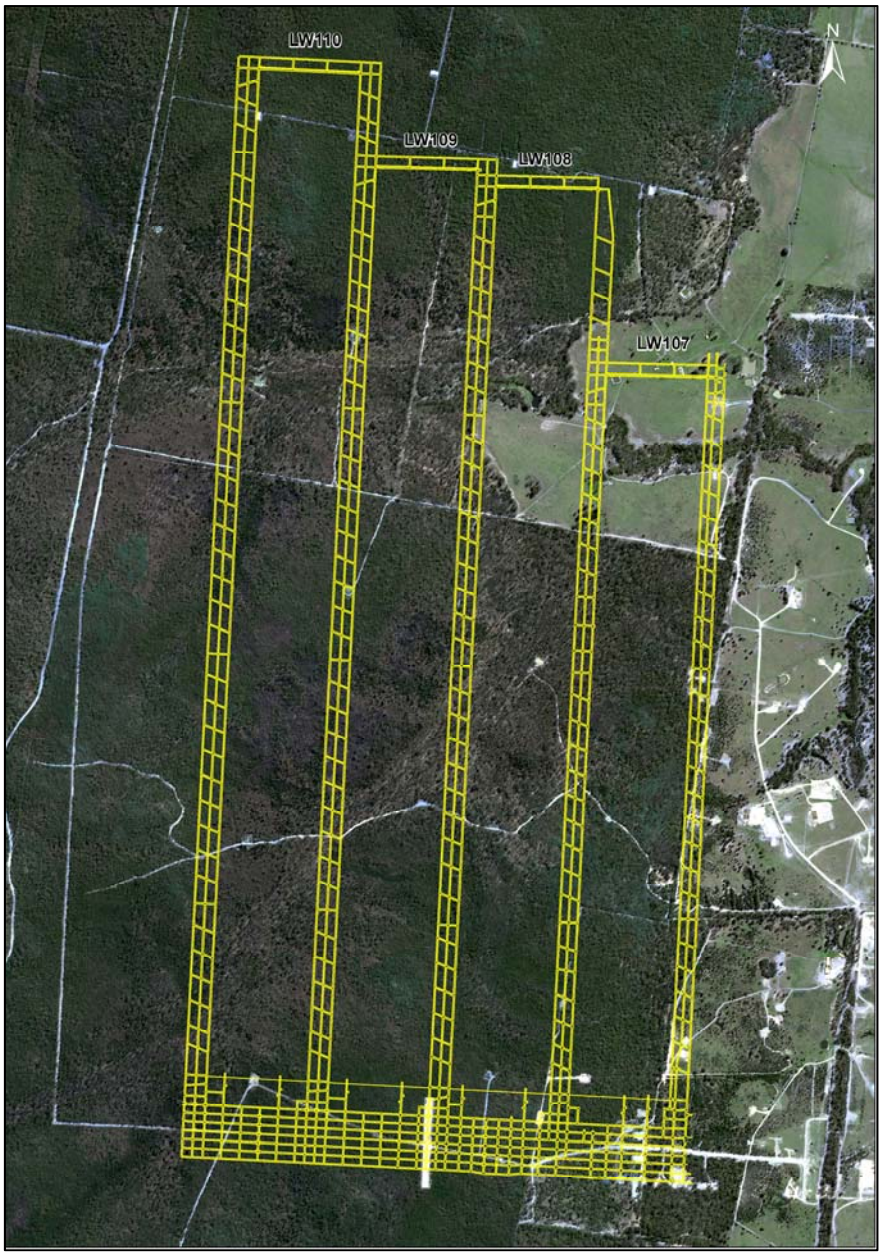
Narrabri Mine

Biodiversity Management Plan (LW107 to LW110)

Prepared for
Narrabri Coal Operations Pty Ltd

6 April 2017



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Project Manager	Nathalie van der Veer 02 8081 2684 92 Taylor St, Armidale, NSW 2350	
Prepared by	Nathalie van der Veer	
Reviewed by	Rachel Murray	Paul Frazier
Approved by	Paul Frazier	
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Contents

List of figures

List of tables

Abbreviations

Abbreviation	Description
AoD	Angle of Draw
BMP	Biodiversity Management Plan
DEE	Department of Environment and Energy
DoPE	Department of Planning and Environment
DRE	Division of Resources and Energy (part of the Department of Trade and Investment, Regional Infrastructure and Services)
EA	Environmental Assessment
EEC	Endangered Ecological Community
ELA	Eco Logical Australia Pty Ltd
EP	Extraction Plan
EPL	Environmental Protection Licence
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
LIDAR	Light Imaging, Detection and Ranging
LMP	Land Management Plan
LSMP	Landscape Management Plan
LW	Longwall
MOP	Mine Operations Plan
NCOPL	Narrabri Coal Operations Pty Ltd
NSC	Narrabri Shire Council
OEH	Office of Environment and Heritage

Abbreviation	Description
PA	Project Approval
RMP	Rehabilitation Management Plan
SRP	Subsidence Reduction Potential
TSC Act	*Threatened Species Conservation Act 1995* (NSW)
WMP	Water Management Plan

1 Introduction

The Narrabri Mine is located approximately 28 km south-east of Narrabri and approximately 10 km north-west of Baan Baa in north-western New South Wales (NSW) (Figure 1). Narrabri Coal Operations Pty Ltd (NCOPL) was granted approval for Stage 2 of the Narrabri Mine under Section 75J of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) on the 26th July 2010 (PA 08_0144).

This plan supports the Extraction Plan (EP) developed to extract a further four longwall (LW) panels in addition to those previously approved (LW101 to LW106). The approved underground mining layout is shown in Figure 2. Longwalls 107 to 110 (herein referred to as LW107 to LW110) define the second area of secondary extraction within the Approved Project underground mining areas and are the focus of this Biodiversity Management Plan (BMP).

1.1 Purpose and scope

In accordance with Schedule 3, Condition 4(h) of PA 08_0144, this BMP has been prepared as a component of the Narrabri Mine LW107 to LW110 EP to manage the potential impacts and/or environmental consequences of the proposed second workings upon flora and fauna. These impacts were identified within the revised Mine Subsidence Assessment prepared for the proposed LW107 to LW110 (DGS 2017), Landscape Management Plan (LSMP) (ELA 2017) and relevant approval documents, including the Environmental Assessment (EA) for Stage 2 of the Narrabri Coal Mine (R.W. Corkery & Co. 2009).

1.2 Structure of BMP

This BMP is structured according to Table 1.

Table 1: BMP Structure

Section	Content
Section 2	Outlines the statutory requirements applicable to the BMP.
Section 3	Outlines consultation undertaken in preparation of this plan.
Section 4	Provides baseline data collected during assessment of impacts for the Environmental Assessment (R.W. Corkery & Co. 2009).
Section 5	Provides an assessment of the potential subsidence impacts and environmental consequences for LW107 to LW110.
Section 6	Details the performance measures and indicators that will be used to assess the LW project.
Section 7	Describes the monitoring procedures required to detect impacts.
Section 8	Describes the management measures that will be implemented.
Section 9	Describes a Contingency Plan to manage any unpredicted impacts and their consequences, including a Trigger Action Response Plan (TARP)
Section 10	Lists the references cited in this BMP

PA 08_0144 requires NCOPL not to exceed the subsidence impact performance measures outlined in Schedule 3, Condition 1, Table 1. In addition, this condition, in relation to biodiversity, states that clearing and disturbance of vegetation above the mining area should be minimised, to the satisfaction of the Secretary.

In addition to the requirements of the PA 08_0144, NCOPL must comply with the 'Statement of Commitments' in relation to subsidence management and ecology. Those commitments relevant to this BMP include:

- Subsidence management:
    - Identify and remediate surface cracks to minimise impacts on local hydrology, ecology and soils (Action 5.1 – 5.7)
    - Identify and minimise the impacts of ponding on the local environment (Action 5.16)
    - Prepare and implement a Subsidence Monitoring Program (Action 5.22 – 5.24)
- Ecology:
    - Manage progressive disturbance over the Mine Site to minimise disturbance to flora and fauna of conservation significance (Action 8.5 – 8.14)
    - Minimise long term impact on flora and fauna on and around the Mine Site (Action 8.15 – 8.20).

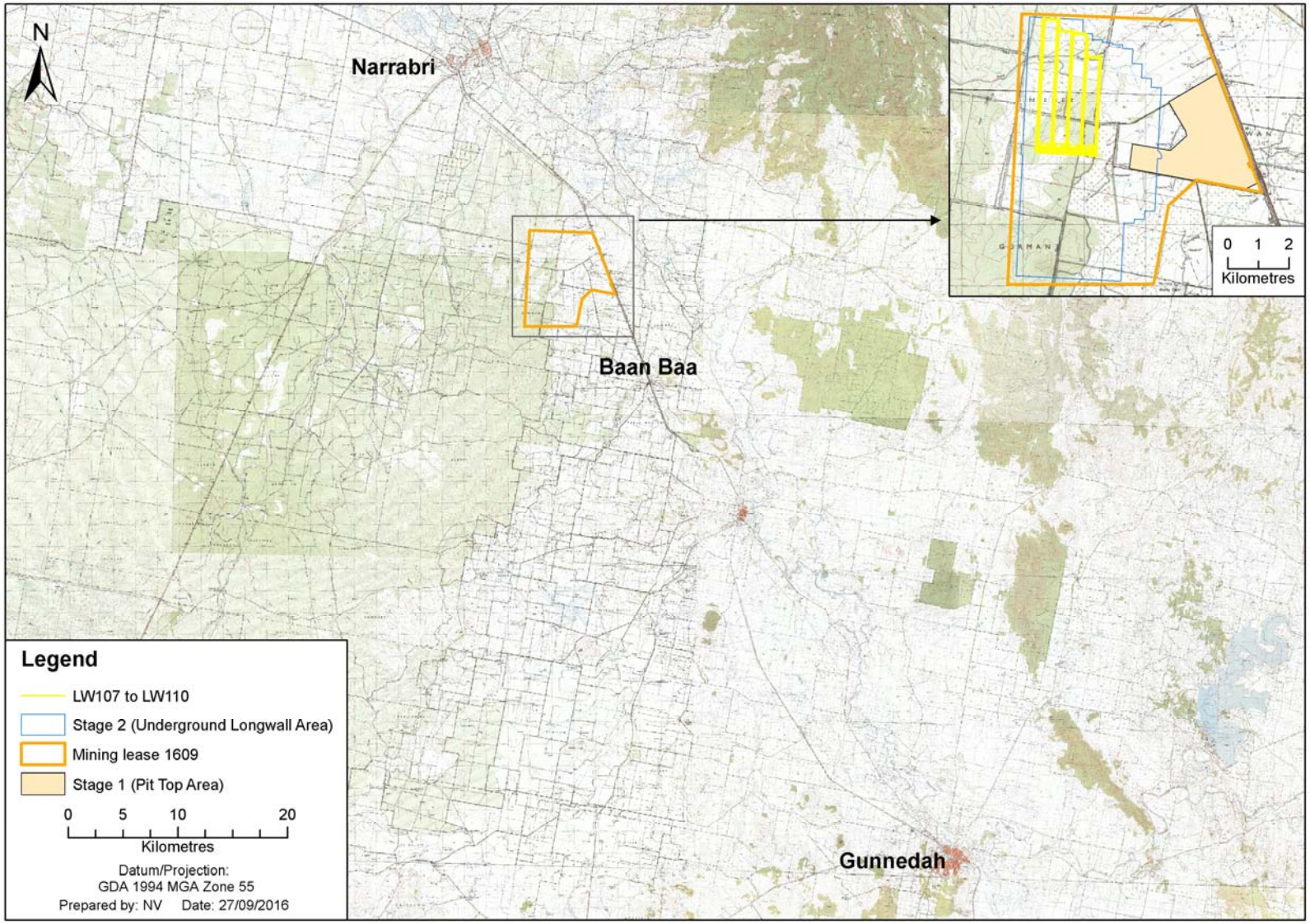

Figure 1: Mine site location

Figure 2: Layout of LW107 to LW110

2 Statutory requirements

NCOPL's statutory obligations are contained within:

- the conditions of PA 08_0144 issued under the EP&A Act
- the conditions of Approval (EPBC Ref 2009/5003) under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- relevant licences and permits, including conditions attached to the mining lease; and
- other relevant legislation.

These obligations are described in further detail below.

2.1 EP&A Act approval

Schedule 3, Condition 4(h) of PA 08_0144 requires the preparation of a BMP as a component of the EP for second workings. PA 08_0144 condition 4(h) is provided in Table 2.

In addition, Schedule 6, Condition 2 of PA 08_0144 outlines the management plan requirements that are applicable to the preparation of the BMP. Table 2 indicates where each component of the conditions is addressed within this BMP.

Table 2: Conditions of Approval associated with PA 08_0144 which are relevant to this BMP

Condition number	Condition requirement	Relevant section of this report
Schedule 3, Condition 4	Include a: • Biodiversity Management Plan, which has been prepared in consultation with OEH and DRE, which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on flora and fauna h) include a program to collect sufficient baseline data for future Extraction Plans.	Overall BMP (this document)
Schedule 3, Condition 5	The proponent shall ensure that the management plans required under condition 4(h) include:	
	• An assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval	Section 4
	• A detailed description of the measures that would be implemented to remediate predicted impacts	Section 7
Schedule 6, Condition 2	Management Plan Requirements The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
	• detailed baseline data	Section 3

Condition number	Condition requirement	Relevant section of this report
	• a description of the relevant statutory requirements (including any relevant approval, licence or lease conditions)	Section 2
	• any relevant limits or performance measures/criteria;	Section 5
	• 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 5
	• a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria	Section 7
	• a program to monitor and report on the: o impacts and environmental performance of the project o effectiveness of any management measures (see c above)	Section 6
	• a contingency plan to manage any unpredicted impacts and their consequences	Section 8
	• a program to investigate and implement ways to improve the environmental performance of the project over time	Section 8
	• a protocol for managing and reporting any • incidents • complaints • non-compliances with statutory requirements • exceedances of the impact assessment criteria and/or performance criteria	Overall EP
	• a protocol for periodic review of the plan	Overall EP
	• A contingency plan that expressly provides for adaptive management	Section 8

2.2 EPBC Act approval

Condition 3 of the EPBC Approval (2009/5003) requires the consideration of Commonwealth listed threatened species and communities within the BMP. Approval Condition 3 states:

- In order to minimise potential impacts on EPBC Act listed threatened species and communities within the mine site, prior to any works commencing and in accordance with the NSW Director General's Assessment Report and approval conditions (26 July 2010), the person undertaking the action must develop and implement an Extraction Plan. The final version of this plan must be submitted to the Department.

2.3 Biodiversity offsets

Condition 6 and 7 of Schedule 5 of PA 08_0144 required the preparation of a suitable biodiversity offset strategy to compensate impacts of subsidence. In addition, the project was determined as a controlled

action under the EPBC Act, which also required the preparation of a suitable biodiversity offset strategy. The biodiversity offset strategy (ELA 2014a) has been prepared according to both the EP&A Act and EPBC Act requirements.

2.4 Licences, permits and leases

In addition to PA 08_0144 and EPBC Approval (2009/5003), all activities at or in association with the Narrabri Mine will be undertaken in accordance with the following licences, permits and leases which have been issued or are in preparation:

- The conditions of the Mining Lease No. 1609 issued by the NSW Department of Primary Industries – Mineral Resources (now Division of Resources and Energy - DRE), under the NSW *Mining Act 1992*.
- The Stage 2 MOP approved for the period 1 July 2011 to 31 December 2017.
- The conditions of Environment Protection Licence (EPL) No. 12789 issued by the NSW Department of Environment and Climate Change (now EPA) under the NSW *Protection of the Environment Operations Act, 1997*.
- Water Access licences issued by the NSW Department of Water and Energy (now DPI Water) in accordance with the *Water Management Act 2000*.
- Mining and occupational health and safety related approvals granted by the Division of Resources and Energy (part of the Department of Trade and Investment, Regional Infrastructure and Services) DRE and SafeWork NSW.

2.5 Other legislation

NCOPL will conduct all operations at Narrabri Mine to be consistent with PA 08_0144 and any other applicable legislation. The following Acts may be applicable to the conduct of the Project:

- *Contaminated Land Management Act 1997*
- *Dangerous Goods Act 1975*
- *Mining Act 1992*
- *Noxious Weeds Act 1993*
- *Rail Safety Act 2002*
- *Road and Rail Transport (Dangerous Goods) Act 1997*
- *Roads Act 1993*
- *Threatened Species Conservation Act 1995* (TSC Act)
- *Work Health and Safety (Mines and Petroleum Sites) Act 2013*
- *Work Health and Safety Act 2011*
- *Crown Lands Act 1989*
- *Dams Safety Act 1978*

- *Energy and Utilities Administration Act 1987*
- *Fisheries Management Act 1994*

3 Consultation

In accordance with Schedule 3, Condition 4 (h) of the Project Approval, the approval of this management plan (and any subsequent substantial amendments) is required by DoPE.

Under the same condition, this BMP is to be prepared in consultation with OEH and NSW Trade and Investment.

Consultation with relevant agencies and stakeholders was undertaken as part of the overall EP preparation and assessment process. This consultation has included:

- Provision of draft copies of the BMP to OEH for comment
- Submission of the full Extraction Plan to DoPE and DRE for assessment

A summary of matters arising from consultation (as relevant to this BMP), and where each is addressed within this BMP, is provided in Table 3

Table 3: Consultation Summary

Agency	Issue raised	Relevant section of this report
OEH	A suitable fauna survey or monitoring program be prepared for the Delicate Mouse and the Pale-headed Snake	Section 7.4
	Update text and tables as appropriate	Section 7.4 Section 7.4
DoPE	Describe frequency of monitoring in terms of period and event	Section 7, Table 8
	TARPS should reflect industry standard ‘multi-level’ documents that show clear escalation of the response measures and reporting based on escalating triggers	Section 9

4 Baseline data

Baseline data incorporated into this BMP has been based on the ecological assessment undertaken by Ecotone Ecological Consultants (2007) for Stage 1 and Ecotone Ecological Consultants (2009) for Stage 2. Site experience gained from other ecological monitoring and pre-clearing surveys undertaken by ELA has also been considered in the preparation of this BMP.

This baseline data, although not detailed specifically for LW107 to LW110, provides data relevant to the vegetation communities, flora and fauna that have been recorded within the entire longwall subsidence area. The monitoring program outlined within Section 7 of this BMP includes the collection of more detailed baseline data specific to LW107 to LW110 before longwall mining operations commence.

4.1 Woodland and riparian vegetation

Six natural vegetation communities and one artificial vegetation community occur across the Narrabri Mine longwall areas. The following vegetation communities are represented above the area of LW107 to LW110 (Figure 3):

- Brown Bloodwood/Pilliga Box Woodland
- Riparian Forest
- Inland Grey Box Woodland
- Cleared Open Grassland (Ecotone Ecological Consultants 2009)

The Inland Grey Box Community is listed as an EEC under both the TSC Act and EPBC Act (Ecotone Ecological Consultants 2009) and occurs as a remnant patch above LW107 to LW109. The majority of this patch is relatively intact; however, edge effects occur as a result of disturbance (clearing for access tracks and historical clearing for agriculture). Abundance of exotic species is generally low and the area is subject to occasional grazing. The patches are partially cleared in the tree and shrub layers, with the abundance of exotic species generally low.

Riparian Forest occurs as a small remnant patch, along the section of Pine Creek that occurs above LW107 and LW108. The community is relatively intact, however, has undergone some clearing and modification and has been subject to regular or intermittent grazing. Weed densities are generally low, although there are patches of noxious and exotic weeds in some areas. This community is not listed as an Endangered Ecological Community (EEC) under either State or Commonwealth legislation; however, this community integrates with the Inland Grey Box Community (described above).

A small area within the north of LW107 and LW108 is used for agriculture. The community is grazed regularly and/or ploughed and cultivated (Ecotone Ecological Consultants 2009).

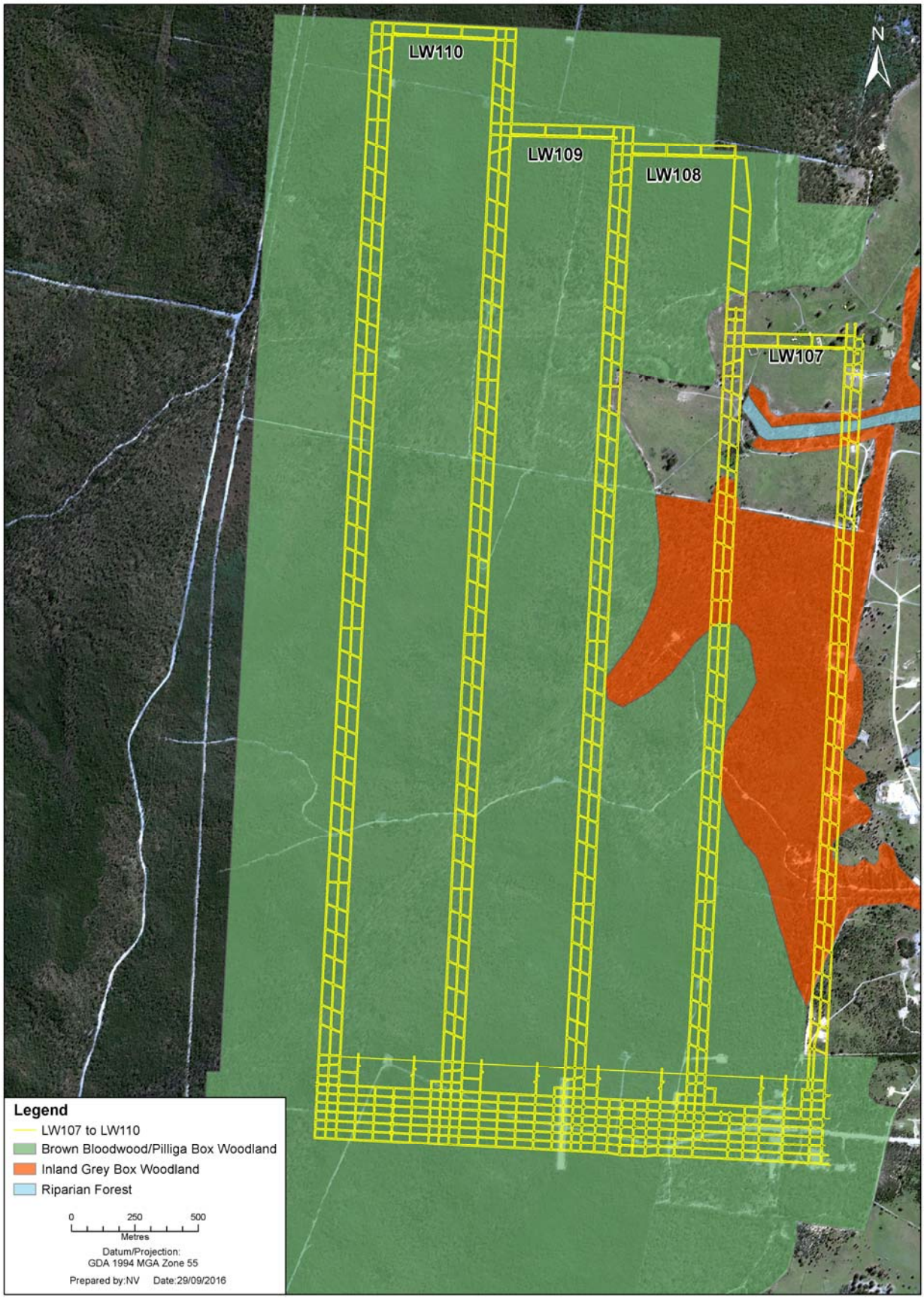

Figure 3: Vegetation communities above LW107 to LW110

4.2 Threatened flora

Threatened flora surveys have been undertaken previously by Ecotone Ecological Consultants in 2009 and by Eco Logical Australia (ELA) in 2010. Three threatened flora species were identified within the overall Longwall impact area. *Bertya opponens* (Coolabah Bertya) which is listed as vulnerable under both the TSC Act and EPBC Act has been found within the western portion of the mining lease (Ecotone Ecological Consultants 2009). *Lepidium aschersonii* (Spiny Peppercress) which is listed as vulnerable under both the TSC Act and EPBC Act has been found in the remnant patch of Inland Grey Box Woodland located above LW102 and LW103 (ELA 2012). *Tylophora linearis* has also been recorded on site during previous surveys (ELA 2014b). *Cadellia petastylis* (Ooline), listed as vulnerable under the TSC Act and EPBC Act, and *Pomaderris queenslandica* (Scant Pomaderris), listed as endangered under the TSC Act, have also been noted as having the potential to occur (Ecotone Ecological Consultants 2009).

4.3 Terrestrial fauna and habitat

Terrestrial fauna surveys across the mining lease were conducted by Ecotone Ecological Consultants in 2009 and identified a total of 162 species, comprising 99 birds, 37 mammals, 16 reptiles and 10 amphibians. Fourteen of the identified terrestrial fauna species are listed as threatened under either the TSC Act. The following ten species have been detected above LW107 to LW110:

- *Calyptorhynchus lathami* (Glossy Black-cockatoo) – listed as Vulnerable under the TSC Act
- *Pomatostomus temporalis* (Grey-crowned Babbler) – listed as Vulnerable under the TSC Act
- *Pyrrholaemus sagittata* (Speckled Warbler) – listed as Vulnerable under the TSC Act
- *Pseudomys delicatulus* (Delicate Mouse) – listed as Endangered under the TSC Act
- *Nyctophilus corbeni* (Greater Long-eared Bat) – listed as Vulnerable under the TSC Act
- *Saccolaimus flaviventris* (Yellow-bellied Sheathtail Bat) – listed as Vulnerable under the TSC Act
- *Chalinolobus picatus* (Little Pied Bat) – listed as Vulnerable under the TSC Act
- *Hoplocephalus bitorquatus* (Pale-headed snake) – listed as Vulnerable under the TSC Act
- *Macropus dorsalis* (Black-striped Wallaby) - listed as Endangered under the TSC Act (Ecotone Ecological Consultants 2009).

Evidence of *Phascolarctos cinereus* (Koala), listed as Vulnerable under the TSC Act, by way of a scat, was found on the mine site (Ecotone Ecological Consultants 2009). No koalas have been recorded on the mine site to date.

Fauna habitat associated with the land above LW107 to LW110 consists of four main habitat types in which the threatened species recorded would occur, and potentially provide habitat for a number of other threatened fauna species that have been recorded across the broader longwall impact area. These habitat types are:

- Woodland areas – the majority of the area
- Open areas comprised of pasture and/or cropping paddocks – a small proportion of the area

- Drainage lines – Pine Creek and associated tributaries
- Farm dams (Ecotone Ecological Consultants 2009).

4.4 Aquatic biota and habitat

Potential aquatic biota habitat across the longwall impact area consisted of two general types of habitat, including creek lines and farm dams. Pine Creek and its tributaries that occur above LW107 to LW110 are ephemeral in nature and lack pools of semi-permanent or permanent water for aquatic biota (Ecotone Ecological Consultants 2009).

Five farm dams occur above LW107 to LW110 of which most contained gently sloping grassy banks and were likely between 1 and 3 m deep. Most farm dams contained areas of emergent and aquatic vegetation while others were bordered by a narrow strip of soil between the water and surrounding grass cover. Most farm dams visited contained relatively clear water and all contained some aquatic macroinvertebrates (Ecotone Ecological Consultants 2009).

4.5 Introduced flora and fauna

There is high variability in vegetation condition throughout the longwall area. The land above LW107 to LW110 is predominantly intact woodland with a small area that has been cleared for grazing within the north of LW107 and LW108. Within the Riparian Forest, there are locally high abundances of noxious and exotic weeds, but the density in most parts is generally low (Ecotone Ecological Consultants 2009). Exotic species abundance is low in the Inland Grey Box Woodland community and absent to very sparse in the Brown Bloodwood/Pilliga Box Woodland. Weeds identified for the purposes of the ecological assessment are most likely to occur in the cleared open grassland (Ecotone Ecological Consultants 2009).

Eight weed species recorded in the study area are declared Noxious Weeds in the Narrabri Shire Council control area (Ecotone Ecological Consultants 2009). These, together with their relevant control classes are:

- *Lycium ferocissimum* (African Boxthorn) – Class 4
- *Xanthium spinosum* (Bathurst Burr) – Class 4
- *Opuntia stricta* (Prickly Pear) – Class 4
- *Oxalis corniculata* (Creeping Oxalis) – Class 5
- *Sorghum halepense* (Johnson Grass) – Class 4
- *Bryophyllum delagoense* (Mother of Millions) – Class 4
- *Xanthium occidentale* (Noogoora Burr) – Class 4
- *Cenchrus longispinus* (Spiny Burrgras) – Class 4

Most of the noxious weeds identified on the longwall impact area had a trace presence or were present in high numbers in very restricted areas. Common or established environmental weeds were also identified within the overall longwall impact area (Ecotone Ecological Consultants 2009).

Nine introduced species (two birds and seven mammals) were recorded during the fauna surveys within the longwall impact area (Ecotone Ecological Consultants 2009), including:

- *Sturnus vulgaris* (Common Starling)
- *Acridotheres tristis* (Common Myna)
- *Mus musculus* (House Mouse)
- *Rattus rattus* (Black Rat)
- *Canis familiaris* (Dog)
- *Vulpes Vulpes* (Fox)
- *Sus scrofa* (Pig)
- *Capra hircus* (Goat)
- *Lepus europaeus* (Brown Hare)

5 Potential environmental consequences

A detailed Mine Subsidence Assessment was prepared for the proposed LW107 to LW110 by Ditton Geotechnical Services Pty Ltd (DGS 2017) for incorporation into the EP. This study was undertaken to update the subsidence predictions and assessment of the impacts relating to the predicted subsidence above LW107 to LW110.

The mine subsidence effect predictions involved:

- reviewing site geotechnical and geological data
- assessing the massive strata Subsidence Reduction Potential (SRP) for land above LW107 to LW110
- measured subsidence over LW101-105

This information was then used to predict the maximum subsidence over the longwall panels, subsidence over the chain pillars between the longwall panels, key subsidence profile parameters (such as goaf edge subsidence, inflection point and maximum convex and concave curvature locations), credible worst-case subsidence and tilt and strain profiles across representative sections using a modified version of the ACARP 2003 model (DGS 2017).

The impact assessment component of the study involved determining the subsidence related impacts that have the potential to occur above the LW107 to LW110, including:

- Surface cracking
- Subsurface fracture zones
- General slope instability and erosion potential
- Valley uplift and closure potential along creek beds
- Potential for ponding upon completion of mining
- Subsidence impact parameter predictions for existing developments and archaeological sites
- A review of the differences (if any) between the subsidence impact predictions made in the EA and the current mining layout (DGS 2017).

5.1 Longwall 107 to 110 layout

LW107 to LW110 lie to the west of the Pit Top Area (Figure 2). The land surface is primarily dense vegetation, with smaller areas cleared for livestock grazing that contain remnant vegetation stands (predominantly along creek lines).

LW107 to LW110 will be mined at depths ranging from approximately 230 m to 350 m below the surface and each longwall panel will be 408.9 m wide. Panel width to cover depth ratio will range from 1.17 to 1.77, indicating both critical and subcritical subsidence behaviour (DGS 2017).

5.2 Overall predicted subsidence

The predicted subsidence effects of secondary extraction (longwall mining) of LW107 to LW110 have been determined (DGS 2017). The predictions take into account the following factors:

- Subsidence reduction potential (SRP) of the overburden and the influence of the overburden and the influence of the proposed mining geometry on single panel subsidence development
- The behaviour of the chain pillars and immediate roof and floor system under double abutment load conditions when longwalls have been extracted along either side of the pillars
- The combined effects of single and chain pillar subsidence to estimate final subsidence profiles and subsidence contours for subsequent environmental impact assessment (DGS 2017).

The mean and worst-case first and final maximum multiple panel subsidence values were predicted based on the predicted maximum single panel, chain pillar and goaf edge subsidence values (Table 4) (DGS 2017).

Table 4: Predicted mean and credible worst-case results for all of the cross-lines (DGS 2017)

Predicted subsidence	Without spanning volcanics	
	Lower limit	Upper limit
First maximum panel subsidence after mining of LW 107 to LW 110	2.53 m	2.71 m
Final maximum panel subsidence after mining of LW107 to LW110	2.58 m	2.75 m
First maximum chain pillar subsidence after mining of LW107 to LW110	0.28 m	0.69 m
Final maximum chain pillar subsidence after mining of LW107 to LW110	0.28 m	0.71 m
Final maximum panel concave curvature after mining of LW107 to LW110	0.3 km^{-1}	1.6 km^{-1}
	Radii of curvature 1.66 km - 0.3 km	
Final maximum panel convex curvature after mining of LW107 to LW110	0.3 km^{-1}	1.3 km^{-1}
	Radii of curvature 2.5 km - 0.38 km	
Final maximum panel compressive strains after mining LW107 to LW110 (smooth profile behavior)	3 mm/m	6 mm/m
Final maximum panel compressive strains after mining LW107 to LW110 (discontinuous movements)	8 mm/m	16 mm/m
Final maximum panel tensile strains after mining LW107 to LW110 (smooth profile behavior)	3 mm/m	5 mm/m
Final maximum panel tensile strains after mining LW107 to LW110 (discontinuous movements)	7 mm/m	13 mm/m

Goaf edge subsidence predictions have been used to predict angle of draw to the 20 mm subsidence contour, it is therefore estimated that the Angle of Draw Prediction (AoD) will range from 18.5º to 32.1º for the proposed LW107 to LW110 and predicted goaf edge subsidence range of 0.05 to 0.32 m (DGS 2017).

5.3 Predicted subsidence effects

The overall predicted subsidence effects and impacts upon land in general above LW107 to LW110 are summarised below.

The primary effect of longwall mining to the land surface is the vertical subsidence, tilts and strains. There are several resulting impacts of subsidence, including: surface cracking, subsurface cracking, slope instability and erosion, valley closure and uplift, and ponding. These impacts may then trigger a number of environmental responses related to biodiversity.

5.3.1 Surface cracking

Surface cracking widths of 30 mm to 130 mm are predicted based on the predicted range of maximum transverse tensile strains of 3 to 10 mm/m. Strain concentrations in near surface rock could double predicted surface crack widths to 60 mm and 260 mm. Measured surface cracks above LW101 to LW105 have ranged from 50 to 100 mm wide, with some cracking of up to 200 mm. Surface crack widths are expected to decrease with cover depth increases over LW107 to LW110 (DGS 2017). Therefore, the revised cracking width range of 30 mm to 130 mm above LW107 to LW110 are considered conservative (DGS 2017).

If there are adverse topographic or geological conditions, these crack widths may be exceeded by 5% of incidences, this is unlikely to occur over the majority of LW107 to LW110. Predicted crack widths are most likely to be exceeded near steep creek banks along Pine Creek and its tributaries (DGS 2017).

Cracks are expected to develop by the time the longwall face has retreated past a given location for a distance equal to 1 to 2 times the cover depth. Cracks will generally develop within several days after the longwall has retreated beneath a given location, with some cracks closing in the compression zone in the middle of the fully developed subsidence trough, together with new cracks developing in the tensile zones along and inside the panel sides several weeks later (DGS 2017).

Tensile strain zone cracks are likely to be tapered and extend to depths of 5 to 15 m and possibly deeper in near surface rock exposures. Tensile type cracks can also occur as a result of buckling and uplift of near surface rock. Compressive strain zone cracks are usually low-angle shear cracks resulting from failure and shoving of near surface strata (DGS 2017).

Crack widths are likely to be wider on ridges than along sandy-bottomed creek beds. Undermining ridges can result in the migration of surface cracks up-slope and outside the limits of extraction for significant distances due to rigid block rotations. This is dependent on the slope angle, vertical jointing and the subsidence at the toe of the slope (DGS 2017).

5.3.2 Subsurface cracking

Subsurface 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 subsurface 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 subsurface flowpaths being altered, and rock mass conductivity and storage magnitudes being altered, however, groundwater or surface water resources may not undergo significant long-term change (DGS 2011).

The Geology Pi-Term Model was used to determine continuous fracture heights. Results from this modelling indicate that it is very unlikely that the continuous fracture zone will encroach within the surface cracking zone (i.e. within 10 m below the surface) for the range of cover depths above LW 107-110 (DGS 2017).

The Geology Pi-Term Model predicts that discontinuous fracturing could interact with surface cracks where cover depths are <335 m. Where this is the case creek flows could be re-routed to below-surface pathways and resurfacing down-stream of the mining extraction limits. Tree stress above extracted longwalls has been found to be due to root sheer, indicating that B-Zone interaction has occurred with tree root systems (DGS 2017).

5.3.3 Slope instability

It is highly unlikely that landslip of the surface terrain over basal siltstone beds tilted by subsidence will occur. In areas where the soils are exposed and dispersive/reactive the rate of soil erosion is expected to increase and slopes of <10º are expected to have low erosion rate increases. Creek channels are an exception where they would be expected to re-adjust to any changes in gradient (DGS 2017).

Headcuts are expected to develop above chain pillars between the panels and on the side where the gradients increase. Sediments are expected to accumulate where gradients decrease (DGS 2017).

5.3.4 Valley closure and uplift

Valley closure typically occurs along cliffs and sides of deep valleys when longwalls are mined beneath them and across broader drainage gullies where there is shallow surface rock. Compressive stress generated by surface deformation can cause the floor rocks of a valley to buckle upwards, resulting in less subsidence taking place in river or creek beds than would be expected in flat terrain. This ‘upsidence’ has been known to extend outside steep sided valleys and included immediate cliff lines and the ground beyond them. There are a number of factors which influence the occurrence and extent of valley closure and uplift movements, including: the level of ‘locked-in’ horizontal stress directly below the gully floors; bedding thickness of floor strata; and, aspect ratio (valley width/depth) with narrow valleys having greater upsidence than broad, round ones (DGS 2017).

The occurrence of upsidence and closure along the creek beds above LW107 to LW110 is likely to be minimal as the valleys across the Narrabri Mine are very broad between crests and are not underlain by thick massive beds of conglomerate and/or sandstone and they are broad between crests (DGS 2017).

In the unlikely event of upsidence occurring minor localised deviation of surface flows along ephemeral creek beds into subsurface routes above the longwall panels may result. Tensile bending or compressive/shear strains resulting in failure and cracking of near surface rocks will also contribute to the deviation of surface flows. It is expected that re-routed surface flows will resurface downstream of the damaged area (DGS 2017).

5.3.5 Ponding

Natural drainage pathways to water courses may be disrupted if closed form depressions form in the central areas of panels should the predicted maximum panel subsidence of 2.75 m take place (DGS 2017). Surface gradients along creeks may also increase or decrease by up to 3%.

Ponding may develop above several of the longwalls and creeks in the flatter eastern areas at maximum depths of 0.1 to 2.6 m after LW107 to LW110 are completed. It is expected that 3.7 ha in total with a combined volume of 19 ML will be affected by ponding (Table 5) (DGS 2017). In-stream and over-bank ponding is predicted (WRM 2009), with in-stream ponding most likely to occur where channels are perpendicular to the LW panels.

Table 5: Potential worst-case ponding assessment for LW107 to LW110

Location	Longwall	Max depth h (m)	Ponded area increase after mining# (m^2)	Ponded volume increase after mining# (ML)
Pine Creek	107	1.0	9,805	4.90
	108	2.6	7,096	9.23
		0.5	2,682	0.67
		0.1	7,502	0.38
	109	0.8	3,503	1.40
	110	0.7	6,126	2.14
Pine Creek Tributary 2	108	0.4	622	0.12

# denotes pre-mining pond areas and volumes assumed to be nil; *italics* denotes ponding on different branch of Tributary 1
Source: DGS 2017

Factors influencing ponding depths and volumes include rain duration, surface cracking, effective percolation rates of the surface soils and fractured rock bars/outcrops along the creeks (DGS 2011).

5.4 Potential biodiversity consequences

The overall predicted effects and consequences on biodiversity as a result of subsidence and its impacts above LW107 to LW110 are summarised below and in Table 6.

The subsidence predictions for LW107 to LW110, as outlined above in Section 5.3 and described within the Mine Subsidence Assessment prepared for LW107 to LW110 (DGS 2017) indicate no major differences from the initial (EA) for Stage 2 of the Narrabri Coal Mine (R.W. Corkery & Co. 2009) for vegetation communities, threatened flora and fauna and aquatic biota and habitat.

5.4.1 Woodland and riparian vegetation

The effects of surface subsidence for LW107 to LW110 may impact vegetation communities, including through the disturbance or loss of woodland and/or riparian vegetation as a consequence of:

- Surface cracking
- Discontinuous sub-surface fracturing causing root shearing and reduction in available moisture resulting in tree stress
- Creek bank slumping
- Changes in soil characteristics (include water and nutrient distribution) due to subsidence impacts

- Erosion
- Overbank ponding, particularly in areas of saline soils
- Vegetation clearing associated with longwall operations and infrastructure development
- Transportation of weed propagules via on-going remediation works associated with mine subsidence and operations
- Potential weed increase due to land disturbance.

5.4.2 Terrestrial fauna and habitat

The consequences of surface subsidence for LW107 to LW110 to terrestrial fauna and associated habitat may include:

- Potential loss of some individual Delicate Mice and Pale-headed Snakes as a result of falling into surface cracks was identified, with regular monitoring recommended (Ecotone Ecological Consultants 2009).
- Surface cracking will form areas capable of 'trapping' some ground dwelling fauna (e.g. frogs and reptiles)
- Localised and limited reduction in the habitat resources available to terrestrial fauna as a consequence of subsidence impacts on woodland and riparian vegetation

The size and extent of surface cracking is expected to be minor. Any impacts on vertebrate fauna due to surface cracking are likely to be relatively minor and very unlikely to result in an impact that would threaten the viability of any vertebrate species population.

5.4.3 Aquatic biota and habitat

Given the lack of aquatic biota and natural aquatic and riparian habitat along Pine Creek and its tributaries, the potential subsidence consequences upon the aquatic biota and associated habitat are limited. Potential consequences include:

- Loss of riparian woodland along Pine Creek and its tributaries due to surface subsidence and bank cracking
- Loss of aquatic biota and habitats in farm dams (either as a consequence of dam cracking or draining).

Table 6: Environmental consequences on biodiversity associated with mine subsidence

Biodiversity component	Subsidence impact	Subsidence consequence	Potential environmental hazard (to biodiversity)
Woodland vegetation	Surface cracking Creek bank slumping Altered surface and sub-surface drainage patterns Overbank ponding Remediation works	Altered localised and/or landscape water and nutrient distribution Increase in weeds and feral animals Water logging Ponding over saline soils Vegetation removal Erosion	Disturbance or loss of woodland and/or riparian vegetation
Fauna	Surface cracking Creek bank slumping Altered surface and sub-surface drainage patterns Overbank ponding Remediation works	Negative effect on woodland and/or riparian vegetation Surface cracks	Reduction in the habitat resources available to terrestrial fauna Disturbance or loss of native fauna species and/or assemblages 'Trapping' of ground dwelling fauna
Aquatic environments	Creek bank slumping and erosion Cracking and/or drainage of farm dams	Negative effect on riparian vegetation Loss of aquatic ecosystems in farm dams	Loss of riparian woodland along Pine Creek and its tributaries Loss of aquatic biota and habitats in farm dams

6 Performance measures and indicators

PA 08_0144 requires NCOPL not to exceed the subsidence impact performance measures outlined in Schedule 3, Condition 1, Table 1. In addition, under this condition NCOPL is to ensure that that clearing and disturbance of vegetation above the mining area is minimised, to the satisfaction of the Secretary.

The monitoring program outlined within Section 7 of this BMP includes the collection of more detailed baseline data specific to LW107 to LW110 before longwall mining operations commence.

Performance measures for the management of biodiversity that are relevant to the environmental consequences of subsidence impacts are listed below in Table 7. If the biodiversity performance measure has been exceeded or is considered likely to be exceeded, the Contingency Plan will be implemented as per Section 9 of this BMP.

Table 7: Performance measures and indicators for biodiversity management (LW107 to LW110)

Objective	Performance measures	Performance criteria
To minimize the clearing and disturbance of vegetation above the mining area	Woodland and riparian vegetation health and habitat value	Areas of NDVI change greater than 1 standard deviation from the mean change and greater than 0.1 ha in area. Canopy dieback is not substantially greater than that observed during baseline traverses and considered beyond natural seasonal dieback and natural variation due to weather. Data does not indicate declining trend in vegetation and habitat conditions. Less than 10% increase in weed cover in impact quadrats in comparison to control quadrats. Clearing does not exceed the estimated area of clearing assessed by the Stage 2 EA and as updated in Modification 5 (Resource Strategies, 2015) for infrastructure above LW107 to LW110.
Identify any impact of surface cracks on Delicate Mouse and Pale-headed Snake	Observance of trapped Delicate Mouse or Pale-headed Snake within surface cracks	Incidence of Delicate Mouse and/or Pale-headed snake becoming trapped in surface cracks.

7 Monitoring

This monitoring program has been developed with consideration to the Environmental Assessment for Stage 2 (Ecotone Ecological Consultants 2009) which determined that mine subsidence will not have a significant impact on biodiversity.

Whole-of-site monitoring using remote sensing data (LIDAR and multi-spectral imaging) will be undertaken to monitor the entire target area (including control areas), followed by targeted field work to examine the causes of any changes highlighted during the remote sensing. The remotely sensed data will provide information that allows quantitative comparison of key land surface condition parameters including woodland and riparian environments. Repeat capture and analysis of the multi-spectral imagery will also highlight areas of change in land cover beyond those found in control areas. Targeted field work will be implemented to examine the causes of any change highlighted.

At the local scale, longwall traverses will be undertaken to identify subsidence related impacts such as deterioration of tree health (related to subsidence or ponding) and weed incursions. The monitoring program is summarised in Table 8.

Table 8: Monitoring program

Data source	Type	Scale	Purpose
Remote sensing	LIDAR	Entire site (every 3 years)	Topographic form and change Woodland parameters
	Multi-spectral imaging	Entire site (annually)	Vegetation clearing and/or loss Woodland cover/biomass Erosion monitoring Direct field survey
Longwall traverses	Transects and permanent monitoring sites	Baseline and during mining, above each longwall every spring, with 15 permanent monitoring sites established over each longwall at random locations along the transects (five sites within each zone – longwall, transition and pillar)	Canopy health and defoliation Vegetation structure Habitat features Weed presence
Targeted fauna survey for Delicate Mouse survey and Pale-headed Snake	Searches for extent and locations of suitable habitat for these two species Once suitable habitat has been identified, it is to be searched for evidence of each species being present.	Baseline and annual surveys to be conducted above each longwall. Surveys can be discontinued above longwalls where surface cracks have been repaired.	Determine presence (or absence) so that appropriate monitoring, future survey effort and impact avoidance controls can be put in place.

7.1 Baseline monitoring requirements

Baseline monitoring will be undertaken to understand current conditions above LW107 to LW110. Baseline monitoring will include remote sensing analysis as described in Section 7.2 and longwall traverses as described in Section 7.3. Targeted baseline fauna survey will also be undertaken to identify presence of Delicate Mouse or Pale-headed Snake.

7.2 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 inform quantitative comparison of key surface condition parameters in woodland, riparian and agricultural environments. Annual spring capture and analysis of multi-spectral imagery will also highlight areas of changes in land cover beyond those found in control areas. Targeted field work will be implemented to examine the causes of any change highlighted.

The target area for this monitoring plan is the surface environment above and surrounding LW107 to LW110.

7.2.1 LIDAR processing and analysis

LIDAR data will be captured across the entire target area and 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.

Each dataset produced will be used to create a map for visual interpretation and analysis and for communication of results. LIDAR processing analysis will be undertaken every three years, commencing with baseline.

7.2.2 Multi-spectral image processing and analysis

The high-resolution multi-spectral imagery (World View, Geoeye, Quickbird or similar) will be processed into a normalised difference vegetation index (NDVI). The initial data capture will be stratified into the 4 impact zones (Longwall, Transition, Pillar, Control) and compared using analysis of variance (ANOVA) to determine if data in any of the zones are significantly different from each other.

Subsequent multi-spectral image captures will be processed into a NDVI. Each dataset will be subtracted from those produced from earlier captures creating a series of change images.

In addition, areas of significant change in NDVI will be highlighted and a targeted reconnaissance survey directed to investigate the source of the change and implement any planning, management action or change in management procedures required (see Section 8).

Each dataset produced will be used to create a map for visual interpretation and analysis and for communication of results. Multi-spectral image processing analysis will be undertaken annually, in spring prior to longwall panel traverses.

Although the primary purpose of this monitoring is to detect changes in vegetation cover, the design of the program is such that other impacts such as weed infestations and disturbance caused by erosion and sedimentation will also be detected. 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.

7.3 Longwall panel traverses

Immediately prior to mining and once undermining has occurred, each longwall panel will be traversed annually in spring to identify any subsidence related impacts.

A series of transects will be established across the width of each longwall. Along these transects, fifteen permanent monitoring sites will be established over each longwall at random locations along the transects (five sites within each zone – longwall, transition and pillar), with a minimum of 50 m between each site. Each monitoring site will be permanently marked with a metal star picket. Data on canopy health and defoliation, vegetation structure and habitat features will be collected as well as plot photographs (Table 9)

Table 9: Woodland vegetation monitoring

Parameter	Measurement/method	Frequency
Canopy health and defoliation	Percentage of epicormic foliage in relation to total tree foliage	Baseline, and then annually in spring for a period of 3 years after longwall is complete.
	Proportion of primary branches within canopy that have died back	
	Percentage of current canopy foliage as a proportion of the estimated canopy foliage volume/potential canopy	
	Percentage of canopy foliage discoloured	
Vegetation structure	Projected foliage cover (PFC – 1-5%, then 5% increments) of native grass/ground cover; native shrubs <1 m height, native shrubs/small trees >1 m height	Baseline, and then annually in spring for a period of 3 years after longwall is complete.
	PFC 5% increments of upper canopy (assessed at each quadrat corner and averaged)	
	Exotic species cover	
	Lower, estimated median and upper height of canopy	Baseline, and then 3 years after longwall is complete
	Lower, estimated median and diameter at breast height (DBH) over bark of canopy stems (cm)	
	Abundance of each canopy species; calculated, total stems per hectare	
Habitat features	Length of fallen logs >10 cm diameter (0.5 cm increments)	Baseline, and then 3 years after longwall is complete
	Number of hollow-bearing trees and stags	

Parameter	Measurement/method	Frequency
Photograph of canopy	Photograph of the canopy (camera placed on top of the star picket, facing up); photograph facing due north, south, east and west from the star picket	Baseline, and then 3 years after longwall is complete

Any evidence of subsidence, such as subsidence cracks, opportunistically observed during transect monitoring will be recorded with a handheld GPS

In addition to annual panel traverses, routine inspections of the surface environment above the longwalls will be undertaken by NCOPL personnel. This will enable prompt detection of impacts to tree health caused by surface cracking, ponding or other longwall mining consequences.

7.4 Targeted fauna surveys

Terrestrial fauna surveys targeting Delicate Mouse and Pale-headed Snake are to be conducted to identify the distribution potential and occupied habitats. Both species have been identified as possibly being impacted upon by subsidence.

Delicate Mouse has been recorded in the study area (Ecotone 2009). Therefore, the aim of future surveys will be to evaluate how much habitat within the study area is occupied by the Delicate Mouse, while searching for evidence of Pale-headed Snake.

Targeted Delicate Mouse surveys should include:

- Assess existing mapping to identify areas of suitable Delicate Mouse habitat
- On ground surveys to validate mapping assessment
- Active searches for direct and indirect evidence species occurring
- Live capture and release surveys for Delicate Mouse using Elliot, pitfall and funnel traps
- Remote survey techniques using movement sensing cameras and hairtubes (Table 10)

Targeted Pale-headed Snake surveys should include:

- Assess existing mapping to identify areas of suitable Pale-headed Snake habitat
- On ground surveys to validate mapping assessment
- Active searches for direct and indirect evidence species occurring
- Nocturnal spotlight transects along tracks in vehicles being driving slowly at 5km / hr to search for Pale-headed Snakes (Table 11)

Search for suitable habitat and evidence of activity searches for each species could be conducted concurrently (Table 10)**.** In Commonwealth of Australia (2009) the recommended survey effort in study areas 5 ha (50, 000 m^2) and larger (in size), is at least two hours search time per a stratified sampling program. The results of the habitat assessment and active searches will be used to improve the likelihood of directly detecting these two species.

Elliot, pitfalls and funnel traps should be set at the same survey sites to ensure captured animals are cleared effectively (Table 10).

Table 10: Delicate Mouse monitoring methods

Method	Detail	Recommended minimum survey effort	Frequency	Season	Location
Baseline daytime habitat and active searches	**Assess mapping and on-ground assessment for potential habitat for each species.**	Assess existing mapping to identify locations and the extent of potential habitat (based upon vegetation types). From this information select sites to conduct active searches and targeted surveys for each species (Paul 2009; Ecotone 2009). Conduct on ground surveys to validate the results of the mapping assessment. In study areas greater in size than 5 ha, searches of at least two-hour period / per stratified unit of habitat are recommended (Commonwealth of Australia 2009).	1st year baseline before longwall mining begins	n/a	Each longwall
	Active searches for signs of activity and / or evidence of site occupancy (direct evidence).	In those areas identified as potential habitat, conduct searches for signs of Delicate Mouse activity. For Delicate Mouse, search for burrow entrances and spoil mounds (focus searches beneath low growing bushes that provide cover to burrow entrances (Diete et al. 2015) (direct evidence of occupancy). Searches for and collect predator scats, owl casts, dead animals and skeletal remains (indirect evidence)	1st year baseline and annually until amelioration of surface cracks has taken place	Autumn and Spring	Each longwall
Live trapping survey	**Elliot A and E traps - small traps placed in suitable habitat set to capture very small animals (<8 grams in weight)**	Twenty-five (25) medium sized Elliot traps (Elliot A) or small (Elliot E) set in 5 x 5 grid with 10 – 25 m spacing's between traps. Trap grids are to set in areas with suitable and / or evidence of Delicate Mouse occupancy has been located. Traps should be set and surveyed for a period of 4 consecutive nights. Commonwealth of Australia (2009) recommendations	1st year baseline and annually until amelioration of surface cracks has taken place	Autumn and Spring	Each longwall

Method	Detail	Recommended minimum survey effort	Frequency	Season	Location
		that a survey effort of at least 160 trap nights should occur per survey within each stratified habitat unit.			
	Pitfall traps (20 litre buckets and 150 mm diameter PVC pipes) with associated drift fences	At least four pitfall traps and associated drift fence set in association with the funnel traps as per Figure 4. Pitfall and Funnel traps should be set near to Elliot trap grids for ease of clearing.	1st year baseline and annually until amelioration of surface cracks has taken place	Autumn and Spring	Each longwall
	Funnels traps	At least six funnels set in association with the pitfall traps as per Figure 4.	1st year baseline and annually until amelioration of surface cracks has taken place	Autumn and Spring	Each longwall
Remote device sampling techniques	**Remote movement cameras**	Unbaited remote movement sensing cameras set on burrows and large hollow bearing trees.	1st year baseline and annually until amelioration of surface cracks has taken place	Autumn and Spring	Each longwall
	Hairtubes	Small hairtubes (diameter of opening 20mm) set in areas of suitable habitat.	1st year baseline and annually until amelioration of surface cracks has taken place	Autumn and Spring	Each longwall

Table 11: Pale-headed Snake monitoring methods

Method	Detail	Recommended minimum survey effort	Frequency	Season	Location
Baseline daytime habitat and active searches	**Assess mapping and on-ground assessment for potential habitat for each species.**	Assess existing mapping to identify locations and the extent of potential habitat (based upon vegetation types). From this information select sites to conduct active searches and targeted surveys for each species (Paul 2009; Ecotone 2009). Conduct on ground surveys to validate the results of the mapping assessment. In study areas greater in size than 5 ha, searches of at least two-hour period / per stratified unit of habitat are recommended (Commonwealth of Australia 2009).	1st year baseline before longwall mining begins	n/a	Each longwall
	Active searches for signs of activity and / or evidence of site occupancy (direct evidence).	In those areas identified as potential habitat, conduct searches for signs of Pale-headed Snake activity. For Pale-headed Snakes search hollow entrances, cracks, crevices and exfoliating park on the large trees within low lying areas or within 160 metres of a riparian zone (Fitzgerald et al. 2010).	1st year baseline and annually until amelioration of surface cracks has taken place	Autumn and Spring	Each longwall
Nocturnal herpetological searches	**Spotlighting from vehicle along established tracks**	Two hours of spotlighting and searching along established tracks travelling at 5km per hour	1st year baseline and annually until amelioration of surface cracks has taken place, during warm summer nights	Summer	On established tracks within the study area

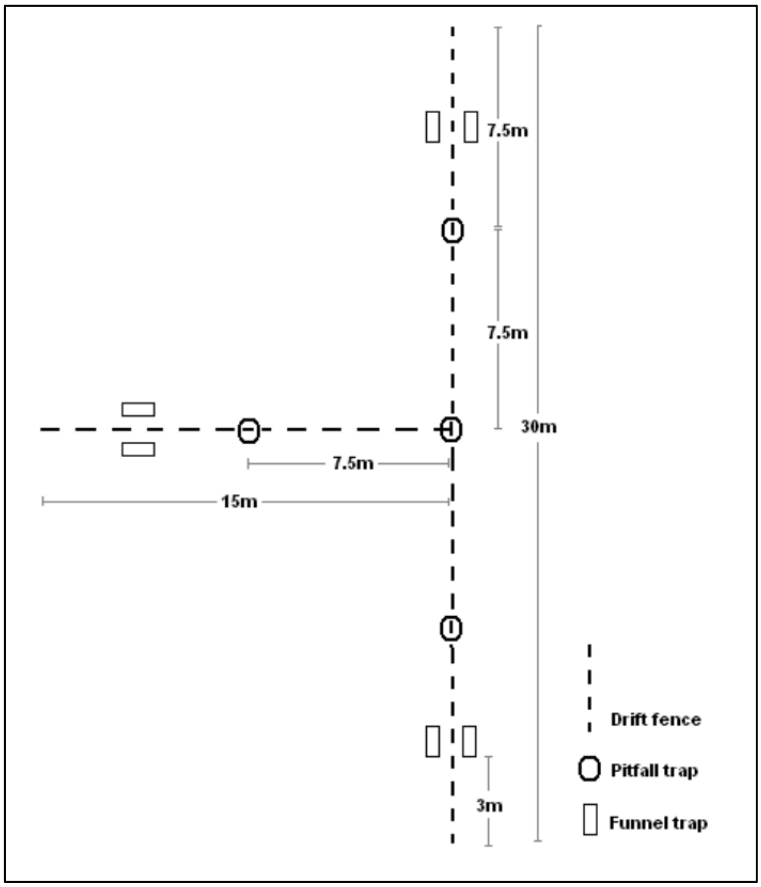

Figure 4: Recommended pitfall and funnel trap configuration to be set at each pitfall and funnel trap location (source: State of Queensland 2014)

7.5 Data analysis

Comparison between control and impact sites and analysis through time should be implemented following each survey period. Depending on the data either an ANOVA or multi-dimensional scaling (MDS) will be appropriate.

ANOVAs will be used to test for changes over time, and to test for differences between control and impact sites. For analysis of native vegetation communities, the variables to be analysed will include % cover, with separate analyses for understorey, overstorey, and total community variables.

7.6 Reporting and review

Reporting of all remote sensing analysis and outcomes of the longwall panel traverses; as well as any additional surveys undertaken in response to a trigger should take place annually in summer following the spring survey and subsequent analysis.

As it is expected that subsidence impacts would be most evident within 12 months of each longwall completion, this BMP has revised the time-frame for when monitoring can be scaled back or ceased. It is recommended that if no impacts associated with subsidence have been observed within 3 years after the completion of each longwall, that monitoring of a number of parameters can be scaled back or ceased. This will be done in consultation with the relevant government agencies.

PA_08_0144 requires a protocol for periodic review of the plan. The review requirements for the Extraction Plan, including this BMP, are outlined in Section 5.3 of the Extraction Plan.

7.7 Assessment against performance indicators

The monitoring results will be used to assess LW107 to LW110 against the performance indicators and performance measures detailed in Table 7 of Section 6. If data analysis shows a performance indicator has been exceeded or is likely to be exceeded the Contingency Plan will be implemented as per Section 8 of this BMP.

8 Management measures

This section describes the management measures that will be implemented to remediate impacts, including subsidence impacts and impacts associated with surface activities in LW107 to LW110. Management measures will be implemented, as appropriate, to comply with the relevant statutory requirements and the subsidence impact performance measure.

As described in Section 5, the environmental consequences from LW107 to LW110 upon the vegetation communities, terrestrial fauna and their habitat and aquatic biota and their habitat are based on the following predicted subsidence effects and impacts:

- Surface cracks
- Subsurface fracture
- Slope instability and erosion
- Valley uplift and closure
- Potential for ponding.

Based upon the predicted subsidence effects and consequences upon biodiversity values with LW107 to LW110, management measures have been prescribed below for:

- Vegetation
- Terrestrial fauna and habitat
- Vegetation clearing
- Weed management
- Feral pest management
- Additional monitoring.

8.1 Vegetation

Potential management measures for impacts on vegetation include the implementation of weed control measures (e.g. mechanical removal or the application of approved herbicides), the preservation of stags (dead trees) and the planting of endemic plant species should monitoring indicate that the impacts are having a negative effect on the distribution and health of the vegetation communities.

Weed management measures should be in line with those represented within the Rehabilitation Management Plan (RMP) and further described in Section 8.3.

Any active planting should use flora species characteristic of the particular vegetation community and will be of regional providence. All rehabilitation methods and species should be line with the RMP.

8.2 Terrestrial fauna and habitat

Potential management measures include the permanent filling of the surface tension cracks in accordance with the LMP, to avoid fauna mortality. Stags and woody debris would also be retained for potential fauna habitat.

The implementation of management measures will be considered with regard to the specific circumstances of the subsidence impact (e.g. the location, nature and extent of the impact) and the assessment of the environmental consequence.

8.3 Vegetation clearing

Any vegetation clearing must follow the protocol outlined in the Statement of Commitments and the Narrabri Mine RMP, which includes:

- Undertaking pre-clearing surveys by qualified staff to identify if any threatened species, populations or communities or their habitat is present
- Assessing whether aquatic or fish habitat is present within the drainage features to be traversed by the access road and/or power line corridors
- Determining appropriate paths for access tracks and other disturbance with the aim of least impact on environmental values where practically possible
- Relocating or re-orientating proposed disturbance if threatened species, populations or communities or their habitat is identified. If the relocation or re-orientation of the area to be disturbed is not practicable (for reasons of mine / operational safety), a qualified ecologist will relocate any fauna species residing within the area to be cleared
- Retaining all substantial habitat trees, wherever possible
- Undertake tree felling, where practicable, outside fauna breeding seasons
- Undertake any tree-felling in accordance with the Clearing Protocol (Appendix A).

8.4 Weed management

Weed management activities will be implemented to limit the spread of noxious and environmental weeds, where weeds are found to occur on LW107 to LW110. Weed management should be in line with the RMP and be targeted at noxious weeds initially. All noxious weeds recorded within the Mining Lease to date are Category 4 noxious weeds, which must be controlled by the land owner according to the measures specified in a management plan published by the local control authority (NSC). Noxious weed management plans have been produced by the NSC for all noxious weed species except Galvanised Burr (*Sclerolaena birchii*).

8.5 Additional monitoring

Where a performance indicator and/or measure has been exceeded, it may be appropriate to conduct additional monitoring (e.g. increase the frequency of monitoring or the parameters monitored) or conduct additional test work. For example, if the analysis of vegetation communities indicates a performance indicator has been exceeded, more frequent monitoring of specific areas, such as incidence of vegetation dieback, may be appropriate.

9 Contingency response

The ongoing monitoring outlined in this BMP aims to identify the consequences of longwall mining on biodiversity above LW107 to LW110. Contingency measures must consider the specific issue and an assessment of environmental consequences. Relevant actions may include the implementation of management measures identified in Section 8.

In the event the subsidence effects and consequences on biodiversity exceed those predicted in the EA and/or the performance indicators nominated in this BMP (or are considered likely to be exceeded at a future date based on observed trends), Narrabri Mine will implement the contingency responses nominated in the EP and the Trigger Action Response Plan below (Table 12). Contingency measures as identified in other plans including the Subsidence Monitoring Program shall also be adhered to.

Table 12: Biodiversity management Trigger Action Response Plan (TARP)

Aspect	Monitoring		Response		
	Methods	Purpose	Trigger	Action	Responsibility
Woodland and riparian vegetation	Longwall panel traverse and floristic-based subsidence monitoring **Parameters:** Refer to Section 7.3 **Analysis:** Comparison of attributes between impact and control zones Comparison of attributes within quadrats over time **Frequency:** Monitoring quadrats - Annually (spring) Longwall inspection – after subsidence Remote sensing – annually prior to spring field surveys	To provide baseline data on vegetation health and habitat value To identify any changes in vegetation health and habitat value	Level 1 • NDVI monitoring identifies no change (i.e. within +/- 1 std dev from average) in an area that exceeds 0.1ha. • Canopy is unchanged from that observed in baseline monitoring (with consideration given to natural variation) • No declining trend observable from preceding 3 years' monitoring data or with comparison to baseline • Increase in weed cover in impact vs control quadrats is <5%	Level 1 • No action required, continue monitoring	Environmental Superintendent
			Level 2 • NDVI monitoring identifies change > +/- 2 std dev from average in an area that exceeds 0.1ha. • Canopy change is greater than that observed in baseline monitoring (with consideration given to natural variation) • Definable trend of decline observable over preceding 3 years' monitoring data or with comparison to baseline • Increase in weed cover in impact vs control quadrats is >5% and <10%	Level 2 • *As for Level 1* • Conduct site investigation to determine the cause of change and appropriate management response which may include planting of endemic species, weed control measures etc • Review monitoring program as required	

Aspect	Monitoring		Response		
	Methods	Purpose	Trigger	Action	Responsibility
Woodland and riparian vegetation	**Sites:** Affected longwall panel/s **Parameters:** Pre-clearing and clearing survey data and mapping **Analysis:** Comparison of Pre-clearing and clearing survey data and mapping Cumulative tally of cleared areas above LW107 to LW110 **Frequency:** Annually	To minimise vegetation clearing To preserve remnant vegetation identified in pre-clearing surveys Map clearing areas to determine if actual clearing aligns with pre-clearing survey recommendations.	Level 1 • Area of actual clearing is within approved	Level 1 • No action required	Environmental Superintendent
			Level 2 • Area of actual clearing exceeds approved	Level 2 • Environmental Superintendent to inform Group Manager – Environment and Technical Services Manager • Investigate reasons for exceedance • DoPE, OEH and DRE to be notified and actions discussed. • Undertake rehabilitation and revegetation of equivalent area in accordance with RMP as required	
Targeted threatened fauna species – Delicate Mouse and Pale-	Routine inspections of subsidence surface cracks by Narrabri Mine personnel	To identify any incidence of Delicate Mouse or Pale-headed Snake becoming	Level 1 • No incidence of Delicate Mouse and/or Pale-headed snake becoming trapped in surface cracks.	Level 1 • Continue monitoring as prescribe and ameliorate surface cracks as soon as practicable	Environmental Superintendent

Aspect	Monitoring		Response		
	Methods	Purpose	Trigger	Action	Responsibility
headed Snake	**Parameters:** Presence of target species in subsidence surface cracks **Frequency:** After undermining and the appearance of surface cracks	trapped in surface cracks.	Level 2 • Incidence of Delicate Mouse and/or Pale-headed snake becoming trapped in surface cracks.	Level 2 • A site specific management report to be prepared and implemented where necessary. Actions may include monitoring to determine overall impact to population of impacted target species.	

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

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Appendix A Clearing Protocol

The protocol used to fell trees is recommended to be as follows:

1) The nearest veterinary clinic, wildlife carer and/or an appropriately trained ecologist phone numbers should be on hand if any fauna is injured during clearing of trees.

2) All trees are to be visually inspected by a qualified ecologist or suitably trained person for fauna immediately prior to tree removal.

3) Care should be taken to allow all fauna to vacate a given tree prior to felling.

4) Habitat trees and or habitat features (Large Woody Debris) should be utilised within appropriate offsetting or natural areas for fauna habitat purposes.

5) Pre-felling procedures for all trees to be felled include shaking or nudging tree trunks with the dozer blade to evacuate mobile fauna, such as birds. The following are possible scenarios and the appropriate procedure to manage these scenarios:

    a. If microchiropteran bats or other nocturnal hollow dwelling fauna are still observed within the tree following pre-felling procedures (i.e. tree shaking), the tree is to be retained in the short term and the following procedure should be applied:

        i. Appropriate licences to “harm” fauna under the *National Parks and Wildlife Act 1974* are to be sourced prior to the felling works;

        ii. An appropriately trained and licensed ecologist with Lyssa Virus vaccination should be contacted and be present during the felling process (Note: Australian Microchiropteran bats can carry Lyssa Virus, a debilitating disease similar to rabies);

        iii. The nearest veterinary clinic and wildlife carer phone number should be on hand;

        iv. Each hollow-bearing section of the tree is to be lopped and carefully lowered to the ground;

        v. All data on species and number of hollow bearing fauna is to be recorded;

        vi. Once on the ground each hollow is to be inspected for resident fauna. And any injured fauna are to be cared for;

        vii. The hollow-bearing limb should then be removed from the tree and positioned in a nearby safe and appropriate location at the same aspect and height of its original location.

    b. All hollow-bearing trees are to undergo a controlled lowering.

    c. For non-hollow-bearing trees, if no fauna are observed to be within a tree to be felled, the “slow drop” technique is to be used to fell the tree. This involves nudging and shaking the tree, followed by a slow drop.

ecological AUSTRALIA

ISO 14001 Environmental Management

AS/NZS 4801:2001 Occupational Health and Safety Management

ISO 9001 Quality Management

HEAD OFFICE
Suite 2, Level 3
668-672 Old Princes Highway
Sutherland NSW 2232
T 02 8536 8600
F 02 9542 5622

CANBERRA
Level 2
11 London Circuit
Canberra ACT 2601
T 02 6103 0145
F 02 9542 5622

COFFS HARBOUR
35 Orlando Street
Coffs Harbour Jetty NSW 2450
T 02 6651 5484
F 02 6651 6890

PERTH
Suite 1 & 2
49 Ord Street
West Perth WA 6005
T 08 9227 1070
F 02 9542 5622

DARWIN
16/56 Marina Boulevard
Cullen Bay NT 0820
T 08 8989 5601
F 08 8941 1220

SYDNEY
Suite 1, Level 1
101 Sussex Street
Sydney NSW 2000
T 02 8536 8650
F 02 9542 5622

NEWCASTLE
Suites 28 & 29, Level 7
19 Bolton Street
Newcastle NSW 2300
T 02 4910 0125
F 02 9542 5622

ARMIDALE
92 Taylor Street
Armidale NSW 2350
T 02 8081 2685
F 02 9542 5622

WOLLONGONG
Suite 204, Level 2
62 Moore Street
Austinmer NSW 2515
T 02 4201 2200
F 02 9542 5622

BRISBANE
Suite 1, Level 3
471 Adelaide Street
Brisbane QLD 4000
T 07 3503 7192
F 07 3854 0310

HUSKISSON
Unit 1, 51 Owen Street
Huskisson NSW 2540
T 02 4201 2264
F 02 9542 5622

NAROOMA
5/20 Canty Street
Narooma NSW 2546
T 02 4302 1266
F 02 9542 5622

MUDGEE
Unit 1, Level 1
79 Market Street
Mudgee NSW 2850
T 02 4302 1234
F 02 6372 9230

GOSFORD
Suite 5, Baker One
1-5 Baker Street
Gosford NSW 2250
T 02 4302 1221
F 02 9542 5622

1300 646 131
www.ecoaus.com.au