shift)	Low level interest from local media  Complaints able to be resolved following existing procedures	Tangible mistrust / opposition among individual stakeholders with minimal influence on public opinion and decision makers  Reparable damage to site or item of low cultural significance	Non-conformance with internal requirement with very low potential for impact	<\$100K

#### LIKELIHOOD

Level	Descriptor	Description	Quantification
A	Almost Certain	The event is expected to occur in most circumstances	Typically occurs once per day to one week
B	Likely	The event will probably occur in most circumstances	Typically occurs once per week to one month
C	Occasional	The event should occur at some time	Typically occurs once per month to one year
D	Unlikely	The event could occur at some time	Typically occurs once in one to five years
E	Rare	The event may only occur in exceptional circumstances	Typically occurs once in five to ten years