Biodiversity Management Plan – Narrabri Mine (LW 101 – 106)

Narrabri Mine

Prepared for
Narrabri Coal Operations Pty Ltd

18 May 2016

DOCUMENT TRACKING

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Abbreviations

Abbreviation	Description
AoD	Angle of Draw
BMP	Biodiversity Management Plan
DRE	Division of Resources and Energy
DP&E	Department of Planning and Environment
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)
LMP	Land Management Plan
LSMP	Landscape Management Plan
LW	Longwall
MOP	Mine Operations Plan
NCOPL	Narrabri Coal Operations Pty Ltd
NM	Narrabri Mine

Abbreviation	Description
NSC	Narrabri Shire Council
OEH	Office of Environment and Heritage
PA	Project Approval
RMP	Rehabilitation Management Plan
SRP	Subsidence Reduction Potential
TSC Act	*Threatened Species Conservation Act 1995* (NSW)
WCL	Whitehaven Coal Limited
WMP	Water Management Plan

1 Introduction

The Narrabri Mine (NM) 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 NM under Section 75J of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) on the 26th July 2010 (PA 08_0144), as modified.

The Stage 2 project involves converting the existing mining operations to longwall extraction of 20 longwall panels. The approved underground mining layout is shown in Figure 2. Longwalls 101 to 106 (herein referred to as LW 101-106) define the first of the secondary extraction mining within the Approved Project underground mining areas and are the focus of the this Biodiversity Management Plan (BMP).

1.1 Purpose and scope

In accordance with Stage 2 Longwall PA 08_0144, as modified, Condition 4(h), Schedule 3, this BMP has been prepared as a component of the NM LW 101-106 Extraction Plan (EP) to manage the potential impacts and/or environmental consequences of the LW's upon flora and fauna as identified through the revised Mine Subsidence Effect Predictions and Impact Assessment prepared for the proposed LW 101-106 (DGS 2015), Landscape Management Plan (LSMP) (ELA 2015) and relevant approval documents, including the Environmental Assessment (EA) for Stage 2 of the Narrabri Coal Mine (R.W. Corkery & Co. 2009).

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 some parameters can be scaled back or ceased. This will be done in consultation with the relevant government agencies.

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 LW 101-106.
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	Content
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

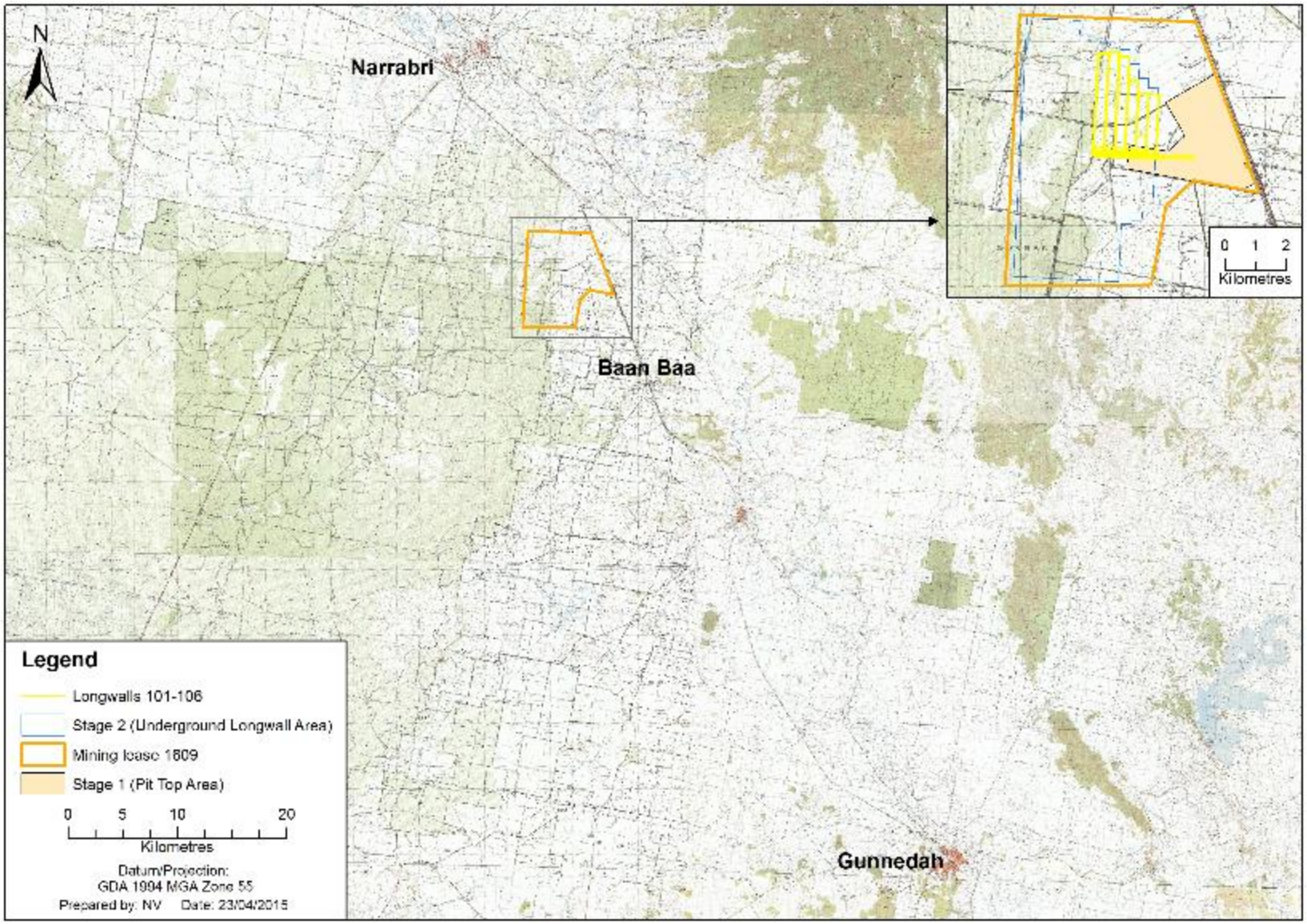

Figure 1: Mine site location

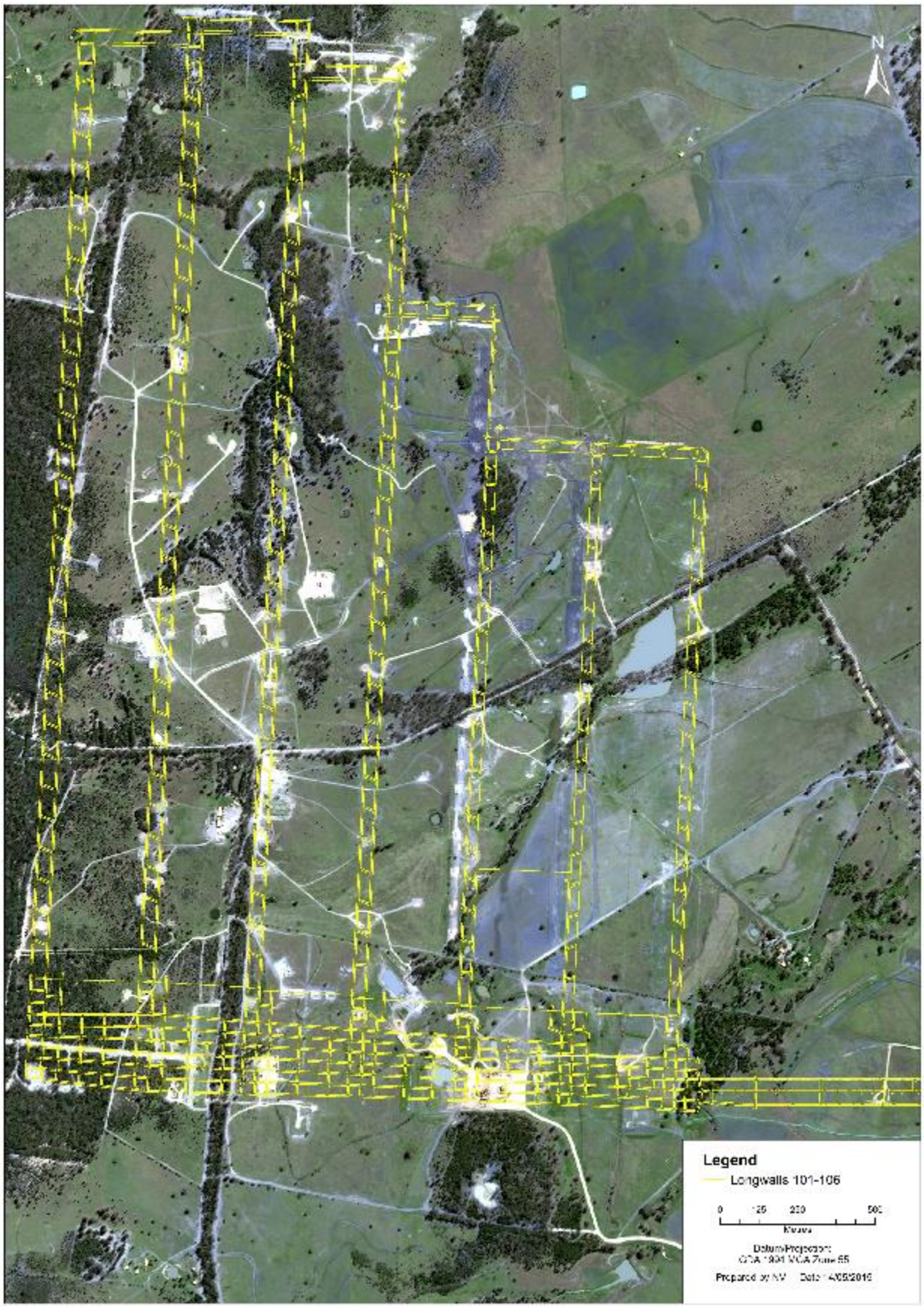

Figure 2: LW 101-106

2 Statutory Requirements

NCOPL's statutory obligations are contained within:

- The conditions of the Project Approval (PA) 08_0144, as modified, under the NSW EP&A Act.
- The conditions of Approval (EPBC Ref 2009/5003) under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).
- Relevant licenses and permits, including conditions attached to the mining lease.
- Other relevant legislation.

These are described below.

2.1 EP&A Act approval

Condition 4(h) of Schedule 3 of the Project Approval (PA 08_0144) under the EP&A Act requires the preparation of a BMP as a component of the EP for second workings. Approval condition 4(h) states:

> *4. The Proponent shall prepare and implement Extraction Plans for any second workings to be mined to the satisfaction of the Secretary. Each Extraction Plan must:*
>
> *h) 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.

Under Condition 5 of Schedule 3, all management plans under Condition 4(h) of Schedule 3 of the Project Approval (PA 08_0144) will include:

- An assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval
- A detailed description of the measures that would be implemented to remediate predicted impacts
- A contingency plan that expressly provides for adaptive management.

In addition, Condition 2 of Schedule 6 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 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
	• 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 6
	• 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 6
	• a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria	Section 8
	• a program to monitor and report on the: • impacts and environmental performance of the project • effectiveness of any management measures (see c above)	Section 7
	• a contingency plan to manage any unpredicted impacts and their consequences	Section 9
	• 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
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 • 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:	

Condition number	Condition requirement	Relevant section of this report
	• An assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval	Section 5
	• A detailed description of the measures that would be implemented to remediate predicted impacts	Section 8
	• A contingency plan that expressly provides for adaptive management	Section 9

The Project Approval requires NCOPL not to exceed the subsidence impact performance measures outlined in Table 1 of Condition 1, Schedule 3. In addition, Table 1 of Condition 1, Schedule 3 in relation to biodiversity of flora and fauna is to ensure that that clearing and disturbance of vegetation above the mining area is minimised, to the satisfaction of the Secretary.

In addition to the requirements of the Project Approval, NCOPL has made a number of commitments within their '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).

2.2 EPBC Act approval

Condition 3 of the Approval (EPBC Ref 2009/5003) under the EPBC Act requires the incorporation 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 Secretary'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 Project Approval under the EP&A Act required the preparation of a suitably biodiversity offset strategy to compensate the impacts. In addition, the project was determined as a controlled action under the EPBC Act, which also required the preparation of a suitably biodiversity offset strategy. The biodiversity offset strategy (ELA 2011) has been prepared according to both the EP&A Act and EPBC Act requirements.

2.4 Licences, permits and leases

In addition to the Project Approval under the NSW EP&A Act and Commonwealth EPBC Act, all activities at or in association with the NM will be undertaken in accordance with the following licenses, permits and leases which have been issued or are in preparation:

- The conditions of the mining lease issued by the Division of Resources and Energy (DRE), under the NSW Mining Act, 1992 (Mining Lease No.1609)
- The Stage 2 MOP approved for the period 1st July 2011 to 30th June 2013
- The conditions of Environment Protection Licence (EPL) No. 12789 issued by the NSW Environment Protection Authority (EPA) under the NSW Protection of the Environment Operations Act, 1997
- Water Access licences issued by the NSW Department of Primary Industries – Water (DPI Water) in accordance with the Water Management Act 2000
- Mining and occupational health and safety related approvals granted by DRE and WorkCover NSW (R.W. Corkery & Co. 2009).

2.5 Other legislation

NCOPL will conduct the Project consistent with the Project Approval and any other legislation that is applicable to an approved Part 3A Project under the EP&A Act. The following Acts may be applicable to the conduct of the Project (R.W. Corkery & Co. 2009):

- 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
- Protection of the Environment Operations Act 1997
- Threatened Species Conservation Act 1995 (TSC Act)
- Work Health and Safety (Mines) 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
- Water Act 1912.

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 under relevant statutory approvals (Project Approval and Mining Lease) by both DP&E and DRE respectively.

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

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 DP&E and DRE for assessment
- Presentation workshop on 18th January 2012 attended by DP&E, DRE and OEH.

Forests NSW, Narrabri Shire Council and the Namoi Catchment Management Authority were consulted and issued no concerns over the draft BMP.

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

Table 3: Conditions of approval (PA 08_0144) relevant to this Biodiversity MP

Agency	Issue raised	Relevant section of this report
DP&E (EP Review)	Demonstration/confirmation that consultation has taken place in the development of this BMP.	Section 3 (this section)
	Approval Condition requirement (Table 1, Condition 1 of Schedule 3) should feature in Section 5 and provide quantifiable performance measures	Section 4
	Detailed baseline data (Condition 2, Schedule 6) needs to be provided	Section 4
	Provide quantifiable performance measures	Section 6
	Prepare Trigger Action Response Plan (TARP)	Section 8
	Lack of evidence of formal risk assessment	Section 5

The draft revised BMP was sent to OEH, and the draft revised EP was sent to DP&E and DRE for comment.

A summary of matters arising from this consultation (as relevant to this BMP), and where each is addressed within this BMP, is provided in Table 4

Table 4: Conditions of approval (PA 08_0144) relevant to this Biodiversity MP

Agency	Issue raised	Relevant section of this report
OEH	Upgrade the performance measures and indicators, monitoring program, management measures or contingency response to with subsidence-induced damage to vegetation	Section 6 – Table 6 Section 7 Section 7.1 Section 7.2 Section 8.1 Section 9 – Table 11

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 visits for the development of the Rehabilitation Management Plan (ELA 2011), site reconnaissance undertaken specific to LW 101-105 in August 2011, and site reconnaissance undertaken specific to LW 106 in April 2015.

This baseline data, although not detailed specifically to LW 101-106, 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 6 of this BMP includes the collection of more detailed baseline data specific to LW 101-106 before longwall mining operations commence.

The monitoring program outlined in Section 7 of this BMP indicates where additional baseline data specific to LW 101-106 is required and the relevant baseline monitoring report referenced (ELA 2012a, ELA2012b).

4.1 Woodland and riparian vegetation

Six natural vegetation communities and one artificial vegetation community occur across the longwall area. The following three are represented above the area of LW 101-106 (Figure 3):

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

Riparian Forest occurs as small remnant patches, along the drainage lines of Pine Creek, Kurrajong Creek and Pine Creek Tributary 1 above LW 101-106. 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 which is listed as an EEC under both the TSC Act and EPBC Act (Ecotone Ecological Consultants 2009).

The Inland Grey Box community occurs as small remnant patches above LW 101-106. The majority of these patches are modified and are subject to occasional to regular grazing. The patches are partially cleared in the tree and shrub layers, with the abundance of exotic species generally low.

The majority of the area above LW 101-106 is occupied by Cleared Open Grassland. Besides isolated paddock trees, this community is composed mostly of cleared open pasture with groundcover generally to a height of less than 500 mm. The community is grazed regularly and/or ploughed and cultivated (Ecotone Ecological Consultants 2009).

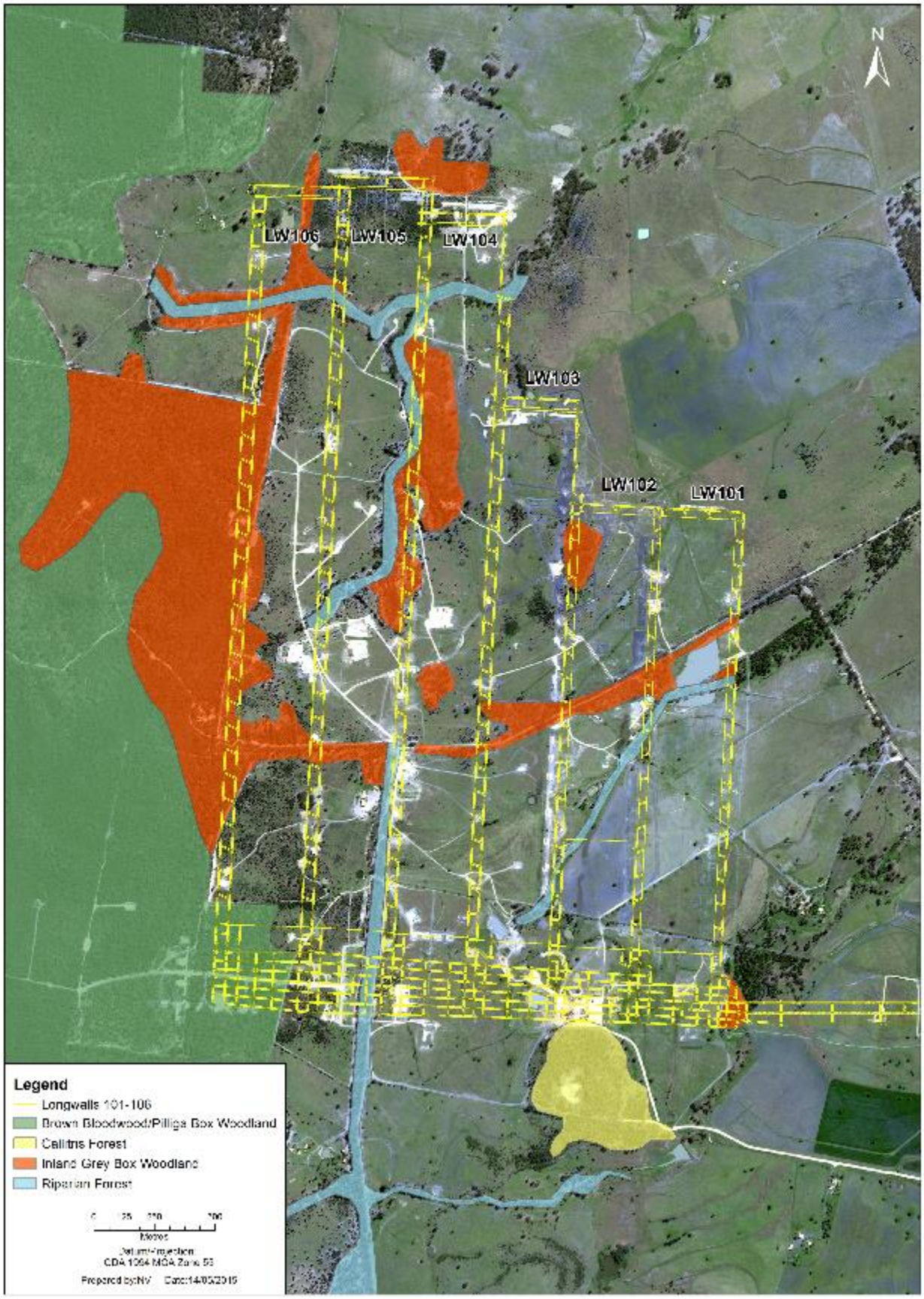

Figure 3: Vegetation communities above LW 101-106

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. Two threatened flora species have been 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 LW 102 -103 (Figure 4) (ELA 2012).

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 or EPBC Act. The following four species have been detected above LW 101-106:

- *Polytelis swainsonii* (Superb Parrot) – listed as vulnerable under the TSC Act and EPBC Act
- *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 (Ecotone Ecological Consultants 2009).

Two of the fauna species recorded during the surveys were migratory birds listed under the EPBC Act, of which one was identified above LW 101-106: *Hirundapus caudacutus* (White-throated Needletail).

During site reconnaissance undertaken by ELA in August 2011, five groups of Grey-crowned Babblers and numerous nests were observed within the remnant vegetation located above LW 101-105 as shown in Figure 5. No threatened fauna species were observed over LW 106 during the site reconnaissance undertaken in April 2015.

Fauna habitat associated with the land above LW 101-106 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 – only as remnant patches
- Open areas comprised of pasture and/or cropping paddocks – the majority of the area
- Drainage lines – Pine Creek, Kurrajong Creek and associated tributaries
- Farm dams (Ecotone Ecological Consultants 2009).

Figure 4: *Lepidium aschersonii* locations above LW 101 - 105

Figure 5: Grey-crowned Babbler groups and nests above LW 101-106

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. The two creek lines and their tributaries that occur above LW 101-106 are ephemeral in nature and lack pools of semi-permanent or permanent water for aquatic biota (Ecotone Ecological Consultants 2009).

Eleven farm dams occur above LW 101-106 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 was high variability in vegetation condition throughout the longwall area. The land above LW 101-106 is an area that has been cleared for grazing and has a number of small patches of remnant vegetation. It is therefore assumed that the weeds identified for the purposes of the ecological assessment are highly likely to occur over this area (Ecotone Ecological Consultants 2009). This was confirmed during the site reconnaissance undertaken by ELA in August 2011 and April 2015, with a number of noxious weed species being recorded within the remnant vegetation above LW 101-106.

Three of the eight noxious weed species declared within Narrabri Shire Council (NSC) control area that were identified in the ecological assessment undertaken by Ecotone Ecological Consultants (2009) were identified during the site reconnaissance of LW 101-106 (Figure 6), these were:

- *Lycium ferocissimum* (African Boxthorn) – Class 4
- *Xanthium spinosum* (Bathurst Burr) – Class 4
- *Opuntia stricta* (Prickly Pear) – 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). Those species being:

- Common Starling
- Common Myna
- House Mouse
- Black Rat
- Dog
- Fox
- Pig
- Goat
- Brown Hare.

Figure 6: Noxious weeds above LW 101-106

5 Potential Environmental Consequences

A detailed Mine Subsidence Effect Prediction and Impact Assessment was prepared for the proposed LW 101-106 by Ditton Geotechnical Services Pty Ltd (DGS 2015) for incorporation into the EP. This study was undertaken to update the subsidence predictions and assessment of the impacts relating to the predicted subsidence over LW 101-106.

The mine subsidence effect predictions involved:

- Reviewing site geotechnical and geological data
- Assessing the massive strata Subsidence Reduction Potential (SRP) for land above LW 101-106
- Measured subsidence over LW 101-104

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, tilt and strain profiles across representative sections using a modified version of the ACARP 2003 model (DGS 2015).

The impact assessment component of the study involved determining the subsidence related impacts that have the potential to occur above the LW 101-106, 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 2015).

5.1 Longwall 101 to 106 layout

LW 101-106 lies immediately to the west of the Pit Top Area (Figure 2 of Section 1). The land surface is primarily used for livestock grazing with some cereal crop farming and contains remnant vegetation stands (predominantly along creek lines).

LW 101-106 will be mined at depths ranging from approximately 160 m to 250 m below the surface and each longwall panel will be 306.4 m wide. A row of chain pillars will be formed between each longwall panel, each pillar will be 3.5 m high and 97.25 m long (solid) with 5.4 m nominal roadway widths. Pillar widths will be as follows:

- 30 m between LW 101-103

- 35 m between LW 103-105
- 39.5 m between LW 105-106 (DGS 2015).

Panel width to depth ratio will range from 1.23 to 1.92, indicating both critical and subcritical subsidence behaviour. The chain pillars are expected to have width to depth ratios of 8.6 to 11.3 and will be expected to strain-harden slowly and not crush out suddenly. The main headings pillars will be 27 m to 36 m wide and 30 m to 96 m long (DGS 2015).

5.2 Overall predicted subsidence

The predicted subsidence effects of secondary extraction (longwall mining) of LW 101-106 have been determined (DGS 2015). The predictions take into account the following factors:

- 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 2015).

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 5) (DGS 2015).

Table 5: Predicted mean and credible worst-case results for all of the cross-lines (DGS 2015)

Predicted subsidence	Without spanning volcanics	
	Lower limit	Upper limit
First maximum panel subsidence after mining of LW 101-106	2.39 m	2.75 m
Final maximum panel subsidence after mining of LW 101-106	2.57 m	2.75 m
First maximum chain pillar subsidence after mining of LW 101-106	0.18 m	0.48 m
Final maximum chain pillar subsidence after mining of LW 101-106	0.21 m	0.54 m
Final maximum panel concave curvature after mining of LW 101-106	0.6/km	3.3/km
	Radii of curvature 1.66 km - 0.3 km	
Final maximum panel concave curvature after mining of LW 101-106	0.40/km	2.6/km
	Radii of curvature 2.5 km - 0.38 km	
Final maximum panel compressive strains after mining LW 101-106 (smooth profile behavior)	6 mm/m	13 mm/m
Final maximum panel compressive strains after mining LW 101-106 (discontinuous	14 mm/m	33 mm/m

movements)		
Final maximum panel tensile strains after mining LW 101-106 (smooth profile behavior)	4.0 mm/m	10.0 mm/m
Final maximum panel tensile strains after mining LW 101-106 (discontinuous movements)	11 mm/m	26 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 12.8º to 24.6º for the proposed LW 101-106 and predicted goaf edge subsidence range of 0.08 to 0.31 mm (DGS 2015).

5.3 Predicted subsidence effects and impacts

The overall predicted subsidence effects and impacts above LW 101-106 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 40 mm to 260 mm are predicted based on the predicted range of maximum transverse and tensile and compressive strains for cover depths of 160 m to 260 m. Measured surface cracks above LW 101-104 have ranged from 50 to 100 mm wide, with some cracking of up to 200 mm. The largest cracks are predicted to occur over LW 101-104, with cracking over LW 106 expected to range between 40 to 110 mm (DGS 2015).

If there are adverse topographic or geological conditions these crack widths may be exceeded in 5 % of incidences, this is unlikely to occur over the majority of LW 101-106. However, it may occur near steep creek banks along Pine Creek and its tributaries (DGS 2015).

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 a mine 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 2015).

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 2015).

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 2015).

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 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 (DGS 2011).

The Geometry 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 101-106 (DGS 2015).

The Geometry Pi-Term Model predicts that discontinuous fracturing could interact with surface cracks where cover depths are <255 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 2015).

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 2015).

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 2015).

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 2015).

The occurrence of upsidence and closure along the creek beds above LW 101-106 is likely to be minimal as the valleys across the NCM mining lease are not underlain by thick massive beds of conglomerate and/or sandstone and they are broad between crests (DGS 2015).

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 2015).

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 2015). 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 0.25 to 2.1 m after LW 101-106 are completed. It is expected that 18.4 ha in total with a combined volume of 122 ML will be affected by ponding (DGS 2015). 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.

5.4 Potential environmental consequences on biodiversity

The overall predicted effects and consequences on biodiversity are a result of subsidence and its impacts above LW 101-106 are summarised below and in Table 6.

5.4.1 Woodland and riparian vegetation

Vegetation mapped by Ecotone Ecological Consultants (2009) above LW 101-106 and surrounds is shown in Figure 3. Vegetation communities identified upon LW 101-106 consisted of Riparian Forest (predominantly along Pine Creek and associated tributaries), Inland Grey Box Woodland and Cleared Open Grassland.

Threatened flora species listed under the TSC Act or EPBC Act that are known to occur or have the potential to occur within the vegetation communities above LW 101-106 are:

- Coolabah Bertya
- Spiny Peppercress.

The subsidence predictions for LW 101-106, as outlined above in Section 5 above and indicated within the Mine Subsidence Effect Prediction and Impact Assessment prepared for LW 101-106 (DGS 2015) indicate that there were are no major differences between the initial (EA) for Stage 2 of the Narrabri Coal Mine (R.W. Corkery & Co. 2009) and the DGS 2015 assessment for LW 101-106.

The effects of surface subsidence for LW 101-106 may impact the vegetation communities, including 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 LW 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

Terrestrial fauna habitats were identified in the habitat types discussed in Section 4.3, namely woodland areas, open areas comprised of pasture and/or cropping paddocks, drainage lines (including Pine Creek and associated tributaries) and farm dams (Ecotone Ecological Consultants 2009).

A number of threatened terrestrial fauna species listed under the TSC Act or EPBC Act are known to occur, or have the potential to occur above LW 101-106 and furthermore across the overall Mining Lease. Threatened terrestrial fauna species recorded above LW 101-106 are identified in Section 4.3.

The subsidence predictions for LW 101-106, as outlined above in Section 5 above and indicated within the Mine Subsidence Effect Prediction and Impact Assessment prepared for LW 101-106 (DGS 2015) indicate that there were no major differences between the EA for Stage 2 of the Narrabri Coal Mine (R.W. Corkery & Co. 2009) and the DGS 2011 assessment for LW 101-106.

The consequences of surface subsidence for LW 101-106 to terrestrial fauna and associated habitat may include:

- Localised and limited reduction in the habitat resources available to terrestrial fauna as a consequence of subsidence impacts on woodland and riparian vegetation
- Surface cracking will form areas capable of 'trapping' some ground dwelling fauna (e.g. frogs and reptiles).

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

Pine Creek (and its tributaries) as well as eleven farm dams occur above LW 101-106. Kurrajong Creek drains a small area of LW 101 to the south; however, it is unlikely to be directly affected by subsidence above LW 101-106. These aquatic environments may provide habitat for aquatic biota including aquatic macroinvertebrates, aquatic macrophytes and fish. However, given Pine Creek, Kurrajong Creek and their associated tributaries are all ephemeral in nature and lack pools of semi-permanent or permanent water, aquatic biota and their habitat is lacking along the creek and tributaries.

The subsidence predictions for LW 101-106, as outlined above in Section 5 above and indicated within the Mine Subsidence Effect Prediction and Impact Assessment prepared for LW 101-106 (DGS 2015) indicate that there were no major differences between the initial (EA) for Stage 2 of the Narrabri Coal Mine (R.W. Corkery & Co. 2009) and the DGS 2011 assessment for LW 101-106.

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

Subsidence impact	Subsidence consequence	Potential environmental hazard (to biodiversity)
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 Disturbance or loss of native fauna species and/or assemblages
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 'Trapping' of ground dwelling fauna
Creek bank slumping and erosion Cracking and/or drainage of farm dams	Negative effect on woodland and/or 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

The Project Approval requires NCOPL not to exceed the subsidence impact performance measures outlined in Table 1 of Condition 1, Schedule 3. In addition, Table 1 of Condition 1, Schedule 3 in relation to biodiversity of flora and fauna is to ensure that that clearing and disturbance of vegetation above the mining area is minimised, to the satisfaction of the Secretary.

The vegetation communities, flora and fauna that occur above LW 101-106 are outlined within Section 4. This information is based upon the ecological assessment undertaken by Ecotone Ecological Consultants (2007) for Stage 1 and Ecotone Ecological Consultants (2009) for Stage 2, site visits for the development of the Rehabilitation Management Plan (ELA 2011), and site reconnaissance undertaken specific to LW 101-105 in August 2011 and LW106 in April 2015.

The monitoring program outlined within Section 7 of this BMP includes the collection of more detailed baseline data specific to LW 101-106 before longwall mining operations commence. Where the monitoring schedule refers to the collection of baseline data, the reader is referred to the Narrabri Coal Mine LW 101 – 103 Baseline Monitoring Reports for Biodiversity and Land Management (ELA 2012a and ELA 2012b).

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 (LW 101-106)

Objective	Performance measures	Performance criteria
To minimize the clearing and disturbance of vegetation above the mining area	Woodland vegetation (Inland Grey Box EEC) composition and health	Clearing does not exceed the estimated area of clearing assessed by the EA for all of Stage 2, namely 210.5 ha Less than 10% change in floristic composition (relative to natural variation found in control areas) Less than 10% increase in exotic species numbers and cover Weed species are identified and managed according to the weed management measures provided in the Rehabilitation Management Plan Identified areas of NDVI change (greater than 1 standard deviation from the mean change and greater than 0.1 ha in area) investigated in the field to determine the source of the change. Site specific management report prepared and recommendations implemented where necessary. No increase in feral animal presence
	Riparian vegetation composition and health	Clearing does not exceed the allowable limit of the Project Approval Less than 10% change in floristic composition (relative to natural variation found in control areas) Less than 10% increase in exotic species numbers and cover No increase in feral animal presence Weed species are identified and managed according to the weed management measures provided in the Rehabilitation Management Plan Identified areas of NDVI change (greater than 1 standard deviation from the mean change and greater than 0.1 ha in area) investigated in the field to determine the source of the change. Site specific management report prepared and recommendations implemented where necessary. Less than 20% increase in length of eroding creek line
	Terrestrial fauna habitat for threatened species	Fauna populations located within these habitats do not experience adverse impacts, including reduction in habitat area, hollow-bearing trees and woody debris Fauna records decrease by greater than 10% (relative to natural variation found in control areas)
	Aquatic macroinvertebrate and macrophyte assemblages in farm dams	No decline in aquatic habitat quality relatively to natural variation in control areas

7 Monitoring

Given the size of the target area and the multiple land uses and key environments a multi-scale, multi-data source monitoring approach has been developed (Table 8) to monitor the environmental consequences of longwall mining on land and biodiversity above LW 101-106.

Whole-of-site monitoring using remote sensing data (LiDAR, multi-spectral imaging and EM38) will be undertaken to monitor the entire target area including control areas followed by targeted field work to examine the causes of any change highlighted. The remotely sensed data will provide information that provides for 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 changes 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 a program of field survey based on a targeted design will be implemented for woodland and riparian areas. Surveys will be directed into control and impact areas and will allow direct comparison between these areas through time and space.

Where the monitoring schedule refers to the collection of baseline data, the reader is referred to the Narrabri Coal Mine LW 101 – 103 Baseline Monitoring Reports for Biodiversity and Land Management (ELA 2012a and ELA 2012b).

Table 8: Multi-scale 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
Biodiversity survey	Vegetation Monitoring	Within remnant and riparian patches	Woodland health and function
	Fauna survey	Within remnant and riparian patches	Woodland health and function

7.1 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 provide data that provide for quantitative comparison of key surface condition parameters in woodland, riparian and agricultural environments. Repeat capture and analysis of the 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 LW 101-106 within the predicted impact zone.

7.1.1 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.

7.1.2 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 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.

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.

7.2 Woodland and riparian vegetation monitoring

The vegetation monitoring will focus on the patches of remnant Riparian Forest (approximately 25 ha) and Inland Grey Box Woodland (approximately 72 ha) in the target area and a selection of control areas that have similar stand characteristics (similar size, condition, etc) outside of the impact area. Control areas will be identified and established during baseline surveys within LW101-106. Surveys will focus on the condition and function of the woodland vegetation.

Vegetation condition monitoring will include a suite of parameters that relate to woodland vegetation health and habitat value (Table 9). Key parameters will be collected for the upper, mid and under storey at both impact sites and control sites to permit comparison.

Table 9: Ecological attributes to be measured within condition plots

Theme	Attribute	Description
Native overstorey (canopy)	Cover	Measured as Projected Crown Cover along a 100m transect Measured as Projected Foliage Cover under three canopies
	Health	Categorised into four simple categories based on proportion of canopy dieback
	Richness	List of native overstorey species (including emergents)
	Recruitment	Presence/absence of trees in the juvenile and sapling diameter classes
Native midstorey (shrub and small tree)	Cover	Measured as Projected Crown Cover along a 100m transect
	Richness	List of native midstorey species
Native ground layer	Cover	Measured as Projected Foliage Cover of native groundcover plants at each of 100 points along a 100 m transect
	Richness	List of native groundcover species
Exotic species	Cover	Measured as Projected Crown Cover along a 100m transect for exotic canopy and exotic midstorey species. Measured as Projected Foliage Cover at each of 100 points along a 100 m transect in exotic ground layer species.
	Richness	List of exotic flora species
Groundcover	Large woody debris	Measured in the sub-plot as the total number and combined length of all sections of dead fallen timber ≥ 10 cm diameter, ≥ 0.5 m in length, and completely detached from living or dead standing trees
	Organic litter	Recorded as a 'hit' or 'miss' at each of 100 points along a 100 m transect, then calculated as % litter cover
	Cryptograms	Recorded as a 'hit' or 'miss' at each of 100 points along a 100 m transect, then calculated as cryptogram
	Bare ground	Recorded as a 'hit' or 'miss' at each of 100 points along a 100 m transect, then calculated as bare ground
	Rock	Recorded as a 'hit' or 'miss' at each of 100 points along a 100m transect, then calculated as rock

The base plot is to be 50 m x 20 m. It incorporates a 20 m x 20 m nested subplot, a 50 m centre transect, a photo point, and an alignment point. Figure 7 shows the plot layout and Table 10 summarises the sampling units. The standard plot layout is to be used in both modules.

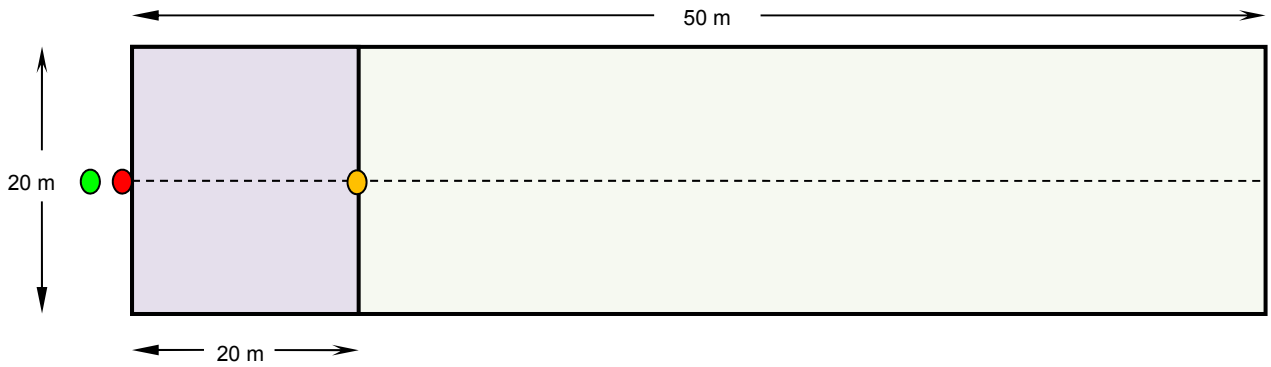

Figure 7: Plot design

Table 10: Sampling units

Sampling unit	Attributes measured
Photo Point	Point from which plot is located and oriented, and from which plot image is recorded 5 m back behind reference point (taken after plot laid out)
Reference point	Site marker post with ID tag and flagging tape attached
Alignment Point	Positioned 20 m from photo point along the transect
Baseplot (50 m x 20 m)	Native canopy health Native and exotic canopy species Native and exotic midstorey species (shrub and small tree) Large tree density (native species only) Recruitment of native canopy species
Subplot (20 m x 20 m)	Native and exotic ground layer species Coarse woody debris
---- Transect (50 m)	Native canopy cover Native midstorey cover Native groundcover Exotic cover Organic litter Cryptogram Rock Bare ground

Survey will be undertaken at sites located within the remnant and riparian patches of LW 101-106 and 2 control sites to be determined during baseline surveys (Figure 8). Baseline surveys were undertaken for LW 101-103 in spring 2011, LW104 in spring 2014 and will be undertaken for LW105 -106 during spring 2015. Ongoing monitoring will be undertaking annually in spring.

In addition to annual spring monitoring, routine inspection of the surface environment above the longwalls will be undertaken by NCOPL environmental officers. This will enable prompt detection of impacts to tree health caused by surface cracking, ponding or other longwall mining consequences.

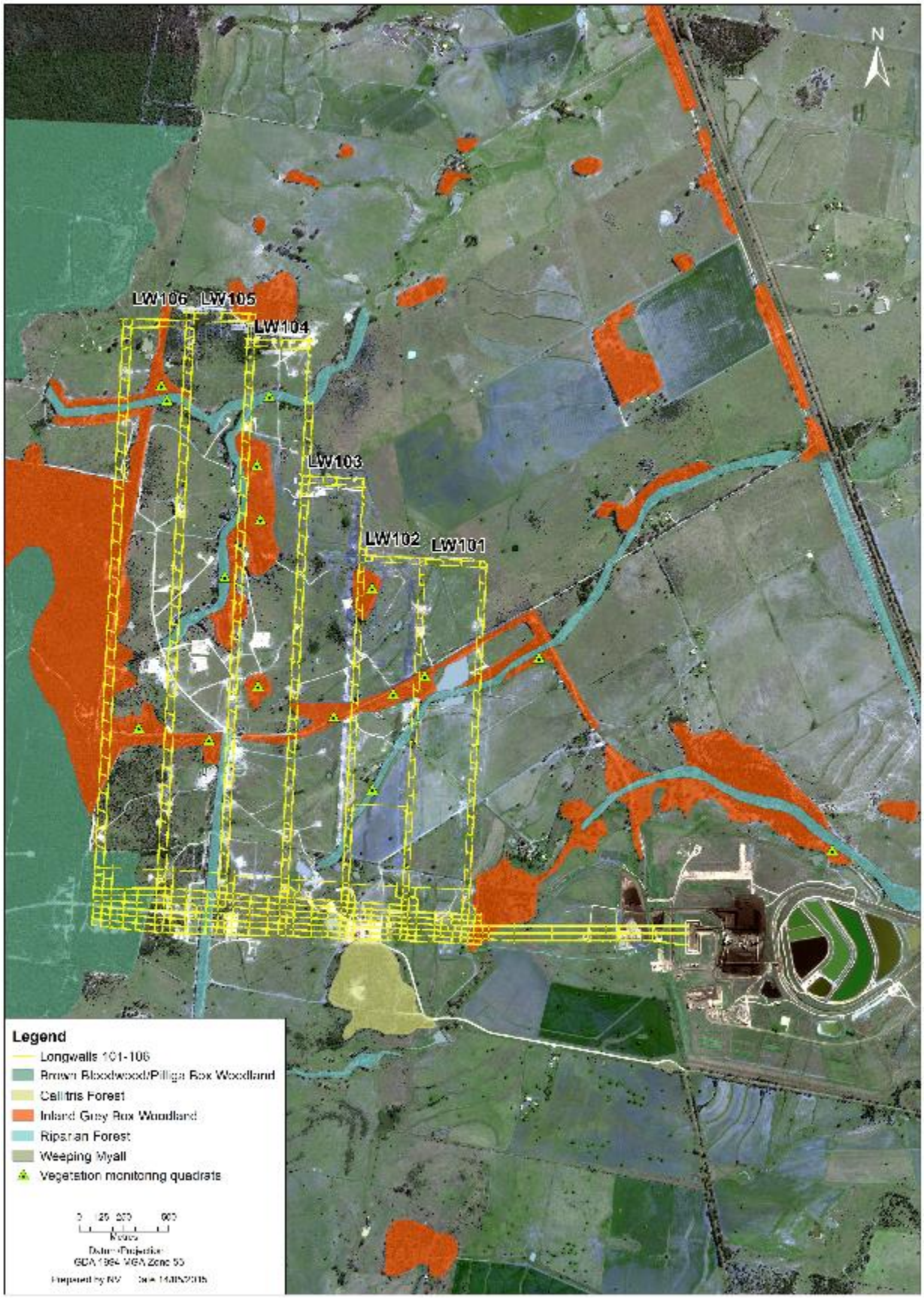

Figure 8: Indicative vegetation monitoring plots

7.3 Terrestrial fauna and habitat monitoring

Terrestrial fauna and habitat monitoring surveys will focus on the patches of remnant and riparian woodland in the target area and a selection of control areas outside of the impact area.

The terrestrial fauna and habitat monitoring will target threatened species listed under either the TSC Act and/or EPBC Act that are known to occur or potentially occur within the LW 101-106 impact area. The monitoring will focus on the remnant and riparian woodland in the LW 101-106 area and a selection of control areas outside of the impact area.

The terrestrial fauna and habitat monitoring within the LW 101-106 impact area is to occur at the sites identified in Figure 9. Control sites will be required to be established for each corresponding terrestrial fauna habitat area to allow for comparison.

Terrestrial fauna monitoring will focus on rapid approaches to species identification and notes on habitat use. Where suitable proxy measures for fauna (e.g. evidence of usage such as nests, scratching or scats) will also be assessed.

Targeted faunal groups for monitoring and methodologies for survey will be as per Table 11 below.

Table 11: Data to be collected for terrestrial fauna

Parameter	Analysis	Purpose	Survey method	Sampling frequency
Superb Parrot	Presence/absence Habitat usage	Establish presence and habitat usage	A standardised search with a stopping rule as per Watson (2004) will be used to survey for woodland birds at dawn and dusk. At each site, from a fixed point position, two randomly selected transects will be established. Birds will be recorded while walking in a meandering path along each transect, with all birds recorded either through observation or calls. All birds seen or heard will be recorded in 5 minute intervals and recording continued until no new species are recorded for three consecutive 5 minute periods.	Baseline Annual in autumn
Grey-crowned Babblers	Presence/absence Habitat usage	Establish presence and habitat usage		Baseline Annual in spring
Woodland birds	Presence/absence Habitat usage	Establish presence and habitat usage		Baseline Bi-annual in spring & winter
Koalas	Presence/absence Habitat usage	Establish presence and habitat usage	Koala searches to be conducted at each mammal site and include observations along a transect line, identifying direct sightings, scratching and scats.	Baseline Annual in spring
Hair tubes	Mammal species diversity	Establish presence	A trap line containing a combination of 5 large hair funnels and 5 small hair funnels will be placed on the ground or within habitat trees that may occur along the trap line for a period of 4 nights. Hair funnels would	Baseline Annual in spring

Parameter	Analysis	Purpose	Survey method	Sampling frequency
			be baited with a mixture of honey, peanut butter and oats (ratio of 1:3:3).	
Infra-red Camera	Mammal species diversity & feral animals	Establish presence and presence of feral animals	Infra-red Camera with a closed baited trap placed at each site over four nights.	Baseline Annual in spring
Bat detection	Microbat species diversity	Establish presence and habitat usage	Two Anabat detection devices placed at each mammal monitoring site, potentially within flyways or over water bodies for a two night period.	Baseline Annual in spring

Note: Baseline surveys were undertaken for LW 101-103 in spring 2011, LW104 in spring 2014 and will be undertaken for LW105 -106 during spring 2015.

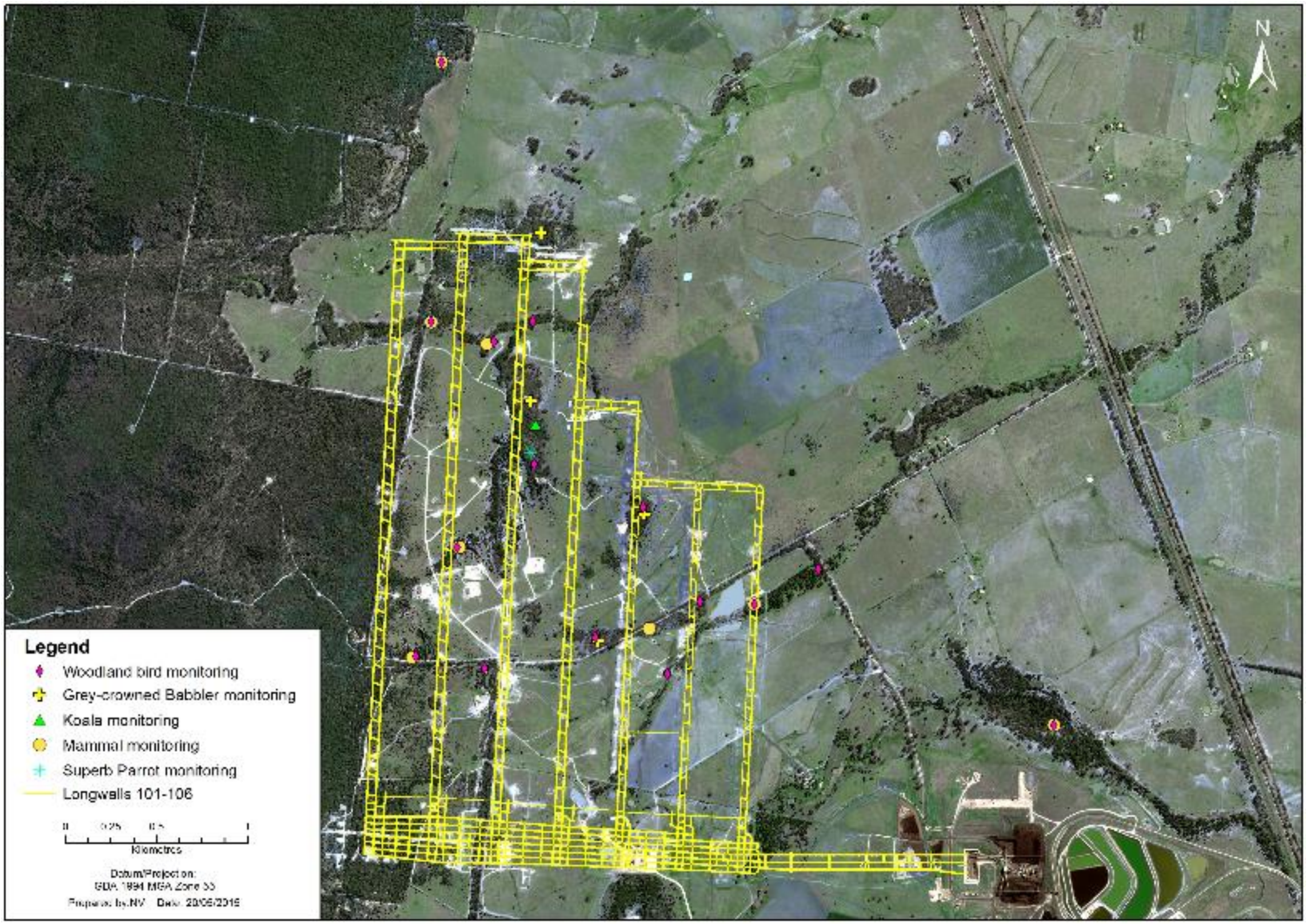

Figure 9: Terrestrial fauna monitoring sites

7.4 Aquatic biota and habitat monitoring

Permanent aquatic habitat in the area is limited to farm dams. No threatened or endangered aquatic species or endangered ecological communities have been identified to date above LW 101-106.

A baseline survey was conducted in spring 2011 of LW101-105 and found no significant habitat likely to sustain threatened species (ELA 2011). Therefore no further surveys are recommended.

It is likely that subsidence will create ponding in the ephemeral creeks. These ponds may provide favourable habitat for aquatic species, both native and exotic. Ongoing monitoring should be directed at these pond areas if they form.

7.5 Quantitative methods

Comparison between control and impact sites and through time should be implemented following each survey period. Depending on the data from either an analysis of variance (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 analyses of native vegetation communities, the variables to be analysed will include species richness and % cover, with separate analyses for understorey, overstorey, and total community variables. Analyses for changes in the faunal community will be made using species richness and count data.

Multivariate data, such as vegetation, woodland bird, reptile, and mammal community assemblages will be analysed using MDS. MDS plots will be used to assess changes in each community relative to the control sites, and differences through time will be assessed using analyses of similarities (ANOSIM).

7.6 Review and reporting

Reporting of all survey results and comparative analysis should take place annually in summer following the spring survey and subsequent analysis.

Review of the entire program should be undertaken after the first survey and from then on every 3 years to examine the trends in the data, investigate sampling effort in terms or redundancy or shortfall and to incorporate new monitoring technologies or techniques if appropriate.

The review should include consultation with key government agencies to ensure continued acceptance of the methodology and results.

7.7 Assessment against performance indicators and measures

The monitoring results will be used to assess LW 101-106 against the performance indicators and performance measures detailed in Table 7 of Section 6. If data analysis indicates a performance indicator has been exceeded or is likely to be exceeded, an assessment will be made and appropriate response developed to remediate or prevent the exceedence.

If the biodiversity performance measure is considered likely to have been exceeded or is likely to be exceeded, the Contingency Plan will be implemented as per Section 9 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 LW 101-106. 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 LW 101-106 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 LW 101-106, management measures for have been prescribed below for:

- Vegetation
- Terrestrial fauna and habitat
- 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 utilise flora species characteristic of the particular vegetation community in that area and will utilise seed collected from the mining lease or adjacent reserves. All rehabilitation methods and species should be line with the RMP.

Any vegetation clearing must follow the protocol outlined in the Statement of Commitments and the NM Rehabilitation Management Plan, which includes:

- Undertaking pre-clearing surveys by a qualified ecologist 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 a Tree Felling Protocol. The Tree Felling Protocol will be developed by a qualified ecologist and will include, but not necessarily be limited to a description of:
    - the best time of the year for felling
    - pre-felling mapping of habitat trees
    - inspections of trees on the day of felling
    - procedures for the safe removal of fauna species
    - a relocation/release protocol
    - a protocol for the assessment and salvaging of tree hollows (R.W. Corkery & Co. 2009).

8.2 Terrestrial fauna and habitat

The terrestrial fauna monitoring will be used to assess the potential environmental consequences of the recorded subsidence impacts, including the nature and extent of impacts on flora and fauna habitats and evidence of impacts on terrestrial fauna (e.g. observed fauna mortality). 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.

Potential management measures include the permanent filling of the surface tension crack in accordance with the LMP and retention of stags and woody debris for potential fauna habitat.

8.3 Weed management

Weed management will be implemented to limit the spread of noxious and environmental weeds, where weeds are found to occur in LW 101-106. 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 landowner 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*).

8.4 Feral pest management

A number of feral pests have been recorded within LW 101-106. The Rabbit (*Oryctolagus cuniculus*) is a declared pest under the NSW *Rural Lands Protection Act 1998* (RLP Act). The Red Fox (*Vulpes vulpes*) is considered a nuisance species in NSW under the RLP Act and one other significant pest species Brown Hare (*Lepus capensis*) was also recorded within land overlying LW 101-106.

Feral animal management will be consistent with those techniques outlined within the Narrabri Mine RMP. These techniques are consistent with procedures recommended by the North West Local Land Services and will have due regard to the welfare of the animals being controlled. If control is required, all available control methods will be investigated with the most effective and appropriate technique utilised. It must be noted that an integrated approach to feral animal control is often more effective and will involve several different techniques to control feral animal populations effectively.

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 LW 101-106. 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. 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	**Sites:** Vegetation monitoring quadrats (including controls), routine longwall inspection by NCOPL environmental officers, and remote sensing **Parameters:** Refer to Table 8 **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	Greater than 10% change in floristic composition (allowing for natural variation due to weather etc) Greater than 10% increase in exotic species and/or weed cover in impact quadrats in comparison to control quadrats Areas of NDVI change greater than 1 standard deviation from the mean change and greater than 0.1 ha in area Data indicates declining trend in vegetation conditions	Engage ecologist to undertake investigation to determine the cause of change. A site specific management report to be prepared and implemented where necessary that aligns with Rehabilitation Management Plan. Actions may include planting of endemic species and weed control measures.	Environmental Officer
Woodland and riparian vegetation	**Sites:** Affected longwall panel/s **Parameters:** Pre-clearing and clearing survey data and mapping	To minimise vegetation clearing To preserve remnant vegetation identified in pre-clearing surveys	Area of actual clearing exceed pre-clearing survey recommendations by greater than 5%	Environmental Officer to inform Group Environmental Manager and General Manager. DP&E, OEH and DSEWPAC to be notified and actions	Environmental Officer

Aspect	Monitoring		Response		
	Methods	Purpose	Trigger	Action	Responsibility
	Analysis: Comparison of Pre-clearing and clearing survey data and mapping Cumulative tally of cleared areas above LW 101-105 **Frequency:** Annually (spring)	Map clearing areas to determine if actual clearing aligns with pre-clearing survey recommendations		discussed. Where clearing exceeds trigger value, undertake rehabilitation and revegetation of equivalent area in accordance with RMP.	
Terrestrial Fauna & Habitat	**Sites:** Fauna monitoring sites (Figure 8) **Parameters:** Fauna species occurrence **Analysis:** Comparison of species occurrence **Frequency:** Annually (spring)	To provide baseline data on terrestrial fauna and habitat values To monitor any change in fauna species occurrence	Loss of habitat presence, hollow bearing trees and woody debris Greater than 10% decrease in recorded fauna numbers (allowing for natural variation due to weather etc) Data indicates declining trend in fauna species presence and/or abundance	Engage ecologist to undertake investigation to determine the cause of change. A site specific management report to be prepared and implemented where necessary that aligns with Rehabilitation Management Plan. Actions may include planting of endemic species, weed control measures, filling of surface cracks and additional monitoring.	Environmental Officer

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