NARRABRI MINE

EXTRACTION PLAN
LAND MANAGEMENT PLAN

PANELS 201 - 202

WHC_PLN_NAR_ LAND MANAGEMENT PLAN - PANELS 201 - 202

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Onward document number:
NCO-004J-0 PLN

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
AHD	Australian Height Datum
ANOVA	analysis of variance
BMP	Biodiversity Management Plan (as Appendix H to the Extraction Plan)
CHPP	Coal Handling and Preparation Plant
DEM	digital elevation model
DGS	Ditton Geotechnical Services
DPE	The NSW Department of Planning and Environment
EA	Environmental Assessment
EMS	NCOPL's Environmental Management System
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
ha	hectare
km	kilometre
LiDAR	light detection and ranging
LMP	Land Management Plan (this document)
LSC	Land and Soil Capability
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
NDVI	normalised difference vegetation index
NSC	Narrabri Shire Council
OEH	The former NSW Office of Environment and Heritage
ROM	run of mine
SoC	Statement of Commitments
SRP	subsidence reduction potential
TARP	trigger action response plan
TG	tailgate (i.e. TG1 = tailgate 1)
U95%CL	upper 95 % confidence level
WAL	water access licence
W/H	width to height (ratio)

Acronym	Description
WHC	Whitehaven Coal Limited
WM Act	*Water Management Act 2000* (NSW)
WMP	Water Management Plan (as Appendix G to the Extraction Plan)
WSP	water sharing 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[1]. 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 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 allows for up to 0.7 Mtpa via bord and pillar extraction at pillar reduction panels CF 201 to CF 205[2]. 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. 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] For full details on the joint venture ownership, please refer to the introduction of the Extraction Plan.

[2] The pillar reduction panel naming 'CF' is an acronym for 'cut and flit'.

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

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— — Underground Mine Footprint

—E— Electricity Transmission Line (Constructed)

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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 Land Management Plan (**LMP**) 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(h) of the Project Approval, which states that the Extraction Plan is to include an LMP which has been prepared in consultation with any affected public authorities, to manage the potential impacts and/or environmental consequences of the proposed second workings upon land in general.

Land impacts associated with Panels 201 to 202 have been identified in the Ditton Geotechnical Services Mine Subsidence Predictions Report for Panels 201 to 205 (Ditton Geotechnical Services [**DGS**], 2021), presented as Appendix B to the Extraction Plan, and other relevant approval documents, including the Stage 2 EA, MOD 5 and MOD 7.

1.3 Objectives

The objectives of this LMP are to:

- detail all proposed mine activities and potential impacts associated with land management within the Extraction Plan Area during the extraction of coal from Panels 201 to 202;
- provide clear and concise descriptions of the responsibilities in relation to the LMP during the operation of the Narrabri Mine; and
- describe the performance measures and criteria for land management.

NCOPL will implement all practical measures to prevent and/or minimise any harm to the environment that may result from construction, operation or rehabilitation activities at the Narrabri Mine.

1.4 Statutory requirements

This LMP 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 the requirement of Project Approval Schedule 3 Condition 4(h) for the Extraction Plan to include an LMP (refer section 1.2), Schedule 3 Condition 5 states that the LMP shall include:

(a) an assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since the Project Approval;

(b) a detailed description of the measures that would be implemented to remediate predicted impacts; and

(c) a contingency plan that expressly provides for adaptive management.

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

Statement of Commitments

The Statement of Commitments (**SoC**) is contained as Appendix 3 of the Project Approval. The specific commitments applicable to this LMP are listed in Table 1.1.

Table 1.1 - Relevant SoC requirements

SoC requirements		LMP reference
SoC	**Summary of the requirement**	
5.1	Inspect the identified 'cracking zones' above each longwall panel to identify occurrence of cracks.	Section 8
5.5	Inspect local drainage lines above the active and completed longwall panels. Monitoring should assess any restriction of flows and hence restriction of fish passage to facilitate appropriate restorative measures.	Section 8
5.8	Inspect areas of the Mine Site susceptible to landslip or accelerated erosion, e.g., drainage lines and steeply sloped areas of exposed Purlawaugh Formation derived subsoils.	Section 8
5.11	Establish survey lines along ephemeral drainage gullies and along gully crests and monitor during and after mining of each longwall panel to identify any signs of cracking or 'upsidence'.	Section 8
5.15	Inspect the watercourses over the subsidence zone to identify the location and extent of ponding.	Section 8
5.16	For ponding where there is little or no vegetation of conservation significance, monitor the location and extent of ponding.	Section 8
12.12	Minimise erosion on the Mine Site as a consequence of subsidence.	Section 9

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 LMP.

1.4.3 Mining lease

The original ML 1609 issued in 2008 has been amended to include a reference to Extraction Plans, removing the requirements for a Subsidence Management Plan. There are no specific ML conditions related to this LMP.

1.4.4 Extraction Plan Guidelines

As stated in the Extraction Plan Guidelines, the LMP should give appropriate consideration to risk assessment and risk management. This is further addressed in section 1.5. There are no other requirements identified in the Extraction Plan Guidelines that relate directly to this LMP.

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. The potential environmental consequences to land are further discussed in section 6.

1.6 Consultation and approval

In accordance with Schedule 3 Condition 4(h) of the Project Approval, NCOPL has prepared this LMP in consultation with any affected public authorities, to manage the potential impacts and/or environmental consequences of the proposed second workings upon land in general. However, since no public utility infrastructure exists within the Extraction Plan Area above Panels 201 to 202 or within ML 1609, there is no requirement for any specific consultation.

The overall consultation 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 LMP are uncontrolled.

2. Baseline information

2.1 Topography

Narrabri Mine is located in the Namoi Catchment in an area that transitions from the open plains in the Walgett and Coonamble areas to the west, the Nandewar Ranges to the northeast, and the Warrumbungle and Liverpool Ranges to the south. As stated in the EA, the topography is generally flat to undulating with elevations ranging from 400 m Australian Height Datum (**AHD**) in Jacks Creek State Forest to the west, to approximately 230 m AHD toward the Namoi River in the east.

The surface terrain across the ML is generally flat with slopes ranging between 2 degrees (°) to 5°. Maximum slopes of approximately 18° are located in the southwest of the ML and minimum slopes of less than 1° occur in the northeast. Along the creeks and tributaries of Kurrajong Creek slopes can increase to 10° to 15°.

Topographic relief within the Extraction Plan Area ranges from 279 to 340 m AHD. The surface terrain is generally flat with slopes ranging from 1° to 5°. Slopes increase to 10° to 35° in several rocky 'hillock' locations, including the ephemeral creeks and tributaries (or gullies), which drain the mining area towards the north-east. The hillocks have Pilliga Sandstone exposures with local topographic relief ranging between 10 and 15 m above the surrounding plains (DGS, 2021).

2.2 Land use

Land use varies from east to west, with the eastern portion of the ML being predominantly cleared (except for some remnant patches of riparian vegetation) for cattle and sheep grazing and a limited area of cereal cropping and horticulture. To the west, vegetation cover increases with topography to the Pilliga East State Forest and Jacks Creek State Forest, which are managed by the Forestry Corporation of NSW.

The land directly above Panels 201 to 202 is predominantly cleared with one small remnant patch of Callitris Forest situated within the northern section. There are two farm dams above CF203(F) that may be inundated by post-mining ponding.

The area above Panels 201 to 202 is exclusively owned by NCOPL. The existing surface and sub-surface features above and surrounding Panels 201 to 202 include:

- semi-cleared, gently to moderately undulating terrain (that is owned by NCOPL);
- one ephemeral watercourse with a sandy bed & exposed sandy clay banks with slopes up to 15° (Kurrajong Creek Tributary 1);
- one Aboriginal Heritage site of 'low' archaeological significance (Claremont grinding groove site on exposed sandstone, possibly a partially buried loose boulder);
- several unsealed access roads and property fencing;
- five earth embankment dams for stock watering (D49, D66, D66a, D67 and D68); and
- soil conservation banks (contour banks).

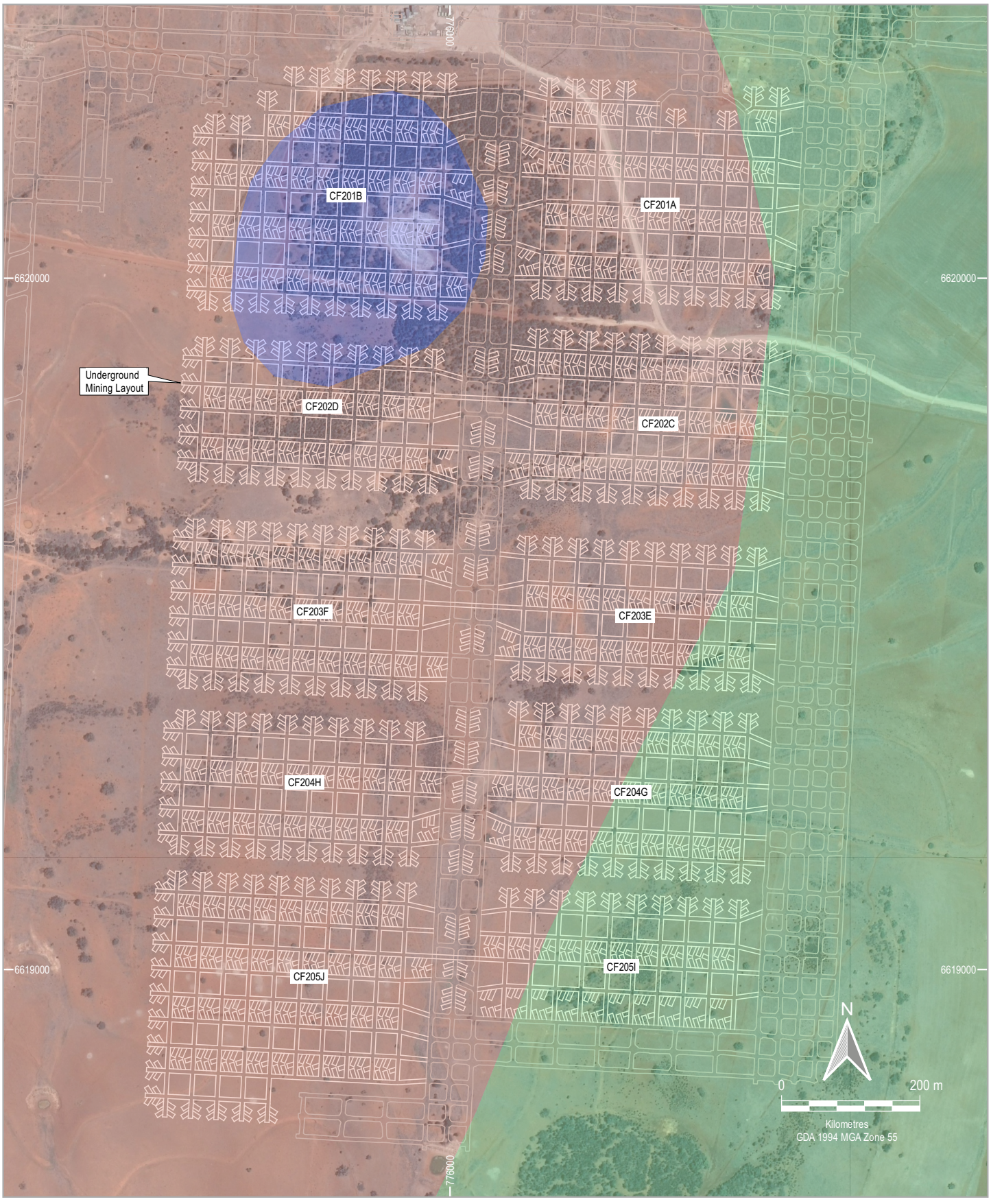
2.3 Soils

Geological formations below the Extraction Plan Area include the Purlawaugh Formation, Pilliga Sandstone and Garrawilla Volcanics, as presented in Figure 2.1. Topsoils (up to 400 mm below surface with the exception of drainage lines) are slightly dispersive with subsoils displaying high to very high dispersibility, particularly for areas above the Purlawaugh Formation. Soils across the ML have been variably affected by soil erosion, particularly within drainage lines and floodplains of the Purlawaugh Formation. The presence of soil conservation works, such as contour banks and waterway systems indicate that soil erosion has been an issue in the past.

The EA quantified a range of soil attributes that have the potential to cause adverse impacts to land if subsidence occurs following mining. Soil properties that may be associated with land degradation after subsidence have been identified for the Extraction Plan Area. Typical soil attributes associated with the geological formations and landform units are provided in Table 2.1 and Tables 2.2 and 2.3 respectively.

The landform units associated with Panels 201 to 202 are:

- Garrawilla Volcanics - drainage Line
- Garrawilla Volcanics - floodplain
- Garrawilla Volcanics - crests
- Garrawilla Volcanics - upper slopes
- Pilliga Sandstone - upper slopes
- Purlawaugh Formation - crests
- Purlawaugh Formation -major drainage lines
- Purlawaugh Formation - floodplains
- Purlawaugh Formation - lower Slopes
- Purlawaugh Formation - midslopes



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

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- Garrawilla Volcanics
- Pilliga Sandstone
- Purlawaugh Formation

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Figure 2.1: Geological Formations Underlying Panels 201and 202

Table 2.1 - Soil attributes and limitations associated with land degradation following subsidence

Soil attribute	Surface geology								
	Purlawaugh formation				Pilliga sandstone		Garrawilla volcanics		
Soil depth	Usually very deep profiles on the crests where profiles tend to be shallower				Generally less than 0.25 m; shallower on crests and slopes		Generally quite deep profiles on slopes, floodplains and in drainage lines; more likely to be shallower on upper slopes and crests		
	Not limiting				*Not limiting*		*Not limiting*		
Typical soil depths	Drainage lines	Floodplains	Slopes	Upper slopes	Upper slopes	Mid slopes	Drainage lines	Floodplain	Crests
Topsoil	0<1.0 m	0~0.35 m	0~0.30 m	0 ~0.35 m	0~0.15 m	0~0.40 m	0-0.30 m	0~0.40 m	0~0.25 m
Subsoil	1.0-3.0 m	0.35-2.5 m	0.30-2.6 m	0.35-2.5 m	0.15-1.38 m	0.40~2.20 m	0.30-2.5 m	0.4-2.50 m	0.25-1.30 m
Soil texture	A mix of often coarse textured topsoil and more clayey subsoils				Generally the most sandy soils across the mine site		Usually finer textured (more clayey)		
	Not limiting				*Not limiting*		*Not limiting*		
Soil surface characteristics	Surface stone often absent but noted on slopes; surface sometimes self-mulching; not hydrophobic				Surface stone usually absent but noted on upper slopes; surface sometimes self-mulching; often hydrophobic		Surface stone usually absent, but noted on upper slopes; surface sometimes self-mulching; not hydrophobic		
	Not limiting				*Not limiting*		*Not limiting*		
pH	Generally favourable to plant growth; usually increasing with depth but some lower horizons quite acidic				Generally lower than in the other Geological Formations and not increasing much with depth		Generally favourable to plant growth; usually increasing with depth		
	Not limiting				*Not limiting*		*Not limiting*		
Erodibility	May be some limitations where subsidence results in slope increases and in drainage lines				May be some limitations where subsidence results in slope increases and in drainage lines		Some limitations where subsidence results in slope increases		
	Low to moderate limitations				*Low limitations*		*Low to moderate limitations*		
Topsoil dispersibility	Topsoils usually slightly dispersible				Topsoils usually slightly or moderately dispersible; may be limiting near subsidence cracks or where slope gradient increases following subsidence		Topsoils generally not or only slightly dispersible		
	Usually not limiting				*Usually not limiting*		*Not limiting*		
Subsoil dispersibility	Often moderately to highly dispersible				Slight to very highly dispersible, particularly in drainage lines		Variable but often moderate to high		
	May be limiting near subsidence cracks or where slope gradient increases following subsidence but may be an advantage in filling in cracks				*May be limiting near subsidence cracks or where slop gradient increases following subsidence but may be an advantage in filling in cracks*		*Limitation in vicinity of subsidence cracks*		
Salinity	Slight to moderate salinity detected in drainage line, floodplain and some slopes areas				Salinity not recorded		Salinity not recorded		
	Limitation in areas associated with subsidence cracks where down slope saline areas may develop after erosion				*Not limiting*		*Not limiting*		

Table 2.2 - Soil attributes of geological formation/landform units

Geological formation	Purlawaugh formation			Pilliga sandstone		
Landform	**Major drainage line**	**Crests**	**Floodplains**	**Lower slopes**	**Midslopes**	**Upper slopes**
Surface condition	Loose, soft or firm, surface stone absent	Loose to firm, surface stone absent or low to medium amounts of rounded angular surface stone (to 15 cm)	Loose to firm or hardsetting, surface stone absent	Loose, surface stone absent or some rounded surface stone (1-2 cm)	Firm, sometimes self mulching and cracked, surface stone absent or some angular surface stone (<1 cm) and some flat sandstone to 15cm present	Firm, surface stone absent
Topsoil	Up to 103 cm deep Sand, clayey sand to sandy light clay pH 6.0-7.5 Poorly structured (massive/single-grained), although sometimes well structured Slight dispersibility (D% and EAT) Non-saline	Up to 27 cm deep Clayey sand or sandy medium clay pH 5.0-5.5 Moderately to well structured Moderate dispersibility (D%) Slight dispersibility (EAT) Non-saline	Up to 39 cm deep Sandy loam to medium clay pH 6.0-6.5 Well structured Slight dispersibility (D% and EAT) Non-saline	Up to 25 cm deep Sandy clay loam to light clay Well structured Slight dispersibility (D% and EAT) Non-saline	Up to 37 cm deep Silty clay to medium clay pH 6.0-7.5 Well structured Slight dispersibility (D% and EAT) Non-saline	Up to 21 cm deep Clayey sand to light to medium clay pH 4.5-6.5 Moderately to well structured Slight dispersibility (D%) Not or slightly dispersible (EAT) Non-saline
Subsoil	Up to 3 horizons (to 300 cm) Sand to medium to heavy clay (sometimes sandy) pH 5.5-7.0, although sometimes 9.0-10 at depth Poorly structured (massive) or well-structured in more clayey horizons Very highly dispersible (D%) Slightly to high to moderately dispersible (EAT) Lowest horizon sometimes slightly saline	2 horizons (to 127 cm) Medium clay (sometimes sandy) pH 5.5-8.5 Well structured, although sometimes poorly structured Moderate dispersibility (D%) Slight dispersibility (EAT) Non-saline	Up to 4 horizons (to 255 cm) Sandy loam to medium (gritty) clay pH 6.5-7.54 sometimes 8.0-9.0 Well structured, occasionally massive Slight to very high dispersibility (D%) High to moderate and very high dispersibility (EAT) Lowest horizon slightly saline	Up to 4 horizons (to 260 cm) Clay loam to heavy clay pH 6.5-7.5, sometimes 8.0-9.0 (4.0 recorded at lowest horizon) Well structured Negligible to very high dispersibility (D%) Very high dispersibility (EAT) Most subsoil horizons slightly to moderately saline	Up to 5 horizons (to 270 cm) Light to medium clay to heavy clay pH 7.5-9.9 (4.5 in some lowest horizons) Usually well structured, sometimes massive Slight to moderate dispersibility (D%) High to moderate or very high dispersibility (EAT) Lower horizons slightly to moderately saline	Up to 4 horizons (to 230 cm) Sandy clay loam to medium to heavy clay pH 4.5-6.5, up to 9.5 at depth Poorly structure (massive), at times well structured Slight dispersibility (D% and EAT) Non-saline

Note:

D% - dispersion percentage
EAT - Emerson Aggregate Test

Table 2.3 - Soil attributes of geological formation/landform units

Geological formation	Garrawilla volcanics		
Landform	**Drainage line**	**Floodplain**	**Upper slopes**
Surface condition	Firm, surface stone absent	Loose to firm, surface stone absent or sometimes medium amounts (angular) to 15 cm	Loose or self mulching, some angular surface gravel and stone (1-15 cm) in upper layers
Topsoil	Up to 30 cm Medium to heavy clay pH 6.5 Well structured Slightly dispersible (D% and EAT)** Non-saline	Up to 46 cm Light sandy clay loam to sandy clay loam pH 5.5-6.0 Well structured Slightly dispersible (D% & EAT) Non-saline	Up to 36 cm Medium to heavy clay or heavy clay pH 6.0-9.0 Well structured Slightly dispersible (D%) Not or slightly dispersible (EAT) Non-saline
Subsoil	3 horizons (to 250 cm) Medium clay or medium to heavy clay pH 8.0-9.0 Well structured Very high dispersibility (D%) High or high to moderate dispersibility (EAT) Non-saline	3 horizons (to 250 cm) Light to medium clay to heavy clay pH 6.0-7.5 (sometimes 8.0-9.0 at depth) Well structured Slight to moderate dispersibility (D%) Slight to very high dispersibility (EAT) Non-saline	Up to 4 horizons (to 250 cm) Light to medium clay to heavy clay pH 7.0-9.0 Well structured Slight dispersibility (D%) Not or slightly dispersible (EAT) Non-saline

3. Land and soil capability classification

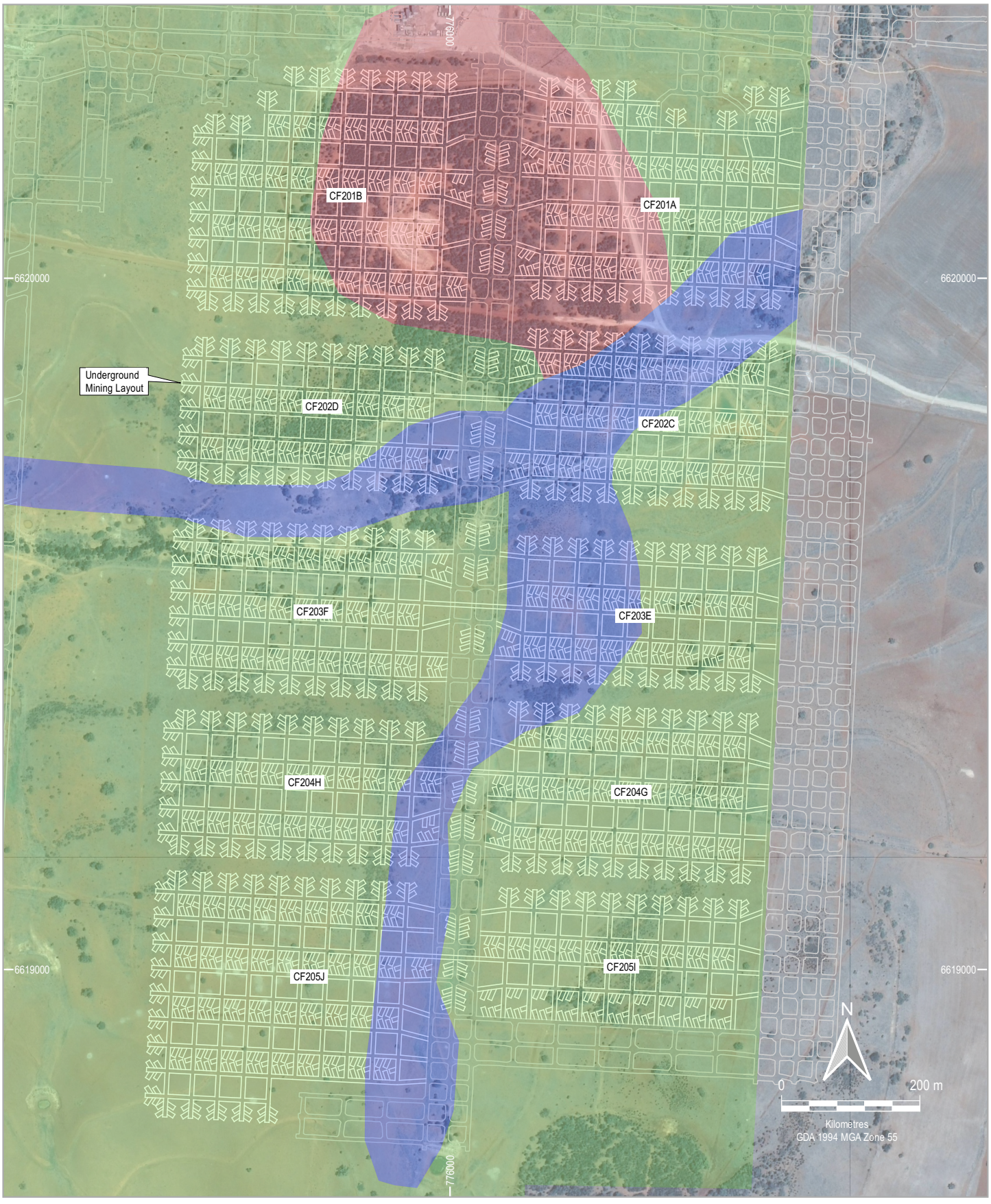
The *Land and Soil Capability Assessment Scheme - second approximation* (OEH, 2012) uses the biophysical features of the land and soil including landform position, slope gradient, drainage, climate, soil type and soil characteristics to derive detailed rating tables for a range of land and soil hazards. The land and soil capability classification (**LSC**) gives an indication of the land management practices that can be applied to a parcel of land.

Consistent with the current and historical land use practices, the Extraction Plan Area is capable of supporting grazing with small areas capable of opportunistic cropping and a limited portion capable of supporting a more frequent cropping regime. Land within the boundaries of ML 1609 has been classified according to its agricultural suitability. The majority of land above Panels 201 to 202 is LSC Class 3, with remaining areas Class 4 and Class 7. Table 3.1 provides a breakdown of the LSC class definitions, with Figure 3.1 presenting the LSC classification across Panels 201 to 202.

Table 3.1 - Land and soil capability classes

LSC class	General definition
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation).	
1	**Extremely high capability land:** Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.
2	**Very high capability land:** Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
3	**High capability land:** Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation).	
4	**Moderate capability land:** Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment, and technology.
5	**Moderate to low capability land:** Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.
Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)	
6	**Low capability land:** Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation
Land generally incapable of agricultural land use (selective forestry and nature conservation)	
7	**Very low capability land:** Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
8	**Extremely low capability land:** Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

Source: Table 2 in OEH, 2012.



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

LEGEND

- Land Capability Class 3
- Land Capability Class 4
- Land Capability Class 7

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NARRABRI COAL MINE

Figure 3.1: Land and soil capability classification above Panels 201 and 202

4. Surface water

4.1 Drainage

Narrabri Mine is located within the Tulla Mullen and Pine Creek Sub-catchment of the Namoi River Catchment. The Namoi River is located approximately 4 km to the east of the eastern boundary of the ML. As shown in Figure 4.1, tributary catchments in which Panels 201 to 202 are directly located include Kurrajong Creek Tributary 1, a 3rd-order watercourse. The creek, together with a number of smaller drainage features, are ephemeral watercourses that drain the mine site towards the north-east.

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. Kurrajong Creek No. 1 Tributary has 1 to 3.5 m high banks that extend for 20 to 120 m (DGS, 2021).

As highlighted in the EA, although surface water flows on and around the mine site only provide a minor contribution to the overall flows within the Namoi Catchment, the water is important to local landowners who use the water for stock watering and irrigation. Surface water flows are also important to the ecological health of the catchment, in particular the local flora and fauna which rely on good quality water.

Surface water and drainage are further addressed in the Water Management Plan (**WMP**), provided as Appendix G to the Extraction Plan. Water quality is further addressed in the Site Water Management Plan, required under a separate condition of the Project Approval.

4.2 Water storages

There are five farm dams for livestock watering (D49, D65, D66, D67 and D68) that have been assessed in the Extraction Plan Area. The dams are nearly all located within the 20 mm subsidence contour from the proposed Panels 201 to 202.

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

LEGEND

Drainage

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NARRABRI COAL MINE

Figure 4.1: Drainage Lines Above Panels 201 & 202

5. Potential subsidence impacts

5.1 Subsidence predictions

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 (Figure 5.1). 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 (from 34 % of the mining height [h] to 43 %h respectively), with the maximum gateroad access pillar subsidence ranging from 0.50 to 0.73 m (12 %h to 18 %h). The maximum panel tilt ranges from 14 to 36 mm/m, with the maximum panel concave curvatures range from 0.7 per kilometre (**km^{-1}**) to 3.3 km^{-1} (radii of curvature 1.4 to 0.3 km).

Maximum panel convex curvatures range from 0.7 to 3.1 km^{-1} (radii of curvature 1.4 to 0.32 km) with maximum panel compressive strains ranging from 7 to 31 mm/m. Maximum panel tensile strains range from 7 to 33 mm/m.

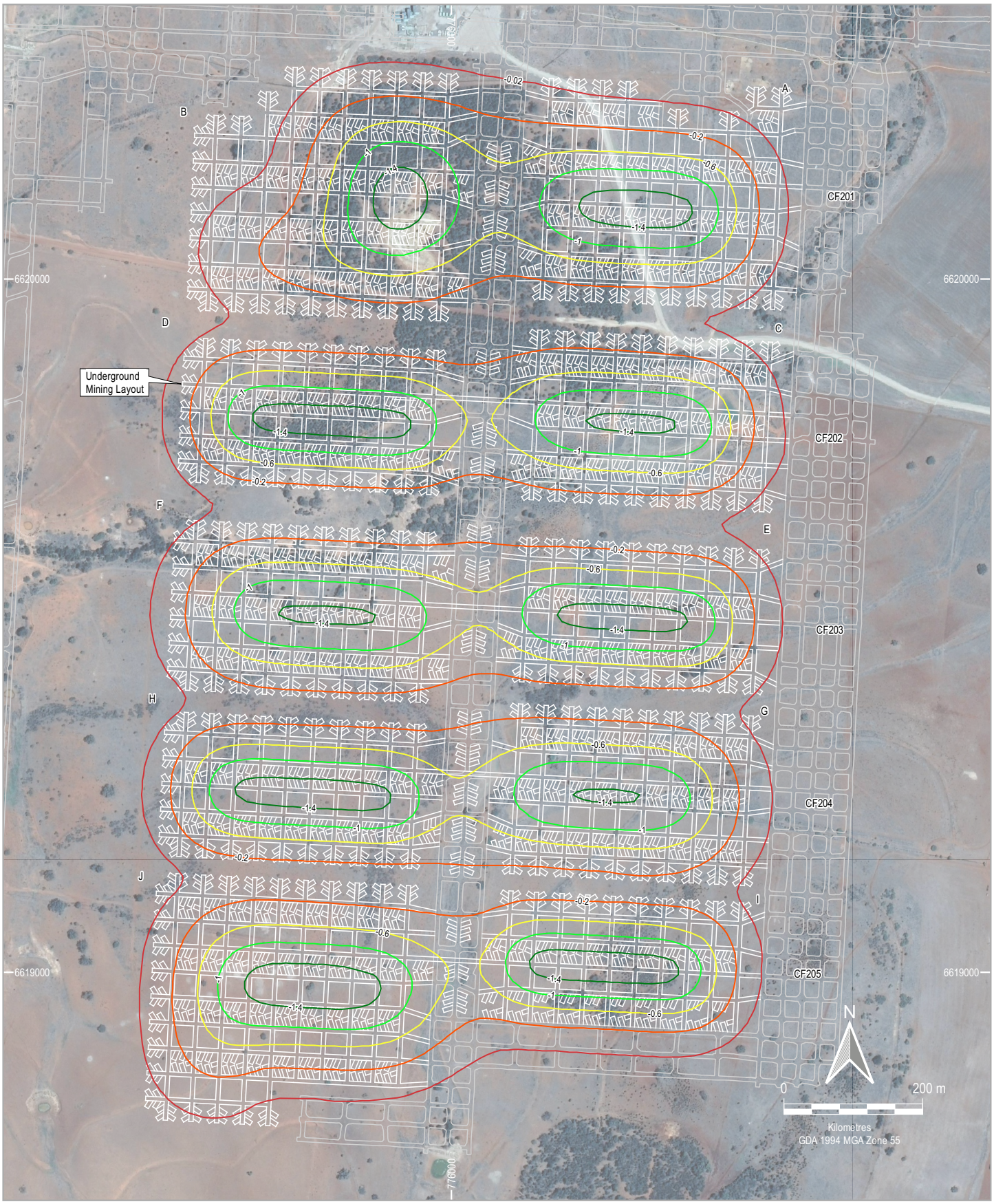
Detailed subsidence predictions are outlined within the Mine Subsidence Assessment for Panels 201 to 202 (DGS, 2021a and b), provided as Appendix B to the Extraction Plan. The subsidence effects (subsidence, tilt, curvature, horizontal displacements and strains) for the pillar reduction panels have been estimated based on published subsidence data for a broad range of coalfield geometries. Maximum predicted and observed subsidence values (worst-case scenarios) for extraction of these panels, as presented in Table 5.1, have been adopted for the purposes of this LMP.

Note that 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).

Table 5.1 - Maximum subsidence predictions

Panel	Final maximum subsidence (S_{max}) (m)	Maximum tilt (mm/m)	Maximum tensile strain (mm/m)	Maximum compressive strain (mm/m)
CF 201-A	1.77	22	16	17
CF 201-B	1.77	21	14	15
CF 202-C	1.77	24	19	20
CF 202-D	1.77	32	27	29
CF 203-E	1.77	31	27	29
CF 203-F	1.77	23	18	19
CF 204-G	1.77	23	18	19
CF 204-H	1.77	32	27	29
CF 205-I	1.77	36	31	33
CF 205-J	1.77	22	16	17

Source: Table 7A and Table 7B in DGS, 2021a.



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

LEGEND (m)
- -0.02
- -0.2
- -0.6
- -1
- -1.4

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NARRABRI COAL MINE

Figure 5.1: Predicted Subsidence Panels 201 and 202

5.2 Subsidence estimates

5.2.1 Surface cracking

Based on the predicted range of maximum strains and cover depths, DGS (2021, Table 12) has indicated the maximum surface cracking widths for sandy or loamy soils above the Extraction Plan Area are expected to be between 130-320 mm (Table 5.2). Where strain concentrations occur in near-surface rock, these widths may double locally to between 620-650 mm (Table 5.2). Crack widths may also exceed the predicted range near steep creek banks along Kurrajong Creek Tributary 1. Based on experience in the Newcastle Coalfields, cracks are likely to have fully developed by the time the longwall face has retreated past a given location by a distance equal to one to two times the cover depth.

Table 5.2 - Predicted maximum crack width for Extraction Plan Area in flat terrain

LW	XL	Panel width (m)	Cover depth (m)	Effective bay length (m)	Predicted maximum tensile strain (mm/m)		Predicted U95%CL crack width (mm)	
					Mean	U95%	Sand or loam	Clay or rock
CF201-CF205	6	235	182	10.0	7	31	310	620
	6	273	210	10.5	7	31	325	650

Source: Table 12 DGS, 2021

5.2.2 Sub-surface cracking

Sub-surface fracturing can either be continuous or discontinuous. Continuous fracturing refers to cracking above a longwall panel which would create a hydraulic connection to the workings if a sub-surface aquifer were intersected. This would result in increased water at seam level during longwall extraction. Discontinuous fracturing refers to an increase in horizontal and vertical permeability due to bending or curvature deformation of the rock mass. This type of fracturing can result in surface and sub-surface flow paths being altered, and rock mass conductivity and storage magnitudes being altered, however, groundwater or surface water resources may not undergo significant long-term change.

As presented in Table 5.3, direct hydraulic connection to the mine workings due to sub-surface fracturing is estimated to encroach within 27 to 70 m depth below the surface. The continuous fracture zone will likely develop below the surface, with surface to seam connectivity predicted as ‘likely’ by the SCT and Tammetta (non-Narrabri Coalfield) models. Fracturing above the Extraction Plan Area is predicted to extend to within 49 to 70 m depth.

Table 5.3 - Maximum subsidence predictions

Panel	Panel width (m)	Cover depth (m)	Predicted maximum A-zone height above Panel (m)		Depth to A-Zone (m)	Height of depressurisation (m)
CF201-CF205	188-287	182 - 210	99 - 149	89 - 131	49 - 70	0 - 59

Discontinuous fracturing would normally be expected to occur above the Extraction Plan Area, causing an increase in rock mass storage capacity and horizontal permeability without direct hydraulic connection to the workings.

Impacts associated with the discontinuous fracturing zone include:

- potential re-routing of creek flows into open cracks to below-surface pathways, with subsequent re-surfacing down-stream of the mining extraction limits;
- lowering of the water table; and
- disruption of tree root systems.

5.2.3 Erosion

Surface cracks on steep slopes may allow surface runoff to enter the rock mass. The seepage pathways could result in internal erosion and local instability to develop. Water pressures or concentrated flow may contribute to future instability such as reducing the effective frictional strength along the potential slide plane or contact surface. The likelihood of significant water pressures developing behind the slope faces however is low, as water is likely to drain through open joints or cracks and limit the head of water that can develop.

The rate of soil erosion is expected to increase significantly in areas with exposed dispersive/reactive soils and slopes <10° are expected to have low erosion rate increases, except for the creek channels, which would be expected to readjust to any changes in gradient for predicted gradient changes in the Extraction Plan Area of +/- 1.5°. Erosion along the creek beds would be expected to develop above Panels 201 to 202, between the panels, and on the side where the gradients increase. Sediment would be expected to accumulate where gradients decrease.

Significant erosion i.e., gully erosion is typically associated with unstable creek banks and soils exposed to flowing surface water. Field assessments in 2015 identified that larger gullies within the mining area were of similar characteristics to gullies observed outside the mining area, suggesting a broader land management influence on their origin. Further, smaller erosional features tended to be associated with subsidence cracks that had concentration of overland flow and led to erosion. Where these cracks intersected the creekline, erosion was generally exacerbated. Gully erosion can be classified according to the depth and width as shown in Table 5.4 and is further described in the Narrabri Mine Erosion and Sediment Control Plan.

Table 5.4 - Gully erosion rating

Gully depth	Associated rating
Cracks	A
<0.5 m deep, <0.5 m wide	B
0.5 – 1 m deep, <1 m wide	C
>1 m deep, >1.5 m wide	D

5.2.4 Valley closure and uplift

As detailed in the Mine Subsidence Assessment, 'valley closure' (or opening) movements can be expected across deep valleys whenever longwalls are mined beneath them. Valley closure can also occur across broader drainage gullies where shallow surface rock is present. When creeks and river valleys are subsided, the observed subsidence in the base of the creek or river is generally less than would normally be expected in flat terrain. This reduced subsidence is due to the floor rocks of a valley floor 'buckling' upwards when subject to compressive stresses generated by surface deformation. This phenomenon is termed 'upsidence' and mostly occurs in the Southern NSW Coalfields.

Survey measurements across Pine Creek Tributary 1 in October 2014 have indicated maximum closure of 148 mm between the 30 m wide creek bank crests, with compressive strain of 6.2 mm/m and uplift of 64 mm. Lines E and G did not detect any valley closure or uplift movements in the creek above the chain pillars due to LW 101 to 104. The measured movements are within the predicted range.

As the valleys across the Extraction Plan Area (characterised by the ephemeral creek lines described earlier) are very broad between crests, the development of 'upsidence' and closure along the creek beds above the Extraction Plan Area is likely to be 'negligible'.

5.2.5 Ponding and drainage lines

A total of seven potential ponding locations were assessed as part of the Mine Subsidence Assessment. Six of the potential ponding areas already exist along the watercourses and dams. Post-mining pond depths are estimated to range from 0.1 to 5.0 m. Pond depths are estimated to increase by up to 1.3 m or decrease by up to 0.19 m. The maximum changes in pond volume (where positive represents an increase in pond size) are estimated to range from -0.225 to 27.81 megalitres. There are three dams above CF203(F) that may be inundated by post-mining ponding, as presented in Table 5.5.

Overall, the existing ponds are expected to extend laterally from the watercourses for distances ranging from 50 to 500 m. Ponding can cause water logging resulting in tree stress, canopy die back and occasional tree death, altered drainage patterns, and loss of fauna habitat.

Watercourses that may be impacted include the ephemeral Kurrajong Creek Tributary 1. Surface water flowing to the creeks may pond in areas where it currently does not pond as a result of surface gradients changing. There may be a decrease in the quantity of water reaching the creeks as it ponds and evaporates rather than flowing to the creeks. There may also be a change in water quality as salinity may increase if water ponds over saline soils.

Subsidence ponds can become important features within an environmentally degraded landscape as they can provide habitat for waterbirds (including migratory species), frogs, eels, invertebrates and other aquatic species. Overtime it is expected that ponding will create enhanced ephemeral aquatic habitats.

Table 5.5 - Potential ponding summary for Panels 201 to 202

Potential Pond No. (Dam No.)	Panel	Pre-Mining Pond Levels (m, AHD)		Maximum Pre-Mining Pond			Post-Mining Pond Levels (m, AHD)		Maximum post-mining pond			Pond area change (10^6 L)
		Top	Bottom	Depth h(m)	Area (ha)	Vol (ML)	Top	Bot	Depth h(m)	Area (ha)	Volume (ML)	
Pillar reduction panels												
P19	CF201(B)	299.9	299.3	0.60	0.336	0.672	298.6	298.2	0.41	0.530	0.724	**0.052**
P20	CF203(F)	290.0	289.9	0.10	0.280	0.093	289.1	288.8	0.33	1.214	1.335	**1.242**
P21 (D67/68)	CF203(F)	289.9	289.76	0.15	0.355	0.178	289.3	288.6	0.71	1.496	3.541	**3.363**

6. Potential environmental consequences to land

The predicted subsidence impacts may trigger a number of environmental consequences related to land. The assessment of the predicted impacts and potential consequences on land include:

- agricultural consequences:
  - soil erosion and deposition;
  - altered soil moisture and nutrient distribution; and/or
  - reduced pasture productivity.
- creek line consequences:
  - in-stream ponding;
  - over-bank ponding;
  - alteration of overland flow paths;
  - localised bank and channel erosion and scouring; and/or
  - increased in-stream sedimentation.

Potential land resource impacts describe in the MOD 5 environmental impact assessment would be limited to impacts associated with mine subsidence as the size of the surface development footprint has remained unchanged. Potential impacts on soils and agricultural productivity assessed as part of MOD 5 were assessed to be associated with the following subsidence impacts:

- surface cracking; and
- ponding and changes in stream alignment.

Incremental subsidence effects due to MOD 5, including changes to potential cracking and ponding/stream alignment would be limited (i.e., the level of impact would not change relative to the original approval). Therefore, changes to impacts on land resources are not anticipated to be material. The predicted subsidence impacts, consequences and hazards associated with land are summarised in Table 6.1.

The MOD 7 environmental impact assessment identified that the change in coal extraction from longwall panels to board and pillar would generally result in reduced subsidence effects as the approved surface development footprint would be unchanged; therefore, no material change in approved impacts are expected.

Potential environmental consequences associated with subsidence are detailed in Table 6.1.

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Table 6.1 - Environmental consequences associated with land subsidence

Subsidence impact	Subsidence consequence	Potential environmental hazard to land	Ecological/agricultural response to land
Surface subsidence troughs	Altered surface and sub-surface flow.	• Re-routed surface flows into areas not currently subject to concentrated flows leading to redirection of soil moisture and material/chemicals transported by flow; and/or • increased risk of erosion.	• altered drainage / erosion patterns, altered soil moisture and/or nutrient distribution patterns reducing vegetation condition; • soil loss, bank instability, loss of agricultural land, decrease of water quality (elevated turbidity and total suspended solids (TSS)) of flows during rainfall events; and/or • decreased land and agricultural capability.
	Damage to contour banks.	Increased erosion.	Soil loss, bank instability, loss of agricultural land, decreased land and agricultural capability.
	Ponding (in-stream and overbank).	• drainage channel re-alignment; • localised water logging of pasture; • potential decrease in water quality (elevated EC) of receiving catchment (where ponding occurs over saline soils); and/or • increased surface infiltration.	• Altered soil moisture or nutrient distribution patterns; • Reduced land and agricultural capability, loss of agricultural land; and/or • Reduction in surface water quality.
	Landslip of surface terrain.	Increased erosion.	• soil loss and exposure of sub-soils; • sedimentation of drainage lines; and/or • loss of agricultural land.
	Altered ground surface, including sequence of troughs and ridges akin to chain-of-ponds (corresponding with subsidence troughs and chain pillars respectively).	• altered overbank surface gradients; • altered channel gradients and/or alignments; and/or • headcuts associated with increased land surface slope.	• increase or decrease in surface flow velocity, including deposition of suspended solids • increased erosion of creek bed / banks leading to loss of riparian vegetation, loss of soils, loss of agricultural land, increased sedimentation of drainage lines; and/or • altered drainage / erosion patterns, altered soil moisture and/or nutrient distribution patterns reducing vegetation condition.
Surface and sub-surface cracking	Exposure of dispersive subsoils.	Increased erosion.	• soil loss; • bank instability; • loss of agricultural land; and/or • decreased land and agricultural capability.
	Interconnection from seam to surface and near surface cracking (increase in infiltration).	Altered surface and sub-surface flow - reduction in surface and stream flows.	• changes to both surface and groundwater availability; • redirection/loss of soil moisture and material/chemicals transported by flow; and/or • decreased land and agricultural capability.
	Redeveloped cracking.	• risk to livestock, stock handlers as well as personal safety; and /or • increased erosion.	• risk to safety of stock and/or mine personnel; and/or • soil loss, loss of agricultural land.
Valley closure and uplift	Localised deviation/re-routing of surface flows.	Localised loss of surface flows.	• redirection/loss of soil moisture and material/chemicals transported by flow; and/or • decreased land and agricultural capability

7. Performance criteria

The performance criteria have been developed to measure performance against the maintenance and re-establishment of agricultural land of comparable land capability (e.g., LSC Class 3). Performance measures and performance criteria are listed in Table 7.1.

Table 7.1 - Performance measures and indicators for land management for Panels 201 to 202

Objective	Performance measures	Performance criteria
To maintain the pre-mining land and agricultural capability of the mine site.	Surface cracking	Permanent cracks (which do not self-close within one month after mining) are remediated as soon as practicably possible (and safe to do so).
		Surface cracking that does not self-correct will be remediated to prevent erosion and slope instability issues within 1 month after mining.
	Topographic form (LiDAR):	
	Landscape morphology	Subsidence across landscape does not exceed subsidence predictions for Panels 201 to 202.
	Creek lines	Change to overall drainage pattern is not more than predicted.
	Groundcover (multi-spectral images – erosion and pasture cover)	Identified areas of normalised difference vegetation index (**NDVI**) change (greater than 1 standard deviation from the mean change) investigated in the field to determine the source of the change.
		Site specific management report prepared, and recommendations implemented where necessary.

8. Monitoring

Given the size, multiple land uses and key environments across the ML, a multi-scale, multi-data source monitoring approach has been developed to monitor the consequences of mining on land within the Extraction Plan Area. This is presented in Table 8.1.

At the local scale, a program of field surveys based on a stratified random and targeted design will be implemented for agricultural, creek line and gully areas. Surveys will be directed into 'control' and 'impact' areas to allow direct comparison between these areas through time and space. Whole-of-site monitoring using remote sensing data (LiDAR and multi-spectral imaging) is proposed to monitor the entire target area including control areas followed by targeted field work to examine the causes of any change highlighted.

It is to be noted that the Subsidence Monitoring Program is presented in Appendix C to the Extraction Plan.

Table 8.1 - Multi-scale monitoring program for Panels 201 to 202

Data source	Method	Scale	Purpose
Visual Inspection	Visual assessment	Area immediately behind longwall face for full panel width	Immediate consequences of subsidence, particularly surface cracking, landslip, and erosion
Remote sensing	LiDAR	Entire site	Topographic form and change
	Multi-spectral imaging	Entire site	Agricultural pasture cover / biomass Erosion monitoring
Direct field survey	Field inspection and sampling/testing as required	Areas of change[1] identified using remote sensing techniques	Confirm changes in pasture, biomass or soil characteristics and areas of erosion to identify cause and management requirements
Creek line and gully survey	Geomorphic survey	Along creek lines and gullies	Creek stability and condition
	Cross-sections	Targeted pools and ponds	Bank and bed stability

Note:

1. Compared to control sites and/or over time (not related to seasonal or broad scale variation).

8.1 Baseline monitoring

LiDAR data has been collected over the approved mining area and used to identify the extent of steep slopes, cliffs and subsidence contours for all of the extracted longwalls to-date. The measured subsidence contours were derived from the December 2009 and December 2020 LiDAR levels.

Subsidence monitoring lines have been installed above LW 101 to 109 and have been used to calibrate the subsidence model for the mining area above Panels 201 to 202. The subsidence lines consist of star pickets driven to refusal at 10 m spacing. The star pickets are surveyed using total station with static point control before and after mining effects. The surveys to date indicate systematic errors between surveys ranging from <20 mm to >45 mm, which are mainly due to seasonal clayey soil moisture changes.

Ground truthing of the LiDAR-based subsidence contours was conducted from the survey lines. LiDAR of the ground surface in the mining area was then processed to develop a 3-D digital model of the landscape on a

1 m square grid. Slope locations (slope and height) were ground-truthed, with the mapping information and are clearly definable where slope gradients exceed 18°.

8.2 Visual inspections

Visual inspection of the surface environment above each Panel will be undertaken by NCOPL personnel. Observations of any subsidence effects such as surface cracking, ponding, landslips, and erosion will be recorded and reported to the Environment Superintendent as they are identified. Surface cracks are considered permanent if they have not closed within one month of the longwall face passing. Where this occurs, appropriate management measures will be implemented as detained in section 9.

8.3 Ponding

Identification of ponded areas will be performed during the visual inspections to determine the location and extent of ponding within the predicted subsidence zones. Monitoring will record the location, the extent of ponding (size) and if there is significant vegetation within the ponded area that may require monitoring of vegetation health[3]. For ponding where there is little or no vegetation of conservation significance, the extent of ponding will be monitored to assess the risk of downstream impacts.

Where impacts to significant vegetation are detected (e.g., canopy dieback), vegetation monitoring will be conducted in accordance with the Biodiversity Management Plan (**BMP**).

8.4 Remote sensing

It is proposed to use remote sensing data (LiDAR and multi-spectral imaging) to monitor the entire target area, including control areas. The remotely sensed data will allow quantitative comparison of key land surface condition parameters in creek line and agricultural environments. Repeat capture and analysis of the multi-spectral imagery will highlight areas of change in land cover beyond those found in control areas. Targeted on-ground assessments will then be undertaken to examine the causes of any change highlighted.

The target area for this LMP is the surface environment above and surrounding Panels 201 to 202 within the predicted subsidence impact zone. Control sites will be selected from zones where no subsidence impacts have been predicted. These control sites will have similar characteristics and biological condition to the target area. Table 8.2 details the surface zones to be used for impact monitoring.

Table 8.2 - Surface zones for monitoring

Surface zone	Definition	
Longwall	Zone of maximum subsidence.	>2 m predicted subsidence.
Transition	Zone of maximum stress and tilt.	0.1 – 1.5 m predicted subsidence.
Pillar	Zone above the pillar with minimal subsidence.	
Control	Zones of no impact located outside of any predicted subsidence zone.	

[3] Vegetation health will be monitored in accordance with the Biodiversity Management Plan.

8.4.1 LiDAR processing and analysis

The purpose of these surveys is to detect changes in topographic form and landscape morphology over time, including creek slope, width and depth. LiDAR processing and analysis will be undertaken at baseline and then every three years (triennially) thereafter. LiDAR data will be captured across the target area and identified control areas. The data will be processed into a land surface digital elevation model (**DEM**) across the entire landscape. Subsequent LiDAR captures will be processed similarly (i.e., DEM products) and each new dataset will be subtracted from those produced from earlier captures creating a series of DEM change images.

LiDAR datasets can describe channel width and depth, especially where a creek has formed a distinct channel (>1 m depth and 2 m wide). These datasets will enable the long-profile and volume of a creek/s to be documented and changes in creek slope, width and depth quantified.

Best results will be derived from repeat data capture and image to image comparison. These comparisons may provide accurate reach length assessment of erosion and deposition. Each dataset produced will be used to create a map for visual interpretation and analysis and for communication of results.

8.4.2 Multi-spectral image processing and analysis

The purpose of these surveys is to detect changes in vegetation cover characteristics and erosion in agricultural areas. The high-resolution multi-spectral imagery (World View, Geoeye, Quickbird or similar) will be stratified into four impact zones (i.e., longwall, transition, pillar, control) and processed into a normalised difference vegetation index (NDVI). Each subsequent dataset will be subtracted from those produced from earlier captures creating a series of change images.

A targeted field survey will be performed (section 9) where monitoring indicates potential impacts have/are occurring (e.g., weed infestation or erosion impacts to vegetation). Significant weed infestations are likely to be detected as changes in image derived vegetation density information. Erosion and sedimentation can result in loss and/or smothering of vegetation, which would also register in imagery, and would be targeted for direct field survey. Targeted surveys will be directed to investigate the source of the change and implement any planning, management action or change in management procedures required.

8.5 Creek line and gully surveys

Creek line and gully surveys have been designed to identify the main geomorphic zones and to provide quantitative information that can document changes in channel cross-section, bed erosion and deposition. Geomorphic zones will be defined during the baseline survey based on stream order, dominant channel bed material, bed stability, channel geometry etc.

Locations for cross-sections will be determined during the baseline survey to confirm channel parameters (i.e., channel width, depth, area, and bank full level). A reach of at least 100 m in length shall be surveyed from each geomorphic zone and at least four cross sections recorded at equal intervals along the reach. Two to three reaches each at least 100 m long within a control zone should also be surveyed to provide information on natural channel variability between survey periods. These control surveys will provide an indication of natural variability due to rainfall events that can be used to determine if channel changes are mining-induced (e.g., changes to channel area and bed slope, erosion of channel banks and bed, or sediment deposition). Permanent pegs will be established at each cross-section to ensure comparability of cross-section sequences.

Creek line surveys should be undertaken annually either in late winter or early spring and after significant rainfall event (defined as a 5-day 95th percentile rainfall event which is 38.4 mm over 5 consecutive days).

Restriction of flows and hence restriction of fish passage will be assessed following a rainfall event to facilitate appropriate restorative measures (if required). The final location of on-going monitoring reaches and cross-sections will be determined following the completion of the baseline survey.

8.6 Monitoring program

Table 8.3 provides the monitoring program which details the monitoring required under this LMP.

Table 8.3 - Land monitoring program

Aspect/feature	Frequency	Method and analysis	Parameters
Surface cracking			
Surface cracking within predicted subsidence zones.	Weekly and following a significant rainfall event. Continue for a period of at least 2 years following mining of each panel.	Visual inspections to: • identify areas of surface cracking; • document cracking locations, depth and width using GPS; • identify erosion/potential erosion; • record nature and extent of sedimentation (location, extent, depth, sediment calibre); • displacement monitoring above proposed LW 204; and • determine appropriate management response.	• crack location and size; and • evidence of erosion (e.g., nick points, head cuts).
Areas susceptible to landslip, drainage lines and steeply sloped areas of exposed Purlawaugh Formation derived subsoils.	Quarterly following identification via visual inspection of landslip or gully erosion.		• landslip location and impact; and • location and size of steep slope or drainage line erosion (e.g., gully erosion).
Surface cracking in drainage lines.	Following a significant rainfall event (defined as a rainfall event >38.4 mm over 5 consecutive days)		• bed and bank stability; and • erosion and potential for erosion.
Ponding	Quarterly for a period of 2 years following mining of each panel.	Visual inspection of watercourses over the subsidence zone and predicted ponding areas to identify the location and extent of ponding.	• location, width, depth, area. • vegetation health monitoring is to be conducted in accordance with the BMP and water quality electrical conductivity monitoring in accordance with the WMP.
Remote sensing			
Topography and landscape morphology.	Baseline then every 3 years (triennially).	LiDAR over entire site.	• high resolution topography; and • creek line slope and volumes.
Vegetative cover characteristics and erosion monitoring.	Baseline and then annually in early spring.	Multi-spectral imaging (NDVI).	• vegetative biomass and cover (pasture); • weed presence; and • erosion.
Soil water monitoring in agricultural areas.	Annually in spring.	EM 38[1]	Data capture: • soil moisture; and • nutrient zones.
Agricultural survey	Annually in spring.	Pasture survey and soil survey within agricultural zones (soil type, paddock).	• pasture biomass and composition; and • soil nutrient status
Woodland survey	Annually in spring.	Vegetation, fauna and soil survey within remnant and riparian patches.	• woodland health and function; and • soil condition.
Creek line surveys			
Geomorphic survey	Baseline and then annually in late winter/early spring.	Geomorphic survey: • mapping and description; and • survey (100 m reach).	Representative geomorphic zones.
Channel survey	Baseline and then annually in late winter/early spring.	Cross-sections: • cross-section diagrams; and • channel parameters.	• identification of ponding - width, depth, area; • advancement of gully erosion; and • effectiveness of gully erosion stabilisation methods.
Direct field survey	Following changes detected during remote sensing (ANOVA).	• field inspection; and • sampling/testing as required.	Determined during field survey.

Note:

1. EM 38 - proprietary electromagnetic monitoring device for rapid soil water moisture monitoring.

9. Management measures

9.1 Surface cracks

Minor cracks are not expected to require remediation as geomorphological processes would likely result in these cracks filling naturally over time. However, if surface cracks have not self-corrected within one month, remediation will be required. Remediation of the larger surface cracks would generally be undertaken using conventional earthmoving equipment (such as backhoe or grader) and would involve ground disturbance associated with in-filling of surface cracks by cultivation of the ground surface or in-filling with suitable soil or other material.

The options available for managing surface cracks are (in order of increasing impact to mining):

- post-mining inspections of the surface during subsidence development above a given panel and map crack locations and their geometry (widths, lengths, depth, photograph) (refer to section 8);
- repair large surface cracks after subsidence development for a given panel (rip or grade where necessary);
- large surface cracks that cannot be filled by surface ripping or grading will be filled using subsoil stockpile material from stockpiles maintained at nearby gas drainage or ventilation sites or material from within the footprint of the Reject Emplacement Area; and
- leave a barrier pillar or increase set-back distances from a sensitive area, or restrict mining.

Prior to any remediation of surface cracks, NCOPL will undertake a review of environmental impacts that may result from the remediation at the specific location and consider whether remediation of surface cracks is environmentally beneficial or, if alternative methods of remediating the crack are warranted (e.g., without machinery). Any remediation of watercourses should be undertaken in consultation with the relevant government agencies.

9.2 Sub-surface cracking

The following measures are proposed to manage sub-surface fracturing:

- monitor rainfall deficit and underground water makes or changes to ventilation during active mining to detect surface to seam connectivity;
- repair surface cracks after active subsidence is complete; and
- install further borehole extensometers and piezometers to monitor the height of fracturing development for multiple 400 m wide longwalls after supercritical conditions develop (most of the sub-surface fracturing prediction models consider impacts due to one or two longwalls only).

9.3 Steep slopes

To minimise the hazards associated with steep slope instability, such as increased erosion due to cracking or changes to drainage patterns after longwall extraction, management measures include:

- surface slope displacement monitoring along subsidence cross lines, combined with general subsidence monitoring, to be spatially mapped (start and end coordinates, width, depth, length, and photographed) after subsidence development has ceased via LiDAR surveys);
- in-fill surface cracking to prevent excessive ingress of run-off into the slopes:

  - backfill cracks with durable, free-draining gravel or sand with some erosion control measures such as re-vegetation;
  - repairs to cracks may require additional vegetation clearing and non-conventional repair methods (due to poor access for conventional equipment);
  - methods such as remote pumping of sands (sluicing) and/or cementitious grout may be needed and would require environmental spill and safety management controls.
- conduct mitigation works such as re-grading, installation of new contour banks and revegetation of exposed areas in areas that are significantly affected by erosion after mining; and
- on-going review and appraisal of any significant changes to surface slopes such as cracking along ridges, increased erosion down slopes, foot slope seepages and drainage path adjustments observed after each longwall is extracted.

In the unlikely event of large-scale slope instability and erosion stabilisation remediation actions will be undertaken. Such actions would include:

- installation of deep sub-surface drainage trenches and the construction of catch drains along slope crests so that surface run-off is controlled; and
- stabilisation works undertaken along sections of bank which are damaged or steeply eroded. These works would be conducted in accordance with the Erosion and Sediment Control Plan which forms part of the Water Management Plan for the site.

9.4 Erosion

Measures to minimise erosion as a consequence of subsidence are to be implemented at least quarterly. For gully erosion rated A or B (refer to Table 5.4), management measures are commensurate with the measures for surface cracks as detailed in section 9.1.

For gully erosion rated C or D that is the direct result of subsidence, the following measures may be considered:

- grade banks to stop the upslope concentration of flow and stabilise through revegetation:
  - graded bank diversionary structures may need to be installed on a suitable grade to ensure flows that are diverted away from the gullies with consideration of ground surface, soil type and design flows; and
  - sow perennial pasture species in accordance with the Rehabilitation Management Plan.
- fill using rocks or rubble sourced from site or reshape using an excavator, or a combination of both. After filling, it is recommended that they be dressed with topsoil to encourage rapid establishment of vegetation; or
- diversion banks to convey flows to a safe disposal area where water will naturally spread and not concentrate into erosive volumes and velocities. Where safe disposal areas are not available, the construction of a suitable drop structure to safely convey diverted flows into creek lines will need to be considered.

Depending on the nature of the soils and the availability and quality of topsoil, consideration should be given to the use of soil ameliorants to improve the soil structural stability. This will improve rehabilitation and revegetation outcomes. The mine site may respond particularly well to the use of gypsum to address the highly dispersible soils. Temporary sediment fencing should be installed below any areas to be disturbed and be maintained until such time as disturbed areas have revegetated. Erosion and sediment control planning, installation and maintenance will be implemented in accordance with *Managing Urban Stormwater: Soils and Construction - Volume 1* (Landcom 2004), more commonly known as the ‘Blue Book’.

9.5 Valley closure and uplift

The impact of 'upsidence' and valley bending effects along creek lines have been, and will continue to be, monitored and managed as follows:

- installation of survey lines along and across ephemeral drainage gullies and bank crests during and after longwall undermining. Surveys are correlated with visual inspections to locate damage (cracking, uplift);
- review predictions of 'upsidence' and valley crest movements after the extraction of each longwall; and
- assess whether repairs to cracking, as a result of 'upsidence' or gully stabilisation works, are required to minimise the likelihood of long-term degradation or risks to personnel and the general public.

At this stage, no damage to the creeks as a result of valley closure or uplift has been detected based on visual inspections. It is recommended that the above measures continue to be implemented for the Extraction Plan Area.

9.6 Ponding and drainage lines

The standard management measures for ponding include:

- ponding located in areas with no significant vegetation, or if vegetation is not affected and the water quality of the ponded water is non-saline, the ponding will to be allowed to self-correct; or
- ponding in areas with significant vegetation or if ponding significantly alters or affects flows, these ponds are to be assessed and remedial measures (e.g., drainage) developed and implemented in consultation with a geomorphologist.

Additional management measures include:

- ponding water will be sampled in accordance with the frequency specified in the Water Management Plan to test for water salinity changes. The monitoring frequency can be adjusted, as dictated by the results. Over time, regular water testing will build up a general trend for the condition of the water being collected. Further investigation can then be started, should these trends change during the mining operations;
- if important environmental features are impacted (i.e., riparian vegetation, Endangered Ecological Community or archaeological deposits), or water quality analysis indicates an increase in salinity, the ponding will be assessed, and remediation options will be developed to protect the affected environmental features and prevent saline water discharging downstream.

10. Trigger action response plan

The monitoring program outlined in this LMP aims to identify the impacts that board and pillar extractions may have on land above Panels 201 to 202. In the event that subsidence impacts on land exceed those predicted in the EA and/or the performance measures and indicators nominated in this LMP (or are considered likely to be exceeded based on observed trends), NCOPL will implement the contingency responses and adaptive management detailed in the Trigger Action Response Plan (**TARP**) (Table 10.1).

Contingency measures and adaptive management must consider the specific issue and an assessment of environmental consequences. Relevant actions may include the implementation of the management measures and procedures identified in section 9. Further detail on contingency measures for remote sensing, creek line surveys and mine safety pre-conditioning is provided in Attachment 2.

Table 10.1 - Land management TARP

Aspect	Monitoring		Response		
	Methodology	**Purpose**	**Trigger**	**Action**	**Responsibility**
Surface cracking	**Sites:** • affected panel/s, including drainage lines above affected panels **Parameters:** • crack width and location; and • evidence of erosion. **Analysis:** • appearance of new surface cracks after longwall face has passed; and • permanency of cracking. **Frequency:** • at least weekly and, following a significant rainfall event until cracking disappears and then repeat after a 12-month period.	• identify area/s of surface cracking as a result of subsidence; and • determine appropriate management response and remediation measure/s.	**Level 1** • surface cracks <50 mm remain present within one month of the longwall face passing.	**Level 1** • document occurrence of surface cracks; • continue monitoring; and • summarise occurrence in relevant reports.	Environmental Superintendent
			Level 2 • surface cracks >50 mm and <330 mm remain within one month of the longwall face passing; and/or • erosion as a result of cracking identified.	**Level 2** *As for Level 1* • provide safety fencing and signage if required; • advise relevant stakeholders; • implement remediation measures as appropriate – these may include ripping of surface cracks, filling of cracks with grout, spoil or other self-cementing material; • implement appropriate control measures as outlined in the Extraction Plan Erosion and Sediment Control Plan; and • review monitoring program as required.	
			Level 3 • surface cracks >330 mm remain present within one month of the longwall face passing; and/or • surface cracking prevents functioning of contour banks.	**Level 3** *As for Level 2* • make area safe; • investigate the reasons for exceedance of predictions; and • review and update predictions and assessment of potential impacts.	
Topography and landscape morphology form	**Sites:** • affected longwall panel/s **Parameters:** • digital elevation model derived from LiDAR; and • creek line drainage path/s and creek line slope and volumes. **Analysis:** • comparison to baseline DEM. **Frequency:** • every 3 years.	• document baseline landscape morphology; • identify and quantify topographic change; and • document baseline creek line drainage path/s and creek line slope and volumes; and • identify changes in creek line drainage path/s and creek line slope and volumes.	**Level 1** • surface gradient change as detected by LiDAR is >1.5% and <3%; and/or • length of eroding streambank increases more than 10% compared to baseline.	**Level 1** • document observed changes; • continue monitoring; and • summarise occurrence in relevant reports.	Environmental Superintendent
			Level 2 • surface gradient change as detected by LiDAR is >3% and <5%; and/or • length of eroding streambank increases more than 15% compared to baseline.	**Level 2** *As for Level 1* • consult geomorphologist or other appropriately qualified and experienced specialist to review DEM and conduct site investigation to assess changes and provide recommendations for remediation which may include re-establishing drainage pathways with earthworks and implementation of erosion control measures; and • notify relevant agencies if in-stream works are to be undertaken.	
			Level 3 • surface gradient change as detected by LiDAR is >5%; and/or • length of eroding streambank increases more than 20% compared to baseline.	**Level 3** *As for Level 2* • make area safe (if applicable); • investigate the reasons for exceedance of predictions; and • review and update predictions and assessment of potential impacts.	

Aspect	Monitoring		Response		
	Methodology	**Purpose**	**Trigger**	**Action**	**Responsibility**
Vegetative cover – pasture (multi-spectral images)	**Sites:** • affected panels and control zones outside of subsidence impact zone. **Parameters:** • multi-spectral imaging - NDVI (relative plant biomass and cover). **Analysis:** • comparison to baseline NDVI values and maps; and • comparison against trends documented in control zones. **Frequency:** • annually (spring)	• document baseline variability in vegetative cover; • document ongoing variability in vegetative cover; and • inform targeted on ground assessment/s and subsequent management responses.	**Level 1** • remote sensing change detection identifies no change (i.e., within +/- 1 std dev from average) in an area that exceeds 0.1ha.	**Level 1** • no action required, continue monitoring.	Environmental Superintendent
			Level 2 • remote sensing change detection identifies change > +/- 2 std dev from average in an area that exceeds 0.1ha which is not related to surface activities (e.g. ripping for sowing, installation of infrastructure)	**Level 2** *As for Level 1* • conduct site investigation to determine the cause of change (e.g., weed invasion, erosion, sedimentation, surface cracking) and appropriate management response; and • review monitoring program as required.	
Creek stability and condition	**Sites:** • representative reaches within affected panels and control reaches; and • selected cross sections within representative reaches of panels and control reaches. **Parameters:** • geomorphic characteristics; and channel width, depth via cross sectional surveys. **Analysis:** • geomorphic survey (field survey); and • comparison of cross-sectional surveys to determine any change in cross section and restriction to flows (after rainfall). **Frequency:** • at least annual (ideally in late winter/spring and following a significant rainfall event (i.e., an event which results in continuous overbank surface flow at surface water monitoring locations; and • LiDAR survey every 3 years.	• define geomorphic zones of drainage lines; • establish the baseline status of each zone; and • document ongoing status of each zone.	**Level 1** • field survey indicates <20% increase in length of eroding creek line; and/or • surface drainage pattern is unchanged.	**Level 1** • document observed changes; • continue monitoring; and • summarise occurrence in relevant reports.	Environmental Superintendent
			Level 2 • field survey indicates >20% increase in length of eroding creek line; and/or • surface drainage pattern is significantly altered.	**Level 2** *As for Level 1* • consult geomorphologist or other appropriately qualified and experienced specialist to determine the extent of the impact, identify contributing factors and determine appropriate remediation measures; • implement contingency measures as identified in other plans as relevant (e.g., the Subsidence Monitoring Program as Appendix C to the Extraction Plan); • consult with relevant agencies and stakeholders prior to remediation works being undertaken; and • review monitoring program as required.	

11. Plan implementation

11.1 Roles and responsibilities

To ensure adequate implementation of this LMP, the following responsibilities have been assigned to relevant NCOPL personnel as detailed in Table 11.1. It is also noted that additional responsibilities are referred to within the Extraction Plan and the appended sub-plans.

Table 11.1 - 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 LMP. • Communication with statutory agencies and departments, public authorities and the community.
Mine Manager	• Ensure all contractors, sub-contractors and service-personnel are appropriately qualified, competent and licensed to undertake the required work and have a good environmental performance record. • Ensure the LMP is implemented and adhered to.
Environmental Superintendent	• Ensure that all environmental monitoring and reporting are undertaken in accordance with this LMP and various approval requirements, and is checked, processed, and filed appropriately. • Advise on matters identified in all approval, permit, licence and consent documents and ensure all operations are conducted in compliance with those conditions, and all other environmental obligations. • Liaise with stakeholders regarding subsidence impact management. • Authorise changes to this LMP.
Registered Mine Surveyor	• Ensure that all surveys are carried out to the accuracy required, within specified timeframes and are checked, processed, and filed appropriately.

Though retaining the responsibilities identified above, these personnel may, at their discretion, delegate specific tasks to suitably qualified and experienced operational personnel or consultants.

12. Reporting, evaluation and review

12.1 Annual Review

In accordance with Schedule 6 Condition 6, NCOPL will review the performance of its land management 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 management measures to prevent, and if prevention is not reasonable and feasible, to minimise any impact associated with land management.

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 land management process.

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

12.2 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.

12.3 Management plan 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 LMP. 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 Plan provides the details of each review.

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

13. Incidents and non-compliance

13.1 Incident notification

An incident is defined under the Project Approval as *a set of circumstances that causes or threatens to cause material harm, and/or breaches or exceeds the limits of performance measures/criteria*. Material harm to the environment is defined under the Project Approval as *involving actual or potential harm to the health or safety of human beings or to the environment that is not trivial.* This definition excludes "harm" that is authorised under either the Project Approval or any other statutory approval (e.g., the EPL).

In the event of any exceedance of performance criteria, NCOPL will advise the Secretary and any other relevant agencies as soon as practicable after becoming aware of the incident, in accordance with Schedule 6 Condition 4. Within 7 days of the event, NCOPL will also provide the Secretary and any relevant agencies a detailed report which will:

- describe the date, time and nature of the exceedance/incident;
- identify the cause (or likely cause) of the exceedance/incident;
- describe what action has been taken to date; and
- describe the proposed measures to address the exceedance/incident.

Notifications to the EPA will be made by contacting the Environment Line service on 131 555 and written details of the notification will be provided within 7 days of the date on which the incident occurred.

Incident reporting and emergency response is further described in NCO's Environmental Management System.

13.2 Non-compliance notification

In accordance with Schedule 6 Condition 2, where a non-compliance with statutory requirements or an exceedance of the relevant criteria or performance measures has occurred, NCOPL will, at the earliest opportunity, take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur. Once this has been achieved, all reasonable and feasible options for remediation (where relevant) will be considered.

In accordance with Schedule 6 Condition 4, within seven days of becoming aware of a non-compliance, NCOPL will notify DPE of the non-compliance[4]. The notification will be made in writing via the Major Projects website and identify the development (including the development application number and name), set out the condition or requirement that the development is non-compliant with, why it does not comply and the reasons for the non-compliance (if known) and what actions have been, or will be, undertaken to address the non-compliance.

NCOPL will implement any reasonable remediation measures as directed by the Secretary, to the satisfaction of the Secretary.

[4] A non-compliance which has been notified as an incident under section 13.1 does not need to also be notified as a non-compliance.

14. Complaints management

Any complaints received in relation to this LMP will be managed in accordance with the complaints management protocol, as follows:

- publicly advertised telephone complaints line, 1800WHAVEN, will be in place to receive complaints;
- each complaint received will be recorded in the Complaints Register, which will include the following details:
  - date and time of complaint;
  - method by which a complaint was made;
  - personal details the complainant wishes to provide or, if no such details are provided, a note to that effect;
  - nature of the incident that led to the complaint;
  - action taken by NCOPL in relation to the complaint (i.e., any required remedial actions), including any follow-up contact with the complainant; and
  - if no action was taken, the reason why no action was taken;
- the Environmental Superintendent will be responsible for ensuring that an initial response is provided within 24 hours of receipt of a complaint (except in the event of complaints recorded when the mine is not operational or outside of usual business hours);
- once the identified measures are undertaken, the Environmental Superintendent will sign off on the relevant complaint within the Complaints Register;
- if necessary, follow-up monitoring will take place to confirm the source of the complaint is adequately mitigated; and
- a summary of the complaints will be maintained by NCOPL and made available to the Community Consultative Committee, the complainant (on request) and on the WHC website. A summary of complaints received every 12 months will be provided in the Annual Review.

The Environmental Superintendent retains ultimate responsibility to ensure that complaints received are properly recorded and addressed appropriately.

In the event that any complainant considers that NCOPL has not adequately addressed their concerns, the NCOPL representative will convene additional meetings with the complainant. If the complainant believes the matter remains unresolved, and no further agreement can be reached as to additional measures to be undertaken, then they may refer the matter to DPE.

15. References

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

Ditton Geotechnical Services (2017) *Mine Subsidence Assessment for the Proposed LW107 to LW110 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.

Eco Logical Australia (2019). *Narrabri Mine Landscape Management Plan (LW101 to LW110)*. Prepared for Narrabri Coal Operations Pty Ltd.

Eco Logical Australia (2019). *Narrabri Mine Rehabilitation Management Plan (LW101 to LW110)*. Prepared for Narrabri Coal Operations Pty Ltd.

Landcom (2004). *Managing Urban Stormwater - Soils and Construction: Volume 1*.

NSW Office of Environment and Heritage (2012). *The land and soil capability assessment scheme – second approximation*.

NSW Trade & Investment (2013). *ESG3: Mining Operations Plan (MOP) Guidelines*. Department of Trade and Investment, Regional Infrastructure and Services - Division of Resources and Energy.

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 (2009) *Environmental Assessment for the Narrabri Coal Mine Stage 2 Longwall Project*, Project Application No:MP08_0144. Prepared for Narrabri Coal Operations Pty Ltd.

SLR (2019). *Narrabri Coal Mine - Revised Conceptual Mine Closure Plan for Stage 2 Longwall Operations*. Prepared for Narrabri Coal Operations Pty Ltd

16. Glossary

Term	Definition[5]
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).
Cover depth	The depth of coal seam from the ground surface (metres).
Environmental consequences	The environmental consequences of subsidence impacts including: damage to built features; loss of surface flows to the sub-surface; 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
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 Project
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
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).
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.

[5] The majority of the definitions are as provided in Project Approval 08_0144.

Term	Definition[5]
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

Attachment 1 Compliance conditions relevant to the LMP

Table A1.1 - Relevant Project Approval 08_0144 requirements

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
Schedule 2 Condition 1	The Proponent shall implement all practicable measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation of the project.	Section 1.3
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 LMP for Panels 201-202
Schedule 3, Condition 4 (h)	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 include a: Land Management Plan, which has been prepared in consultation with any affected public authorities, to manage the potential impacts and/or environmental consequences of the proposed second workings on land in general;	This Plan
	***Notes**:* *Management plans prepared under condition 4(h) should address all potential impacts of proposed underground coal extraction on the relevant features. Other similar management plans required under this approval (eg under conditions 13 and 23 of schedule 4 or condition 3 of schedule 5) are not required to duplicate these plans or to otherwise address the impacts associated with underground coal extraction.*	
Schedule 3, Condition 5	The Proponent shall ensure that the management plans required under Schedule 3 Condition 4(h) include:	
	(a) an assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval;	Section 6
	(b) a detailed description of the measures that would be implemented to remediate predicted impacts; and	Section 9
	(c) a contingency plan that expressly provides for adaptive management.;	Section 10
Schedule 6, Condition 2	The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
	(a) detailed baseline data;	Section 2
	(b) a description of:	

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
	• the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Section 1.4
	• any relevant limits or performance measures/criteria;	Section 7
	• the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures	Section 7
	(c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria;	Section 9
	(d) a program to monitor and report on the;	
	• impacts and environmental performance of the project;	Section 8
	• effectiveness of any management measures (see (c) above);	
	(e) a contingency plan to manage any unpredicted impacts and their consequences;	Section 10
	(f) a program to investigate and implement ways to improve the environmental performance of the project over time;	Section 12.3
	(g) a protocol for managing and reporting any;	
	• incidents;	Section 13.1
	• complaints;	Section 14
	• non-compliances with statutory requirements; and	Section 13.2
	• exceedances of the impact assessment criteria and/or performance criteria; and	
	(h) a protocol for periodic review of the plan.	Section 12.1
Schedule 6 Condition 3	Within 3 months of the submission of an:	Section 12.3
	(a) audit under condition 7 of Schedule 6;	
	(b) incident report under condition 4 of Schedule 6; and	
	(c) annual review under condition 5 of Schedule 6; and	
	(d) 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 4	The Proponent shall notify the Secretary in writing via the Major Projects website and any other relevant agencies of any incident associated with the project as soon as practicable after the Proponent becomes aware of the incident. Within 7 days of the date of the incident, the Proponent shall provide the Secretary and any relevant agencies with a detailed report on the incident.	Section 13.1

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
Schedule 6 Condition 5	The Proponent shall provide regular reporting on the environmental performance of the project on its website, in accordance with the reporting arrangements in any plans or programs approved under the conditions of this approval, and to the satisfaction of the Secretary.	Section 12
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 12.1
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 12.2
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 Management procedures

Remote sensing

A two-tiered system of triggers for management is proposed in response to changes identified via remote sensing as presented in Figure A2.1.

The first tier of response is triggered by changes detected in the remote sensing time series analysis which instigates further investigation, including targeted on-ground assessments (refer to Table A2.1).

The second tier of response is triggered if changes are confirmed or discovered during the targeted on-ground assessments (Table A2.2). These triggers instigate the development of site-specific management responses and remedial actions.

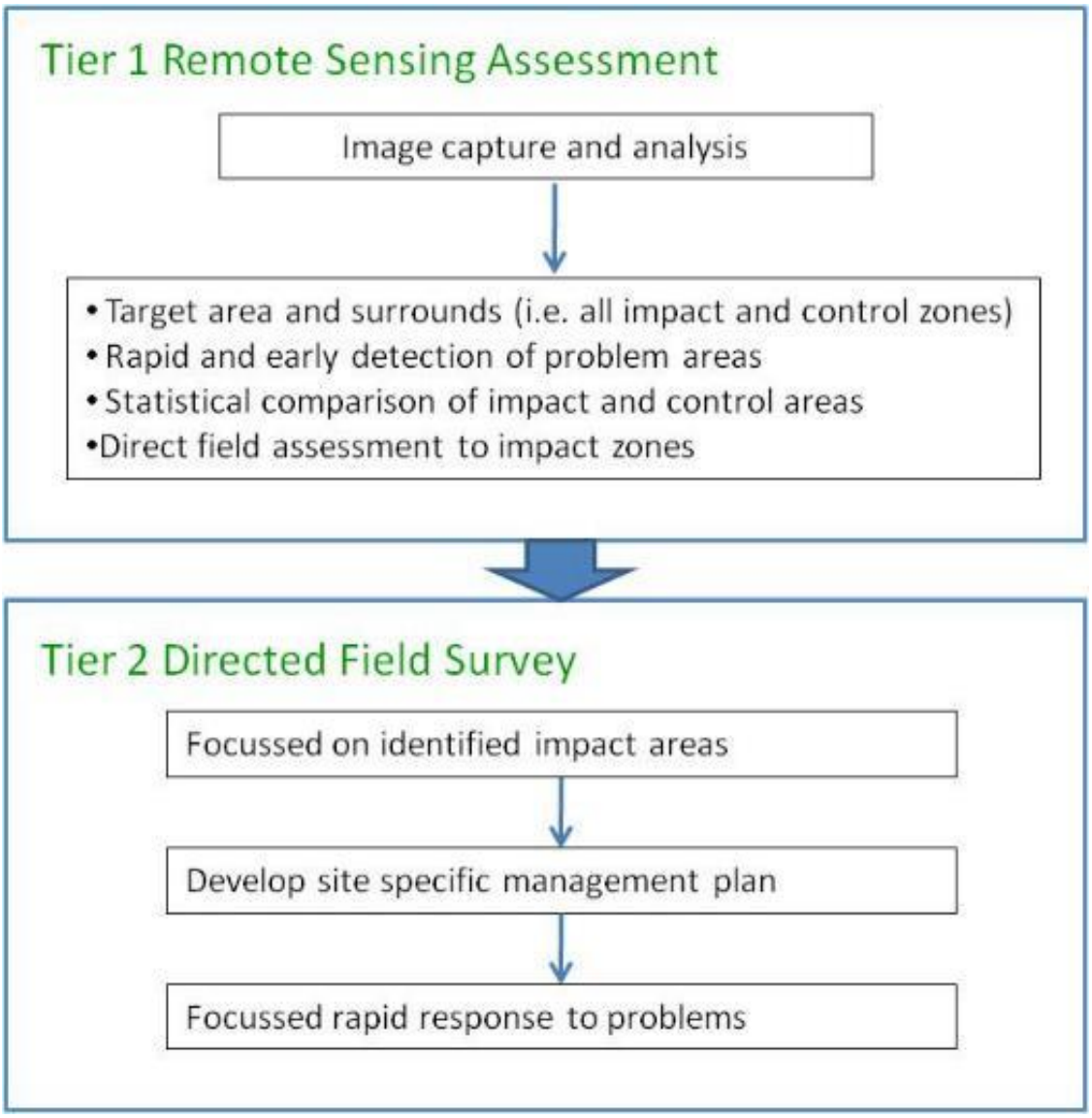

Figure A2.1 - Two-tiered remote sensing monitoring and management approach

Table A2.1 - Remote sensing monitoring for management

Trigger	Investigation	Management
Remote sensing time series analysis - statistical change in a region not consistent with regional patterns.	Corroborate statistical analysis with visual image inspection.	• investigate via on ground assessment based on the impacting factor and on-ground effect and determine what further action is required; and • the need for this on ground assessment and the direction for where it is to be undertaken will arise from the specific changes observed in the remote sensing.
Remote sensing change detection identifies area of change (> +/-1 std dev from average) in area greater than 0.1 ha	Investigate sources of change via desktop assessment: • obvious external influence e.g. fire, major storm, or unrelated development) • potentially due to altered sheet flow, significant weed infestation and/or erosion / sedimentation	Respond to change based on likely source of impact: • identify region of change and tag it as non-project specific impact • undertake directed field investigation via rapid field checking protocol

Table A2.2 - Rapid field checking protocol and management

Parameter	Method	Management
Erosion or sedimentation	On ground inspection record nature and extent of erosion (location, erosion type, depth of soil loss).	Identify cause / source and refer to the Extraction Plan Erosion and Sediment Control Plan or seek expert advice to develop site specific management and remediation measures.
Sedimentation (deposition)	On ground inspection record nature and extent of sedimentation (location, extent, depth, sediment calibre).	
Surface cracking	Visual assessment.	Record cracking locations (e.g., GPS) and refer to Table 8.3.

Creek lines

The management measures detailed in Table A2.3 are to be adopted as per the Narrabri Mine Erosion and Sediment Control Plan and Site WMP. If necessary, advice should be sought from a qualified geomorphologist or other suitably qualified professional.

Table A2.3 - Creek line monitoring triggers for management

Trigger	Management
• Detected change in surface drainage paths; or • Detected change in surface vegetation in areas of ponding; or • detected alteration in channel dimensions or channel processes outside of normal range or in comparison to the control site (statistically significant compared to baseline and/or control sites).	• stabilise the damaged or eroded banks in accordance with the Extraction Plan Erosion and Sediment Control Plan and Water Management Plan; and • management actions for ponding is to be undertaken in accordance with the Extraction Plan Ponding Management Plan (with DPE for approval).

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 +/- 3 mm between co-ordinated monitoring points. Each survey will be conducted in 3-D. The monitoring schedule is explained in greater detail in the following sections.