NARRABRI MINE

EXTRACTION PLAN

SUBSIDENCE MONITORING PROGRAM

PANELS 201 - 202

Prepared by:

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Document review history

In accordance with Project Approval Schedule 6 condition 3, this document has been reviewed as follows:

Review Date	Reason for review	Reviewed by	Revision required (Y/N)

Acronyms and abbreviations

Acronym	Description
º	degree
ALS	aerial laser scanning
AHD	Australian Height Datum
AR	Annual Review
BFMP	Built Features Management Plan (as Appendix D to the Extraction Plan)
BMP	Biodiversity Management Plan (as Appendix H 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
EPA	The NSW Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EP&A Regulation	Environmental Planning and Assessment Regulation 2000
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPL	environment protection licence under the POEO Act
ha	hectare
HSE	health, safety and environment
IEA	Independent Environmental Audit
IPSMP	Individual Property Subsidence Management Plan
km	kilometre
LiDAR	light detection and ranging
LMP	Land Management Plan (as Appendix I to the Extraction Plan)
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)

Acronym	Description
SoC	Statement of Commitments
ROM	run of mine
TARP	trigger action response plan
VWP	vibrating wire piezometers
WHC	Whitehaven Coal Limited
WMP	Water Management Plan (as Appendix G to the Extraction Plan)

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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. The underground mine is covered by Mining Lease (**ML**) 1609 which covers an area of 5,298 hectares (**ha**) for the predominant 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[1]. The bord and pillar mining will occur concurrently with longwall operations, and is scheduled to commence in 2022 for a period of approximately five years. There is no change to the previously approved longwall panels LW 203 to LW 205. 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.

[1] 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

—E— Electricity Transmission Line (Constructed)

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NARRABRI COAL MINE

Figure 1.1 : Underground Mining Layout for Panels 201 and 202

1.2 Purpose and scope

As required by Project Approval Schedule 6 Condition 2, this Subsidence Monitoring Program (**Program**) 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**). It complies with Schedule 3 Condition 4(g) of the Project Approval, which states that, as part of the Extraction Plan, a Subsidence Monitoring Program is to be prepared to the satisfaction of the NSW Resources Regulator to:

- provide data to assist with the management of the risks associated with subsidence;
- validate the subsidence predictions; and
- analyse the relationship between the subsidence effects and impacts under the Extraction Plan and any ensuing environmental consequences;

In order to comply with the above requirement, this Subsidence Monitoring Program provides details of the following:

- features potentially affected by underground mining in the Extraction Plan Area and a summary of the subsidence predictions, categorised into:
  - natural features;
  - public utilities;
  - farm land and facilities;
  - industrial commercial and business establishments; and
  - items of archaeological significance;
- survey monitoring standards, method, and program;
- summary of monitoring of subsidence consequences to built features (refer to the Built Features Management Plan for full details); and
- summary of monitoring measures provided for environmental features (refer to the applicable management plan of the Narrabri Mine Environmental Management System for full details).

1.3 Objectives

The objectives of this Subsidence Monitoring Program are to set out the program for monitoring the subsidence effects associated with the proposed coal extraction from Panels 201 to 202; and to summarise and consolidate the various environmental monitoring programs presented in each of the sub-plans appended to the Extraction Plan. The environmental monitoring programs are to be directed towards monitoring the subsidence impacts and environmental consequences of mine subsidence.

Note that monitoring programs for potential environmental impacts not associated with subsidence are addressed in the applicable management plan of the Narrabri Mine Environmental Management System.

1.4 Statutory requirements

This Subsidence Monitoring Program 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

Apart from Project Approval Schedule 3 Condition 4(g) which is reproduced in section 1.2, there are no other Project Approval conditions specifically related to this Subsidence Monitoring Program.

Statement of Commitments

The Statement of Commitments for Site Operations and Management (**SoC**) is contained as Appendix 3 of the Project Approval. In SoC 5.22 and 5.23, NCOPL has committed to prepare a Subsidence Monitoring Program prior to the commencement of mining in each panel, which includes the elements specified in Table 1.1.

Table 1.1 - Relevant Statement of Commitments requirements

Statement of Commitments requirements		Reference
SoC	**Summary of the requirement**	
5.22	Prepare a Subsidence Monitoring Program which includes the following elements:	This document
	• A transverse subsidence line across the northern and southern panels. The lines will be installed to at least the middle of the next adjacent panel before undermining occurs;	Section 3.2
	• A longitudinal line extending in-bye and out-bye from the starting and finishing point of each panel, for a minimum distance equal to the cover depth;	Section 3.2
	• A survey line along the riparian management zone of Kurrajong Creek Tributary 1 over the Extraction Plan Area;	Section 2.1
	• A minimum of three monitoring pegs spaced 10 m apart in a line or triangle at any feature of interest, e.g.. dam walls, archaeological sites, to measure subsidence, tilt and strain; and	Attachment 2
	• Visual inspections and mapping of damage before, during and after mining.	Section 3.4
5.23	Place monitoring survey pegs between 10 and 20 m apart with a minimum of two baseline surveys of subsidence and strain completed before mine subsidence effects occur	Section 3.2 Attachment 2

The Project Approval conditions directly relevant to this Subsidence Monitoring Program have been presented in full in Table A1.1 in Attachment 1, together with a cross-reference where the requirements are addressed within this Program.

1.4.2 EPBC approval

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

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 Subsidence Monitoring Program provides data to assist with the management of the risks associated with subsidence, allows for the validation of subsidence predictions; and analyses the relationship between the subsidence effects and impacts under the Extraction Plan and any ensuing environmental consequences.

1.4.4 Extraction Plan Guidelines

As stated in the Extraction Plan Guidelines, the Subsidence Monitoring Program must provide sufficient information on subsidence effects to fully support implementation of the Extraction Plan. It should have clearly stated objective(s) and address the items listed in Table 1.2.

Table 1.2 - Extraction Plan Guideline requirements

Extraction Plan requirements		Reference
Item	**Summary of the requirement**	
1	The Subsidence Monitoring Program must address the following elements:	
2	• proposed subsidence monitoring activities (individually specified);	Section 3
3	• information or subsidence parameters to be obtained from each monitoring activity;	Section 3.4
4	• proposed locations and/or extents where each monitoring activity will be undertaken, in particular, the proposed layout and/or locations of instrumentation, monitoring points or inspections (including graphical plans);	Section 3.2
5	• proposed timing, frequency and duration of each monitoring activity;	Section 3.4
6	• proposed monitoring methods, technologies, industry standards (eg ICSM Standards (SP1) Version 2.0) or Codes of Practice to be applied in undertaking each monitoring activity;	Section 3.2 Attachment 2
7	• proposed measures and procedures for quality assurance and competence of personnel undertaking monitoring activities;	Section 4.1
8	• proposed procedures to record monitoring results;	Section 3.4 Table 3.1
9	• proposed reporting monitoring results, including the frequency of reporting. The primary recipient of reports is the Resources Regulator, and required reporting frequency will depend on the significance of features which are subject to risk of subsidence impact and consequence, and the scale of that risk; and	Section 4.2
10	• capacity of the program to detect early warning of deviations from the defined performance measures and associated performance indicators	Section 3.1

1.5 Risk assessment

A subsidence risk assessment has been undertaken to identify the risks associated with subsidence at the Narrabri Mine. It builds on previous risk assessments completed for LW 101 to LW 110 and is presented as Appendix K to the Extraction Plan.

The updated risk assessment for Panels 201 to 202 has not identified any high-risk items and as a result, risks associated with subsidence within the Extraction Plan Area for the Narrabri Mine have been assessed as low to moderate.

1.6 Consultation and approval

Although this Subsidence Monitoring Program does not require any specific consultation during preparation it needs to be prepared to the satisfaction of the Resources Regulator.

A draft (Revision B) of the Extraction Plan and sub-plans was submitted for consultation on 3 December 2021. The Resources Regulator provided a response with no specific comments regarding this Program on 23 February 2022.

The overall approval process required for the Extraction Plan by the Project Approval is detailed in section 1.9 of the Extraction Plan.

1.7 Access to information

In accordance with Schedule 6 Condition 10 of the Project Approval, the approved Extraction Plan and all appendices, audits and reports, and summaries of all monitoring data (where relevant) will be made publicly available on the WHC website. All information will be kept up to date.

Note that any printed copies of this Subsidence Monitoring Program are uncontrolled.

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. The western area of ML 1609 is heavily vegetated with woodland areas consisting of dry sclerophyll forest. The Pilliga East State Forest covers the areas further to the west. Vegetation includes several stands of native vegetation across the agricultural land use areas and riparian zones along the ephemeral watercourses associated with Kurrajong Creek Tributary 1.

Topographic relief within the ML ranges from 279 m Australian Height Datum (**AHD**) to 340 m AHD. The surface terrain is generally flat to gently undulating, with most slopes ranging from 1 to 5 degrees (º). Slopes increase to 10° to 35° in several rocky 'hillock' locations, including ephemeral creeks and tributaries (or gullies), which drain the Extraction Plan Area towards the north-east. The hillocks have Pilliga Sandstone exposures with local topographic relief and steep rocky slopes ranging between 10 and 15 m above the surrounding plains. The strata bedding generally dips towards the south-west to west at less than 5º. There are no defined steep rocky slopes within the Extraction Plan Area.

Silty sand and sandy clay surface soils to 4 m depth are present in the Extraction Plan Area and are mildly to highly erosive/dispersive. The clayey soils are associated with the outcropping Garrawilla Volcanics and overlying Purlawaugh formation. Sandy alluvial deposits exist along the creek channels with no rock exposures present. The channels are typically incised with steep to very steep banks between 0.5 and 3.5 m high. Sub-surface groundwater aquifers at depths range from 5 to 50 m and are typically of poor quality.

A range of built features are located within the Extraction Plan Area, which can be summarised as the following elements:

- private roads and unsealed gravel access tracks;
- water storage dams (earth embankments) and associated soil conservation banks;
- property and livestock fences;
- residential dwellings and machinery sheds (all owned by NCOPL); and
- mine infrastructure, consisting of:
  - surface to in-seam gas drainage wells and associated surface plant;
  - groundwater monitoring bores; and
  - personal emergency device (PED) cables.

2.1 Natural features

Natural features potentially impacted by mining activities and monitored under the scope of this Program for Panels 201-202 and the ML include:

- rivers and creeks:
  - tributaries and contributing catchment area of Kurrajong Creek, which is an ephemeral creek that drains to the Namoi River;
  - aquifers, known groundwater resources;
  - alluvial aquifers associated with creeks; and
  - saline groundwater associated with the coal measures.
- land prone to flooding or inundation:
  - floodplain associated with Kurrajong Creek Tributary 1.

- threatened and protected species (for details refer to the Biodiversity Management Plan, provided as Appendix H to the Extraction Plan)
- natural vegetation, including riparian forest, box woodland and cleared open grassland.

2.2 Public utilities

Land overlying Panels 201-202 is owned by NCOPL. A detailed list of all affected built features is provided in the Built Features Management Plan (**BFMP**), provided as Appendix D to the Extraction Plan. There are no known public utilities that exist above Extraction Plan Area.

2.3 Farmland and facilities

The land associated with the Narrabri Mine has been historically used for agriculture (grazing, some cropping) and consists of:

- agricultural land classified according to its agricultural suitability, as detailed in the Land Management Plan, provided as Appendix I to the Extraction Plan;
- soil conservation banks (contour banks).
- farm buildings / sheds and associated infrastructure
- fences, gates and grids
- farm dams and water storages.

2.4 Industrial, commercial and business establishments

No industrial, commercial or business establishments are located within the mining area, with the exception of infrastructure associated with the Narrabri Mine. Affected mine infrastructure is limited to the surface facilities associated with surface to in-seam gas drainage bores and unsealed access tracks. A number of buried PED cables are also located within previously mined areas.

2.5 Areas of archaeological or heritage significance

The surface area overlying Panels 201-202 includes known Aboriginal heritage sites. These are predominantly found along riparian zones associated with Kurrajong Creek Tributary 1.

Archaeological surveys undertaken for the Narrabri Mine have identified a total of 178 Aboriginal cultural heritage sites within the Narrabri Mine. Of these, 24 are located in the Panels 201-202 Extraction Plan Area. This total includes 18 artefact scatters, five isolated artefacts, and one grinding groove site. All 24 sites have been assessed as being of low scientific significance due to disturbed contexts and low artefact densities (<12 artefacts). The ‘Claremont’ grinding groove has also been assessed as being of low scientific significance due to the presence of only one grinding groove on what appears to be a floating sandstone boulder.

Potential subsidence-related impacts to these sites will be monitored and managed in accordance with the Heritage Management Plan (HMP) provided as Appendix J to the Extraction Plan. A site-wide Aboriginal Cultural Heritage Management Plan addresses the management of potential impacts to heritage sites for other mining-related activities.

2.6 Residential establishments

'Moderate' to 'significant' damage to existing buildings and tanks are likely where tilts exceed 7 mm/m and tensile or compressive strains exceed 4 mm/m. The severity of the damage would also be dependent on the type and geometry of each structure and whether localised 'humps' and 'troughs' develop over the goaf as it consolidates.

There are no dwellings or sheds located above the proposed Panels 201 and 202.

3. Subsidence monitoring

3.1 Overview

The subsidence monitoring program consists of survey monitoring to quantify subsidence parameters, i.e. vertical movements, ground tilts and strains (refer to section 3.2) and a consolidated summary of environmental consequence monitoring (refer to section 3.3) to identify subsidence-related impacts to environmental and built features. Additional monitoring to identify height of fracturing will be conducted using a network of surface extensometers. The analysis of piezometric data to determine impacts on groundwater is dealt with separately in the WMP.

The objectives of this monitoring program are to:

- measure baseline information – establish background data for the surface and environment above the mining area;
- monitor the effects of mining – monitor identified subsidence parameters and environmental aspects at key positions relative to the panel position;
- regularly assess and interpret monitoring – analyse monitoring data to identify any deviations or variations to the predictions or unexpected anomalies;
- report subsidence results;
- re-assess subsidence impacts – where variations are greater than predictions, review of impacts will be undertaken; and
- identify and implement remedial actions / contingency plans – review of impacts may indicate that remedial action is required. Implementation of remedial work and contingency plans will be undertaken in consultation with relevant stakeholders where appropriate.

The monitoring program will also enable NCOPL to obtain data on subsidence parameters and subsidence impacts relating to the extraction of Panels 201-202. This data will be used to confirm that actual subsidence and environmental consequences are within predicted limits, as well as to:

- validate the subsidence modelling methodology and predictions; and
- establish and develop a subsidence database at Narrabri Mine for the purpose of future mine planning, subsidence prediction and assessment of environmental consequences for subsequent longwall and possibly bord and pillar extraction.

3.2 Subsidence survey monitoring

A subsidence survey monitoring program has been developed which includes the following elements:

- a transverse subsidence line across the panels installed on an existing access track. The line will be installed into the next adjacent panel before undermining occurs and will be discontinued in areas where movement has ceased;
- install a longitudinal line extending in-bye and out-bye from the panel starting points where it is feasible (i.e. does not require excessive clearing) for a minimum distance equal to the cover depth, both at starting and finishing points; and
- complete aerial laser scanning (**ALS**) annually.

The installed/proposed subsidence monitoring lines are shown in Plan 7 of the Extraction Plan.

ALS surveys will be conducted, which will allow comprehensive ground movement monitoring over the entire panel. The ALS may be linked into the already established survey markers and provide subsidence data to within +/-0.1m, and will be calibrated using the subsidence line monitoring over Panels 201-202. It is anticipated that ALS scanning will provide a more thorough picture of the subsidence development along creeks and surface terrain generally. Provided the ALS proves adequate as a monitoring technique, the longitudinal monitoring lines will be progressively phased out. The subsidence line monitoring standards, schedule and methodology is detailed in Attachment 2.

3.3 Monitoring of environmental consequences

The monitoring proposed under the Extraction Plan and all relevant sub-plans to identify and assist in the management of environmental consequences is summarised in Table 3.1. All subsidence impacts monitoring is detailed in the relevant sub-plan to the Extraction Plan. These are as follows:

- Built Features Management Plan (BFMP);
- Public Safety Management Plan (PSMP);
- Water Management Plan (WMP);
- Biodiversity Management Plan (BMP);
- Land Management Plan (LMP); and
- Heritage Management Plan (HMP).

Various monitoring programs are also proposed as part of the LMP, which includes the Rehabilitation Management Plan and Mine Closure Plan as attachments. These monitoring programs are generally an extension of the monitoring contained in the above plans, as suitable for monitoring post-mining remediation and rehabilitation. As such, monitoring under the LMP and its sub-plans is not summarised here.

3.4 Monitoring for extent of fracturing

A monitoring program to determine the height of fracturing and extent of subsidence over the mining panels has been developed in conjunction with SCT Operations Pty Ltd using surface extensometers. This data has been used to update the height of fracturing information in the subsidence predictions provided in Appendix B to the Extraction Plan.

Table 3.1 - Environmental consequences monitoring summary

Aspect / feature	Frequency	Monitoring measures	Management Plan / reference
Built Features Management Plan			
Roads and access tracks	Pre-subsidence	Survey (ALS or similar) to locate drainage structures; confirm road location/widths; and direction and capacity of table drains.	BFMP
	Pre-subsidence	Erect temporary signage advising of the potential for subsidence risks	
	During active subsidence	Visual monitoring of access tracks and roads affected internal access to note any subsidence impacts that require remediation or implementation of additional traffic controls. Grade roads as required.	
	Post-subsidence	Remediate affected areas as required within 1 month of undermining	
Water storage dams and soil conservation banks	Pre-subsidence	Obtain 'xyz' coordinates along contour banks and water storage dams, using either light detection and ranging (**LiDAR**) or field survey methods.	BFMP
	Pre-subsidence	Photographic records of all dams and contour banks	
	During undermining of structure.	Visual inspections of dams noting their condition and any indications of the following: ▪ cracking or failure of earth embankment requiring immediate attention; ▪ erosion of bank or spillway requiring repair.	
	Post-subsidence	Inspection survey on completion of active subsidence to identify impacts for remediation. Implement any required remediation works within 12 months of undermining.	
Property and livestock fences	Pre-subsidence	Baseline aerial survey of fence lines and in-field visual assessment.	BFMP
	During active subsidence	Visual monitoring during active subsidence. Exclude stock.	
	Post-subsidence	Visual inspection survey on completion of active subsidence to identify impacts for remediation. Remediation to occur prior to re-stocking.	
Dwellings and machinery sheds	Pre-subsidence	Undertake inspection to identify the presence of harmful materials/substances unable to remain in situ. Vacate buildings and services disconnected.	BFMP

Aspect / feature	Frequency	Monitoring measures	Management Plan / reference
	Post-subsidence	Buildings affected by subsidence will remain secured to prevent unauthorised access until such time as they are structurally assessed, demolished or repaired. They will remain secured until prior to the intended re-use, or if being demolished, this will occur within 2 years of undermining.	
Mine infrastructure	Pre- and post-subsidence	Inspect decommissioned SIS gas drainage sites to confirm all structures have been safely decommissioned and site is stable and safe. Design/install PED cable with enough 'slack' for subsidence related impacts.	BFMP
	Pre- and post-subsidence	Survey collars of affected piezometers and groundwater monitoring bores to confirm accurate levels for measuring of groundwater levels.	
Survey markers	Pre- and post-subsidence	Apply to damage State survey markers at least 14 days prior to undermining. Once undermined, restore the mark and update details following subsidence. **NOTE 1**	BFMP
Water Management Plan			
Surface water quality monitoring			
Kurrajong Creek Tributary 1	Prior to active subsidence (baseline) and during runoff events (as practical)	Obtain baseline data on surface water quality in Kurrajong Creek Tributary 1 prior to mining and during runoff events for electrical conductivity (EC), oil and grease, pH, total suspended solids (TSS), total organic carbon (TOC).	WMP
Surface ponding	Monthly	Sampling for EC.	
Changes in water course morphology	Monthly visual inspection during subsidence	Identification of changes in planform, creek grade, bank erosion and sedimentation. Consult with geomorphologist/DPI-Water if changes significant.	
Groundwater level monitoring			
Namoi River Alluvial	Baseline and throughout duration of mining	Monitoring of groundwater levels: monthly monitoring - manual sampling locations, and recording at automatic groundwater level sampling at vibrating wire piezometers (VWPs) daily (data downloaded monthly).	WMP
Permian to Jurassic hard rock aquifers	Baseline and throughout duration of mining	Monitoring of groundwater levels: monthly monitoring – manual sampling locations, and recording at automatic groundwater level sampling at vibrating wire piezometers (VWPs) daily (data downloaded monthly).	

Aspect / feature	Frequency	Monitoring measures	Management Plan / reference
Hydraulic conductivity	Pre-mining and post-subsidence	Monitoring of groundwater levels: monthly monitoring – manual sampling locations, and recording at automatic groundwater level sampling at vibrating wire piezometers (VWPs) daily (data downloaded monthly).	
Mine water inflows	Daily (data logger)	Measurement of groundwater volumetric flow rates at extraction bores, sumps/pumps, box cut sump and water entry to mine.	
Springs	Monthly	Spring discharge rate including the Mayfield spring.	
Groundwater quality monitoring			
Monitoring bores	Monthly	Sampling of monitoring bores for EC and pH.	WMP
Bore water quality	Annually	Sampling of full suite of parameters (refer to the WMP for the list of parameters to be tested).	
Mine water inflows	Monthly	Measurement of mine water pumped into and out of the mine (EC pH,).	
Mine water inflows	Quarterly	Sampling of full suite of parameters (Refer WMP for list of parameters to be tested).	
Biodiversity Management Plan			
Woodland and riparian vegetation monitoring			
General	Baseline, Annually (spring)	LiDAR (3-yearly) and multi-spectral imaging to measure changes in topographic form, woodland parameters (i.e. extent, cover, biomass) extent of erosion.	BMP
Canopy health, vegetation structure, habitat features, weed presence and clearing areas	Baseline, Annually (spring)	Mining panel transects, floristic-based subsidence monitoring and pre-clearing/clearing surveys.	
Terrestrial Fauna and Habitat Monitoring			
Delicate mouse and Pale-headed snake	Baseline, Annual (spring)	Elliot traps, pit falls, funnel traps, remote sampling techniques and active searches.	BMP
Land Management Plan			
Surface Cracking			
Surface cracking after completion of mining panel	Weekly and following a significant rainfall event	Visual inspections for surface impacts (including surface cracking, ponding, landslips and erosion) of areas immediately after completion of a mining panel.	LMP

Aspect / feature	Frequency	Monitoring measures	Management Plan / reference
Surface cracking in drainage lines	Following a significant rainfall event (defined as a rainfall event > 38.4 mm over 5 consecutive days)	Monitor drainage lines to identify erosion and potential erosion following rain events.	
Remote Sensing			
Topography and landscape morphology	Baseline, Every 3 years	LiDAR survey to identify changes in topographic form over time, including creek slope, width and depth.	LMP
Vegetative cover characteristics and erosion monitoring	Baseline, Annually (early spring)	Multi-spectral imaging, processed into a normalised difference vegetation index (NVDI) to measure variability in vegetative biomass and cover (pasture) over time and compared to control sites, followed by targeted field survey where analysis (ANOVA) indicates potential impacts have/are occurring – for example weed infestation or erosion impacts to vegetation.	
Creek line Surveys			
Geomorphic survey	Baseline, Annually (in late winter/spring).	Geomorphic survey to define geomorphic zones – mapping and description, survey (100m reaches).	LMP
Channel survey	Baseline, Annually (in late winter/spring).	Cross-sectional survey to monitor change in channel parameters (width, depth, cross-sectional area).	
Heritage Management Plan			
Known archaeological sites	Prior to and following each mining panel	Visual inspection (including photographic record) by qualified archaeologist to record pre and post subsidence condition of each archaeological site to assess whether any intervention and remediation works are required.	HMP
Known archaeological sites	Monthly during undermining	Monthly inspection to observe relation of surface cracking or erosion (if any) in relation to archaeological sites.	
Artefact find	As required	If artefacts or potential artefacts are identified during subsidence rectification works.	
Artefact disturbance	As required	If artefacts or potential artefacts are disturbed during subsidence or subsidence rectification works.	

NOTE 1:

A request to remove the relevant survey markers was granted by Spatial Services on 29 October 2021 (SMR reference: SO-738).

4. Program implementation

4.1 Roles and responsibilities

To ensure adequate implementation of this monitoring program, the following NCOPL responsibilities have been assigned to relevant NCOPL personnel as presented in Table 4.1. It is also noted that additional responsibilities are referred to within the Extraction Plan and the appended sub-plans.

Table 4.1 - Roles and responsibilities

Roles	Responsibilities
General Manager	• Ensure that adequate resources are available to NCOPL personnel to facilitate the completion of their responsibilities under this program.
Mine Manager	• Ensure this Subsidence Monitoring Program is implemented and adhered to.
Environmental Superintendent	• Ensure that all monitoring and reporting under the BFMPs and Subsidence Monitoring Program is carried out within the timeframes specified, and is checked, processed and filed appropriately.
	• Liaise with stakeholders regarding subsidence impact management.
	• Authorise changes to this Subsidence Monitoring Program.
Registered Mine Surveyor	• Ensure that all subsidence monitoring is carried out to the accuracy required, within specified timeframes and are checked, processed and filed appropriately.

4.2 Annual Review

In accordance with Schedule 6 Condition 6, NCOPL will review the performance of its subsidence monitoring program for the previous calendar year and report the relevant results within the Annual Review, to the satisfaction of the Secretary. The Annual Review will at minimum provide information regarding the effectiveness of the program.

Further, the Annual Review requires a number of items to be reviewed or assessed. In summary these are:

- monitoring results and complaints;
- non-compliances and incidents;
- compliance with performance measures;
- discrepancies between predicted and actual impacts; and
- measures to be implemented to improve environmental performance.

The Annual Review may also make recommendations for any additions, changes or improvements to the subsidence monitoring program.

The Annual Review will be made available on the WHC website.

4.3 Independent environmental audits

Prior to 13 September 2010, and every 3 years thereafter, unless the Secretary directs otherwise, NCOPL will commission and pay the full cost of an Independent Environmental Audit (**IEA**) of the operations at Narrabri Mine (Stages 1 and 2), to be conducted in accordance with the requirements under Schedule 6 Condition 7.

The audit team will be led by a suitably qualified auditor and the IEA will be conducted by suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Secretary.

4.4 Monitoring program review and evaluation

As required by Schedule 6 Condition 3 of the Project Approval, within three months of any of the following:

- completion of an independent environmental audit (as required by Schedule 6 Condition 7);
- submission of an Incident Report (as required by Schedule 6 Condition 4);
- submission of an Annual Review (as required by Schedule 6 Condition 6); and
- any modification to the conditions of the Project Approval (unless the conditions require otherwise),

NCOPL will the review, and if necessary, revise this Subsidence Monitoring Program. This is to ensure that the strategies, plans and programs are updated on a regular basis, and incorporate any recommended measures to improve the environmental performance of the Narrabri Mine operations. The review history table in the front of this Program provides the details of each review.

Condition 3 of Schedule 6 further states that if the review determines that this Subsidence Monitoring Program requires revision, then this will be completed to the satisfaction of the Secretary.

5. References

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

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.

6. Glossary

Term	Definition
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 20mm.
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 surface area predicted to be affected by the proposed secondary extraction of Panels 201 to 202
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
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 Environmental Planning and Assessment Act 1979 by the Department of Planning & Infrastructure (as modified).
Second workings	Extraction of coal from longwall panels, mini-wall panels, or pillar extraction.

Term	Definition
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.
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
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

Attachment 1 Compliance conditions relevant to the Program

Table A1.1 - Relevant Project Approval 08_0144 requirements

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
Schedule 2 Condition 11	With the approval of the Secretary, the Proponent may submit any management plan or monitoring program required by this approval on a progressive basis. ***Note**: The conditions of this approval require certain strategies, plans, and programs to be prepared for the project. They also require these documents to be reviewed and audited on a regular basis to ensure they remain effective. However, in some instances, it will not be necessary or practicable to prepare these documents for the whole project at any one time, particularly as these documents are intended to be dynamic and improved over time. Consequently, the documents may be prepared and implemented on a progressive basis, subject to the conditions of this approval. In doing this however, the Proponent will need to demonstrate that it has suitable documents in place to manage the existing operations of the project.*	There is no staging for the Subsidence Monitoring Program for Panels 201-202
Schedule 3 Condition 4	The Proponent shall prepare and implement Extraction Plans for any second workings to be mined to the satisfaction of the Secretary. Each Extraction Plan must:	
	g) include the following to the satisfaction of the Resources Regulator:	
	• a Subsidence Monitoring Program to:	This document
	▪ provide data to assist with the management of the risks associated with subsidence;	Section 3
	▪ validate the subsidence predictions; and	Section 3.1
	▪ analyse the relationship between the subsidence effects and impacts under the plan and any ensuing environmental consequences	Section 3.3
Schedule 6 Condition 3	Within 3 months of the submission of an:	Section 4.3
	(a) audit under condition 7 of Schedule 6;	
	(a) incident report under condition 4 of Schedule 6; and	
	(b) annual review under condition 5 of Schedule 6; and	
	(c) any modification to the conditions of this approval (unless the conditions require otherwise),	
	the Proponent shall review, and if necessary revise, the strategies, plans, and programs required under this approval to the satisfaction of the Secretary.	
Schedule 6 Condition 6	By the end of March each year, the Proponent must submit a review of the environmental performance of the project for the previous calendar year to the satisfaction of the Secretary.	Section 4.2
Schedule 6 Condition 7	Prior to 13 September 2010, and every 3 years thereafter, unless the Secretary directs otherwise, the Proponent shall commission and pay the full cost of an Independent Environmental Audit of the project (Stages 1 and 2).	Section 4.3

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
Schedule 6 Condition 10	The Proponent shall: (a) make copies of the following publicly available on its website: • the documents referred to in Condition 2 of Schedule 2; • all current statutory approvals for the project; • all approved strategies, plans and programs required under the conditions of this approval; • a comprehensive summary of the monitoring results of the project, reported in accordance with the specifications in any conditions of this approval, or any approved plans and programs; • a complaints register, updated on a monthly basis; • minutes of CCC meetings; • the annual reviews of the project; • any independent environmental audit of the project, and the Proponent's response to the recommendations in any audit; • any other matter required by the Secretary; and	Section 1.7
	(b) keep this information up-to-date, to the satisfaction of the Secretary.	Section 1.7

Attachment 2 Survey monitoring method and schedule

STANDARDS

All monitoring will be planned and surveyed to ensure these surveys satisfy the conditions to achieve a standard of accuracy of "Class D" as prescribed in ICSM SP1 (The Inter-Governmental Committee on Surveying and Mapping Special Publication 1 "Standards and Practices for Control Surveys"). Target accuracy for survey of all points in the following tables will have a relative accuracy of +/- 3mm between co-ordinated monitoring points. Each survey will be conducted in 3D. The monitoring schedule is explained in greater detail in the following sections.

Subsidence line monitoring

Subsidence lines are to be installed to monitor subsidence, tilt, strain and angle of draw across Panels 201 and 202. The installation and monitoring details for the subsidence lines are shown in Table A2.1.

Table A2.1 - Subsidence line monitoring details

Mark Type	Star pickets driven to refusal at 10 m intervals
Depth of cover (extension)	TBC – depending on panel
Survey monitoring method	Total station traverse from terrestrial baseline
Monitoring frequency	Prior to and post mining each panel
	6 monthly until movement ceases

Attachment 3 Visual monitoring method

Visual inspection of roads and access tracks

Visual monitoring of affected sections of unsealed access road will be conducted on as needs basis whilst affected by active subsidence. Monitoring to note and document where appropriate:

1. location of longwall relative to the affected section of road;
2. confirmation that any required signage under the BFMP and PSMP is located in an appropriate location and is visible / legible to road users;
3. presence and width of any subsidence cracking within the road pavement;
4. any subsidence effects that on inspection may affect the road formation and safe use of the road (i.e. compression humps or ground tilts);
5. affected cattle grids (i.e. sharp edges protruding or gaps) or gates not able to be easily opened /closed;
6. any damage/alteration to table drains or culverts that may result in water ponding or inadequate drainage during rainfall; and
7. any other road obstructions.

Any observations of subsidence impacts requiring remediation or repair are to be recorded in the checklist provided in the BFMP and reported to the Technical Services Manager.

Visual inspection of water storages

Visual inspection of water storages/dams (if storing water) during active subsidence to note and document where appropriate:

1) any sudden changes (drops) in stored water level compared to previous day's inspection (use painted wooden survey stake or similar);
2) condition of the dam wall and spillway, in particular noting any:
   a) cracking within embankment;
   b) signs of possible embankment failure (i.e. slumping or collapse of partial section);
   c) formation of erosion (particularly formation of tunnel erosion or holes);
   d) water seepage through wall; and
   e) spillway damage (should be level, lower than embankment height and non-eroding).

If any of the above signs are noted, they should be reported to the Technical Services Manager. Assessment of the dam undertaken and works implemented in accordance with the BFMP.

Visual inspection of property and livestock fences

Visual monitoring of affected sections of fence lines will be conducted whilst affected by active subsidence. Monitoring to note and document where appropriate:

1) any breakage of permanent or temporary fencing; and
2) location of grazing stock in relation to damaged fencing and confirmation that they are safely contained (or otherwise).

Where damage to fence lines may result in unplanned movement of livestock (i.e. Kamilaroi Highway), this is to be reported to the Environmental Superintendent.